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CONSTRUCTION ASPECTS

FOUNDATION ON SOFT MARINE DEPOSITS IN A RECENTLY RECLAIMED POLDER

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Summary

The upper layers of the soil of the polder "Flevoland" in the central part of the Netherlands consist of very soft clays and peat. The construction of the new towns Lelystad and Almere on these soft layers needs special attention concerning the soil mechanical aspects.

The recently reclaimed polder "Flevoland" in the central part of the Netherlands is not only important for agricultural purposes, but plays an important role in the migration of people from Amsterdam. The poly-nuclear town Almere is planned in the south-western part of "Flevoland". Building activities started in Almere-Haven in 1976, the first nucleus. After completion Almere will house about 250.000 inhabitants.

The houses, buildings, bridges and other constructions are built on concrete piles. The toplayers are to weak for building and will settle too much. Embankments cannot be made without special care or improvement to the subsoil and special attention is needed for the transition from a stiff construction to the adjacent weak soil.
This paper describes the general soil profile and it pays attention to the specific problems during the construction period, the way soil

investigation are carried out, advice is given and some special solutions are presented.

2 Soil description

The upper part of the subsoil consists of young marine deposits, the Holocene. These holocene clay- and peatlayers are deposited on a thick pleistocene sandlayer. The Holocene at Almere is 3 to 7 meters thick with local channels of more than 10 meters, filled with clay. The ground level is about 3 meters below mean sea level.

The Holocene in general contains the following layers from bottom to top (see figure 1):

peat
clay, sometimes more or less organic or more or less sandy
peat, often with a disturbed fabric due to erosion and resettlement of the material
clay, strongly organic in the lower part, less organic above

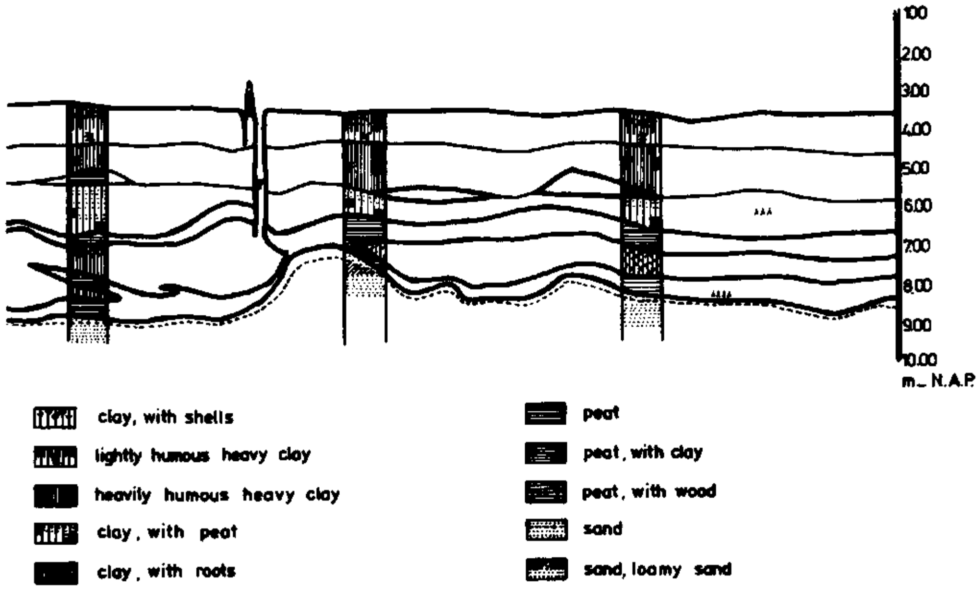


figure 1 Holocene layers in "Flevoland"

The parameters of the different layers are given in table 1

table 1. Soilparameters

description	unit weight kN/m3	watercontent % dry weight	particles < 2μm %
clay, light organic	17,5	50	26
clay, heavy organic	13,0	145-195	28,5-30
peat, disturbed fabric	10,1	550	10,5
heavy clay, organic	14,1	95-125	30-50
peat	10,1	525	5

internal	friction	cohesion		consolidation	compressibility	permeability
ϕ^{o}	ϕ' °	c kN/m	c' kN/m	coëff. c_v m /s	coëff. m_v m /kN	coëff k m/s .
17	35	10	5	8,3 10^{-8}	4,5 10^{-4}	10^{-10} 3,8
12-18	33-42	7,5-9	5-7	2,7-3,7 "	25-32 "	" 6,7-11,8
17,5	40	8	7	8 "	23 "	" 8,7
12-13	34-37	7,5-11	3,5-6,5	2,7-5,8 "	10-14 "	" 3,9-6,8
18	46	9	8	6,5 "	11 "	" 7,4

3 Specific problems

3.1 Settlements and subsidence

The holocene layers are very weak and compressible; heavy traffic and construction equipment cannot enter areas with these soil types. The IJsselmeerpolders Development Authority therefore covers areas for urban development with a layer of 1 meter sand. Due to this layer on the one hand and the lowering of the ground water table on the other hand settlements occur. In the urban areas the water table is lowered by means of an artificial drainage system. In the areas without the layer of sand the water table is also lowered by means of a dewatering system of canals, ditches and subsurface drains. Due to this dewatering the upper part of the bottom ripens. The settlement caused by the ripening and dewatering is called subsidence. The amount of settlement as function of time, thickness of the holocene layers and load in the area with the sand cover of 1 meter is given in figure 2.
The settlement in this area can be calculated with the formula of Terzaghi-Buisman-Koppejan (Huizinga, 1969). In this formula the coëfficients are

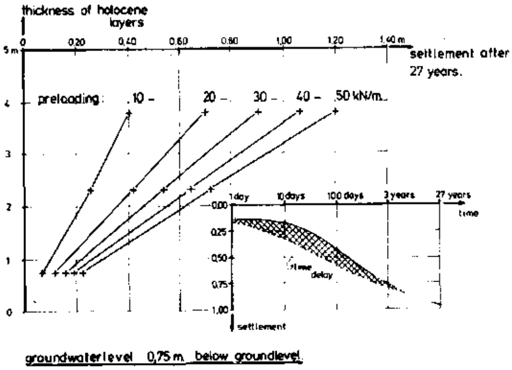


figure 2 Settlement as function of preload, thickness of holocene layers and time

taken from the results of the oedometertest. The time-delay due to the restricted seepage of the porewater overpressure in the clay- and peatlayers is simulated by the formulas given by Terzaghi (Terzaghi, 1951).

The validity of the calculations are regulary measured, both in special test set-ups and in advised work in execution. In this way the prediction proved rather accurate.

Settlements do not affect constructions in the field as long as the settlements are equal at all places and the construction is not placed on piles. Unequal settlements need in many cases special solutions.

3.2 Stability problems

The more recently deposited clay- and peatlayers have a high water content and a low internal stability. Excavations or building up of embankments cause very often stability problems. In "Flevoland" the excavation of canals was only possible, in the very young polder, at angles of 1:3 with a normal or high water level, excavation with a low water level was only possible at angles of 1:5. Special attention needs the place of the excavation machines and the transport of the excavated soil. Storage beside the freshly excavated canal and transport with heavy trucks is often not possible.

Calculation of stability with circulair slide planes (for example Bishops method, Bishop, 1955) is not always sufficient. Figure 3 shows an example in which failure took place by means of squeezing. The

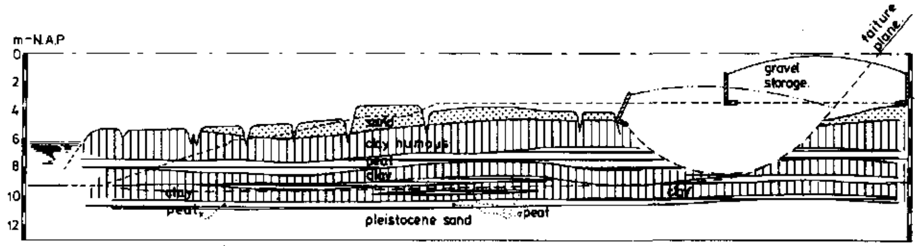


figure 3 Example of a failure plane

distance between the gravel storage and the canal was 35 meters, the height of the gravel storage was raised in a few days to 5 meters. Generally the building of embankments or storages needs flat slopes, construction in several phases with enough time between each phase or special treatment or replacement of the subsoil.

3.3. Deformations

Deformations and changes in stresses not only take place in a vertical direction, but also in a horizontal plane. Special beside incidental loads, such as embankments or storage of unpacked goods in barns, these loads cause deformations in a horizontal direction. Special constructions on piles beside the loads, such as sewer pipes on piles, pile foundations of barns or bridges at the end of an embankment or other constructions on piles must be able to resist these horizontal forces. Deformation of the piles causes very often cracking of the piles and untolerable deformations of the upper construction.

Figure 4 shows an example of the relation between the thickness of the holocene layers and the resulting horizontal force on piles in "Flevoland". This relation depends on geometry of the load and piles and on the soil strength parameters cohesion and angle of internal friction.
In "Flevoland" a special set up is made to measure forces on a sewer pipe

system on piles (Viergever, 1981). For this reason four sections of the

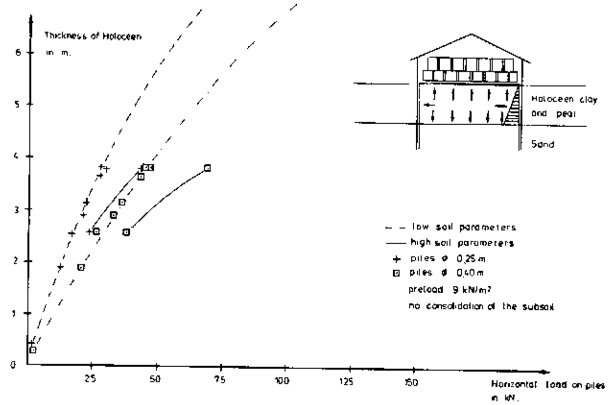


figure 4 Relation between thickness of holocene layers,load and horizontal force on piles in "Flevoland"

sewer are placed on pressure cells (figure 5). During a period of more than one year forces and porewater pressures are measured. It was shown that vertical loads can be calculated very accurate with the method of Roske (Roske, 1961). Local replacements of ground caused horizontal forces of 50% of the vertical forces. Later designs have been adapted to take account of these forces.
Traffic passing by on the road caused only dynamic response of the porewater pressure. The porewater pressures rise with growing traffic load or higher speed of the traffic on the road.

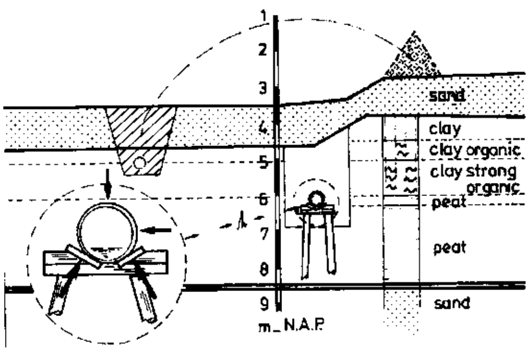


figure 5. Test set up for measuring forces on a sewer pipe on piles

Soil investigation is done at several stages of the building process. A general survey is made when the planning of the town and location starts. It is in this way possible to choose an optimal place in relation to the soil conditions. The following stage is soil investigation for specific projects and the last stage is investigation and advising during the construction of the project.

The following field investigations are made to survey the thickness and composition of the layers:

- measuring the heigth of the ground and the ground-water level
- electrical soundings with a straight electrical cone with adhesion jacket
- borings, made by hand or Ackermann apparatus
- field vane test
- pocket penotrometer test and tor vane test on samples

Samples from the Ackermann boring are tested in the laboratory:

- determination of water content, content of organic matter and grainsize distribution
- oedometertest to determin consolidation, compressibility and permeability coëfficients
- undrained consolidated triaxial test for the determination of cohesion and angle of internal friction of the clay samples
- direct shear test for the determination of the same parameters of the peat samples

5 Influence of settlements on construction details

Special care need constructions that are fixed at one point and must be able to follow at the other site the deformations and settlements in the field. Also unequal settlements need special attention.

Unequal settlements are caused by:

differences in thickness of the layers

differences in the composition of the layers

differences in the load

differences in the height of the embankment

Some examples of problems and solutions are given here

5.1 Crossing of a tube, pipe or cable with an embankment

Beneath an embankment for a bridge the holocene layers will settle. Crossing of a tube, pipe or cable with this embankment causes local deformations. Often the pipe, tube or cable is not able to take this deformations. The solution in this case is the use of a jacket pipe or roof supported by sheet piling walls (figure 6).

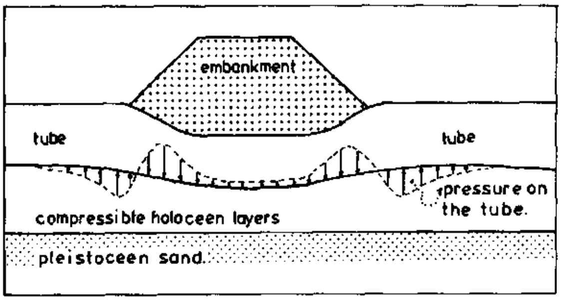


figure 6 A tube crossing an embankment

Special care should be taken when a tube crosses an embankment with local

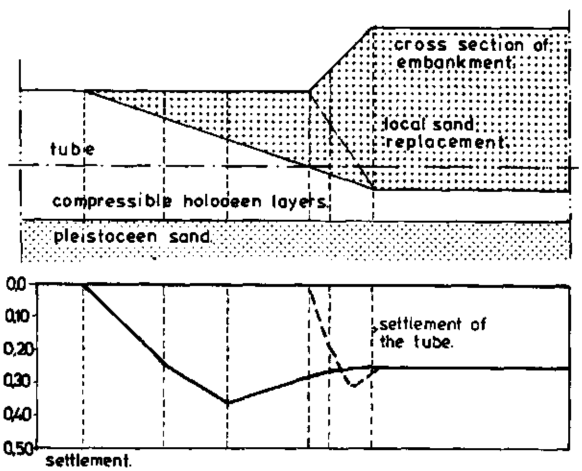


figure 7 A tube crossing an embankment on a place with ground replacement

ground replacement. It seems to be a good solution to make the ground replacement somewhat greater to create a smooth transition.
Calculations however show that on one hand the load diminishes slowly, but the thickness of the compressible layers increases on the other hand. As a result there is no smooth transition but a stronger settlement. The dashed line (figure 7) gives the settlement when there is no smooth transition in het ground replacement.

5.2 Transition from a fixed point to sites with settlements

Houses and constructions in "Flevoland" are mostly built on concrete piles. The surrounding soil often settles 0,20 to 0,30 meter after completion of the buildings.
The transition of a pipe, such as a sewer, gas or water pipe from the stiff construction placed on piles to a section without support in the field must be able to follow these big deformations. The usual solution of a transition of a sewer pipe without support to a section placed on piles is given in figure 8. The connection of a sewer pipe to a house in figure 9 is called a "polder connection", this connection is able to follow deformations of about 0,20 meter. The connection of a gas pipe is made with two additional curves. The deformation gives rotation in the two sections before and after the connection (figure 10). Cables should have some extra length. In this way the sinking ground level outside the house causes no untolerable stress in the cable.

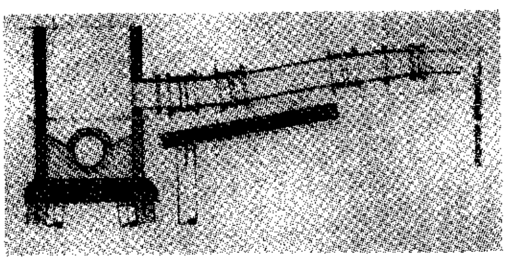
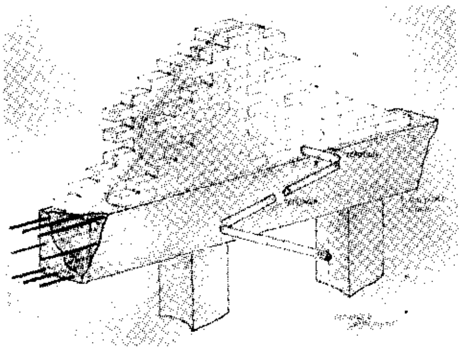


figure 8 Connection of a sewer pipe on piles with a section without piles



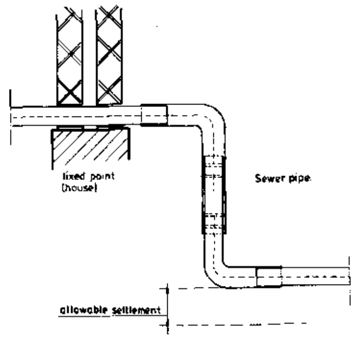


figure 9 and 10 Transition from a stiff construction to the adjecent weak soil for a sewer and gas pipe

6 Resumé

The subsoil in the freshly reclaimed polders "Flevoland" consists of weak holocene clay- and peatlayers. A description of consistency and soil parameters is given. Due to the load of the hydraulicly transported sand layer and drainage activities in the future urban areas settlements take place. Special constructions are necessary. Some examples are given. Attention is paid to horizontal deformations and stability problems with some examples.

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FREE SURFACE POTENTIAL THEORY FOR A GRAVITY WELL

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Abstract

In polder construction and maintenance and other groundwater control problems vertical pump wells are often used to keep the water table below the soil surface. The pumping results in a draw-down curve or cone of depression about the well. The writer has developed potential theory for the shape of the cone of depression for the classical problem of an unconfined well centered in a circular island. And he has compared the theory with experimental (laboratory model data) and relaxation results of Hall (La Houille Blanche, 1955, p. 29) and others. Let, for Hall's model, a = well radius, b = radius of island, d = height of the well water level above the impervious model bottom, s = height of the well water where the free surface streamline exits, and h = height of water at the inflow edge of the model. Then, with Hall's parameters given by a = 0.1h, b = 1.6h, d = 0.25h, h = 122 cm (= 4 ft), our theory gives s = 0.53h. This compares with a value of Hall, s = 0.70h, which is a considerable discrepancy. However, Hall's model had capillarity effects and his top streamlines were not orthogonal to equipotentials. Use of the writer's theoretical values, including s = 0.53h, orthogonalizes the net. The theory seems applicable to a number of free surface problems, for example, upward seeping polder water, "kwel." To make the theory apply to a square island or to a set of equally spaced pumped wells, the radius of an equivalent circle may be used.

Figure 1 represents the well geometry and defines symbols a, b, d, h, s, r, z, ρ, ζ, $\bar{k}$, and Q; for example a = well radius. Line CDE is a free surface and streamline; ψ = const is a general streamline; numbers 1, 2, 3a, 3b, 4a, and 4b are for boundary conditions. Principal objective is to determine the seepage face EF = s-d for flow to the well; a flow net and groundwater velocities are also desired. The figure shows the potential (hydraulic head) ϕ to be given by

$$\phi(r,z) = z + (p/\gamma g) \tag{1}$$

where $p/\gamma g$ is the pressure head of the water at point P, and z is the gravitational water head at this same point; γ is the density of water, and g is the acceleration of gravity. At points D on the free surface,

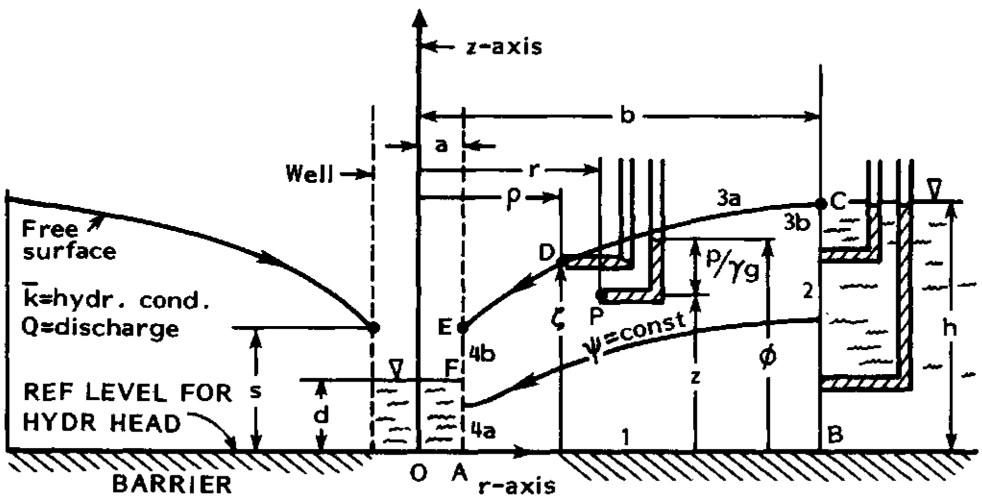

Figure 1. Free surface flow to a well

where the coordinates (r,z) become (ρ,ζ) and p becomes zero, the potential ϕ in (1) becomes

$$\phi(\rho,\zeta) = \zeta \tag{2}$$

The well discharge Q passing underneath the free surface EDC has, independently of any detailed form of ϕ, been derived by Çharnii, as is seen in Polubarinova-Kochina [1962, pp. 281-283]. The Charnii formula is

$$Q = \pi k \ (h^2 - d^2)/\ell n(b/a) \tag{3}$$

The writer has referred to (3) in an earlier paper (Kirkham, 1964), where effort was made to give an "exact" theory for the problem of Figure 1 by successive approximations. However, the author's students found that the solution did not give improving accuracy at higher orders of approximations. Here the writer presents a different attack. Some of the earlier functions and procedures, including Charnii's formula Equation (3), will be used. Figure 1 shows a streamline labelled ψ = const. The stream function ψ was not used in Kirkham (1964). Here its use will be vital, but we first need to consider ϕ. We shall, in the following, often cite Kirkham and Powers (1972) abbreviated as KP (1972). Further background is in Boast (1977).

2 Analysis

2.1 Laplace's equation and boundary conditions

The potential function ϕ must satisfy Laplace's equation subject to boundary conditions. In cylindrical coordinate the equation as in KP (1972, p. 71) is

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial\phi}{\partial r}\right) + \frac{\partial^2\phi}{\partial z^2} = 0 \tag{4}$$

The boundary conditions (Figure 1) may be written (a capillary fringe is neglected) as

1. $\partial\phi/\partial z = 0, \quad a \leq r \leq b, \quad z = 0$ (5)

2. $\phi = h, \quad r = b, \quad 0 \leq z \leq h$ (6)

3a. $\phi = \zeta, \quad r = \rho, \quad z = \zeta$ (7)

3b. $Q = 2\pi\rho \int_0^\zeta \bar{k}(\partial\phi/\partial r)_{r=\rho} dz$ (8)

4a. $\phi = d, \quad r = a, \quad 0 \leq z \leq d$ (9)

4b. $\phi = z, \quad r = a, \quad d \leq z \leq s$ (10)

Condition 3a or Equation (7) states that surface EDC is a free surface because on a free surface the pressure p of Equation (1) is zero. Condition 3b or Equation (8) states that a free surface is a streamline, because by flow continuity the same flow Q passes through all cylindrical shells of height ζ and circumference $2\pi\rho$. To satisfy the boundary conditions, we shall select a solution ϕ from particular solutions of Equation (4) tabulated as velocity potentials

$\Phi = \bar{k}\phi$, ($\bar{k}$ = hydraulic conductivity as in meters per day) (11)

in KP (1972, p. 129).

2.2 The potential function

With m defined by m = 1, 3, 5, ...; A_m, B_m, D_m constants to be determined; J_o, Y_o, I_o, K_o Bessel functions, we select the hydraulic potential ϕ in the form

$$\phi = s - s\Sigma A_m R_o\left(\frac{m\pi r}{2s}\right)\cos\frac{m\pi z}{2s} + s\Sigma B_m C_o\left(\mu_{(m+1)/2}\,\frac{r}{a}\right)\frac{\cosh \mu_{(m+1)/2}\,\frac{z}{a}}{\cosh \mu_{(m+1)/2}\,\frac{h}{a}}$$

(equation continued)

$$+ s\Sigma D_m S_o(\frac{m\pi r}{2h})\cos\frac{m\pi z}{2h}, \quad (m = 1, 3, \ldots) \tag{12}$$

where

$$R_o(\frac{m\pi r}{2s}) = \frac{K_o(m\pi r/2s)I_o(m\pi b/2s) - K_o(m\pi b/2s)I_o(m\pi r/2s)}{K_o(m\pi a/2s)I_o(m\pi b/2s) - K_o(m\pi b/2s)I_o(m\pi a/2s)} \tag{13}$$

$$S_o(\frac{m\pi r}{2h}) = \frac{K_o(m\pi r/2h)I_o(m\pi a/2h) - K_o(m\pi a/2h)I_o(m\pi r/2h)}{K_o(m\pi b/2h)I_o(m\pi a/2h) - K_o(m\pi a/2h)I_o(m\pi b/2h)} \tag{14}$$

$$C_o(\mu_{\frac{m+1}{2}}\frac{r}{a}) = J_o(\mu_{\frac{m+1}{2}}\frac{r}{a})Y_o(\mu_{\frac{m+1}{2}}\frac{b}{a}) - J_o(\mu_{\frac{m+1}{2}}\frac{b}{a})Y_o(\mu_{\frac{m+1}{2}}\frac{r}{a}) \tag{15}$$

$$\mu_{\frac{m+1}{2}} = \text{roots } (m = 1,3,5,\ldots) \text{ of } C_o(\mu_{\frac{m+1}{2}}\frac{a}{a}) = 0 \tag{16}$$

In Equation (12), and subsequently, the symbol Σ is for summing with respect to index m = 1, 3, 5, ... The functions R_o, S_o, and C_o of Equations (13)-(16) have been constructed to give

$$R_o(\frac{m\pi a}{2s})=1, \quad R_o(\frac{m\pi b}{2s})=0, \quad S_o(\frac{m\pi a}{2h})=0, \quad S_o(\frac{m\pi b}{2h})=1, \quad C_o(\mu_{\frac{m+1}{2}}\frac{b}{a})=0 \tag{17}$$

for any values of m, a, b, h, s, and $\mu_{(m+1)/2}$. In Equation (16) a ratio a/a is purposely maintained in the argument of C_o to emphasize the argument is for r = a. Use of a/a for 1 now and subsequently helps prevent error. The ϕ of Equation (12) satisfies boundary condition 1 for any values of the A_m, B_m, and D_m. We next determine the A_m and D_m.

2.3 Determining the constants A_m and D_m

To get the A_m we use boundary conditions 4a and 4b. We apply Equations (16) and the first and third of (17) to Equation (12) and after defining a function f(z) by

$$f(z) = \begin{cases} 1 - d/s, & 0 \leq z \leq d \\ 1 - z/s, & d \leq z \leq s \end{cases} \tag{18}$$

we find that Equation (12) gives

$$f(z) = \Sigma A_m \cos\frac{m\pi z}{2s}, \quad 0 \leq z \leq s \tag{19}$$

From Equations (18) and (19) and use of a quarter range odd index cosine series of KP (1972, p. 135) we now find the A_m as

$$A_m = \frac{8}{\pi^2}\frac{1}{m^2}\cos\frac{m\pi d}{2s}, \quad (m = 1, 3, \ldots), \quad 0 \leq z \leq s, \text{ (inclusive)} \tag{20}$$

To get the D_m we use boundary condition 2. We put h for ϕ and b for r in Equation (12) and in view of the 2nd, 4th, and 5th of Equations (17) find that Equation (12) may be written as

$$\frac{h - s}{s} = \Sigma D_m \cos\frac{m\pi z}{2h}, \quad (m = 1, 3, \ldots), \quad z \neq h \tag{21}$$

which by use of Dwight (1961, formula 416.06) gives

$$D_m = (\sin\frac{m\pi}{2})\frac{4}{\pi}(\frac{h-s}{s})\frac{1}{m}, \quad (m = 1, 3, \ldots), \quad z \neq h \tag{22}$$

The D_m do not yield the correct potential at the point (b,h). For that point we can use the free surface streamline boundary condition 3b. We use it next to find the constants B_m.

2.4 The constants B_m, the stream function ψ

We multiply Equation (12) through by $\bar{k}$ to get it as a velocity potential $\Phi = \bar{k}\phi$. From this form, by use of Cauchy-Riemann type equations with solutions as tabulated in KP (1972, p. 129, Table 3-2, lines 2,4,6,8 and 13), we may find after some factoring the stream function ψ corresponding to $\bar{k}\phi = \Phi$ as

$$\psi = kh\frac{s}{h}\, r\, \Big[\, \Sigma A_m R_1(\tfrac{m\pi r}{2s})\sin\tfrac{m\pi z}{2s} -$$

$$\Sigma B_m C_1(\mu_{(m+1)/2}\,\tfrac{r}{a})\frac{\sinh \mu_{(m+1)/2}\,\frac{z}{a}}{\cosh \mu_{(m+1)/2}\,\frac{h}{a}} - \Sigma D_m S_1(\tfrac{m\pi r}{2h})\sin\tfrac{m\pi z}{2h}\,\Big] \tag{23}$$

where

$$R_1(\tfrac{m\pi r}{2s}) = \frac{K_1(m\pi r/2s)I_o(m\pi b/2s) + K_o(m\pi b/2s)I_1(m\pi r/2s)}{K_o(m\pi a/2s)I_o(m\pi b/2s) - K_o(m\pi b/2s)I_o(m\pi a/2s)} \tag{24}$$

$$S_1(\tfrac{m\pi r}{2h}) = \frac{K_1(m\pi r/2h)I_o(m\pi a/2h) + K_o(m\pi a/2h)I_1(m\pi r/2h)}{K_o(m\pi b/2h)I_o(m\pi a/2h) - K_o(m\pi a/2h)I_o(m\pi b/2h)} \tag{25}$$

$$C_1(\mu_{\frac{m+1}{2}}\,\tfrac{r}{a}) = J_1(\mu_{\frac{m+1}{2}}\,\tfrac{r}{a})Y_o(\mu_{\frac{m+1}{2}}\,\tfrac{b}{a}) - J_o(\mu_{\frac{m+1}{2}}\,\tfrac{b}{a})Y_1(\mu_{\frac{m+1}{2}}\,\tfrac{r}{a}) \tag{26}$$

and an arbitrary constant in the right-hand side of (23) has been taken equal to zero to make $\psi = 0$ at point (a,0) and at all points (r,0) along the barrier in Figure 1; K_1, I_1, J_1 and Y_1 are Bessel functions. With the streamline Equation (23) at hand we can now get the constants B_m. Boundary condition 3b, Equation (8), tells us that ψ of Equation (23) must have the same value for point (b,h) and point (a,s). So we write ψ down for these two points and equate results to find

$$b\,\Big[\,\Sigma A_m R_1(\tfrac{m\pi b}{2s})\sin\tfrac{m\pi h}{2s} - \Sigma B_m C_1(\mu_{(m+1)/2}\,\tfrac{b}{a})\frac{\sinh \mu_{(m+1)/2}\,\frac{h}{a}}{\cosh \mu_{(m+1)/2}\,\frac{h}{a}} -$$

$$\Sigma D_m S_1(\tfrac{m\pi b}{2h})\sin\tfrac{m\pi h}{2h}\,\Big] = a\,\Big[\,\Sigma A_m R_1(\tfrac{m\pi a}{2s})\sin\tfrac{m\pi s}{2s} -$$

$$\Sigma B_m C_1(\mu_{(m+1)/2}\,\tfrac{a}{a})\frac{\sinh \mu_{(m+1)/2}\,\frac{s}{a}}{\cosh \mu_{(m+1)/2}\,\frac{h}{a}} - \Sigma D_m S_1(\tfrac{m\pi a}{2h})\sin\tfrac{m\pi s}{2h}\,\Big] \tag{27}$$

We have put together potential forms that cause the sums in Equation (27) to converge. Therefore, the two sides of Equation (27) will be equal if corresponding terms (m=1,3,5, ...) on the left are equal to corresponding terms (m=1,3,5, ...) on the right. That is, the two sides will be equal if we drop the sigmas (Σ's) in Equation (27) and solve the result for the B_m. So we do this and by algebra find

$$B_m = \{ A_m [R_1(\frac{m\pi a}{2s})\sin\frac{m\pi s}{2s} - \frac{b}{a}R_1(\frac{m\pi b}{2s})\sin\frac{m\pi h}{2s}] +$$

$$D_m [-S_1(\frac{m\pi a}{2h})\sin\frac{m\pi s}{2h} + \frac{b}{a}S_1(\frac{m\pi b}{2h})\sin\frac{m\pi h}{2h}] \} \div$$

$$[C_1(\mu_{(m+1)/2}\frac{a}{a})\frac{\sinh \mu_{(m+1)/2}\frac{s}{a}}{\cosh \mu_{(m+1)/2}\frac{h}{a}} - \frac{b}{a}C_1(\mu_{(m+1)/2}\frac{b}{a})\tanh \mu_{\frac{m+1}{2}}\frac{h}{a}] \quad (28)$$

In Equation (28) simplify $R_1(\frac{m\pi b}{2s})$, $S_1(\frac{m\pi a}{2s})$, $\frac{b}{a}C_1(\mu_{\frac{m+1}{2}}\frac{b}{a})$ by Watson (1948).

2.4 The free surface heights s and ζ

We must find s and ζ. If s is found, then because we will then know all constants in Equation (12), we can apply boundary condition 3a (put $z = \zeta$ and $r = \rho$ in Equation (12)) and obtain an equation for ζ versus ρ of Figure 1.

To find s, we may put B_m, which is a function of s of Equation (28), in Equation (27) and solve the result by iteration or some other process for s. There is another procedure. It may be proved as in Zaslavsky and Kirkham (1964) that well flow Q_1 between the bottom $\psi = 0$ streamline and a streamline passing through a point (r_1,z_1) is given by

$$Q_1 = 2\pi \psi_1(r_1,z_1) \quad (29)$$

so that the total well discharge Q is

$$Q = 2\pi \psi(a,s) \quad (30)$$

Equating the right-hand sides of Equations (3) and (30) gives

$$\pi\bar{k}(h^2 - d^2)/\ln(b/a) = 2\pi\psi(a,s) \quad (31)$$

We put $\psi(a,s)$ from Equation (23) in (31) and simplify to find by algebra, with the conductivity $\bar{k}$ cancelling and with lengths normalized with respect to h, the result

$$L(\frac{s}{h}) = R(\frac{s}{h}) \tag{32}$$

where (with m = 1,3,5, ...)

$$L(\frac{s}{h}) = \frac{s}{h} \tag{33}$$

$$R(\frac{s}{h}) = \frac{\frac{1}{2}\frac{1}{(a/h)}\frac{1-(d/h)^2}{\ell n[(b/h)/(a/h)]}}{\sigma_A - \sigma_B - \sigma_D} \tag{34}$$

$$\sigma_A = \Sigma A_m R_1(\frac{m\pi a/h}{2s/h})\sin\frac{m\pi s}{2s} \tag{35}$$

$$\sigma_B = \Sigma B_m C_1(\mu_{(m+1)/2}\frac{a}{a})\frac{\sinh \mu_{(m+1)/2}\frac{s/h}{a/h}}{\cosh \mu_{(m+1)/2}\frac{h/h}{a/h}} \tag{36}$$

$$\sigma_D = \Sigma D_m S_1(\frac{m\pi a}{2h})\sin\frac{m\pi s}{2h} \tag{37}$$

Solving equation (32) with its auxiliary equations gives the solution s/h of our problem.

3. Results

I have solved Equation (32) graphically for the parameters of the sand tank model of Hall (1955)

$$a/h = 0.1, \quad b/h = 1.6, \quad d/h = 0.25 \tag{38}$$

with the result s/h = 0.53. This value does not agree with Hall's s/h = 0.7. Capillarity in his model may account for the discrepancy. A free surface point that I calculated as $(\rho/h, \zeta/h) = (0.4, 0.82)$ falls nearly on his curve point (0.4,0.80). A line through my points (0.250,0.53), (0.4,0.82) is orthogonal to his measured equipotentials. I made another check. Axially symmetric theory can by methods of Kirkham (1964, p.2543) go over to two-dimensional rectangular seepage theory (but not vice versa) as in a two-dimensional dam seepage problem of Muskat (1946, p. 314, case vi) for which Muskat found s/h = 0.719/1.823 = 0.394. For Muskat's example by present theory I calculated s/h = 0.393.

4. Conclusions

Free surface well flow theory as here developed seems correct. More calculations are needed, such as for complete flow nets. The theory should be applicable to other free surface problems such as upward seeping polder water, "kwel." To make the theory apply to a square island or to a set of equally spaced pumped wells, the radius of an equivalent circle may be used.

Acknowledgement

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APPENDIX

The Appendix is a longer version. To obtain a copy* contact the Photo Service, Iowa State University, Ames, Iowa 50011, requesting Supplement to Publication No. STP 5/21/82 Kirkham 1982, Symposium Polders of the World, TNO, Lelystad, the Netherlands Oct. 4-10, 1982. Submit $.50 in the form of check, cash or money order. Give your name and complete address for mailing. *microfiche

THE POSSIBILITY OF USING UNDERGROUND DAMS TO IRRIGATE POLDERS IN TROPICAL AREAS

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Abstract

In tidal lands such as coastal areas in Southeast Asian countries, the underground dam system could be used in place of the tidal irrigation system. This could be expected to lead to an increased yield of rice.

1 Introduction

Most of the swampy areas in Indonesia are located in coastal areas and/or along rivers. The boundary separating swampy areas and the sea consists of either mangrove forests or coral sands -- both of which have a very high permeability (C x 10^{-2} - 10^{-3}). This means that sweet water can be found only just after heavy rainfalls during the rainy season.

On the other hand, the salinity of water in swampy areas along rivers may exceed the limit of salinity for rice-ingrow, depending on the gradient and the salinity front.

For this reason, most paddy fields in swampy areas are undeveloped rain-fed and tidal irrigation has been the only available irrigation system for such areas up to the present time.

However, I propose that, if reservoirs of sweet water could be located and used during the period of rice-ingrow, a much higher yield of rice could be expected because there are many wide-ranging rain-fed areas which have a great potential for development and high productivity.

2 Problems with ground water irrigation

2.1 Weaknesses

a) Generally speaking, it is very expensive.
b) It requires the use of energy sources.
c) Water may possibly re-permeate into the ground.
d) Shortages may occur if the water supply is not conserved and/or supplemented.
e) It often causes either ground subsidence or permeation of sea water.

2.2 Advantages

a) It allows for effective utilization of land resources.
b) It brings new selected intensive products into a region and raises the level of production techniques.
c) It promotes the growth of forests in flat and low lands.
d) It protects land against erosion.
e) It teaches farmers the effective use of water resources.

2.3 Political benefits

a) It reduces transportation and distribution costs for food from other regions.
b) It eliminates the inferiority complex natives in undeveloped areas have towards developed areas.
c) It keeps areas inhabitable.
d) It stabilizes the lives of the people.

3 The process of making a ground water irrigation plan (using the situation in Izu Ohshima as an example)

3.1 Background

Izu-Ohshima is located about 110 kilometers south of Sagami Bay and belongs to the prefecture of Tokyo. The island is 754 meters above sea level and has a total area of 598 ha. It is a volcanic island (formed from the Mihara volcano) and a caldera. The annual average rainfall of the island is more than 3,000 millimeters but we find almost no surface water because the geological structure of the island, especially its ground surface, is highly permeable. Therefore, the rainfall permeates into the ground and flows out into the sea. This means that the inhabitants must use the ground water for domestic and irrigation purposes before it flows out into the sea. The balance between supply (input) and demand (output) is barely being maintained at the sacrifice of demands for an increase in the water supply.

The island has a comfortable climate, a beautiful landscape which includes the Mihara volcano, sandy beaches and fine Camelia flowers. For this reason, the number of tourists visiting the island has been increasing year by year. This, in turn, has meant that the water balance is becoming increasingly difficult to maintain. Nowadays, the town offices on the island are compelled to produce drinking water by the ion-exchange method.

From the economic point of view, because of such conditions as a good climate and rich soil, the island has a high potentiality for producing fine upland crops for which the islanders could get good prices in Tokyo provided they could get the needed irrigation water. Being self-sufficient in agricultural products would be of great help to the islanders because they are cut off from supplies from the mainland at certain times during the year due to typhoons and other bad weather.

3.2 Commencement of investigation

For the above-mentioned reasons and at the request of the prefecture of Tokyo, the Central Construction Guidance and Service Center of the Ministry of Agriculture headed by me began a simulation test by computer in which we tried to realize the improvement of water balance in southern Ohshima as a prefectural development project. (I might note here that I was despatched to Indonesia by the Ministry before the test was completed.)

In addition to the test, Asia Air Survey Co., Ltd. took some false-color aerial photos of the same area. Both results showed that large quantities of sweet water were flowing out through many geological apertures and gaps into the sea. This meant that the supply of water could meet demands if only we could find some method of containing this ground water and maintaining the existing water level.

In fiscal year 1977/78, the Directorate of Planning and Programming, Kanto Regional Office, Ministry of Agriculture, headed by me from the 1st of April, 1978 began a three year prefeasibility study for real implementation of the project.

3.3 Results of the study

The density of Cl-ion ground water in old geological stratum is approximately 80 ppm. This means that it is suitable for both irrigation and domestic water supplies. However, this sweet water soon flows out into the sea after a rainfall since there are no catchment facilities.

The density of Cl-ion of ground water in new geological stratum is approximately 800 - 900 ppm. It means that the water is useful neither for irrigation nor domestic water purposes.

In our opinion, the true ground water will consist of rainfall which falls on the upper part of Mihara volcano and flows down through the aperatures and/or cracks of old geological stratums and is kept in these old stratums. The ground water in new geological stratums seems either to be sea-water permeated or strongly influenced by Cl-ion of sea-water.

We must use this ground water from deep and old stratums in Ohshima because there is actually no surface water, but we must make sure the sea-water doesn't permeate into the old stratums if we are to preserve the ground water balance in the future. We must choose a suitable method with which we can guarantee the preservation of our important water resources for future generations.

Possible methods are as follows:

a) to control the use of the ground water;
b) to construct some underground dams with which to keep the water from flowing out into the sea;
c) to construct a dike and some related facilities at the mouth of the port (Port Habu) which will result in changing the water in the harbor from sea-water to sweet water.

3.4 Decision

In making a final decision, I reasoned as follows:

- As for method a), I could find great merit in it.
- Concerning method c), as an experienced polder engineer, I am sure I could succeed in doing it, not only from a technical point of view but also because it has the cheapest initial costs and operating costs. However, I could not overlook the usefulness of the harbor as a port of shelter against typhoons and storms. Therefore method c) was eliminated.
- This leaves us with method b) -- that is, the underground dam. The detailed designing of this project will commence in fiscal year

1982/1983 by the Kanto Regional Office of the Ministry of Agriculture. During fiscal years 1980/81 and 1981/82, both the Directorate of Construction and the Directorate of Planning and Programming executed some supplemental surveys and investigations. Unfortunately, I am not now in a position to lead this project. However, I am satisfied that I was able to lay the foundations for this project. I will continue to have deep interest in this project and I hope my successors succeed in fulfilling our aims.

4. Minafuku underground dam in Miyako Island, Okinawa

4.1 Background

In the prefecture of Okinawa, especially in Miyako Island, the fluctuation of the annual rainfall is very variable; that is to say, 1,000 millimeters to 3,000 millimeters. This fluctuation depends entirely on the rains brought by typhoons. From the beginning of June to the end of September, the water balance in Miyako Island is either too high or too low.

Miyako Island consists of coral reefs and porus limestone deposited on top of impermeable mudstone. This means that the original permeability is approximately 5×10^{-2} cm/sec and that, therefore, the inhabitants can use neither surface water nor ground water. Moreover, the only suitable location for a reservoir is in the northern part of the island which has only a small catchment area.

Miyako Island is located far from developed areas in Japan where inhabitants can enjoy the fruits of modern development in the fields of culture, economy and so forth. The island cannot produce the necessary foods for the inhabitants nor the specialities which the farmers could exchange for money and/or food. On the other hand, the island has a large area capable of being irrigated, if only there were water resources.

According to the Development Plan of Okinawa Prefecture, the water resources needed for irrigation for a year on the island is estimated to be approximately 340 million m^3 for 55,400 ha of existing agricultural land (3,100 ha of paddy fields, 45,000 ha of upland and 6,900 ha of fruit-farming), while the annual shortage of irrigation water for existing agricultural land and newly reclaimed lands of about 24,000 ha is estimated to be approximately one million m^3.

4.2 Improvement plan

After considering the above situation, Dr. M. Momikura (previously Chief Geologist of Kyushu Regional Office of the Ministry of Agriculture and, now, Chief Geologist, National Land Agency, Government of Japan), suggested that the underground dam system might be useful in solving the irrigation water shortage. Therefore, the government officers concerned organized a project team to study the use of the underground dam.

The Project Team for Improvement of the Irrigation System in Miyako Island, Bureau of Agricultural Structure Improvement, Ministry of Agriculture found that the only way to keep and/or supply the necessary water resources was by the so-called "underground dam." The underground dam would have to be constructed at the lowest part of the impermeable stratum.

According to many investigations and surveys on available ground water, it has been estimated that 200,000 m^3/day would be available except for the fact that most of it flows out into the sea. This means that the necessary water resources could be maintained by an underground dam if the dam were constructed skillfully enough.

4.3 Construction plan

4.3.1 Outline

Construction work commenced in September, 1977. The most important structure of the dam was a wall of vertical impermeable curtains. The method selected to make the wall was the grouting method and the material used was portland cement milk. The thickness of the grouting wall was about 5.0 meters. The depth depended upon the geological conditions. By constructing a grouting wall we got good permeability of 3×10^{-5} cm/sec. The height of the grouting wall also depended on the geological conditions near the surface of the ground. Therefore, the mean height of the grouting wall was fixed at 8.0 m beneath the surface of the ground in accordance with the results of simulation for correlation between rainfall and saturation and so forth.

4.3.2 Attached facilities

An underground spillway was also constructed by the pipe system. The spillway has two main purposes:

a) to prevent landslides, piping and other occurrences caused by over-saturation;

b) to exchange reserved water if its quality becomes bad for any reason.

4.3.3 Interim Report

The ground water level rose about 10 meters at just the upper side of the dam and about 3 meters at about 650 meters from the upper side of the dam. These directly observed results coincided with the simulation test which was performed before the detailed designing was done.

4.4 Follow-up observation

During and after the construction works the quality and quantity of the reserved water was observed at least once a month at 10 selected locations.

4.5 Evaluation

The project itself is still underway and so we cannot give a final evaluation of it. However, from the interim investigations, surveys and observations, we are optimistic that the project will bring good results not only for the inhabitants of Miyako Island but also for we irrigation engineers for whom this project represents an excellent technical experience.

5 Possibility of using this system to irrigate polders and/or swampy areas in tropical areas

Most tropical areas, especially Southeast Asian countries such as Indonesia and Thailand, have a rainy season and a dry season. During the rainy season the average rainfall is usually more than enough for growing rice; in fact, farmers often experience overflooding resulting in ruined harvests. On the other hand, during the dry season, there is no rainfall at all. Thus, farmers are confronted with the two extremes.

In theory, the tidal irrigation system appears to be very good system and relatively easy to put into operation. In fact, however, actual implementation of this system is difficult due to meteorological conditions which are variable and which cannot be forecasted.

Therefore, if an underground dam could be constructed in a poldering area and if the rainfall that had accumulated on the dam during the rainy season could be used to irrigate the land, we could expect more development and improvement in agricultural land utilization leading to an increased rice yield and stabilized rice production.

I regret that I cannot give you proof (i.e. an actual test case) of the worthiness of this underground dam system in tropical areas because, unfortunately, my assignment in Indonesia as a Colombo Plan expert was concluded before I could finish my study of this application in swampy and poldering areas. However, I did succeed in realizing the potential of the underground dam system during tests in coral sand areas in Japan, and for this reason, I am sure fruitful results could be obtained with this system in tropical coral sand areas and mangrove forest areas.

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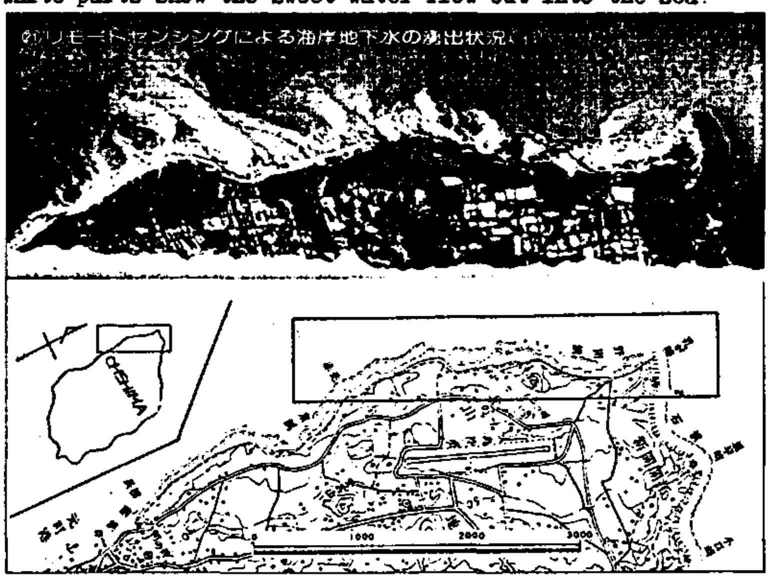
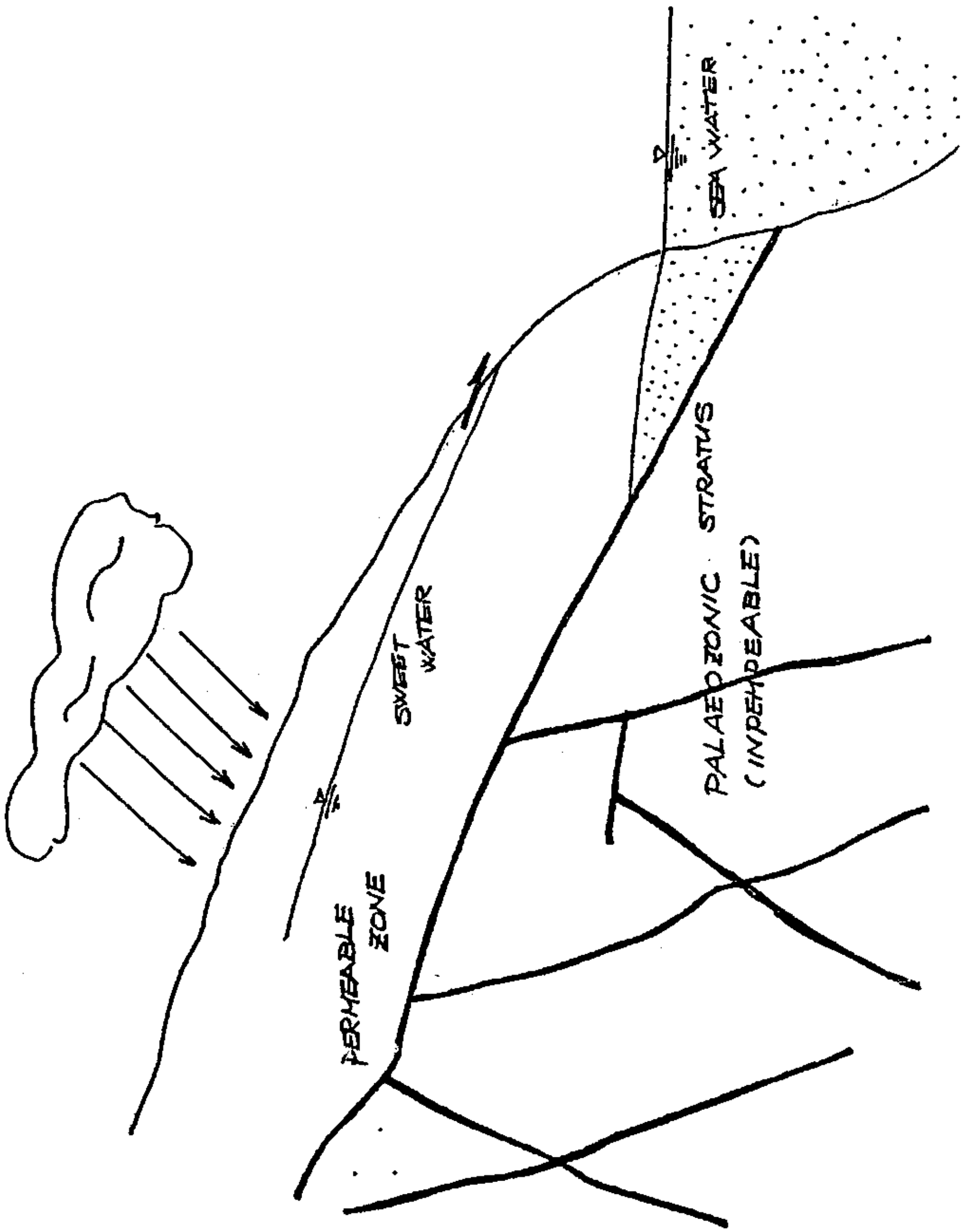
Existing circumstances of flowing out of sweet water into the sea water in Nòrthwest Area of Ohshima by Infra-Red-Aerophoto and it's analysis

White parts show the sweet water flow out into the sea.

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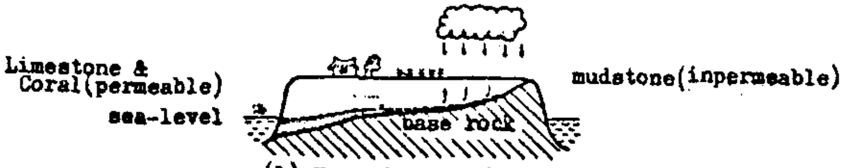
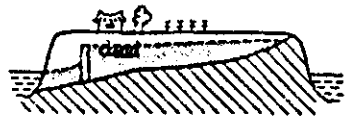
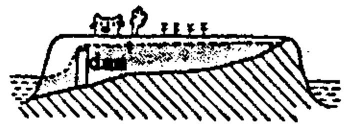


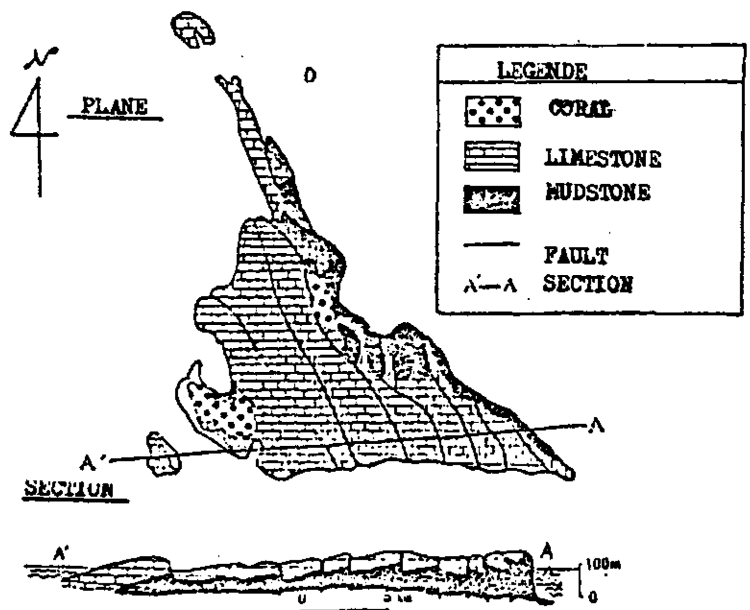
(1) No underground-dam



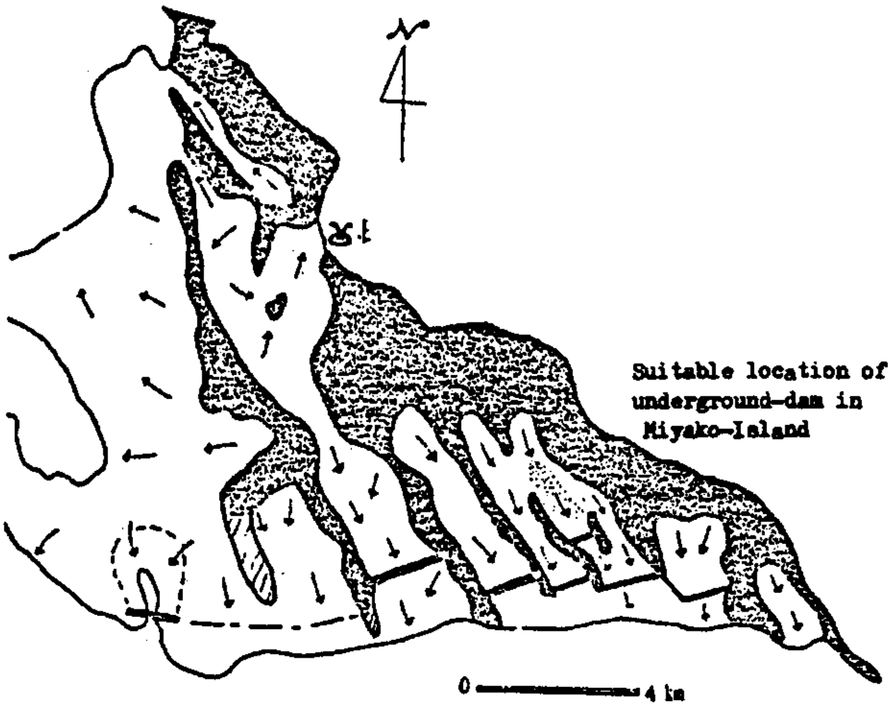
(2) with underground-dam,in the case of drought



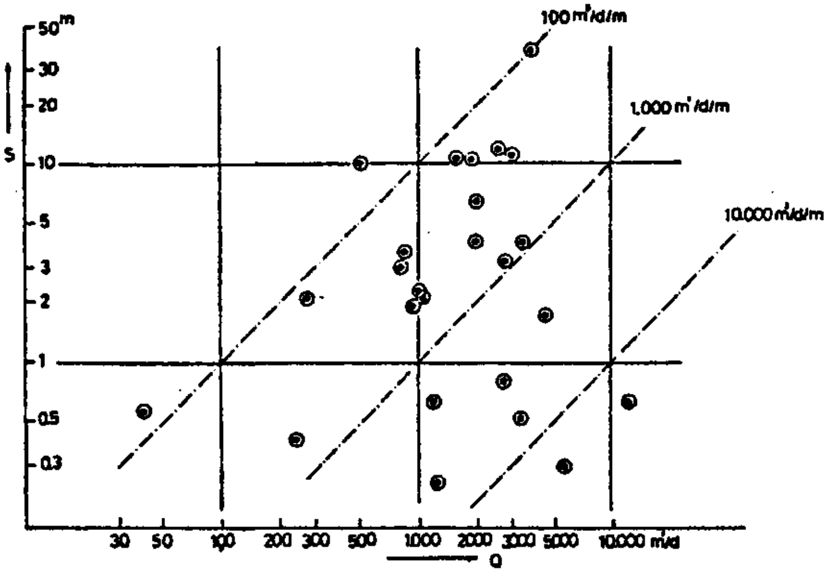
(3) with underground-dam, in the case of rainy season



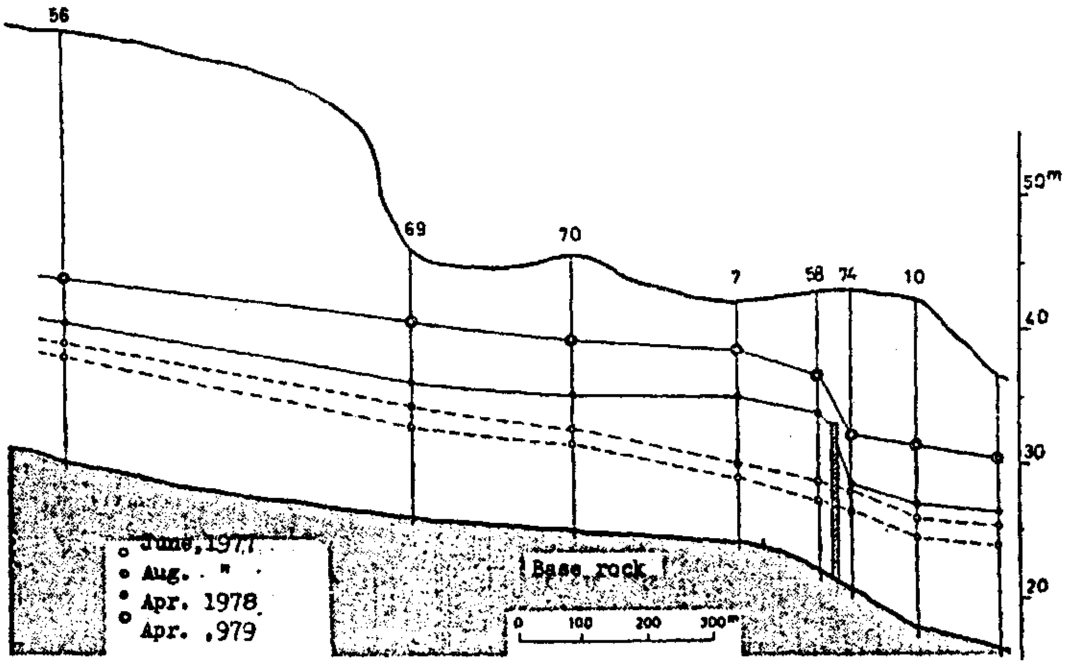
GEOLOGICAL STRUCTURE OF MIYAKO-ISLAND



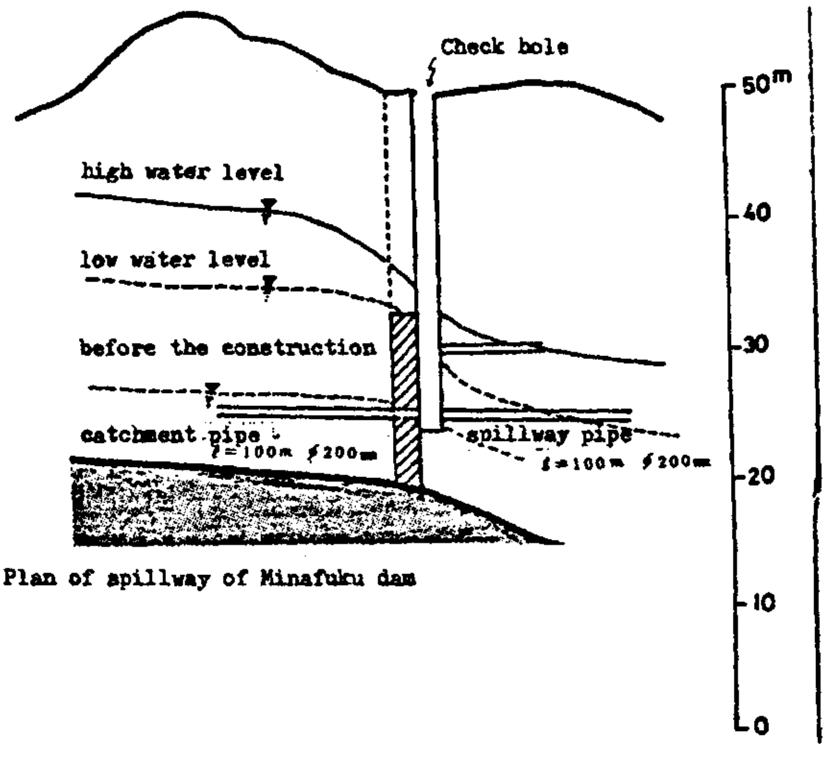
Suitable location of underground-dam in Miyako-Island



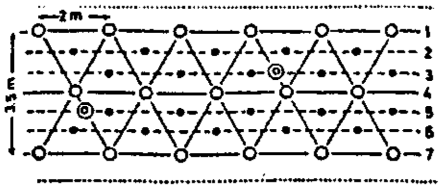
Correlation with Q-S, by Pumping Test



Progress of reserved gound water level

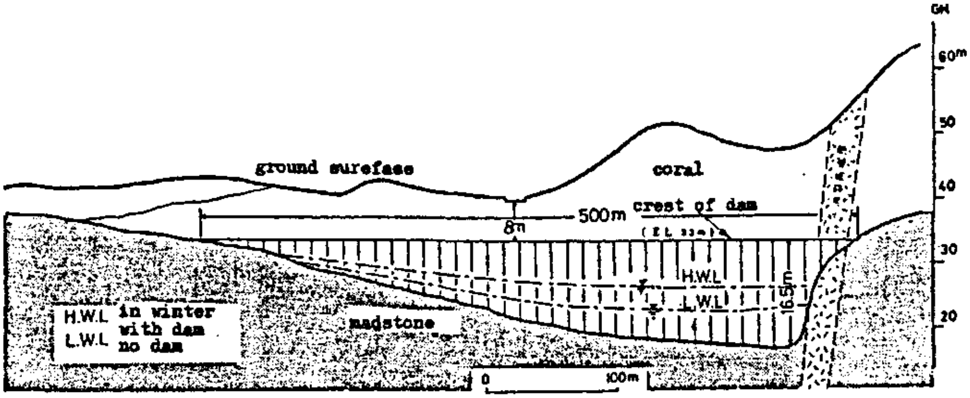


Plan of spillway of Minafuku dam

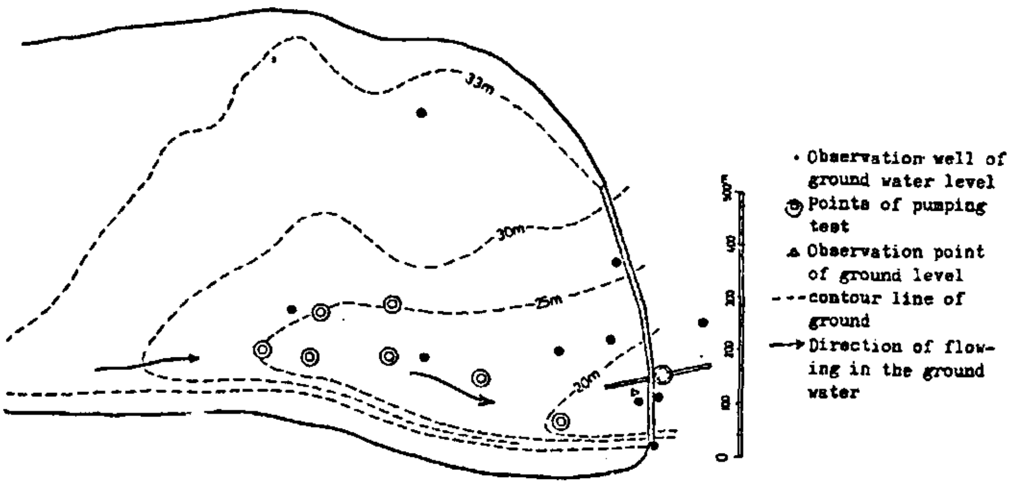


*The material has been grouted into the ground with four steps depend on the condition of permeability.

Position of grouting holes
○ Cement
• Cement + Cly
◎ Check boring



Cross section of Minafuku underground dam



Plane of Minafuku underground dam

EFFECTIVE PROTECTION OF POLDER DIKE

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Abstract

In Japan due to overproduction of rice, polder projects are not as intensive as they were in the past decades. However protection of dikes is important to prevent disaster and construction of desalted reservoirs is also significant. The following two works are designed by the author: a) The amount of leakage at the Nishino polder dike (675 m in length) was 10,000 m^3/day at the beginning. A series of steel sheet walls was driven into the center line of the dike along 575 m. A certain amount of cement paste was grouted into the remaining 100 m length on both sides. After the work, leakage was reduced to 200 m^3/day. b) The beach of Naka River, which is 2,500 m long, has received a heavy scouring by sea current and waves. For recovering lost land, polderworks (50 ha) have been carried out. Offshore breakwaters and jetties are under construction. To prevent heavy subsidence of breakwaters, three grades of stone layers were installed as a base mound. The subsidence of the breakwaters, which had been recorded 3 m maximum during typhoon, were effectively diminished.

Introduction

The polders in Japan, though each is rather small, are large in number because Japan has long coastlines in comparison with her total land area. According to the author's research thus far, the number of polders in Japan built after 1958, numbers more than 125. Due to the varied conditions of the polder locations, there were many difficulties in construction.

The Nishino polder, which was built by closing the mouth of the bay at Osaki Kamishima island in the Inland Sea, Osaki Toyota-gun Hiroshima Prefecture, Japan, used decomposed granite (weathered granite soil) for embankment soil. The dike was constructed in two stages using a sand pump. Because of the washing away of fine grains and stratification of coarse grains, water leakage was extremely high. Though strenuous efforts to prevent leakage were fruitless, finally success was obtained by driving 15∿20 m long sheet wall lines into the center line of the dike. The first part of the thesis introduces countermeasure engineering for leak-stoppage and is the result of four years of research from April 1977 to March 1981.

Due to the rapid development of industry, and the need to secure industrial water supplies and electricity, in various places reservoir dams were constructed. As a result the sediment of the river decreased extremely, and the supply of coastal drift sand decreased and balance of the flow were destroyed. One example is found at the left bank of Naka River in Naka-gun Tokushima Prefecture.

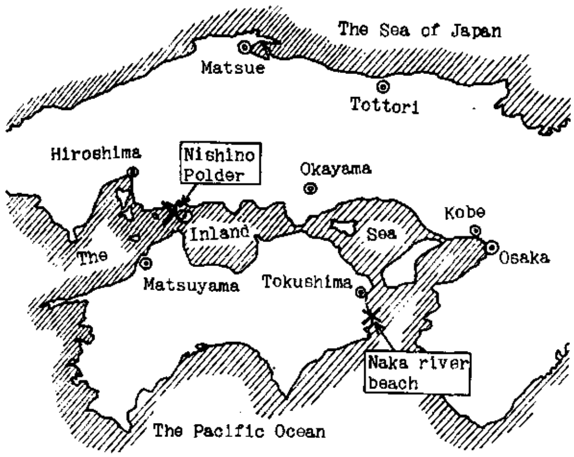

Figure 1. Map showing two polders

In order to prevent new erosion and to recover a part of the lost land coastal levees were constructed. Then construction of offshore breakwater and jetties was needed to prevent scouring of the fore facing of the levee. However, the base of offshore breakwater was considerably scoured. It once sank 3 m during a typhoon. Sinking at the time of typhoons and seasonal winds was extraordinarily decreased by using a newly designed rip-rap mound which used three different sizes of particles on the base of breakwater which was previously constructed by concrete blocks. The latter part of this thesis introduces the fielding execution of the works and its effectiveness from May 1981 to the present.

2 A leakage countermeasure and its effectiveness on the east bank in Nishino polder

2.1 Specifications and early circumstances of leakage in Nishino polder

Nishino polder was constructed by building two dikes, east and west connecting the old polder at Osaki Kamishima island with Nanami Shima island. The west dike was constructed on the sand spit on the west side, and the east dike was executed.

2.1.1 Specifications of Nishino polder

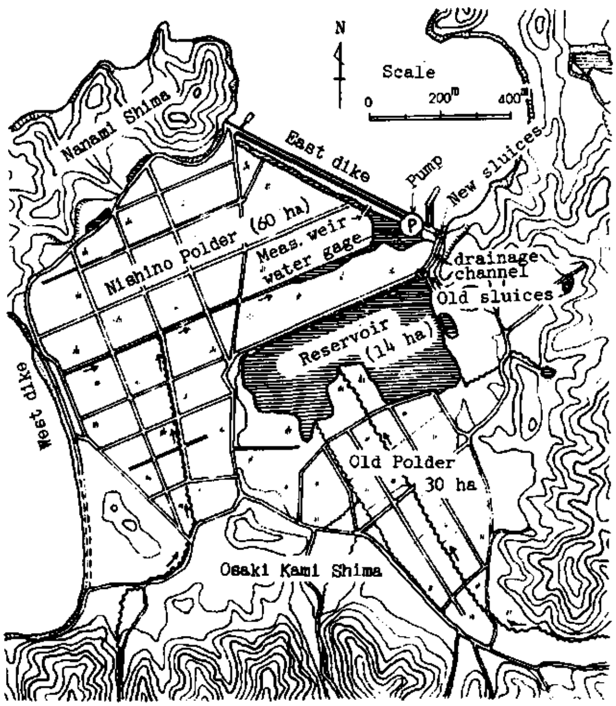

Figure 2. Plan of Nishino polder

a) Total area; 82.9 ha

b) Farm area; 60.5 ha

c) Soil of polder bed; silty clay

d) Elevation of farms; (-)2.0 ∿ (-)2.7 m (by Tokyo peil.)

e) Range of tide; max. (+)2.85 m, min. (-)1.85 m

f) Elevation of parapet wall and dike; (+)4.5 m, and (+)3.5 m

g) Total length of dike; 1,147 m

n) Enclosing works; from November 1951 to March 1962.
i) Back farm of the Nishino polder or old polder was constructed about 150 years ago, and is about 30 ha in area and a regulating reservoir of 14 ha.

2.1.2 *Leaking conditions of the East dike*

Though the East dike in Nishino polder is only 675 m long, the amount of leakage from this dike was considerable in spite of frequent countermeasures. As an urgent countermeasure to prevent this dike from collapsing, light-weight steel sheet-piles shown in (Figure 3) as old rear sheet-pile were driven into the land-side berm on the dike during 1966 and 1967. However, leakage over the steel sheet-pile continued as before. Consequently the fee of water drainage had increased year by year, and agriculture was impossible because of the excess of salt.

2.1.3 *Reinforcement of fore facing in the dike*

Cement was grouted into the cavities under the fore facing area in the dike on the sea-side in order to reinforce the dike. The total amount of cement grouting was 2,264 m^3 along 612 m of the dike, the area of which was 6,570 m^2. The average amount of cement grouting was about 0.345 m^3/m^2, and 0.86 m thick considering 40 % porosity. The combination of the cement mortar used was as follows. Results of a strength test showed about $\sigma_7 \geq 30$ kg/cm^2 and thus the following mixture was used. Cement 0.9 + bentonite 0.1 + fine sand 4.0 + water 1.7 + Posolis 0.05. Posolis is a kind of accelerating agent for the cement.

2.1.4 *Adoption stoppage engineering methods*

a) Restoration of the banking joining the rear sheet-piles.
b) Grouting with cement along the center line of the levee crown.
c) Driving sheet wall along the center line of the levee crown to cut off the leaking water. After consideration of these three methods of

construction, the third was chosen owing to the safety and security of work operations and for economic reasons.

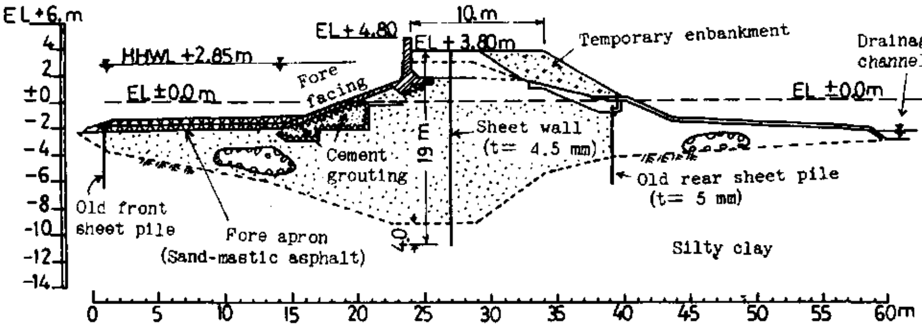

Figure 3. The adopted plan for driving the sheet wall

2.1.5 *Decision of the depth of the sheet wall in the banking foundation of levee body*

As the silty clay soil under the banking of the levee body had been there for nearly 20 ∿ 30 years after the banking was made, consolidation was considerable. The length of the sheet wall to be used was decided after presuming several factors of soil mechanics in the silty-clay banking foundation. This decision was of great importance for the piping prevention on the top parts of the sheet wall, the estimation of the amount of leaking water, and the calculation of the construction cost. a) (Figure 4) shows the conditions under the levee body and the depth of the placement of the sheet wall into the ground. Various figures used in

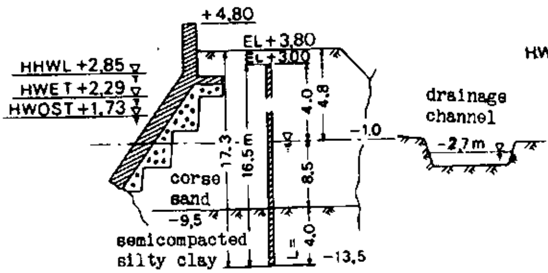

Figure 4. Driven sheet wall

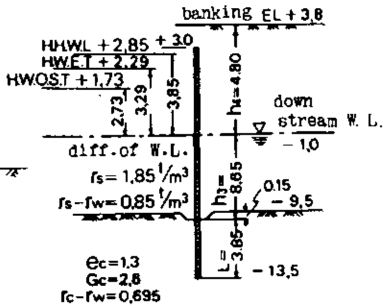

Figure 5. Various figures

calculation are shown in (Figure 5). The calculations were made estimating that the surface of the silty-clay after the sheet wall was driven would decline by about 0.15 m.

b) Length (L) of the distance the sheet wall was driven into the ground was investigated from the following four points:

1) Water level at the downstream side of the driven sheet wall. As a result of driving the sheet wall, the leakage is decreased and the underground water level is lowered at the downstream area. Since at present the old sheet-pile remains, it was estimated that the water level would decrease to one meter below the crest of the old sheet-piles. The result was as expected.

2) Estimation of creep ratio (C) needed for preventing of piping through Lane's experimental formula. C=3.0 is needed, and it makes each of the following insufficient.

HHWL C= 2.0 , HWET C= 2.34 , HWOST C= 2.82

3) Estimation of factor of safety (F) needed for preventing piping by way of the Terzaghi theoretical formula. In this case, the value of the needed safety facter (F) was made considering that the banking of the levee body holds the surface of the soft clay. The values used in calculation were as follows: Banking; r_s=1.85 ton/m^3, r_s-r_w =0.85 ton/m^3. Foundation soil; real-specific gravity of soil G_c=2.6, void ratio e=1.3, underwater weight=0.695 ton/m^3. In (Figure 6), h_a=mh_1 is the relative uplift pressure head, U is the total relative uplift ton/m. Using the symbols in it.

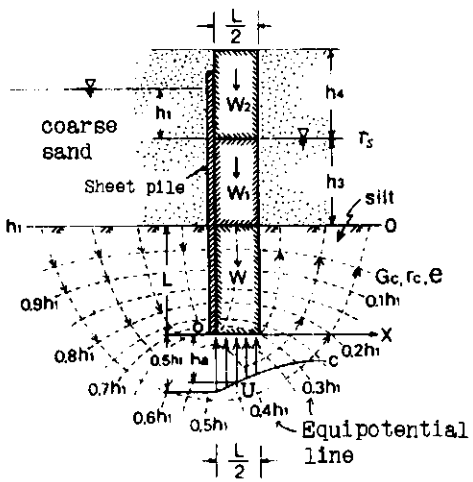

Figure 6. Safety factor estimation

$$\Sigma W = 0.5L^2 r_w (G_c - 1)/(1+e) + 0.5Lh_3(r_s - r_w) + 0.5Lh_4 r_s$$

$$F = \Sigma W/U = (G_c - 1)/(1+e) \cdot L/mh_1 + [h_3(r_s/r_m - r) + h_4 r_s/r_w]/mh_1$$

Supposing m=0.5 in this case

HHWL h_1=3.85 m , F=9.82

HWET h_1=3.29 m , F=11.49

HWOST h_1=2.73 m , F=13.84

In Japan the value $5 \leq F \fallingdotseq 8 \sim 12$ is considered reasonable. Therefore, L=4.0 m is enough.

4) The relationship of the holding filter and grain diameter of the foundation soil, and necessary thickness of the filter. It is difficult to take a sample in natural conditions from the banking near the foundation soil at present and the sampling data varies in different areas. However, the banking is considered to satisfy the necessary conditions of the filter.

2.1.6 *Effectiveness of stoppage construction*

(Figure 7) shows the general view of grouting at the junction part of the sheet wall. As the coarse particles which entered the junctions during driving work by water jet could not be removed to the ground surface, the water in the jet was replaced by liquid cement mortar in the course of washing and the junctions were grouted.

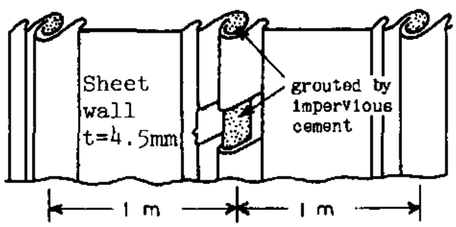

Figure 7. Junction of sheet wall

The longitudinal section of the dike along with the center line of the dike after the completion of stoppage construction is shown in (Figure 8). Total amount of leaking water of the dike is the sum of the following:

a) Percolation from the foundation soil of the sheet wall.

b) Leaking water at the points of both poor junction and inferior driving of the sheet wall.

c) Infiltration from the dike after the grouting of cement mortar.

After the completion of the construction, the amount of daily leaking water was measured from December 1980 to March 1981, at about 200 m^3/day, except for rainfall run-off, in conditions of Highest High Water Level

·(+)2.0 m and Lowest Low Water Level (-)2.2 m, which shows a decrease to 2 percent of the leakage before construction.

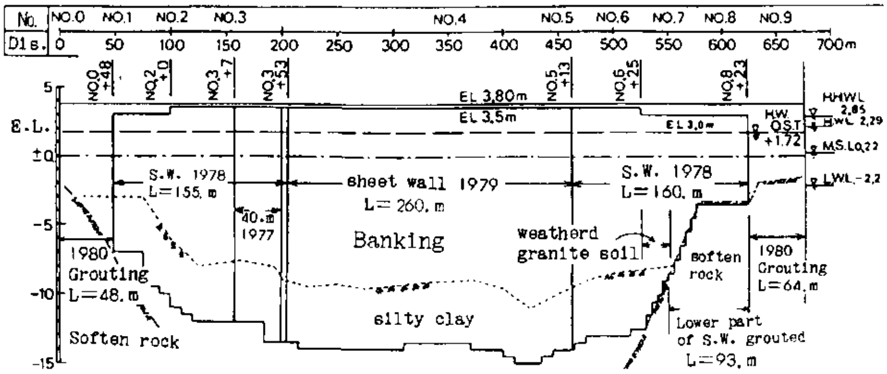

Figure 8. Longitudinal section of the dike

3 New design and its effectiveness in the offshore breakwater in Naka River beach

3.1 Erosion in Naka River beach and its countermeasure conditions

The balance of drift sand on the left bank of the Naka River collapsed and caused coastal erosion because of both dam construction at Naka River upstream and jetty construction at the harbour. The new dike shown in (Figure 9) is under construction to restore those defects. Actual loss by erosion is more than twice as large as the recovering area (about 50 ha) in this work. The design wave is estimated H_0=5.9 m, T_0= 9.4 sec. A number of offshore breakwaters and jetties were constructed for protecting the dike. The distance between offshore breakwaters and the main bank is about 100 ∿ 200 m, the

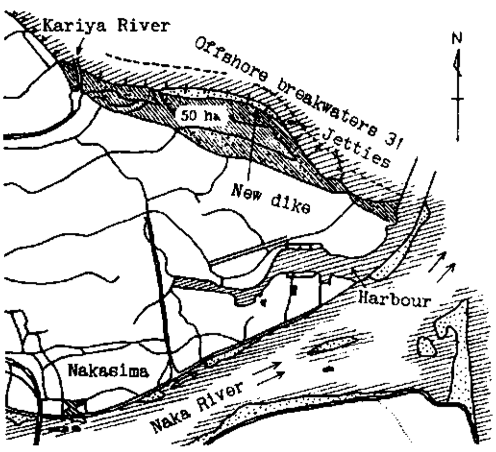

Figure 9. Plan of Naka River beach

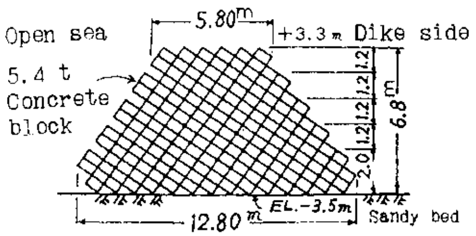

Figure 10. The old breakwater

length of each offshore breakwater is 50 m at 20 m intervals, and the jetties are about 60 m long. As shown in (Figure 10), the old offshore breakwater was made of 5.4 ton concrete blocks simply placed directly on the sandy bed with three blocks on the crest, five stages high. In designing this breakwater it was expected that the bottom stack would settle, but the differential settlement was extraordinary because of the waves, and a part of the blocks fell down.

3.2 Effectiveness of the new design

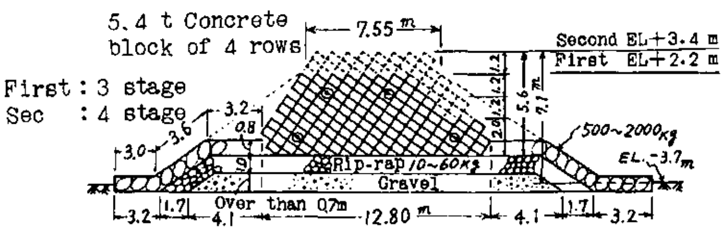

Figure 11. The new breakwater

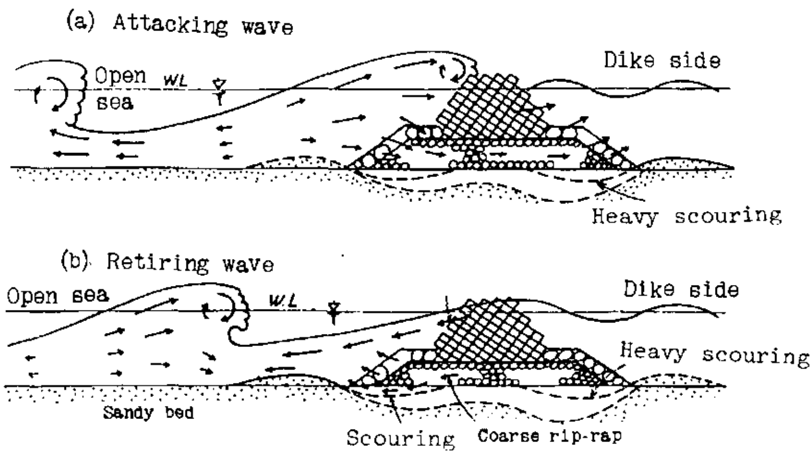

Figure 12. Scouring in the coarse rip-rap foundation without gravel

(Figure 11) shows a section of the new offshore breakwaters. Gravel with ϕ= 0.5 ∿ 10.0 cm was placed more than 0.7 m in depth on the foundation soil. Moreover, a mound was constructed using 1.0 m rip-raps.
The sand moved by the waves falls into the gravel layer to reinforce the foundation and restrains breakwater from marked settling.

4 Conclusion

In this paper we have demonstrated an effective engineering method for leakage prevention in polder embankments and that of settling prevention in offshore breakwaters. That is to say;

a) In case of the Nishino polder dikes, leakage was decreased from a daily maximum of 10,000 m^3/day to 200 m^3/day using sheet walls driven into the dike.

b) In case of settling prevention at the offshore breakwaters in Naka River beach, we could very effectively prevent the breakwaters from sinking, by using three layers with different sizes of stone particles to make a basic mound following the idea of a filter.

POSSIBILITIES OF DIKE ENLARGEMENTS INCREASED BY USE OF THE COLBOND VERTICAL DRAINAGE SYSTEM

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Abstract

Dike-enlargements on soft subsoil can only be carried out if special measures are taken to ensure the stability of the dike during and after construction. In The Netherlands the technique of soil improvement by vertical drains has been applied on several occasions. The theory behind this technique as well as examples of application in reference to the Colbond system are presented.

Introduction

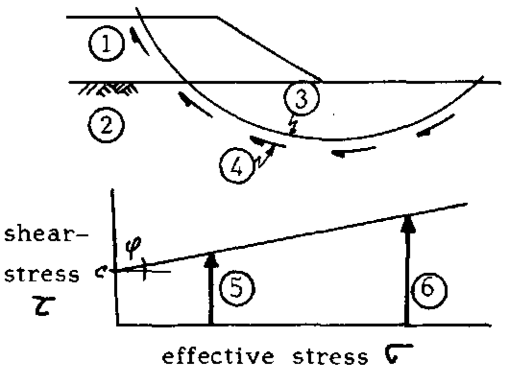
The western part of The Netherlands has to be protected against flooding because the groundlevel lies below or only a little above mean sea level. This protection consists of both natural dunes and artificial dikes.
At present many dikes have to be enlarged in order to prevent a repeat of the disastrous flooding which occured in 1953.
In these regions however, the subsoil consists of sedimented layers of clay, peat and silt, and are characterized by low bearing capacity and low permeability.
The required bearing capacity for dike building on such soils, in general exceeds the available capacity. Consequently, special measures have to be taken such as installation of vertical drains, by which the bearing capacity of the subsoil is improved in a relatively short period of time.

Soil improvement by vertical drains

Construction of an embankment will cause an increase of the stresses in the subsoil. In the case of saturated soil, these stresses are to be divided in water pressures and stresses between the individual soil particles, the so-called effective soil stresses. These stresses can only increase if the soil particles can move towards each other. Since the pore water itself is incompressible, water will have to dissipate in order to enable this movement of the soil particles. The process of dissipating pore water and simultaneous compression of the grain skeleton is called consolidation.

With fine grained soils, such as silt and clay and with peat, the permeability is very low (10^{-7} m/sec or less), resulting in a very long period of time for the pore water to dissipate.So, initially the total weight of the embankment is carried by the water and gradually, as dissipation of pore water proceeds, the soil particles take over (increase in effective stresses).

The stability of the embankment however, largely depends on the shearing resistance of the soil, which is a function of the effective soil stress (Figure 1). The pore water itself does not deliver any contribution to the shearing resistance of the soil.
Since initially the effective soil stresses are low, alse the shearing resistance is low, and in many cases insufficient to ensure a stable embankment.



1 embankment or dike
2 original subsoil
3 possible sliding plane
4 shear- stress τ
5 τ, initial value
6 τ, after dissipation of excess pore water pressure
c = cohesion
φ = angle of internal friction

Figure 1. Shearing resistance of soil

From the above, it follows that execution of the works is only possible, if one or more of the following measures are taken:

a) the rate of construction is slowed down, allowing the shearing resistance to increase sufficiently for each stage;
b) the rate of dissipation of pore water is increased;
c) the strength of the subsoil is improved.

With (a) the execution time of the works will be very extensive which is often undesirable. To comply with (b), vertical drains can be installed. With (c), the installation of stone columns can be considered.

In many cases, from the points of view of cost and time, the installation of vertical drains has proved to be the most attractive solution.

Normally vertical drains are installed in a triangular pattern at spacings of 1.5 to 2.5 m etc. Consolidation is now much faster, because the pore water has to flow along a much shorter distance than without vertical drains (Figure 2).

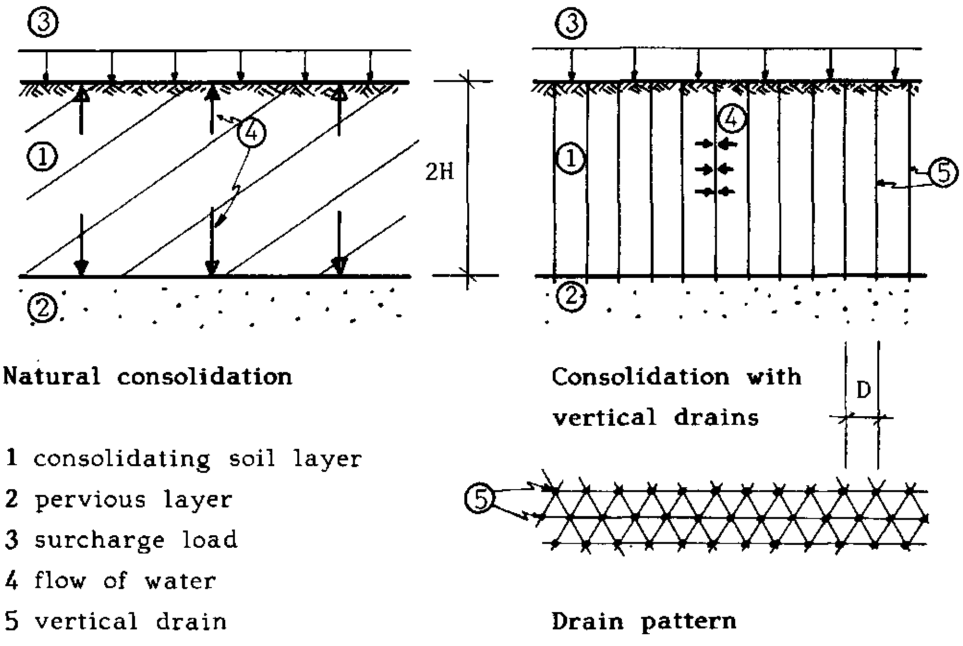


Figure 2. Consolidation

Theory of consolidation

According to Terzaghi (1936), the time required to reach a certain degree of consolidation can be written as follows:

$$t = T.H^2 / c_v \qquad (1)$$

where

- t = time (years)
- T = factor, dependant on the average degree of consolidation (-)
- H = half the thickness of the consolidating soil layer (m)
- c_v = coefficient of consolidation for vertical compression and vertical flow of water (m^2/year)

If vertical drains are installed, a similar formula, derived by Kjellman (Hansbo 1977) and Barron (1948), is to be used:

$$t = T_r.D^2 / c_h \qquad (2)$$

where

- T_r = factor dependant on the average degree of consolidation and on the ratio of drain spacing and drain width (-)
- D = drain spacing (m)
- c_h = coefficient of consolidation for vertical compression and horizontal flow of water (m^2/year)

From both formulas it can be seen that the time to reach a certain degree of consolidation increases very rapidly if the flow path (H in eq. 1 and D in eq.2) increases. Also it is shown that the larger the value of the coefficient of consolidation, the shorter is the required time. Generally c_h is 2 to 5 times higher than c_v. For clay soils, typical values for c_h range from 0.5 to 5.0 m^2/year.
The two phenomena, length of flow path and magnitude of coefficient of consolidation, clearly show that the rate of consolidation is increased effectively when vertical drains are installed.
Generally values for c_v and c_h are obtained from laboratory tests on undisturbed soil samples.

Plastics for vertical drains

Originally, sand was used for the construction of vertical drains (Barron 1947). To overcome some of the disadvantages of the installation of sand drains, Kjellman (1948) had already investigated the use of other materials. Since 1970 the use of plastics has increased enormously, leading to a large number of different types of drains, for example Colbond, Geodrain, Alidrain etc (McGown and Hughes, 1981).

The Colbond drain, that was a result of the cooperation of a contractor and Akzo, was first used at a test site in Delfzijl, in april 1973 (Van den Elzen et al, 1977). Based on laboratory investigation (Den Hoedt, 1981) and following in-situ tests (at Schipluiden in 1974, at Amsterdam Hem-spoorbaan in 1976, at Diemen in 1979 and at Amsterdam Abr. Kuyperlaan in 1980), the drain was further improved.
Today, two types of Colbond drains are available, namely:

- KF 650, a monolith structure;
- CX 1000, a composite structure consisting of an open core enwrapped by a filter jacket.

With type KF 650, polyester fibres form a coarse porous innerlayer (high water discharge capacity) that is envelopped by fine porous skin layers (filtering function).
With the second type, CX 1000, the central core consists of an Enkamat drain body, enwrapped by a filter jacket of Colbond (Figure 3). Both core and jacket are made from polyester. From laboratory tests, it could be concluded that soil particles up to 0.005 mm pass the filter jacket, thus creating a layer with increased permeability just around the drain. In this way, the zone of smear that is caused during installation, and that has a negative influence on the performance of the drain, vanishes rapidly (Atkinson and Eldred, 1981).
The strength and the stiffness of the filter jacket are such that even with high soil pressures at great depth (up to 40m), the jacket does not close off the channels of the central core, keeping the water discharge capacity as high as possible.

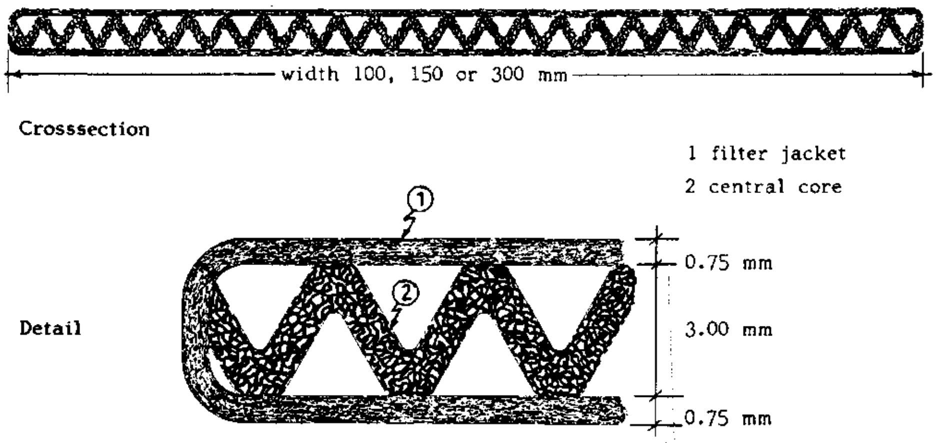


Figure 3. Colbond CX 1000 drain

The installation of the drain is usually done by lowering a speciallly designed mandrel that is housing the drain to the required depth. The mandrel is guided by a leader that is suspended on a crawler crane. The lowering of the mandrel is done by means of vibrating and, if thin hard layers have to be penetrated, water jetting. During sinking, the lower end of the mandrel is closed-off by an anchoring plate. When the required depth is reached, the mandrel is pulled out, leaving the drain behind kept in place by the anchoring plate. Next the drain is cut-off just above groundsurface and the rig is moved to the next position. The drain material is supplied in coils containing 200 linear meter.
Depending on the length of each individual drain, a total number of 2000 to 4000 linear meter can be installed by one rig in one working day.

Dike enlargement projects

a) Bruinisse
By order of the Dutch Public Works Department (Rijkswaterstaat), in 1976 vertical drains, length 8.0 m, were installed at the back side of a sea dike. Without these drains, the heightening and enlarging of the dike would have been possible only at a very slow rate and with increased risk for instability.

b) Ridderkerk

For the same reasons as mentioned above, vertical drains with lengths ranging from 6.0 to 12.0 m were installed close to a river dike, prior to its heightening. This work was instructed by the Public Works Department of the province of South-Holland and was also carried out in 1976.

c) Puttershoek

To the west of Puttershoek, outside the dike along the river Oude Maas, the sugar refinery company uses the land as a deposition area for the soil that is washed off the sugar beet. This mixture of soil and water contains a great many fine particles.
A few months after the 1974 harvest deformations of the toe of the outer dike of the mud lagoons were discovered. Since the deformations formed a threat to neighbouring dwellings and hothouses, the Delft Soil Mechanics Laboratory was called upon for investigation to avoid similar occurence in adjacent mud lagoons that are to be filled with future harvests. Moreover, the deposition area had to be increased for which a dike had to be enlarged. This was allowed only if measures were taken to prevent instabilities and deformations.
To be able to explain the phenomenon, borings were made and piezometers installed. Stability calculations, in which the information obtained from this investigation was used, showed low factors of safety in the regions where the thickest mud deposit occured. The conclusion was that the excess pore water pressures below the toe of the dike had increased and the shearing resistance of the soil had decreased such that large deformations could occur. It was proposed to limit the build-up of pore water pressures in the other lagoons by installing vertical drains ranging in length from 15.0 to 21.0 m. A cross section of the dyke is given in figure 4. The drains were installed without the use of water (Figure 5).

Piezometer readings showed that practically no increase in pore water pressure occured, neither as a result of dike enlargement, nor as a result of deposition of soil washed off the sugar beet. It was further concluded that deformations of the dike were negligible, which may partly be attributed to a reinforcing effect of the plastic drains.

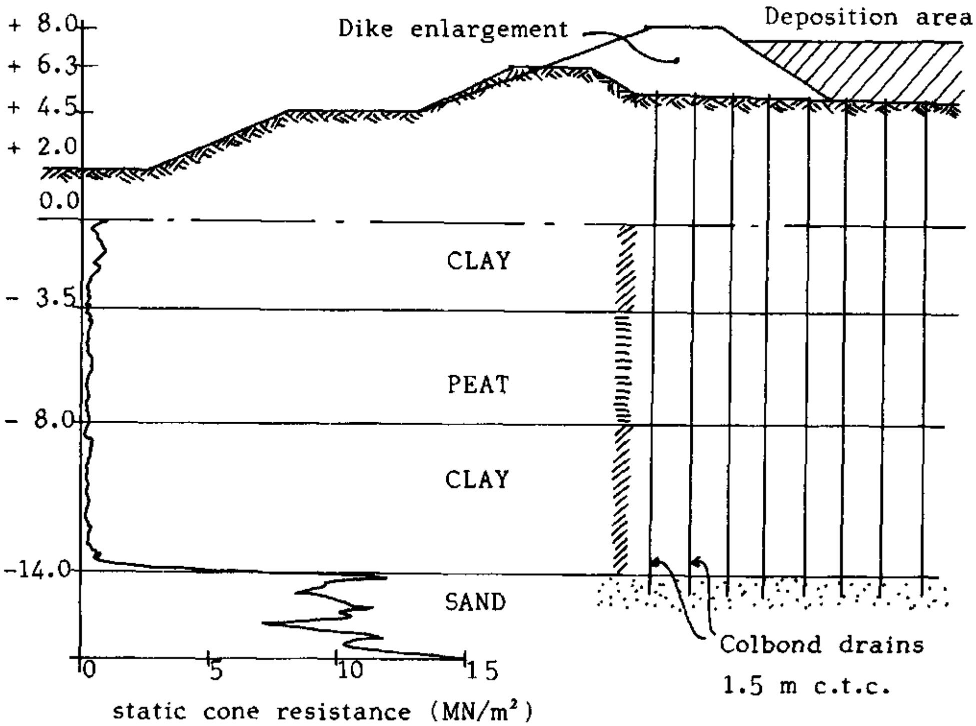


Figure 4. Dike at Puttershoek

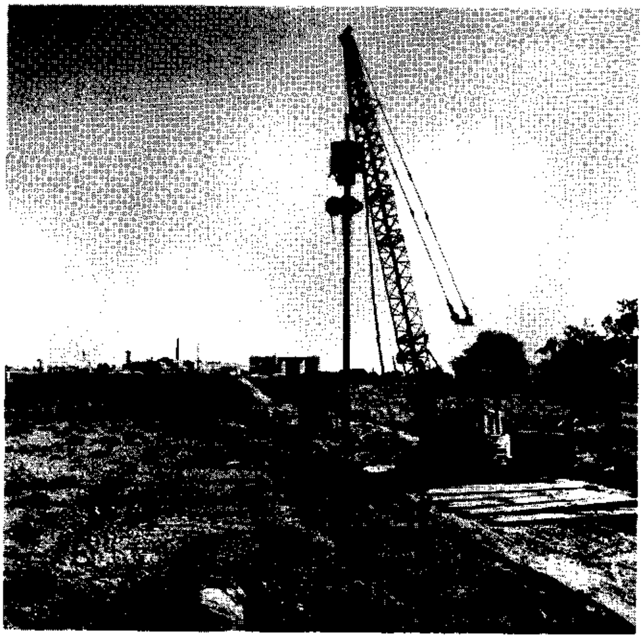


Figure 5. Installation of Colbond drains.

d) Alblasserwaard

The dike on the left bank of the river Lek between Nieuw-Lekkerland and Streefkerk, that forms the northern boundary of the polder Alblasserwaard, had to be raised from approximately 4.5 m+NAP to a height of 5.6 to 6.0 m +NAP. At some locations, the heightening of the dike is being carried out at the outside, while at other locations it is being carried out at the inside (Figure 6). The subsoil of this part of the polder consists of approximately 14.0 m of clay and peat layers, underlain by sand. The static cone resistance in the cohesive layers amounts to 0.5 MPa or less. It is obvious that special measures have to be taken in order to avoid instability of the dike during and after construction.

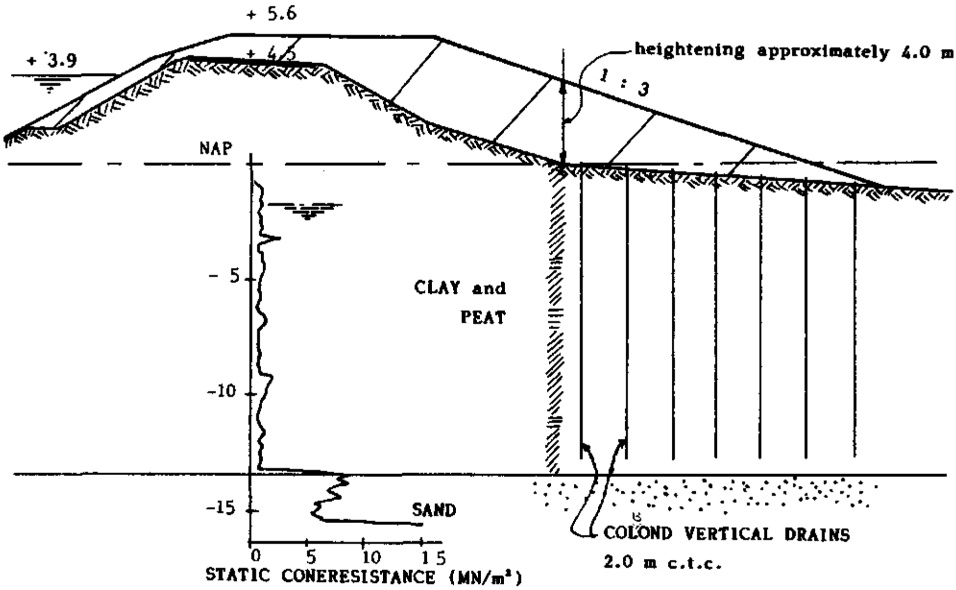


Figure 6. Northern dike of Alblasserwaard

The Delft Soil Mechanics Laboratory recommended the use of material with a low specific gravity (i.e. Flugsand) and to install vertical drains before the heightening of the dike. To avoid seepage beneath the dike, the toe of the drains must not reach the deep sand layer. Also it was envisaged that a type of drain had to be used, in which the water discharge capacity would decrease with time due to impregnation of the filter by the fine particles.It was concluded that the Colbond KF 650 drain was the only available drain that would meet this requirement.

Due to the vertical drains the excess pore pressures did not increase much and consequently sufficient resistance against failure was provided. In the coming years several similar projects will be realised, bringing the total quantity of installed KF 650 drains in the Alblasserwaard to approximately 1.500.000 linear meter.

Acknowledgement

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CALCULATION OF HYDRAULIC HEAD FOR RIVER EMBANKMENT DESIGN USING A NUMERICAL GROUNDWATER MODEL

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Abstract

The shear strength of a saturated soil is strongly determined by the pore-water pressure. In order to design a safe embankment along a river, it is therefore essential to know the actual pore-water pressure within and underneath the embankment at high river stages. This pore-water pressure depends on the regional and local conditions e.g. geometry, lithology, geohydrological parameters, river stages and polder water-levels.The first step in determining the pore-water pressure where semi-pervious strata overlay an aquifer is to calculate the hydraulic heads in the aquifer on a regional scale. For this purpose a model for saturated two-dimensional groundwater flow (WASTRO) has been developed. One of the special features of this model is that it takes into account the occurrence of the "critical uplift head", a factor which strongly effects the regional groundwater flow and the hydraulic head distribution.

1. Introduction

During periods of high discharge, the level of a river may rise up to several metres above the ground level behind its embankments. Adjoining lands are often cultivated and sometimes densely populated. As great damage would be caused if the embankments were to fail, considerable emphasis is laid upon safe and reliable construction. In the past (and embankments to protect people and property against flooding have been built since the 11th century) the lack of geohydrological and geo-technical knowledge has made design a matter of experience. Nowadays, experience is supported by a far greater knowledge of the occurrence of high river stages and the geotechnical and geohydrological aspects of dike stability. One of the models which has been developed to calculate hydraulic head distribution on a regional scale, in an aquifer covered with semi-pervious strata, is WASTRO.

2. Geohydrological situation

In many parts of the river systems in the Netherlands, clayey deposits of low to moderate permeability cover coarse sand and gravel layers with high permeability (Figure 1).

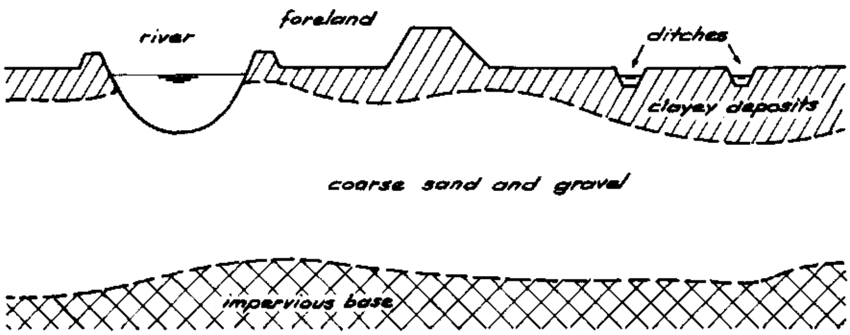

Figure 1 Geohydrological cross-section

The water-level in the river fluctuates, generally spoken, between a low stage in summer and a high to very high stage in spring. Behind the embankments, however, the water-level in the ditches is kept within narrow limits by pumping (polder area). Nonetheless the groundwater level is not completely controlled by this system. When the river level is high, water seeps into the pervious substratum through the river bed and through the semi-pervious top strata of the flooded forelands. This creates overpressure in the aquifer at the land-side. Due to this hydraulic gradient, upward seepage occurs. There are analytic solutions for the hydraulic head distribution for some cases of one-dimensional seepage. In reality, however, the conditions upon which these solutions are based are practically never met. For example, the embankment may be very tortuous, the width of the foreland and the thickness of the semi-pervious top strata show enormous variation, and different polder-water levels obtain. In view of the many different situations which may be encountered, the need for numerical groundwater models is evident.

3. Geotechnical aspects

The principal load on an embankment occurs during periods of high river stage. The high water-level causes a potential line as indicated in Figure 2.

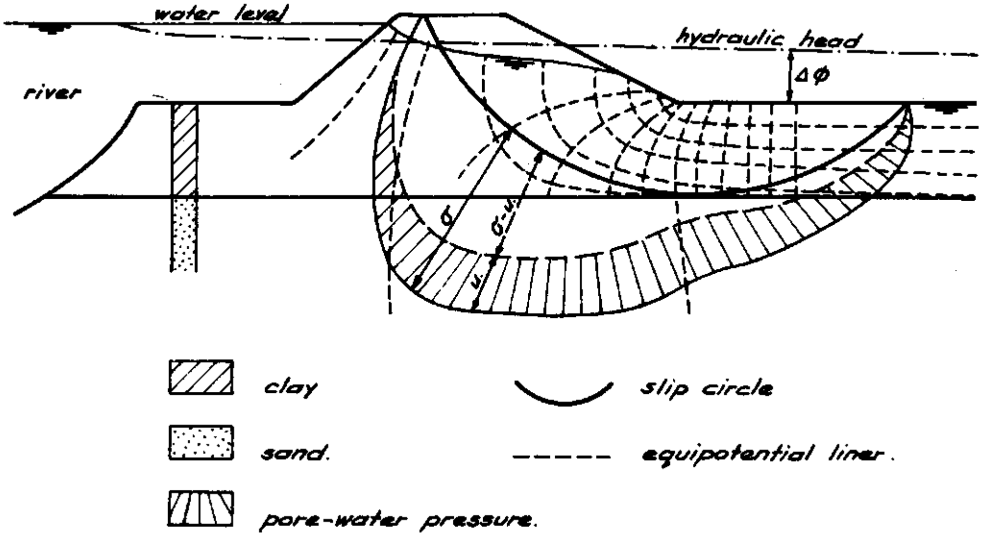

Figure 2. Distribution of pore-water pressure during high water-level

The potential line is greatly influenced by the geohydrological situation in the area. Due to the difference in potential above and below the semi- pervious strata, water flows upwards towards the polder water. This causes an increasing pore-water pressure in the semi-pervious layers and a rise of the phreatic level in the embankment, which may undermine the ability of the dike to hold back water in one of two ways:

a) Stability.

It is known that the shear strength of a saturated embankment is strongly determined by the existing pore-water pressure.

$$\tau = c' + (\sigma - u) \text{ tg } \theta \qquad (1)$$

where

- τ = shear strength (N/m^2)
- c' = cohesion (N/m^2)
- σ = total normal stress (N/m^2)
- u = pore-water pressure (N/m^2)
- θ = angle of shearing resistance

As pore-water pressure increases, the shear strength decreases proportionally.

Figure 2 indicates the influence of the pore-water pressure on the shear strength in the case of a slip circle. When the shear strength of the ground becomes too small (caused by a high shear stress induced by external forces) the embankment collapses.

b) Piping

The existence of a difference in potential above and below the semi-pervious top strata means that an uplifting force acts upon them. The weight of these strata must counterbalance that force. The pore-water pressure, u, also has an upper limit u_c.

$$u_c = \rho_s gd \ (N/m^2) \tag{2}$$

where

ρ_s = volumetric mass of soil (kg/m^3)

g = acceleration due to gravity (m/s^2)

d = thickness (m)

So the hydraulic head in the aquifer reaches the upper limit ϕ_{cuh} (critical uplift head) when:

$$\phi_{cuh} = u_c/\rho_w g \tag{3}$$

where

ρ_w = volumetric mass of water (kg/m^3)

At places where the critical uplift head is reached, sand boils (piping) may occur.

In calculating stability, efforts therefore have to be made to determine as well as possible the hydraulic heads beneath the embankment and the pore-water pressure within the embankment.

4. Requirements on a model

In groundwater hydrology, many types of numerical models are nowadays available. In this paper no attention will be paid to the different types (e.g. finite difference, finite element, boundary integral methods) or to their pros and cons, as these topics have been widely discussed in the literature. The model which we were looking for had to meet the following requirements:

- wide range of possible use (e.g. local, regional variations and discontinuities in the semi-pervious top layer, widths of foreland, dike course);
- form of input closely related to available data;
- minimum user's effort in generating model and input data;
- possibility of taking uplift pressure into account.

5 Description of the WASTRO model

The WASTRO model is largely based on the work of Tyson and Weber (1963) and Weber et al (1968); a similar approach is used by De Ridder (1968, 1972). A detailed description is to be found in Thomas (1973) and in Boonstra and De Ridder (1981).

The partial differential equation for unsteady two-dimensional saturated groundwater flow in a semi-confined aquifer, derived from combination of Darcy's law and the continuity equation, is:

$$T\left(\frac{\delta^2\phi}{\delta x^2} + \frac{\delta^2\phi}{\delta y^2}\right) + q(x,y,t) = S\frac{\delta\phi}{\delta t} \qquad (4)$$

where

- T = aquifer transmissivity (m^2/d)
- ϕ = hydraulic head (m)
- q = source or sink term (m/d),
- S = aquifer storativity (-)
- t = time (d)

In the case of a semi-confined aquifer, the term q represents the seepage or leakage:

$$q = (p - \phi)/c$$

where

- p = phreatic level (m)
- c = hydraulic resistance (d)

The hydraulic resistance is defined as:

$$c = d'/k'$$

where

- d' = thickness of semipervious layer (m) k' = hydraulic conductivity of semi-pervious layer (m/d)

The model area is divided into a number of elements. In the WASTRO model regular elements have been applied: equilateral triangles, squares, rectangles or regular hexagons. For each element the water balance during a timestep, Δt, is set up. The water balances for all elements form a system of equations with the hydraulic heads in the model points at time $t+\Delta t$ as unknowns. This system is solved with the Gauss-Seidel method, using an over-relaxation factor (SOR-method).

The possible boundary conditions are:
* head-controlled
* flow-controlled
* zero-flow or flow line boundary

The model is provided with a model network generator, requiring only a minimum of effort on the user's part. Additional computer programs provide maps of the network on a required scale with calculated heads as well as maps of interpolation between these heads as a basis for the drawing of equipotential lines.

6. Example of application

As an example of the application of this model we have taken the modelling of part of the area along the River Waal.
The application of the model consists of the determination of:
- model area
- boundary conditions
- size and shape of the elements

and for each element:
- geohydrological parameters
- surface levels
- average thickness of semi-pervious layer
- phreatic levels

In this paper we will not consider the way in which these parameters are established (e.g. by using existing data and maps, geotechnical investigations, drilling, field and laboratory testing).
Borings in the model area showed that there is an alternation of layers with different hydraulic conductivity. Nonetheless, it proved possible to derive a geohydrological schematisation similar to the cross-section given in Figure 1. The model area is divided into rectangular elements of 100 by 150 m (Figure 3).

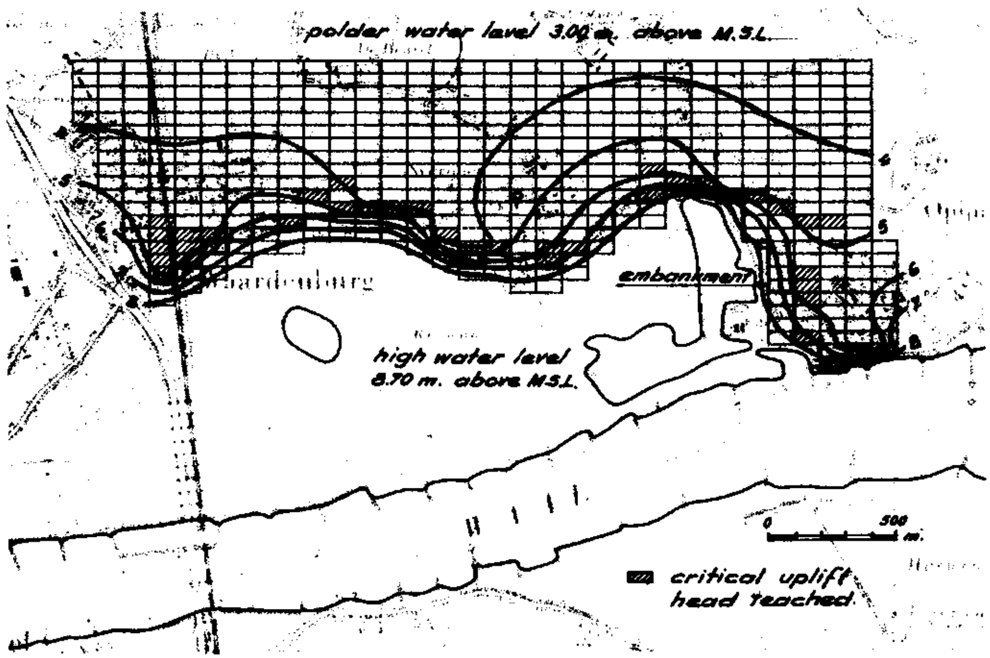

Figure 3: Model area with equipotential lines

The first run generally shows that the head is significantly higher than the critical uplift head in many places. So the computer program has to be rerun with these critical heads as upper boundaries starting with the most critical nodes.

Figure 4 shows the calculated hydraulic heads in part of the model area, as well as the elements in which the critical uplift head is reached.

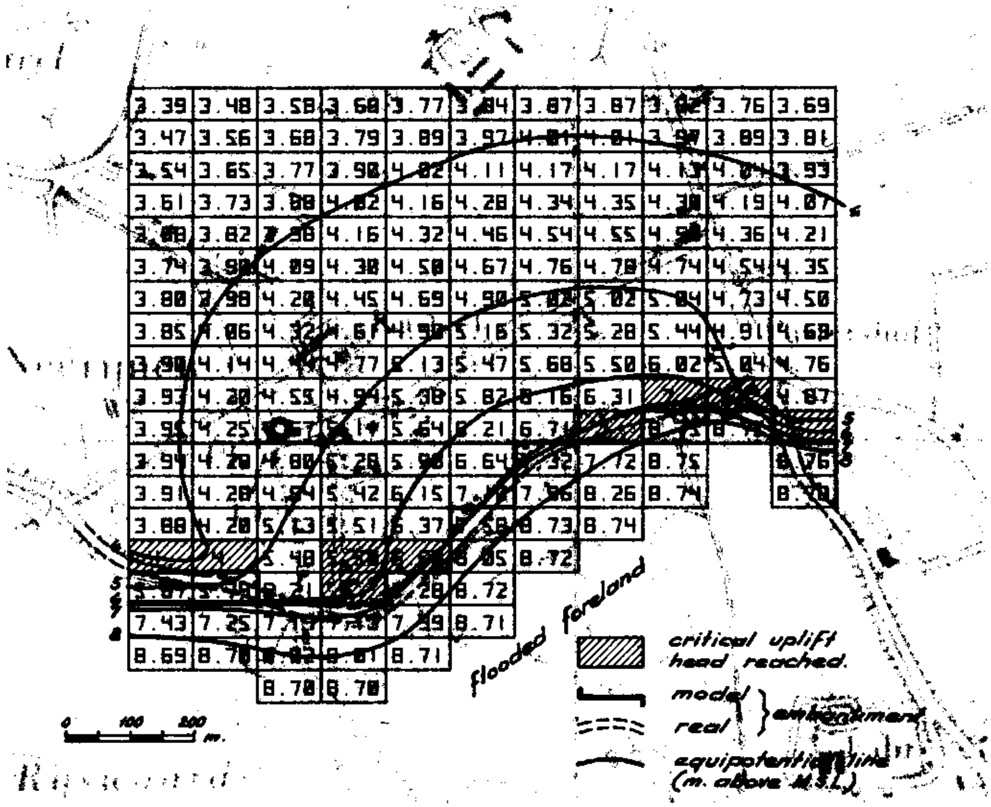

Figure 4 Calculated hydraulic heads (m above MSL)

The calculated heads are used as a basis for the drawing of equipotential lines (Figure 3) and as input in more detailed models (vertical cross-sections), by which the phreatic level and the pore-water pressure are determined.

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THE RAISING OF THE DEFENCES OF CANVEY ISLAND TO RESIST A 1 IN 1,000 YEAR TIDAL SURGE

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Abstract

Problems associated with the raising of the surge tide defences of a reclaimed island are discussed together with the solutions adopted.

1 Location

Canvey Island is situated on the north side of the Thames estuary approximately 60 km downriver from London. It is about 1600 ha in extent and is separated from the mainland by tidal creeks (Figure 1). Until 1931, when a bridge was built, access was possible only by water or by foot at low tide across a narrow part of the creek.[1] Like the strip of land on the mainland adjacent to the river it is thought to have once been salt marsh.

2 History

Canvey Island was known for its valuable grazing land from early times but has suffered encroachment from the sea during high tides more and more often. One of the reasons for this is the increase in sea level relative to the land, at the mouth of the Thames, of 300-400mm per century.[2] In 1622 defences were provided by building embankment walls

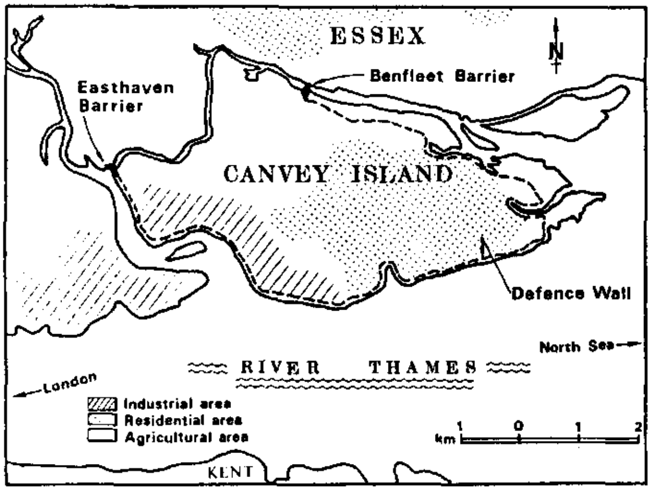

Figure 1. Canvey Island

with clay dug from borrow pits behind the embankments. However, these defences were breached many times since in spite of periodic repair, strengthening and raising.

Until the beginning of the twentieth century the island had been used for agricultural purposes but from then a change took place. Large areas of land were sold for building and the population increased from 111 in 1851 to 11,500 in 1953.

In the 1953 floods which caused such extensive damage and loss of life in the low lying areas on both sides of the North Sea, the Canvey Island embankments were overtopped by 600mm and the whole island was flooded. Fifty-eight people lost their lives on the night of January 31st.

A new standard of defence was then adopted which meant raising the crest of the embankments to a level of 900mm above the 1953 tide level in residential and industrial areas, and 600mm above the 1953 tide level in agricultural areas.

The population of Canvey Island has continued to grow to a present total of 34,000 and has been accompanied by industrial expansion.

3 Defence Levels

The rise in mean sea level relative to the land may be due to a number of causes including a general tilting of south-east England and the melting of the polar ice cap. Secondary causes may be the consolidation of the London Clay which underlies the Thames estuary and the consolidation of the layer of alluvial clay which outcrops on the island. The level of the island is now 1.5 to 2.0m below the mean high tide level.

The other and more significant reason for the periodic inundation of the island has been the incidence of surge tides caused by abnormal barometric pressures combined with northerly gales. The 1953 surge tide reached a level of 4.7m above datum which is up to 3m above the present general ground level on the island.

In 1954 a committee recommended that consideration be given to the provision of a barrier in the Thames to protect London from abnormally high surge tides. To complete the protection it would be necessary to increase the level of the defences downriver of the barrier.

The 1953 surge tide had a return period of 50 years and it is significant that the surge experienced by Hamburg in 1956 showed that abnormal tide levels of extreme return frequency were possible. The public authorities responsible for the Thameside defences decided that protection should be provided against a surge tide with a return period of 1000 years. This event was extrapolated to the year 2030 AD to allow in some measure for future rise in sea-level relative to the land. This give a surge tide level of 6m above datum at Canvey Island, that is, 1.3m above the 1953 surge.

The Essex River Authority was responsible for implementing the improved defences on the north bank of the Thames downriver of London and appointed Binnie & Partners as consultants for the design and supervision of substantial sections of the work including the whole of Canvey Island.

Recent alluvial deposits are present over the whole of the area. The surface deposit is a very soft to soft silty clay. This is typically up to 14m deep on the south (river) side of the island. At lower depths it contains silt and sand lenses. The clay layer thins towards the north and in places is only 2m thick adjacent to the tidal creek. Under the clay is a layer of silty fine sand of varying density which increases in thickness towards the east where it is 16m thick. On the north side of the island this sand layer itself contains layers of clay. Under the sand is a medium dense to dense sandy gravel up to 7m thick which is underlain by the London Clay, a stiff over-consolidated clay of the Eocene period. A log of a typical borehole on the river frontage is shown in Figure 2 together with the results of strength and classification tests.

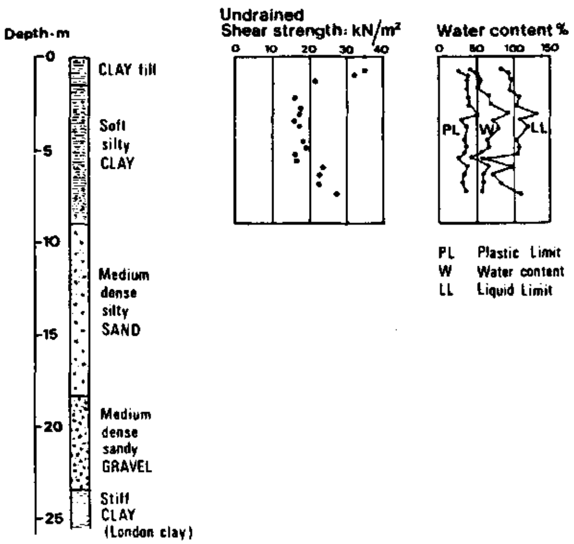

Figure 2. Typical borehole log and soil properties

The upper part of the clay layer is slightly overconsolidated by drying. It is very compressible with a coefficient of volume compressibility ranging between 10 and 1 m^2/MN. The coefficient of consolidation ranges between 16 and 0.3 m^2/yr. The sand layer has a permeability of 10^{-5} to 10^{-6} m/sec.

5 Defences before raising

A typical embankment constituting the tidal defences before the present raising started is shown in Figure 3. The embankment consists of clay built up over the centuries which after the 1953 floods was capped with a sheet piled parapet. Other materials such as chalk and rubble are present in some places especially at old breaches. The river face of the embankment is revetted with either stone or concrete blocks grouted with bitumen.

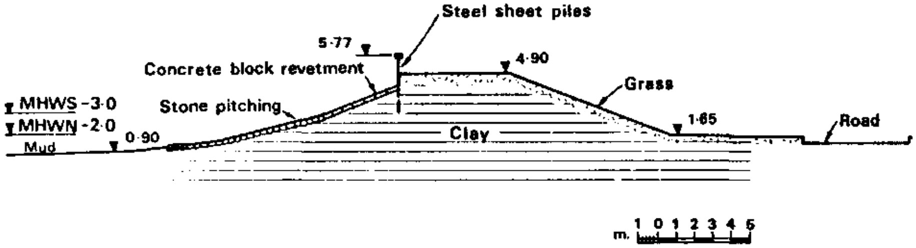

Figure 3. Typical defence before raising

There were three important features of the existing embankments which had to be taken into account in any modification to provide a defence against a higher surge tide. These were:

a) the extensive fissuring of the clay which penetrated up to a depth of 1.5m and formed a pattern of closely spaced fine cracks. This fissuring was thought to have led to failures in the past by seepage through the bank leading to sloughing.

b) the embankments were at or near their critical heights as defined by Taylor.[3] Although the gradual raising of the banks in the past had been responsible for a degree of consolidation in the soft clay its shear strength was still low. This was demonstrated when difficulty was experienced in achieving stability of some lengths of embankment which had been raised in earthfill since the 1953 floods.

c) residential and industrial development had taken place right up to the landward side of the embankments over considerable lengths. Improving the stability of higher embankments by the use of berms was therefore impossible. The industrial expansion had also attracted shipping which precluded the use of extensive stability works to riverward of the existing embankments.

6 Development of new designs

6.1 The traditional form of defence has always been earth embankments and so consideration was given to raising the defences using fill but taking into account the features listed in para 5.

6.2 The existing embankments were typically about 3m high. In addition to meeting the new flood level requirement, allowance had to be made for settlement and freeboard and thus new embankments would have to be 60-70% higher than existing.

6.3 New materials and methods were examined. To reduce the load on the foundation, the use of lightweight materials was considered. Pulverised fuel ash (PFA) from coal fired power stations was readily available and showed a substantial saving in weight. This meant that a higher embankment could be built with a relatively modest increase in load on the foundation. A typical design using PFA with a berm of granular material on the landward side is shown in Figure 4 (a). Drainage layers are included to control seepage safely. This design was appropriate where land could be acquired to landward of the existing embankment although it would have involved the diversion of existing roads or industrial installations.

A variation of this design entailed building in tidal conditions to riverward of the existing embankment using rock and sand fill to form a berm.

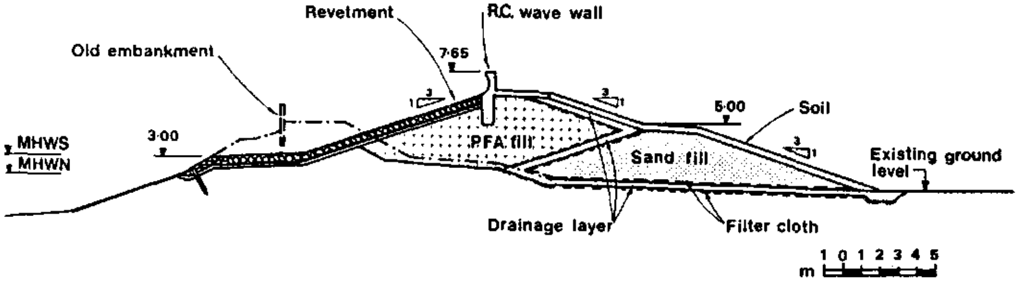

Figure 4 (a). Raised defence using PFA fill

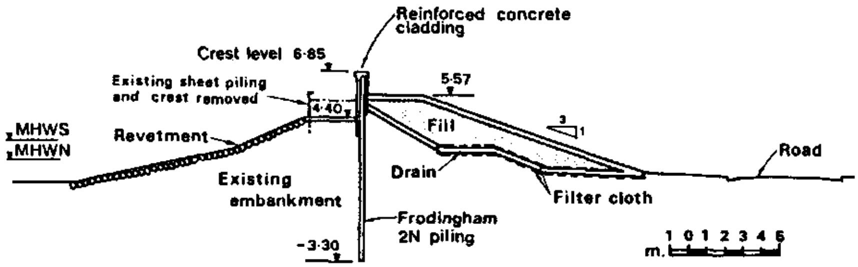

Figure 4 (b). Raised defence using sheet piling and fill

6.4 However, PFA suffers from disadvantages as a fill material because although it is a strong material, it is brittle, liable to crack and is susceptible to erosion. A design using more conventional fill such as clayey gravel was therefore developed. Such materials are heavier and the increase in load on the foundation is greater than in the case of a design using PFA. It is therefore necessary to build up the strength of the foundation by employing a two-stage construction allowing consolidation after the first stage. This method also reduced the final settlement by the amount of settlement after the first stage, but the overall construction period was longer. In some cases vertical sand drains were found to be necessary to accelerate consolidation.

6.5 Alternative designs to those based on earthworks were examined. These did not appreciably increase the existing load on the foundation and the crest level could therefore be lower than that for the earthworks designs.

One design used a reinforced concrete wall with a base covering the existing crest, anchored to seaward into the sand layer under the soft clay. However, as the sand is fine and silty, the allowable loads on a ground anchor would be modest. The high wall constituting this design would have caused a considerable loss of amenity obstructing the view of, and access to, the river frontage which in many places has been developed as a recreational beach.

Another design was based on the use of steel sheet piles and fill in combination as shown in Figure 4 (b). The sheet piling was driven through the existing embankment into the foundation to a depth sufficient to prevent rotation and at the same time forming a satisfactory cut-off in the fissured clay. To gain passive resistance it was generally necessary to add fill to the landward slope of the existing embankment. The parapet of the wall varies in height but over considerable lengths it has been possible to retain a view riverward over the sheet piling. The piling was clad in reinforced concrete over that part liable to corrosion i.e. the exposed part, and for a limited depth into the embankment. This cladding also serves as a wave wall. Protection of the riverward slope of the embankment by bitumen grouted stone or concrete blocks was retained.

6.6 Other designs were prepared for comparatively short lengths where particular circumstances apply. Alongside a creek, where the existing embankment was already comparatively high, a concrete wall to act both as a parapet and a cut-off in the fissured clay was found sufficient. Over another length it was possible to incorporate a refuse tip, operated by the County Authority, into the defences by facing it with clay and revetment.

Where the sand layer under the soft clay foundation is near the surface special consideration was given to the increase of pore pressure in the sand which will occur under a high surge tide. Wide berms to counter uplift and wells and drains to relieve the pressures were provided.

6.7 Drainage water from the island can only be discharged to the sea by pumping or through outfalls at low tide. Modifications to these structures were designed to prevent transmission of surge tide pressures into the landward part of the embankments by provision of a control, such as a flap valve and penstock, on the line of the crest.

Recreational use of the beaches facing the Thames was retained by allowing frequent access through the defences by gates or ramps.

Modified defences were necessary at jetties to retain access and to provide for multi-pipeline services to the oil and gas installations. Manually operated floodgates were provided at many jetties to provide pedestrian and vehicle access.

7 Barriers

7.1 The defence of the north bank of Canvey between Easthaven and Benfleet has been achieved by gated barriers across the arms of the creek, allowing the sea wall between to remain unraised (Figure 1).

7.2 This part of the creek is used only for recreational purposes and for navigation by small pleasure craft. The barrier at Easthaven has a navigation opening 13m wide and 8.3m deep and two openings for tidal flow 13m wide and 6m deep. At Benfleet there is one opening 12.5m wide and 5.25m deep for navigation and two openings 12.5m wide and 4.5m deep for tidal flow.

7.3 At the appropriate surge warning stage the openings are closed by lowering the top hinged flap gates, under hydraulic control. Lowering can be achieved at both barriers by hand operation alone, although powered operation is the normal mode.

8 Final design

8.1 The design eventually adopted for the greater part of the defences of Canvey is that based on the use of steel sheet piling and fill as described in para. 6.5 and shown in Figure 4 (b). The main advantages of this design are:

a) minimum disruption to existing facilities
b) positive cut-off in the fissured clay
c) saving in the revetment work necessary for an earthworks solution
d) minimum settlement
e) competitive cost

8.2 Construction of the defences started in 1976 and is now almost complete. The work has been executed by the Anglian Water Authority, who took over the responsibilities of the former Essex River Authority in 1974. Part of the work has been done by the Authority's staff and part by contractors. The cost of the works for Canvey Island including the two barriers is £17m. A completed defence wall is shown in Figure 5 and a barrier under construction in Figure 6.

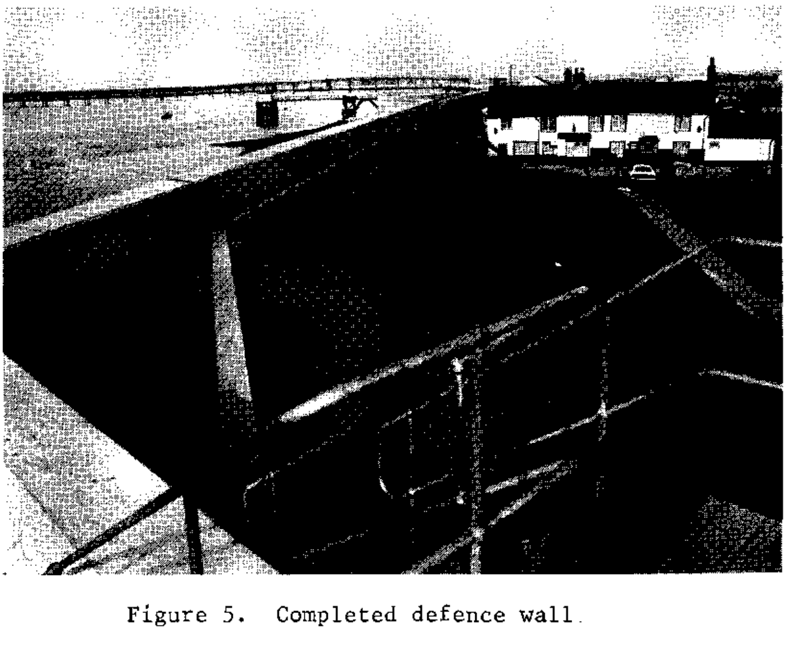

Figure 5. Completed defence wall

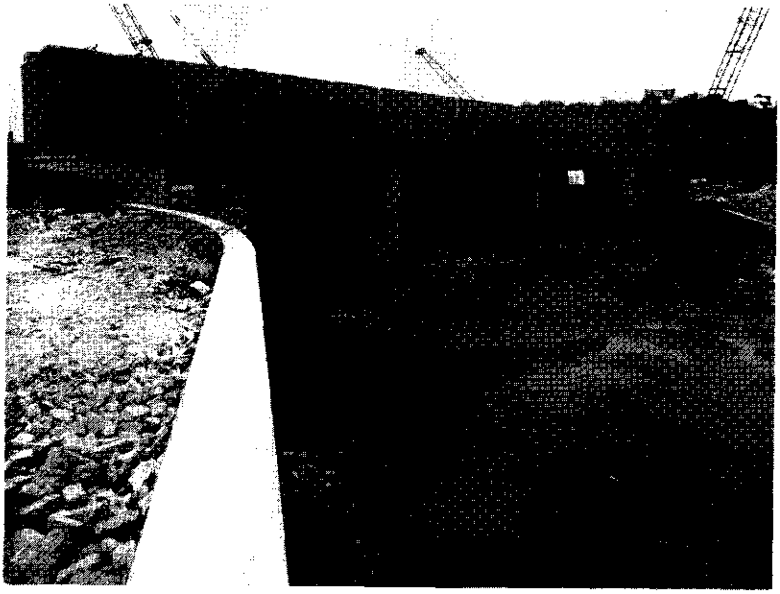

Figure 6. Benfleet barrier under construction

9 Acknowledgements

The authors wish to thank the Anglian Water Authority for permission to publish this paper.

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DESIGN AND CONSTRUCTION OF THE SEA DEFENCES OF GUYANA

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Abstract

In the early seventies the problems met in constructing and maintaining sea defences in Guyana were thoroughly studied. As a result a new type of sea defence was developed and constructed. This new type of sea-defence can protect in future Guyana's polders successfully against salt water intrusion and resist a further regression of the coast line.

1 Introduction

The fertile coastal plain of Guyana is a comparively narrow, low-lying area which consists of soft clayey soils. The area slopes very gently down to the sea. Along the shore line groundlevels vary between one ft below and one to two ft above mean sea level (MSL). The tides, however, normally rise to some five ft above MSL. Consequently, occupation and cultivation on the coast is only possible when there is a natural or man-made protection against higher sea levels. In spite of these natural disadvantages, however, agricultural development of the coastal plain started over 200 years ago near the mouths of the Essequibo and Demerara Rivers. Until the present day nearly all of Guyana's population lives in the coastal area.

When there were no natural sand reefs, flooding was checked by earthdams built some distance inland and parallel to the coastline. At the start earth embankments could be kept low because of their location and the natural protection provided by mangrove and gourida bush. The coast is however subject to a periodic occurrence of accretion and erosion. During an erosion period the earth embankments are being destroyed. In the past the solution was to accept the regression of the coast line and to build a new earth dam further inland.

During the last sixty years, however, it has become practice in the relatively densely populated and more developed agricultural areas to strengthen the earth embankments against wave attack by revetments and coping walls.(Figure 1). The system turned out not to be successful. Probably the seadefences (as we will call them from now on) have retarded the erosion process to some extent but hardly anywhere the seadefence could be held in spite of high expenditure on maintenance and repairs.

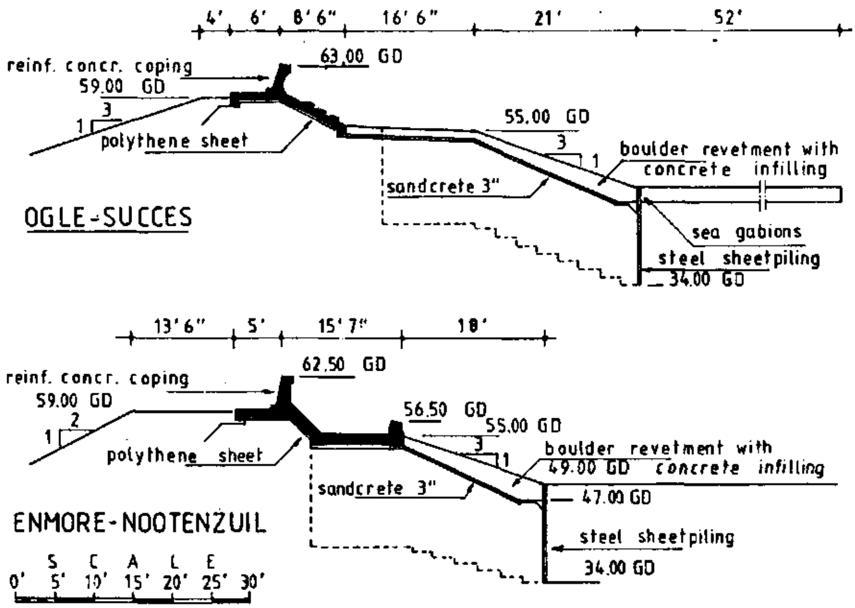

Figure 1: Types of seadefences in use prior to 1970

In the late sixties this situation was not any longer accepted and with the assistance of the World Bank the Government of Guyana initiated studies aiming at:

- design of sea defences which do not collapse, can permanently resist erosion and check regression of the coast line;
- determination of a economically viable programme of sea defence works along the Guyana coast for the following 20 years.

2 Studies

The studies made to answer the two main questions given in the preceding section involved the following disciplines:

- coastal hydraulics and morphology;
- soil mechanics;
- structural design and construction of sea defence;
- economics;
- maintenance and management.

In this paper only the structural design and construction of sea defences will be discussed as well as the results of hydraulic, morphological and soil mechanical studies.
Moreover, the subsequent detailed design and construction of 2.5 kilometers of new sea defences in front of Georgetown, Guyana's capital at the mouth of the Demerara River will be briefly reviewed.

3 The project area

3.1 Geographical, geological and climatological aspects

Geologically the main parts of the Guianas consist of the old Pre-Cambrian Guiana Shield. The coast is buried under sediments of ages, varying from young Cretacean to Recent; these deposits of sands and clays consist mainly of erosion products from the Guiana Shield (Figure 2).

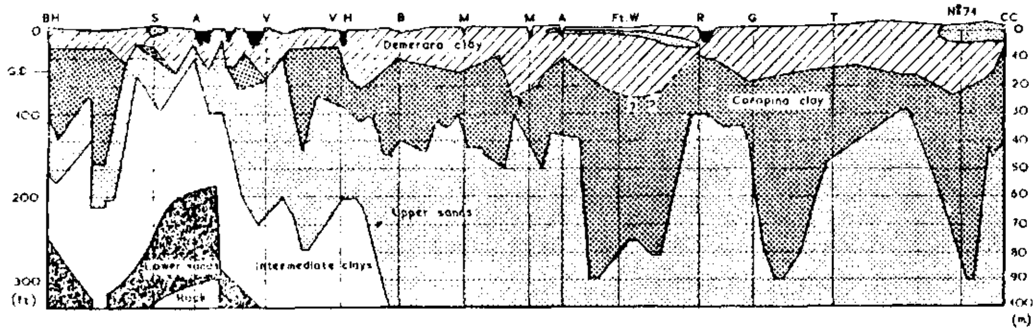

Figure 2: Geological profile of the Guyana coast

The climate is humid and tropical, with temperatures ranging between 26°C and 28°C. The humidity is not excessive. The coast is situated in the field of the trade winds, virtually constantly blowing from north-easterly directions, with a speed at sea of about 6 m/s. Tropical storms or cyclones do not occur in the area.

3.2 Existing sea defences

Depending on the physical conditions in the area concerned and economic considerations various types of sea defences have been constructed in the past. (Table 1).

3.3 Hydrography and cyclic morphological developments

The most striking feature of the offshore hydrography of the Guyana coast is the occurrence of large mud banks travelling along the coast at regular intervals. The average length of a bank is about 45 kilometers. The pattern of mud fades away at a depth of about 18 meters at a distance of about 25 kilometers from the coast. This is also the place

Table 1: Classification of existing sea defences

Classification	Overall length in km	%
natural sand reefs	77.28	24
earth dams without protection	168.62	53
earth dams with slope protection	4.25	1
earth dams protected at the toe, on the slopes and with copings	70.59	22
total	320.74	100

where the muddy bottom of the coastal belt changes to the harder and coarser surface of the continental shelf.
The mud banks travelling along the coast cause a more or less cyclic development of the shore at each place on the coast.
The offshore bottom becomes steep in the area where the trough between two mud banks meets the shore. Here, swell penetrates up to the coast and breaks on or near the shore. The erosion of the coast proceeds until another mud flat starts forming in front of the eroded shore. Fixation of a shore by a sea defence will prevent a recession of the shore but of course it cannot prevent the erosion of mud from the off-shore bottom of the sea.

3.4 Tides and water levels

Although the Guyana cost is over 400 kilometers long the uniformity of the tides makes a description of the tide at Georgetown hold true for the whole of the coast, with minor correction. The tide is of a semi-diurnal type with the range varying between 1.2 m in an average neap tide and 2.6 m during spring tide. Maximum predicted (astronomical) tide levels are 54 G.D. at the mouth of the Waini River to slightly over 56 G.D. at the mouth of the Corantijn River*).
Extreme water levels observed differ only 0.2 to 0.3 meters from the extreme astronomical tides.

3.5 Waves

Information from oceanographic sources indicates that waves arrive from easterly and north-easterly directions in the region where the bottom of the shelf does not yet influence the propagation. Subsequently, these waves enter the shallow coastal waters and ultimately they break on the shore or on the sea defence. Between 1949 and 1970 four series of observations were made on wave periods and wave heights. (Table 2).

Table 2 clearly illustrates the attenuation of the waves on their way towards the coast. The height of the waves decreases by friction and breaking. The apparent wave period increases because short waves are damped faster than the long ones.

3.6 Soil-mechanical characteristics

The main feature of the soil layers of the Guyana coast is the striking uniformity along the whole of this coast. In general the soil consists of soft clay layers resting on the stiff to very stiff over-consolidated coropina clay. Thickness of soft clay layers varies generally between 10 to 20 metres although in some areas the thickness varies between 4 to 6 metres.

4 Scope of problem

Between the passing of two travelling mudbanks the shore in front of the sea defence erodes and average level of the foreshore becomes signi-fically deeper. This in turn results in higher waves reaching the sea

Table 2: Summary of four series of wave observations

Location	Distance from coast	Depth	Significant height average	max.	Period average	max.
	km	m	m		sec	
Ocean	50	20	1.3	4	6	13
Buxton	15	11	0.75	2.4	9	15
Demerara Beacon		6.6	0.65	1.7	8	12
Kitty Groyne	0.5	1	0.3	1.2	11.5	35

defence and, consequently, heavier wave attack and higher wave run-up on the sea defence. This was acted upon during the past by protecting the earth dam with a revetment and by placing a concrete wall (coping, 0.5 - 2 metres high) on top of the earthdam. The latter was introduced when it was experienced that an earth dam having a height of 4 to 5 metres lost its stability on the soft clay layers.
The erosion of the foreshore however increases the required height of the sea defence in relation to the level of the foreshore and practically everywhere the sea defence collapsed and had to be abandoned during the period (5-10 years) lapsing between the passing of two mudbanks. The authorities then had only one option left: accept the regression of the coast and to place the sea defence further inland.

5 Design of new cross section for sea defences

5.1 General

Because of the interdependance of the various parameters involved the design of the optimal cross-section of a sea defence is more difficult than one would expect it to be. There is nearly always need for physical model tests and it is not possible to describe all relationships between parameters in mathematical functions and ask the computer for the solution. Such approach is also hampered by a lack of basic data. Normally studies on the one described here start simultaneously with the collection of data, field observations and surveys, tests and calculations. The optimal design is finally arrived at by means of iteration. Optimal design of the cross-section is the design which meets the design criteria and requires the least construction costs.

Design criteria are:

- prevention of flooding caused by high water levels,
- fixing of coastline,
- stability for the case that max. erosion depths at outer toe of dyke develop during life time,
- very limited overtopping during exceptional circumstances,
- limited seepage through dykebody,
- lifetime of minimum 100 years without any major repairs, reconstruction or replacement of structural elements.
- limited year to year routine maintenance.

5.2 Gradient of seaward slope in relation to wave run-up

The seaward slope of a seawall is subject to continuous attack by waves. The zone of attack shifts up and down with the tide. The effect of the waves on the slope depends on the gradient of the slope and from this point of view a gentle slope is preferable. However, length of slope and volume of earthworks increase with a flattening of the slope. Consequently, the slope's gradient is a compromise between hydraulic, structural and economic considerations.

5.3 Overtopping

Assuming that a sea defence is sufficiently high to prevent overtopping during high water levels, overtopping will then only take place by wave

action. The rate of overtopping normally accepted in the Netherlands for sea defences having well tended grass cover on a landward slope of 1 in 3 is 2 litres per metre per sec. This figure, however, is valid for very rare storm surge levels. In Guyana design water levels or water levels of one ft below design water level are much more frequent. Frequent overtopping with saline water is detremental to grassed slopes and will also increase the salt content in the acquifer in the polder.
Loss of the grass cover on the slopes will utlimately result in a dryed-out cracked clay layer which is easily weakened by rain and seawater and this in turn may lead to soil-mechanical failure of the slope. Bearing this in mind a design criteria of 0.1 litre/per m/per sec. for overtopping was taken.

5.4 Hydraulic model tests

Hydraulic model tests have been carried out to test wave run-up and overtopping for various slopegradients (1 in 3 to 1 in 8), different levels of foreshore, different levels and lengths of berms, smooth and 'rough' (rock armour layer) revetments. All tests were carried out with waves having a significant height in deep water of 3 meters and a wave period of 8 sec.

5.5 Stability analysis

An important constraint for the development of a cross-section of a sea defence in Guyana is the limited height an embankment can reach without loss of stability. In order to be able to make stability analyses with a minimum factor of safety an extensive programme of site investigations (static cone penetration tests, borings, in-site measurements of pore pressures) was carried out along Guyana's coast line followed by laboratory tests on undisturbed samples: sedimentation, sieving, permeability, consolidation, cell and triaxial tests.
Firstly stability calculations were done by using total stress analysis, later on the effective stress analysis of Bishop was used. Shear characteristics of the subsoil used for this analysis are determined with the

cell tests and the consolidated undrained triaxial test. On the basis of various considerations it was decided to accept a minimum safety coefficient of 1.0.

Stability calculations were made for a large number of cross-sections. Slope gradients, crest levels, foreshore levels were varied while also the local characteristics of the subsoil were taken into account. Given the crest height (and slope gradient) determined by water levels and overtopping criteria on the one hand and the foreshore level as it was expected to become after erosion, it could be concluded that a low berm would be needed for stability reasons between upper and lower parts of the seaward slope.

5.6 Cross section of Georgetown Sea Defence

The cross-section of the sea defence at Georgetown was developed on the basis of (a) local hydraulic, morphological and soil-mechanical conditions, (b) overtoppings criterion (c) stability analysis using a safety factor of 1.0.

It was found that apart from a berm for soil-mechanical reasons a rock armour layer had to be placed on the upper part of the slope in order to decrease wave run-up (and thus overtopping) and, consequently, crest level. It is recalled that the latter had to be relatively low for reasons of stability.

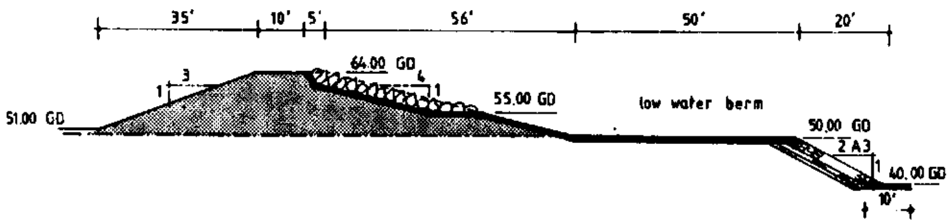

Figure 3: New design for sea defence

5.7 Departure points for structural design

The structural design of Guyana's sea defence was made by studying and evaluating thoroughly

- causes for collapse of seadefences and prevention thereof.
- construction materials: availability, characteristics, required equipment, cost, maintenance requirements.
- construction schedules and methods.
- local conditions such as wind, tide, average sea level in relation to ground level, foundation properties.

5.8 Collapse of sea defences in the past

A number of factors has caused collapse of sea defences in the past:

- erosion near the toe followed by loss of stability,
- overtopping,
- damage to coping,
- damage to revetments,
- a combination of these factors.

For each item it was considered whether or not the reason of collapse could be omitted either by adapting the design or introducing new technologies.

Erosion of the foreshore has to be accepted but introduction of a toe-protection would prevent erosion of the sea defence proper and a berm would prevent loss of stability.

For limiting the overtopping the earlier mentioned criterion was introduced which was reached by selecting a gentle seaward slope (1 in 4), a crest level of 62 - 65 ft GD (depending on local conditions) and a rock armour layer (thick 0.85 m, long 10 m). Damage to copings and revetments was analysed. One of the main reasons for damage turned out to be the rigidity of the concrete structures (concrete walls, grouted boulder slopes, reinforced concrete slabs) in relation to the flexible clay embankment underneath which is apt to differential settlements.

The original type coping wall which was of large size and had an important function in the sea defence design was not considered for the new design. However, a small adapted coping was introduced again in an alternative design.(Figure 4). For the revetment more flexible types were proposed to overcome the problem of differential settlement.

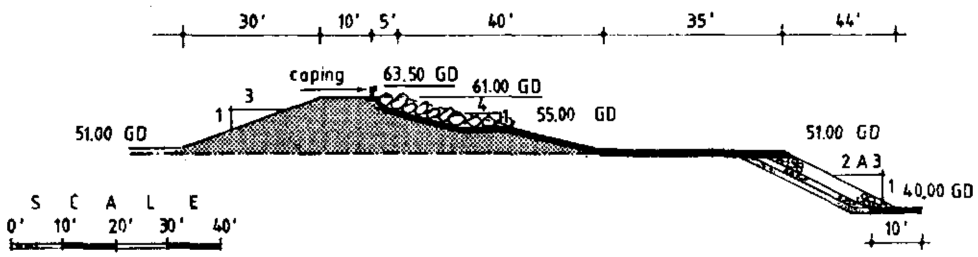

Figure 4: Alternative for new design: with coping

5.9 Toe protection

The toe protection is required between the berm at a level of 50 or 51 GD and the foreshore, the level of which may vary but for oceanic coasts can be considered to be at 40 GD.
In addition to its primary purpose to stop the cyclic erosion undermining the sea defence the toe protection should resist eroding forces of wave action and the downward rush of water following the breaking of waves at lower tidal levels. Moreover, the design should allow for possible differences between the pore pressure inside the sea defence and the water level outside, when the tide is out.
After due consideration of various alternatives it was concluded that a graded filter type toe protection would meet fully the design criteria and would also be cheapest to construct.

5.10 Revetments on seaward slopes and berms

The revetment forms the protection of the seaward slopes and berms against wave action. It is to be designed bearing in mind:

- strength in relation to wave attack,
- flexibility and tightness in relation to underlying clay embankment,
- durability with a view to maintenance (which is difficult in the tidal zone, while also possible cracks and voids are difficult to detect).

Revetments can firstly be classified as flexible types and rigid types. As follows from Section 5.8 only flexible types should be considered.
A further distinction can be made between permeable and impermeable type revetments.
In the design stage 3 permeable types and 3 impermeable types of revetments were considered:

open types:
- open filter
- concrete blocks having open joints
- stone pitching

closed types:
- sand mastic grouted stones
- concrete blocks, joints filled with bitumen
- asphaltic concrete.

The types "stone pitching" and "asphaltic concrete" were considered to be unsuitable on technical grounds. Of the remaining four types the sandmastic grouted stone type revetment not only is to be preferred on technical grounds (high flexibility combined with physical strength, water tightness and durability) but provides also the most economical solution. The latter is mainly due to the reduced layer thickness of stone as compared to all types of revetments constructed in the past or mentioned above.

5.11 Copings

Though copings in general cannot be recommended for incorperation in sea defences. It was felt that use of a coping of limited height would reduce the cost of construction of the sea defence significantly. It was therefore decided to present an alternative cross-section for the sea defence incorporating a coping (Figure 4).

5.12 Protection of inner slopes

The slope on the landward side of a sea defence depends mainly on the mechanical characteristics of the soil. Rainfall, overtopping, passage of men and animals all tend to have an eroding effect on the slopes. A good grass layer is adequate to protect the slope against erosion, provided overtopping is limited (see Section 5.3), the slope must not be steeper than 1 in 3, and access for people and goods should not be allowed. For Guyana a grass protection would appear to be a feasible solution.

6. Construction of Georgetown Sea Defences

The design briefly reviewed in the foregoing sections was applied in practice for Georgetown Sea Defence which was re-constructed during the period 1973 - 1976. The Nedeco study predicted a next period of erosion of the foreshore to start at around 1973. Actual erosion started during 1974 lowering the foreshore gradually from an average level of 54 GD (1936 - 1969) down to 49 GD (1976) at 30 metres from the toe of the defence. The progressing erosion during the construction period affected also the progress of works since coffer-dams had to be built in front of the old sea-wall.

Now, in 1982 the re-constructed sea defence has been in operation for six to eight years and so far has fully satisfied the design criteria. This cannot be said about adjacent sections of sea defence reconstructed at about the same period, where oversplash still poses problems occasionally and where applied rigid concrete slab revetments on the outer slope tend to deteriorate already.

Obviously, future cost of maintenance in these sections will be relatively high.

Notes

*) G.D. = Georgetown Datum, levels are in ft.

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STATISTICAL RISK ASSESSMENT OF POLDER PROTECTION STRUCTURES

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Abstract

Development of polder regions requires proper protection works against the sea. These must be adequate to resist overtopping by reasonably expected storm surges. One of the basic functions of the engineer in design of the protective structure is determination of the magnitude of this storm surge or, conversely, the recurrence interval of a specified wave height. It is usually necessary to extrapolate limited data to much longer periods. The problem is then fitting of data to the proper statistical distribution. It has been shown that storm surge phenomena can be well described by superposition of an extreme value distribution for the storm surge over a normal distribution for the astronomically generated tides. The work presented here supports this generalized view.

Introduction

Polders, by their very nature, require protection against all but the most infrequent high water levels. Therefore, the designer engaged with shore protection structures must make decisions concerning (a) the maximum water level to be expected in a given time interval and (b) the recurrence interval associated with a specified tide height. Overtopping of dikes can lead to great loss of life and property. Great care must be exercised in deciding the height of protection works and determining the recurrence interval of associated water levels.

The practicing engineer is not usually well versed in statistical reasoning and yet the underlying concepts concerning protection works are statistical in nature. Often in engineering it is most necessary to know when to not use certain statistics. Improperly applied statistical reasoning can give results which are far from the proper solution for a physical problem. Storm tides are not true tides[4]. Large waves generated in open water by wind stress at the air-water interface are driven onto a lee shore. The sea surface can be tilted due to barometric pressure differential. True astronomical tides are mathematically predictable. During intense and durable storms waves generated are superimposed over normal tides. The resulting combination can be catastrophic. The storm of 1953 is an excellent example of this and the analysis presented by the Delta Commission[1] have given great insight into the problems encountered in predicting recurrence intervals.

It is not always possible to obtain tide height records for the location of prime interest. It is necessary, therefore, to utilize available data from recording stations in close proximity and extend the results the place in question. Periods for which records exist are usually much shorter than than the return period for which prediction is necessary. Existing data must be extrapolated to longer periods. Therein lies the basic problem. It is common engineering practice to fit the recorded data data to a statistical distribution. Frequently data are fitted, or forced to fit a normal distribution.

A frequency polygon, such as that shown in Figure 1, can give some clue as to the distribution which may best describe the data. It can be seen that there are two peaks. For extrapolation, the raw frequency polygon is of little utility. Ranking of the raw data and summation of the cases gives the S Curve. In preparation of the summation curve it is assumed that one case of greater magnitude than any was recorded might occur. Thus, the ranking of the m th case in a total number of n cases would be m/n + 1. The S, or summation, Curve is given in Figure 2. There is little predictive capability in this curve. However, paper which will linearize summed data is most valuable. Normal probability paper, which was invented by the american sanitary engineer Alan Hazen, does give a straight line when summed normal data is plotted on it. An example is displayed in Figure 3. It is an all too common practice to endeavour to fit many distributions to this plot. Extrapolation for determination of responses of infrequent occurences is most dangerous. The use of the logarithm of the variable in place of the arithmetic value does solve one problem in that the zero point is eliminated. However, if data are forced to fit either arithmetic or log normal probability plots there are the basic problems of validity and credibility of results. The most commonly applied extrapolative techniques utilize extreme value statistics. Usually, phenomena of engineering significance are those which are infrequent but have the greatest potential for great loss. In treating data by this method the maximum value in each period is used[3]. Smaller values in a period, even though larger than the largest value in another interval, are not used. Data are ranked and summed, then plotted on paper in which the abscissa is arranged to linearize

$$p = \exp - (\exp - b) \qquad (1)$$

where p is the probability of occurence and b is a function of the physical system. Equation 1 gives emphasis to the more infrequent cases. An extreme value, or Gumbel, plot of all yearly highest tides at the Battery, New York, is displayed in Figure 4.

Data analysis

In a previous paper[4] it was suggested that separate occurences might be segregated and treated by superposition of the less frequent phenomena over the more frequent responses. A subsequent work[2] presnted supporting evidence for this view. Thom[5] has shown that extreme winds follow an extreme value distribution. Abnormally high water levels are due, in great part, to the high winds associated with deep weather disturbances. In the work reported here all of the responses were lumped together and no effort was made to differentiate between wind effects and tilting of the sea surface.

Records for the following stations were analyzed: La Jolla, California; Miami Beach, Florida; Sandy Hook, New Jersey; Battery, New York; Bar Harbor, Maine. It has not been possible to include results of examinations of European water level records in the work reported here. At the Symposium discussion of European records will be presented.

The Battery, New York, is of particular interest. The recording station is located at the confluence of the Hudson (North)River and the East River, a tidal estuary. The East River connects the Lower Harbor and Long Island Sound. Flow patterns are extremely complex. Monthly highest tides and yearly highest tides were treated.

The frequency polygon of Figure 1 gives an indication that the data do not follow a simple response. Little insight is gained from Figure 2 except that there is a definite bias. Figure 3, an arithmetic normal plot, shows that the data do not follow a simple normal distribution. It should be noted that the characteristic deviation to the right in the upper reaches does appear. This deviation begins at 11.0 feet. Tides taken from published Tide Tables have upper limits close to this value. Treatment of this portion of the data as a separate extreme value distribution is illustrated in Figure 4. For comparison purposes the water level of 13.3 feet, the highest recorded level will be examined. The product of the probability of the highest level on the linear portion of Figure 3 is 0.20 and the probability of a level of 13.3 feet from Figure 4 is 0.06. The product 0.20 x 0.06 = 0.012. The data are yearly highs and the recurrence interval will be 1/.012 = 83.3 years. Figure 5 is an extreme value plot of all yearly highs. The recurrence interval for 13.3 feet here is found to be 1/.014 = 71.4 years. The agreement between the two somewhat independent determinations is reasonably close. Figures 6 and 7 are, respectively. arithmetic and log normal plots of all monthly highest tides. The deviation points are the same for both plots. Deviation from the linear portion of the plot is at 81% and the probability of occurence of this value is 0.19. Figure 8 gives the plot of all monthly highest tides above 9.7 feet. From Figure 8 the probability of occurence of a water level of 13.3 feet is .007. The product 0.19 x 0.007 = 0.00133 and the recurrence interval is 1/.00133 = 751.9 months = 62.7 years. All monthly highest tides are illustrated on the extreme value plot of Figure 9. The results of this display are too inconclusive to be of great value.

Conclusions

For the engineering practicioner elegant mathematical analyses are not always practical or necessary. A method has been presented by which it is possible to reach reasonable conclusions concerning recurrence interval of water levels or water levels of definite return periods. It is most desirable that separate determinations be made whenever this is possible. The station presnted here for discussion is most complex and a nearby station, Sandy Hook, gives much more regular results[4]. It appears that the method of superposition is a legitimate analytical tool.

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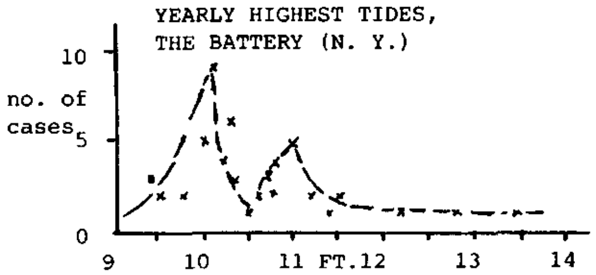


FIGURE 1.

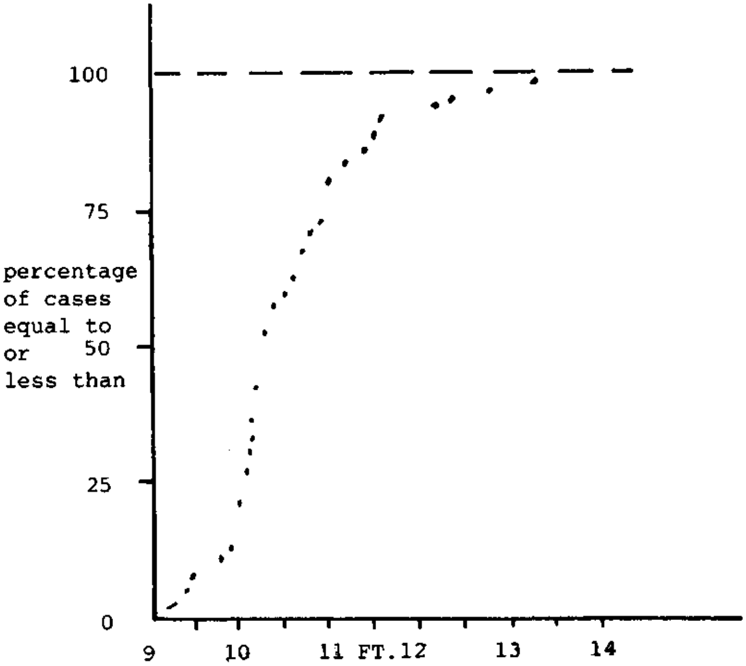


FIGURE 2.

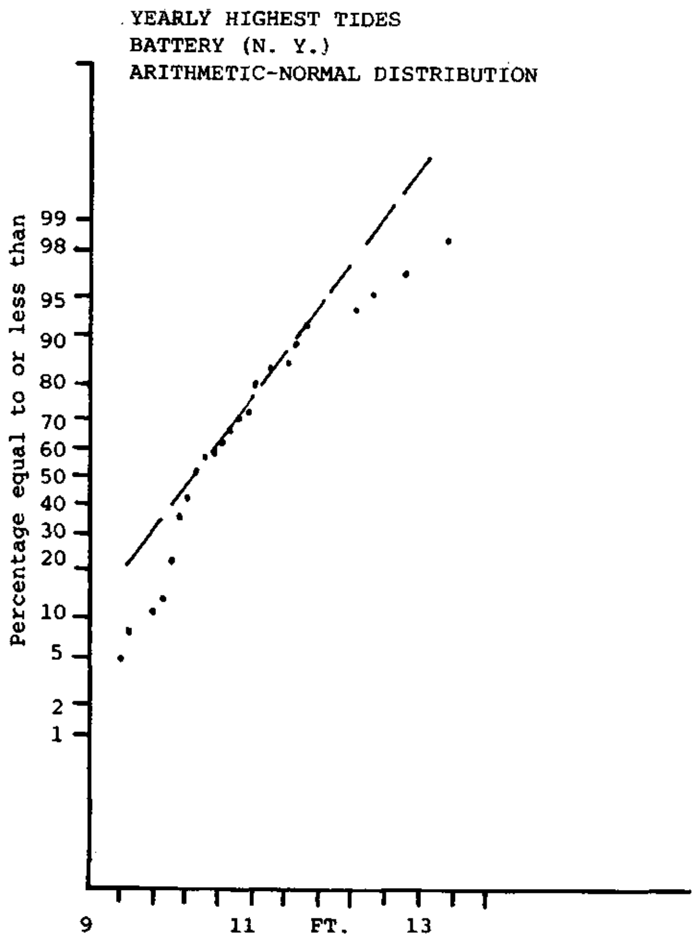


FIGURE 3.

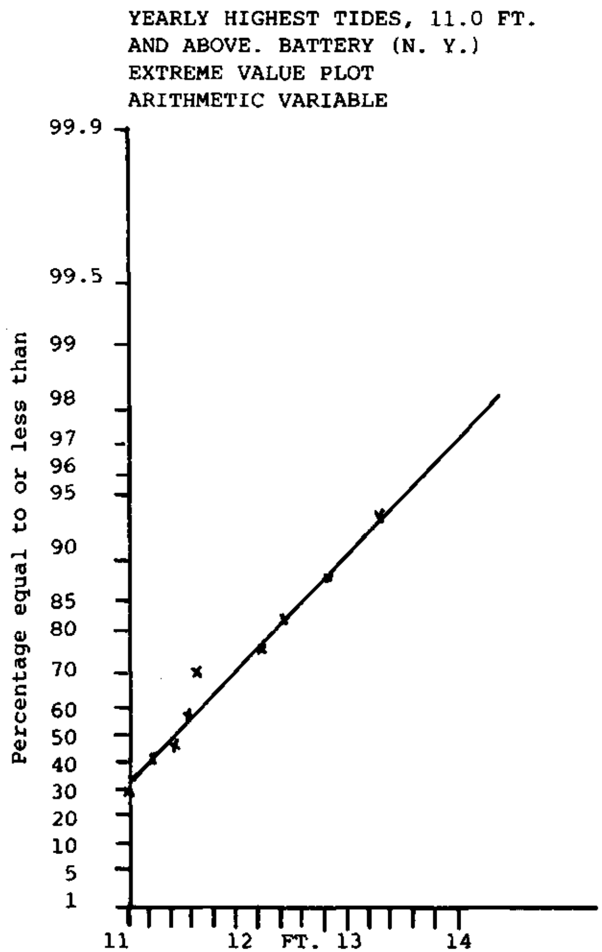
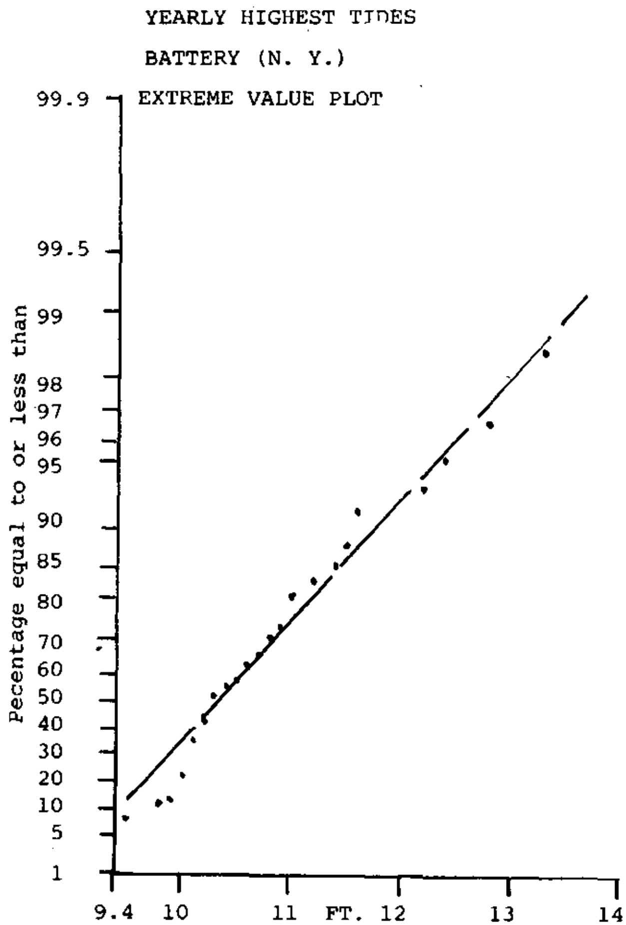


FIGURE 4.



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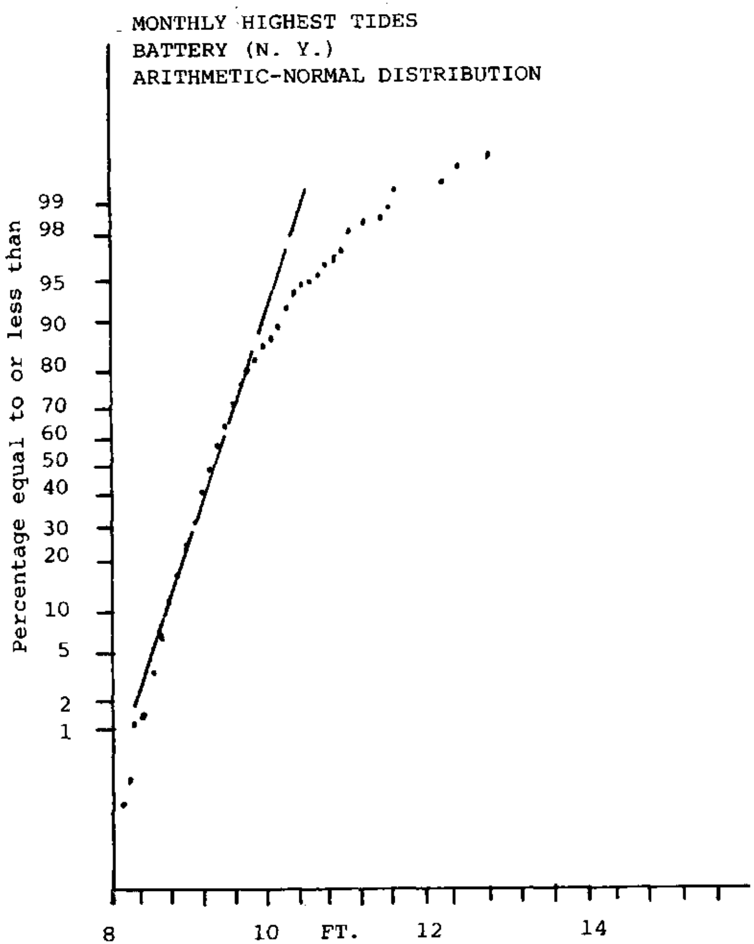

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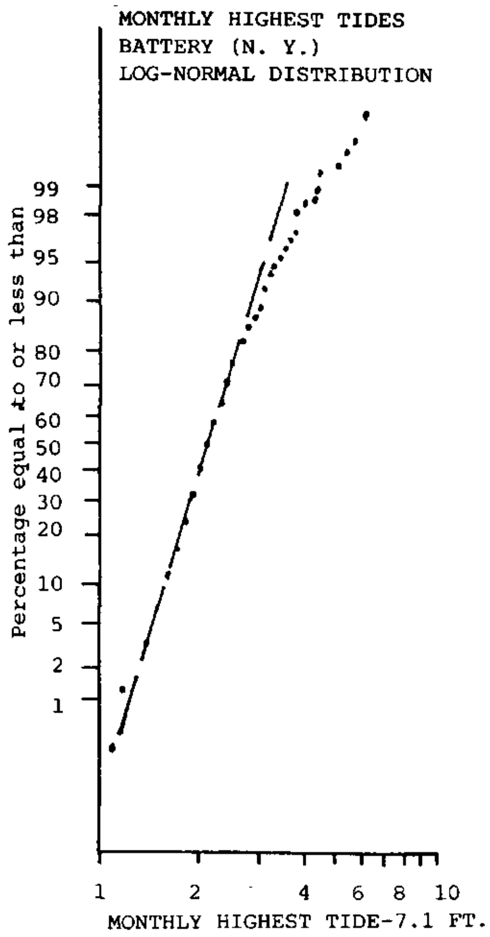

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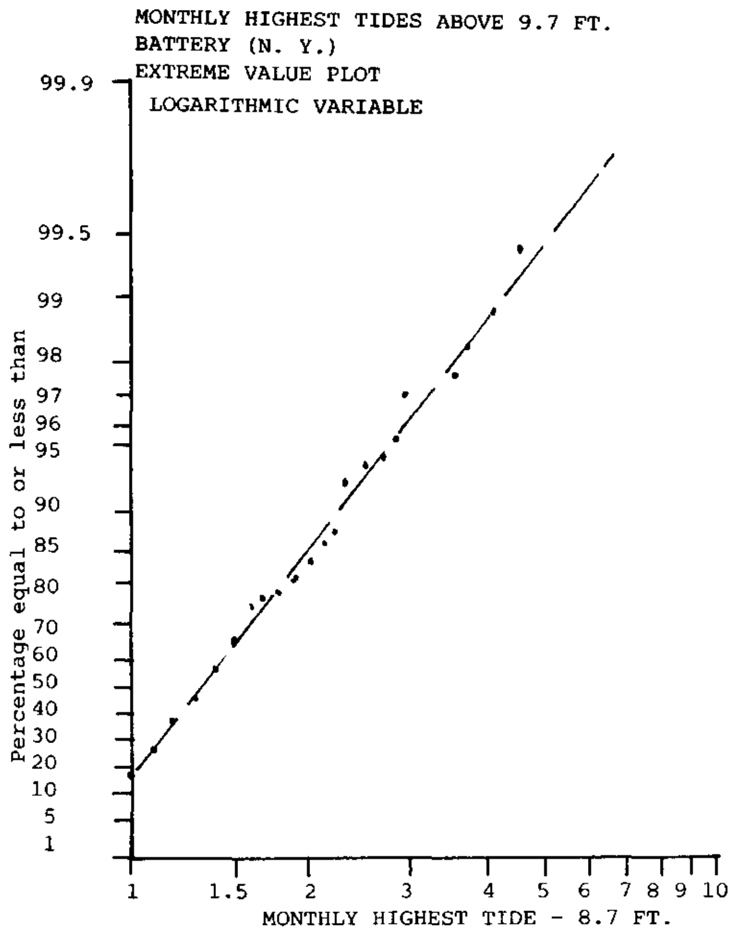

FIGURE 8.

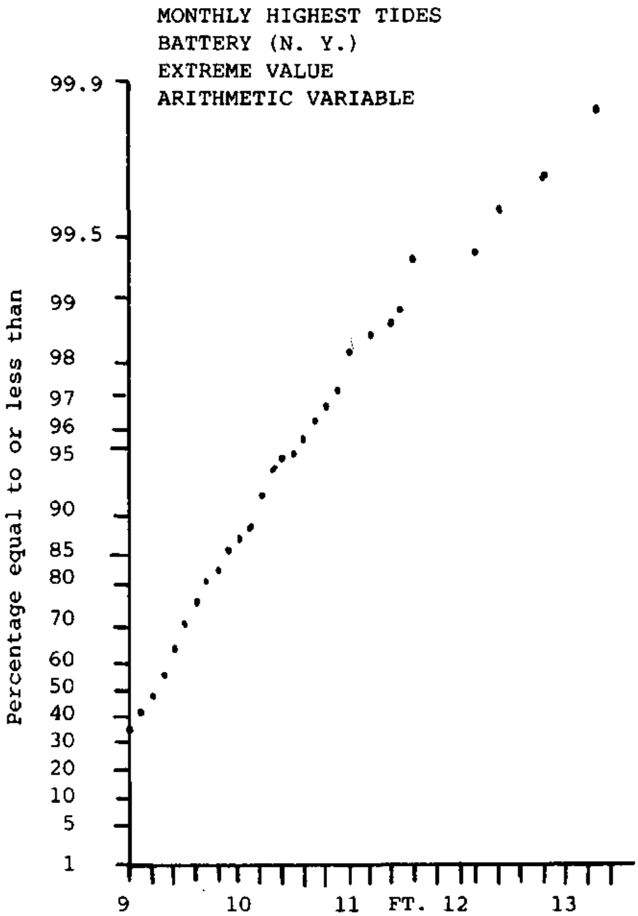
MONTHLY HIGHEST TIDES
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FIGURE 9.

CONSTRUCTION ASPECTS IN THE POLDERS OF THE LEFT BANK AT THE LOW GUADALQUIVIR MARSHES, SEVILLA, SPAIN.

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Abstract

The construction aspects described concern the building of dykes, execution of a drainage, irrigation and roads network in flooded marshes at the estuary of Guadalquivir. Works resulting in a polder area of 75.000 ha.

1 Introduction

In order to elude the overflows produced in the damp periods of the rainy years at the marshes of the Guadalquivir river, in 1929 the dykes were made in the marshes of the left bank of the river totalling 28.500 ha.

On the right bank of the river an area for rice cultivation was protected with a dyke in 1940. This co-called Mayor Island of Guadalquivir, in the beginning occupied an area of 1.650 Ha. Today it covers 18.500 Ha.

In 1958 dykes were built to canalize the Guadiamar River, tributary of the Guadalquivir, to put under irrigation the new area of Almonte-Marismas. Plane number 1.

2 Impoldering of selected areas by construction of dykes to avoid the overflow of the river and of water from the surrounding high lands.

The dykes were built up to 5 m height over the zero level of tides. As the maximum height of the tide in the river is 3.60 m there is a protection security against the equinox tides and the overflows of the Guadalquivir river; this height will never be surpassed.

Dyke building is done in clay soil of A-7-5 class (H.R.B.) and the sectional view is trapezoidal. The minimum width of the top is 6 m and the slopes are outside 1:3 and interior 1:2. The dykes are used as a network of principal roads and the ditch resulting from excavation of the earth is used as collector of the drainage network.

The machinery used in the construction comprises: scrapers and bulldozers for earthmoving, vibratory compactors and the like.

3 Drainage network to control rain or irrigation water, mainly by gravity but in some areas by pumping stations.

In order to elude the excess of rain and irrigation water, to support the phreatic level up to the required depth for the crops, and remove by leaching the toxicant salts in the soil, a drainage network was built. Its characteristics are the following:

a) Basic performance by gravity since fluctuation of the tide makes this procedure possible, supplemented with pumping stations to evacuate water from the low areas.
b) A network of collectors, primary and secondary ditches with open drain of big section and minimum slope (collectors and primary drains 0'1 to thousand, secondary drains 0'25 to thousand).
c) Subsurface drainage of parcels to 1 m medium deep, 10 m spacing and 250 m maximum length of 30 cm. That means a network of 1 km per Ha.

The machinery used: Dragline for collectors and primary ditches, retro-excavators for secondary ditches and trenching machines to place tile drains.

In this vertic soil it is forbidden to use drain machines with ripper because of ominous results observed in the experimental plots.
Plane number 2 shows the standard plot and the final scheme, not only for drainage but also for irrigation.

4 Irrigation network, according to the different types of soils and crop plants.

In the area the irrigation is effected by gravity and by sprinkling. The gravity system used 0,8 liter/ha.and as the soils are vertic irrigation by furrows is applied, using polyvinyl chloride pipes for the distribution of water. The land is levelled with longitudinal slope of 2 to thousand and transversal slope of 1,5 to thousand. The surface of a plot is 6 ha requiring earth moving of 650 m^3/ha.
To hold the salts equilibrium one needs a surplus irrigation of 25-20%. The sprinkler irrigation system uses 0,6 liter/ha and the distance between valves is 84 m with a sprinkler network of 18 x 12 m. This system is used in saline soils for berth irrigation and after the gravity irrigation to avoid water logging due to lack of permeability.
In the first phase of the reclamation of saline soils a change of the natural development of the vegetation can be observed. The original halophilous vegetation disappeared, giving way to an invasion of wild plants, creating a plant cover which can be utilized by livestock. In the three years that followed dry crops were planted, like barley, beans, colza, etc.
In the second phase irrigated crops were planted like wheat, sugar beets, cotton, etc. and when the soil is reclaimed it is possible the cultivate corn.
For construction a prefabricated channel of parabolic or circular section is used in the gravity system and concrete pipes for the sprinkling system.

5 Road network

The standard plots have a surface of 12,5 ha; and their shape is rectang-

ular: measuring 500 x 250 m; a network of rural roads covers 1 km.
The soils are A-7-5 class; this requires that the top of the road is based 1 m over the ground surface. The width of the top is 8 m; 6 m for the road and 2 m for the borders.
The construction is realised by stabilization of soils: sub-foundation of 20 cm. (6% calcium hidroxide of the dry weight of soil) and foundation of granular material.

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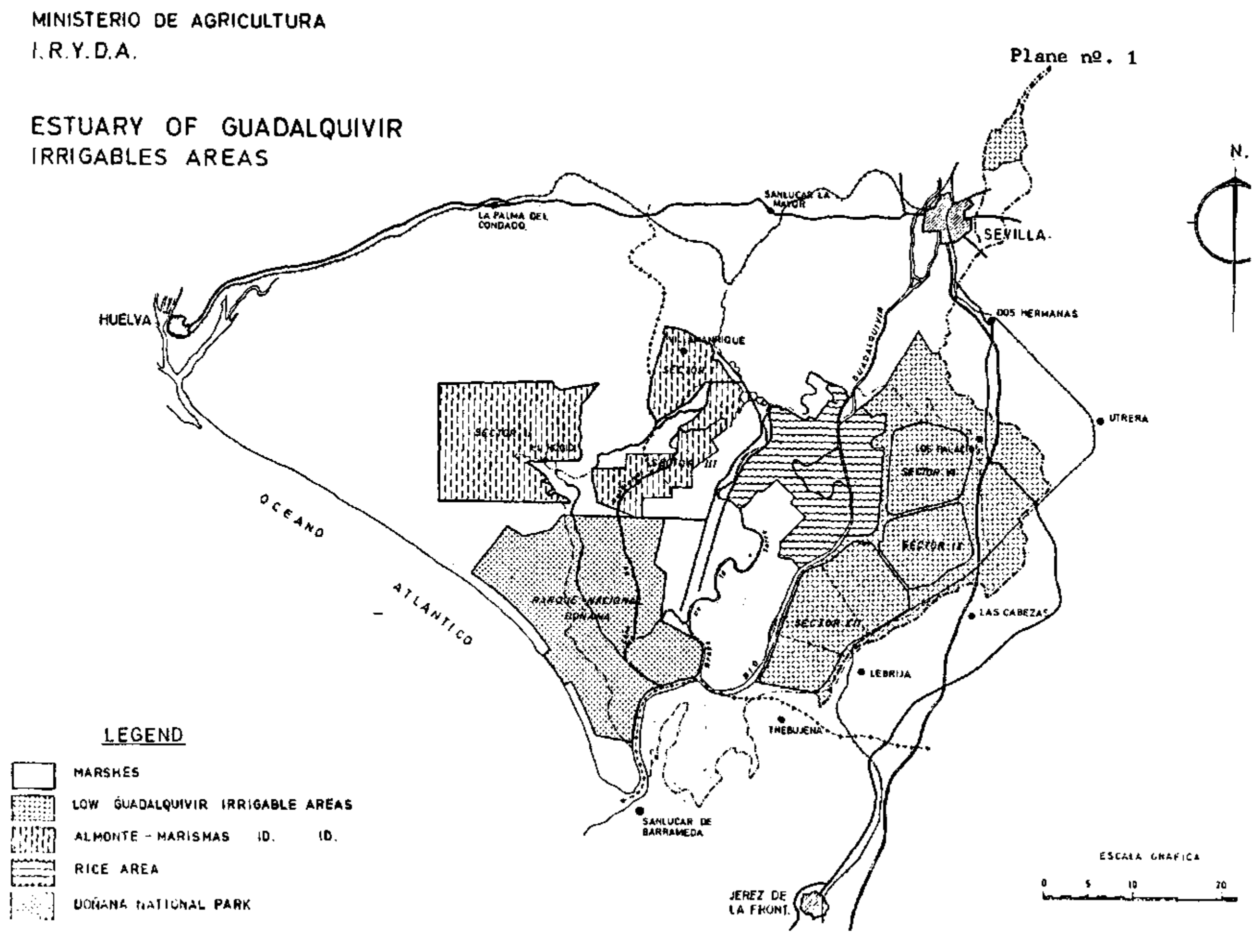
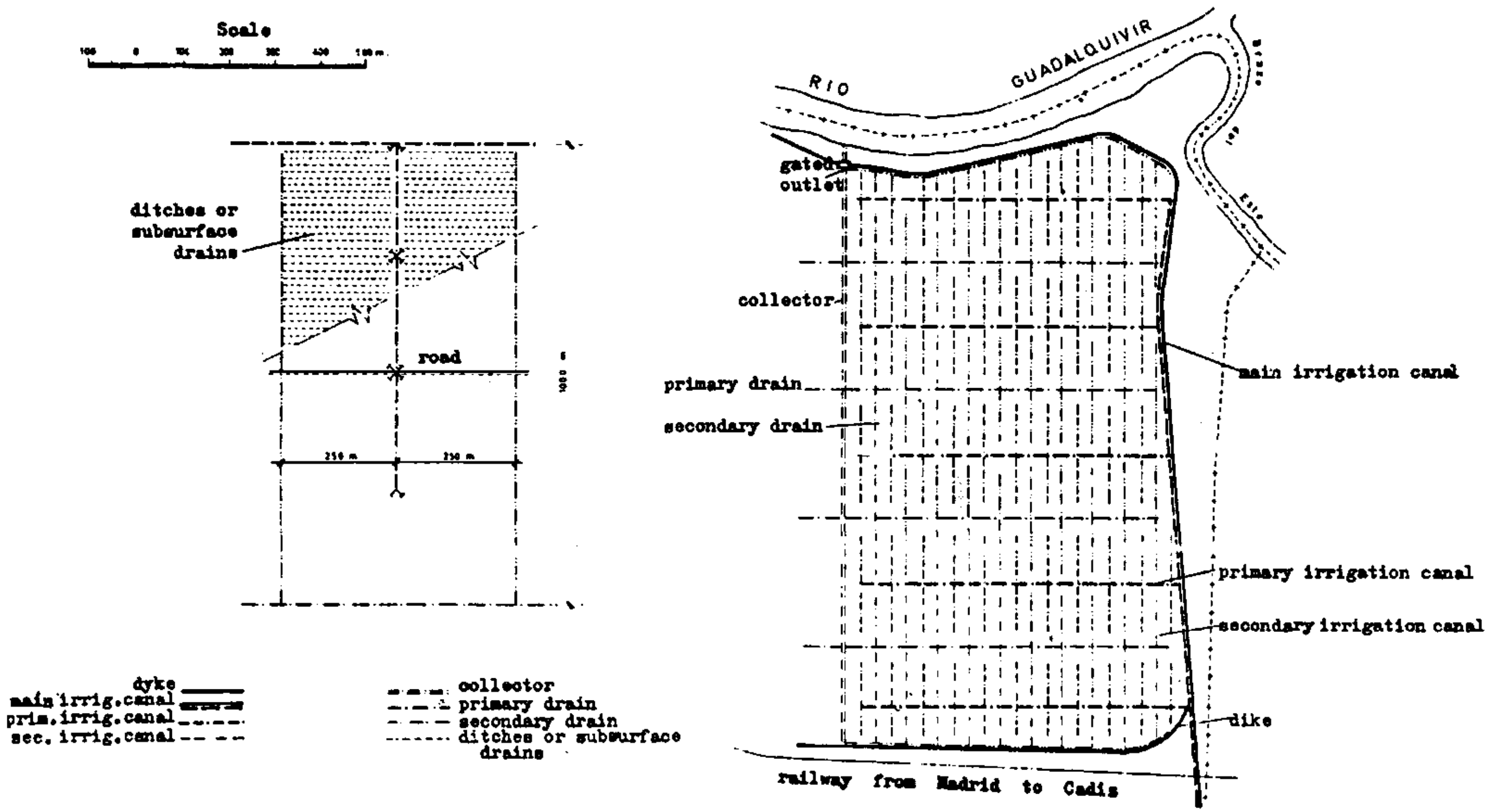

MINISTERIO DE AGRICULTURA
I.R.Y.D.A.
Plane nº. 1
ESTUARY OF GUADALQUIVIR
IRRIGABLES AREAS
N.
HUELVA
LA PALMA DEL CONDADO
SANLUCAR LA MAYOR
SEVILLA
DOS HERMANAS
UTRERA
VILLAMANRIQUE
SECTOR I
SECTOR II
SECTOR III
GUADALQUIVIR
SECTOR IX
SECTOR XII
LAS CABEZAS
LEBRIJA
TREBUJENA
PARQUE NACIONAL DOÑANA
SANLUCAR DE BARRAMEDA
JEREZ DE LA FRONT.
OCEANO
ATLANTICO
LEGEND
MARSHES
LOW GUADALQUIVIR IRRIGABLE AREAS
ALMONTE - MARISMAS ID. ID.
RICE AREA
DOÑANA NATIONAL PARK
ESCALA GRAFICA
0 5 10 20

Drainage scheme applied in the Sector B-XII
Low Guadalquivir irrigable.

Plane nº. 2



THE CONTROL OF PUMPING AGGREGATES AND THE MEASUREMENT OF DISCHARGE IN POLDER PUMPING STATIONS

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1 Introduction

The function of polder pumping stations is drainage of agricultural areas from which destructive surplus water can't be continuously or periodically drained naturally /by gravitation/ to the receiving stream. Not only the properly equipped pumping stations drain the land but they also supply water from the receiving stream to the polder during the periods of moisture deficiency. So polder pumping stations being of great importance in water-economic systems, their work must be very efficient and reliable. This enables easier and cheaper exploitation of the station which is important for the costs of the electric energy are very high.

2 Formulation of problem

Both investigation and practice have shown that the improper standstill and work distribution of pumps can bring about, mostly in periods of sudden water inflows to the pumping station, great damage of crop and exploitation troubles. These undesirable phenomena can be prevented by equipping polder pumping stations with automatic control systems.Various types of control equipment, that have been used in Poland so far, and the greatest number of which is placed in the tidal flats of the Wisła river delta, do not guite meet the requirements of the users of pumping stations especially as far as their efficiency and technical designs are concerned. The deficiency of device for the direct measurement of discharge in pressure pipes enables the control of the actual pumps wear. In this situation the further pumping aggregates exploitation isn't economical because of the decreasing efficiency factor and improper use of electric power. Therefore the Institute of Land Reclamation and Improvement, Agriculture University, Wrocław has been asked to construct automatic control systems of pumping aggregates of simple structure, high efficiency and great reliability. At the same time Institute has been developing a device for measurement and recording of high flow rates irrespectively of pipes diameters and level of water pollution.

3 The characteristic of the control devices working in Polish polder stations.

- the float breakers-the corrosion of the mobile mechanical elements and contacts often stops the control system.
- the electrode detectors of cluvo type - 220 V between the electrodes are dangerous for servicing personnel, on the other hand, when the voltage is reducted to 24 V, the pumping aggregates do not engage because of lowered current between the electrodes, especially when they are corroded.
- the set of electrodes connected with electronic converter of ESP-50 type - high current between the electrodes accelerates corrosion and stops the control device.
- sounder control - its main elements are reed relays - the work of their contacts depends on the position of float in which there is magnet; this device functions properly only in plain water.

4 The author's solution of the problem.

4.1 The device for the automatic control of pumping aggregates.

The device presented by the authors is based on semiconductor elements which together with relief relays and control circuits compose a separate box. The distribution board having simple structure we do not need to stop it in case of eventual break-down. The sets controlling the work of particular pumping aggregates are constructed separately. This facilitates the sub-assembly replacement which can be performed by the servicing personnel of the station. Figure 1. is the scheme of information flow from electrode detectors to pumping aggregate.

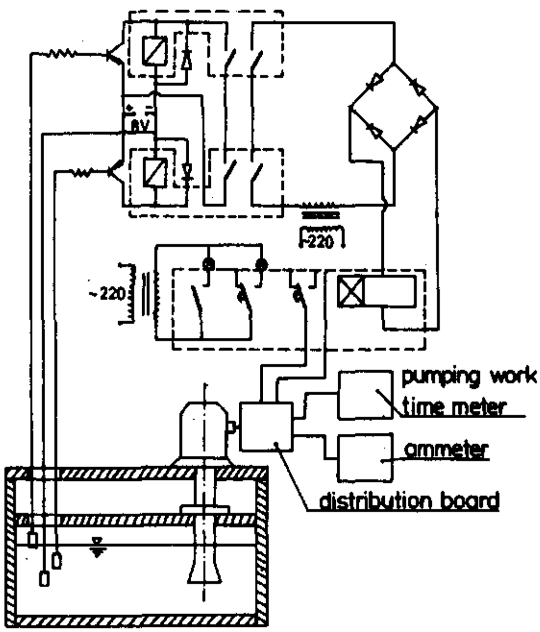

Figure 1. The scheme of the pumping aggregates control.

The principle of device operation is based on transistor keys controlled by signals coming from electrodes. The set of electrodes made of acid-resistant steel in plastic guard performs as detector. Figure 2. presents section of this detector.

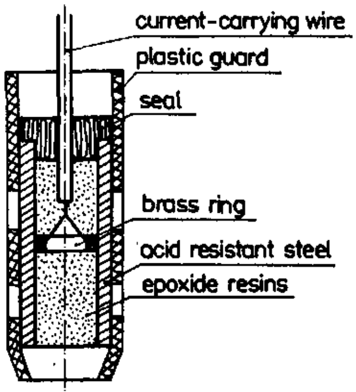

Figure 2. Section of detector.

In control electrodes circuit occurs low voltage of about 7 V. So it is safe for the servicing personnel of the station and by reducing galvanic corrosion it decreases maintenance and prolongs work-time of electrodes. The device has been patented in Poland No 221011 and installed at three polder pumping stations.

4.2 The measurement-recording device of high flow rates.

The analysis of such methods of measurement of intensity of flow, as magnetohydrodynamic or reducers proved that they do not fulfil conditions occuring in polder pumping stations because of big pipelines diameters, high pressure losses, water pollution and others. Among various types of converters only Venturi tube fulfils conditions occuring in polder pumping stations. Another problem is measuring of pressure in Venturi tube. The authors using detecting elements which main part is membrane with extensometer sticked on it, constructed a special device.It works transforming the pressure of water P_1, P_2 on the membrane into electric signal.

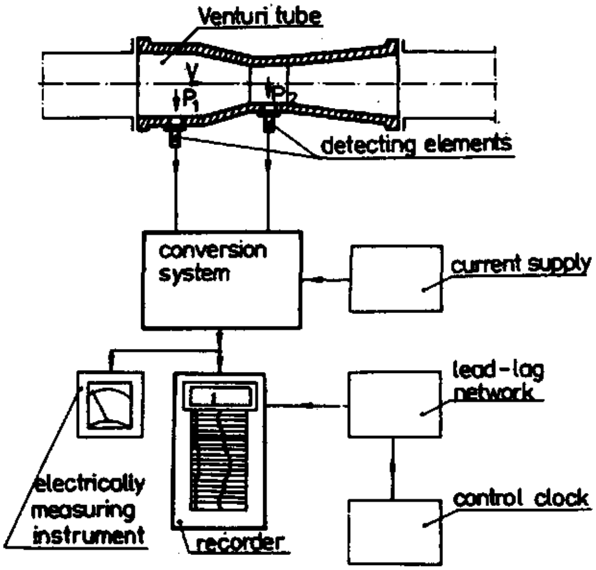

Figure 3. Measuring-recording device for high flow rates.

For adopting this device for different diameters of pressure pipe and flow rates, there has been developed algorithm for digital computer. This device has been patented in Poland No 107877 and is now being installed in one of the newly built pumping stations.

5 Conclusion

The automatic control of pumping aggregates has been working for two years in three pumping stations and our observation has shown its full efficiency and operational reliability. The main advantages of device are rather simple structure, simple service, and great economical effects.

The measuring-recording device will be also used for examining the rate of inflow to the pumping station which lets us to recon pumps parameters better adjusted to hydrological conditions.

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TEST RUNS AND ACCEPTANCE TESTS OF POLDER PUMPING STATIONS

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Abstract

Test runs and acceptance tests of polder pumping stations are carried out for different reasons. Test runs are arranged for scientific reasons such as investigation of the hydraulic and technical cooperation of pumps and drivers and other hydraulic structures. Acceptance tests are performed to measure characteristics of installed pumps, non-return valves, drivers, etc., to compare these values with the manufacturer's guarantee characteristics and to accept or reject the installed devices. The intent of this article is to define the problems, describe the tests to be performed and arranged and to show an example of a test report. The article deals only with field tests at the place of installation by the use of simple measuring devices easily to be arranged on site. It is based on investigations executed by the author at a large number of polder pumping stations in Finland since 1968.

1 Introduction

The results of test runs and acceptance tests are used for different purposes but the tests themselves are arranged mainly in a similar way. The exceptions are scientific investigations with sofistic purposes where very exact measuring devices need to be used for special measurements. These types of test runs are more related to the testing and development of pumps and normally not undertaken on site at polder pumping stations.

2 Definition

2.1 Test runs of polder pumping stations

A test run of a polder pumping station is done with the purpose of investigating, measuring and estimating its technical, hydraulic, economical or operational characteristics.

2.2 Acceptance tests

An acceptance test at a polder pumping station is a test run with the special purpose of clearing questions on the fulfillment of contracts between the owner of the station (customer) and the manufacturer (seller) of the installed devices to be tested (pumps, valves, motors, etc.).

3 Symbols and units

At polder pumping stations, the lifting head is a well to be recognized and measured quantity and it will be used although not in agreement with the SI-system.

The ancient technical system has as its basic quantities force, length and time. Therefore, the lifting head of the pump is defined as in this system "energy per unit weight". The specific energy of the pump Y in the SI-system is defined as "energy per unit mass". If we employ both "specific energies" Y and H we notice in advance that

$$Y = g \cdot H$$
$$(m^2/s^2) = (m/s^2 \cdot m) \qquad (1)$$

Table 1. Qualifications, symbols and units

Qualification	Symbol	Dimension in SI ($^{+}$Dimension in techn. system)
Discharge	Q	m^3/s
Lifting head	H	^{+}m
Specific energy	Y	$Nm/kg = m^2/s^2$
Volume	V	m^3
Velocity	v	m/s
Pressure	p	N/m^2
Specific pressure energy	p/ρ	$Nm/kg = m^2/s^2$
Elevation	z	m
Liquid power, net power	PQ	$kg \cdot m^2/s^2 = Nm/s = W$ (kW)
Power demand	P	$kg \cdot m^2/s^2 = Nm/s = W$ (kW)
Efficiency	η	-
Rotational speed	n	1/s (1/min)
Local gravitational constant	g	m/s^2
Density of liquid	ρ	kg/m^3
Cavitation factor	σ	-
Specific speed	nq	dim.
Mass rate of flow	$\dot{m}$	kg/s

Subscripts

Available	av	Value at the shaft of the pump	a
Mean value	m	Value at motor	mo
Minimi value	min	Pumps value	PU
Maximi value	max	Pumping station value	PST
Mechanical value	mech	Static value	stat
Hydraulic value	hydr.	Manometric value	man
Suction side	s	Value at bestpoint	*
Pressure side	d	Rated value	ra
Atmospheric	atm		
Vapour	vp		

4 Characteristics to be measured and calculated

4.1 General information

The operation of pumps and the pumping station is described by special characteristics which partially have to be measured, partially calculated and partially estimated.

4.2 Characteristics of interest in test runs

Of importance are the H-Q curve, respectively Y-Q, that is the head as a function of discharge, and the discharge as a function of the head. Power demand and efficiency can be plotted as functions of discharge or head.

Investigations should be prepared at such lifting heads that the characteristics on both sides of the bestpoint can be fixed. The specific speed as a criterion of type of pump and its characteristics is calculated using bestpoint values.

It is common practise for pump factories to report all other characteristics as functions of the discharge. At polder pumping stations at least the static head is the value most easily to be measured. Therefore, it is the author's opinion that all characteristics estimated within the test run shall be presented as a function of the lifting head H.

4.3 Measured characteristics and quantities

$H_{stat.}$ (m) Static lifting head that is the difference in free water levels on the inflow- and the outflow side of the polder pumping station.

$H_{1,2,3...}$ (m) Head taking into account losses at different parts of the pumping station.

H_{man} (m) Manometric head of the pump, structure or devices included in the pump. It is the difference in energy levels between the discharge- and the suction side of the pump.

Q (m^3/s) Discharge of the pump or the whole pumping station for conditions with more than one pump in operation.

v (m/s) Velocity of flow at a special section of the pumping station. This can be calculated via continuity condition.

Pa (kW) Power demand at the shaft of the pump. This value is difficult to measure under field conditions and may be calculated using the exact known characteristics of the driver.

P_{mo} (kW) Power demand of driver of driver input. It represents the power to be paid for and can be measured at the kWh-meter of the pumping station.

n (1/min) Rotational speed of the pumps or shaft of driver.

4.4 Calculated characteristics

$v^2/2g$ (m) Velocity head. This is of importance when the energy level of the pump is to be calculated. The velocity head is based on the mean velocity through a cross section.

PQ_{PST} (kW) Liquid power or net power of the pumping station based on static head.

$$\begin{aligned} PQ_{PST} &= \dot{m} \cdot Y_{stat} = \rho \cdot Q \cdot g \cdot H_{stat} \\ &= Q \cdot H_{stat} \cdot 1000/102 \end{aligned} \quad (2)$$

$\dot{m} = \rho \cdot Q$ ... mass rate of flow

$Y_{stat} = H_{stat} \cdot g$ ... specific energy

PQ_{PU} (kW) Liquid power or net power of the installed pump based on manometric head that may include, for example, a non-return valve.

$$\begin{aligned} PQ_{PU} &= \dot{m} \cdot Y_{man} = \rho \cdot Q \cdot g \cdot H_{man} \\ &= Q \cdot H_{man} \cdot 1000/102 \end{aligned} \quad (3)$$

η_{PST} (%) efficiency of the polster pumping station

$$\eta_{PST}\ (\%) = 100 \cdot PQ_{PST}/P_{mo} \quad (4)$$

η_{PU} (%) Efficiency of the installed pump

$$\eta_{PU}\ (\%) = 100 \cdot PQ_{P\ddot{U}}/Pa \quad (5)$$

n_q Specific speed of installed pump

$$n_q = n \cdot Q^{0.5}/H_{man}^{0.75} \quad (6)$$

NPSHav Net positive suction head available.
In ancient technical units.

$$NPSHav\ (m) = Hatm - H_{yp} - H_s \quad (7)$$

NPSHav In SI units

$$NPSHav\ (m^2/s') = \frac{Patm}{\rho} - \frac{Pvp}{\rho} - (gH_{s\ stat} + Y_s) \quad (8)$$

σ cavitation factor $\sigma = f\ (n_q, \eta_h)$ Rütschi

$$\sigma = 7.5 \cdot 10^{-4}\ n_q^{1.33}/\eta_h^{3} \quad (9)$$

η_h = hydraulic efficiency of pump

Table 2. Cavitation factor of polder pumps

n_q	50	80	100	150	200	250	300	350	400
σ	0.2	0.3	0.5	1.0	1.7	2.3	3.0	4.5	6.0

The maximum suction head required for cavitation-free operation can be calculated with equation (10). A negative value reports wet installation of pump.

$$H_{s,\ max} = 9.8 - \sigma \cdot H_{man} \quad (10)$$

n'/n Testruns under different speeds

When test runs are carried out at different speeds, characteristics have to be transformed to a rated speed. This can be done by the equations 11, 12 and 13. Index ' shows test run quantities. Eq. 13 is valid only approximately, since η is dependent on the rotational speed.

$$Q' = Q\, n'/n \tag{11}$$

$$H' = H(n'/n)^2 \tag{12}$$

$$P' = P(n'/n)^3 \tag{13}$$

5 Arrangement of test runs at polder pumping stations

5.1 General

Polder pumping stations are planned to operate under widely varying conditions. Depending on the hydrology of the drainage area of the polder and the storage volume of the pump reservoir and ditches the operation may vary from an intermittent run of one single pump for a short duration or continuous operation of all pumps installed at the plant for many days. Depending on the elevation of the discharge side water level, the head might vary largely. The purpose of test runs is to cover, with an economical amount of work, the whole operational scheme of the pumping station. (Full characteristics of pumps as well as the whole pumping station.) Test procedure should be selected depending on local conditions.

5.2 Planning of test runs and inspection of pumping stations

After making oneself familiar with the design of the pumping station to be investigated, an inspection on site should be executed. To ensure proper operation of the pumps, careful inspections should be done continually both during and after tests (hydraulic passages, available connections for measurement of pressure, manufacturer's

serial number, types, model description, calibration factors of kWh-meter etc.).
Time of the test runs and operational conditions should be fixed at this time. The planning of the test equipment and the whole test run should be layed out taking that into account.

5.3 Arrangement of the test run and the test equipment

5.3.1 Test procedure

It is advisable to make one or more preliminary tests for the purpose of determining the adequacy of the instruments and the apparatus, and the training of the personnel. When conditions do not permit such preliminary runs, operations may be started and testresults may be accepted starting at a time when conditions may become satisfactory. Oscillations of a mean value occur many times, when observations are made. Acceptable fluctuations in test readings should not exceed:

$\pm$ 2...3 % of pressure or head
$\pm$ 2 % of discharge
$\pm$ 1 % of power input to pump.

These values are applicable at or near the best efficiency point under non-cavitating conditions. All measurements within one test run shall be prepared time dependent so that all measured quantities for one point of the characteristics are observed directly or estimated by time dependant interpolation. Results of the test will be computed and found acceptable before the test can be considered terminated and the test equipment removed.
The arrangement of the test run, test equipment and -methods described in the following is not complete, but simple test methods were found to be suitable and were used in test runs of a large number of polder pumping stations in Finland.

5.3.2 Measurement of discharge

Depending on the function of the measuring device or method we may speak about quantity or rate meters.

5.3.2.1 Estimation of flow by quantity measurement

If there is a reservoir on the suction side of the pumping station or if the main channel is large enough and there is a possibility to close the reservoir at a place like a bridge or a culvert, the volume of that reservoir can be estimated for example by measuring the surface areas of different water elevations. The volume is spread against elevation of water level.

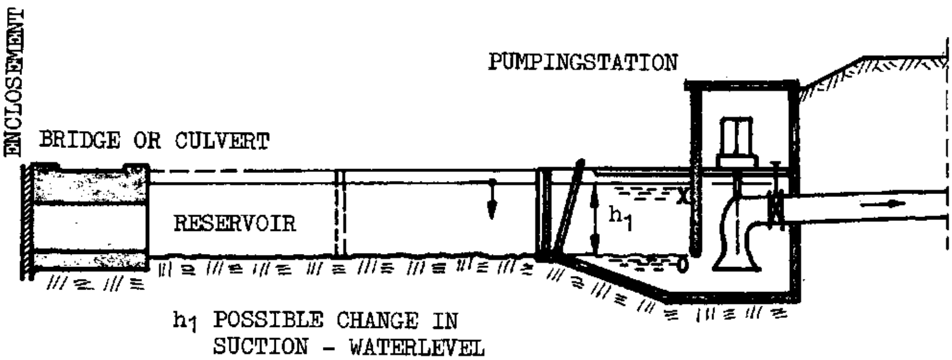

Figure 1. Use of reservoir for measuring discharge

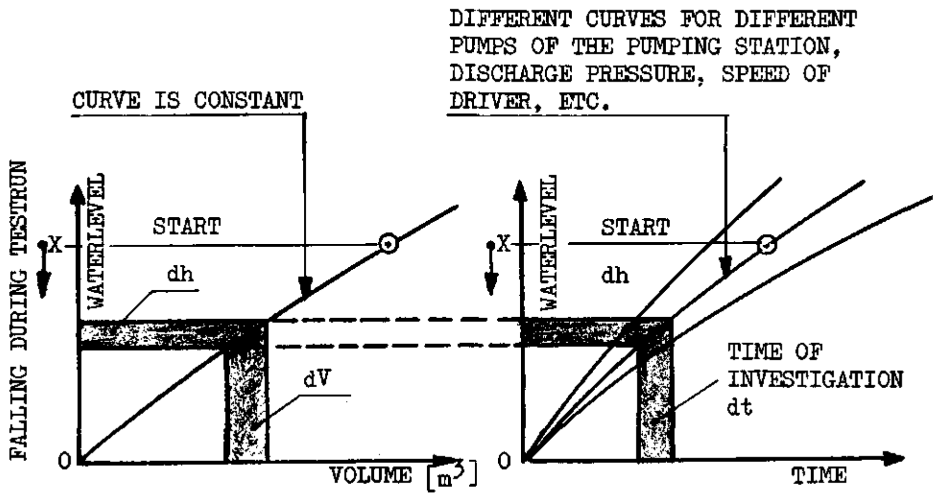

Figure 2. Graphic computation of discharge

In pumping, water level will fall and this falling level at an investigated time is measured and the volume of water dV pumped from the layer dh taken from fig. 2. Taking the investigated time dt into account we get the discharge Q = dV/dt. This arrangement is inexpensive, quick and exact but can only be used in dry periods when the amount of natural water to be pumped is very small.

The size of the reservoir should be chosen large enough that the time it takes to empty it will not be shorter than half an hour. Using this method for big pumps and narrow reservoirs, problems with wave action may occur. The reservoir is refilled for a new test run from the delivery side through the pumping station or by natural inflow from the polder side. Naturally, the same measuring arrangement can also be used for reservoirs on the discharge side of the pumping station.

5.3.2.2 Rate meters

Meters like Venturi, Nozzle, Orifice plate and Pitot-tube measure differential head and when calibrated give the discharge depending on the head difference. They are reliable instruments for factory and field tests when properly installed. A certified curve showing the calibration must be obtained.
using velocity meters like propellers the velocity figure of a given cross-section can be investigated. (Main channels at suction or delivery side.) This method can only be used when there is enough water for continuous pumping.
Special methods might be used when very big pumping plants are to be investigated. Measurement by radio-active tracers, by the salt-velocity method or chemical dilution method (using Rhoadamine B and Fluorimeter) may take a considerable time to install and the observations need skilled interpretation.
Head area meters can very well be applied for the kinds of discharge measuring we have to do. At many pumping stations for drainage or irrigation supplies it is quite possible to install a weir at the outflow building of the pumping station.

Vortex and unstraight flow conditions effect the accuracy of this measurement but in the authors investigations, when calibrating measure weirs of equal conditions with propeller current meter and by the volumetric method, the author found that the accuracy is given within ± 0 and -5 %. The theoretic calibration curves yield figures somewhat too low.

In investigations done in Finland, measure weirs fixed to a frame and installed into the grooves for stoplocks at the outflow building, were used.

By putting some stoplocks more under the weir frame, the overflow edge will be lifted up and with it a different head can be investigated (important, when investigating pumping stations of open construction with small heads).

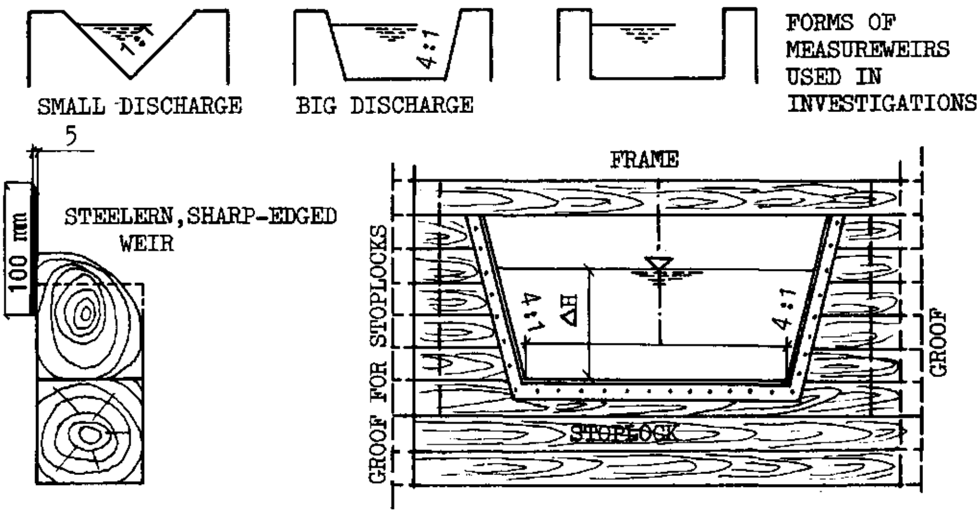

Figure 3. Measureweir fixed into a frame

Of course, a weir or flume can also be installed into the main delivery channel. Values for weir- or flume discharges can be taken from various hydraulic handbooks.

5.3.3 *Measurement of water elevations or pressure*

At polder pumping stations, the elevation of water levels at the suction- or delivery side of the pumping stations as well as the free water level in the suction- or delivery chambers are easy to measure from locally levelled fixpoints or installed levelling rods.
For calculation of manometric head, pressure measurement has to be arranged from closed conduits (suction- and delivery flange of the pumps). It is very important that steady flow conditions exist at the point of instrument connection. If possible, three or four taps or orifices should be installed at a given measuring section equally spaced around the pipe.
At a polder pumping station with relatively low pressure heads, water columns or a manometer can be used as instruments. Most simply the pressure head can be read in a fix-installed plastic tube.

5.3.4 *Measurement of rotational speed or number of rotations of the pumps*

Measurement of speed can be done by means of revolution counters, tachometers or stroboscopic devices.

5.3.5 *Measurement of power input*

An inferential method can be used for already installed equipment. The power transmitted from the electric motor to the pump it is driving can be estimated from the instruments that measure the electric supply to the motor. The load-dependent efficiency of the motor has to be taken into account for calculation of the power input to the pump.

Table 3. Efficiency of electro-motors (synchr.rot.speed 1500 r/min)

Rated power P_{ra} (kW)	Efficiency (%) at load factor P/P_{ra}					
	0.2	0.4	0.6	0.8	1.0*	1.2
5	70	80	83	84	84	83
10	73	82	86	87	87	86
20	80	87	88	89	89	88
50	83	90	91	92	92	91
100	85	92	94	94	94	93
200	87	93	95	95	95	94
500	87	93	95	95	95	94
1000	87	93	95	95	95	94

Volt and Ammeter

This measurement gives the most inexact results since the Volt- and Ammeters of pumping stations are normally very small and the slip or $\cos\phi$ in the net is not known. For that reason, this kind of a measuring system should only be used for getting some indications for direction.

$$P\ (kW) = \cos\phi \cdot \sqrt{3} \cdot V \cdot A \qquad (14)$$

$\cos\phi$ = slip
V (volt) = voltage
A (Ampere) = current

kW-hour meter

With this kind of a meter, the error can be ± 5 % but is far smaller under normal conditions. The time the armature disk of the kWh meter needs for a chosen number of rotations (3, 5, 10 or 20) is taken with a timer.

This number depends on the size of the meter and the measured power.

Power can be calculated with the following formula:

$$P\ (kW) = 3600 \cdot y \cdot A_k / r \cdot a \qquad (15)$$

r = kWh-meter's rotations per kWh (r/kWh)

y = kWh-meter's calibration factor

A_k = chosen number of rotations of the armature (disc)

a = time needed for A_k-rotations in seconds.

Special Watt meters

There is a great number of such measuring devices on the market. The best ones give results within an error of ± 0.5 %.

Other drivers than electric motor

If the pump is driven by a steam turbine or an oil engine, evidently it will not be easy to assess the true H.P. fed to the pump shaft. Measuring the fuel consumption is one possibility.

5.3.6 Cavitation test

Cavitation tests on site at the polder pumping stations can be arranged by holding the speed and suction pressure (ps) constant and by varying capacity. Especially with low head, maximum discharge conditions have to be investigated. For any given suction pressure, the pump head may be plotted against capacity. Test series will result in a group of curves. The cavitation factor σ may be calculated at the break-away points. The phenomenon of cavitation is very difficult to measure in pumps with high specific speed (Polderpumps).
In addition, it should be noted that at least in serious cavitation conditions pitting, noise vibration and unstable operations occurs.

5.4 Presentation of results

For each test run, a report will be prepared including a description of the polder and its pumping station, the motivation, arrangement and performance of the test run, the test methods, equipment and results. All test documents, forms and diary should be included in the report as an appendix. As an example, some test results of a Finnish pumping station in North Karelia are presented in appendices 2, 3 and 4.

6. Acceptance tests

6.1 Motivation

Acceptance tests at polder pumping stations are prepared to clear questions on the fulfillment of guaranteed characteristics of pumps and other devices installed in the pumping station.

6.2 Contract and technical guarantees

All technical guarantees and the way they are investigated and stated must be included in the contract between the buyer and the manufacturer. It is obvious that strictly keeping to guaranteed values, as well as testing them is more or less expensive. Therefore, only characteristics of main importance should be included in the guarantee program. The cost of acceptance tests should be balanced in relation to the cost of the equipment and the annual energy demand. For polder pumping stations the main guarantee values should be:

- discharge-head (specific energy) curve
- efficiency
- maximum discharge - minimum head conditions
- minimum discharge - maximum head conditions
- rotational speed
- specific speed.

Non-return valves of polder pumps should be included in the guarantee of the pumps, because their sufficient operation depends very much on pump and driver characteristics.

Important guarantees for non-return valves are:

- time of closing
- strength of water hammer
- reverse rotational speed of pump.

The upper and lower limitation values within which the acceptance of the device is agreed upon, varies widely and must be clearly stated in the contract.

6.3 Performance of the acceptance test

The arrangement and performance of acceptance tests and polder pumping stations may be prepared as shown in chapters 1 to 5. A test manager is responsible for the entire acceptance test and the test-report. He may be employed either by the owner of the pumping station or by the manufacturer of the pump. A third very common way is to choose a neutral expert. The test manager and a primary test program prepared by him should be accepted by both sides before ratification of the contract.

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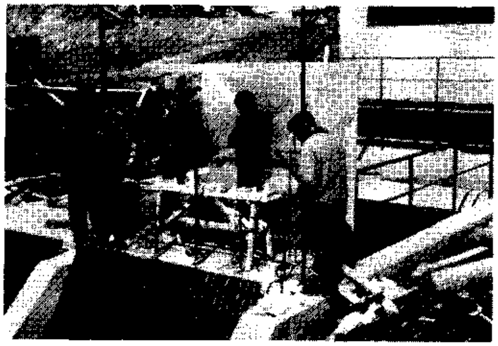
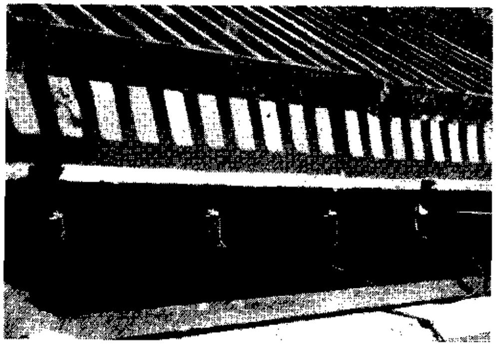


1.



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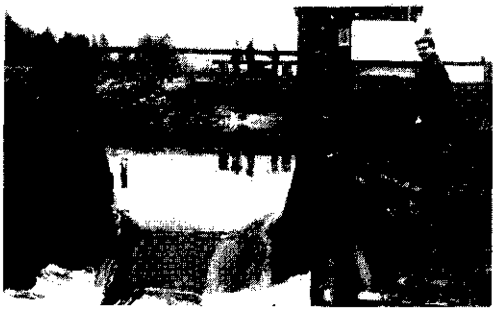

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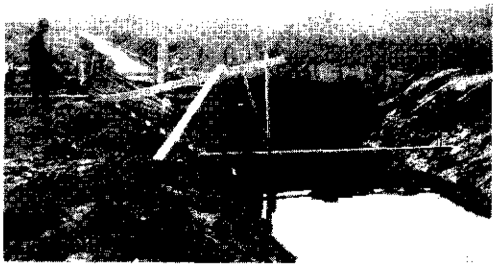


5.

6.

7.

METHODS OF MEASUREMENT

1,2 Flow measurement with current-meter at the suctionside.

3,4 Measure weir at dischargeside of different pumpingstations.

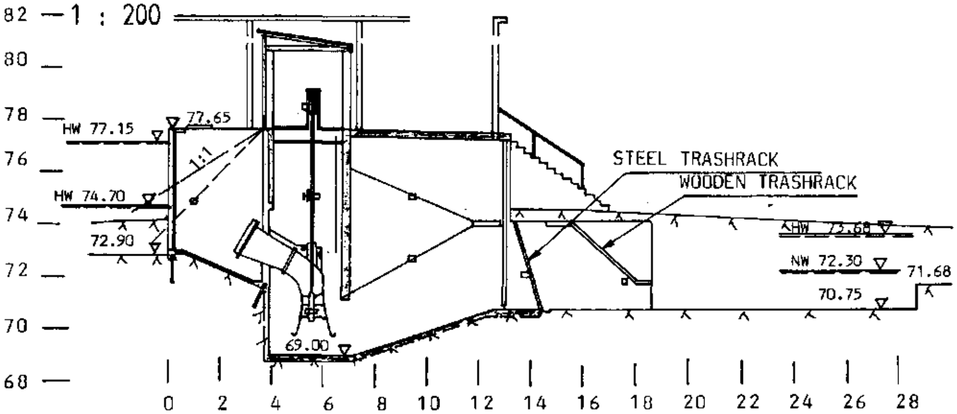
5 Enclosure of polder ditch for quantity measurement.

6 Connections of pressure tubes.

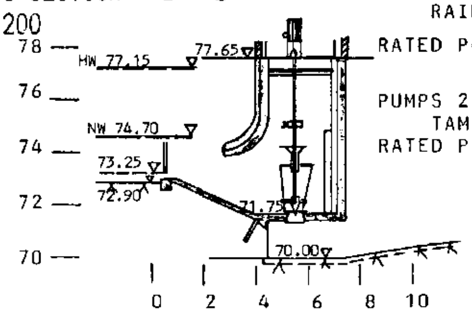
7 kWh-meter at its calibration with special AEG-wattmeter.

POLDER PUMPINGSTATION AT ORAVISLAHTI

CROSS-SECTION A - A
1 : 200



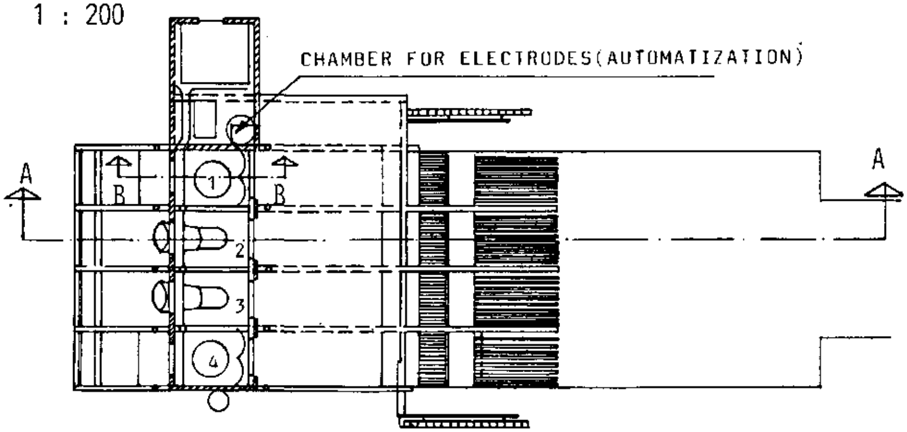
CROSS-SECTION B - B
1 : 200



PUMPS 1 AND 4
RAIKKO Q= 1m³/s
RATED POWER OF ELECTRIC MOTOR 75 kW

PUMPS 2 AND 3
TAMPELLA Q=1m³/s
RATED POWER OF ELECTRIC MOTOR 55 kW

PLAN
1 : 200



(623)

PUMPING STATION O R A V I L A H T I WATER DISTRICT OF NORTH KARELIA

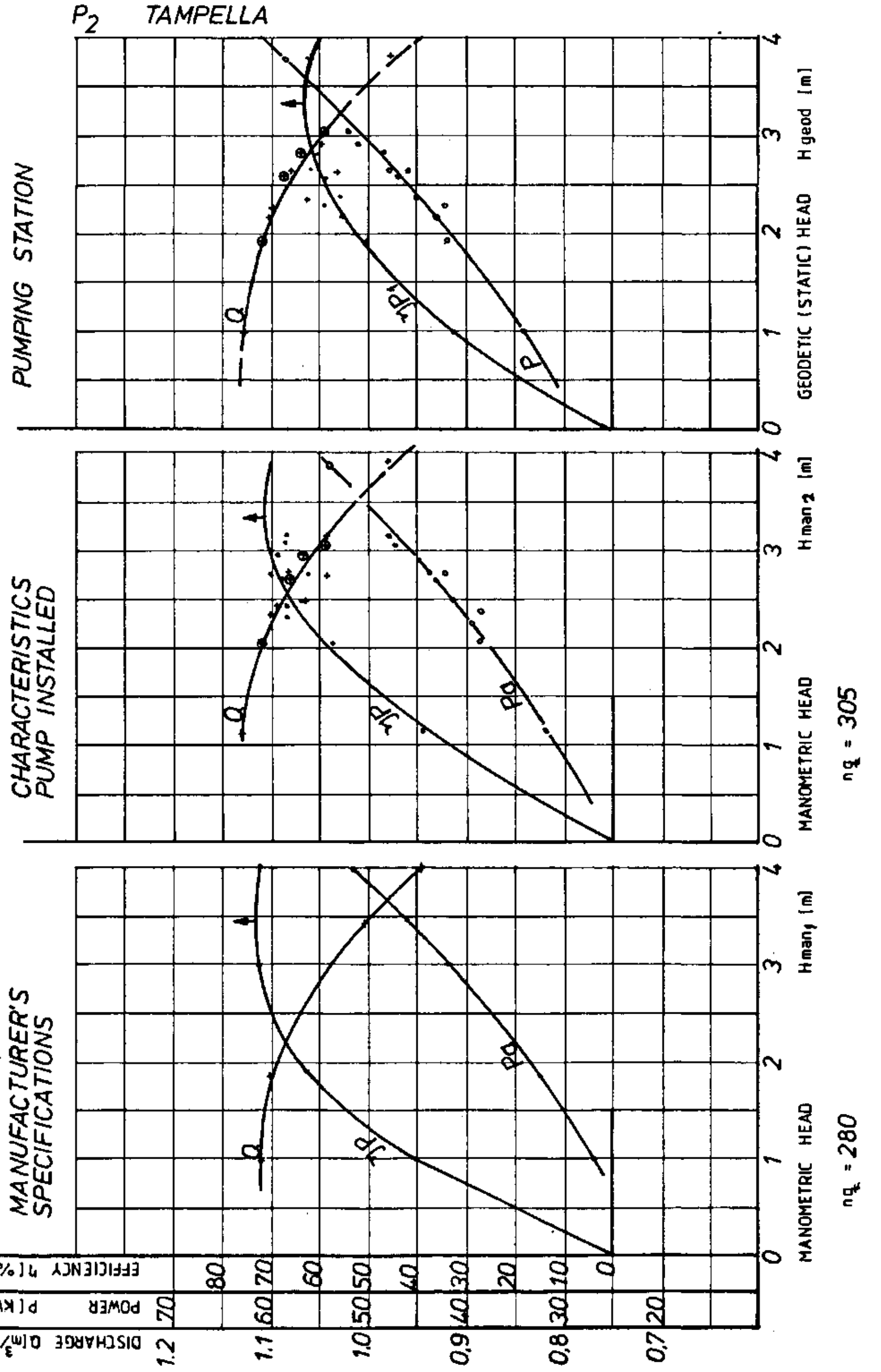
PUMP Nº 2, 3 MODEL: T A M P E L L A

MOTOR MODEL: S T R Ö M B E R G H X U R

55 kW 380 V 110 A

cos φ = 0,84 732 r/m

RUN Nº	TIME	DRIVER INPUT kwh meter rot./kWh kal. factor y= r= dis.rot Ak	P [kw]	PUMP INPUT $P_a = \eta_{mo} \cdot P$ [kW]	HEAD [m] GEOD. h_1	MANOM. h_2	MEASUREMENT OF CAPACITY Δh	q^1	ε	DISCHARGE Q [m^3/sec]	LIQUID POWER P_1 $\frac{Q \cdot h_1}{102}$ [kw]	EFFICIENCY OF P.ST. η_{PST} P_1/P	LIQUID POWER P_2 $\frac{Q \cdot h_2}{102}$ [kW]	EFFICIENCY OF PUMP η_P P_2/P_a
Pump 2														
1	85.5	3	42.1	38.7	1.94	2.04	CURRENT METER			1.110	21.1	0.502	22.2	0.573
2	78.0	3	47.0	43.2	2.61	2.71				1.085	27.8	0.592	28.8	0.667
3	123.0	5	48.8	44.9	2.83	2.93				1.068	29.6	0.607	30.7	0.684
4	115.0	5	52.2	48.0	3.03	3.14				1.044	31.0	0.595	32.2	0.671
5	75.0	3	48.0	44.2	2.64	2.74	66.5	1.008	1.025	1.033	26.8	0.559	27.4	0.620
6	80.0	3	45.0	41.4	2.40	2.50	68.0	1.042	1.020	1.063	25.1	0.557	26.1	0.630
7	84.2	3	42.8	39.4	2.20	2.30	69.9	1.085	1.015	1.101	23.8	0.555	24.8	0.629
INVESTIGATION		1966												
8	62.7	3	58.5	53.8	3.84	3.94	62.2	0.940	1.040	978	36.9	0.630	37.8	0.702
9	67.7	3	51.0	46.9	2.95	3.05	65.6	1.020	1.027	1.048	30.3	0.595	31.4	0.670
10	76.8	3	45.9	42.2	2.67	2.77	67.4	1.060	1.021	1.082	28.3	0.617	29.4	0.700
11	83.3	3	42.0	38.6	2.30	2.40	67.9	1.075	1.020	1.096	24.7	0.588	25.8	0.669
12	105.6	3	34.5	31.8	1.02	1.12	69.4	1.110	1.016	1.128	11.3	0.328	12.4	0.390
Pump 3														
1	81.2	3	44.3	40.8	1.98	2.08	CURRENT METER			1.110	21.8	0.493	22.8	0.558
2	75.1	3	47.9	44.1	2.61	2.71	67.8	1.040	1.020	1.060	27.1	0.567	28.2	0.640
3	81.0	3	44.5	40.9	2.38	2.48	68.0	1.042	1.020	1.063	24.8	0.558	25.8	0.630
4	84.0	3	42.9	39.5	2.18	2.28	70.0	1.088	1.015	1.103	23.6	0.550	24.7	0.627
INVESTIGATION		1966												
5	64.5	3	55.9	51.5	3.67	3.77	59.7	0.925	1.045	0.965	34.7	0.622	35.7	0.692
6	73.3	3	49.1	45.2	2.91	3.01	61.6	0.970	1.043	1.010	28.8	0.588	29.8	0.660
7	79.9	3	45.0	41.4	2.31	2.41	63.9	1.025	1.033	1.058	24.0	0.534	25.0	0.605
8	87.3	3	41.2	37.9	2.04	2.14	64.7	1.040	1.031	1.070	21.4	0.520	22.5	0.594
9	106.0	3	33.9	31.2	1.01	1.11	66.7	1.080	1.025	1.112	10.7	0.316	11.8	0.378


P2 TAMPELLA
PUMPING STATION
CHARACTERISTICS PUMP INSTALLED
MANUFACTURER'S SPECIFICATIONS
GEODETIC (STATIC) HEAD H geod [m]
MANOMETRIC HEAD H man2 [m]
MANOMETRIC HEAD H man1 [m]
nq = 305
nq = 280
DISCHARGE Q[m³/s]
POWER P[KW]
EFFICIENCY η[%]

STRATEGIES AND METHODS FOR CLOSING DIKE BREACHES

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Abstract

In spite of the development of science and increasing practical experience in constructing dikes as a protection of polders against high floods, the probability of dike breaches anywhere in the world exists.

In the past many of these disasters took place; the experience gained in the very first action to be taken and in the reconstruction of the dikes should not be allowed to be lost, so that if somewhere in the world a stormsurge occurs and causes flooding of polders, this experience can be mobilised as soon as possible for fast and adequate action.
This paper deals about strategies, based on experience gained in historical floods and recent closures of tidal basins, for a quick analysis to determine an optimal procedure for restoration of the dike breaches in a polder or polder system.

1 Introduction

Several times a year "somewhere" in this world people are confronted with flood disasters, which always result in human distress and tremendous upheaval. After some time, in nearly all cases, when the sea has calmed down and the river discharges have decreased, the land dries and then the cleaning, clearing away of debris and also the reconstruction can begin.

In the Netherlands, arable land and residential areas in the polders lie mainly below the daily low water levels. When a dike slips and is breached by the churning waters, this break is known as a "flow gap", if the bottom of the gap reaches below the daily low water level.
This means that during 24 hours a day the gap is subject to the erosive action of the current. During flood, the water will flow from the outside into the polder and during ebb in the opposite direction.
As a consequence, the gap tends to widen and deepen. If dike-breaches cannot rapidly and forcibly be closed, the extent of the disaster will increase steadily even after the storm has subsided.

2. Closure strategies

When drawing up plans for the repair works on the breached dikes encircling an inundated polder,an overall picture of the prevailing situation, including the hydraulic situation,is necessary. Such an overall picture should preferably be composed systematically, i.e. an inventory must be made of the dike breaches and the inundated areas and ranged according to their hydraulic and geo-technical characteristics. In addition, a survey mus be made as quickly as possible of the endangered residential areas, communications, etc.
The flood-volume and the storage area will be indicative of the severity of the danger to the inundated areas. The flood-volume stored in the polder presents itself as a water level, known as the inundation depth. This is the determining factor as to the severity of the situation to be expected.

2.1 The water motion

With the help of mathematical formulae of the water motion in the inundated area, a clear picture emerges based on which a systematic inventory can be made of the area. Calculations made by using these formulae and equations and, where necessary, supplemented by prototype and model-research, are indispensable for the execution of the repair works.

The water motion in the inundated area is two-dimensional. Generally however, the latter will be simplified to an one-dimensional motion as, in the inundated polder area, the water will flow via erosion channels or existing water courses. The flow velocities will be much lower in the areas adjacent to these channels, as they only have a storage function. The one dimensional water motion can be described in the continuity equation and the equation of motion.

Continuity equation: $$\frac{\partial Q}{\partial X} = B \frac{\partial (h + a)}{\partial t}$$

in which : Q = the discharge through the total cross-section

x = distance

B = storage width

h = water level related to reference level

a = ground level related to reference level

t = time

Equation of motion : $$\frac{\partial (h + a)}{\partial x} = \frac{1}{b(\bar{h} + a)g} \quad \frac{\partial Q}{\partial t} - \frac{Q\,|Q|}{C^2 b^2 (\bar{h}+a)^3}$$

in which : b = stream width

$\bar{h}$ = mean water level

C = Chezy coefficient

The equations will be solved by using the finite differential method, for which the inundated area will be schematized into a number of sections. The differences in the hydraulic characteristics will hereby be taken into account.

The inertia factors, in particular, will determine the motion around the flow gap. In the inundated area itself, the friction factors will be dominant. The boundaries of the sections will be so plotted, that the contraction losses can be taken into account with the aid of contraction factors and discharge formulae.

2.2 Compilation of data

From above it will now be clear which hydraulic information must be available to be able to predict reasonably accurately the behaviour of the water motion.

The extent by which the current velocity will cause erosion channels and scourings will depend upon the condition of the soil. In practice, attempts could be made to conserve the current-resistant layers of clay as much as possible either by using a bed protection or by decreasing the velocities through the flow gap by extending the latter(provided the clay is evenly distributed over the area).
Therefore, information must be available about the erosion-resistance. The data should, of course, be gathered before a (storm-)flood occurs. All the aforementioned factors should be determined by surveys taken in the area involved. The discharge through the gap can also be calculated by measurements, e.g. $Q = \mu . A . \sqrt{2g \Delta h}$ of which Δh can be determined from gauge observations, whilst can be assessed by using existing data from literature or calibrated by taking discharge measurements and A (conveying cross-section) can be determined by soundings. The elevation of the ground level can be determined by using topographical maps which, obviously, must have been made prior to the flood-disaster. Great changes will be brought about, particularly at the onset of the flood situation; current information about these changes by aerial photography or remote-sensing techniques is essential.

The Chezy factor throughout constitutes the balancing item of the calibrated calculations. To assess the prevailing situation in the area, the water levels and discharges are registered. Due to the fact that the level of the inundated terrain is highly irregular, the Chezy factor has a low value e.g. $30(m^{\frac{1}{2}} s^{-1})$.

2.3 Closure strategies

In figure 1, the tidal wave runs from South to North along the coast, which means that High Water occurs earlier in estuary A than it does in estuary B.
In this figure also a survey is given of situations that might occur. (cases I to III). Combinations of these situations are, of course, possible. The elevation of the ground levels behind these hypothetical breaches must still be determined.
In Case Ia and Ib a general view is given of only one dike breach, located near the mouth of the estuary. Assuming that the ground level of this area is not much lower than the mean sea-level, the area will only be inundated during higher water levels. Therefore, the best strategy would be to raise a dike at ground level during low water, which will quickly result in a clear overfall(supercritical flow, see figure 4), thus reducing the velocities and consequently the tidal volume and the inundation depth.

Case Ic depicts a dike breach which lies more landinwards. The tidal range will be greater than in Case Ia, b due to the funnelshape of the estuary. As a consequence, closure of this flow gap will require more effort. It is recommended that the damaged secondary dikes or natural ridges in the inundated area be repaired first or that they should be raised in order to decrease the storage area and thus reduce the discharge through the flow gap.
To repair these dikes is not only advantageous from a hydraulic point of view, but also because the road connections, which often are built on these dikes, can be repaired.

Case II is a combination of the cases Ia and Ic. The water volume through both the flow gaps will depend on the elevation of the terrain, the height and phase shifts of the water levels in the estuary, the presence of partition dikes etc. As a rule, the flow gap lying more landinwards will be larger(see Case Ic) or, if a state of equilibrium has not been reached, be enlarged. For hydraulic reasons, the closure of this flow gap will have priority over the smaller one.

Other aspects such as accessibility of personnel, material and equipment or repairs of communications in the polder etc. may result in a change of priority.

In Case III the flood will enter the southern flow gap sooner than the northern one. The flood-water entering the polder through the southern flow gap will return as ebb-water to the sea via the northern flow gap. Therefore, the ebb-volume via the northern flow gap will be much larger than the flood-volume. The best strategy will be to close the "upstream" (southern) flow gap first.

3 Closure methods

When building a dike to close off a dike breach, the inflow and outflow through the narrowed gap will be hampered, causing a decrease in the tidal range in the polder and higher current velocities through the remaining opening. As a consequence, the scouring effect on the bottom near the dike will be increased which endangers the stability of the bed and thus the foundation of the seawall to be built on it. This implies that the bottom, when consisting of easily erodable sand, must be protected by current resistant material.
If the gap to be closed is wide, the velocities will usually be low; therefore, relatively cheap materials may be used initially to narrow the gap - if possible (and if available) sand, and otherwise small sized rubble (gravel) or clay. The gap is narrowed by building out from the sides or by heightening a sill. If the velocities accelerate to 2 to 3 m/s heavier material must be used. The difficulties in effecting the closure will augment if velocities further increase as then navigation in the gap will not be possible during the whole tidal cycle, and the scouring effect will become more serious. To close the final gap there are two groups of closure methods: I gradual and II suddenly.
The reconstruction of the damaged dike can be done along its original course, which involves the closing of gullies. A second method is the construction of a "horse-shoe" dike around the gap on the land side on ground level or outside the original dike along the shallows(see figure 3), which involves the closing of a wide gap on ground level.

In the case where a system of gullies has already developed far inland it is often necessary to use a combination of the methods.
To this end the soil allong the course of the "horse-shoe" dike around the bottom of the gullies to be crossed is first of all protected against erosion by means of e.g. mattresses and/or dumping stones or gravel. Then the gullies are closed, where upon the enclosing dike at ground level is built up across the polder land.

3.1 The gradual closure (see figure 2)

If a closure gap with a low sill is horizontally constricted the current velocities increase in proportion to the gradual decrease of the cross-section area. Therefore very heavy material will be needed to close the final gap, whereas, at the same time, the bed protection will be heavily attacked.

During a gradual vertical closure the gap is filled up in horizontal layers. As a consequence, the velocity increase and, therefore the weight of the dumping material to be used must also increase.
By heightening the dam, the total quantity of water flowing over the crest, will, decrease. The increase in the maximum velocity will end when the flow over the crest of the embankment becomes critical during maximum flow(figure 4)). The situation of a clear overfall has been reached. A further raising of the embankment will result in a decrease of the maximum velocity until the dam has attained its full height.
A requirement for a gradual horizontal or vertical closure is that the material to be used should have sufficient weight to resist erosion, whereas for a sand closure the material(sand) has to be supplied in such large quantities, that the main portion is not carried away by the current. If the current velocitites are of moderate magnitude (order 2,5 m m/s or less) local sand, if available, may be used. A part of this material will be lost during the closure operation.
However, the costs of an expensive bottom protection and current resistant materials will be spared. Therefore, the loss of sand may well be accepted in the overall economics of the works.

3.2 The sudden closures (see figure 2)

In this method structures are used which seal off the whole gap at once. Usually, these structures are caissons which are placed in the gap during a slack water period. Another solütion can be achieved by using sluice caissons which are placed during several subsequent slack water periods, and are kept open during the whole period all other sluice caissons are placed. When the final caisson has been placed all caissons are sealed at the same slack water period by closing their gates.
Sluice caissons should be used when the gap to be closed is a large one and the tidal motion is considerable.
Closed caissons are usefull in small gaps, requiring not more than 1 to 3 caissons, or in areas where only an insignificant tidal motion occurs.
Characteristic for a sudden closure by sluice caissons is, that an as wide as possible effective wet area of the closure gap is maintained untill all the caissons are sunk in position on the sill.
By using open caissons, a great increase of the velocity in the gap is avoided, so that strong scouring does not occur, provided the flow pattern is not too much unfluenced by the walls of the caissons and abutments.

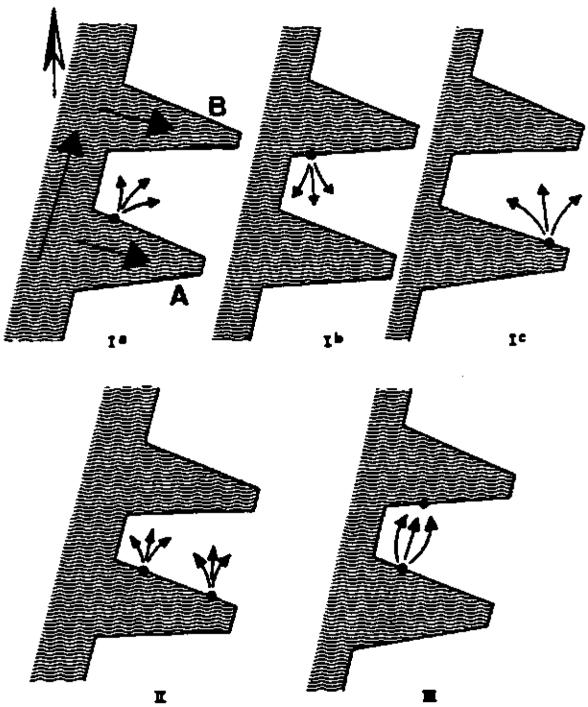

fig.1

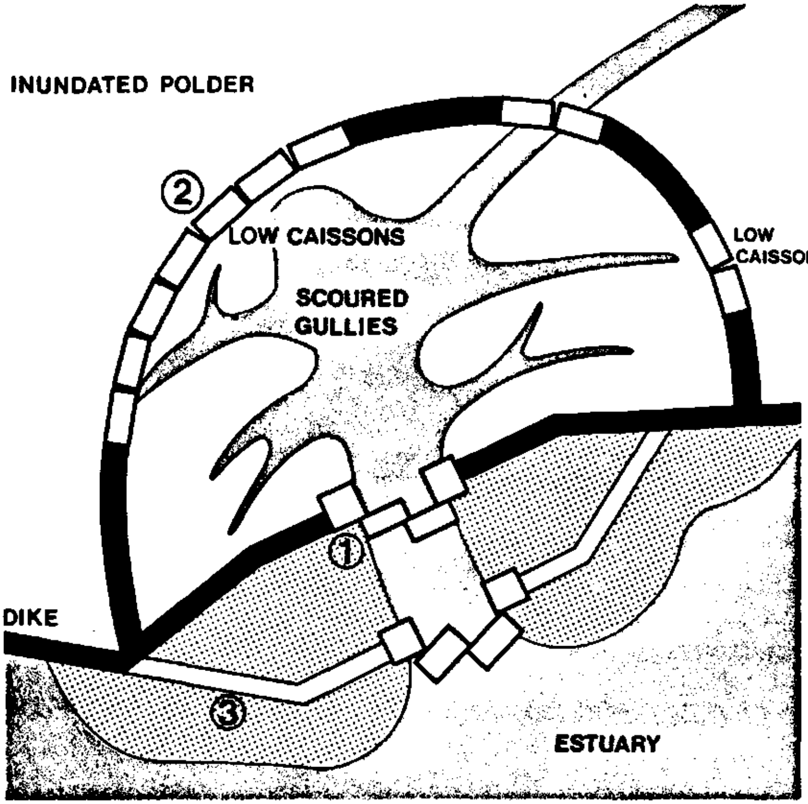

fig.3

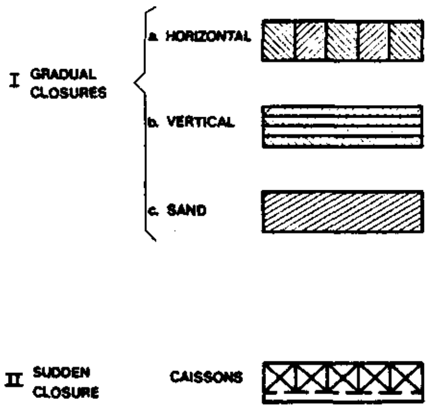

fig.2

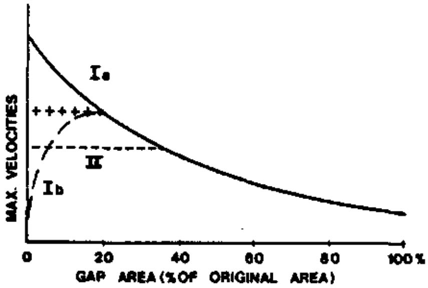

fig.4

MANAGEMENT ASPECTS OF CATCH-WATER EMBANKMENTS IN 'DE OUDE VEENEN' DRAINAGE DISTRICTS

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1 Abstract

The 'De Oude Veenen' drainage district has ordered the drafting of an inventory and management report concerning the catch-water embankments and dykes that are managed or maintained by the drainage district.
The purpose for the assignment was formulated as follows:

- the inspection should provide insight into the present condition of all catch-water embankments and dykes;
- the inspection should provide insight into the cost of maintenance at medium term (< five years);
- the assignment should provide a start for a management system for the catch-water embankments and dykes in the drainage district possibly to be developed in future.

In the following paragraph a description of the design of a management system is discussed. Within this framework surveys of the catch-water embankments have been carried out. Next these surveys are discussed and some striking results are mentioned.
All 44 polders within the borders of the drainage district have been arranged in an order based on their proneness to damage; this for the support of the establishment of the urgency order in behalf of the execution of maintenance or reinforcement works.
The method of work is also directed at being able to draft an annual (or periodical) improvement programme, based on a budget.

2 Introduction

2.1 General

Within the 'De Oude Veenen' drainage district there are about 183 km of catch-water retaining embankments. These embankments are mainly maintained by the drainage district, some lengths of embankments are maintained by the province and a few municipalities. The management of all embankments lies with the drainage district.
The geological constitution of the area above the pleistocene consists, in sequence of origin, of Basic peat (peat at a greater depth), the Sediments of Calais (old marine clay) the 'Hollandveen' (peat at the surface) and Sediments of Dunkirk (young marine clay).
This constitution causes subsiding of the embankments all the time, as a result of settling and subsidence of the layers of peat. It is therefore necessary to raise and improve embankments periodically, in order to protect the interior areas against flooding. Also damages caused by waves, the occurence of seepage or other causes may necessitate execution works.
Considering the great lengths of embankments to be maintained it is not surprising that the periodical improvement of the embankments requires large financial sacrifices. In practice this means that the drainage district endeavours to keep the water retaining constructions in a shape as good as possible, with limited financial means. In doing so an effort is made to obtain an output as high as possible of the budget spendable. To achieve this the application of a management system may be useful.

2.2 Management system

As has been mentioned, the application of a rational way of tackling the management and maintenance problems regarding embankments may be a good aid in establishing a way of spending the maintenance budget as efficiently as possible.
Based on purely economical motives this means that it should be endeavoured to create, by means of the improvement works, a sum as small as possible of the capitalized values of the annual expectation of damage caused by disaster and the cost of building or improvement.

The annual expectation of damage caused by disaster is defined here as the product of the amount of damage with dyke burst and the frequency of dyke burst in a year (Figure 1).

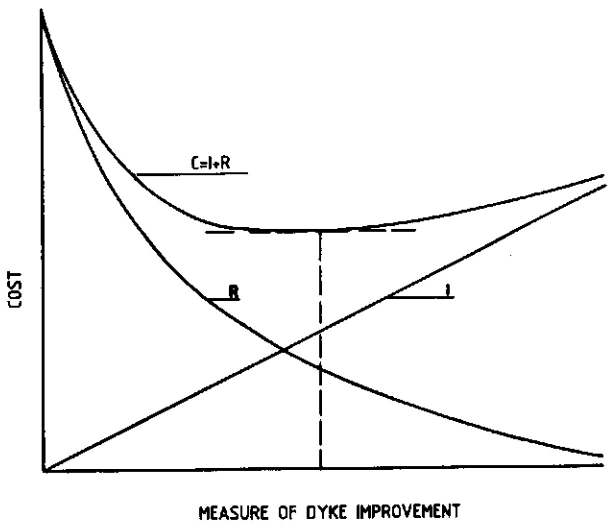

Figure 1

Other reasons however, such as of a budgetary, technical or governmental nature, may also determine the extent of the dyke improvement.
With the design of a rational way of maintenance of embankments it will first of all be necessary to try to build up a registration system of data. These data bear on the profile of the embankment, height at the crown, seepage etc. If these data are collected periodically it will be possible to obtain an impression of the condition of the dyke in a given period. This condition will, as time goes by, worsen. It will be imperative to prevent this condition to worsen below a standard to be determined. Before the time that the 'standard-condition' will be exceeded improvement of the embankment will have to take place.
It will be necessary to direct the management system thus that the time of improvement of the embankment may be predicted more or less accurately by extrapolation of the data available of the condition of the section of the dyke concerned. This will then offer the possibility

for the making of a forecast of improvement works and the cost pertaining to them in a somewhat longer run (Figure 2).

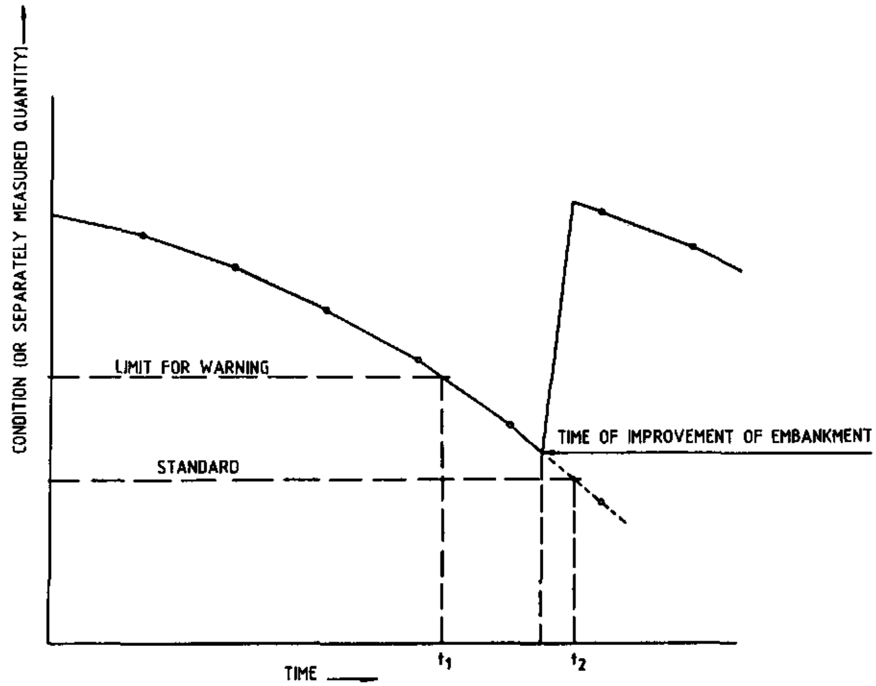

Figure 2

More specifically, a rational way of management of the embankments might be thus:

1 General orientation
1.1 Orientation on the problems
1.2 Study of financial, personal and organizational aspects regarding the present method of maintenance of embankments within the drainage district
1.3 Study of technical bottlenecks in connection with the geography and the geology within the drainage district
1.4 Study of management aspects with regard to maintenance up to now
1.5 Formulation of the purpose(s) of the system.

2 Technical inventory

2.1 General

Providing an answer to the following questions:

- will staging be necessary with the inventory?
- what data will have to be collected?
- what methods of inventory will have to be followed?

2.2 Laying out a system of data:

- numbering all embankment sections; in doing so, adherence to a ledger to be made if possible
- all embankment sections to be indicated in maps.

2.3 Draft of schedule for routine inspection. This to be able to trace damages that may be repaired at once. This inspection may also facilitate the establishment of an annual inspection programme.

2.4 Rough visual inspection and survey for the purpose of:

- selection of embankments for further inspection
- pointing out damages
- comparing the condition of the embankment with that of the year before (condition dependent on time).

The rough visual inspection should take place periodically. The closer the condition of the embankment approaches the standard condition, the shorter the period between each inspection can be. On the other hand, it will probably not be necessary annually to inspect an embankment that has only recently been improved.

2.5 Drafting a programme of inspection of selected embankment sections.

3 Formulating minimum standards

These criteria or standards refer, e.g., to crown height, stability and shape of profile.

They will, partly, depend on the location of the embankment section, liability to damage of the area to be protected, geological condition of the site, the presence of shipping and attack by waves.

4 Test

The inventory and surveying information will be compared with the standards mentioned under item 3. Based on this, suggestions concerning maintenance can be made for:

- maintenance that is immediately necessary
- improvement activities on a medium term (< 5 years).

5 Rough estimates of cost
Drafting of rough estimates concerning the execution of the suggested maintenance.

Periodically, the approach, as mentioned in items 1 up to 5, should be altered in view of new ideas and experiences. In diagram 3 this has further been specified in a current-schedule.

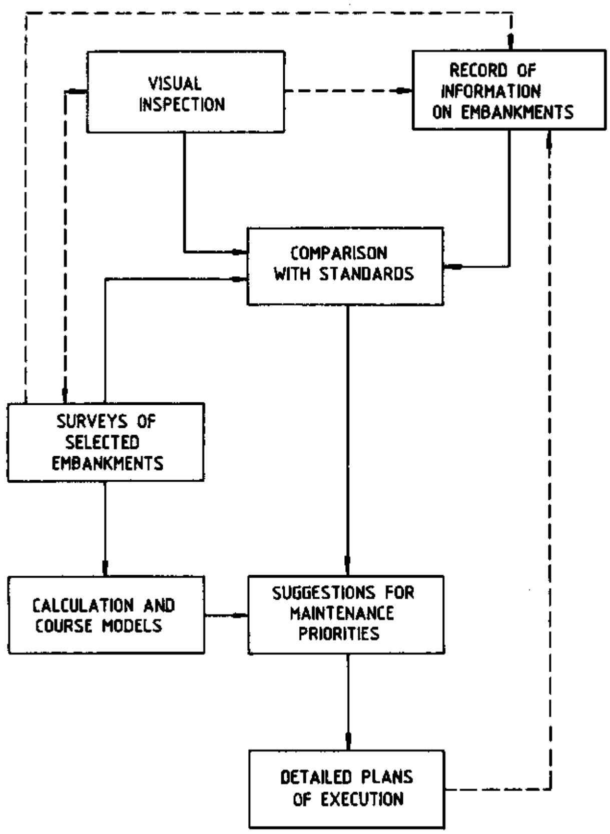

Diagram 3

3 Study

3.1 General

The study carried out in assignment of 'De Oude Veenen' drainage district should be considered as a first rough visual inspection and survey, as laid down in item 2.4 of paragraph 2.2. The surveys have taken place in the period of February-April 1981.

3.2 Approach of the study

For the recording of the results a form was designed. In this parameters are recorded that are considered representative for each part of the embankment in the profile. The parameters refer to:

A nr. of embankment section
B km beginning
C km end
D width of inner slope
E width of crown
F width of outer slope
G width of foreland
H angle of inner slope
I angle of outer slope
J height of crown with regard to NAP (Amsterdam Ordnance Datum)
K use (grazing) agriculture/horticulture (recreation
L overgrown with trees and shrubs
M buildings
N moored ships
O occurrence of seepage
P mechanical damages to embankment
Q presence and type of pavement
R damage of bank protection
S attack by waves
T growth with reeds/rushes

All parameters have been included in a computer file, per polder and per section of the embankment, partly in code.
On the next page an example is given of the results of the survey in the Rodepolder.

3.3 Analysis of the results

With the aid of a computer programme developed to that end, it is possible to make an analysis of the results of the inspection.
Thus in figure 4 it is indicated with what percentage of the total length of catch water embankments a height of crown is exceeded.
In the graph an important height can be distinguished, namely that of NAP - 0,10 m, the minimum height of crown from the Drainage District Regulations at which the embankments have to be maintained.

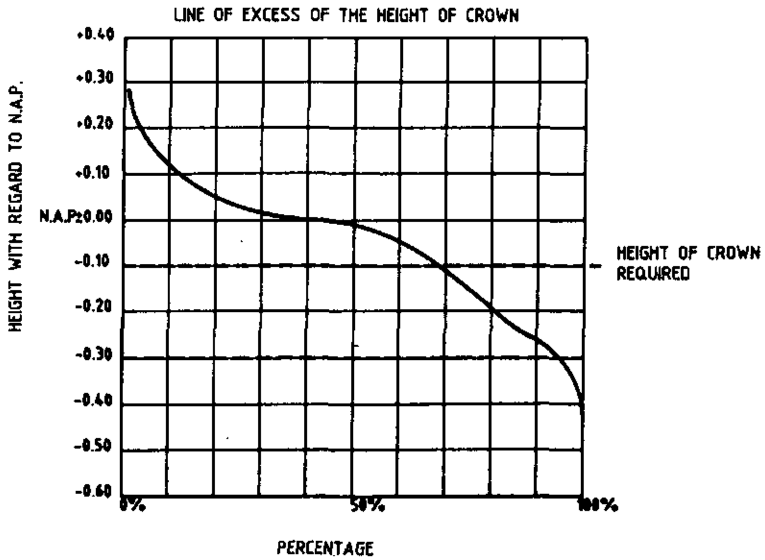

Figure 4

It is also possible to determine where inadmissible seepage may occur, when the embankment does not possess the required profile, etc.

POLDER : 39.

```
-A-  -B-     -C-    -D-   -E-   -F-   -G- -H- -I-    -J- -K-
                                                   -L-M-N--O- -P- -Q- -R- -S- -T-

 1  0.000   .910   3.4   1.2   1.2    .5 2:4 2:4   .05 401
                                       BINNENTALUD 0 0    100 000
                                       KRUIN       0 0        000 401
                                       BUITENTALUD 0 0 1      100     000 100
                                       VOORLAND    0                          400

 2   .910  1.670   3.0    .8   1.1   0.0 2:3 2:4  -.10 401
                                       BINNENTALUD 0 0    100 010
                                       KRUIN       0 0        010 500
                                       BUITENTALUD 0 0 3      400     000 000
                                       VOORLAND    0                          000

 3  1.670  1.850   0.0   0.0   0.0   0.0 2:N 2:E  -.20 005
                                       BINNENTALUD 1 1    000 000
                                       KRUIN       1 1        000 410
                                       BUITENTALUD 0 0 3      000     000 000
                                       VOORLAND    0                          000

 4  1.850  2.210   3.5   1.0   1.1   0.0 2:3 2:5   .05 302
                                       BINNENTALUD 0 0    000 020
                                       KRUIN       0 0        100 500
                                       BUITENTALUD 0 0 2      000     000 000
                                       VOORLAND    0                          000

 5  2.210  2.610   3.0   1.2   1.0   0.0 2:4 2:4  -.05 500
                                       BINNENTALUD 0 1    100 100
                                       KRUIN       0 0        000 500
                                       BUITENTALUD 0 0 1      000     000 000
                                       VOORLAND    0                          000
```

4 Determination of the economically desirable order with improvement works

As has already been discussed in paragraph 2.2, the economically desirable order should be determined based on a minimalization of capitalized annual expectation of damage caused by disaster and cost of improvement of embankments. The problem however lies in the practical application of this principle. With the assessment of damage caused by dyke burst in a polder and beyond, a great number of objective and subjective factors play a part. Of the subjective factors the loss of human lives may be mentioned, as well as the social disorder etc.
As it is not possible to express these factors by way of money in a quantitative sense, the determination of total damage caused by disaster is not possible as yet and therefore it is not possible to apply the method mentioned in paragraph 2.2.
Yet, to get an impression of the order in which embankments should preferably be improved, the method for the determination of urgency of improvement works for embankments mentioned below has been used. Starting point with this method is that the urgency is determined by the chance of a burst and the rate of damage occurring when this happens. The factors determining the chance of a burst and a valuation figure of the dyke section going with it, are mainly determined here as follows:

factor determining chance of burst	*valuation figure*
a normal stable profile, with which a deviation of 0,05 m in the width of the crown with regard to the width by regulation is yet accepted	1
b heavy profile, crown too low or profile too light	2
c light profile, crown too low	3
d light profile, with occurrence of seepage	4
e heavy profile with characteristics of instability	4
f light profile with characteristics of instability	6

The factors assessing the damage refer to movables and immovables situated in the polder, as well as to damages that may occur outside the polder. The factors for the assessment of damages and their valuation figures in this system are as follows:

factor for the assessment of damage	*valuation figure*
1 Protected polder surface	
smaller than 100 ha	1
100 up to 500 ha	2
larger than 500 ha	4
2 Polder water level	
higher than NAP - 1,70 m	1
NAP - 1,70 m up to NAP - 2,50 m	2
NAP - 2,50 m up to NAP - 3,50 m	4
below NAP - 3,50 m	8
3 Built up areas in the polder	
not or hardly present	1
some building	4
much building	8
residential area	16
4 Important industries, infrastructural objects (airports, motorways etc.)	
not or hardly present	1
some objects present	2
many objects present	4
5 Use of soil	
predominantly grassland	1
predominantly or to a large extent agricultural	2
predominantly or to a large extent horticultural	4

The factors assessing damage 1 up to 5 mainly refer to the interests within the polder. Besides there are factors that are of interest to the manager of the catch-water basin and third parties. For practical reasons these factors have not been considered in the determination of urgency. From this however may not be inferred that with a burst the involvement of the manager of the catch-water basin and third parties will not exist or be of insufficient significance.

For the determination of the urgency order of the worst sections of embankments in the polder the following procedure is employed:

- the largest figure regarding chance of burst determination in the polder should be established (= chance figure)
- the final figure for the assessment of damage should be established in every polder in a cumulative way, by considering all factors for the assessment of damage
- for every polder the final figure for the assessment of damage should be multiplied with the largest figure of chance of burst determination in the polder (= risk figure)
- the urgency order is now determined by a decreasing risk figure

After every embankment improvement or periodical inventory this order will have to be reconsidered, since the chance figure and/or the final figure for the assessment of damages may change. With burst of any parts of embankments other polders may be flooded as well in a number of cases. The final figures for the assessment of damages are then determined by the damage factors to be determined for the entire flooded area.
In the following tables the determination of the risk figure and the urgency order are indicated in succession, for a number of polders.

Determination risk figure

polder nr.	*polder*	*factor for the assessment of damages*					*final figure for the assessment of damage*	*chance figure*	*risk figure*
		1	*2*	*3*	*4*	*5*	Σ		
10	Achthoven / Huis ter Doespolder	4	8	16	4	2	34	4	136
11	Aderpolder	1	2	1	1	1	6	4	24
12	Dr. Akkersloot-, Hertogs- en Blijverspolder	2	8	8	1	1	20	2	40
13	Blauwepolder	2	2	8	4	1	17	4	68
14	Bospolder	2	2	4	4	1	13	4	52
15	Boterhuispolder	2	2	4	4	1	13	2	26

Urgency order

polder nr.	*polder*	*risk figure*	*number*
10	Achthoven / Huis ter Doespolder	136	1
13	Blauwepolder	68	2
14	Bospolder	52	3
12	Dr. Akkersloot-, Hertogs- en Blijverspolder	40	4
15	Boterhuispolder	26	5
11	Aderpolder	24	6

5 Budgeting

To be approximately able to check what sections of embankments may be improved with a given budget the next method may be followed:

- consider the polder with the largest risk figure and its embankment section with the largest chance figure (see paragraph 4) and assume that this section will be improved
- calculate for this polder a new risk figure and determine a new order for all polders
- consider again the polder with the largest risk figure and its embankment section with the largest chance figure and assume that this section will also be improved
- repeat this, until the sum of the estimates of cost for improvement of the embankment sections mentioned, equals the budget

It is obvious that these calculations may be carried out rapidly with the aid of a computer, certainly so when a change in the factors for the assessment of damage will occur as well.

RECLAMATION IN DELTAIC REGIONS

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Abstract

Optimum protection against high waterlevels caused by the sea as well as high river discharges (or a conbination of the two).
Principle: complete safety is beyond the bounds of possibility.
Flooding (with fertile silt) now and again has to be accepted (in tropical area's high water levels caused by cyclones (typhoons) are not predictable).

The following subjects shall come under discussion: closure-methods of tidal inlets and riverbranches in soft (silty clay) subsoil carried out as much as possible in manual labor (by hand), the construction of submersible dikes, the supporting safety-philosophy and the strategy to follow in a deltaic region.

1. Preface

Deltaic regions (the river flood plains of great rivers like Rhine, Meuse and Scheldt, Nile, Yellow River and Yangtze, Ganges and Brahmaputra, Mekong, Niger, Missisippi, Rio de la Plata) are of old concentration points of human activities (agriculture and shipping). The continuous periodicity of floodings with as a result the deposition of fertile silt make these regions pre-eminently suitable for the cultivation of crops. Because of the increasing population pressure man has continuously taken possession of these fertile regions by means of reclamation. The sometimes crapicious nature of the riverdischarges, the tendency to meander and the more and more diminishing of the highwaterbed of the rivers as a result of reclamation sometimes lead to disastrous floodings.

In order to keep the land fertile a flooding must take place almost once a year deposing fertile silt (e.q. the river Nile before the building of the Asuan dam). The inhabitants must adapt themselves to these floodings. In fact floodings are never to banish completely. In view of statistics a still higher flood is always possible. But the frequency of exceeding becomes continuously lower. In this paper we will only discuss the problems to be dealt with in deltaic regions with weak (silty) subsoil. We are of the opinion that the creation of complete safety is beyond the bounds of possibility.

2. Subsoil conditions

In deltaic regions with the subsoil consisting of more or less thick layers of soft clay, the placing of extensive bottom protection is mostly not necessary. Clay in fact is generally more durable against erosion than loose-packed sand. In the case of layers of soft clay the closure-dam will sink into the soft subsoil, if no special provisions are taken. We must keep the pressure on the soft subsoil as low as possible. If scouring occurs on one or both sides of the closure-dam the scouring-holes must be filled as quick as possible to prevent loss of stability of the dam.

For dikes and closure-dams on soft subsoil the following points are important:

- the clay of the dike may sink,
- settlement of the subsoil,
- failure of the body of the dike.

The settlement of the subsoil can be diminished by:

a. reducing the load on the subsoil.
b. spreading the load.
c. improvement of the subsoil.
d. sand-replenishment as a foundation.

ad a: . if possible make a foreland before the dike (this reduces the wave-height and thus the wave-runup).
. apply gentle slopes, if possible with a rough and porous revetment.
. apply a berm on storm-flood level (this reduces the wave-runup).
. apply a low-water berm.

ad b: . spread the load with the aid of mattresses and apply gently slopes.

ad c and d: the mostly thick layers of soft clay do not allow to make an improvement of the subsoil or a sand-replenishment.

The danger of failure can be restricted by the following measures:

a. reduce the load on the subsoil.
b. spread the load.
c. improve the subsoil.
d. use a sand-replenishment as a foundation.
e. apply gently slopes and berms.
f. apply the load on the subsoil gradually.
g. fit a "cohesive bedding" underneath the dike.

The water-permeability of the subsoil is also very important. The permeability of clay is mostly bad. If the soft layers of clay are loaded, first of all the neutral stress (pore-water pressure) is increased. Due to this the effective (grain) stress decreases and therefor the risk of failure becomes greater.

3. Polder dikes

Before closing a tidal inlet in order to reclaim a certain area dikes must be build - if those dikes do not exist of course.

3.1 Cross section

The cross section of the dike is also dependent of the function the dike has to fulfil.
Two types can be distinguished:

- a seadike: to stem high waterlevels of short duration; a gently outer slope (in connection with wave runup) and a steeper inner slope.
- a riverdike and a (reservoir)dam: has to withstand high waterlevels of long duration; a riverdike has a somewhat steeper outer slope (for here there is normally no wave-runup) and a gently innerslope (high waterlevels of long duration give a fully developed phreatic surface in the body of the dike).

It is favourable, in connection with waveattack, to apply a rather long length of foreland before the dike in order to reduce the wave-height and thus the wave-runup. In addition to this a foreland is favourable for the stability of the dike.
The starting-point is that those dikes are made by hand and with clay available on the spot. A rather big foreland, which can be used as a borrow pit, is required.
As argued in the preface (flooding with fertile silt) and the impossibility to predict a high waterlevel, which e.g. only occurs once in a century (cyclones and no measurements of waterlevels), the dikes must be submersible. In addition to this overflows (lowered parts) in the dikes must be made to direct the inflowing water and to reduce the damage on the dikes and in the polders. It is necessary to protect the overflows with strong revetments and also the natural ground level in the vicinity of the overflow.
To diminish the damage on the inner slope, when the water also discharges over the high parts of the dike, it should be favourable to create close behind the dike a small inundation area, say of a width of about 60-80 m, provided with low small dikes. This inundation area

is first filled with water and this layer of water diminishes and spreads the force of the water, that flows over the high parts of the dike.
In this solution it is necessary that the inhabitants stay to live on the high grounds. A warning-system therefor must be established.

3.2 Revetment

The revetment of the dikes has to be made if possible with materials available on the spot. In most cases natural stone is not available and imported stone is too expensive. From the available clay big bricks can be made. The waste can be used in the rubble layer under the revetment from big bricks and eventually in mattresses.
The dike (cross-section) can be protected as follows:

- the underwater slope and the low water berm can be protected by a fascine mattress covered with dumped rubble (brick-waste) or bags filled with clay. If a revetment is not necessary, than a low water berm can be planted with reeds.
- the slope between the LW-berm and the berm on stormfloodlevel can be protected by a stone pitching from big bricks.
- the berm on stormfloodlevel (or HW-berm) can be planted with bamboo for dual purposes:
  - . a dense bamboo-planting reduces the wave-runup,
  - . the maintenance of the bamboo-planting supplies material for the mattresses.
- the slope above the HW-berm can also be protected by a stone pitching from big bricks.
- the top of the dike and the inner slope must be provided with a dense strong low overgrown (e.g. grass).

4. Closure

4.1 Hydraulic aspects

In general the maximum water velocity can be calculated with the formula

$v = \sqrt{2\ g\ z}$, with z = hydraulic head and g = acceleration due to gravity.
The max. hydraulic head (in the case of end-tip method) equals half the tidal difference, thus $v_{max} = \sqrt{2\ g.\ \frac{1}{2}\ H}$, with H = tidal difference (difference between H.W. and L.W.).
We must keep in mind that the discharge formula's are a strong schematization of reality and must be adapted to what can be measured in prototype.

4.2 Feasable methods

There are 3 possibilities: the method of extension (end-tip method), the method of gradual raising a sil (transverse-dumping method) and a combination of those.
With the end-tip method the material is tipped from both banks to the deepest part of the channel. This method gives the max. velocity.
The waterlevel in the area to close goes to the mean waterlevel.
Disadvantages of this method:
- as the work progresses the amount of material increases (for loose dumped material).
- the speed of the work decreases, whil the watervelocity increases.
- the effect of contraction of the current and the local scour caused by the vortex streets.

With the transverse-dumping method the sill becomes gradually raised over the whole width of the channel. At a certain height of the sill the state of critical flow occurs. Further heightening of the sill shows a decreasing velocity.
Disadvantage:
the waterlevel in the closed inlet reaches the high waterlevel.
The max. hydraulic head in the closed state is twice as high as with the method of extension (end-tip method).
Advantages:
- by raising the sill the amount of material to be used decreases,
- no concentrated current. The attack of the current is spread over

the complete width of the sill.
- the velocity is limited; the max. velocity is lower than $\sqrt{2 g \frac{1}{2} H}$.

In both cases it is recommendable to carry out the ultimate closure in a period of neap tides, in order to keep the velocities as low as possible.

To close tidal inlets and river branches with a weak subsoil the gradual raising of a sill is far preferable.

The principal reasons are:
- the watervelocity is limited (critical flow),
- the current is not concentrated, but spread over the complete width of the inlet to close.
  The chances for large erosion are much smaller.

For bottom protection and in order to spread the load mattresses should be applied. These mattresses are to be ballasted with rubble (bricks) or with bags filled with clay.
The closure-dam should be carried out as a dike profile with the aid of mattresses. This distributes far better the pressure over the subsoil and gives a more stable construction (use slopes, no steep talus). Moreover in the last phase of the closure the need for material is less, the chance of succes is therefor greater. After the closure the dam must be broadened and raised with clay and a revetment must be applied. The danger of piping must always be kept in mind.

5. Materials to apply

Summarising:
- use local materials as much as possible. Imported materials are expensive.
- one can make good mattresses from bamboo, jute, straw and the like.
- make bricks (big size) from the available clay. Use clay in bags as ballast-material.

- the weights of the units must be adapted to manual labor.
- normally timber is available (for stakes, toe-plates and the like).

6. Execution

The execution strongly depends on the local circumstances. We can therefor only make some general remarks.
For the execution by hand with much people on the site a good organisation of the entire work is absolutely necessary. The work must be planned in a way that

a) the last phase of the closure takes place in a period of neap tides and
b) not during the harvest.

The transport distances must be short and there must be room enough to stock the materials. The fascine mattresses must be made as close as possible to the dam-site.

7. Strategy to follow

An overall plan has to be the starting-point. One has to start with the small closures as far as possible from the sea to gain experience.
It is necessary to preserve the tidal forests, because:

- they damp the flood-wave and the wind waves coming from the sea;
- they hold the silt etc.;
- and last but not least the tidal forests are ecologically of incalculable value as they are unique resources of species.

8. Safety philosophy

Our principle is: complete safety is beyond our reach. To live is to run risks. To strive after complete safety is meaningless. Not a single construction is 100% safe.

Summarising:

Because it is impossible to predict high waterlevels (e.g. occurring once in a century) (cyclones and no measurements of waterlevels) means that submersible dikes are highly preferable. This means that the height of the dikes has to be limited. The dikes must be able to withstand the overflowing water. The inhabitants must live on the high grounds.

As an aftereffect the land is again and again covered with fertile silt. If possible make overflows (lowered parts) in the dike.

If tidal forests exist, they must be preserved. A warning-system has to be established.

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THE ZUIDERZEEPROJECT; CONSTRUCTION OF DIKES

Jhr. ir. A.M.van Nispen tot Pannerden

1 Introduction

This project includes the enclosure of the Zuiderzee - a large shallow estuary of the North Sea - of appr. 4.000 km^2 - by a dam between the coast of North Holland, via an island Wieringen, and the Frisian coast over a total length of 32.5 km and

the partial reclamation of the enclosed area.

The plan for the Zuiderzeeproject was designed by Dr. ir. C.Lely (1854-1929).

Fifty years ago - at 28 May 1932 - the last gap in the Enclosing dam was closed and the Zuiderzee separated from the North Sea. By the completion of the Enclosing dam the safety as well as the watermanagement of the adjacent area has been improved. The length of the sea-defence along the Zuiderzee, of about 300 km, was shortened to 45 km.

The salty Zuiderzee turned into a fresh water lake - called IJssellake - by the fresh water supplied by a number of rivers - mainly the river IJssel. Any surplus water is flowed off at low tide, through the 5 groups of 5 sluices build in the Enclosing dam, into the North Sea.

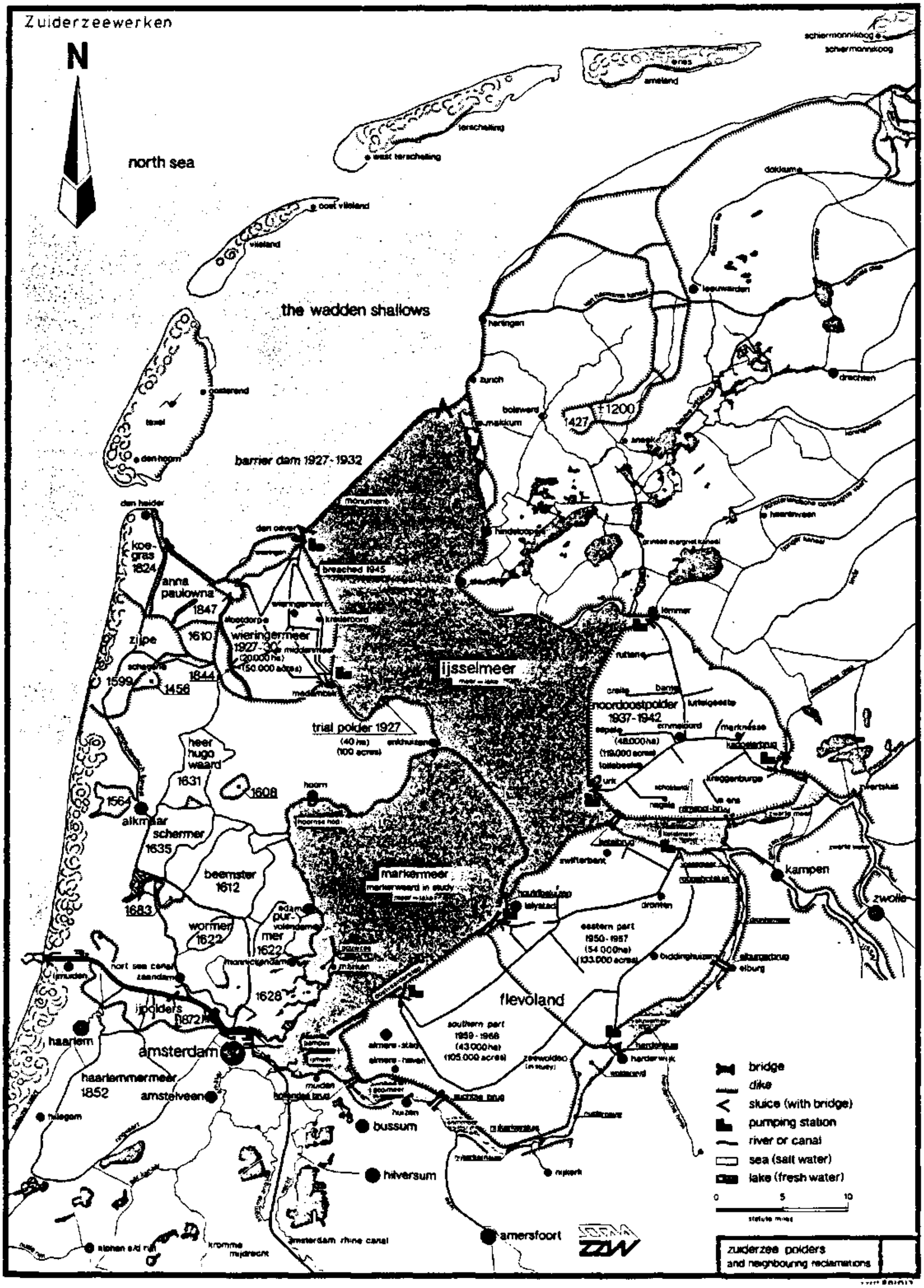
In behalf of the watermanagement of the surrounding countries the minimum seize of the, after the reclamation of the 5 polders remaining, lake has to be at least 1200 km^2.

The level of the IJssellake is maintained in the winter, relatively low, about 0.40 m, in the summer about 0.20 m below mean sea level.

The maintained level, without tidal movement or stormfloods, facilitated the dikebuilding activities for the 5 polders, planned inside the IJssellake.

In 1920 it seemed possible to complete the whole plan within 30 à 40 years. The economical crisis of the thirties, the second world war and the postwar reconstructionperiod delayed the works for many years. The reclamation is still in progress - four polders the Wieringermeer, the North East polder, Eastern and Southern Flevoland are drained and

FIGURE 1



Zuiderzeewerken
N
north sea
the wadden shallows
barrier dam 1927-1932
ijsselmeer
markermeer
flevoland
noordoostpolder
1937-1942
wieringermeer
1927-'30
trial polder 1927
eastern part
1950-1967
southern part
1959-1968
koe-
gras
1824
anna
paulowna
1847
1610
zijpe
1599
1456
1844
heer
hugo
waard
1631
1608
1564
alkmaar
schermer
1635
beemster
1612
1683
wormer
1622
pur-
mer
1622
1628
ijpolders
1872
haarlem
amsterdam
haarlemmermeer
1852
amstelveen
bussum
hilversum
amersfoort
kampen
zwolle
1427
1200
bridge
dike
sluice (with bridge)
pumping station
river or canal
sea (salt water)
lake (fresh water)
0
5
10
zuiderzee polders
and neighbouring reclamations

cultivated. The completion of the plan - by the fifth polder, the Markerwaard - is foreseen within the next two decades (Figure 1).

2 The construction of the dikes

2.1. The design-criteria

The dikes in the Zuidersea have to meet a high standard of safety. Failure of one of the dikes would mean an innundation and damage to all objects in the adjacent area or in the low-lying polder. In the course of years the methods defining the height (the crest) of a dike changed and evoluated by the increasing analysis of the phenomena - tides and windeffects - and by the insights in the theories of statistics. Traditionally the highest known waterlevel was chosen as design-level which was heighted with a, by experience and out of observations estimated, height of the uprush of the waves along the slopes of the dike - the 'watch height'.
It had to be expected, that by the enclosing of the Zuidersea, in which the tides of the Northsea via the Waddensea penetrated, the stormtides in the Waddensea would increase to a higher level than before.
The maximum level - to be expected in the Waddensea - was calculated (in 1920-1928 by a Royal Commission under the chairmanship of Prof. H.A. Lorentz) at 3.60 m (at the westside) à 3.80 m (at the east side of the planned Enclosing dam) above the mean sea-level (=reference datum N.A.P.). This level was chosen as 'design-level' and heighted with the height of an estimated wave-uprush, the watch height, of 3.50 m, unto the ultimate height of the crest of the Enclosing dam at N.A.P. + 7.10 m à N.A.P. + 7.60 m.
This height is about 3.50 m above the highest-then-known level in the Waddensea.

During the preparations for the reclamation of the North East polder (1937-1942) the necessary data for the determination of the cross section of the planned dikes were assembled by observations, in nature, and by model investigations. At the same time were the, for the cross section defining factors, as

- the actual waterlevel in front of the dike - i.c. the variations of the level of the IJssellake

- the denivellations of the watersurface due to the wind and
- the uprush of waves along the slopes of dikes

more and more analised.
The variations of the waterlevel of the IJssellake are depending from the water-supply to the lake and from the natural discharging capacity of the sluices in the Enclosing dam and the tides in the Waddensea or the management-regulations to storage fresh water for periods of drought.

With the formula for windeffects in closed channels (1926, Lorentz), for the height and length of the waves in shallow water (1948, Thijsse) and with the results of modelinvestigations for the wave uprush on dikes (1957, Wassing) the determining factors were calculated separately for the most unfavourable conditions (a great watersupply - limited discharge-capacity and storm) for each point along the dike of the North East polder. Frequencies of occurance and the, for each point of the dike different, importance of each of the mentioned factors, have not been considered, until then.

During the floods in 1953 and 1954 in the Delta area a great number of the dikes failed by water or waves exceeding the crest and by the following erosion and loss of stability of the slopes on the inside of the dikes.
The Governement's Delta Commission has, on account of these events, prescribed and defined the design-criteria for the height of the existing and future dikes in the Netherlands. The height of a dike has to be determined at a level, which, in a chosen design-frequency (=mean-chance of exceedance) for the combination of waterlevel and windeffects will be exceeded by only 2% of the total number of waves.
The design frequency for the combination of waterlevel and windeffects was, for the time being, chosen for the dikes of Flevoland at 10^{-3} of the Markerwaard at 10^{-4}.
This 'deterministic' method, again, will be replaced by an approximation according to theory or probabilities, as soon as this theory is applicable to dike-designing.

2.2 The materials

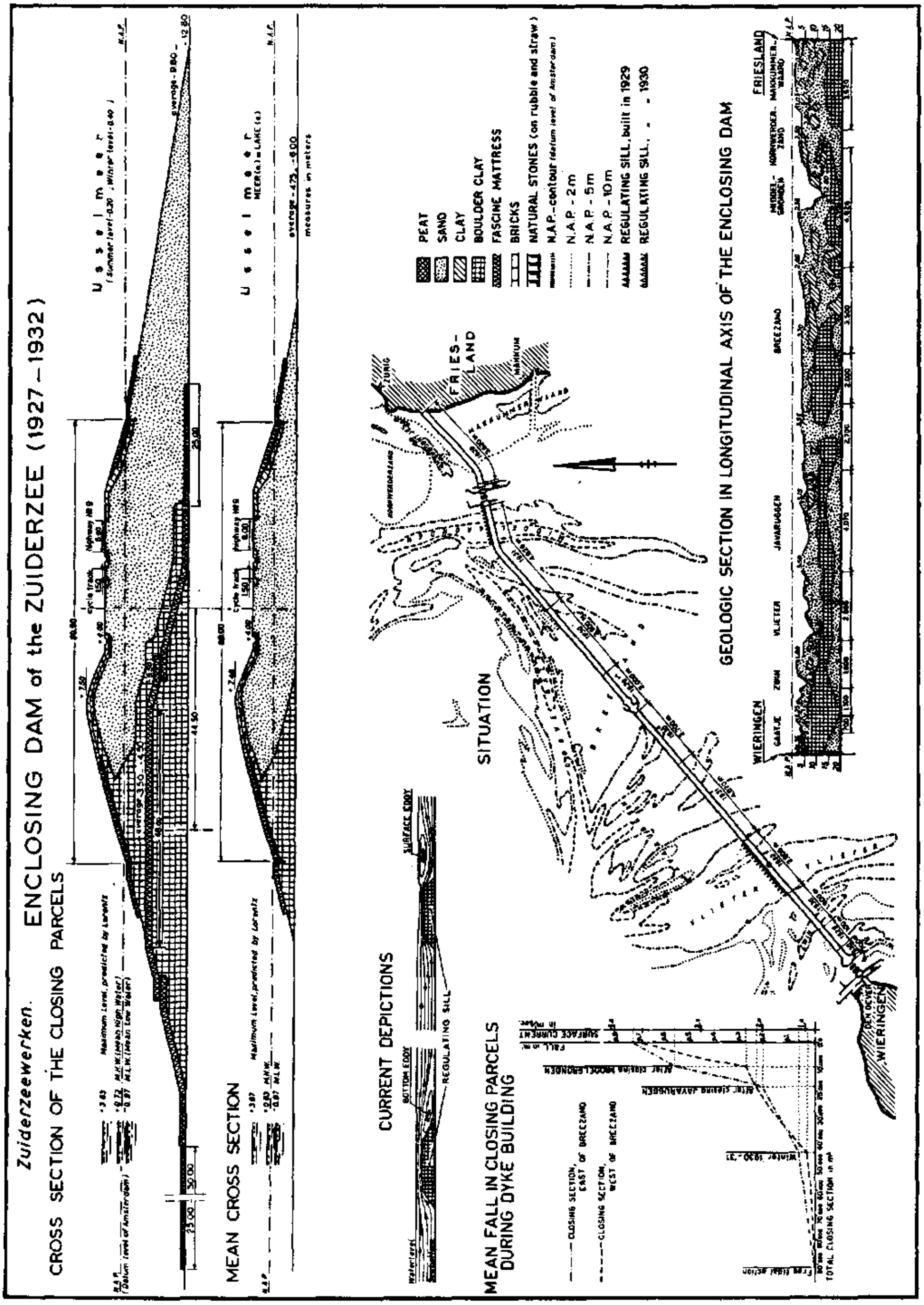
The Enclosing dam and the dikes around the polders consist mainly of sand and boulderclay

- Sand, sucked out the bottom in the immediate vicinity of the works, is the cheapest buildingmaterial for the body of the dike.
- During the geological explorations of the bottom of the Zuiderzee also 'boulderclay' was found in several places in the Northern parts and, particularly, at the planned site of the Enclosing dam.
- Boulderclay - a glacial deposit - is a heavy loam that is nearly impervious and temporary resistant to current and waves. It has a high bearing strength.
  Boulderclay can be dredged by bucketdredgers to a moderate depth (25 m below the waterlevel).
  Boulderclay is an excellent dikebuilding material and is usable for temporary dams and as a permanent, impenetrable, cover between the sandbody and the protection layers of the dikes.
- The brushwood - needed for the braiding of the fascine-mattresses - is supplied by the holms in the outermarches of the rivers.
- The sheetpiling is made of creosoted firwood.
- The rubble, rip-rap and basaltblocks have been imported from abroad.

2.3 The foundation

The sand, underlain by boulderclay, found at the site of the Enclosing dam enabled a foundation directly on the seabottom. In the closing gaps, where a strong current had to be expected, boulderclay was dumped (by hopper barges) and formed to a retaining dam or sill.
The sill was protected by fascine mattresses against a current velocity of 5 to 6 m/sec (Figure 2).
The polders, however, are, in view to reclaim arable land, projected in the southern parts of the former Zuiderzee where the toplayers of the seabottom consist of fertile clay, alternated by layers of peat (thick 2-25 m).
In order to construct a dike, without any danger for the stability of the construction or risk of considerable settlement, these soft layers are

FIGURE 2



Zuiderzeewerken.
ENCLOSING DAM of the ZUIDERZEE (1927-1932)
CROSS SECTION OF THE CLOSING PARCELS
MEAN CROSS SECTION
Maximum Level, predicted by Lorentz
M.H.W. (Mean High Water)
M.L.W. (Mean Low Water)
N.A.P. (Datum level of Amsterdam)
Ijssel meer
measures in meters
CURRENT DEPICTIONS
BOTTOM EDDY
SURFACE EDDY
REGULATING SILL
Waterlevel
MEAN FALL IN CLOSING PARCELS DURING DYKE BUILDING
CLOSING SECTION, EAST OF BREEZAND
CLOSING SECTION, WEST OF BREEZAND
TOTAL CLOSING SECTION in m²
SITUATION
FRIES-LAND
WIERINGEN
PEAT
SAND
CLAY
BOULDER CLAY
FASCINE MATTRESS
BRICKS
NATURAL STONES (on rubble and straw)
N.A.P.-contour (datum level of Amsterdam)
N.A.P. - 2m
N.A.P. - 5m
N.A.P. - 10m
REGULATING SILL, built in 1929
REGULATING SILL, " 1930
GEOLOGIC SECTION IN LONGITUDINAL AXIS OF THE ENCLOSING DAM
WIERINGEN
FRIESLAND
BREEZAND
VLIETER
JAVARUGGEN

removed and replaced by sand up to about 2.00 m below the normal waterlevel. The clay and peat layers are normaly underlain by strata of sand containing artesian water.
A layer (thick about 1.00 m) was left on top of the sand-strata in the excavated trench. This layer forms, compacted by the load of the dike, a nearly impervious separation between the sandbody of the dike and the deep sand-strata and prevents seepage to penetrate via the sandbody of the dike to the, low-lying, polder.
During the construction-period some extra height was given to the dike to overcome the small settlement of the remained soft layers.

2.4 The cross-section

Beyond the depth of 2 m, sand will be stable without any covering layer, provided the angle of the slope is below the angle of natural repose of sand under water. The gradient of the uncovered sandslopes is, normally, 1:6.
During the construction of the Enclosing dam boulderclay dams were dumped at the seabottom (i.c. of the polderdikes at the improved foundation) and raised, by floating cranes, up to the waterlevel and afterwards up to the design-level. Behind and between these dams the sandcore of the dike was built by hydraulic fill. The submerged slope of the boulderclay dams is protected by brushwood mattresses, loaded with rip-rap (500-1000 kg/m^2).
Under normal conditions the waterlevel in front of the dikes flutuates around the mean sea level (= the reference datum N.A.P.).
The part of the dike, on that level, is exposed to the daily wave attack. A horizontal berm is made in the brushwood mattresses and loaded with heavy rip-rap (120-300 kg) to dissipate the energy of the waves and to deminish the wave-uprush along the slopes.
The upper-slopes of the Enclosing dam are contonious and convex (Figure 3). In (the cross-section of) the polderdikes another berm, was made on the design-level of the IJssellake. The berms turned out to be the most effective, if the width of the berms is at least ¼ of the length of the waves.
The angle of the slopes are chosen on stability and economical considera-

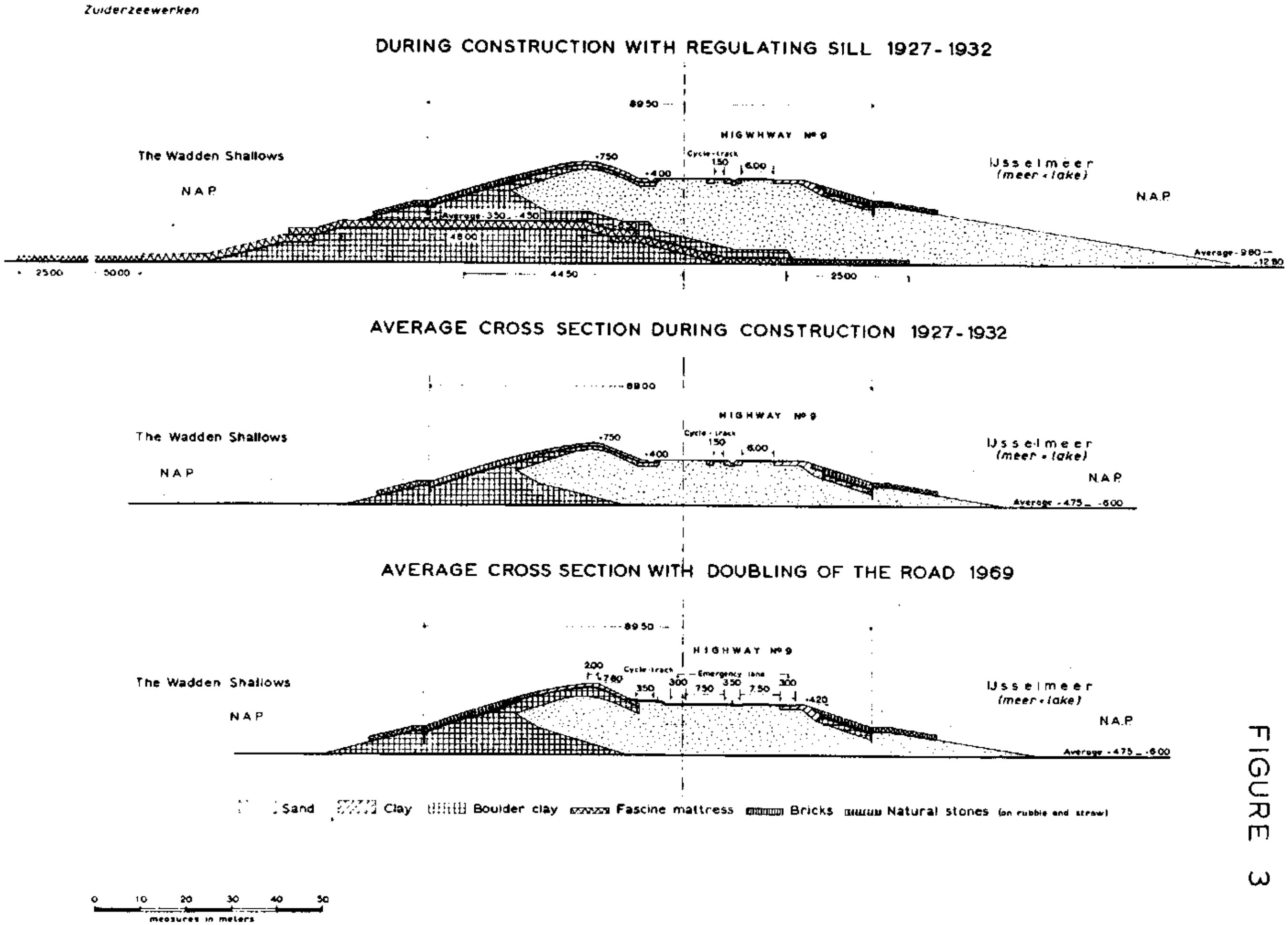


FIGURE 3

CROSS SECTIONS ENCLOSING DAM

tions,between 1:4 or 1:3. A steeper slope requires heavier stones a more gentle slope occupies a larger area to be covered.
The strongest protection (500-600 kg/m^2) is made on that part of the slope that is exposed to the strongest wave attack, just underneath the design level (= berm in the polderdike). A Lighter and cheaper protection is made on the heigher parts of the dike, that will, only under extreme conditions, be reached by the tops of the waves.
The slopes on the polderside of the dikes are, during the construction-period of the polder, temporary protected by a stone or concrete pitching (300-500 kg/m^2). After the polder has been drained, these materials can be used for a further protection of the slopes on the outside of the dike or for the next polder to be drained.
In the ultimate situation the inner slopes and the crest of the dike are, concerning the fact, that the crest can be exceeded by waves, covered by a layer of clay and grass. At the foot of the polderdikes a drainage-system had to be made to discharge the water, that will penetrate in the parts of the sandbody of the dike that are not covered by impervious layers, to the low-lying polder. Such a drainagesystem protects, by lowering the phreatic-line, the impervious layers against damage by the pressure of the water from inside the sandbody of the dike. On an especially, behind the main body of the dike, made berm and, occasionally, on the crest of the dike,traffic accommodations are made.
A mean cross section of a polderdike, during construction, is shown in Figure 4.

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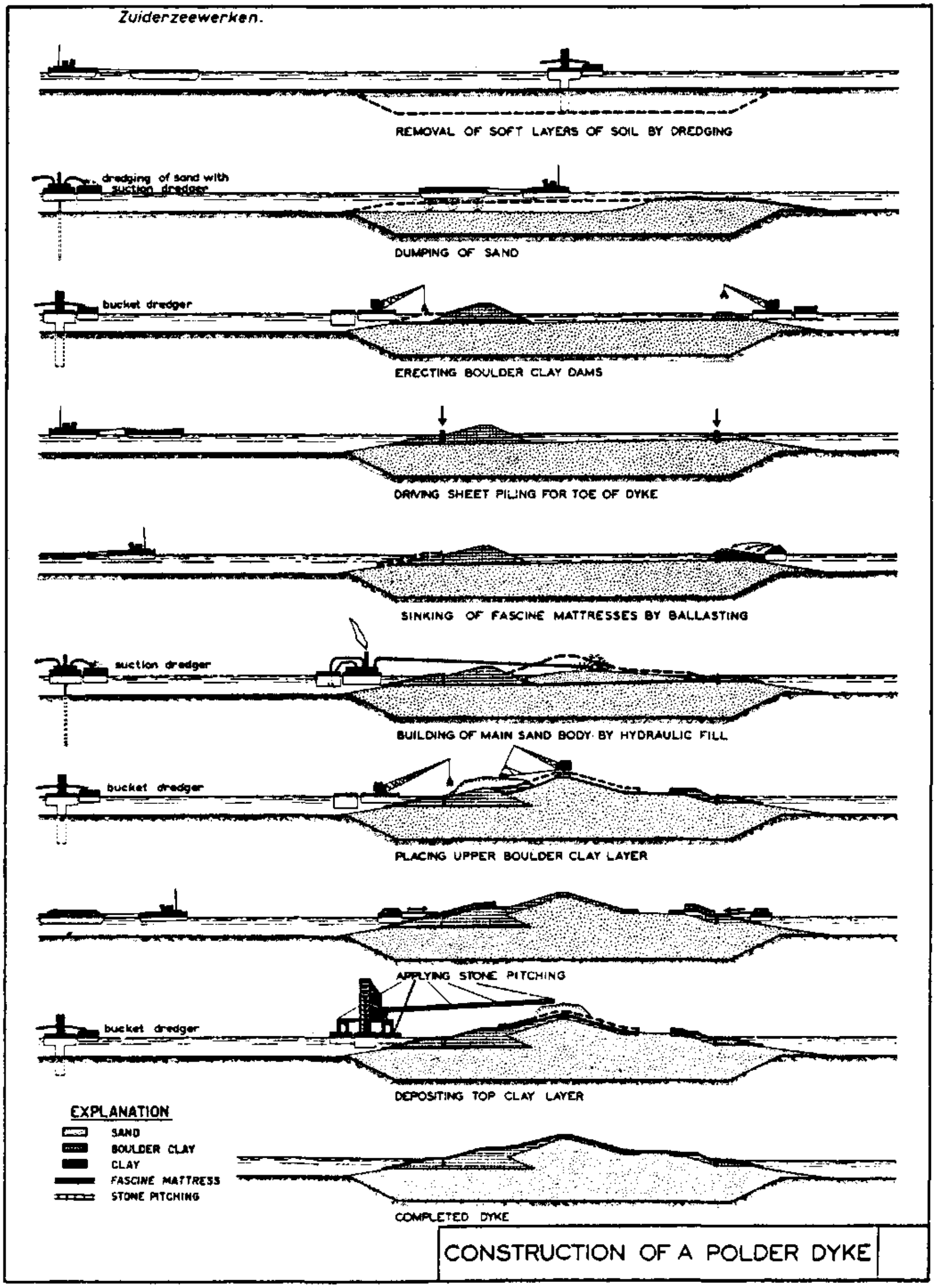
FIGURE 4



CONSTRUCTION OF A POLDER DYKE

RELIABILITY OF DUTCH POLDERDIKES

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Abstract

Most polders in the Netherlands have been reclaimed during the last 800 years. Though the Dutch have gained much experience with construction and maintenance of polderdikes, it was decided to gather more knowledge about the reliability of these dikes. This was one of the considerations for the installation of the Technical Advisory Committee on Water Defences (TAW) in 1965. The technical staff of the TAW, formed by the Netherlands Water Defences Research Centre (COW), is in charge of the investigation of the reliability of all dikes in the Netherlands.
Data on the dikes are collected by the COW. The geotechnical investigations are carried out by the Delft Soil Mechanics Laboratory. The present method with the geotechnical aspects investigating several hundreds of kilometres of polderdikes will be presented, with a short review of the development of this method since the start of this project.

1. Introduction

The landscape in the western part of the Netherlands originally consisted of water and marshes, with optimal conditions for peat formation. This landscape was formed in a geologically short period during the last 10.000 years. In this low area of the Netherlands stirring geological processes have taken place. Repeated floods from both the sea and rivers and also periods of peat formation caused the nature of the soft subsoil. The free game of sea and rivers was continuously threatening the life of the inhabitants of the "Low Countries". In the first centuries of the Christian era no dikes existed and the inhabitants settled on high places, such as pleistocene emergings and streamridges of rivers. In the northern part of the Netherlands people lived on artificially heightened places, the so called "wierden". About the 10th century people started building dikes in order to protect themselves against high floods. The surface of the land before the estuaries had been dammed lay above mean sea-level and also above the level of the inland waterways, so it was possible to drain these areas freely at low tides. The building of dikes continued for areas not previously protected.

After the 15th century it became more and more necessary to build dikes along the inland waterways for protection against inundation. By draining the diked-in area for agriculture, the groundwatertable was lowered, causing settlement of the soft compressible layers. As a result of this settlement, and the influence of a rising sea-level, the surface of the diked-in area was becoming lower and lower. From the 15th century on windmills were used for draining these areas and since the middle of the 19th century pumping-engines are used.

In the 16th century the inhabitants started to reclaim land from the lakes. Small ring-dikes around these lakes were built after which the lakes were drained with windmills. To reclaim land around the isles in Holland and Zeeland, new dikes were built outside those already existing. Outside these dikes the development of clay and peat was still going on so it was possible to continue reclaiming new areas. There was also loss of reclaimed land as a result of peat-digging for energy purposes. Salt was also extracted from peat flooded during periods of high sea-levels.

The remaining lakes and pools were becoming larger under the influence of wind and waves. These lakes were also reclaimed and are called "droogmakerijen". A reclaimed area with a controlled waterlevel is called a "polder". In general the superfluous water inside a polder is pumped out into a "boezem", a consistent system of inland waterways which serves as a provisional reservoir.

Today more than 2000 kilometres of polderdikes have to give protection against flooding of the polders by water from the boezem.

The authority responsible for the upkeep of the dikes of a polder is usually a "waterschap" or "hoogheemraadschap" and in some cases a province. A waterschap is a local self governing body having jurisdiction over the local waters and dikes of a polder. The activities of the waterschappen are controlled by the provinces and the supervision lies with the governmental "Rijkswaterstaat". A complex system of dikes, polders and boezems is always vulnerable and there have been several inundations caused by the bursting of dikes. In 1960 a polderdike near Amsterdam failed in its protective function and a polder in which the village Tuindorp-Oostzaan is situated was inundated with water from the boezem. There was no loss of life but the economical and material damage was considerable.
It was found necessary to pay special attention to the condition and the reliability of all Dutch polderdikes as plans increased for extending towns in the low lying areas. This could not only be a task for the different waterschappen. The complexity of the whole water- and poldersystem and the mutual coherence of the problem needed a central and universal approach, both technical and scientific. So in 1965 the Dutch Government installed the Technical Advisory Committee on Water Defences (TAW). The technical staff of the TAW, formed by the Netherlands Water Defences Research Centre (COW), is in charge of the investigation of the reliability of all dikes in the Netherlands and was founded in 1969. In the period 1965 - 1972 the Delft Soil Mechanics Laboratory investigated a number of polderdikes, in order to develop methods to investigate great lengths of polderdikes in a reasonably short time and with sufficient accuracy. This resulted in a routine approach by which the various proceedings are carried out by the COW and the Delft Soil Mechanics Laboratory. (DSML).

2. Systematic examination of the polderdikes in the Netherlands

2.1. Proceedings of the COW

The COW started the examination by drawing up of a program of urgency for the polderdikes to be investigated, paying particular attention to the economic consequences for the polder and the boezem, resulting from a dike failure.

For each polder a preliminary investigation is made consisting of a study of the history of the polder and the polderdike, a visual inspection of the polderdike, followed by the survey of a number of characteristic cross sections at regular intervals. Pore pressure measurements are carried out in some cross sections to determine the position of the ground watertable.

2.2. Proceedings of the Delft Soil Mechanics Laboratory

A few cross sections were chosen for a preliminary examination of the soil, consisting of continuous borings Ø 29 mm., and cone penetration tests. These examinations were carried out to gain insight into the composition of the polderdike, the different layers of sub-soil and volumetric weights.
Some of these cross sections were chosen for a more extensive investigation. To obtain undisturbed samples for laboratory tests continuous borings Ø 66 mm are carried out.
The distance between borings taken for preliminary examinations was rather large so another method was needed to give a more comprehensive image of the polderdikes. Geophysical and geoelectrical methods appeared to be too rough, or even unmanageable, or just as expensive and time consuming as a close net of preliminary examinations without giving substantial extra information.
During the systematic examination of the polderdikes there was a development in the method of investigation. A lot of geological and geotechnical data was already available and with the increased amount of data it was possible to create a rather continuous image of the subsoil of most of the polderdikes.
The part of the systematic research by the Delft Soil Mechanics Laboratory now starts with the geological description of the polder concerned. Together with the available geotechnical data, a geotechnical profile is set up. The cross sections for further investigation are now chosen with the aid of the geotechnical profile.
The values for the effective shear parameters showed considerable variety and it was decided to make continuous borings Ø 66 mm instead

of the Ø 29 mm borings of the preliminary investigations to provide more data from different parts of the dikes.

2.2.1. *Some geological and geotechnical aspects of the systematic examination*

Figure 1 shows a very simplified geological map of the Netherlands with the contours of the top of the pleistocene deposits below sea level (NAP), which generally consists of dense sand layers with a good bearing capacity.

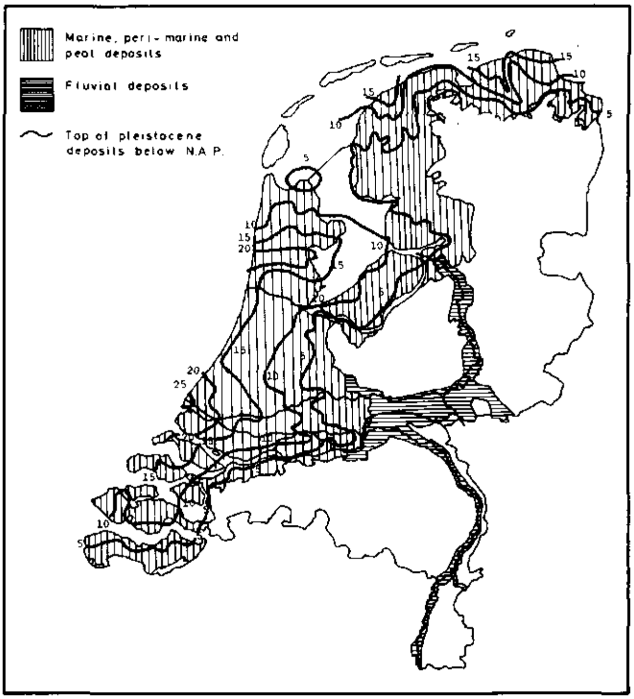

Figure 1. Simplified geological map of the Netherlands.

According to these contours it appears that the bottom of the holocene layers is found at a depth of NAP-20 à 25 m and is rising to the east. The schematic cross section of the western part of the Netherlands (Figure 2) shows that this holocene deposit consists of 4 genetic unities: dune and beach sands, marine deposits, fluvial (peri-marine) deposits and organic deposits (peat). With the exception of the dune and beach sands these holocene deposits mainly consist of compressible clay or siltlayers, often 3 à 6 m thick between which very soft peat layers were formed. In this holocene deposit, sand layers may irregularly occur due to a subsequent filling of old channels and creeks. Detailed and high quality methods of soil investigation are required as the soil mechanical properties of these layers may vary substantially.

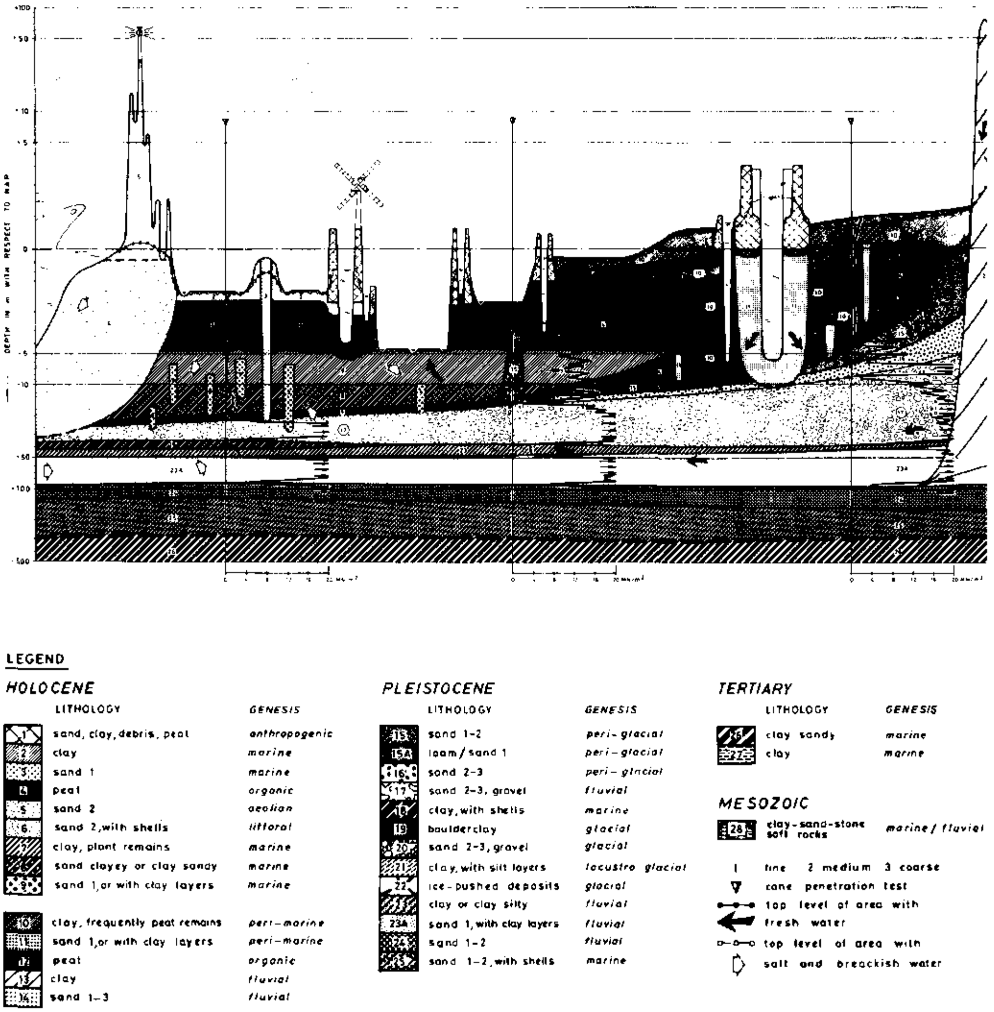

Figure 2. Schematic cross section of the western part of the Netherlands.

For the mapping of tertiary and quarternary deposits the Rijks Geologische Dienst in Haarlem applies the so-called Lithostratigrafic system. This system classifies all natural deposits of the Netherlands which are formed under equal conditions, in the same period in a uniform way and so the holocene deposits are classified to the Westland Formation, which is further subdivided because the marine and peri-marine sediments are deposited during several transgressive, respectively regressive phases.

Due to the close connection between the nature and structure of the subsoil with its genesis, it was obvious to make use of the Lithostratigrafic system interpreting and arranging the results of the soil investigations of the systematic examination of the polderdikes. The importance of the geological research for systematic examination is the fact that the results of the soil investigations (borings and samples) are described and arranged adequately, uniformly and according to one classification. This provides for a mutual interpretation of all soil mechanical parameters which are used for the geotechnical profiles and geometric soil models. Furthermore it is possible to collect soilmechanical data for the statistic determination of effective shear parameters.

2.2.2. *Stability analysis*

In view of the very low stability of the polderdikes to be investigated, it is necessary to use accurate methods for the stability analysis. The continuous borings Ø 66 mm and cone penetration tests give exact information about the layers of the subsoil and the material of the polderdikes. For the stability calculations it is necessary to use effective shear parameters Ø' and c' and the cell test (fig. 3) has been developed mainly for this purpose. This test is a multiple stage stress controlled drained creep test.

Critical stress combinations are determined at several vertical stress levels by reducing the lateral stress carefully with a tap. The procedure used limits the deformation of the sample and also the rate of deformation. These low values were deliberately chosen.

A safety factor of 1 in the stability calculations is coupled to the limit of the permissable deformation, rather than to a shear value and the chosen safety factor then has more significance. The result of a cell test on a peat sample is shown in figure 4.

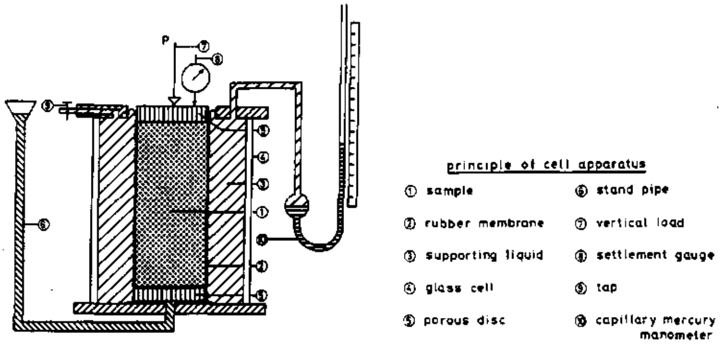

Figure 3. Principle of cell apparatus.

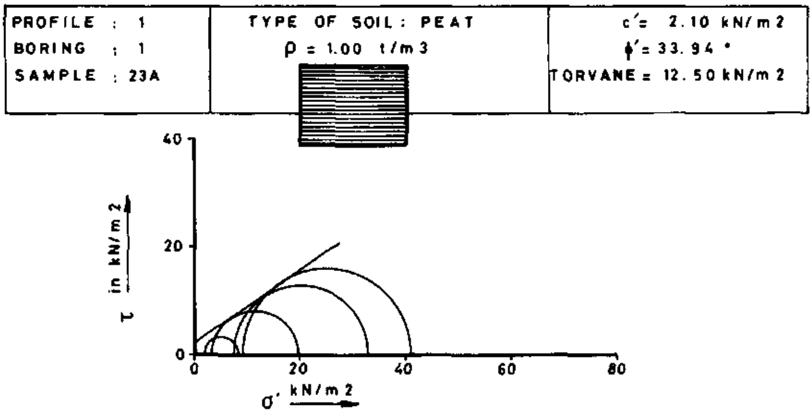

Figure 4. Result of a cell test

The Lithostratigrafic system provides the possibility to determine statistical values for a large number of results of cell tests.
Figure 5 shows the result of a statistical approach to cell tests on peat from the dikes of the Blauwe Polder.
This shows that the calculated mean value corresponds well with the 95% lower bound value calculated by the COW for peat in the western part of the Netherlands.
The stability calculations have to satisfy several requirements: quick, cheap, and using easy to determine soil parameters.

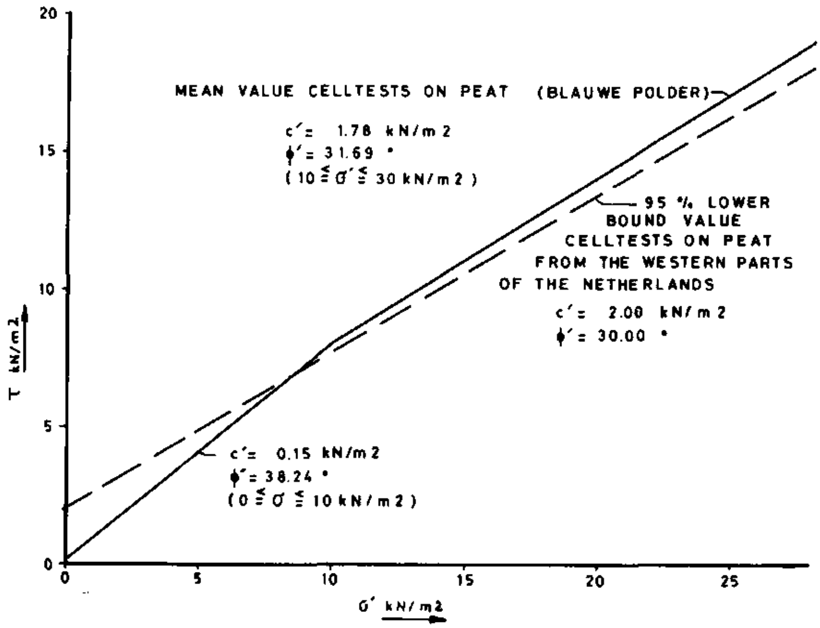

Figure 5. Result of a statistical approach to cell tests on peat.

Finite element methods are not considered and only the orthodox limiting equilibrium methods Bishop and Spencer, by means of a computer program "STAGROM" are now used.
The potential failure surface is assumed to be a circular arc and figure 6 shows a result of a stability analysis on a cross section of a polderdike.

3. The state of affairs and results of the systematic examinations.

This year (1982) about 55% of the systematic examination on the reliability of polderdikes has been completed. Present results show that about 20% of the examined polderdikes do not fully satisfy the criteria chosen for this examination.

LAYER	SAMPLE	ρ t/m3	c' kN/m2	ϕ' in °	LITHOLOGY
①	known from 3 other profiles	1.81	1.04	24.93	CLAY, SAND, RUBBLE
②	mean statistic value	1.06	1.78	31.69	PEAT
③	24	1.62	0.83	23.15	CLAY, HUMIC
④	25A	1.75	1.49	21.44	SANDY - CLAY
⑤	25B, 26	1.45	3.44	19.40	CLAY; CLAY-HUMIC

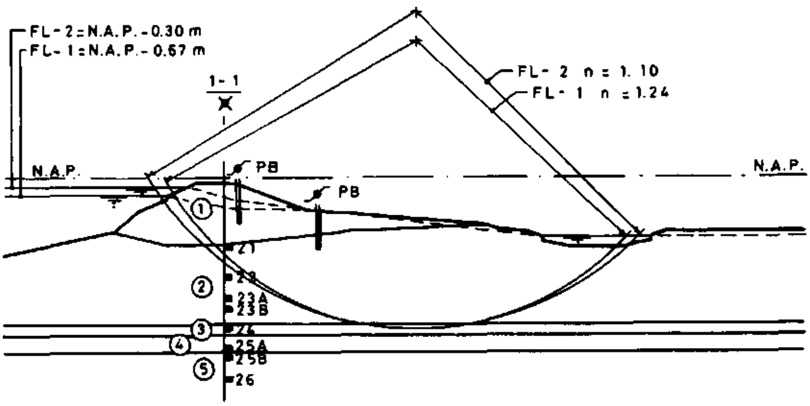

Figure 6. Result of a stability analysis of a cross section of a polderdike (Blauwe Polder).

Acknowledgements

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PROTECTION OF THE CITY OF VENICE AND ITS LAGOON: FLOW OF FRESH WATER AND POLLUTANTS INTO THE LAGOON

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Abstract

Environmental quality control of the Lagoon of Venice is approached by selecting as a key point the budget of matter (water, salt, pollutants) and energy. An inspection of the contributors to the budget from the mainland shows that some are systematically controlled by the local authorities, while the majority of them are seldom controlled. Only some of them appear to be really significant under normal conditions. To measure the discharge from these main contributors, a series of field measurements is in progress and will be presented here. Only some key pollutants are selected: nutrients and some heavy metals.
If the Lagoon is not a quasi-stationary system, then the measure of the exchange between the Lagoon and the Adriatic Sea and between the Lagoon and its bottom must be taken into account. Problems arising in the control of bottom samples are discussed.

1 Introduction

The protection of the city of Venice and its Lagoon is an objective stated by a national law and by local regulations. For such protection, plans have been developed which foresee the installation of fixed and movable barriers at the three inlets to the Lagoon in order to prevent the flooding of the city, and/or the diversion of highly polluted channels. In any case these works affect and may even worsen the present environmental situation, because they will lower the exchange between the Lagoon and the sea or they will decrease the input of fresh water into the Lagoon. Figure 1 shows a small map of the Lagoon of Venice.

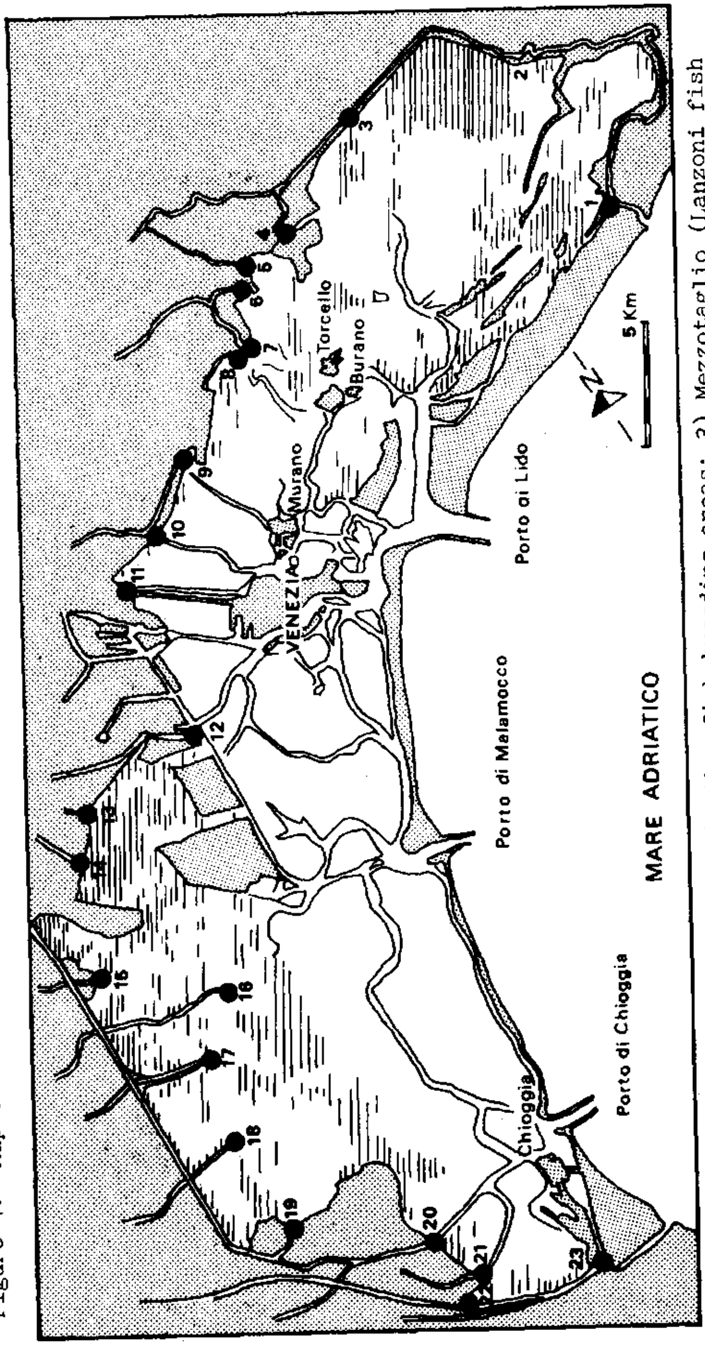

Figure 1. Map of the Venice Lagoon. Numbers indicate points of fresh water input

Legend: 1) Sile River; 2) Canals feeding fish breeding areas; 3) Mezzotaglio (Lanzoni fish breeding area); 4) Silone Canal (Businello); 5) Siloncello Canal; 6) Canal of S. Maria; 7) Dese River; 8) Orsellino Canal (Pagliaga); 9) Orsellino Canal (Tessera); 10) Orsellino Canal (S. Giuliano); 11) Canal Salso; 12) Naviglio Brenta; 13) Bondante di Sotto; 14) Navigable canal; 15) Canal of Lugo; 16) Cornio Canal; 17) Canal of Lova; 18) Cavaizza Canal; 19) Taglio Brenta (Fogolana); 20) Taglio Novissimo of the Brenta River; 21) Scarpion Canal; 22) Morto Canal (Trezze); 23) Lombardo Canal

2 Matter and energy budget in the Lagoon

The aim of the research work concerns the budget of matter and energy in the Lagoon of Venice which is a quasi-closed system. Matter from the canals and rivers of the mainland enters into the Lagoon where it remains for sometime afterwards flowing out into the Adriatic Sea. Eventually some matter can be trapped and also released by the bottom of the Lagoon. At the present stage of the work, all the contributing parts of the budget are being collected for a thorough evaluation of the budget. The final goal has yet to be obtained.
Concerning energy, the purpose is not to achieve a complete budget,since no exchange between the Lagoon and the atmosphere, and the Lagoon and its closed borderline will be considered. Therefore the energy budget is evaluated only as heat (positive or negative) transferred from the mainland and exchanged with the Adriatic Sea.

3 Choice of the channels to be studied

City aqueducts and sewers are controlled by the local authorities who can provide information about the quantities and the quality of their water. Industrial sewers are controlled by a joint authority. Water purification and quality control measures are made with existing systems; others will be available in the near future.
In any case the input of matter from above mentioned sources can be known. On the contrary the situation of rivers and agricultural canals is not known since there is no systematic control. For this reason the I.S.D.G.M. has chosen to investigate the contribution from such sources. It has been confirmed that the rivers and canals carry not only agricultural pollutants but also industrial ones.

4 Morphological investigation

Before starting the measurements a careful field inspection of the rivers and agricultural canals has been carried out. Twenty-three outlets were inspected and recorded. Many of these outlets are usually closed by movable barriers which are opened only in particular situations (flooding, special agricultural or aquicultural periods, etc.). Other canals are rather shallow becoming flooded only under extreme conditions. Still others may not be neglected.

Since the number of field measurements and monitoring system should be as small as possible, a final number of 6 main contributors was selected. On the basis of this choice, more than three-fourths of the input from rivers and agricultural canals are recorded. It must be pointed out that this choice is suitable only during normal conditions, but it is not sufficient if exceptional conditions of heavy rainfalls must also be controlled. In Figure 1 the positions of the outlets are shown.

5 Field measurements

Field measurements were made at the outlets with a houseboat suitably equipped for such measurements (Figure 2) and a utility vehicle. At present only a few of the main contributors have been measured. Measure-

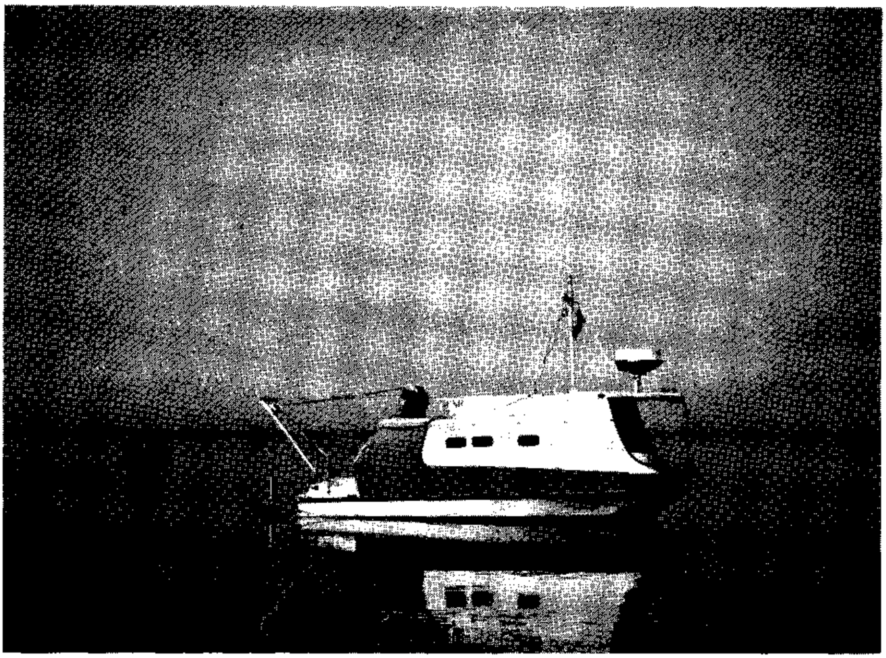

Figure 2. Houseboat "Rivo Alto"

ments were performed under normal weather conditions and were repeated after approximately 6 months to have an idea of seasonal effects. Such effects seem to be unimportant except for temperature. The main difficulty in the measure arises from the tidal oscillations. A spot measurement is meaningless. Also a time series of measurements at half the depth of the channel at its outlet might not be very meaningful due to the stratification of the water (salt wedge). Therefore vertical profiles were measured at 20 cm intervals, approximately every 4 hours. The overall period of measurement lasted 15 days.

Pollutants were detected in offline analysis on water samples. No attempt was made to obtain a profile of these. Only one sample was collected in the layer of fresh river water.

6 Fresh water, salinity, temperature and key pollutants

In each measurement the vector velocity of the water was measured in order to obtain its longitudinal component along the canal. Also salinity and temperature were simultaneously measured.

The possible pollutants are too many to be all measured. Therefore a choice was unavoidable. It was decided to limit the organic pollutants to the nutrients therefore excluding complex organic molecules as those coming from pesticides, herbicides and fertilizers and other similar compounds. Thus the following organic matter was detected: nitrogen as nitrite, nitrate and ammonia; and phosphorous as phosphate and orthophosphate.

Similarly the inorganic pollutants were limited to a few heavy metals: Cu , Fe , Mn , Ni , Hg , Pb. They were detected by exposing a precipitate of the water sample to accelerated protons which excite the x-ray fluorescence of the heavy atoms (PIXE).

7 Mixing processes

Figure 3 shows a typical section of a river somewhat upstream from its

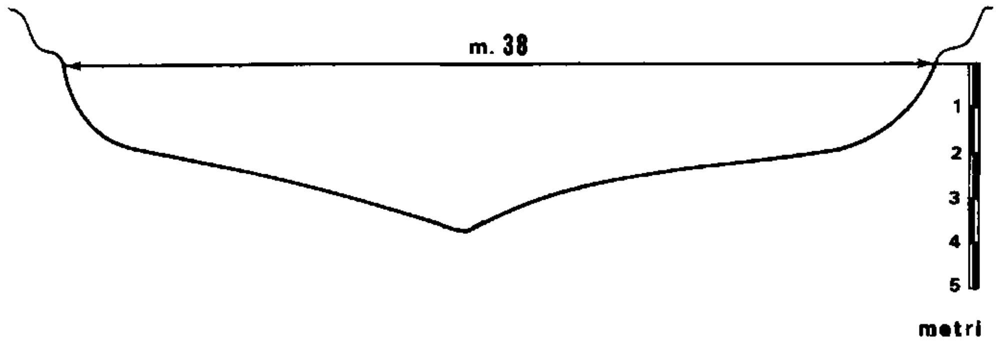

Figure 3. Cross-section of the Silone Canal

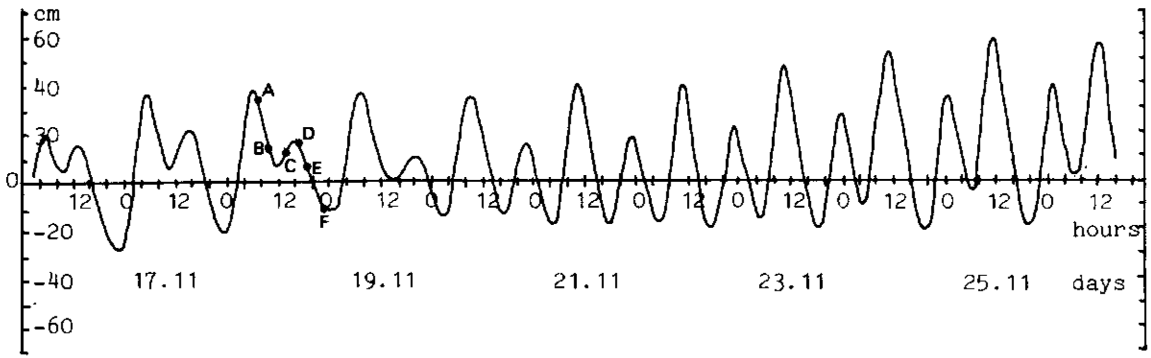

Figure 4. Tide recordings in the Silone Canal (November 17-25, 1981)

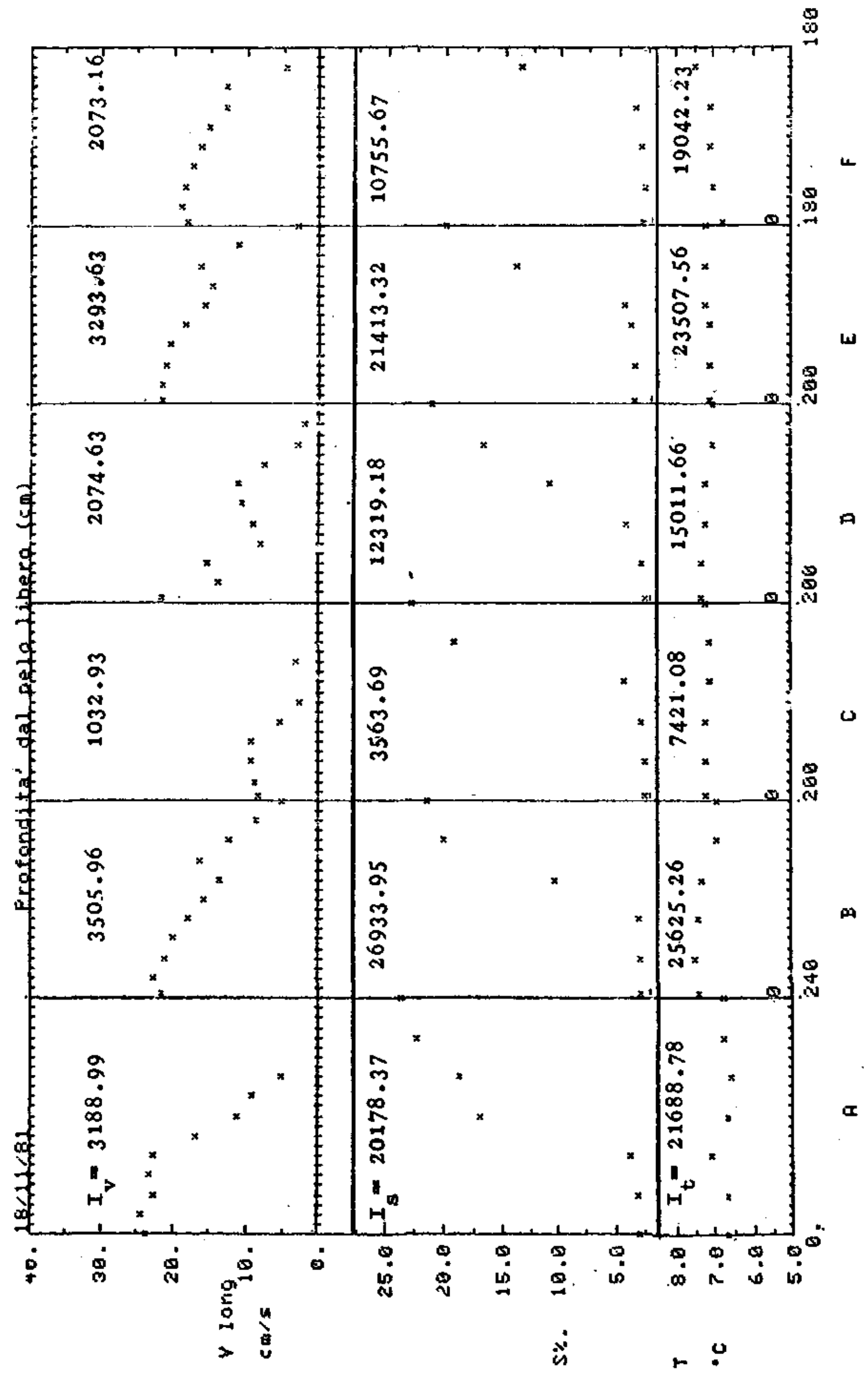
18/11/81
Profondita' dal pelo libero (cm)
V long cm/s
S‰
T °C
I_v = 3188.99
3505.96
1032.93
2074.63
3293.63
2073.16
I_s = 20178.37
26933.95
3563.69
12319.18
21413.32
10755.67
I_t = 21688.78
25625.26
7421.08
15011.66
23507.56
19042.23
A
B
C
D
E
F

Figure 5

outlet. In Figure 4 the behavior of the tide is shown and the time when the vertical profiles were measured. Six typical vertical profiles of longitudinal velocities, salinity and temperature measured during one day is reported in Figure 5. They are plotted versus the depth: the free surface has a depth of zero. Due to the tide the depth changes in each measurement. The numerical value in the rectangle pertaining to the longitudinal velocity corresponds to the integral

$$I_v = \int_o^h v_{long}\, d\, h$$

where h is the depth.

If l is the equivalent width of the river $l \cdot I_v$ equals the water flow through the section of the river. Similarly

$$I_S = \int_o^h S \cdot v_{long}\, d\, h \qquad \text{and} \qquad I_T = \int_o^h T \cdot v_{long}\, d\, h$$

are presented in the rectangle of the salinity and that of the temperature respectively. Such integrals multiplied by the equivalent width l give the salt and heat flow through the section. From Figure 5 it appears that the fluid is sometimes stratified and sometimes partially mixed.

8 Asymptotic values

The integrals I_v, I_S, I_T are obtained about six times each day during the 15 days of field operations. Therefore a running average is computed starting always from the first integral up to the running value. The behavior of the running average for the three integrals is shown in Figures 6,7,8 in a typical example. The running average reaches an asymptotic value. This value multiplied by the equivalent width of the river and by the representative time of the measurement (season, year, etc.) gives the total discharge.

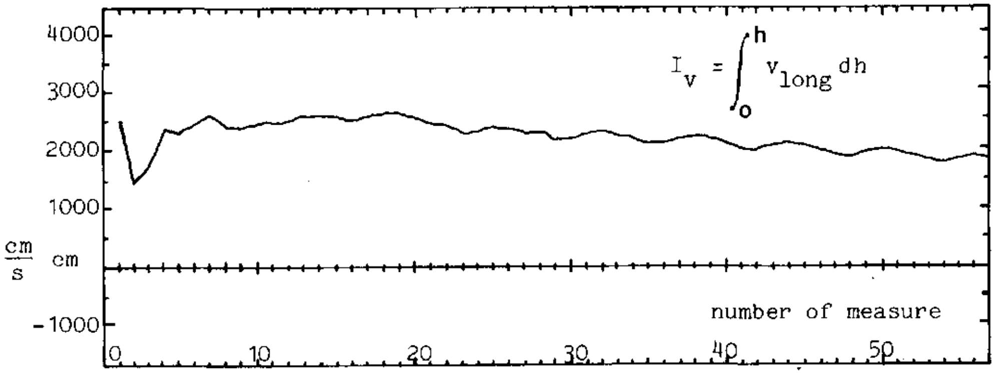

Figure 6

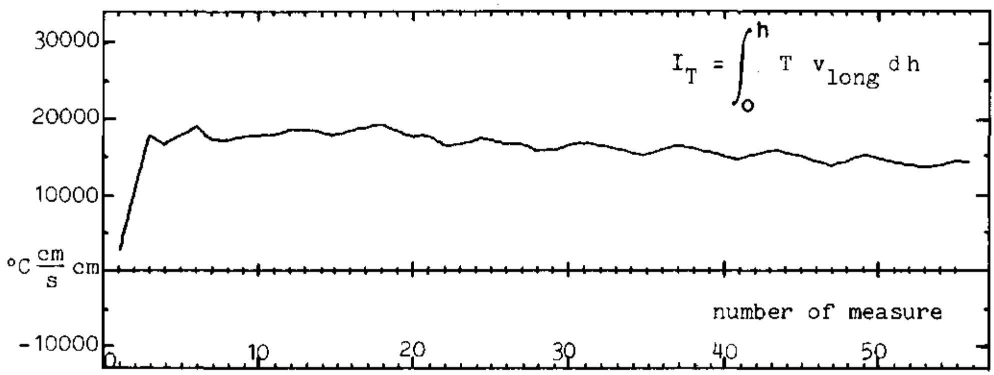

Figure 7

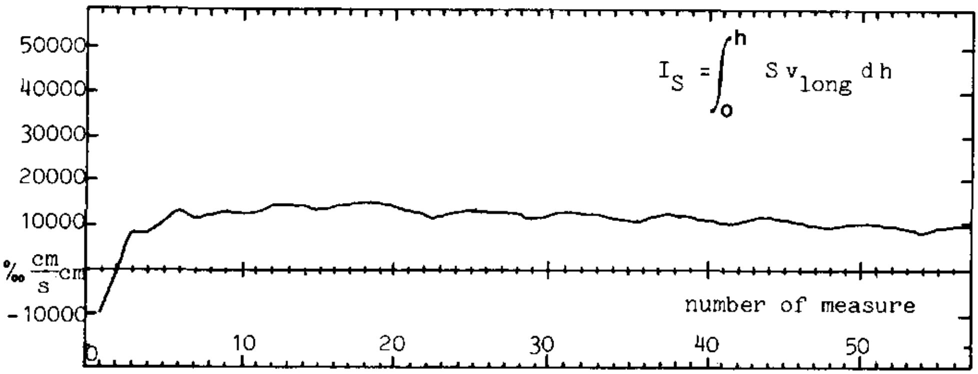

Figure 8

9 Nutrients and heavy metals

As mentioned before, the concentration of pollutants is measured off-line after sampling the water approximately every 4 hours. No clear pattern correlated with the tide has been identified. Therefore the discharge of the pollutant is estimated by multiplying its average concentration by the water discharge. Table 1 reports typical average concentrations for nutrients; Table 2 reports typical average concentrations for heavy metals.

Table 1

Nutrient		Range	Mean value (mg/l)
Ammonia	as N	0.27 - 0.54	0.345
Nitrite	as N	0.063 - 0.100	0.08
Nitrate	as N	1.00 - 2.20	1.55
Total orthophosphates	as P	0.08 - 0.13	0.10
Total phosphates	as P	0.11 - 0.19	0.13
pH		7.3 - 9.0	7.8
Salinity		1.4 - 5.6	3.0 ‰
Dissolved oxygen		6.8 - 10.3	8.3 mg/l

Table 2

Heavy metal	Mn	Fe	Ni	Cu	Hg	Pb
Mean value (μg/l)	180	485	5	13.5	168	31

10 Exchange with the sea and with the bottom

The exchange between the Lagoon and the sea is more difficult to evaluate since the water volumes exchanged during each tide cycle are very large compared to the net outflow. A measurement would require better precision and a longer time series than those achieved in the rivers and canals outflowing into the Lagoon. Unfortunately the experimental conditions for the three outlets to the sea are more restricted and severe than those for the internal canal system.
The measure of the deposit and the release of matter in the bottom of the Lagoon requires many samples to be significant. Moreover the measurement of bottom samples is rather long.
A program to implement the estimation of the budget with measurements at the outlets to the Adriatic Sea and at the bottom has been envisaged. Up to now a hypothesis of quasi-stationary transfer (in cyclic terms) has been often assumed.

11 Modeling

The construction of a circulation model of the Lagoon is foreseen. The diffusion of the pollutants will be superimposed to the circulation.

USE OF HYDROMECHANIZATION FOR HYDRAULIC EARTHWORKS IN HUNGARY

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1 Summary

In our opinion the technology of hydromechanization is one of the most economical and favourable methods in the field of hydraulic construction. When calculating economy, beside the direct comparison of costs the facts should also be considered that a work done so will not be burdened with the costs of land appropriation and compensation and that after completing the work no vast borrow pits unsuitable for cultivation will be left behind. At the same time the need for transport capacity and manpower is at a minimum level which fact, considering the permanent increase of wages, must not be ignored.

2 Introduction

When the construction of hydraulic structures takes place with the use of earth conveyed as slurry and there are suitable working conditions /existence of earth transportable hydraulically and of water in sufficient quantity/ the structures will be economical and techically perfect to such an extern that, for solving their tasks professionals engaged in hydraulic construction must not ignore the advantages of this method.
Construction with hydromechanization has spread since the early

19oo's, due above all to its economic advantages.
In Hungary the first application of hydromechanization had taken place in 1927 to remove sedimentation from a harbour.The mass intrusion of this building practice into Hungary happened after World War II when is was utilized primarily for levee reinforcement and river training tasks.
Due to requirements and possibilities arising from Hungary's geographic features not only there is a possibility to make use widely of the advantages of the hydraulic construction method but in many cases practically the only suitable technique is offered just by it.

With its territory amounting roughly to 93000 sq.km Hungary is located in the lowest part of a basin encircled by the Alps and the Carpathians. Some 75 per cent of its territory is of lowland character, however, as to the origin of floods occurring here it is not the domestic topography that has the decisive role.
In general it is still upstream of the borders that the rivers enter the plains and, partly as a consequence of this, nearly 25 per cent of the country's territory lies under the critical flood level.
As a consequence of the infrastructuring impact of rivers the areas endangered by floods have become at the same time the most valuable and most densely populated regions of the country.
Flood control by levees in the low-lying areas had started in the middle of the last century and it was completed practically by the turn of the century.
As a result of these flood control works, beside local developments made in the 19th century there are at present levees with a total length of nearly 4200 km to guarantee the security of the endangered areas. As to their height and cross section levees were built always in accordance with the current prescriptions which fact, joined by the gradual rise of flood levels, has necessitated a continuous reinforcement of the protective structures.
Nowadays the outlined reinforcement work is to be solved under conditions becoming gradually harder, within an increasingly sensitive environment.On the one hand, the densely populated industrialized or more and more valuable agricultural areas exclude the cre-

ation of borrow pits and, on the other hand, in case of conventional construction with the movement of a great number of machines and vehicles is a difficult task involving the disturbance of the environment.

Beyond economic savings and under the circumstances outlined perhaps the only practicable method is to exploit building material from river beds,to convey and incorporate it through hydromechanization to the site of reinforcement. It is because when using hydromechanization the material dredged off is continuously replaced by the river, the factors interfering with the environment are reduced to a minimum and the working process can be organized efficiently.

Following from the mentioned circumstances not only in levee reinforcement works in Hungary but in the field of hydraulic construction elsewhere as well in the recent decades the spread of hydromechanization technology has been especially strong which has resulted here in a material transport and incorporation performed by the use of the technology in question amounting annually to more than 3 million cu.m.

3 Main application fields of hydromechanization in Hungary

The main application fields of the hydromechanization technology in Hungary are as follows: material transport, regulation of rivers and lakes, reinforcement and construction of levees, landfill work.

In practice the differentiation of tasks in never possible so definitely as indicated by this listing;either the problems to be solved are of complex nature or several criteria have to be fulfilled in the course of planning and execution. In general, the problem of deposition have to be solved for all excavation works.

Within the listed fields of application the widest utilization may be attached to the building and reinforcement of levees, concludingly, in this country the majority of experience has gained in the frame of these works; out of these several technological methods will be presented below.

4 Reinforcement and building of levees

Sediment and bed materials in our rivers can be used excellently for loading and reinforcing the back side of levees although built with various types of earth and different compactness but being nevertheless impermeable.
New levees with watertightness or a slight permeability can also be constructed by hydromechanization however, the dimensions and the volume of material needed in this case represent a constraint to economy.

4 1 Reinforcement of levees using hydromechanization

4 1 1 Excavation of material

In most cases the material needed for the reinforcement of levees is obtained from river beds, utilizing the sediment transport and replacing capacity of rivers. In the desing of dredging work it is the character of the river and the aspects of its regulation that should be considered above all. However, the problem of bank stability should also be stressed here because a large-scale "pit"-like excavation may impose hazard to stability, especially in case of small rivers.

4 1 2 Methods for assembling the delivery pipeline

The slurry is delivered to the site of construction by suction dredger through a delivery pipeline.
The delivery pipeline consists of two sections namely a floating and an on-bank one the latter comprising two parts, delivery and discharge pipes /Fig.1/. The function of floating section is to assure the free movement, manoeuvring and continuous advance of the dredger.

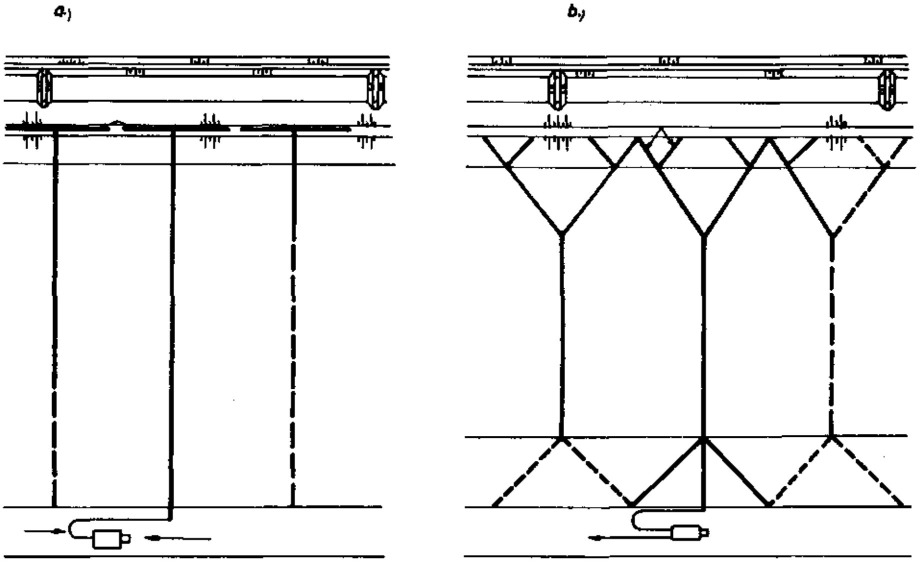

Fig 1 Sketch of pipe-laying

The correct choice of pipe assembling method along with the skillful rapid organization thereof has proved to be one of the basic supports to the hydromechanization technology.

After the slurry field belonging to the individual pipeline arrangements has been filled up the dredger will, of course, pass on and connect itself to the next pipe section; concludingly, it is essential that by the time of this change the new section should be completed. In a general formulation: when, for example, the dredger is operating at the on-bank section "n" then the disassembling of section n-1 and, using the parts thereof, the assembling of section n+1 is being done.

Also to assure the continuous operation of the master machine a T-or maybe a Y-shaped assembly of the on-bank section is performed, occasionally along with the application of valves at the bifurcation points.

The most favourable distance between the delivery pipe sections can be determined expediently through economic calculations.

In such calculations two contradicting aspects should be considered. Delivery sections located at greater distances while involving lower mounting cost will, due to the increased distance of delivery, result in reduced output whereas a system with smaller spacing will result in higher cost for mounting but at the same time in increased output.

For the calculation of economy a possible method is presented here the concept of which is:

$$N=TA-K/t$$

where

N - specific benefit /forint per hour/

T - specific output /m3/hour/

A - unit cost/forint per m3/

K - cost of mounting/forint/

t - operation time of a pipeline /hour/.

The results obtained from calculation can, of course, be modified by the site conditions /e.g., great distance for delivery/ but as a starting base the presented calculation may be used.

In case of levees to be reinforced and with the T-shaped mounting system the delivery pipe leading to the slurry field to be filled is laid parallelly to the axis of the levee. Discharge from the slurry pipe takes place generally with free outflow, the end section being turnable by angles between 30 to 40 degrees laterally and by an angle of 45 degree upward. The pipe ends formed in this manner are continuously transferred in accordance with the filling sequence of slurry fields. The distance between discharge places can be determined on the basis of experience gained in the site /as a function of the spreading ability of the material/; requirement is, in general, to assure a uniform level of filling. In case of a Y-shaped mounting shown in Fig.1/b the lengthening of the pipeline on the crest is unnecessary because discharge directly through the delivery pipe is possible.

4 1 3 Formation of slurry fields

The function of slurry fields is to receive the material transported

by hydromechanization to the site of incorporation or to the immediate vicinity thereof, where the solid fraction is then settled.
As the material of dikes around slurry fields /compartment dikes/ the layer of humus removed from the levee to be reinforced is utilized.
The choice on the width of slurry fields is governed by the volume of material needed and the space available.
A narrow slurry field will result in a necessity of heightening the dikes and an increased burdening thereof while in case of broader fields the volume of earthworks for preparation and completion and the required area will be greater.
Compartment dikes should be dimensioned as an earth structure holding water. This is of especially importance along narrower flood channel sections touching populated areas where, in order to prevent damages, the use of higher and more compact earth structures is necessary.
The final determination of the most favourable distance between dikes and the dimensions thereof can be made expediently on the basis of experience gained with test operations, in the knowledge of the angle of repose.
Primarily to prevent the inundation of the more remote parts of the working area s casket like partition thereof by means of cross dikes is desirable.

4 1 4 Filling of slurry fields, drainage

The title of this chapter intends to give emphasis to the fact that these technological working phases are connected closely to one another so that because of the interaction between them they cannot be separeted.The bifurcation of the shore pipeline running to the levee to be reinforced is achieved generally by the use of valves. Through such a solution continuous operation may be assured within each pipe arrangement. Within sections belonging to the individual arrangements of shore pipelines the filling sequence of slurry fields is determined by the current possibilities for drainage.

Theoretically, drainage can take place either across the dikes to wards the outer side or across the levee towards the flood channel. Either of these is chosen water outlets or pumping sites will be necessary. Using these and through choosing a proper sequence of filling the excess water can and should be directed. Depending on the location of crossing possibilities in principle three types of filling arrangements can be formed. /Fig.2/.

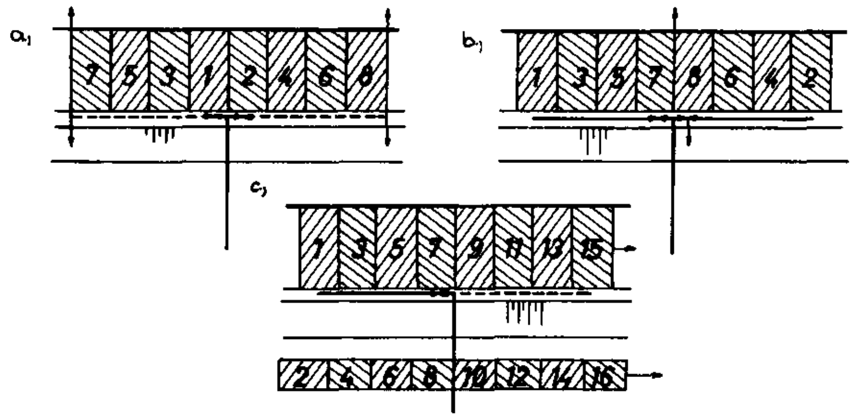

Fig 2 Sketch for the sequence of filling the slurry fields

When the creation of outlets is possible at the two ending points of the T-shaped pipe branch then it is sufficient that both branches of the discharge pipe on the levee is laid only to the first point of pumping while the other pipes will need preparation only.
For instance, as shown in Fig.2/a the operation will start at field No.1, then, continuing it at field No.2, the water is driven away from the valves and the pipe branches are always lengthened. The numbering of fields indicates the sequence of drainage.
In cases contrasting the above situation namely when the deepest point suitable for drainage is located at the middle of the operating discharge section, opposite to the distributing valve, then both branches will be built up, operation will start with the filling of field No.1 and, after its filling, a change will take place for field No.2. By a gradual shortening of the pipe section assembled completely on the levee water inside will be driven toward the outlet /Fig.2/b/.
In cases where in the vicinity of a given pipe section there is a

borrow pit in the flood plain which has to be filled up an arrangement forming double T may be chosen in a way where, for instance, the left branch on the levee will be assembled completely while in the flood plain both the left branch and the closures on the right hand side will assembled only to the first fields. After the dredger connected itself to the pipeline fitted together in this way in a sequence shown in Fig.2/c first the fields at the left hand side and those at right will be filled. As a result of water diversion in the same direction as the unidirectional advance of building the outlet is located at the farther depressions of the prepared slurry field.

From the viewpoint of drainage, from among the operation methods described the one shown in Fig.2/c is the most advantageous while the method where the wather is driven together is the most unfavourable because of the gradually lessening settling field, namely, when the last fields are being filled the load of dikes will increa se. In special cases, of course, the combination of the three described methods may also occur. Doing so the solution can be concluded plainly from the obove presentation. The methods presented here guarantee the permanent operation of the dredger.

The methods shown in Fig.2/a and 2/b may be applied when the drainage of slurry water discharged by on individual delivery pipe has to be executed independently within the system.

In case of the method indicated in Fig.2/c the excess slurry water from more than one delivery pipe can be elevated or drained off from the slurry field at corresponding points.

The sequence and system of filling have to be planned depending on the possibilities of drainage. In a case shown in Fig.2/a and at b the spacing of outlets should be more dense in the slurry field being just filled. The crossing of compartment dikes can take place by a culvert or by used delivery pipes installed in advance or by means of syphon. Based on the foregoing it can be realized that after a choice has been made on the technology of levee reinforcement the planning work may be started expediently with the design of the drainage system while the further features are to be studied and formed depending thereon.

Behind the levee the drainage of water discharged outside the slurry fields takes place toward a recipient through a collector canal. In order to provide protection against underseepage in areas of higher value or in cultivated land the collector canal may be located expediently along the outer side of the dike. In this case the same canal can be used to collect water appearing as underseepage and to drain the water of slurry as well.

4 1 5 Description of the technology of earthworks

In Hungary several variants of levee reinforcement by hydromechanization is known and applied. The proper solution can be chosen, of course, by considering the task to be solved and the local conditions. Making classification from the viewpoint of tasks to be solved a few characteristic examples are presented below.
The presentation starts with the description of technologies applied for the reinforcement of levees at their outside slope since the case occurring most frequently in the application of hydromechanization in Hungary is this. One of the simplest technological variants is seen in Fig.3: reinforcement on the outside slope without heightening.

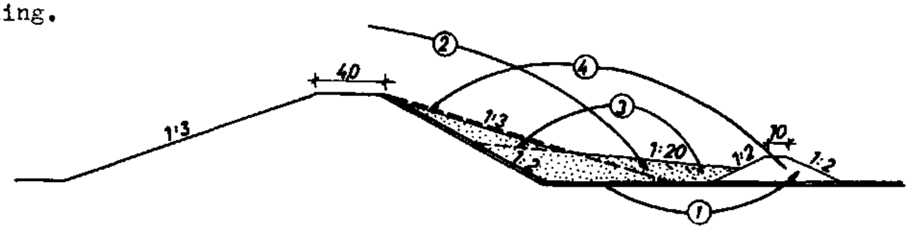

Fig 3 Levee reinforcemet at the outside slope without heightening

A slightly improved version of the above technology is the case presented in Fig.4: reinforcement of a levee on the outside slope along with supplementation in height with remote transport.
In favourable cases the cohesive impermeable material needed to heighten the levee can be obtained by grading the slope facing the channel as shown in Fig.5.

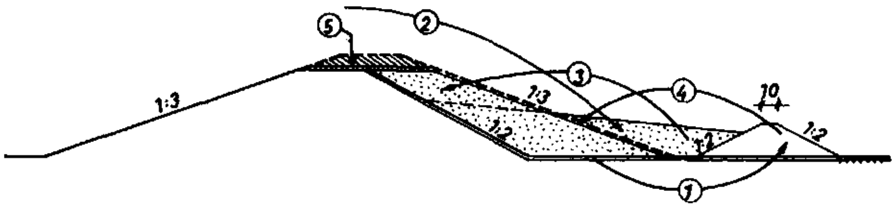

Fig 4 Levee reinforcement at the outside slope with heightening

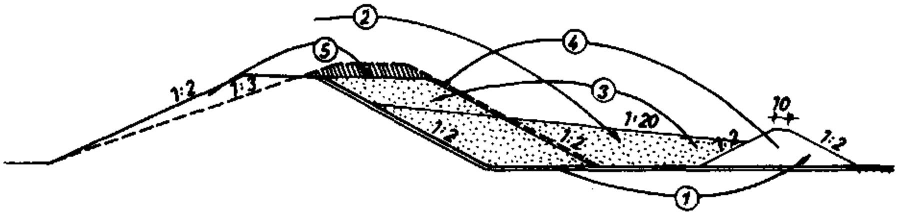

Fig 5 Levee reinforcement at the outside slope with heightening and slope grading at the other side

Shown by experience one of the most widely used methods is that seen in Fig.6.

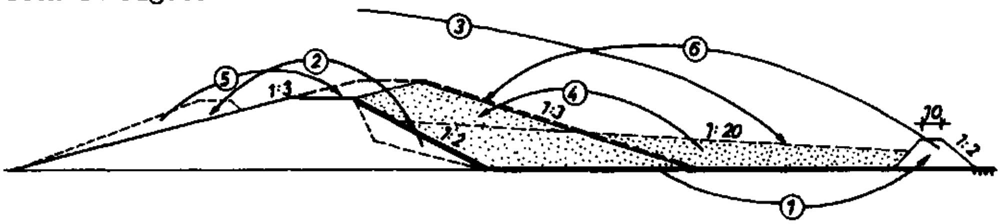

Fig 6 Reinforcement at the outside slope. Heightening by using the cohesve material of this slope

The described technologies represent the principal basic cases which can be utilized as characteristic types. Other combined solution may of course, also occur, however, in fact they can be derived from the aforementioned ones.

4 2 Levee construction

Similarly to those described in the previous section the technology of hydromechanization can be used to build levees, too. However, as mentioned before, the sphere of application is substantially nar-

rower than for levee reinforcement.
The items described in section 4.1 apply also to the case of levee construction in the field of material exploitation, mounting delivery pipelines, forming slurry fields, providing drainage and filling of slurry fields.
From the view point of earthworks technology there are two basic cases to be distinguished.
In Fig. 7, within certain limitations, a case spread in a relatively wide sphere is shown. Here such a version of levee construction by hydromechanization is seen where the construction of the impervious body of the levee takes place in advance in the convertional manner.

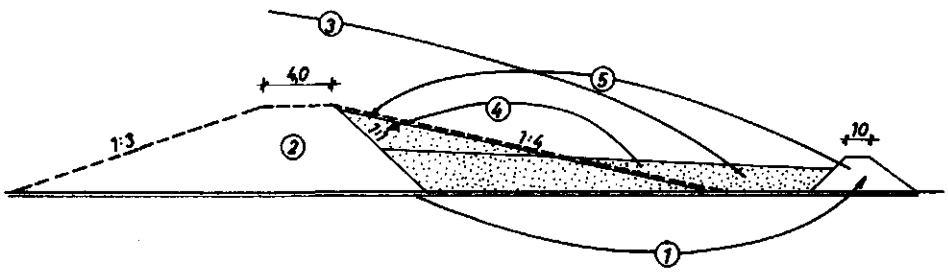

Fig 7 Levee construction Building of impermeable body by means of remote transport

In Fig. 8 such a building method is presented where the levee is constructed in its whole cross section by the use of hydromechanization.
When designing the presented method, the dimensions of the body should, of course, be determined with careful calculations.
Following from the periodic execution of earthworks the assurance of continuous work for the dredger requires the creation of more than one working place.
The section of delivery pipeline connected to the discharging pipe can be laid expediently in the slurry field; this requires pipe assembly to be taken place in sections, repeated at each level.
Beyond thosen mentioned above an additional advantage of the described technology is that the work of construction can be made independent of the elements of weather and water regime to a considerable extent and the individual phases of technology can be organized

in a connected sequence.

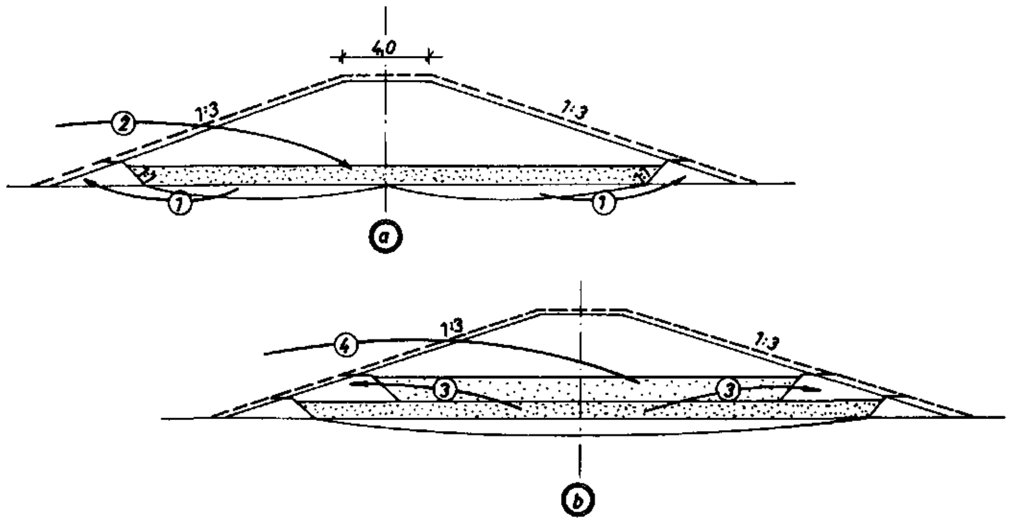

Fig 8 Levee construction with hydromechanization using granual material

The outlined advantages may appear in an increased measure in densely populated countries with limited usable land where the tolerating capacity of the environment against the described harms is continuosly declining. Due to the nature of her territory Hungary may also be ranked among countries of this type; here, due among others to the mentioned reasons, during the recent decades the technology of hydromechanization has spread over wider and wider fields.

LABOUR-INTENSIVE POLDER CONSTRUCTION IN INDONESIA

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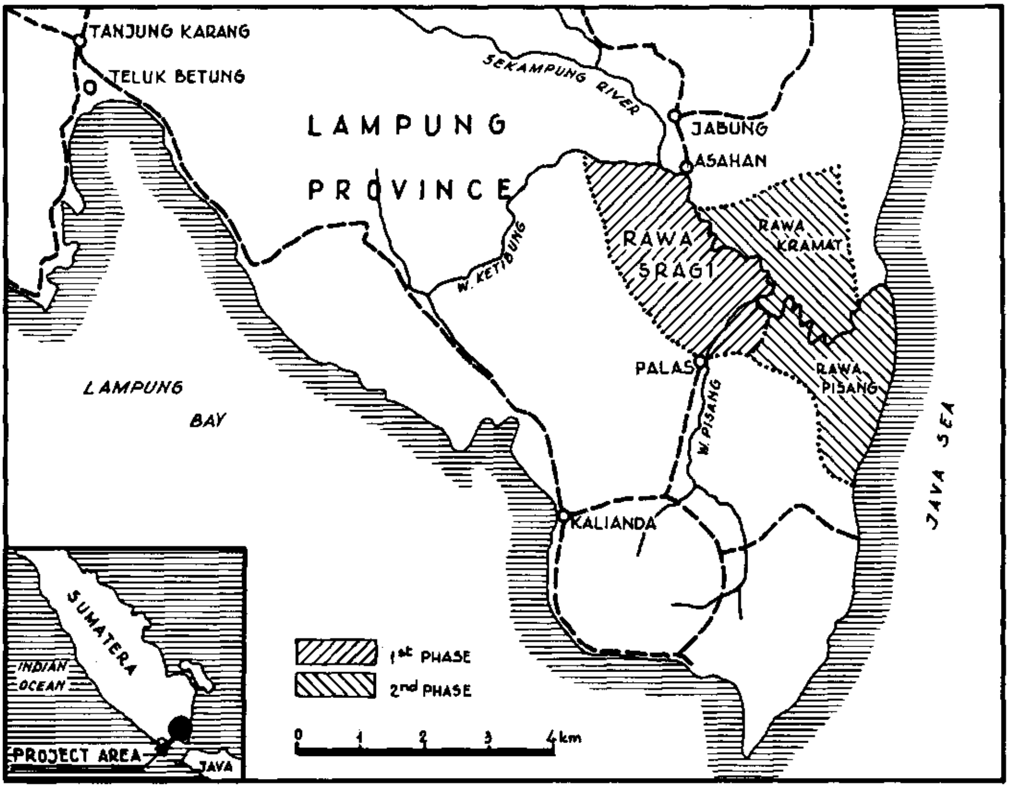
Abstract

This paper deals with the technical implementation of the Rawa Sragi project in Indonesia.
A large part of the construction was carried out manually. Only the works which were difficult to construct by manpower, such as deep drains, were carried out by heavy equipment in combination with manpower.
Because of the labour-intensive nature of the works, which were executed by several relatively small contractors, a rather extensive supervisory organization had to be established.
After the greater part of the implementation had been completed, it was concluded that, although manual execution was slightly more expensive than mechanical execution, the quality of the manually constructed embankments was considerably better than that of the embankments constructed by heavy equipment. Moreover, the additional cost is very well justified by the fact that the project provided employment for a large number of people while a large amount of hard-currency expenses for purchase of foreign-manufactured equipment was saved.

1 Introduction

1.1 General

This paper is based on the experience obtained during the construction



of the Rawa Sragi swamp reclamation project in Indonesia. Although the technical aspects of this project are very interesting (rather complicated soil properties), this paper will mainly deal with organizational matters.
For the greater part the construction was carried out manually. Only works for which, from a technical point of view, manual construction would be very difficult, such as deep drains, were carried out by heavy equipment in combination with manpower.
In connection with the selected construction methods a rather extensive supervisory organization had to be established.

1.2 The project

The project area of gross 10 000 ha is situated along the downstream part of the Way Sekampung river in the Lampung Province of Indonesia (see map).

The project aims at improving the living conditions of farmers engaged in agriculture in the area and reclaiming new land for settling. This is attained by improvement of the water management, i.e. providing a low-technology flood protection and drainage system. At this moment drainage is accomplished by gravity only, while irrigation is limited to a small area.
A second phase of the project, covering some 15 000 additional hectares is in the implementation phase at this time (see map).

1.3 Background and History

As a result of an increasing population pressure in Lampung, spontaneous settlement in the project area started in 1952. Up to 1974 all the reclamation activities, including forest clearing and land levelling, were carried out by the settlers themselves. In 1974 the Department of Public Works started a programme for improving the works made by the settlers.
After negotiations between the governments of Indonesia and the Netherlands in 1977 an agreement on technical and financial assistance was reached. For the technical assistance Euroconsult, Arnhem, the Netherlands, was requested to collaborate with Public Works on the execution of the project.

2 The selection of construction methods: mechanically of manually

The flood protection and drainage works comprise the construction of river embankments, the excavation of main, secondary, and tertiary drains, and several structures including the new diversion works and those, for water conservation and flood protection.
Considering the high rate of unemployment (especially in Java, but in Lampung as well) it was the desire of both the Indonesian government and the Dutch government that the execution of the project be as labour-intensive as possible. Notwithstancing this main criterion the

selected construction method should of course be feasible from a technical point of view and, moreover, guarantee completion of the construction within a reasonable period of time.
On the basis of these criteria it was decided that manual execution would be applied on the construction of the river embankments (relatively favourable soil conditions), the excavation of tertiary drains (dimensions manageable by hand tools), and the excavation of some of the smaller secondary drains. The construction of the structures would of course also be carried out manually.
Works to be executed by machines comprised the larger main and secondary drains the dimensions of which were too large (and the water depths too great) to enable execution by manpower.

Some figures on earth movement

earth movement (excavation and compacted fill)	2 492 730 m^3
length main drains	40 805 m'
length secondary drains	46 185 m'
length tertiary drains	207 500 m'
length river-embankments	20 551 m'
number of main structures	2
number of secondary structures	24
number of tertiary structures	148

3 Organization

3.1 The contractors

Although from an organizational point of view it might have been attractive to have all the works executed by only one contractor (total contract price Dfl. 18 million), it was decided to tender a total number of approximately 20 contracts. This was not done because Indonesian contractors capable of handling large contracts were not available. As a matter of fact quite a number of large contractors (generally semi-governmental) are operating on the Indonesian (and

sometimes international) market.
The main reason for tendering in smaller contracts was that according to the policy of the Indonesian government small contracts have to be executed by locally licensed contractors. That way the construction budget for the project almost entirely contributes to the local economy. Moreover, smaller contractors are usually better geared for labour-intensive execution of construction works.

3.2 Supervisory structure

The disadvantage of having many contracts is that the organization of the supervision is made more complicated. The number of supervisors required, the quantity of correspondence, and the number of progress-reports necessary is much more than if only one contractor is involved. Quite a large supervising organization was thus required, consisting of the following personnel:

- 2 construction engineers,
- 2 chief-supervisors,
- 20 supervisors,
- 2 surveyors,
- 2 mechanics.

4 Execution

4.1 General

The execution of earth works for a swamp reclamation project is - more than any other project - dependant on climatic and field conditions. Before construction started the Rawa Sragi project area was generally flooded between December and April. During that period execution, either manually or mechanically, was impossible. Even during the dry season the construction was often hampered by heavy rainfall and occasional floods which inundated the construction sites. Consequently the contractors had to mobilize manpower and equipment for an effective period of 6 - 7 months only and within that period had to reckon with suspension of the work of sometimes up to 1 month.

In many cases they did not succeed in completing the works within one construction season and therefore had to leave the jobsite and to re-mobilize after the floods had receded. Apart from the repeated cost of mobilization this often entailed repair-cost of flood-damages to unfinished works.

4.2 Manual execution

4.2.1 Recuitment

The recruitment of manpower was not an easy task for the contractors. Although efforts were made to employ local labour it appeared that the area surrounding the project could supply only about 20% of the labour force of approximately 2500 labourers. Therefore the majority was recruited from unemployment areas in Java, between 600 and 1000 km from the project.

It is estimated that the total time between starting the first recruitment-rallies in Java and commencing construction on the project with a group of 200-400 labourers was approximately 2 months. This means that each contractor participating in tendering had to establish a recruitment organization long before receiving a "letter of intent". First of all a local agent (sometimes a sub-contractor) started looking for foremen, who each would gather a group of 30 - 50 workers. These foremen in general asked a substantial advance payment, covering the cost of travelling by train and ferry to Lampung and at least a one-month salary for all of his people. Officially for each labourer travel and work permits had to be requested; whether this in practice really happened is not known.

4.2.2 Construction of embankments

Basically, the construction of an embankment has to be carried out in 3 main operations:

a) preparatory activities,

b) production activities,

c) complementary activities.

For the preparatory activities, consisting of clearing of trees and other vegetation and subsequently stripping of tree-roots and stumps, generally the locally employed labourers were used. They received daily wages and normally worked eight hours a day.

The labourers who came from Java refused to do any such work. They had come to earn as much money as possible, which was only possible via a piece-work system. Therefore they were put on production activities, i.e. excavation of the soil from borrow pits or drain, filling in horizontal layers and compacting each layer.

Each foreman leading a gang of 30 - 50 labourers more or less subcontracted a section of 50 or 100 m of the embankment. Each of his people, irrespective of the kind of work he was doing (excavation; transporting the soil by yoke; levelling and compacting) received an equal share of the bargain.

This way of working, i.e. subcontracting very small sections, made the supervision very difficult because the job-site became rather unsurveyable. Generally, construction of an embankment (or any other ribbon-shaped earth work) is started at one point and develops in only one direction, following the sequences of operation. Whereas, with so many subcontracts it could happen that the work at a location far from the starting point was almost completed while at another location near the starting point hardly any progress had been made.

It was attempted to solve this problem by prohibiting subcontracting but this resulted in large numbers of subcontractors leaving the uncompleted work which new subcontracotrs refused to complete. Subcontracting to some extent was therefore unaivoidable but consequently daily supervision had to be quite intensive.

4.3 Mechanical execution

4.3.1 Introduction

Although the bulk of the construction was carried out manually, a still quite substantial part, such as excavation of large main drains and their ambankments, was carried out by earthmoving equipment in combination with manual labour.

4.3.2 Equipment

The excavation equipment was used for the Rawa Sragi project was partly owned by the Department of Public Works and partly by the contractors themselves. The equipment of the Department consisted of 1 large floating hydraulic excavator, 1 drag-line and 9 hydraulic excavators. The equipment owned by the contractor consisted only of hydraulic excavators; their total number was not constant during the construction period but averaged 7.
Contractors who used equipment supplied by the Department of Public Works, had to bear the cost of operation and maintenance only, while all other costs were borne by Public Works. Unit rates for this equipment were calculated in this basis. Before the contractor received the equipment a separate contract was made concerning the use of each machine.
Contractors who used their own equipment, in general requested an advance payment of 20 % of the contract price in order to purchase new equipment.

4.3.3 Mobilization

The mobilization of the equipment was quite a laborious undertaking. After disembarkation in the nearest harbour (approx. 90 km from the project) the machines were transported by low loaders via muddy roads of a very poor quality (with bridges which had to be reinforced) to the edge of the swamp.
Since in general excavation of drains has to be started at the downstream end, in most cases the excavators had to travel along the full length of the drain before any production-excavation could be started. For doing so the machines moved slowly on top of tree-log mattings while simultaneously digging a small drain and using the spoil for making a small dike. Although the speed was very limited (under optimum conditions not more than approximately 1 km/week) this system had the advantages that firstly the access of the following excavator was much easier and, secondly, the thus created drain could be used as

a waterway for personnel and fuel.

4.3.4 Compaction and finishing

In the Rawa Sragi project only production activities, that is excavation and filling of embankments, can be carried out efficiently with heavy equipment.
The preparatory activities, clearing and stripping, require too many machine-movements and are therefore cheaper to be carried out by hand.
The complementary activities, compaction and finishing, were also carried out manually because the nature of the excavated soil, wet and sometimes partly clay, made it very difficult to move with the excavators on top of the freshly filled material.
From a technical point of view the most desirable system of construction would have been to fill layers of not more than 0.25 - 0.30 m and to have each layer compacted thoroughly such as was done with manual execution.
This, however, would have required the excavators to travel 8 - 12 times along the same drain/embankment which is extremely expensive. Therefore, the soil was deposited in heaps in the filling-areas in one or sometimes two movements and then left for a couple of weeks to dry sufficiently.
As soon as the labourers could walk on top of the fresh fill, they started spreading and reworking the soil in layers of not more than 0.25 m and reducing the clod size of the material to a diameter of less than 0.10 m. Subsequently compaction was carried out by concrete hand-tampers and hand-operated vibrating rammers.
The application of campaction-rollers and sheep-foot rollers has been experimented with but was found to be less suitable.
Although the degree of compaction of the mechanically filled embankments was quite satisfactory with little or no hollow spaces and sufficient consolidation it was noted that the compaction of the manually filled embankments was considerably better.
This was due to the fact that with manual execution the rate of progress was much slower and that during the execution the embankments settled considerably. Also settlement of the subsoil was already partly

compensated for when the embankment was finally at design height. Therefore the initial settlement of the embankments executed by manpower was much lower.

5 Comparisons and Conclusion

5.1 Some comparisons

The average construction cost of manually constructed river embankments was approximately Ind.Rp. 1900/m^3 (=Dfl. 6.60; 1980). This price included all costs of clearing, stripping, excavation, filling and compacting, finishing and grass sodding.
The cost of constructing comparable embankments by heavy equipment is estimated at approximately Ind.Rp. 1700/m^3.
In general the quality of manually filled embankments was considerably better than that of mechanically filled embankments.
The fill material as heaped by equipment sometimes contained undesirable matter, such as wood or peat, which because of the relatively thick fill layer could not always be detected and removed.
The project provided employment for an average number of 2500 labourers. If a capital-intensive construction system would have been applied the required number of labour would have been 300 - 400.
The supervising organization consisted of 28 persons. For a capital-intensive execution a total number of 18 persons would have been required.

5.2 Conclusion

Although under the local circumstances manual execution was approximately 20% more expensive than mechanical execution, it can still be concluded that a labour-intensive construction system is favourable for a project like the Rawa Sragi project.
Apart from the fact that the quality of the manually constructed embankments was better than that of the embankments constructed by heavy equipment, it should be realized that the project has provided employment for a large number of people while a large amount of hard-currency expenses for purchase of foreign-made equipment was saved.

CONSTRUCTION OF POLDERS IN SURINAME

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Abstract

The construction of polders is characterized by the low position of the soil surface in relation to hydrological parameters and the often uncompleted ripening of the soils. Construction methods in Suriname were adapted to these conditions. Under pressure of a growing need for reclaimed land and the scarcity of skilled labour construction methods changed. This paper deals with the execution of polders in Suriname nowadays, with emphasis on the construction of ricepolders. Various aspects of clearing the original vegetation and peatlayers are dealt with. Other aspects in this paper are execution problems and their solutions related to logistics, low bearing capacity of the soils, non cohesive soillayers in the subsoil, machine efficiency and cost aspects.

Introduction

The Republic of Suriname lies on the north coast of South America. It is bordered in the west by Guyana, in the east by French Guyana and in the south by Brasïl. Geologically Suriname can be divided in three zones, the young coastal plain, the old coastal plain and the interior. The young coastal plain is formed from mud of the Amazone river transported to the Guyanas by sea currents (Figure 1). Polders are mainly developed in the young coastal plains and to a much smaller extent in the older coastal plains.

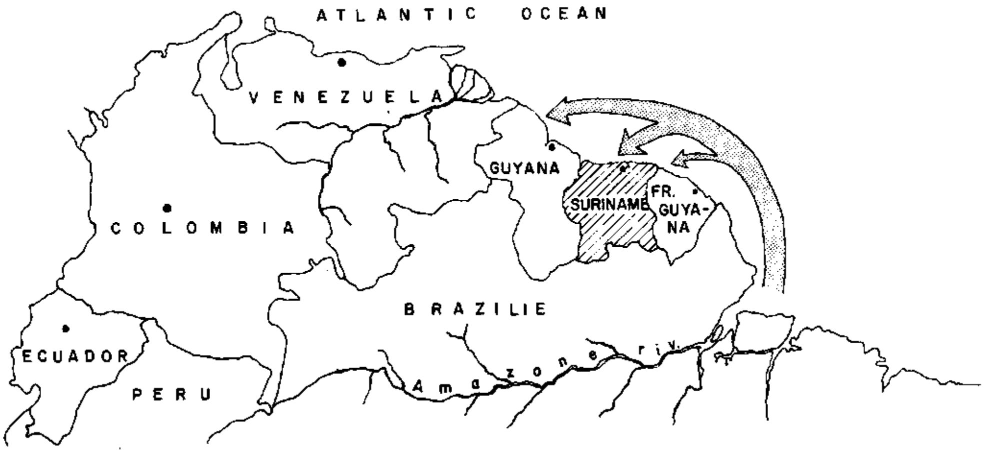


Fig. 1 Situation of Suriname. Source: De Grote Bosatlas Wolters_Noordhoff 1971

Soils

Details of soils are given in Brinkman and Pons (1968). It is important for the execution of polders that the young coastal plains exist of alluvial claysoils with a flat topography, from time to time interrupted by sand or shell dunes. Quite often fine sand layers are found in the subsoil. Topographically higher areas have siltloam or even fine sand in the subsoil. Sand in the subsoil is often a problem for the execution of canals and drains. Generally the claysoils are not completely ripened. Potential catclays and pseudo catclays exist in the young coastal plains and even more in the older coastal plains. The soils are characterised by its unripened or half ripened character. They form an extra difficulty in the execution of polders because of their lack of bearing-capacity for heavy machinery.

Vegetation

The coastal plains are mainly covered by swamp vegetation. A clear oversight is given by P.A. Teunissen (1978). Important for the execution are the differences between higher situated places where, through the influence of man, regular swampfires occurred and the lower, wetter areas, where swampfires could not regularly burn the vegetation. In the first case swampgrasses are found while in the latter swampforests are found. Areas with too much surface water throughout the year to allow a forest to develop are covered with ferns, grasses and other low vegetation.

Climate

In Kamerlingh G.E. (1974) the climatological data of Suriname are given. Important for the execution of earth moving projects like polders is the rainfall distribution. Officially we know four seasons:

december - january	- short rainy season	(2 months)
february - march	- short dry season	(2 months)
april - july	- long rainy season	(4 months)
august - november	- long dry season	(4 months)

This enumeration seems to indicate well defined dry and wet seasons. Reality is different. The only constant factor in the rainfall distribution is the variability. Yearly differences are big. Especially the short dry season and the short wet season are very variable and often do not occur at all. Some polderworks are very dryweather dependent. So progress in polderexecution is a derivation of the quality of the dry seasons.

Hydrology

The coastal plains dewater by means of natural drainage canals. Because of the flatness of the plains, the absence of slope and subsidence by ripening processes, natural drainage is bad. Under natural conditions the area is covered with surface water most of the time. Fluctuations in the waterlayer on the surface are governed by the quality of the dry and wet seasons. The average yearly fluctuations in the surface water determine the vegetation species and the thickness of the peatlayer.

Development of polder construction

From the eighteenth till the twentieth century execution of polders in Suriname has been carried out with manual labour. Where canals had to be constructed the vegetation was cut down and burnt in the dry season. The canal was excavated with spades and hoes and the excavated material was placed on top of the vegetation rests and residual peatlayer.

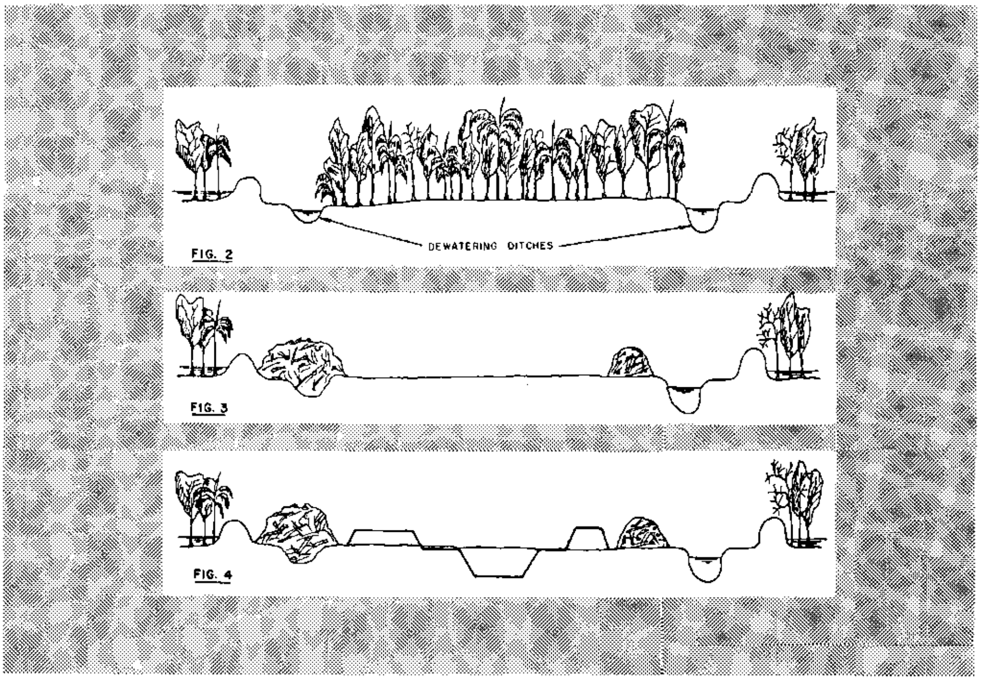
In the twentieth century manual labour became scarce and the demand for riceplots increased. Both developments triggered mechanisation of the heavy work in polder construction. Small draglines were used to remove vegetation and peatlayers from alignments of irrigation canals and drains. These machines were light and had to work on wooden mats because of the low bearing capacity of the subsoil. Moreover they had to work in a layer of water which made it difficult to remove almost-floating organic material. The same draglines excavated the canals. Standing vegetation in the future riceplots was cut manually and burnt in the dry season. Stumps and peatrests were let to rot while the plots were grazed by cattle. After a few years the new plots were cultivated with rice. Execution capacity was small while riceproduction started several years after construction of the polders. Since mechanized agriculture found its way into ricecultivation in Suriname the demand for developed rice-plots multiplied. Execution capacity had to grow to meet the demand. This was only possible if clearing could be done by more appropriate machinery like bulldozers and if the excavation works could be done by bigger machines with more capacity. With the above mentioned demand for more execution capacity as a starting point, a completely mechanized system of polder execution developed since 1965.

Present polderconstruction

The introduction of mechanized execution of polders puts more emphasis on watermanagement than in the past. For this reason the works have to start with enclosure of the polder area to be sure no water from outside can flow into the area, making it an independent hydrological unit. In the same time the necessary works are carried out to drain the hydrological unit. In Suriname this means making a controllable outlet to a natural drainage canal or river or to an already existing drainage system with sluices. In the new polder the drains are excavated first. This is necessary for two reasons: watermanagement and roadbuilding. Access roads are mostly built alongside drains. With this system enough material is found to built a roadbody and at the same drainage of the road is guaranteed. However the excavated material is not completely ripened and needs time to mature. Starting with the excavation of the drains provides the necessary time for the ripening process before the roads are constructed.

In order to carry out the clearing of the alignments under dry conditions they are treated as small polders. Works are carried out in the following sequence:

a. Staking out. This is a difficult and heavy job because of the swamp-conditions. Often waisthigh surface water and plenty mosquitoes.
b. At both sides of the right of way dewatering ditches are dug with hydraulic excavators on low groundpressure tracks. With the excavated soil a dam is built at the swampside to prevent surface water to flow into the alignment (Figure 2).



c. Through these ditches the alignment is drained. The ditches are used to enter the area by boat.

d. When the peatlayer and soil have been allowed some time to dry, the alignment is first cleared of vegetation and afterwards the remaining peatlayer is cleared. Both activities are carried out with bulldozers on swamptracks (Figure 3). For logistical reasons one of the dewatering ditches is left open.

e. After clearing, draglines excavate the canal and use the excavated soil to construct the dams (Figure 4).

f. Dams are modelled by bulldozer and hydraulic excavator. In the same time drainage outlets for the future plots are constructed.

Irrigation canals are constructed in the same way as drainage canals. Early construction of drains and irrigation canals allows the works on the plots to be carried out under much drier circumstances. The surface water can be controlled now by a functioning drainage system. Moreover the subsoil gets time to dry making it possible to work the year round. The works to be carried out in the future plots are:

- Constructing field ditches. A bulldozer clears the right of way and an excavator digs a small ditch and constructs a field dam.
- Clearing the plots. For ricepolders it means clearing from vegetation and peat. Polders for other purposes do keep the peatlayer as much as possible.
- Levelling. Swamp areas in Suriname are rather flat. Nevertheless levelling is needed in transitional zones. This is done by bulldozer. Plots may partly have a different level. If possible this should be avoided because it causes problems in the exploitation fase. Grading is done by the farmers.
- Structures. These consist of common p.v.c. tubes ø 0.30 m or 0.40 m for inlet and outlet of irrigation and drainage water. The tubes have a plain flap to be able to stop in- and outflow.

As soon as ripening of excavated soil from the drainage canals affords machinery to form a dam, roadbuilding has to start. First the top of deposited soil is levelled by bulldozer with a low ground pressure track type. The hydraulic excavators form the roadbody and excavate a cunette. As this is done in rather soft clay it takes a lot of time to dry the roadbody enough to allow trucks to bring in the sandbase. For agricultural roads a base of 0.30 m - 0.50 m fine sand is used. On top of this a layer of 0.20 m broken shell or sandshell mixture is placed to form a semi-permanent construction which after a few more years of settling can be covered with an asphalt or concrete brick construction. Sometimes a fabric is used first under the sandbase. It allows an earlier construction without the troublesome deformation problems in the subsoil.

The structures mostly used in Surinamese polders are culverts, bridges, sluices and controllable intake structures. Construction is carried out as far as construction of canals and drains progress and accessibility is provided to the construction place. The only problems which may arise are the swampwater being too acid to be used for the concrete mix or the groundwater being too salty so it has to be kept away from fresh concrete. In the total of polder construction structures are an unimportant activity. They are generally easy to construct, they do not ask big investments in machinery and they do not take much construction time in relation to other activities. Moreover their construction generally not influence other activities.

Polder construction in Suriname takes at least four years independent of the size of the polder if started from virgin area. This time is necessary for the dewatering and consequently the ripening process. In those four years construction of the irrigation and drainage canals followed by roadbuilding form the bottlenecks. For this reason the following paragraphs will deal mostly with construction problems during these activities. If clearing of the finished plots is done by the farmer construction of the polder takes at least five years.

Clearing aspects

As described before, the first machinework is the excavation of dewatering ditches and the construction of small dams to prevent the surface water to flow into the drained alignment. For this work it is necessary to clear a width of approximately 12 m. The clearing cannot be done by bulldozer and has to be done by the excavator itself. However the excavator is not entirely suited for this work. As a result many breakdowns occur. But they are unavoidable especially in areas with heavy swampforest. Contractors and planners have to take this into account.

In polder construction in swampy areas the clearing of the alignments is the most sensitive work. It is dependent on subsoil, dry season and vegetation. The following table gives performance data of 140 - 155 HP bulldozers on swamptracks in clearing the 100 m wide right of way of the Corantijn canal.

Table 1. Performance data of 140-155 HP-bulldozers on swamptracks in clearing the 100 m wide alignment of the Corantijn canal of vegetation and peatlayer

Vegetation	Season	Subsoil	hr/ha
-Heavy marsh forest no peat layer	dry	ripened	28,4
-Heavy swamp forest 0.20 m peatlayer	dry	ripened	26,5
-Medium swamp forest 0.20 m peatlayer	wet	half ripened	40,3
-Heavy swamp forest 0,60 peatlayer	dry	unripened	75,7
-Heavy marsh forest no peatlayer	wet	ripened	24,0

It is shown that clearing a right of way covered with heavy swampforest and a thick peatlayer takes an extremely high number of machinehours. The more time these canalstretches are given to dry out, the less machine hours are required.

Another effect on the performance in clearing activities which should not be underestimated is the width of the alignment to be cleared of vegetation and peat. In Figure 5 the relation is given between the width to clear and the productive machinehours for heavy swampforest. The data were obtained from the execution of the polders Jarikaba IV, Europolder Zuid and Uitbreiding Groot Henar and the Corantijn canal. It seems a good practice for designers to keep clearing width as modest as possible.

Clearing of the alignments is done in the early phase of the project. This means that in later phases clearing machinery is available for clearing of the plots. If windrows are left to rot in the field as is practice in Suriname and with maximum clearing distances of 30 m, plotclearing takes 8 to 12 productive machinehours per hectare. A contractor in poldercon-struction who has to clear alignments as well as plots can schedule clearingwork in such a way that it becomes a yearround activity. It allows for a more effective use of expensive machinery.

Logistics

One of the biggest problems of the execution of works in unaccesible areas is the supply of the machines with personnel, fuel, lubricants and maintenance facilities. Especially the hydraulic excavators making the dewatering ditches in advance of the other activities are difficult to reach. For these machines it takes too much time to bring the operating personnel daily in and out to a basecamp. The personnel have to spend the nights in the swamps close to their machines.

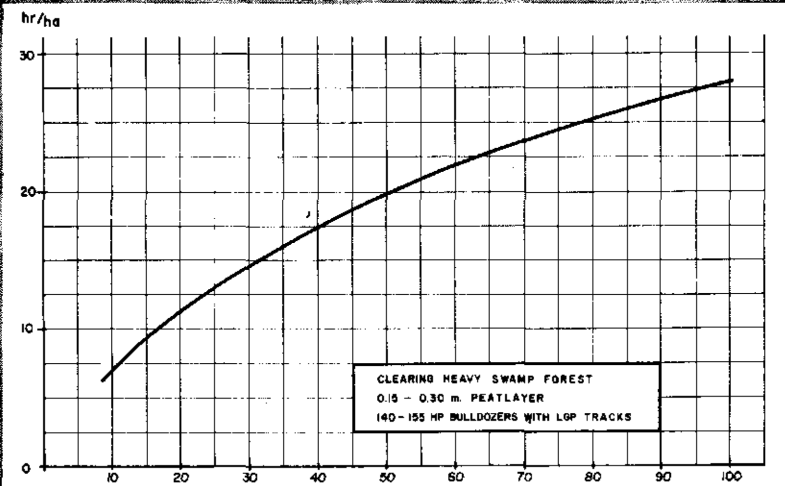


Fig. 5 Clearing alignments — width to clear in m. →

They live in temporary shacks on top of the small dams just built in the swamp by their machines. It is necessary to plan a few machines working not far from each other so the crews can support each other and be supplied together.

The dewatering ditches have an important function in the logistical system because small boats (corjaals) can navigate them. The organisation of the contractor should be focussed on transport of fuel, personnel and supplies in small units through the dewatering ditches (Figure 6). Of course this small unit transport system has to be kept as short as possible. After digging a maindrain it is possible to float bigger units. It fascilitates a fuel transport system with small tankboats in the drain to a reservoirtank at the end. From there the fuel is transported through the ditches to the individual machines in barrels. The biggest difficulties are met in supplying the clearing machines with fuel. When clearing takes place the waterlevel in the dewatering ditches is kept low to keep the alignments dry even in the lowest stretches. At the same time fuel requirements are very high (bulldozers). The solution of this problem lies in making a stock in the field in advance of the clearing activities while the waterlevel in the ditches is still high.

Figure 6

Transport in dewatering ditches

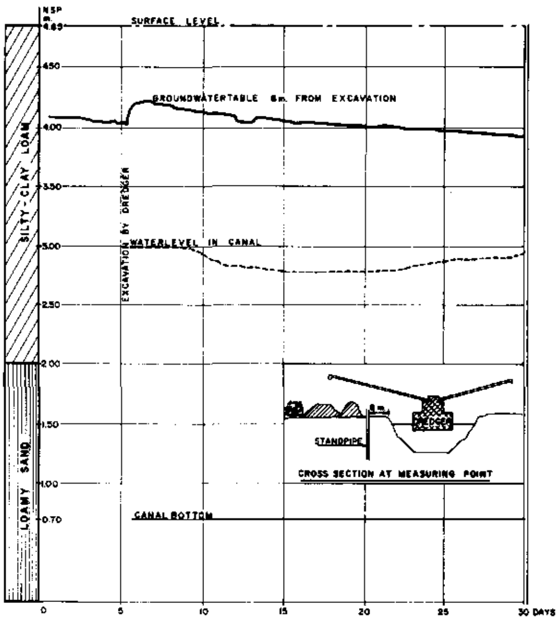


FIG. 7 SHORTTERM EFFECT OF A CANALEXCAVATION ON THE GROUNDWATERTABLE.

For maintenance and repair of machines the contractor should provide his own facilities in the project itself. The existing specialized organisations (heavy machinery dealers) are generally not willing and unable to supply adequate service under the circumstances in which the machines work. It is often not possible or at least very time-consuming to transport the machines out of the swamp to a place where they can more easily be repaired or serviced. So while the contractor has to provide everything himself it is not worthwhile to do this for a few machines.

To be able to provide for a well running logistical organisation in the field the polder project should be of sufficient extent. Conditions in Suriname ask for a polder size of approximately 3.000 ha.

Low bearing capacity of soil

Another problem in the execution of polders in Suriname is often low bearing capacity of the soil. In general this is solved by using light machinery on a 'Low Ground Pressure'-track type. However if the machines are too light they cannot effectively carry out the work.

A practical relation exists between the thickness of the peatlayer and the bearing capacity of the soil beneath. Draglines (800 l and up) have to travel on wooden mats as soon as the peatlayer is thicker than 0,10 m. Excavators have to travel on wooden mats as soon as the peatlayer is thicker than 0,30 m and the surfacewater is over 0,50 m deep.

The problem is the most intense in the early phase of the project when the drainage and irrigation canals have to be constructed. It reaches its peak with the clearing of the alignments by bulldozers. To solve it the alignments are drained as soon as possible. The longer they are dewatered, the more drying is stimulated and better carrying capacity is obtained.

In potential catclays and other unripened soils the process of drying of the topsoil usually takes more time than available. Other methods have to be used here. If these soils are found far enough from the coast not to be recently deposited, they are covered with a thick peatlayer. First of all these stretches of the alignment get bigger dewatering ditches and accompanying swampdams. After that the alignment is drained to a depth just beneath the peatlayer. To reach this it might be necessary for the excavator to dig the ditches for a second time, to remove all peat and muck and to excavate them even deeper. Also every 50 m superficial trenches are dug across the alignment in order to dewater the peatlayer thoroughly and to give it the opportunaty to dry. These activities are planned in such a way that at the beginning of the dry season everything is ready. The dry season causes an irriversible drying of the peatlayer.

After three months of drying the bulldozers with swamptracks are able to deforest the alignment deriving the necessary bearing capacity for this work from the dried peatlayer. In a later fase the remaining mixture of peat, branches and roots can be removed by bulldozers or if it rains too much by hydraulic excavators.

Non-cohesive layers in the subsoil

If canals have to be dug in a subsoil of fine sand or loamy sand it is often found impossible to excavate the canal at the right depth. The high groundwater table is suddenly lowered during the excavation. A new equilibrium between the open waterlevel in the excavation and the higher groundwater table has to be installed. With the resulting waterflow in the subsoil the instable sand particles flow into the excavated canal. The sides of the canal cave in and the original excavated depth is disturbed considerably. Figure 7 shows the behaviour of the groundwater table measured in standpipes placed well before the canal was excavated. After an initial short period of overstressed groundwater just after excavation the watertable declined very slowly till equilibrium was reached after three months. After one month the canal was excavated again to the right depth and no more disturbance of the bottom level occurred. It seems that the short period of overstressing in the groundwater is responsible for caving in.

Machine efficiency and cost aspects

It can be imagined that machines working under heavy conditions as in the Suriname swamps often break down. The operating personnel who have to live a fortnight in the swamps experience regular illnesses and often take a longer restperiod than normal. Cases are known when the operator cut the fuelline of the machine to be able to escape his harsh environment for a few days. Experiences in the execution of three ricepolders and a bananapolder show that under these conditions hydraulic excavators were only 35% of the time productive. Recent experiences with the Corantijn canal show that if done on a larger scale, with a good logistical organisation and repair facilities on the job and more pay for hard work and good performance and fines for long downtimes, the productive time goes up to an average 75%. Swampdozers, generally only productive in the dry season and the dryer part of the wet season, compared in the same way as the excavators gave a rice from 66% to 77% productive time. Even more important was the experience that with a good project organisation and a thorough scheduling of the stretches on different soil types the clearing activities became a yearround occupation in the Corantijn canal project. Theoretically this may be achieved in polder construction too if clearing of alignment and plots is done by the same contractor. In Suriname this could safe $10,-- per productive machinehour.

Table 2 gives cost estimates for the construction of new polders. Costs are not including main irrigation works outside the polder (irrigation dam, pumping stat.)

Table 2 - Construction cost of polders in US $ per bruto ha

	Ricepolder	Dry crops/cattle
Primary polderdikes and dewatering	1.000	1.000
Watercourses	710	420
Structures	620	430
Roadbuilding	610	550
Clearing	880	550
Landlevelling	440	310
Design and supervision	430	330
Total	4.690	3.590

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DESIGN AND CONSTRUCTION OF FLOOD CONTROL DYKES AROUND 43,000 HA OF IRRIGATION AREAS IN THE RHARB PLAIN, MOROCCO

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Abstract

Extensive flood control and water development studies of the Sebou River Basin in northern Morocco (1972-1975) led to the conclusion that irrigation areas under construction in the Rharb flood plain (43,000 ha) could most economically be protected against floods by a balanced system of dykes, floodways and temporary storage of floodwater in low-lying areas. In order to determine required crest elevations of the dykes as accurately as possible, flood levels in the plain were calculated by means of a comprehensive flood routing model.
Because of the swelling proportions of the heavy clay soils occuring in the floodplain, the use of it as earthfill material was tested in a number of experimental dykes. The finally proposed dyke designs for a total length of some 225 km, requiring a total volume of earthfill of 3.6 Mm^3, were largely based on the results of these experiments. The design further includes structures for crossings with roads, railways, irrigation and drainage channels.

1 Introduction

The coastal flood plain of the Sebou river (the Rharb plain) is one of the most densily populated areas of Morocco and has a great agricultural development potential. In 1968 the Moroccan Government in conjunction with the F.A.O. formulated a general development plan for this area, comprising, amongst other things, the irrigation of 212,000 ha in the fertile Rharb plain. The first phase of this irrigation development plan, presently under construction, covers an area of 43,000 ha and is situated in between the lower Sebou river and one of its main tributaries, the Beht river (Figure 1). Irrigation water for this first phase will be mainly drawn from the Sebou river, of which the flow is partly regulated by the 1,265 Mm^3 Idriss I dam on the Inaouène river.

The Rharb plain, however, is subject to periodical flooding, causing considerable and sometimes catastrophic damage to the crops and physical infrastructure. Flood protection of the irrigation areas in the Rharb plain would be partly achieved through construction of a 3,000 Mm^3 multi-purpose dam (M'Jara) on the main tributary of the Sebou river, the Ouerrha river, which contributes to an important part of the floodwaters in the plain.
As the proposed M'Jara dam will not become operational before 1990, the first phase of the irrigation development plan would remain prone to flooding for another 20 years.
The Moroccan Government, therefore, considered it appropriate to study in detail the feasibility of a flood controle scheme for the Rharb plain and in particular the immediate protection of the 43,000 ha first phase development. This study, carried out between 1972 and 1975, led to the conclusion that the irrigation areas in the Rharb plain could most economically be protected by a balanced system of dykes, floodways and temporary storage of flood waters in low-lying areas.

These so-called "immediate protection measures" would have to be materialized within a rather short period (1974-1980) and would provide temporary protection of the first phase of the irrigation development plan, awaiting completion of final flood control measures for the entire Rharb plain, of which the main elements are the M'Jara dam and possibly a diversion channel on the left bank of the lower Sebou. However, part of the temporary protection works could yet effectively be incorporated in the final scheme.

2 Design of the flood control dykes

2.1 General criteria

As the flood protection dykes around the 43,000 ha irrigation area are partly of temporary nature, cheapest and most economic solutions should be pursued.

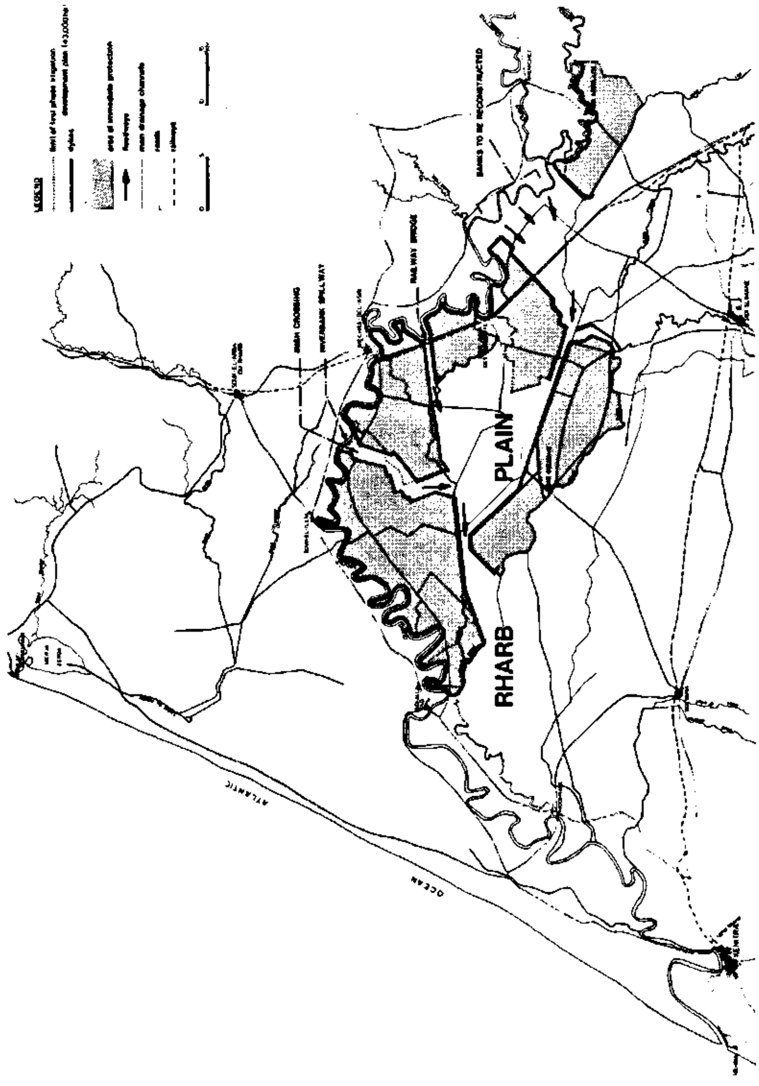

Figure 1 Map of Rharb Plain and lay-out of flood control measures.

Nevertheless, minimum requirements with regard to height, imperviousness, stability and solidity will yet have to be met.

The total length of the dykes and earthmoving volumes should therefore be reduced to their minimum, whilst construction materials to be used should be cheap and borrowed from areas closest to the proposed construction sites. Moreover, construction methods to be applied should be as simple and cheap as possible.

2.2 Height of dykes

The dykes are designed for flood levels with an estimated return period of 50 years. Minimum crest elevation will be 0.70 m above the design flood level in order to allow for incertainties in flood level estimates as well as expected settlement of the dyke.

Flood levels in the plain have been calculated by means of a mathematical model for the lower Sebou river, taking into account the various proposed flood protection measures (flood routing through floodways). The adopted return period of 50 years is a compromise between what is economically desirable and socially and/or politically acceptable. The most economic design return period was found to be in the order of 1 in 10 or 20 years.

2.3 Construction materials

A number of heavy and moderately heavy clayey soils can be found almost every where in the plain. These soils are very impervious and can in general be used for construction of the dykes. Two major types of impervious soils can be distinghuished:

(1) the heavy clay loam (40-70% clay, Montmorrillonite), with a plasticity index (>25%) and locally known as 'tirs'
(2) the sandy clay loam, with a lower plasticity index (<25%) and a higher percentage of sand, locally known as 'dhess'.

The 'dhess' soils are found along the Sebou river, whilst 'tirs' occur mainly in the plains proper.

Pervious materials can only be found in the river bed itself and use of large quantities thereof would lead to excessive hauling costs.

2.4 Lay-out and alignment

The basic alignment of the dykes is defined by the lay-out of the first phase of the irrigation scheme (43,000 ha). Moreover, it was tried to protect the major residential and settlement areas as much as possible.

Detailed alignments are guided by specific and local considerations, such as river meandering, bank stability and erosion, stability of dyke foundation, existing and planned infrastructure (canals, drains, roads etc.), availibility of construction materials and existing vegetation. Finally, waterlevels in the non-protected areas should not increase excessively due to the construction of the dyke system.

The resulting optimum lay-out of the dykes is shown in Figure 1, requiring a total length of 145 km along the rivers ('dhess') and 82 km of dykes in the floodplain ('tirs').

2.5 Typical dyke designs

The required crest elevations vary between 0.50 and 4.0 meter above ground level. The top width at crest level is primarily determined by the following factors:

(1) the operating width of the construction equipment (minimum of 2.0 m)

(2) the minimum permissible width of the dyke at design flood level (5.0 m is considered sufficient, as the inundations never last more than a few days only)

The minimum required side slopes depend mainly on:

(1) mechanical proporties of construction and foundation materials (internal friction and cohesion)

(2) method of construction

(3) availibility of various construction materials

(4) external effects (erosion, damage by animals).

Owing to the prevailing types of construction materials, two main types of dykes can be distinguished:

A. Dykes made of 'dhess' soils

Stability analysis of a homogeneous dyke section of 2.5 m high and a topwidth of 2.5 m showed that a side slope of 1:1.5 may be safely adopted (assumed radius of slip circle 6.5 m). Considerations, however, relative to construction methods (chiefly the compaction along the side slopes) have led to a finally adopted side slope of 1:2. For this analysis the following average soil properties were assumed (based on laboratory tests):

	dyke	foundation soil
angle of internal friction	28°	22°
cohesion (kgf/cm^2)	0.16	0.20
dry density (ton/m^3)	1.55	1.40
water content (%)	20	10

The expected seepage rate through the dyke during periods of floods have been analysed by means of an electrical analogue model. For an average isotropic permeability of 10^{-5} m/day, the maximum seepage rate was found to be in the order of 1.2 l/sec per 100 m length of dyke, which is considered to be acceptable. The seepage flow will emerge at the inside slope over a distance of 1.0 to 1.5 m from the toe. A typical dyke section is shown in Figure 2. For dykes with a height of less than 1.0 m, a reduced topwidth of 1.50 is proposed.

B. Dykes made of 'tirs' soils

Owing to their high content of montmorillonitic clay, their high plasticity index and a very low shrinkage limit, 'tirs' soils are not entirely without problems when used as construction material for dykes.

Firstly, the embankment slopes are subject to gradual creep of the toe, as the foundation soil, during the continuous process of shrinkage and swelling,

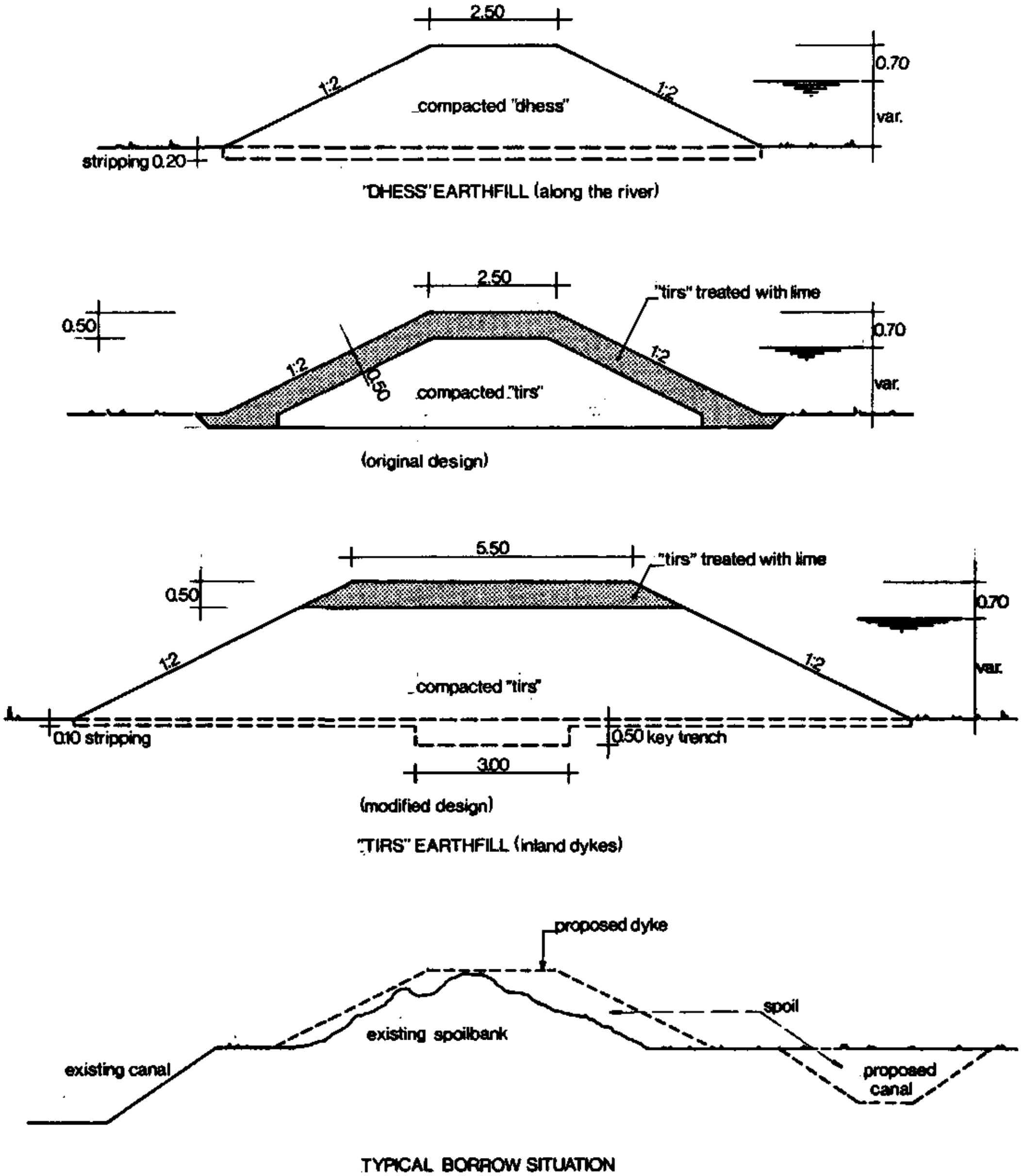

Figure 2 Typical dyke sections

cannot return to its previous position and gradually moves away from the centre line of the dyke. Secondly, the continuous variations in moisture content cause the formation of large and deep cracks during the dry periods, which may give rise to considerable local percolation with risks of piping through progressive erosion in these cracks.
Lastly, the water content of 'tirs' has a considerable effect on its workability, i.e. compaction and excavation are extremely difficult when the soil is too dry and even impossible when it is too wet.

Before concluding to the optimum dyke design, a number of experimental dykes were constructed. Special aim of these experiments was to find a suitable method to prevent the core of the dyke from drying out too much, however, without adversely affecting its water retaining function.

Best results were obtained with a dyke consisting of a core of well compacted 'tirs', lined with a continuous layer of 0.50 m thick non-compacted 'tirs' treated with 6% lime (Figure 2). The formation of cracks in the treated layer proved to be unsignificant, hence preventing the core sufficiently from suffering too great variations in water content. When 'tirs' soil is saturated the permeability is close to zero. Stability analysis for a 3 m high dyke with 1:2 side slopes and a 2.5 m topwidth gave satisfying results (Safety factors ranging from 1.7 to 2.1). When foundation soil is 'tirs' as well, the settlement after 10 years is estimated between 10 and 15 centimeters.

Some major disadvantages of the above design, however, are:

- the large quantities of lime required
- high construction costs
- vegetation will not develop on the treated layer
- a white bare dyke is not very attractive in the landscape.

During the detailed engineering phase of the project the typical design of the 'tirs' dykes, as discussed above, was modified. As construction materials proved to be available in larger quantities than assumed earlier (for instance spoil from proposed parallel drains and from existing canals), it was found that replacing the lime treated layer on the side slopes by a 1.50 m thick layer of compacted 'tirs' would result in an equally effective but cheaper solution. Since observed cracks in the experimental dykes were never deeper than 1.50 m, this solution will provide sufficient protection of the core and diminish the risk of progressive internal erosion or piping. Evidently the topwidth of the dyke will also increase as a result of the modified design. In addition a 0.50 x 3.00 m key trench has been included in the final design. (See typical section in Figure 2).

3 Construction aspects

3.1 Earthmoving volumes and costs

Estimated earthmoving volumes amount to some 1.0 Mm^3 for dykes made of 'dhess' and 2.6 Mm^3 for dykes made of 'tirs'. Hauling distances vary between 30 to 1500 m, however, the median being less than 500 m.

Cost estimates based on 1977 prices are summarized below:

	million US $
earthworks	23.3
related structures	4.1
road improvements and crossings	0.9
railway crossings	1.8
Total	30.5

The additional costs of land transactions and expropriation are estimated to be in the order of 1.6 million US $.

3.2 Excavations and borrow areas

In general, the availibility of suitable earthfill materials along the proposed dyke alignment exceeds the requirements. Nevertheless, it is proposed to use as much as possible the spoil and excavated materials resulting from other necessary earthworks and to reduce the opening up of new borrow areas to the minimum. Such necessary earthworks include for instance the construction of drainage channels (mostly parallel to the dykes) and the mass excavations required to improve the floodways in between the irrigation areas. The spoil resulting from the latter is estimated to some 2.1 Mm^3, mainly 'tirs' soil and covers about half of the total earthfill requirements. Other usable sources of construction materials are:

- existing deposits of spoil and old dykes along the river and canals (Figure 2);
- existing borrow areas, already in use for other purposes.

Only in a few cases new borrow areas will be required.

On the basis of actual earthfill requirements along the various dyke sections, a comprehensive earth movement schedule was prepared, minimizing for each sector the hauling distances (The resulting hauling distances only seldom exceed 1,5 km).

3.3 Construction specifications

A. 'Dhess'

The construction of dykes with 'dhess' soil should comply with the following general specifications:

(1) the permissible deviations from the optimum water content are +1% and -2%. These tolerances can be rather high because of a flattened peak of the compaction test curve;

(2) Materials having a plasticity index of less than 10% are unsuitable for earthfill in embankments (too sandy and too pervious);

(3) compacted earthfill should have a minimum dry density of 92% Standard Proctor, with a mean of 94%;

(4) side slopes should be properly trimmed and 'grassed'.

B. 'Tirs'

(1) similar as for 'dhess';

(2) a minimum of 90% of the Proctor maximum dry density is required for compacted earthfill, with a mean of 92% Proctor Standard;

(3) side slopes as for 'dhess';

In case the lining of 'tirs' treated with lime would be applied to certain dyke stretches, the following additional specifications should be complied with:

(4) in order to obtain a suitable and workable mix of 'tirs' and lime (6% by weight), the mixing should be carried out with special equipment (e.g. pulvimixer) on the site. Because of the high water absorption capacity of lime, more water is required to obtain the specified degree of compaction than in the case of untreated 'tirs';

(5) lime used for mixing with 'tirs' should have a $Ca(OH)_2$ content less than 60%, a SiO_2 content less than 5%, less than 5% Fe- and Al-oxides and a very low CaO content. The water content may not exceed 5%.
The size of the lime particles may not exceed 0.6 mm, whilst the percentage of particle sizes less than 0.08 mm may not exceed 15.

AGRICULTURAL ASPECTS

LAND EVALUATION FOR AGRICULTURAL DEVELOPMENT IN LEZIRIA GRANDE, PORTUGAL

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Abstract

Lezíria Grande is a flat island of about 13,000 ha in the river Tagus upstream from Lisbon, with predominantly salt-affected marine clay soils. The present land uses are extensive grazing, rainfed arable farming and intensive irrigated horticulture done by small scale landless farmers. The problems in this area are many - insufficient flood-protection, an inadequate water control system, a deficient irrigation water supply, as well as a bad external and internal drainage situation - and a project team including Portuguese and Dutch technicians studied four alternatives that would allow to solve these problems and reach the following goals: increasing land productivity, providing more employment opportunities, obtaining more export produces and avoiding imported ones, as well as promoting a better income distribution. For this aim the F.A.O. land evaluation methodology was applied for the first time in the country, allowing to make land quantitative suitability classifications for specific uses.

1. Introduction

Lezíria Grande is one of the most promising agricultural areas of the country;however the problems affecting this area are many (Pereira and Bos, 1982). As it was the first time that F.A.O. methodology was applied, too many details and data were used, which delayed all the programs of the project team. However we consider that the balance was very positive and the experience can be used in other projects in the country.

2 Land utilization types (LUT)

Information about this concept is given by Beek, 1978

2.1 Key attributes

These define the LUT according to the F.A.O. methodology

a) Produce: HOR(W) - Autumn/Winter horticultural crops; HOR(S) - Spring/Summer horticultural crops; HOR(B) - biannual or perennial horticultural crops; FOR(W) - Autumn/Winter fodder crops; FOR(S) - Spring/ /Summer fodder crops; CER(W) - Autumn/Winter cereals; CER(S)- Spring cereals; OIL(R) - rainfed oil seed crops; OIL(I) - irrigated oil seed crops; MEA(R) - temporary rainfed meadows; MEA(I) - temporary irrigated meadows; RICE - irrigated rice.

b) Labour (levels of intensification)

Low intensity <100 man.hr./ha.year
Medium intensity 200-250 "
High intensity >250 "

c) Capital (intensity)

Low intensity $< 10 \times 10^3$ esc./ha.year (1977 prices)
Medium intensity 10-30 "
High intensity >30 "

d) Farm and parcel size - Four year rotations were considered as most frequent; on that basis three levels for farm and parcel size were assumed:

Size	Farm (ha)	Parcel (ha)
small	< 10	< 3
medium	10-50	3-15
large	>50	>15

e) Technology - It was defined in terms of mechanization intensity and farm power.

Mechanization intensity: (i) highly mechanized - all the field operations are done mechanically except harvesting (mechanical or manual) ; (ii) partly mechanized - seedbed preparation and fertilizing are done mechanically, some of the other operations are manual. Farm power (depending on farm size): (i) - small size farms - 70 hp traction for seedbed preparation and 35 hp for other field operations; (ii) - medium size farms - 70 hp for all the field operations with aerial application of fertilizers and pesticides; (iii) - large size farms- 90 hp for seedbed preparation and 90 and 70 hp for the remaining field operations, with aerial application of fertilizers and pesticides.

f) Management - two levels were considered : good and medium. The level is considered good when it fulfils the following requirements: (i) - field operations are done in the right season, depending on the climatic factors and soil conditions; (ii) - machinery is correctly used and has good maintenance; (iii) - there is an optimal utilization of the inputs (including irrigation water); (iv) - the farmers are able to adapt to new techniques; (v) - the farmers have a good knowledge of the commercial aspects of the inputs and outputs. When some of these conditions are not fulfilled the level is classified as medium. It was assumed that traditional land uses (grassland, rainfed agriculture, rice production, etc.) would have a good level, the new land uses with high technology (new horticultural crops) would have a medium level.

2.2 Description of LUT

The relevant LUTs in Lezíria Grande, in the present situation and after the implementation of different project alternatives, are the following ones: I - Small scale irrigated and rainfed crop production; II - Medium scale irrigated and rainfed crop production; III - Large scale irrigated and rainfed crop production; IV - Medium/Large scale irrigated and rainfed mixed farming (IVa with annual forages and IVb with temporary meadows); V - Medium/Large scale irrigated rice production; VI - Medium/ /Large scale rainfed agriculture; VII - Medium/Large scale rainfed mixed farming; VIII - Extensive grazing.
Definition of the relevant LUTs with key attributes is presented in Table 1.

3. Land characteristics

3.1 Soils and drainage

Table 1. Definition of land utilization types

	LUT (See 2.2)	I	II	III	IVa	IVb	V	VI	VII	VIII
Produce see 2.1	HOR (W):									
	pea	x	x	x						
	horse bean	x	x							
	HOR (S.B):									
	celery	x								
	lettuce	x								
	garlic	x	x	x						
	leek	x	x							
	onion	x	x	x						
	cauliflouwer	x	x							
	beans	x	x							
	melons	x	x							
	tomatoes	x	x	x						
	sweet pepper	x	x							
	strawberries	x								
	FOR (W)	•	x	x	x		•	x	•	
	FOR (S)		•	•	x					
	CER (W,S)		x	x	•	•	•	x	•	
	OIL (R)		x	x				x		
	OIL (I)		x	x						
	MEA (R)								x	x
	MEA (I)					x				
	RICE						x			
Labour (intensity)	low			x	•	•		x	x	x
	medium		x	•	x	x	x			
	high	x	x							
Capital (intensity)	low								•	x
	medium		x	x	x	x	x	x	x	
	high	x	x	x						
Farm and parcel size	small	x								
	medim		x		x	x	x	x	x	
	large			x	x	x	x	x	x	x
Technology: Mech. level	partial	x	•							
	total	•	x	x	x	x	x	x	x	
Technology: Farm power	low(35 hp)	x								
	medium(30hp)	x	x	x	x	x		x	x	
	high(90hp)		•	x	x	x	x	x	x	

x – predominant crops
• – secondany crops

The Lezīria Grande area is covered with three different groups of sediments according to their origin, age and sedimentation conditions (Constantino, 1977): (i) - basal formation of marine origin (T) with big predominance of fine material (clay and silt), usually without CO_3Ca in the first 50 cm (25% of the total area); (ii) - recent sedimentary marine deposits (C) developed over basal formation along areas under tidal influence with equal parts of clay and silt, usually with CO_3Ca appearing from the top downwards (38,5% of the area); (iii) - material from continental origin (alluvial deposits, F) over basal formation

(36,5% of the area). More information is given by(Perdigão et al., 1982,) and(D.G.H.E.A., 1980.)
The soil survey was based on aerialphotographs and was carried out in two phases : semi-detailed 1:25 000 map and detailed 1:10 000 map (see Constantino, 1977. The soil maps are not present here due to scale of presentation). Descriptions were made with borings 2m deep and 15 soil pits were digged and described in a more detailed way (including sample analyses). The soil map legend expresses the relevant soil characteristics for land use, land productivity, and major land improvements:origin of sediments, presence of CO_3Ca, top soil texture, nature of subsoil, salinity level, permeability, groundwatertable. According to the U.S.D.A. Soil Taxonomy, the F.A.O. and the Portuguese systems (S.R.O.A.) the soils of Lezíria can be classified as referred in Table 2.

Table 2. Soils classification

Nature of sediments	U.S.D.A.	F.A.O.	S.R.O.A.
ancient marine (T)	Aquic Vertic Xerofluvents	Gleyic Solonchaks	Asa, Assa
recent marine (C)	Aquic Vertic Xerofluvents	Greyic Solonchaks	Asac, Assac
fluvial (F)	Aquic Xeropsamments, Aquic Xerofluvents, Aquic Vertic Xerofluvents	Calcaric Fluvisols , Eutric Fluvisols, Gleiyc Solonchaks	Alc, Ac Aac, Al, A, Asc, Assc, As, Ass

To quantify and complete the information given by soil survey, several fields measurements were made, samples were taken, groundwater regime was surveyed, and several experimental programs were carried out (drainage and dessalinization, workability, soil tillage, fertilization).

3.2 Topography

The topographical survey included the preparation of an ortophotomap and a counterline map (scale 1:10 000).Longitudinal profiles and cross sections, main existing ditches, piezometer network, experimental plots, and profiles of the Lezíria exterior dikes were other surveys which were carried out.

3.3 Climate

Meteorological data from the project area (20 years) and Lisbon (30 years) concerning rainfall, air temperature, evaporation, air moisture and winds were used.

4. Land qualities (LQ)

The main constraints to the physical productivity of the land are represented by the relevant land qualities (F.A.O., 1976, Beek 1978):

a) LQ related to yield level - availability of oxygen in the rooting zone (o); soil salinity (s); risk of waterlogging in the winter (g); risk of waterlogging under irrigation (f); risk of crust forming (u); quality of seedbed (b); loss of area (v).
b) LQ related to management and recurrent inputs: workability (w); risk of compaction (c); ease of cultivation (p); risk of salinization (r).
c) LQ related to major improvements: drainability (d); perspectives for dessalinization (t).

Table 3 and 4 give respectively the definition of the LQ workability and conversion LC-LQ for the same one. The other LQ are described in the final report of the Land Evaluation Group (D.G.H.E.A.,1980).

Table 3. Definition of LQ workability [1] : no. of days required after soil saturation

Grades	October, April	November, March	Dec., Jan., Feb.
w_1	6	9	13
w_2	7	10-11	14-17
w_3	8	12-15	18-23
w_4	9-11	16-18	24-27
w_5	>12	>18	>27

[1] Workability is defined as the number of days in a certain period of

the year in which it is possible to enter the field for soil tillage without soil degradation (Reis et al., 1982).

5. Land evaluation units (LU)

These are groups of land units with the same behaviour (in terms of LQ) relatively to a specific land use. Fifteen LUs were established in Lezíria, they can be described as shown in Fig. 1.

Table 4. Conversion of LC in LQ (workability)

Texture topsoil	Microrelief	Wintergroundwatertable (cm)			
		>80	50-80	30-50	<30
S; LS; SL	l	w_1	w_1	w_1	-
	u	w_1	w_1	w_1	w_3
L; SiL	l	w_1	w_1	w_2	w_3
	u	w_2	w_2	w_3	w_3
SiCL	l	w_2	w_3	w_3	w_4
	u	w_3	w_4	w_4	w_5
SiCL/SiC,	l	w_3	w_4	w_4	w_5
SiC	u	w_4	w_4	w_5	w_5

S - sandy; LS - loamy sand; L - loamy; SiL - silty loam; SiCL - silty clay loam; SiC - silty clay; SL - Sandy loam.
l - levelled ; u - uneven

6. Land Improvements and inputs

Cropping intensification and increasing productivity of the land will only be possible if a certain number of physical constraints are removed by land improvements (F.A.O., 1979, Beek, 1978). The major land improvements are implemented with the application of non-recurrent inputs. Four drainage/irrigation alternatives were considered in the project area (Pereira and Bos, 1982, Vieira et al., 1982) resulting in an evolution of the LQ grades after different time intervals in each land evaluation unit (see Table 5).

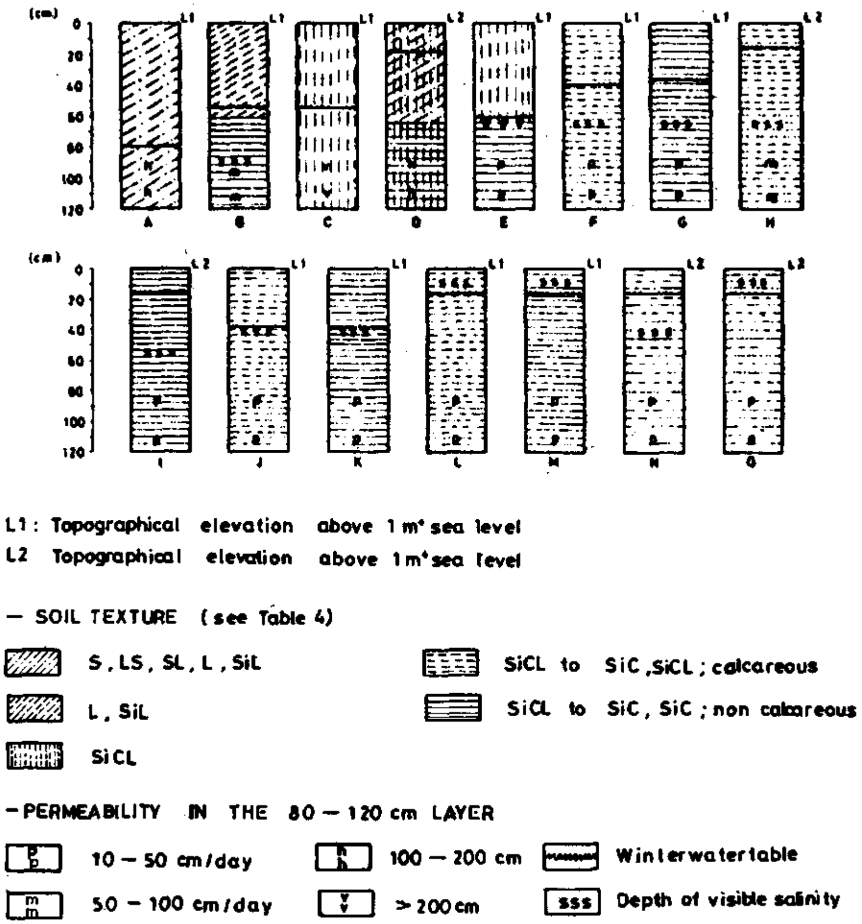

Fig. 1 Description of land evaluation units

7. Output and recurrent input predictions

The estimated evolution of the LQ after implementation of the different project alternatives is basically determined by the application of the non-recurrent inputs and on the other hand determines an evolution in the outputs and corresponding recurrent inputs (Beek et al., 1979, Reis et al., 1982). For every land evaluation unit and every project alternative the criteria for land productivity have been estimated: crops that can be grown, yield level, cropping and irrigation intensity. Predictions have been made by confronting the levels of constraining land qualities with the requirements of each particular land use (in terms of crops and crop rotations). Other sources of data were in-

Table 5. Examples of the evolution of LC and LQ (Dessalinization and Full Irrigation Alternatives) [1]

LU	year	LC (see 3) WT	BIR	ESP	OM	NCP	MR	SL	LQ (see 4) o	s	g	f	u	b	v	w	c	r	p	d	t
B	0	50-80	>15	<7	<3	8-15	u,l	>80	2	1,2	2,1	2,1	2	1	1	2;1	1	1,2	1	4,3	1
	1	>80	>15	<7	<3	8-15	u,l	>80	1	1	2,1	2,1	2	1	1	2;1	1	1,2	1	–	–
	10	>80	>15	<7	<3 >3[2]	>15	l	—	1	1	1	1	2,1	1	1	1	1	1	1	–	–
L	0	<30	<15	>15	<3	8-15	u	<30	4	5	4	3	5	4	3	5	4	4	3	5	6
	1	50-60	<15	7-15	<3	8-15	u	30-50	2	4	3	3	5	4	1	4	3	3	3	–	—
	10	50-80	>15	<7	<3 >3[2]	8-15	l	—	2	1	1	1	4,3	3,2	1	4	3,2	1	3,2	–	—

WT – winter groundwater table (cm); BIR – basic infiltration rate (cm/day); ESP – exchangeable sodium percentage (%) OM – organic matter (%); NCP – non capillary porosity (%); MR – microrelief; SL – salinity level.

1 Evolution of the other LUs can be found in the Land evaluation final report (D.G.H.E.A., 1980)

2 OM > 3 only with LUTs I, IV and VII

quiries to farmers and crop specialists, as well as experimental stations. Yield predictions have been made for the reference years 0, 1, 10, 20 and 30 after project implementation; the criteria used was to consider increases in the present yield levels according to two components: improvements made by the project (until year 10) and general trends. Examples of cropping patterns and yield/recurrent input estimations for wheat and melons are given in Table 6

Table 6 . Examples of yield/recurrent inputs estimations (year 10, dessalinization alternative)

Crop	L U	Inputs: Machines (hr/ha)	Labour (hr / ha)	Seeds, plants, fertil, pestic. (10^3esc/ha) [1]	Yields (ton/ha)
wheat	A,B,C,E	9.2	13.2	4.7	4.9
	F,G,J,K,L,M	10.6	14.6	4.7	4.4
	H,I,N,O	12.9	20.4	4.7	3.4
melons	A,B,C,E	132.5	457	2.2	19
	D	132.5	457	2.2	18
	F,G,J,K,L,M	139.6	524	2.5	17
	H,I,N,O	139.6	524	2.5	15

1 1977 prices

8. Land suitability classifications

In the Lezíria Grande project a semi- quantitative and a quantitative land suitability classification were made for every LUT, considering every project alternative. This was done for an optimal utilization of land potentialities, without allowing any land degradation. The criteria for land suitability classification were the following (Table 7):

Table 7. Semi-quantitative and quantitative suitability classification (LUT IVa)

Suitability classes	Yield		Cropping intensity (%)	Irrigation intensity (%)	Non-recurrent inputs		Net return 10^3esc/ha
	% max.	10^3esc/ha			% max.	10^3esc/ha	
S_1	95	84	200	100	80	150	25-35
	90	73	100	100	25	50	
S_2	90	73	100	100	100	180	10-25
	70	58	100	100	25	50	
	90	51	100	50	25	50	
S_3	70	58	100	100	100	180	0-10
	60	50	100	100	25	50	
	75	43	100	50	25	50	
	90	51	100	50	80	150	
N	more severe limitation than in S_3						<0

a) Semi-quantitative classification - related to the outputs, inputs and responsible LQs for sustained production

b) Quantitative classification - the indicator was the net return value (Kuiper, 1971) defined by R = y-(a+b+c+m), where R is the net return value, y the gross production value, a the recurrent inputs, b the operating and maintenance costs (for irr. and dr.), c the cost recovery factor for land development inputs, m the management allowances (10% of net production value, y-(a+b+c)).

A land suitability map is given in Annex (TUT IVa, DA)

9. Conclusion

After comparing the land suitability classes (for every LUT) in the situation without project with the different project alternatives (Perdigão et al., 1982), we can conclude that the present productive capacity of Lezíria is very much below its potentialities. With the land improvements some of the limitations can be totally or partially removed, resulting in higher yields, land use intensification,increasing irrigated area as well as introduction of new crops and land use systems.

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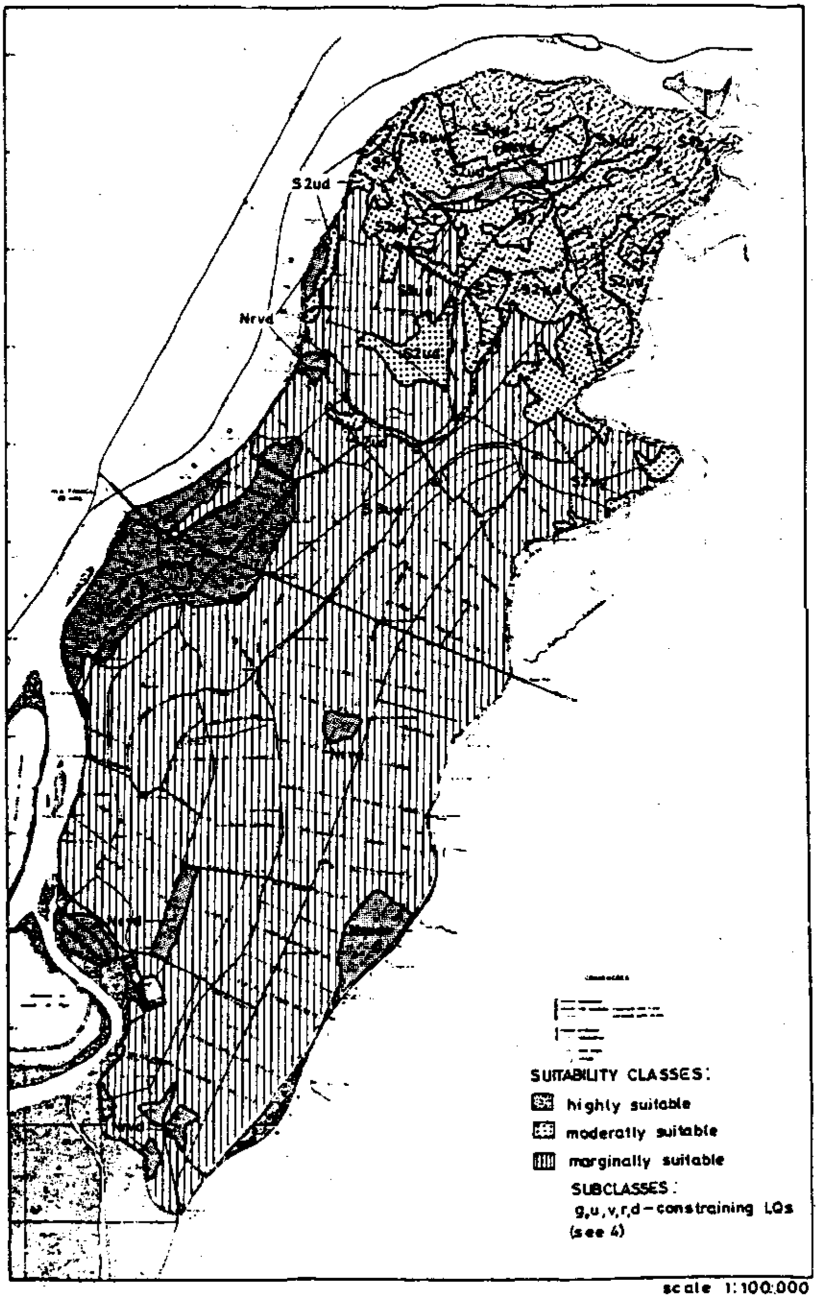
LAND SUITABILITY MAP (LUT IVa, AD)



AGRICULTURAL DEVELOPMENT OF TIDAL LANDS IN INDONESIA

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Abstract

Because of a continuing increase of population and the scarcity of land suitable for agriculture, the Indonesian Government is forced to bring into cultivation areas whose reclamation is not without problems. The tidal lands of Sumatra, Kalimantan and Irian Jaya are such areas. They certainly have agricultural potential provided that water management is adequate. Under such conditions spontaneous and transmigrant settlers have obtained favourable results in producing their main crop 'rice'. The success of tidal land projects sponsored by the Government depends on a low-cost development approach whereby extensive single rice cropping is gradually replaced by a more intensive cropping system. During the initial period of the project settlers should receive ample support, both social and financial, to enable them to acquaint themselves with and adapt to the new conditions of life and work.

1 Objectives of tidal land development

It is the aim of the Government to provide landless rural people and the small, poor farmer with a piece of land from which they can obtain a reasonable income, to increase food production and to promote development in remote areas.

2 Agricultural potential

Tidal lands definitely have potential for agriculture despite their complex problems. Soils are clays with a fairly high cation exchange capacity (CEC 30-50 m.e.), which makes them productive after reclamation unless they are covered by peat topsoils. Total rainfall and its distribution is adequate for a wet season crop. The groundwater table is high during the rainy season, being lowered to a maximum of 70 cm during the dry season when rainfall is not sufficient for cropping.
On the basis of these factors and because of the flat topography the tidal lands are considered suitable for the growing of a wet season rice crop in the first place. Rice with its shallow root system and its oxygen supply via the leaves is very well adapted to the prevailing water regime, i.e. water abundance.
The cultivation of upland crops such as cassava, maize and soya bean is possible, provided that drainage measures are taken.
Without additional irrigation dry season cropping of annual crops (both rice and upland crops) is hardly feasible. Some perennial crops like coconut and oil-palm may do well, having a rooting system which can deal with the wetter conditions in the rainy season and the drier conditions in the off season.
With proper varieties, inputs and cultivation practices paddy yields between 2500 and 3500 kg per hectare are attainable for the rice crop, and copra yields between 1500 and 1500 kg per hectare for coconut, at present the second principal crop in the tidal lands.

3 Constraints to agricultural development

Major constraints refer to soil and water with a strong interrelationship. Although the soils are of a heavy clay type they are fairly permeable in the upper layers which is not favourable for rice production. This permeability is caused by the high content of organic matter and is extremely high when the top layers consist of pure peat. The presence of potential acidity due to the occurence of pyrites (iron sulfides) is another bottleneck in many tidal areas. The permeability of soils together with this potential can easily lead to oxidation and acidification and the resulting release of toxic elements and fixation of plant nutrients, both impairing crop production. Moreover, permeable soils in case of rice cultivation promote weed growth and can cause water deficits in the crop in years of below average wet season rainfall.

Excess water which is a problem in the non-reclaimed areas is no longer regarded as such when the areas have been taken into cultivation because of evacuation facilities. During the rainy season salinity never occurs as an adverse factor. It may be one in the dry season if irrigation is considered and the irrigation water has been affected by the intrusion of saline sea water.

Other constraints refer to the accessibility. Many tidal land areas are remote or difficult to reach. It hinders the supplies of the necessary inputs and the appropriate marketing of the farm produce. It interferes with the recruitment of hired labour, often required for harvesting the rice crop. Also the manpower to manage the project and to support the farmers are not easy to get when communications with the bigger towns are time-consuming.

Clearing of land in vast areas of heavy swamp forest and the presence of stumps and trunks for a number of years inevitably creates the problem of heavy rat infestations and their damage to crops.

4 Approach to the problems

4.1 Water management

Water management is the key factor for successful tidal lands development. Water control to the appropriate levels is not only required to prevent excess water or water deficit to crops, but also to manipulate acidification in such a way, that the upper soil layers will be gradually freed from harmful substances without damaging the crops markedly.

A drainage system is needed to bring the tidal lands into cultivation. In case of rice production over-drainage could easily occur owing to the permeability of the soil. The rice crop has specific requirements to the

water regime for optimum development and the control of weeds. To this end a waterlayer of 10-25 cm should be maintained during the greater part of the growing season.
Also during the dry season the water control is important. It is aimed at the highest possible water-levels to prevent oxidation and hence acidification. Owing to the negative balance between rainfall and evapotranspiration, the groundwater table is inclined to drop. Water management requirements for upland crops are different from those for rice. Upland crops need an aerated soil layer of at least 50-60 cm. To attain this criterion in potential acid soils the groundwater table has to be carefully and gradually lowered so that acidification and the subsequent removal of acids will be under control. This is a long-term process. Quicker use of land can be obtained by the construction of raised beds and throughs in the so-called 'surjan system'. The beds are some 40 cm above the original surface and the throughs 40 cm below. On the beds upon upland crops are grown and in the lower parts rice or fallow.
The water management will be feasible through a canal system with fairly simple structures and in addition with bunded fields in case of rice. Structures in the canals will prevent in-flow of saline water into the fields.

4.2 Supporting services

The settlers are dependent on reliable supporting services to overcome the initial difficult years of tidal lands projects and to get involved in agricultural development. New living environment and unfavourable production conditions in the beginning will have an adverse impact on yields during the first few years, aggravated by the presence of stumps and trunks from land clearing and the inherent high rat population. Hence good services are essential with emphasis on the timely supply of fertilizers and rodenticides, and of good quality seeds. Extension activities should start simultaneously with the project, to recommend the farmers what to do under the prevailing conditions. Marketing of farm produce will be a matter of a later date since production will be needed for self-sufficiency for a couple of years.

4.3 Living conditions

Life will not be easy during the initial years of the project. Apart from getting used to the new situation the settler has a lot of work to do to improve the yields. Initial yields will be low and not sufficient for providing food and cash. A good credit system is needed so that the settler can meet his (and his family's) food requirements and have some consumptive credit, thus not being demotivated. The success of tidal land development is closely related to a positive participation of the settler.

Directly related to the living conditions are the transport facilities. In these remote areas they should receive full attention not only with a view to the settler but also to all other persons involved in the tidal land development on the site.

5 Agricultural development

5.1 Present and past development

Both spontaneous and government-organized tidal lands development started some 50 years ago and are still going on, covering in total an area of several hundreds of thousands of hectares. The spontaneous settlement projects are generally small-scale, concentrating on areas close to the rivers. The government projects are dealing with larger and hence more complex areas, which are more difficult to develop.

The most common cropping system is that of single wet season rice cultivation. In some of the spontaneous settlement areas part of the rice crop has been replaced by coconut. Where it is difficult to keep a continous water-layer on the field essential for rice, upland crops are grown. In case both upland crops and rice are preferred, the 'surjan' system has to be followed (quite common in Kalimantan). Occasionally double cropping of rice occurs in the Government schemes and then on a trial scale only.

Up till now the small-scale spontaneous settlement projects have been doing better than the large-scale transmigration projects, water management being more problematic in the latter ones. Still, some very promising results have been obtained in some of the older government projects in Kalimantan.

5.2 Future development

Future government schemes should start from a sound basis to stimulate settlers' participation. Development will be phased, attuned to low-cost technology and enabling the farmers to increase their income over a fairly long period.

Each farmer's family will get a two-hectare holding, which it can work with its own labour force. The cropping system normally consisting of 1.75 ha single cropped rice and 0.25 ha home yard should provide the family with sufficient food and a reasonable income for a number of years after settlement.

Initial cropping intensity and yield will be low. Stumps and trunks left after the forest clearing have to decay, toxic substances in the soil will only gradually disappear and the settler has to familiarize himself with the new social- and farming conditions.

Along with the removal of constraints the cropping intensity will reach 100 percent, meaning that all the two hectares are cropped and the yield will increase. Ten years after the start of the project the farmer must be able to produce 2000 - 2500 kg paddy/ha. Assuming that a farmer's family consists of six persons consuming each 250 - 300 kg paddy per year, a quantity of some 2000 kg will remain for sale. Cost of production will be low on the fairly productive soils, limited to nitrogen fertilizer (30 kg N/ha) and chemicals to control rats. Land preparation can be and must be shallow to avoid increased oxidation. It is confined to the slashing of weeds which will be incorporated in the topsoil after initial decomposition.

A further growth of income could be obtained from an intensification of agriculture, e.g. through the cultivation of upland crops (soya bean, maize) on residual moisture and dry season rainfall after the rice crop has been harvested. Yields of these crops will be moderate because problems of excess water may occur at the start of the growing period and of water deficit in the middle of it.

Double cropping of rice is a better proposition to increase income but it requires irrigation facilities for supplemental water during the dry season. Irrigation water could be supplied by low-lift pumps from the existing project's canal system. The problem is that the water in the canals during the dry season is often saline as a result of salt intrusion in the rivers and cannot be used for rice cropping. Hence the cultivation of dry season rice willl be possible only in areas not affected by salt intrusion.

In areas where land is not a scarce factor or where labour is scarce, part of the area under rice can be replaced by coconut as shown in some of the spontaneous settlement projects. Coconut has as advantage over rice that it requires a considerably lower labour input and that its production is fairly evenly spread over the year. This production distribution provides the farmer with a regular cash income in contrast to the single harvest of the rice crop.

The introduction of coconut in the cropping system requires special provisions since the drainage requirements of rice and coconut are totally different. In that case it is necessary to divide the holding in parts where various water regimes can be maintained.

Coconut performs in some areas better than in others. It prefers good drainable soils, preferably tidal lands with a high organic matter content. Location in terms of distance to river and sea also appears to be important. Coconut is fairly salt-tolerant and can withstand the effect of intrusion of saline water such as occurs in the coastal areas.

The availability of new high yielding varieties, with a production of some 2500 kg copra/ha when palms are mature, could make coconut competitive with rice in certain areas. Pyrites responsible for the acidification of potential acid soils should be absent or removed from the upper 70 cm of soil. To meet this requirement the cultivation of cocos on raised beds is imperative.

6 Achievements

Tidal lands development has not been an overall success, but in some

government projects in Kalimantan and in a number of spontaneous settlements in Kalimantan and Sumatra promising results have been obtained.
In general the initial years are difficult. Clearing of land continues, while at the same time production for self-sufficiency has to take place. And this production is low at the start because of still dirty fields and unfavourable soil conditions, aggravated by a rat problem common in areas bordering the forest. However, after 5-10 years reasonable production levels can be sustained if proper area selection has been carried out. For rice cropping other selection criteria are required than for coconut.
Of the two successful government settlement projects one comprises a vast rice area along the Serapat canal with sustained yield levels of 2000 kg paddy per hectare for some 50 years and the other with coconut plantations near Purwosari yielding 1500 kg of copra/ha. The rice area is on potential acid clays between the Kapuas and Barito rivers and the coconut area is on potential acid clays but overlain with a fairly thick layer of highly organic clays. The population in both areas gives the impression of prosperity.
The results of the more recent government settlements are less impressive. Mostly, inappropriate water management is the cause, either due to soil conditions or to the system itself. Still, there is progress and upgrading of these projects could bring about further improvement.

Even in settlement projects with disappointing results in parts of the area, transmigrants do not want to return to their region of origin. They have their own piece of land, their house and their home yard, and they can always earn money as hired labourers.
Agricultural development in spontaneous settlements is often successful. Remarkable achievements are reported from Samuda Keoil in Kalimantan where 6-10 ha coconut holdings provide the settlers with a good income. A promising rice area belonging to spontaneous settlers is located in Lagan, Sumatra. Paddy yields between 1500 and 2000 kg are quoted from large areas, providing plenty of work at harvest for people from even hundreds of kilometres away.

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DRAWDOWN AGRICULTURE AS A SUITABLE SUBSTITUTE OF TRADITIONAL FADAMA LAND CULTIVATION IN THE KAINJI LAKE BASIN

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Abstract

The impoundment of river Niger submerged some of the fertile flood plains (fadama land) in the process of creating Kainji Lake which introduced new environment into this part of the Nigerian savanna. The annual drop in the lake water level during April - August for about 10m from 141.8m altitude exposes extensive wetlands suitable for drawdown cultivation. A wide variety of crops such as upland rice, maize, millet, sorghum, groundnut, cowpea, kenaf etc. could successfully be grown there on higher elevations, while deep water rice is important at lower elevations of this drawdown area. The promise of drawdown agriculture and newly developed drawdown cultivation technology in the context of traditional fadama land which has been disturbed to a considerable extent by the creation of the lake has been identified. Due to the similarities of the fadama land farming and the drawdown agriculture, there seems to be much scope for enhancing crop production through more or less traditional cropping systems.

1 Introduction

Existence of potentially good land in Nigeria provides ample grounds for great hope, provided these lands are carefully exploited. Among the land resources the prized lot belongs to the flood-plains locally know as "fadamas". Generally speaking these fadamas comprise of rich alluviums with very high agricultural potential and cover thousands of hectares in the northern and dry half of West Africa (Morgan and Pugh 1969). The fadama lands are extensive and their size ranges from less than half hectare to hundreds of hectares (FAO 1970). In recognition of the importance of land and water resources, the Federal Government of Nigeria has established eleven River Basin Development Authorities in Nigeria with their concomitant commitment to the development of large scale rain-fed-irrigated agriculture.

The agricultural potentials and the land resources of the Kainji Lake Basin were thoroughly investigated and some guide lines were set for future development (FAO 1975, Sideruis 1974, Amaugo 1977 a, b, c, Amaugo et al. 1978, Chaudhry 1981, Chaudhry and Ayotade 1980 and 1982, Chaudhry and Ogo 1982). Kainji Lake Research Institute is concentrating on the development of improved crop production technology, while the Niger River Basin and Sokoto Rim Basin Development Authorities are exploiting the land resources.

Kainji Lake under normal circumstances fills during the dry-season and empties during the rainy-season (March-May) thus exposing thousands of hectares (Fig. 1) of varied grade of agriculture land for exploitation for rainfed agriculture (Siderius 1974). Here the drawdown cultivation technology is being pleaded as a substitute for the traditional fadama land farming.

2 Kainji Lake Basin

2.1 Lake and its Climate

The impoundment of River Niger has given rise to Kainji Lake (approx. Lat. 10^{o} N and 4^{o} 4É) with a surface area of 1270 km^2 (Fig. 1). The lake is situated in the Nigerian Savanna and weather conditions, during most of the year are favourable to agricultural activities (FAO, 1975).

2.2. Drawdown Area

With vertical fall of over 9m between the maximum operational lake level 141.8m above the mean sea level (AMSL) and minimum lake water level of 132.6m AMSL an estimated area of 65,330 hectare (ha) is exposed. This area is termed as the drawdown area and it ranges from gentle running slopy mud flats in the east the 'rocky' unculturable areas in the West of the lake (Sagua 1977, FAO, 1975 Siderius 1974). However, due to the timing of submergence and the exposure an area of 18900 ha was identified to be suitable for crop production without much risk of loosing the crop to the upcoming floods (Siderius 1974). The greatest of agricultural potential, however lies in the alluviums downstream the Dam.

2.3 Soils

Geomorphologically the Kainji Lake area is primarily Nupe sandstone terrain. There are three evident schematic shore profiles viz high relief rocky coast; medium relief rocky coast; and low relief alluvium flats. Generally speaking the area is a broad alluvium valley with gently inclined margins. The land-scape is rolling with occasional steep ridges or sharply incised stream beds (Halstead 1971).
Upland soils comprise of moderately well drained sandy soils and moderately deep loamy soils. Low relief alluvial flats are the ones, which command the highest importance from crop production point of view. These soils are akin to the traditional valley soils (fadamas) and are fertile and less prone to erosion (Siderius 1974, FAO, 1975). The largest block of the alluvium flat lies on the eastern bank of the lake in the form of mud flats (Fig 2).

2.4 Size of the fadama holdings

Due mainly to the higher labour input demand the size of the fadama holdings is very small end it varied from 1-4.0 ha. (Luning 1963).

3 Fadama land Agriculture in the pre-impoundment period

In case of Niger, the water level rises in May, rains begin and reaches peak in Septmeber/October. During this period vast lands around the river bank used to be flooded, until the peak begins to fall during the dry season. Among these areas fadamas flooded in August, the river drawdown (the land between the maximum and minimum water levels of the river), and the alluvium islands of Niger used to be planted with rice and harvested in January/February (Adeniyi 1970). During this period August-February farmers lifted water to irrigate their onion, sugarcane and vegetable crops.

4 Fadamas in the Post-impoundment days

Impoundment of the Niger after the construction of the Kainji Dam submerged 14,4000 ha of cultivated land and displaced some 40,000 persons which were resetiled (Oyedipe 1977, FAO, 1975). It also rendered about 12,000 ha fadamas downstream only good for upland crops (Adeniyi 1970) but the flood level was very much regulated thus making the downstream farming less a risky business. On the whole the impoundment adversely affected the crop yields in the fadamas, but it was rightly compensated by reduction in the flood level downstream and consequent expansion of upland agriculture on the rich alluvium, notably thousands of hectare sugarcane crop at Bacita.

5 Drawdown Agriculture

5.1 Current Land Use

Drawdown area is most extensively utilized on the northern eastern bank of the lake, which comprises of alluvium in the form of mud flots built by the enlarged Niger River. The majority of the resettlement village s are in this area (Siderius 1974). The major crops of the drawdown area are upland rice and onions. In addition some other popular crops such as sorghum, groundnut and vegetables are also cultivated. The size of the holdings mostly vary from 0.04 ha to 2 ha.

5.2 Land Management

The following schedule is being followed by the farmers in the Kainji Lake Basin.

	Land preparation	Planting	Harvesting
I Draw-down, Residual moisture-rainfed crop	March-April	March-May	July-August
II Drawdown, Rainfed	May-June	June-July	Oct.-November
III Upland, Rainfed	April-July	May-July	Sept.-January
IV Transition upland, Irrigated	Sept.-Nov.	Nov.-Feb.	April-May

5.3 Crop Yields

Average yield of important field crops are generally low. In the draw-down area of the lake, however, higher yields could be achieved e.g. groundnuts 2t /ha, rice 1.5t /ha, maize 2t /ha, cowpea around 1t/ha, sorghum 1t /ha and cotton 1t /ha, which are about twice the average yields. On the whole various crops displayed differential response to their planting at various contour levels, depending upon their growth period. Upland crops such as groundnut, rice, cowpea, maize, sorghum performed well between contour levels 140.3 - 141.8m AMSL, and crops like cotton, water melon, pigeon peas (deep rooted crops) favoured transition zone 141.8 - 144.8m AMSL. The only crop that flourished at lower contours (138.8 - 140.3m AMSL was the deep-water flooting rice.

6 Discussion

Traditional fadamas used to be a key factor for upcoming of a village nearby, because those not only provided fertile land for crop production in general and the production of high value crops in particular, but these spots under water-logged conditions ensured the water supply for for house-old use as well as for livestock. When the riverine environment was transformed into lake environment, the change was tremendous. It could have driven people away, however, through the supporting research findings it is established that the drawdown cultivation is more or less akin to that of traditional fadama land cultivation, as in both cases:

> the land is submerged under water intermittantly; soils are rich alluvium with little bit hydromorphic characteristics; have very high agricultural potential with the highest gross returns; these lands provide longer as well as off season crop production period for intensive agriculture; the type of agriculture is drawdown and draw-up; these lands stand as an assurance against droughts; these soils are difficult to manage; due to the heavy texture and serious pest (weeds, birds, insects) problem; under abnormal conditions sudden rise or fall in the flood level could adversely effect the crops.

7 Conclusions and Suggestions

With the technical know how in hand (FAO, 1975, Amaugo 1977 a, b, c, Amaugo et al. 1978, Chaudhry and Chachu 1979, Chaudhry and Ayotade 1980 and 1982, Chaudhry 1981, Chaudhry and Ogo 1982) it is being envisaged that the drawdown area could be exploited in a rewarding manners, as it is infact a replacement of submerged fadamas. However, a large scale exploitation of drawdown areas will require a high level of soil - water management. Since conventional tillage encourages silting, which is detrimental to the life and health of the lake, there is dire necessity for the development of conservative technology e.g. use of minimum tillage and mulching (crop residue mulch, plastic mulch, killed sod, soil, live mulch).

In order to minimize the risk in drawdown farming larger areas of highest potential (viz. Wara-Gafara mud flats), the drawdown area should be terraced and the possibilities of construction of diversion drain for flood control and protection irrigation be explored.

Acknowledgements

The author wishes to thank the Director of Kainji Lake Research Institute for his permission to present this paper. Help of Dr. Oyedipe for providing opportunities for some worthwhile discussion and going through the manuscript and the typist Mr. **Michael David for his** dedicated efforts to rescue me from the delay is gratefully acknowledged.

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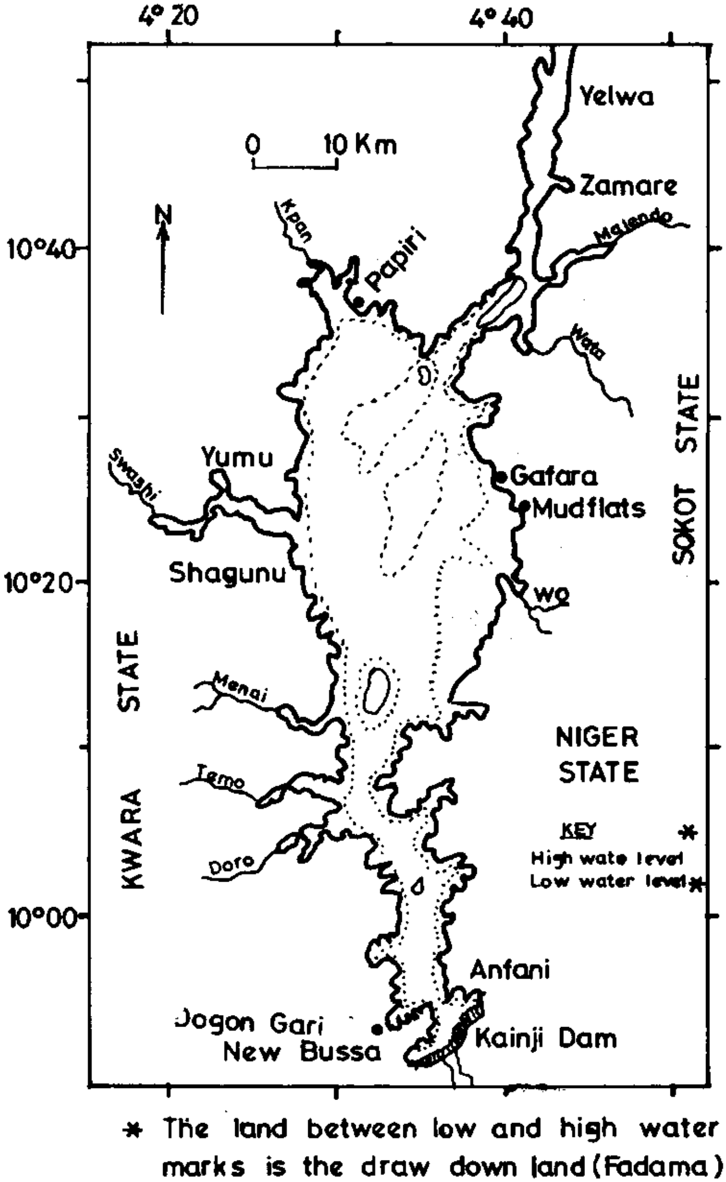

Fig. 1. Map of Kainji Lake Showing the draw down area.

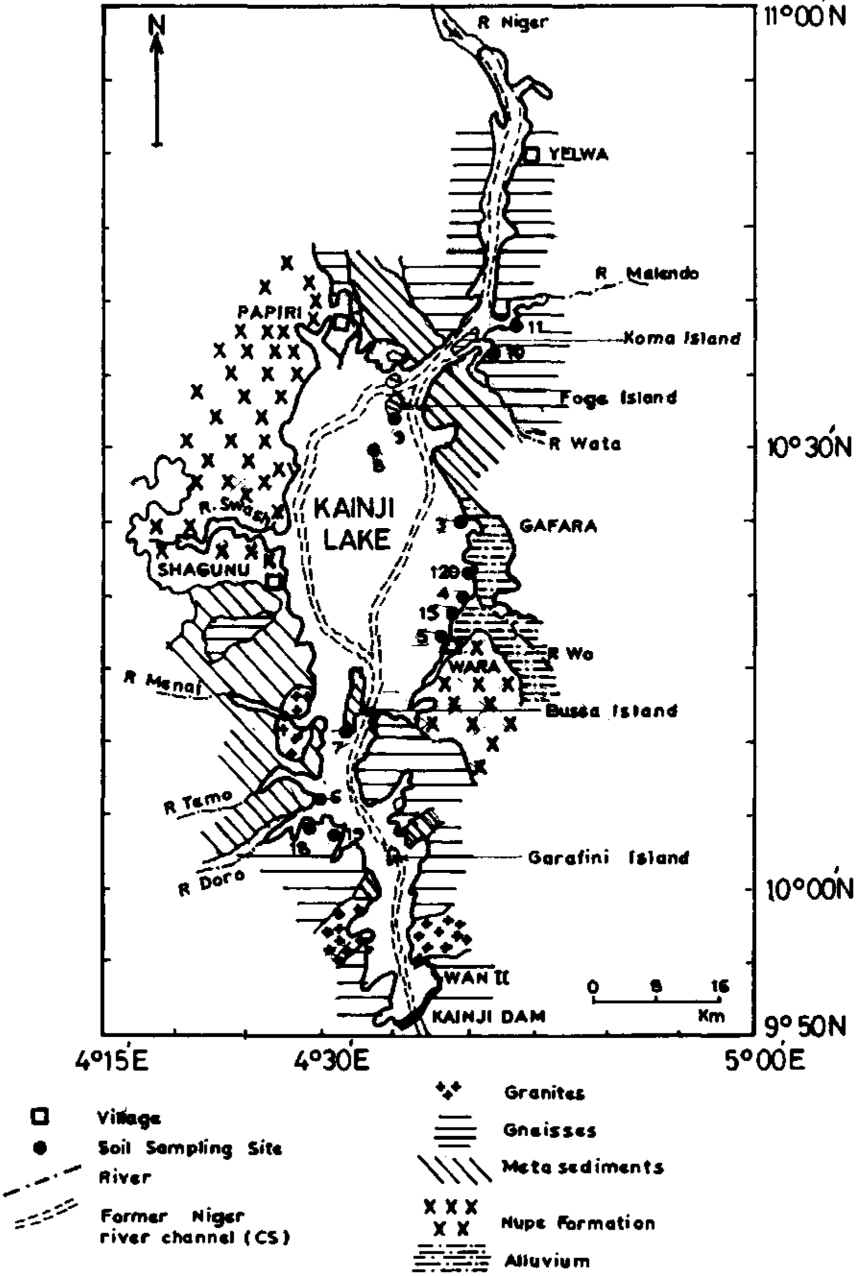

Fig 2 Geological Setting of the Kainji Lake Basin.

AGRICULTURAL ASPECTS OF BANANA CULTIVATION IN POLDERS IN SURINAME

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Abstract

In Suriname the total cultivated banana area is about 1,650 hectares. Plant density is 2,000 plants per hectare and total year production nowadays is about 38,000 tons.
Due to the heavily textured clay soils and the high amount of precipitation maintenance of a good drainage system is of paramount importance.
Agricultural operations require a high labour demand.
Besides an adequate drainage, control of diseases is important for a good production.
From socio-economic point of view the banana industry is of great importance to Suriname. Due to the high labour demand about 1,500 people are employed.
Today banana is one of the most important foreign currency earning crops of Suriname.

1 Introduction

Banana cultivation for export is not new for Suriname. In the years 1906 to 1914 and again around 1931 serious attempts were undertaken to start a Banana Industry.
Mainly because of variety susceptibility to the Panama Disease (Fusarium oxysporum f.cubense) results of the first attempt with

Gros Michel were disappointing.
Prior to a second attempt, field trials were conducted with the Panama Disease resistant variety Poyo (Robusta).
However, these trials revealed that the soils of the old plantation polders were not suitable for this culture. It was decided then to start the banana cultivation on newly empoldered land; the outbreak of the second world war intervened.
A third attempt was undertaken in 1957 to establish a commercial culture of banana in this country. This was indispensable to overcome some main problems in the agrarian sector viz. unemployment and epidemic outbreaks of the Hoja Blanca virus in rice.
In addition the introduction of banana would create a diversification in the local agriculture and generate foreign currency too.
All banana farms are managed by Surland Ltd., a fully state owned company.
The bananas are sold to Fyffes Group Ltd. in London and are for about 80 percent exported to the United Kingdom; 20 percent of the yearly production is exported to Italy.

2 Existing banana areas in Suriname

Suriname has a rather flat Coastal Plain, which stretches all along the East-West width and is about 40 km wide in the East and 120 km in the West (Figure 1). It consists mainly of marine heavily textured clay deposits.
Further to the South the soils are of a much lighter texture, although less fertile.
Almost all economic activities take place in this coastal area and it is here too where the majority of the population lives. This, together with the existing infra-structure, is the main reason why banana cultivation is situated in the Coastal Plain.

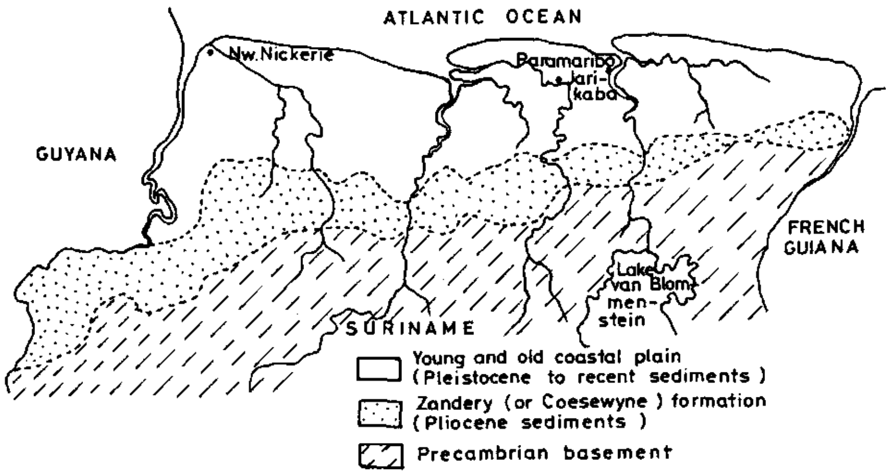

Figure 1. Situation of the Coastal Plain in its geological setting (schematized)

Apart from advantages there are disadvantages for a banana industry in this area.

The advantages are:

- high fertility of the soils;
- availability of labour;
- existing infra-structure with roads and port facilities.

The disadvantages are:

- most of the clay soils are very heavy soils with a clay content varying between 60 and 80 percent;
- most of these soils have a poor natural drainage with K-factors of less than one meter per day;
- the average pH is rather low for banana growing: 4.5-5.0;
- the soils are under swamp conditions.

To solve the disadvantages the construction of polders with a good drainage system is necessary.

The Suriname banana industry at the moment is concentrated in the Western district of Nickerie with two polders of 450 and 550 hectares, and in the Central district of Saramacca with three polders of 250, 310 and 480 hectares each (located at Nw Nickerie and Jarikaba in figure 1).

3 Agricultural aspects

3.1 Polder lay-out

All polders have basicly the same lay-out.
A main canal collects the water from the secondary drains or ditches and discharges it through a sluice (often combined with a pumping station) to a regional canal that is connected with a tidal river.
Each ditch controls an independent hydrological unit called "kavel", which is 6 - 9 hectares in size and is fed by small drains of about 90 cm deep and 6 meter apart, thus creating a cambered bed system.
Each "kavel" consists of 100 - 150 six-meter beds and alongside each "kavel" there is a clay road or dike, which can only be used in the dry season (Figure 2).

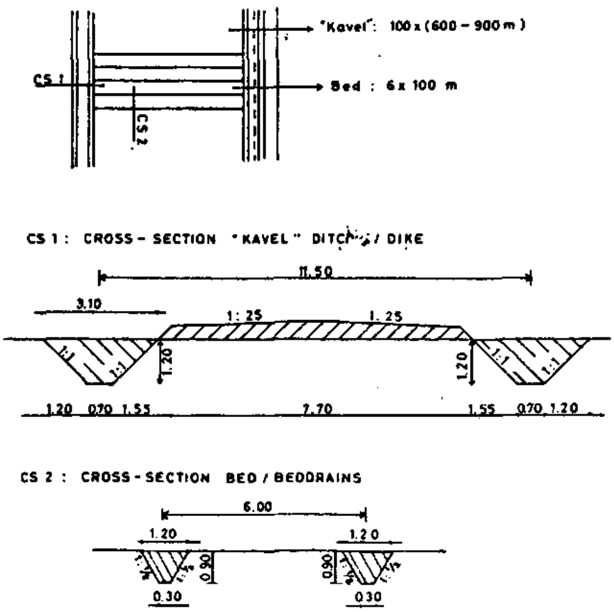

Figure 2. Cross-sections of a "kavel"

For the transport of the fruit from the field to the boxing stations a system of aereal cableways is constructed in such a way that the maximum carrying distance for a labourer never exceeds 100 meters. In the rainy seasons the cableways are also used for transport of fertilizers and other bulky material to the field.

3.2 Farm management

As a result of the soil conditions a high plant density is required. Because of the rather high permanent watertable (90 cm below surface with a good drainage) and the sometimes occurring compacted soil horizons the root system is rather restricted. For this reason the plants are relatively small compared to other banana growing areas. Planting is done in rows 3 meter apart with 1.65 meter between the plants in the row, thus giving a plant density of about 2,000 production units per hectare. In Central America plant populations do not exceed 1,500 p.u./ha.

The polder lay-out has some consequences for the farm management. First of all the costs to maintain such an intensive drainage system are very high. Because of the swelling and shrinking of the clay soils large amounts of clay fall frequently into the bed drains, blocking the water outlet, while as a result of the heavy rainfall clay is washed into the drains too.
As an average about half of the bed drains have to be repassed every year, which means about 1,500 kilometers.
This has to be done by hand, because a suitable machine has not been found yet. It has to be a small, manœuvrable machine with a low ground pressure and capable to operate on very uneven soil.
Although the costs of maintaining the drainage system are high, this money is well spent, because experiments as well as practical experience have learned that the production declines very fast with deterioration of the drainage system.

All the other plantation maintenance is also done by hand. As the consequence of the large amount of bed drains and the high plant density, machinery cannot enter the plantation. Chemical weed control for example is done by handspraying.
An example how the lay-out influences the maintenance of the farms is the method of fertilizer application.
This cannot be done by air or broadcasted freely in the field. As a result of the fact that 20% of the area consists of drains and another 30% of sloping area along the bed drains fertilizer has to be applied

carefully by hand in order to prevent losses.

In average there are 30 harvests a year, each lasting 3 days. This means that about 30% of the available days are used for harvesting the fruits. Especially in the rainy seasons this is a very hard job because of the large amount of drains, the uneveness of the soil and the danger of slipping.

3.3 Crop protection

Besides drainage, crop protection is very important in banana cultivation. In Suriname the main problems to be controlled are the Sigatoka leafspot disease, a disease called Yellow mat, nematodes and insects. Other pests and diseases are of minor importance at this time.

3.3.1 *Yellow Sigatoka Disease*

The main disease in the banana industry of Suriname is the Yellow Sigatoka (leafspot) Disease caused by the fungus Mycosphaerella musicola. Since environmental conditions (e.g. precipitation, relative humidity, temperature) are favourable for this disease the whole year round, the danger of being involved in high disease pressure exists continuously To keep the disease under control, chemicals with fungicidal effect against the leafspot pathogen are spread cyclically as a prophylactic treatment.
Good results are obtained in controlling the disease by fixed wing aircrafts (Grumman Ag Cat), equiped with Micronair atomizers (Type AU-3000).

3.3.2 *Yellow mat*

Due to an affliction, described as "Yellow mat" (R.H. Stover, personal communication) a serious depletion of production area occurred in 1976. The disease is characterized by a severe leaf chlorosis, retarded plant growth, markedly reduced rootsystem, small fruits and rozetting of older plants, accompanied by death of suckers in further disease stages.

An anatomical study on rhizomes from Yellow mat affected plants revealed the distinctive signs of the disease: slightly discolouration of the constituent tissues as a whole and conspicuous occlusion of the phloem vessels by a brown coloured, amorph substance; in all cases the xylem vessels remained unaffected.

Holes dug with the aid of a soil auger in both, apparently healthy looking sites of the farm and areas suffering from Yellow mat, revealed that mottling was always found in Yellow mat areas at 30 - 35 cm depth; beneath, there was a grey coloured sticky clay bank in which the plants did not root. In non-Yellow mat affected areas the situation was quite different; here mottling and water table were found at respectively 90 and 110 cm.

From these observations the disease is regarded as to a symptomatic effect of the impeded internal drainage of the heavy clay soil, although an interference with mycoplasma under conditions of water stress is not excluded.

Better plant growth and production were obtained in areas, associated with Yellow mat, after splitting the 12 meter beds into 6 meter ones, concurrently with repassing the secondary drains or ditches and bed drains frequently to discharge the surface water and lower the water-table adequately.

3.3.3 *Nematodes*

Weakening and subsequent death of the banana plant from high populations of root-attacking nematodes are very commonly in 6 to 8 year-old plantings. Mainly because of the heavy clay with low hydraulic conductivity, application of nematicides with systemic action to control these root-inhabiting parasites, to date did not give protection as to justify continued application with them.

Heavily infested areas with low production and high cost are therefore chopped and subjected to a 6 month-flooding period. After fallowing, the area is drained, dried and replanted immediately with cleaned and heat treated (56-58°C for 10 minutes), rhizomes. Departing from this tightly regulated control schedule may show marked repercussions on production (Figure 3).

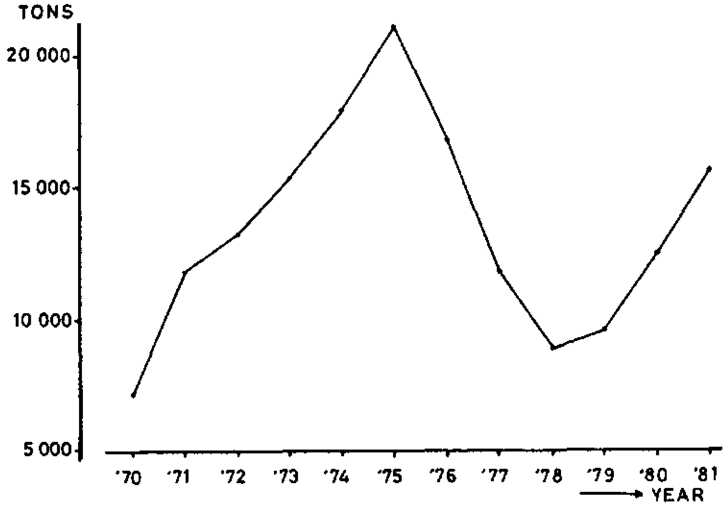

Figure 3. Banana production in the Jarikaba area

An experimental control program with Furadan and Vydate L is going on now to study the benefit of both, the nematicidal and insecticidal effect.

3.3.4 *Insects*

Damage to the banana corm by larvae of the insect Cosmopolites sordidus has been observed in the field. However, the average number of larvae per plant which can be tolerated without significant detriment to the plant most often shows fluctuations within a safe range.
An other insect (Colaspis hypochlora)feeds on the immature fruit peel and may cause severe damage to the exportable fruit.
Covering the bunches with polyethylene bags in an early stage, prevents damage.

4 Contribution to the national economy

The banana industry in Suriname is rather small in average but it covers a very important part of the agrarian sector in the national economy.
It provides well-payed work for about 1,000 people and additionally 500 during the harvests.
With the multiplier effect this means that about 10,000 people are dependent on the banana industry.

It is a crop with the lowest investment per labourer, about Sf 36,000.-- (=US$ 20,000.--) compared with Sf 126,000.-- (= US$ 70,000.--) for rice.
With a present production of about 38,000 tons exportable fruit per year it brings about Sf 14,000,000.-- (=US$ 8,000,000.--) into the country (Figure 4).

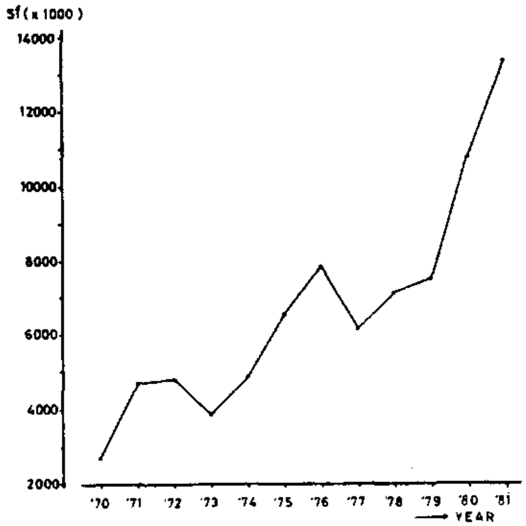

Figure 4. Foreign currency earnings by banana exports of Suriname

The average income per hectare is about Sf 9,000.-- (=US$ 5,000.--); this is one of the highest for crops in Suriname.
As a result of the high labour demand more than half of the banana income is spent on wages and social chatges, so a large percentage of the income is not re-exported.

MECHANIZED RICE PRODUCTION IN SURINAME

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Abstract

A survey is given of the mechanization of rice production, which was limited in the beginning only to the tillage, but contained afterwards all agricultural activities. The whole process of mechanization cumulated in several large centrally organized rice farms (2.000-10.000 ha). Tillage is carried out with crawler tractors; pregerminated seed, 3 fertilizer applications and several pesticide sprayings are given by aircraft and harvest is carried out by combine harvesters.

After the succesfull introduction of mechanization on the large estates, the small farmers (2-6 ha) also converted their traditional system of rice growing (e.g. transplanting of seedlings) into a fully mechanized system resulting in higher yields and two crops/year, but also in hidden unemployment, too much leisure and losses of hard currency. The main problem of the large rice estates, such as unmotivated labourers, high wages, shortage of fully qualified staff etc. are summarized.

Finally post-harvest methods (column versus bin drying and vertical versus horizontal storage) are reviewed.

1 Introduction

Since the beginning of agricultural cultivation in Suriname (around 1650 A.D.) polders have been used. This cultivation started along the rivers, the only way to enter the primary forest land. As the coastal areas were often low, dikes were needed at the backside to keep out the water from the swamps. In these polders plantations were established growing mainly sugar, cotton, coffee and cacao.

With the arrival of indentured labour from India and Indonesia the cultivation of rice was introduced and since around 1900 rice was one of main crops planted by the small farmers and therefore drainage canals and later on also irrigation canals had to be excavated in the polders. The rice was transplanted and harvested by hand. The size of the polders was therefore based on this method of rice production.

After 1933 mechanization of rice growing was tried out and after many years of trial and error large mechanized rice farms were established in N.W. Suriname in the fifties. One of the reasons of the succesful introduction of mechanization was the availability of large, flat, nearly treeless, uninhabited areas, which were very suitable for rice growing due to the fertile clay soil, and the vicinity of rivers with sufficient sweet water. Another advantage for mechanized agriculture is the yearly occurence of two rather well defined dry spells. As shown in figure 1, the total rice production has increased tremendeously since the introduction of mechanized rice production in 1950, with a yield of 4-4,5 ton/ha and two crops a year.

2 Present agricultural methods on large estates

The agricultural activities on large estates such as tillage and harvesting are highly mechanized. Sowing, fertilizer application and cropprotection are carried out by means of airplanes. The increase of mechanization has had a great influence on the lay-out of the polders;

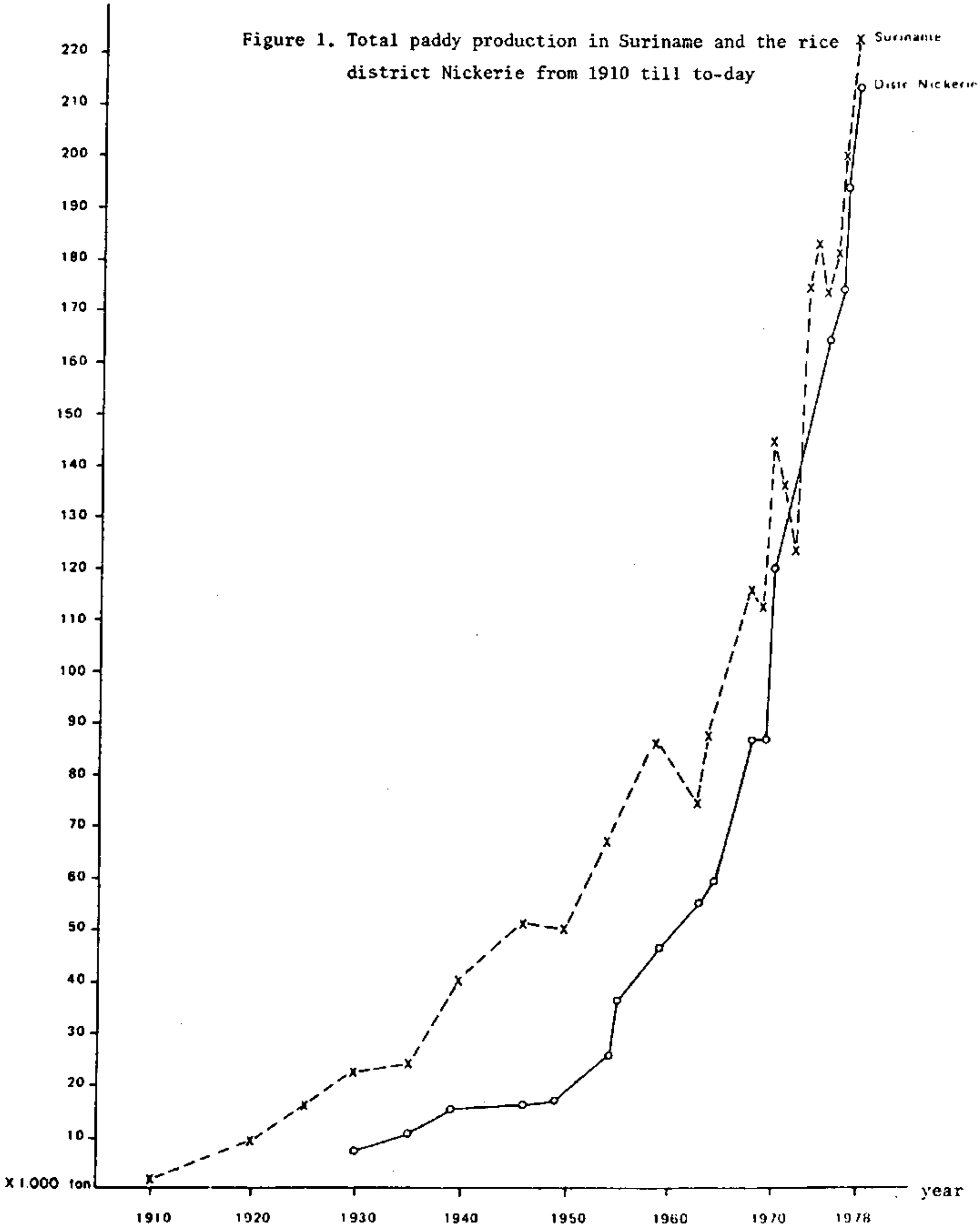
Figure 1. Total paddy production in Suriname and the rice district Nickerie from 1910 till to-day
Suriname
Distr. Nickerie
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
X 1.000 ton
year
1910
1920
1930
1940
1950
1960
1970
1978

the plots have to be about 600 m long and accessible for machinery. Although the basic problems for mechanized rice production have been solved, some topical subjects will be discussed here.

2.1 Controverse crawler - four wheel drive tractor

Both types of tractor are used at the moment, without clear indication which type should be preferred.

Traction in a wet field can be obtained in two different ways:
- by penetration into a firm layer at the plough sole;
- by flotation.

Under rice field conditions wheeled tractors depend mainly on penetration and crawler tractors on flotation. Usually the ground pressure of crawler tractors is about half the (ground)pressure of wheeltractors of comparable weight. Under wet conditions wheeltractors may bog down and slip more easily than crawlers, as long as the tractor is working on unripened clay soils without a defined ploughsole. Another disadvantage of wheeled tractors are the deep tracks in the moist field after the final tillage. However an important advantage of the tractor is the speed (8-10 km/hr), when working under less humid conditions, which is nearly twice as fast as a crawler (in Table 1 some performances are given). In practice, on older (more than 5 years) ripened soils four and eight wheel drive tractors are used besides crawlers. At the bigger estates both types are recommended: for the wetter conditions the crawler; during dry spells the four wheel drive tractor.

2.2 Pregerminated versus not-germinated seed

In general pregerminated seed (24 hrs soaked in water, then drained for 24 hrs) is sown by airplanes (Grumman Agr. Cat.).

Table 1. Equipment used and their performance for big estates as well as small farmer holdings

Equipment	Operation width (in m)	Speed km/hr	Hrs/ha*	Job efficiency** %	Availability*** %	Net hrs/ha	Capacity per day (two shifts) 12 hrs/ day in ha
Dry tillage							
- D-4 SA (68DBHP) with disc-harrow 32 discs of 24"	3.20	4.0	0.92	70	70	1.88	6.4
- D-5 SA (93DBHP) with disc-harrow 40 discs of 24"	4.00	4.6	0.64	70	70	1.31	9.2
- 8 wheel drive tractor (160DBHP) with disc-harrow 40 discs of 24"	4.00	8.0	0.37	70	70	0.76	15.8
- 2 wheel drive tractors (70DBHP) with 3 disc plough	0.75	6.0	2.6	70	70	5.3	2.26
- 2 wheel drive tractor (70DBHP) with disc-harrow 12 discs of 20"	2.00	7.0	0.84	70	70	1.71	7.0
Wet tillage (pudding)							
- D-4 SA (68DBHP) with weedcutter or 3 segment mudroller	4.0	4.0	0.74	70	70	1.51	7.9

Table 1. (cont'd)

Equipment	Operation width (in m)	Speed km/hr	Hrs/ha*	Job efficiency** %	Availability*** %	Net hrs/ha	Capacity per day (two shifts) 12 hrs/day in ha
- D-5 SA (93DBHP) with weedcutter or 5 segment mudroller	5.5	4.6	0.47	70	70	0.96	12.5
- 2 wheeldrive tractor (with cage wheels) with mudroller or disc-harrow	2.0	6	0.98	70	70	2.00	6.0
Harvesting							
- Combine 14'	4.20	3	0.93	55	60	2.82	3.2****

* In this figure is discounted a field efficiency of 85%, which means time losses due to corners, beginning and end of plot etc.

** Job efficiency gives indication of time losses due to personal care, adjustment of equipment etc.

*** Availability indicates how much time the equipment is at your disposal and not in the workshop, based on the whole cropping season.

**** Based on 9 working hours per day.

The advantages of using pregerminated seed are:

- the rice plant has an advantage of about 3 days compared to weed enabling the rice seedling a better competition with weeds;
- emergence is better, more regular and denser and less seed is required;
- in the most sensitive stage the sprouting seed is not exposed for two days to unfavourable field conditions such as pathogens and shortage of oxygen during germination.

The use of not pregerminated seed has the following benefits:

- more seed can be transported per flight, which means less costs;
- cost of handling before sowing is less;
- time of sowing can be delayed;
- sowing is easier and the risks of seed-damage is less.

In most cases a better competition with weeds and an even stand is of decisive importance, so pregerminated seed is preferred.

2.3 Weed control system

For spraying pesticides airplanes (Grumman Agr. Cat) are used. Grasses, like Ischeamum rugosum and Echinochloa Spp. are controlled with propanil (Stam F.34, Surcopur), 14 days after sowing. A dosage of 3 to 4 litres of propanil with 20 litres of water is applied per ha with micronair nozzles in runs of 20 meters. When normal nozzles are used an amount of 40 litres water is used and applied in runs of 14 meters.

Broad leaf weeds and sedges like Sphaenoclea Sp, Jussieua Sp, Fimbristylis Sp, are controlled with 2-4 D. amine about 27 days after sowing. When micronair nozzles are used, half a litre to one litre of 2-4 D. amine is mixed with 20 litres of water and applied in runs of 40 meters. If normal nozzles are used, half to one liter of 2-4 D. amine is mixed with 40 litres of water and applied in runs of 14 meters.

One of the most noxious weeds is the red rice, which is difficult to control by chemicals. The only but expensive solution is repeated ploughing with some weeks interval, which gives the red rice the opportunity to regrow until it finally disappears.

2.4 Methods of maintenance of field roads, drainage and irrigation canals

The maintenance of field roads, drainage and irrigation canals is of great importance for functioning of the polder.

Field roads

Normally the field roads of the large estates are not paved. In the rainy season it is very difficult to travel on these roads, as the soil softens and it is quite normal for farmmachinery to bog down on the road. This results in an uneven road which has to be ploughed and levelled by a grader, mounted behind a wheeltractor in the dry season to keep the road rounded.

Irrigation and drainage canals

Aquatic plants grow abundantly in these canals. For a good functioning of the canals these plants are raked with a dragline once a year. Sometimes they are controlled by herbicides. During the rainy season the canals can be used for transportation of personnel, implements etc. On one big farm the harvested products are transported in barges through the canals. It is necessary to deepen the canals about every two years. Field ditches should be deepened every season. On one farm aquatic weed control is practised by sea-cows (Thichechus manatus), afterall with a poor result due to sensitiveness of the animal to pesticides and passing barges.

3 Present agricultural methods with small farmers

Having practised traditional methods of rice growing in the past, to-day all the small farmers of the rice district have adopted the modern system of mechanization, with two rice crops per year and no transplanting. Recently they started to make use of airplanes for sowing and other treatments.

One of the reasons for the easy transformation from traditional to modern methods was the succesfull introduction of mechanized agriculture at some big state- owned estates, which were situated amidst the small farmer holdings. Hence the technology was easily transferred by visual means. Although most research was directed towards the big farms, the small farmer profited also from it. Another reason of course for the quick adaptation was the possibility for the good manager to make a lot of money in a short period. In the sixties and seventies the price of paddy was good and this was an incentive for several farmers to grow rice using modern technology.

Nowadays the small farmer uses a wheeltractor of about 70 hp for tillage, in dry spells preferably with a 3 disc plough; if the field is too wet he will puddle the field with a disc-harrow or mudroller; afterwards the field will be levelled with a beam. Four wheel drive tractors of about 80 hp are in the process of being introduces now. In most cases sowing, fertilizer application and cropprotection are carried out by means of airplanes.

One of the negative effects of modern farming in traditional rice land is the use of pesticides in inhabited areas. As the family lives on its own plot, the risks of contamination are reasonable when airplanes are used for spraying pesticides. Applying less dangerous pesticides might be a solution, or landconsolidation aiming at removing families from their plots.

In the contrast to the old way of rice cultivation where the small farmer cut his paddy (rough rice) by hand and left it in the field to dry in the sun, the rice must be dried now within a short time (24-48 hours) because of the large quantities harvested by the combine. The Government started with small bin driers consisting of 5-6 bins, each containing 7-10 tons of paddy with diesel engine driven ventilators and mostly extra airheaters, so the paddy was dried in 30-40 hours, depending on the moisture content, with low heat input (airtemperature 40-45°C). The bins are loaded and emptied by hand. They are very simple to run and to control, and the bins with air canals can be made by locally available carpenters and workmen. The bin drying system has become very popular. A local manufacturer developed means to mechanize the installation and to assemble the drying plants and airheaters locally. These mechanized plants were installed by the big rice mill-exporters. With mechanization very little labour is needed. The thickness of the paddy layer was brought back from about 1.50 to 0.75 m, and the duration of drying to about 18-24 hours. These big installation made of cement and wood construction have a capacity of 200-250 tons paddy per 24 hours (20-13% moisture content w.b.).

Nowadays the small farmer mostly sells his paddy, unharvested to a buyer who owns combines, driers and storage, and the farmer becomes totally dependent on a few buyers. And if too much paddy has to be harvested and dried at the same time because there is no mutually agreed upon seeding scheme the farmer gets in a jam. He has to sell and mostly at a low(er) price. Therefore, the Government urges the farmers as much as possible to join forces in cooperatives. The Government is willing and is already busy setting up driers with storage to be run by cooperatives. Because then the farmer, through the cooperative, is able to harvest and dry his paddy at the right time, and wait and sell his paddy to buyers at a better price. The big estates use imported vertical driers, only the biggest estate (about 10.000 ha) uses vertical bins (concrete and steel) for storage. More research should be done about the advantages and disadvantages of bindrying and column drying, and horizontal and vertical storage.

Besides the technical points like quality of the grain with milling yield and use of energy, there are other points of importance to a developing country like Suriname. Building with locally available materials (cement, sand, wood, corrugated sheets, cement blocks) gives much needed help to the local industry and labour market. Simplicity of design, in order to make it possible for ordinary workmen, who are not specialists, to run the drier, is another point. A bin drier can better seperate the different qualities of small farms. Because lower air temperatures are used the product of bin driers can be milled right after drying. All big mills, except one use horizontal storage with aeration and mechanical loading and unloading. Smaller mills use bag storage, or a combination of bag and horizontal storage.

Solar collectors

As fuel makes up a sizable amount of the cost of drying and in view of the impending fuel shortages research has been done on alternative sources of energy. Some research was done on solar collectors resulting in the installation of 2 solar collectors for paddy drying; one small one of 60 m^2 in the sack drier of the research station in Nickerie, the other one of 320 m^2 is used in the van Dijk paddy drier, a column drier, and has been working for 2 seasons. It is a warm air collector giving an air temperature of maximum 50°C. It is fully automatic, as a thermostat regulates the fuel supply to the burners to keep up the needed temperature for the drier. The cost of the locally made collector is payed off in about three years. The following figures of an existing design give an indication of the savings: surface of the solar collector 1300 m^2 max. capacity in full sun 700 KW. Mean capacity from 8 o'clock to 18 o'clock 330 KW. Yearly saving 50.000 liter diesel fuel.

Husk burning for energy

In rice milling about 20% of the total paddy crop becomes available as an energy source. Only the Wageningen mill is converting this energy into electricity with an efficienty of about 10%. The available energy out of husks is about 3000 Kcal/Kilo husk. Research is going on on the use as energy for paddy driers. The very low weight of the husk does not make it attractive to transport it from the mill to driers situated at some distance. Problems of tar and ash production must also be solved before husks can be used extensively for paddy drying.

5 Some topical problems related to mechanization

The main problem of the biggest - state owned - estate, about 10.000 ha, can be carried back to engagement of a large contingent of labour. With the rise of the trade union, rather high wages were claimed, without the required increase of productivity. As a result of this the total amount of wages makes the cost price of the rice too high; moreover due to the high wages there is almost no incentive for the employees to work overtime, which is essential in farming.

Another problem of such a big estate is the non-availability of staff of sufficiently high quality and management capacity. It seems that for a Third-World country like Suriname, it is rather difficult to centrally run a farm of 10.000 ha. At the moment the option to split the farm into smaller undependent units is considered.

For the small farmer the introduction of mechanized rice production has caused, among others, unemployment. In the traditional way the whole family was engaged in the process, now about 15 mandays/ha/crop are required. With reason the modern rice farmer is called telephone farmer, as his main job is telephoning the airspray company. Another consequence of mechanization is that the plots originally designed for transplanted rice, are much too small to justify the purchase of wheeltractors with equipment. Bundling of small farmers into cooperatives might be a solution, although most farmers prefer to possess their own tractor. Due to overmechanization the cost price of rice becomes too high. Returning to partial mechanization (sowing, fertilizer application and perhaps cropprotection done by hand) might decrease the cost price, but the social impediments to re- introduce handwork wil be tremendous.

COST-BENEFIT ANALYSES FOR A PLANNED PART OF THE IJSSELMEERPOLDERS PROJECT

(case study Markerwaard)

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Abstract

In making a cost-benefit analysis for a polder a lot of practical and theoretical problems arise, because one has to do with quantifications and qualifications on direct and indirect effects and on material and immaterial effects. In a qualification personal beliefs of decision-makers play an important role.
For the polder Markerwaard a short description is given about the outcomes of the internal rate of return (IRR) about the benefit-cost ratio (B/C) and about some other comparing possibilities. The length of the article did not permit to give detailed calculations.

1 Introduction

Long term and big (governmental) projects have to be considered on different aspects.
Weighing out one aspect against another and weighing out one project against others is one of the most difficult things in the planning proces.

In making a "social" cost-benefit analysis (C.B.A.) there are still a great deal of problems, practical as well as theoretical. These problems arise especially because in a C.B.A. one should measure and evaluate all positive and negative effects (and/or aspects) of the project. This has

to do with direct and indirect, with material and immaterial effects. One should know all the impacts of a project on a with and without basis. The quantification of many things (of internal as well as of external effects) is still difficult to make, and a qualification is depending on personal views and ideas.
A governmental project should give a maximum net "social" result (in terms of wealth and of welfare), but one can discuss what is a "maximum".

For the making of a C.B.A. of a polder (in this case the planned Markerwaardpolder) a concept of a land-use plan is necessary. This illustrates at once the problems one meets.
A detailed plan for a polder that will be really effective in use after a period of 10 or 15 years is "incredible", because the society needs change in time.
Experience in four former polders has shown that the realisation of a polder differs a great deal from the original plans. In every polder we find: agriculture, towns, nature reserves, forests, recreation sites, infrastructure (road and canals) and so on.

At this moment the choice for an agricultural use as the basis for a C.B.A. is thought to be realistic, because:
the soils are very good fit for agriculture,
agricultural products can be produced at relatively low costprices,
agriculture is a flexible destination and can quickly be turned into other types of land-use,
the costs and benefits of agricultural land-use are fairly well known.

One can easily understand that, if at first an agricultural plan is chosen as a basis and later on one decides to diminish the agricultural area and to increase other forms of land-use, than the chosen plan is valued higher than the original plan with only agricultural land-uses. This means that the results of a C.B.A. on an agricultural basis can be considered as the lower-limit of possible results, because another plan will only be chosen if the total value (whether in money-terms or in other values) is higher.

2 Criteria for measuring the outcome of a project

In money terms several measuring criteria in C.B.A. are found in literature (Dasgupta and Pearce, 1972). Of course one should have in mind that the money-measure is only one of the possible measures. The money-criteria with relatively less disadvantages are:

- the internal rate of return (I.R.R.),
- the net present value (N.P.V.),
- the benefit-cost ratio (B/C).

There is a certain relationship between the different criteria. In the Markerwaard study at first one has chosen for the I.R.R.-criterium and later on for the B/C-criterium, accompanied by qualitative comparisons.

The I.R.R. is chosen because no discount rate has to be chosen. The outcome of the calculations is the I.R.R. The I.R.R. being that percentage that makes the present value of all (yearly) costs equal to the present value of all (yearly) benefits. This means that the total present value of the project is zero, but that all investments and other costs render a rent-percentage equal to the I.R.R.

The B/C requires a carefull definition of what can be considered as benefits and what as costs. By considering some effects as costs instead of as negative benefits the outcome can be influenced.
In the C.B.A.-calculations is reckoned with:

1. constant prices (no inflation), or higher and lower prices. For agricultural products the E.E.C.-prices or 5-year-average inland market-prices are taken;
2. constant labour productivity;
3. constant physical productivity;
4. constant trade-ratio for agricultural products;
5. a project period of 60 years.

All these facts, combined with a competitive market which lowers the consumer prices when the cost-prices diminish, make that the outcome will not be to high (on the contrary).

3 At first three poldersizes, later on only one size

At first calculations were made for three variants:
40.000 ha (the island of Marken remains an island), 50.000 ha and 57.000 ha (the maximum area that eventually could be reclaimed).
In time however several pro and contra discussions about the possible sizes have, at this moment, restricted the choices of the decision makers to one size (the 40.000 ha variant). The general belief is that the recreational and environmental values of the existing water area do not allow to reclaim a greater polder.

4 Costs and benefits during a 60 year period

Calculations are made for a 60 year period. Because of the limited length of this article it is impossible to give details about the calculations. More details are given in the Markerwaard Rapport (1976), and Rapport Verkenningen Markerwaard (1975).

4.1 Investment costs

The investments to get the water out of the polder concern: dike building, pumping plants, canal dredging, sluices, bridges and road connections with the surrounding land. (The costs of the existing dike Lelystad-Enkhuizen are not taken into account). The used prices are without added-value taxes but with overhead costs.
Further investments concern: roads, main ditches, ditches, drain pipes and all other necessary reclamation activities (sowing reed by aircraft, destroying the reeds later on, making trenches, etc.); furthermore the investments for the (temporarily) State agricultural exploitation and after that for the exploitation by the private farmers. This concerns: machinery, silo's, labour costs, farm buildings, office buildings etc.

4.2 Benefits

The benefits concern: all the (yearly) agricultural revenues per hectare (net revenues, land rents, intrest of capital, depreciation), the (rest) values at the end of the 60 year period. These rest values depend on the period the articles have been in use at that time; for the land a selling price is assumed.

5 Results with the criterium "Internal Rate of Return" (I.R.R.) for three poldersizes

The resulting I.R.R. for three poldersizes are shown in table 1.

Table 1. Internal rate of return (I.R.R.) for 3 agricultural used polder sizes of the Markerwaard. Sixty-year period

Polder size	40.000 ha	50.000 ha	57.000 ha
I.R.R.	6.09%	6.97%	7.08%

Table 1 shows that greater polders have a better I.R.R. because they can be achieved at relatively lower costs and can bring higher benefits. Related to an occurring revenue in our country of 2 or 3% for investments in agricultural buildings and in agricultural land, a revenue of 6 or 7% seems fairly well acceptable.

6 Further judgement of the results

6.1 The reclaiming value of the water area

If one considers 3% an acceptable rate of return (as is the practice for farm land and farm buildings now) than the net value of the difference between 3% and 6 or 7% can be paid for buying the water area before reclaiming it. That amounts a sum per hectare of:
- ƒ 18.613 for a 40.000 ha poldersize.
- ƒ 20.135 for a 50.000 ha poldersize.
- ƒ 19.749 for a 57.000 ha poldersize.

These figures can also be used for arguing the value of the water area for other uses than agriculture i.e. for fishing, for sailing and other forms of recreation, for natural water purification etc.

6.2 Other possible assumptions, e.g. about the tempo of dike building and of the reclamation, about other farmsizes, about selling the land after the period of temporary agricultural use

These assumptions cause the following changes in the calculated I.R.R. for a 50.000 ha polder:

- Dike building in 7 years instead of 10 years gives 0.3% extra I.R.R. (7.29% instead of 6.97%).
- Quicker reclamation (6.800 ha per year instead of 3.400 ha) gives 0.8% extra (7.77% against 6.97%).
- Farms of 60 ha instead of 300 ha lowers the percentage from 6.97% to 6.70%.
- If the land is sold after the period of temporary agriculture and 3% intrest on capital is wanted, than the land must be sold at a price of ƒ 18.725.

7 The B/C criterium and other comparing possibilities

7.1 Introduction

A Dutch governmental advisory commission on project-analysis has adviced to use the benefit cost criterium (B/C) for all governmental projects. This criterium should be used at different discount rates, but including 10%. Roughly speaking one can say that an I.R.R. of 6 or 7% is lower than the B/C outcome at the advised 10% rate. However at this moment the acceptability of the 10% rate is in heavy discussion.
The judgement of the acceptability of a certain I.R.R. or B/C is left to politicians.
Besides the money-criteria as a weighing-factor in the judgement of

projects, there are several other aspects that cannot be quantified in money (or other) terms, but can only be qualified. In 1980 a study was carried out in accordance with the B/C wishes of the mentioned governmental commission. In this study there are several forms of land use, not only agriculture. This study cannot be described in detail, but the main motivating aspects for a Markerwaard that were mentioned are:

- aspects of physical planning (wanted areas available for different land uses),
- economic aspects (money aspects and labour aspects),
- social aspects.

For all these aspects the study gives a detailed "with and without" comparison. A part of this comparison is given in table 3.

7.2 B/C ratio's for an agricultural polder

The B/C ratio is calculated for several price expectations of products and for 8 and 10% discount rates (table 2).

Table 2. Benefit/cost ratio's for an agricultural Markerwaard of nearly 40.000 ha for three assumptions on economic growth and at two discount rates

Assumptions on economic growth	I		II		III	
Discount rate	8%	10%	8%	10%	8%	10%
Assumptions about prices of agricultural products and about speed of the reclamation works						
1. E.E.C.prices	1.1	0.9	1.1	0.8	1.3	0.9
2. a. E.E.C.-prices + 25%	1.2	0.9			1.4	1.0
b. E.E.C.-prices - 25%	1.1	0.8				
3. world-market prices			1.0	0.7		
4. E.E.C.-prices combined with a slower investment in dike building and pumping plants (3 years longer)	1.1	0.8				
5. worse possibility: world-market prices combined with a 3 years longer investment period in dike building and in pumping plants			0.9	0.7		

The three assumptions about economic growth are:

I = Until 1995 1% real growth in the added-value per ha, after 1995 no growth (0%).

II = Until 1995 0% real growth, after 1995 also no growth.

III = Until 1995 2%, after 1995 no growth.

7.3 Another comparing possibility

Table 3 gives the outcome of a comparing method not only using quantifications, but also using qualifications.

Table 3. Part of a "with and without" comparison (qualified and quantified as far as possible) for a 40.000 ha Markerwaardpolder

Aspects	Without Markerwaardpolder effects on the country (land)	Without Markerwaardpolder effects on the water area	With Markerwaardpolder (several types of land use)
Agriculture			
- area	diminishing with 10.000-13.000 ha per year		diminishing at a lower rate, in one time an additional area of 20.000 ha (50% of the polder for agriculture)
- production			
. net added value			+ ƒ 158 mln in the polder; + better production possibilities in the country
. balance of payment effect			+ ƒ 90 mln in the polder; + better production possibilities in the country
- structure			
. productivity	unsatisfactorily		+ ƒ 7 mln
. income position	problematic		better
Nature reserves and environmental values	decreasing; problems to get the wanted areas to realise an improvement	waterfowl-wetland of international importance (40.000 ha)	- loss of part of waterfowl wetland + possibilities for natural reserve areas (4.000 ha) + possibilities in the rest of the country
Forestry etc.			

In the same way also the following aspects are compared:

- Forestry (net production, recreational possibilities, degree of selfsupporting, area)
- Employment: direct and indirect (dike building, temporarily agriculture, permanent agriculture, forestry, fisheries, other exploitations, etc.)
- Fisheries (net value)
- Urbanization
- Recreation (boats, harbour places, angling, camping, etc.)
- Airport site
- Military training area
- Infrastructure
- Future physical planning possibilities
- Landscape (cultural and historical values)
- Safety of the polder Southern Flevoland
- Money costs

The summarized conclusion of the study was: a polder costs a lot of money; a polder has considerable effects on the natural environment but ultimately the positive and negative aspects are weighing out; a polder gives an important contribution in solving problems in the sphere of urbanization, agriculture, forestry and recreation and furthermore allows new developments.

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THE SIGNIFICANCE OF AGRICULTURE IN THE DUTCH IJSSELMEERPOLDERS

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Summary

The Netherlands have 3,4 million hectares of land, a decreasing number of farms and farm workers, at present there are 125.000 farms with 300.000 workers, the total population is 14 millions, the working population is 5 millions, the agricultural export surplus amounts 9.000 - 12.000 million guilders per year.
The four original aims of the IJsselmeerpolder project are:
- improvement of safety against inundations;
- reclamation of fertile agricultural land, encouragement of employment;
- a better water management system (as well concerning quantities and qualities);
- shortening the connection lines between the western and northeastern part of the country.

A recent fifth aim is:
- creating more room for urban activities and for forests, nature reserves and recreational sites.

The soils of the polders are very well fit for agriculture, so they produce high yields at relatively low costs. This results in relatively

good income results, gives employment and favours the balance of payments.
This serves the Dutch agricultural policy and the policy of physical planning.

1 Introduction

The area of the Netherlands amounts about 3.4 million hectares of land (excluding the big water areas) of which about 2.2 million ha is in agricultural use. Since the second world war the urban area increases strongly at the expense of the agricultural area (figure 1).
There are about 125.000 farms on which 300.000 persons are employed. The total population of the country is 14 million people, of which about 5 million belong to the working population. This means that 6% of the working population is engaged in the direct agricultural production. Besides there are another 6% engaged to agriculture in an indirect way, e.g. in industries that are delivering to agriculture or that are processing (and/or marketing) the farm products.

The number of persons directly employed in agriculture is decreasing. In 1947 there were 700.000 workers, now there are only 300.000. This means a decrease of 33 persons per day during 33 years already.

Our country imports a lot of agricultural requirements and agricultural products. A certain part of these imports is exported again after being used in a process of "adding value". In this way part of the agricultural income is gained.
The last years the net surplus from agricultural exports amounts 9.000 to 12.000 million guilders a year. This means at least a sum of ƒ 650,-- per inhabitant, which is a good help in achieving a better equilibrium in the balance of payments.

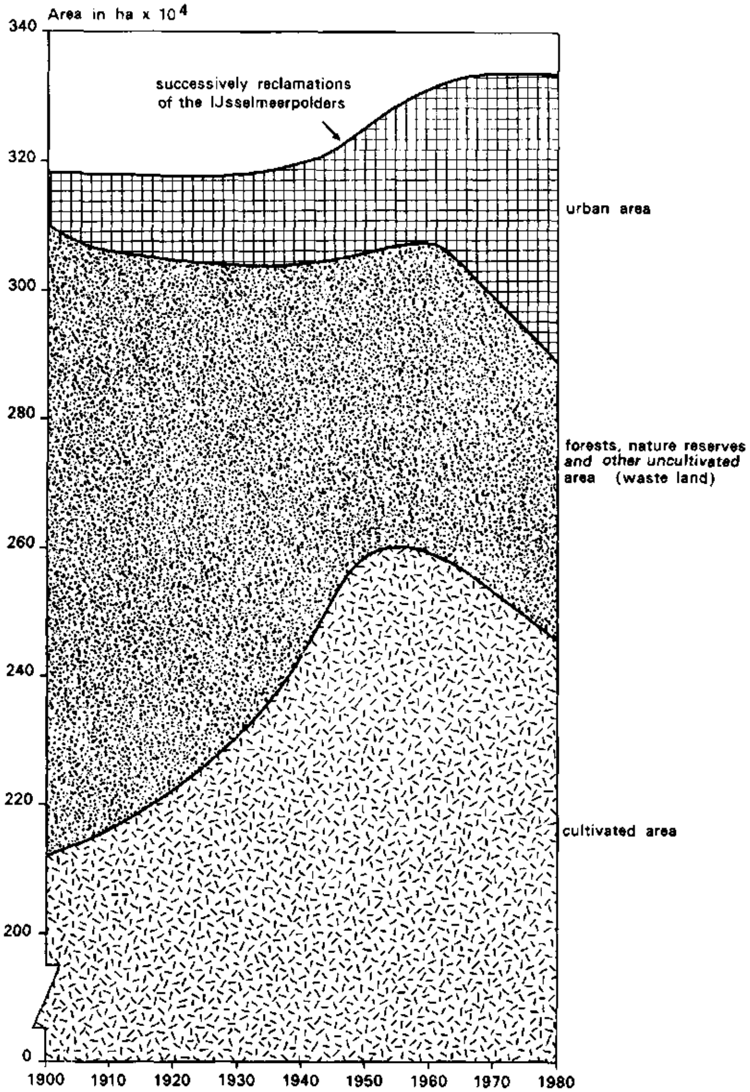

Figure 1. Developments in landuse in the Netherlands since 1900.

2 The original and present aims of the IJsselmeerpolders project

At the starting time of the project, there were four main aims:

- Firstly, the safety of the low-lying areas bordering the former Zuiderzee would be considerably improved.
  The borderline of the sea was shortened from 300 km to 32 km by building an "Enclosing dam".
- Secondly, the reclamation of flat, fertile and optimal allotted farm-land to grow food and to encourage the employment possibilities.
- Thirdly, the improvement of the water management conditions in central Holland. Quantities became controllable and the quality turned from salt into fresh. The latter eliminated the problems of salt intrusion along the borders of the sea.
- Fourthly, the shortening of the (road-) connection lines between the western and the north-eastern part of the country.

As the population increased and the needs for more territory per inhabitant increased (due to higher incomes, more spare time, more cars etc.) and because of an increasing awareness of natural and environmental values,gradually a fifth complex of aims occurred:

- Creating more room for urban activities (town building, industrial sites, road extensions etc.) and for forests, for nature reserves, for recreational sites, etc.

As figure 2 shows, in the last two polders (Eastern and Southern Flevoland) the agricultural area is more and more decreased whereas the urban area and the area for forests and nature reserves increased.

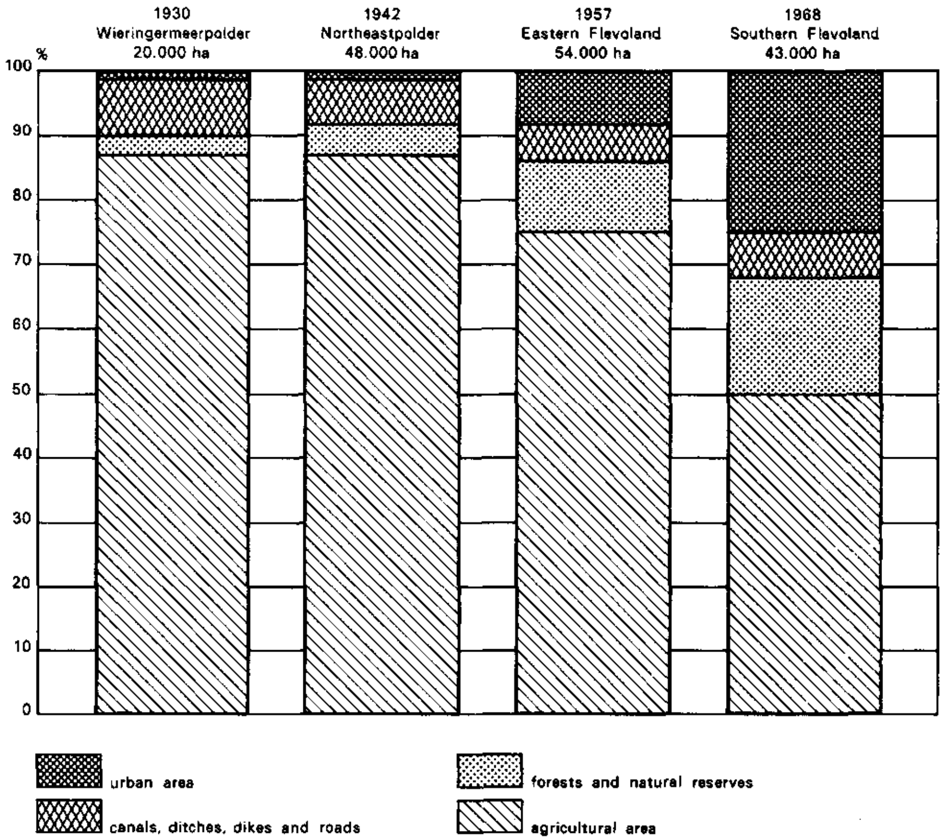

Figure 2. Changes in land use in four successive IJsselmeerpolders

3. Suitability for agriculture of the soils of the IJsselmeerpolders

The former sea bottom of the IJsselmeerpolders is generally very suitable for certain agricultural uses, e.g. for arable land, for grassland, for fruit-growing, for bulb-growing.

The soil types in the four polders are different (table 1). These differences in soil types cause a difference in suitability for the types of agricultural land use. The Northeastpolder had much more differences than Southern Flevoland, so in the Northeastpolder the variation in farm types is far more greater than in Southern Flevoland. These differences affect also the occurring type of landscape.

Table 1. Soil types - in % of the total area - in five IJsselmeerpolders (the fifth not yet being reclaimed)

	clay	heavy loamy soil	light loamy soil	sand	peat soil and boulder clay
Wieringermeer	33	19	17	31	0
Northeastpolder	1	49	29	16	5
Eastern Flevoland	50	39	7	4	0
Southern Flevoland	93	5	1	1	0
Markerwaard (planned)	31	28	16	23	2

The soils of the IJsselmeerpolders are the best agricultural soils in the Netherlands. The soils have a high natural fertility, have a good water management system, are flat and are free of stones. The physical yields are high (table 2), the allotment is nearly optimal in comparison with situations elsewhere in the Netherlands, so the farmers(selected on skill, education etc.)are able to obtain the lowest production costs per unit.

Table 2. Differences in physical yields (average 1971 through 1976) between the polder Eastern Flevoland and the Netherlands

	Physical yield in kg/ha		
	Eastern Flevoland	The Netherlands	Differences
Winter-wheat	6.900	5.800	± 20%
Barley	6.100	5.000	± 22%
Oats	6.100	4.800	± 27%
Sugar-beet	60.000	46.000	± 30%
Potatoes	52.000	34.500	± 47%

This combination of relatively high yields and low costs leads to financial results which are far more better than the average of the Netherlands agriculture, the average net-result in the polders from 1971 through 1976 being about three times higher than on similar soils in the Southwest of the Netherlands.

4 The significance of agricultural landuse in the polders for the Dutch agricultural policy and for the policy of physical planning

The agricultural area of the polders is only a small percentage (between 5 and 6%) of the total Dutch agricultural area.
The Northeastpolder and Eastern Flevoland together possess 1,66% of the Dutch agricultural enterprises. They have 2,17% of the Dutch agricultural workers and they produce 3,08% of the total agricultural production. In these two polders the relative production is the following:
- 8,2% of the Dutch arable land, produces 11,1% of the total production;
- 1% of the Dutch grassland, produces 1,2% of the total production.

This means (as was also already mentioned in par. 3) that one important reason of having agriculture in the reclaimed IJsselmeerpolders lies in its relatively high contribution to the national food production.
This is too important because:
- it is good for the balance of payments;
- it gives employment and good incomes to the people involved in the agricultural production process;
- many countries in the world are interested in how agriculture in these polders is going on. This gives an amount of good-will which is also profitable for sectors of the national economy others than agriculture.

As mentioned in par. 2 (aim five) the amount of room per person in the Netherlands is increasing. Through the whole country reallotment schemes are carried out. These reallotments often are far more easy to execute if some farmers can be offered a new farm in the polders. This is

cheaper, and creates room for some more non-agricultural uses one the one hand and for increasing the existing farm sizes on the other hand (the average farm size in the Netherlands being under 20 hectares and in Southern Flevoland about 50 hectares).
So the landscape of the new polders is a quite particular one.

ALLOCATION OF LAND TO AGRICULTURAL USES IN THE DUTCH IJSSELMEERPOLDERS (FARM SETTLEMENT POLICY)

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Abstract

The four completed Dutch IJsselmeerpolders in succession show a decreasing agricultural area and an increasing area for woods, nature reserves, infrastructure and urban uses. After some years of state arable farming, the agricultural soils are not sold but rented out for private farming of different types and sizes. The development in farm sizes and standard plot sizes is described. The allocation depends on the soil suitability. The farmers are selected (age, education, skill, capital). There are two legal forms of lease:

1. normal lease. Land and farm buildings offered for a first period of 12 years, renewing every 6 years;
2. long lease. Land offered for 40 years, no farm buildings.

A certain area is rented out to enterprises related to agriculture (schools, research institutes).

1 Introduction

In general Dutch agricultural enterprises and farms are private farms. On 60% of the farms the farmer himself is the owner of the land and of

the buildings, on 40% of the farms the farmer rents the land and the buildings.
Only in the IJsselmeerpolders there are also State farms. About 4% of the agricultural area is in use as a State farm, but these farms are operated just like private farms.
They provide valuable data on yields, labour requirements, costs and returns. The private farmers themselves, as well as the farmers of the State farms, can decide what crops to grow and how to manage the land. This is not usual in countries with a central guided (or central planned) economy.

2. The allocation of land to agricultural land uses in the IJsselmeerpolders

In the former lake IJsselmeer the Dutch government so far has reclaimed four polders, with a total area of about 165.000 hectares.
The youngest polders are situated relatively close to the dense populated economic heart of the Netherlands, the so called "Randstad" conurbation.
Therefore the land use has changed from mainly agricultural in the first polders, to more urban uses and uses for forests and nature reserves in the latter polders (figure 1).

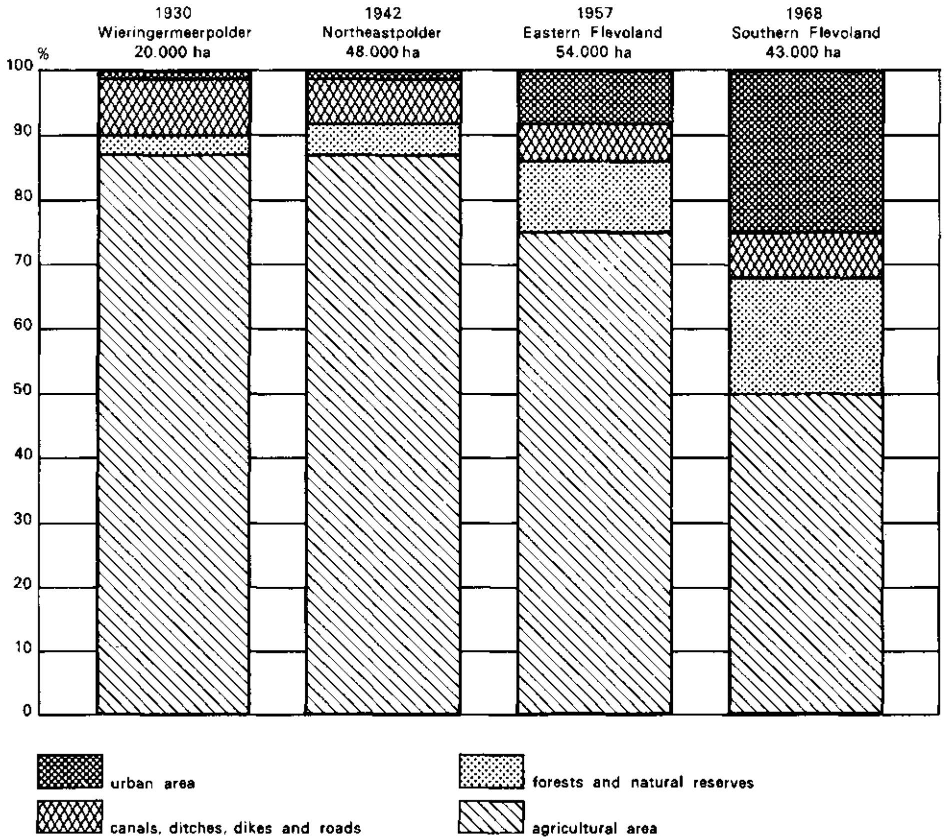

Figure 1. Land use changes in four successive IJsselmeerpolders

All soil types are temporarily farmed by the Government during the reclamation process. After some years of state arable farming, the soils destinated to agriculture are rented out to private farmers.

The main types of permanent agricultural land use in the IJsselmeerpolders are all-arable, all-grassland, mixed farming, fruit growing and market gardening. Each use having its own suitability requirements. Horticulture requires a very high capital investment per ha, and should therefore be allotted only to the most suitable land.
For fruit-growing the suitable soils need such a profile that roots can penetrate undisturbed to a depth of at least one metre below surface.

Furthermore this requires such a drainage that the deepest roots do not die off in periods of heavy rainfall when groundwatertables are generally high.
For market-gardening a distinction needs to be drawn between vegetable-growing outdoors, vegetable-growing under glass and bulb-growing.
For growing flower-bulbs sandy soils with a controlled watertable and slightly heavier soils (up to 8% clay) are needed.
On more heavy soils (between 8 and 25% clay) only tulips and daffodils can be grown.
Vegetables may be grown under glass on sandy soils with a controlled watertable, as well as on heavier soils (under 25% of clay); the same holds for outdoor vegetables, although for these crops somewhat heavier soils are preferred.

During the last 40 years the continual position with regard to other types of farming has been that where the land was suitable for all-arable farming, this has been the most advantageous use for it.
Grassland farming and mixed farming were selected only where this was essential for technical and economic reasons. Soils in this category were those on which average crop yields were too low or too unreliable on account of soil blowing or puddling.

Due to the trend of specialization in agriculture, nowadays mixed farms are no more established. Farms which cannot be all-arable, become all-grassland.

3. Development in farm sizes

Between 1935 and today, except the years 1943 through 1946, farms have been leased to private farmers every year.
In the Wieringermeer (leased 1935-1942) the smallest farm holdings were of 10 hectares. These were expressly intended for workers who had rendered outstanding service, when the land was being brought into cultivation and temporarily farmed by the State.
Considerable numbers of farms ranging from 30 to 50 ha were also set up, as

well as a few larger ones (up to 70 ha).

In these years also plans were made for the second polder, the North East Polder, which was allocated between 1947 and 1958. At that time, farms of 12 ha were regarded as father- and son farms, so about 20% of the total number of farms were in fact set up as 12 ha farms.

The remaining farms ranged in size from 12 to 48 ha.

During the time that the North East Polder was being allocated, it gradually became clear that the Dutch agriculture as a whole was increasingly suffering from a surfeit of undersized farms. The decision was then taken to use the new farms in the IJsselmeerpolders for assistance in agricultural reorganization elsewhere in the Netherlands. A part of the new farms was rented out to farmers on the old land whose fields could be divided among the farmers that remained behind.

In the third polder, Eastern Flevoland, which is being allocated from 1962 to 1976, the farm size question has been a continuing point of investigation. About 1960, it was decided to make the smallest farm 15 ha, but a few years later, at allocation time, this size had already become 20 ha.

From 1968 on - 6 years after allocation began - a drastic increase in the minimum farm size was realized. This minimum is 45 ha; the larger farms have 70 ha and more, as can be seen in table 1.

Table 1. Numbers, sizes and farm types rented out to private farmers in Eastern Flevoland

Farm size in ha	Farm numbers Arable	Mixed	Grass	Total Number	%	Area ha	%
20	39	3	-	42	5,4	832	2,5
25	10	27	3	40	5,1	1.028	3,1
30	115	16	7	138	17,8	4.091	12,2
35	82	18	3	103	13,3	3.562	10,6
40	85	2	7	94	12,1	3.760	11,2
45	126	-	11	137	17,6	6.116	18,3
50	49	-	11	60	7,7	2.982	8,9
55	47	-	18	65	8,4	3.588	10,7
60	38	-	8	46	5,9	2.735	8,2
65	7	-	3	10	1,3	645	1,9
70	16	-	-	16	2,1	1.109	3,3
75	5	-	1	6	0,8	448	1,3
80	2	-	-	2	0,3	159	0,5
85	1	-	-	1	0,1	86	0,3
90	7	-	-	7	0,9	632	1,9
95	1	-	-	1	0,1	94	0,3
100	1	-	-	1	0,1	105	0,3
120	1	-	-	1	0,1	118	0,4
150	1	-	1	2	0,3	292	0,9
200	1	-	4	5	0,6	1.076	3,2
Total	634	66	77	777	100,0	33.458	100,0
Total Area	27.054	1.930	4.474	-	-	-	-
Average farm size (in ha)	42,7	29,2	57,9	43,1	-	-	-

In the fourth polder Southern Flevoland the reclamation and renting out is still going on. During the last four years (1978-1981) 75 arable farms (4100 ha; average size 55 ha), 32 grassland farms (1370 ha; average size 43 ha) and 9 fruit farms (153 ha; average size 17 ha) were rented out.

There is still no end to be seen to the trend to increase farm sizes. The technological and economical possibilities are still tending towards bigger farm sizes, though there is also a social and political tendency to decrease the farm sizes in order to get a greater number of farms. The present optimal farm size on these young IJsselmeerpolder soils should - to satisfy the requirements deriving from the macro-economic situation as well as cost prices - range from ca. 50 ha to ca. 450 ha for arable crops and from ca. 40 ha to ca. 100 ha for grassland. The latter range fulfils the social requirement of a minimum of two labourers on grassland farms. In all cases the management is one of the most important factors for the success of the farm. In comparison with family farms in Western-Europe, the size now planned for the farms in Southern Flevoland is equal to the minimum of the ranges specified (arable farms 50 ha, grassland farms 40 ha). For political reasons, (notably help more farmers), these sizes have been reduced to 40-55 for arable-farms and 35-45 for grassland in recent years, which causes considerable problems in reshaping plot sizes.

4. Developments in plot sizes

The size of the plots in the newly reclaimed land can be chosen so that the costs are minimal, in so far as these depend on the length and width of the parcels (investment and maintenance costs of drainage systems and roads, transport on the plot - for instance a reduction in the milk yield occurs if cows have to walk more than 1000 metres to the milking parlour -, decrease in yield on turning strips along the ditches, etc.). Continual investigations on plot sizes have shown that the optimal size is not constant, but is changing. At this moment plot sizes of 500 m x 1000 m would be a good choice, because this enables the decision makers

to realize farms of ½, 1, 1½, 2 or more times the standard plot size of 50 ha. Figure 2 shows this development in standard plot sizes.
All the plots are situated along a road at the front and a lateral canal or main ditch at the back into which the ditches separating the plots on both sides discharge.

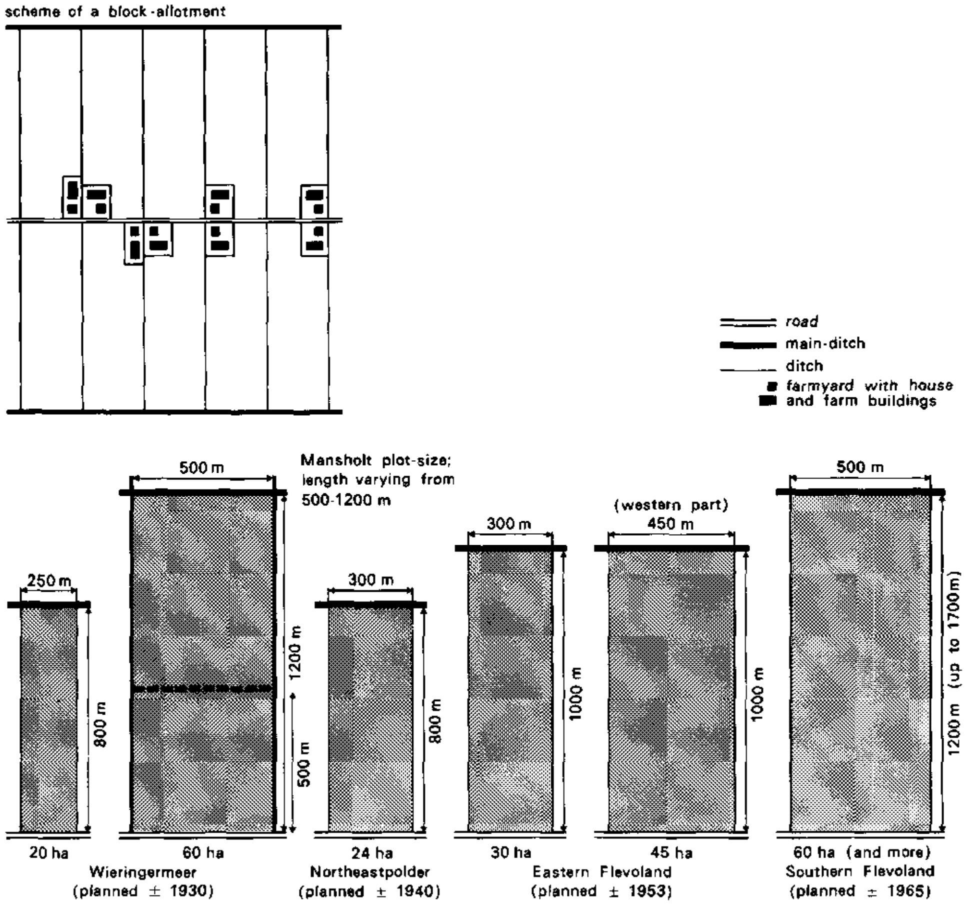

Figure 2. Development in standard plot-sizes (arable land) in the IJsselmeerpolders.

5. The selection of candidates for private farms

Every year a plan for the allotment of private farms is announced in the newspapers and everyone can buy a prospectus.
The ratio between gross returns and costs is such that good incomes are generally possible from these farms. The rentals for land and buildings are relatively low. For the owner these represented a return of only 1.5 to 2% of the market value of the land and the cost of erecting the buildings. Since a few years, however, there is a possibility for the owner of the buildings to get a return of 3-6% of the cost-price of the buildings.

Because of the good income prospects which the farms in the new polders offer, at every allotment the number of candidates is ten to twenty times the number of available farms. Because of this it is possible and necessary to operate a selection procedure as part of the settlement policy.

The selection is carried out in such a way that 75% of the farms are allocated to "priority groups", e.g. to farmers from land reallotment areas and to farmers who have been expropriated of their farms in the public interest (urban expansion, road development, industrialization). The other 25% are being assigned to farmers from the "free sector". This enables a number of special personalities to be brought into the polder for their personal qualities (leadership, prominent stockbreeders or arable farmers). It needs to be borne in mind that not only farmers' organizations (conceptual as well as commercial) need to be founded, but that an entire community structure also needs to be brought into being.

The following basic demands are made of all candidates:

a. They must be between 26 and 50 years old. When they are originating from land reallotment areas, or are dispossessed by compulsary purchase to the goverment for reasons of public interest, their maximum accepted age is 60 years. In that case it must be certain that they have an acceptable successor (e.g. son or son-in-law).

b. They must have received a certain minimum of agricultural school-education and be competent farmers with adequate technical skill to manage a farm.

c. They must have a certain amount of available capital. This amount is at present Dfl. 3.500,- per ha for arable farms and 5.000,- per ha for grassland farms.
   If a farmer intends to built a farmhouse, than therefore he must have available Dfl. 75.000,-.
   Long leaseholders have to built the farmbuildings themselves. For that reason they must also have available Dfl. 2.500,- per ha for a barn on an arable farm and Dfl. 3.500,- per ha for a barn on a grassland farm.

   For fruit-growing farms the amounts are much higher. They must have available a farming capital of Dfl. 50.000,- plus Dfl. 10.000,- per ha. Long leaseholders furthermore need to have available Dfl. 75.000,- for a living house and Dfl. 2.500,- per ha for the barn.

   In every case a large proportion of these sums of money may be borrowed capital.

d. They must have the right mentality to build up a new livelihood elsewhere and be prepared to assist in the shaping of a new community. In the selection also attempts are made to bring in people from all parts of the country and further to obtain a distribution of religious beliefs not to far divergent from the national average.

6 Two legal forms of land lease

As stated before the land is not sold but rented out. There are two possible forms of renting out:

a. normal lease, with a fixed-period tenancy

b. long lease

Under normal lease conditions, the tenant rents the land and the farm buildings (not including the farmhouse) for an initial term of 12 years. He in exchange pays an annual rental.

After this period the tenant has the right to renew the lease for a further 6 years and for every 6 years there after. A son or another qualified relative may also take over. The tenancy conditions are laid down by the "Pachtwet", that is by the Agricultural Holding Act. According to this act rentals have to be approved by the "Grondkamer" (Land Commission); the rent can be revised every 3 years. Security regarding the right to farm the land is obviously sufficient, ownership is not essential in that respect.
Experience in the Netherlands has shown that a very good agricultural situation can be created by renting out the land. Renting has the additional advantage that farmers with relatively little capital can rent a relatively large farm.

The second legal form of lease is long lease (40 years) in which only the land is made available. To obtain long lease in a new polder it is necessary that the farmer (and/or his near relatives) own 50% or more of their present farm. The long leaseholder has to build the farmhouse and the farm buildings at his own expense and therefore needs to have available more capital than the normal (fixed-period) tenants. The land rent is the same as the land rent for the fixed-period tenancy, but can be revised only once every 6 years.

The first two polders (Wieringermeer and North East Polder) were leased almost entirely on normal (fixed-period) tenancy. The third polder has so far been allocated as 60% fixed-period and 40% long lease. The fixed-period tenure is a personal entitlement and not capable of being sold. The long lease, however, is an objective entitlement and may be sold; for that reason it can be mortgaged too.

7 The settlement of agricultural enterprises others than farms

Besides the normal agricultural farms in Eastern Flevoland there are about 2.400 ha rented out to special enterprises. These enterprises are closely related to agriculture e.g.:an agricultural high school with a farm unit, a dependance of the Agricultural University Wageningen with a farm unit, plant-breeding research institutes, research farms for animal husbandry and for cattle feeding, research institutes on animal diseases etc. These enterprises often had already a settlement elsewhere in the Netherlands, but had no room for expansion, they had to leave for reasons of public interest or they were interested in special favourable conditions in the IJsselmeerpolders. A special reason for potato-breeders for instance can be the climate, because of the flat and open landscape there are not many insects causing or spreading potato-diseases.

CRITERIA FOR THE DETERMINATION OF THE MOMENT OF SUITABILITY FOR PRIVATE AGRICULTURAL LANDUSE OF CLAY AND LOAMY CLAY SOILS IN THE DUTCH IJSSELMEERPOLDERS

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Summary

On soils resulting from a landreclamation process in former lake areas, it is impossible to grow crops immediately after falling dry. The soil then is only a muddy mass. The first years after drainage crop growing causes considerable financial risks, risks that are to high for private farmers. So the Dutch government takes the first risks.

The determination of the suitability-moment for renting out the soil for private farming depends mainly on the hydrologic condition of the soil.
The Dutch IJsselmeerpolders mainly consist of clay or loamy clay soils, so the article is restricted to that type of soil-profiles.
The hydrologic condition can be valued by several indicators, such as: groundwatertable (in winter and in spring), ripening (causing subsidence and crack formation), aëration, permeability, bearing capacity of the soil.
Besides the hydrologic condition other indicating factors for the determination of the suitability moment for private farming are:

- the number of years of agricultural cultivation (mainly rape-seed and grains)
- the physical yields
- the moment and type of a necessary soil improvement
- the occurence of weeds

The valuation of the five indicating factors for arable land is shown in a simplified judgement matrix.

1 Introduction

On soils resulting from a land reclamation process of former water (lake) areas it is impossible to grow crops immediately after draining. The soil then is only a wet and muddy mass, without any bearing capacity, with no ripening, no aëration, no cracks and almost no permeability for water. In the first years of the reclamation process crop growing can be accompanied by considerable financial risks for private farmers. The soil is of unknown quality (e.g. cat clay), can be silty, can have a bad hydrology and can have a low bearing capacity for agricultural machines. Therefore nowadays the Government takes the first risks of the reclamation by carrying out some years (temporarily) of agricultural cultivation.
There is a Dutch saying from the 19th century concerning the risks of the first generations of farmers on newly reclaimed polder areas in the province of North Holland and along the coast:

' De eerste ging dood
De tweede had nood
De derde had brood'

This means:
' The first (farmer) died
The second barely survived
The third thrived'

In the first years of the reclamation process no potatoes and sugar-beet can be grown, but mainly rape-seed (colza) and grains are grown. The average yields are quite good but there are parcels with high and parcels with low yields. For private farmers, with farm-sizes of only 40 to 60 hectares, the risk of low yields on part of that area is relatively high; a big governmental exploitation of about 18.000 hectares,as it is nowadays,can take the risk of low yields on a certain area more easily.

So the question rises: 'When is a soil suitable to rent out to private farmers?'

2 Indicating factors for the moment of landuse suitability for private farmers

The IJsselmeerpolders are reclaimed from a fresh water lake, so there are no salt problems. The toplayers mainly consist of a homogeneous profile of clay or loamy clay. That is the reason that this article only deals with that types of soil.

Before the indicating factors are described, a short explanation of the reclamation process will be given.

The Dutch IJsselmeerpolders are parts of a former lake with an average water depth of 4 meters. After the construction of a dam (or dike) the water is pumped out, using canals that are already dredged under water. The soil that remains is a wet muddy mass.
To get rid of the water surplus of the soil and to prevent weeds to cover the muddy plain, the reclamation process starts with sowing reed by aircraft. The natural evaporation, the transpiration and rootformation of the reed strenghtens the soils bearing capacity. The water management system is completed by deepening the canals and by digging a network of watercourses. The pumping station(s) are connected with the canals, the main ditches and the ditches in which the trenches (or open field drains) discharge. After some years the trenches are replaced by subsurface drain pipes (figure 1, after Schultz, 1982).

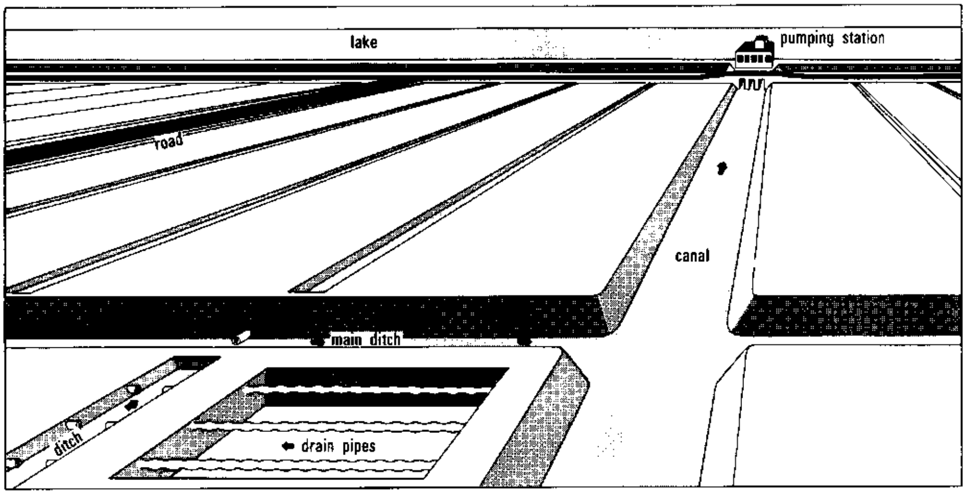

Figure 1. Schematic view of the water management system in the Dutch IJsselmeerpolders

When part of the water is evaporated and the top soil has enough bearing capacity, than every year a part of the reed will be destroyed and a crop (generally rape-seed first) is sown.
The upper part of figure 2 shows how this is going on in practice.
During the following years of agricultural exploitation the soilquality improves and the risk-chances diminish.

As Drok (1970), has already described, the indicating factors for the determination of the suitability moment for private landuse are:

1. the hydrologic condition
2. th number of years that a soil is under agricultural cultivation
3. the physical yields
4. soil improvements carried out
5. the occurence of weeds.

ad 1. The hydrologic condition

On clay soils and on loamy clay soils the hydrologic condition of the soil is a general, but very important criterium to judge the suitability

moment for renting out to private farmers. The hydrologic condition (consisting of a complex of parameters) should be 'adequate'.
As parameters for judging the factor hydrologic condition we use: the winter- or spring ground water table, the ripening depth, the crack formation, the aëration depth, the permeability and the bearing capacity of the soil (Note: on other soils, e.g. sandy soils, the hydrologic condition is also an important judgement criterium, but on such soils the indicators are different).
Every indicating factor is valued separately and then all values are brought together into a valuation-matrix (table 1). The valuation of the hydrologic condition is the most important and is therefore weighed five times heavier than the other used indicators.

1.a. The (winter- or spring-) ground water table

In general young soils have a shallow (high) ground water table and a low storing capacity for water.
In such conditions the ground water table rises quickly under rainy circumstances. This causes low crop yields, high costs and high chances for financial risks because of the unfavourable farm management conditions. The problems of such soils are: low-soil temperatures, bad accessibility and low bearing capacity for machines, shortage of oxygen for the roots, any or low N(itrogen)-mineralisation, bad and/or quickly worsening soil structure.
The natural evaporation and the transpiration of plants causes an almost irreversible ripening process by which the water storage conditions improve.
Under normal Dutch climatic conditions the ground water tables of a clay soil should in winter and in spring (between 1. November and 1. March) not to often exceed the level of 50 cm below surface (at a drain discharge capacity of 7 mm/day). At a different discharge capacity of e.g. 10 mm/day it should not exceed the level of 30 cm below surface. Every profile has its own values that should not be exceeded. For every profile-type there are five value-classes for this indicator (bad, insufficient, sufficient, good, excellent).

1.b. Ripening depth, crack formation, aëration depth, permeability, bearing capacity

The evaporation and transpiration cause a physical (and chemical, e.g. mineralisation) ripening process with shrinkage into two directions:
1. vertical (subsidence);
2. horizontal (crack formation: in time the cracks are increasing in intensity, that means they increase in depth and width as the lower part of figure 2 shows).

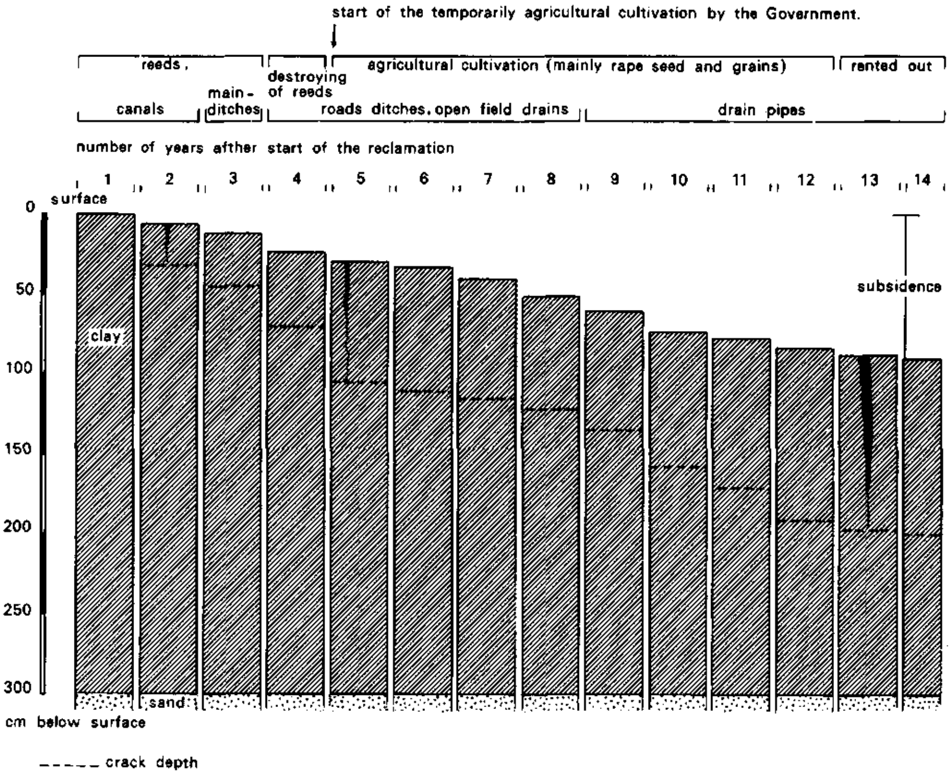

Figure 2. Crack formation (width and depth) and subsidence on clay and loamy clay soils in the IJsselmeerpolders

The crack formation causes an increasing permeability, aëration depth, storing capacity for water, stability, bearing capacity and a thicker discharging layer.

The 100% aeration depth of a clay soil can easily be found. It is the place where the colour of the soil turns from brown-grey (aërated) into black-blue (unaërated).
There is a close correlation between ripening depth, aëration depth etc. on the one hand,and the water table on the other hand. Therefore these parameters are not often used separate in judging the suitability moment. If a measure is wanted one can say e.g. that the 100% aëration depth should be more than 35 cm below surface and that the crack depth should at least reach 70 cm below surface.
Assumed is:

- that the land is equipped with a good function subsurface drainage system (with distance of over 24 meters in clay and loamy clay soils);
- that there are no more open field drains;
- that the bearing capacity of the soil is sufficient;
- that the soil type is fit for the desired type of agricultural exploitation.

One can easely understand that the speed of the ripening process is influenced by measures that can increase the discharge of water and is also influenced by the type of crops and by the climatic conditions in summer (dry or wet).

ad 2 and 3 Number of cultivation years, physical yields

In the mentioned soil types there is a certain positive correlation between the hydrologic condition of a soil (the parameters mentioned sub 1.a. and sub 1.b.), the number of years that the soil is under cultivation and the yields (in kg's).

a. The higher the number of years, the higher the suitability value.
b. The higher the relative yield (in kg's), the higher the suitability value.

Furthermore there is some interrelation between the two factors: number of cultivation years and the relative physical yiels (related to the average yield - in kg's) of the total area cropped with the same crop). There is also a relation between hydrologic condition, years of cultivation and relative physical yields. For instance if the hydrologic condition is not good, normally the physical yields will not be maximal. Practical experience has shown that soils with less than four years of cultivation often are insufficient suitable (low yield, insufficient hydrology) to rent out to private farmers.

ad 4 Soil improvements

Soils with an unfavourable profile can need improvements: deepploughing, mixing of layers (homogenisation), subsoiling or panbreaking.
If such an improvement is carried out there is a risk that an unripened subsoil layer (with a bad structure and a bad aëration) is turned into the topsoil.
This will of course ripen in time, but that takes some years.
Therefore if a soil improvement is necessary, the judgement and valuation depends on the art and results (e.g. has the soil really improved in quality, how many years are passed since the improvement was carried out).

ad 5 Weeds

The more weeds (expressed as a percentage of the covered area on a parcel), the lower the crop yields and the higher the costs to fight the weeds. Therefore when weeds occur (especially weeds that are difficult to destroy) the suitability is lower than if no weeds occur. In arable crops weeds cause more problems than in grassland. Under good hydrologic conditions weeds can be easier killed than under bad hydrologic conditions.

3 The suitability judgement matrix for arable land

A soil is called fit for renting out to private farmers when nearly all usual crops for such a soil can be grown without considerable financial risks (compared with normal conditions elsewhere).
To judge the suitability, a matrix is made in which a parcel in optimal condition can reach 100 points. A parcel with a total of less than 60 points is considered not to be 'adequate' for renting out to a private farmer.

Table 1. Simplified judgement matrix for the determination of the moment of suitability to rent out land to private farmers (possible values for a parcel of arable land)

Indicating factor	Range of valuation points				
	bad	in-sufficient	sufficient	good	excellent (= max.)
1. Hydrologic condition (to be 'sufficient' or 'adequate' 30 points are necessary	10	20	30	40	50
2. Number of cultivation years (to be 'sufficient' 4 years = 6 points are necessary)	2	4	6	8	10
3. Relative physical yields	2	4	6	8	10
4. Soil improvements	2	4	6	8	10
5. Weeds	4	8	12	16	20
Total			60		100

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YIELD AND QUALITY OF POTATOES PRODUCED IN THE NEW POLDERS IN THE NETHERLANDS

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Abstract

The yield and quality of ware potatoes produced in Oostelijk Flevoland is compared with that of ware potatoes produced in the Zuid-Hollandse islands and the yield of seed potatoes in the Noord-Oost Polder with that in Noord-Friesland. It appears that the yield of ware is about 13 tonnes/ha higher in the new Polder and the yield of seed (short growing season) about 2.5 tonnes higher than in the old land. Available evidence suggests that this is due mainly to a better water supply to the plants, resulting from greater root activity and deeper rooting of the crops in the new Polders. This may also explain the lower percentage of non-marketable tubers and, in addition, when combined with the richness of the polder soils in potassium, the lower dry matter content of potatoes from the Polders.
It is not too much to say that the suitability of the new Polders for potato production has contributed considerably to the present strong position of the potato crop in the Netherlands.

1 Introduction

Potatoes, wheat and sugar beet are the main field crops in the Netherlands. Almost one quarter of the total arable land is cropped with potatoes, there being no other country where this crop is grown so intensively.

Another point of importance is that a very large part of the total production is exported - e.g. about half of the ware crop in fresh or processed from, more than two thirds of the seed crop and three quarters of the starch or its derivatives produced from potatoes. This means that, in total, two thirds of the whole crop is exported, making the Netherlands by far the largest exporter of ware potatoes, of seed potatoes and of potato starch or its derivates. Obviously quality if one of the secrets of such a large export trade and favourable growing conditions provided by suitable soil etc. are an essential prerequisite. Although on arable farms only one quarter of the land is, on average, under potatoes, almost half of the income of the farmer is usually derived from this crop. It is therefore quite understandable that the first question asked by farmers moving to the new Polders, of which the main part is destinated for arable farming, is how good is the land for potato production with particular regard to yield and quality?
It is interesting to note that the period of rapid increase in the export trade coincided with the extension of potato production in the newly reclaimed Polders. In the early fifties less than 3% of the ware and seed potatoes produced came from the Polders reclaimed from the IJsselmeer. This has now risen to over 25%. What is the relationship, if any, between these two facts?
In this paper the yield of seed and ware potatoes and the quality of the ware potatoes grown in the new Polders will be compared with that of these crops grown in well known potato producing regions of the old land and an attempt will be made to explain the differences. In conclusion some comments will be made on the significance of the new Polders for potato production in the Netherlands as a whole.

2 Comparison between potato production in the new Polders and in the old land

2.1 Yield

2.1.1 Ware potatoes

For the comparison of the yield of ware potatoes I have taken the most recently reclaimed Polder of which all the land is under cultivation, Oostelijk Flevoland, and the Zuid-Hollandse islands, a long established and well known potato producing region south of Rotterdam. The soil type is more or less similar in both regions although the soils of Westmaas contain slightly more silt than those at Lelystad. For the purposes of the comparison two sources of data have been used:

a) the yield estimation made by the Ministry of Agriculture and Fisheries and processed by the Central Bureau for Statistics (CBS) and the Produktschap voor Aardappelen;
b) the tuber growth curves prepared by C.D. van Loon on the Research Station for Arable Farming and Field Production of Vegetables at Lelystad and by J. Alblas on the Experimental Farm 'Westmaas' in the Hoekse Waard.

Table 1 shows the yield data for the last 5 years.

Table 1. Estimated yield in the Province of Zuid-Holland[1] and Oostelijk Flevoland (data from Produktschap voor Aardappelen)

Year	Zuid-Holland[1] Marketable yield t/ha	Zuid-Holland[1] % Non marketable	Oostelijk Flevoland Marketable yield t/ha	Oostelijk Flevoland % Non marketable
1977	30.0	13	41.5	6
1978	35.0	11	46.0	11
1979	36.0	8	48.0	10
1980	35.5	14	52.5	14
1981	39.0	9	56.0	5
Average	35.1	11.0	48.8	9.2

[1] Yield in Zuid-Holland is almost the same as yield in the Zuid-Hollandse islands

Figure 1 shows the mean tuber growth curves and the variation for the years 1979-81. These data are more accureate but represent only one field in each region. Table 1 and Figure 1 show that the average yield in Oostelijk Flevoland is considerably higher than that in the Zuid-Hollandse islands, the average difference in marketable tubers being about 13 tonnes per ha. This in turn means a difference in profit of about D.fl. 2000.- per ha at a ware price of D.fl. 15.- per 100 kg at harvest, assuming similar production costs which according to official calculations is the case (Anonymous, 1981).

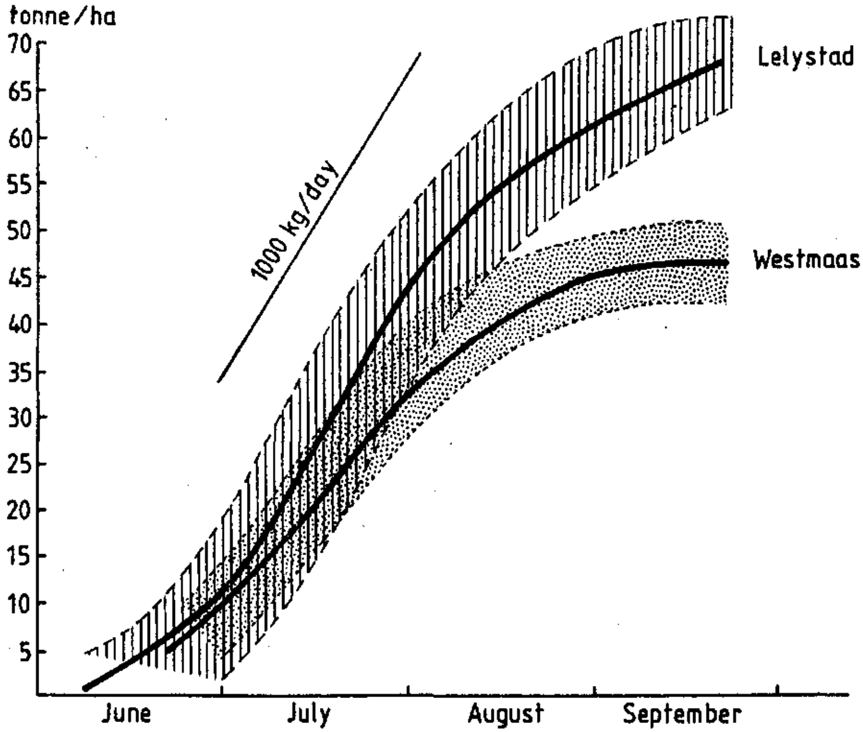

Figure 1. Average tuber growth curves and their variation for Lelystad (Oostelijk Flevoland) and Westmaas (Zuid-Hollandse islands) for the period 1979-81 (data from C.D. van Loon, Research Station for Arable Farming and Field Production of Vegetables (PAGV), Lelystad and J. Alblas, Experimental Farm 'Westmaas')

2.1.2 *Seed potatoes*

The Noord-Oost Polder (N.O.P.) and Noord-Friesland have been chosen for the comparison of seed potato yields because both are well known for seed production.
The Seed Potato Cooperative ZPC at Leeuwarden, which has grower members in both Noord-Friesland and the N.O.P., have submitted data on Class A seed potato yields for the varieties Bintje and Dêsirêe (Table 2). This Table shows that the differences are about 2.5 tonnes per ha in favour

of the N.O.P. This means a difference in profit of D.fl. 1250.- at a seed price of D.fl. 50.- per 100 kg at harvest.

Table 2. Actual yield[1] of Class A seed potatoes in Noord-Friesland and the Noord-Oost Polder (data from the ZPC, Leeuwarden)

Year	Noord-Friesland		Noord-Oost Polder	
	Bintje	Désirée	Bintje	Désirée
	Size grade 28-55 mm	Size grade 28-60 mm	Size grade 28-55 mm	size grade 28-60 mm
1976	23.3	28.7	27.6	32.6
1977	17.8	23.7	18.3	24.1
1978	23.0	24.5	23.5	30.3
1979	26.6	25.5	22.5	31.2
1980	19.0	24.5	25.2	26.1
Average	21.9	25.4	23.4	28.9

[1] The portion planted by the growers themselves is not included

2.2 Quality

Quality in potatoes is both complex and difficult to define. For ware potatoes we will only discuss (1) the percentage of non-marketable tubers such as misshapen tubers, tubers smaller than 35 mm, etc., and (2) dry matter content.

Table 1 gives the percentage by weight of non-marketable tubers. This is in general higher on the old land than on the Polders.

The dry matter content of potatoes from the old land is often somewhat higher than that of potatoes from the Polders, which means that the ware potatoes from the latter are usually slightly less mealy. Depending on consumer preference this can be an advantage or disadvantage. Tubers with low dry matter are less liable to internal bruising than those with a high dry matter content, which is an important characteristic.

The health standard of seed potatoes is the most important aspect of their quality. As the health standard is controlled by the General Netherlands Inspection Service for Field Seeds and Seed Potatoes (NAK), there is, in principle, no difference in this respect between the seed from the Polders and that from the old land.

3 Possible explanation of the differences between the Polders and the old land

3.1 Yield

In any discussion on yield differences between regions, all the more important yield determining factors must be included. Van der Zaag and Burton (1978), discussing the gap between the calculated potential yield of 100 tonnes per ha and the actual yield of 45 tonnes per ha in the Netherlands, came to the conclusion that the length of the period of tuber growth and the daily tuber growth are the principal factors.
From Figure 1 it can be concluded that of these two daily tuber growth is the main factor, although the length of the period of tuber growth may cause some differences, especially as premature foliage death in several crops has been observed in recent years on the Zuid-Hollandse islands. At Lelystad daily tuber growth is 1000 kg and 550 kg per ha respectively in July and August and at Westmaas almost 800 kg and 400 kg. That means that in July at Lelystad daily tuber growth is 25% higher and in August about 35% higher than at Westmaas. According to Van der Zaag and Burton water supply to the crop and the area of active foliage are the main factors influencing daily tuber growth.
The effect of water on the growth of potato plants has recently been discussed in detail by Van Loon (1981). Shortage of water can reduce cell enlargement and leaf expansion and thus the area of foliage of the plants. Already at a leaf water potential of -3 bar, cell enlargement is reduced and at a leaf water potential of -6 to -8 bar the rate of photosynthesis may be decreased.
Although the crops in the Polders usually produce more foliage than do crops on the old land, it is unlikely that the difference in area of foliage alone results in differences in tuber yield. It is more likely that the rate of photosynthesis per unit area of green leaf surface due to a difference in water supply is a much more important factor.
How can this difference in water supply be explained? Table 3 does not show any difference in rainfall and differences in the water holding capacity of the soils between the two regions does not provide a reason.

Table 3. Rainfall and estimated evapotranspiration at Lelystad (L), Oostelijk Flevoland, and Oudenbosch (O), ca. 50 km from the Zuid-Hollandse islands (in mm) (data from KNMI)

Year	Rainfall										Calculated evapotranspiration[1]	
	May		June		July		August		May-August		May-August	
	L	O	L	O	L	O	L	O	L	O	L	O
1981[2]	65	92	82	70	68	60	36	27	251	249	317	301
1980	18	20	80	87	148	148	53	45	299	300	359	331
1979	100	122	118	74	38	34	47	66	303	306	324	317
1978	24	49	75	83	68	72	58	42	225	246	347	343
1977	49	62	50	56	40	42	100	128	239	288	354	339
Average over	46	52	50	57	83	75	88	80	267	264	354	355
30 years	(50)[3]	(52)	(103)	(103)	(110)	(110)	(91)	(90)				

1 The following assumptions have been made: May - Ep = 0.5 Eo; June - Ep = 0.8 Eo; July and August - Ep = 0.9 Eo. Ep = potential evapotranspiration; Eo = open water evaporation

2 For 1981 data from Urk instead of Lelystad

3 Between brackets: calculated evapotranspiration

A more likely explanation would seem to lie in the depth of rooting. Figure 2 shows that the rooting depths of a potato plant at the Research Station at Lelystad (Oostelijk Flevoland) and of one at the Experimental Farm 'Westmaas' are about 80 and 40 cm respectively.

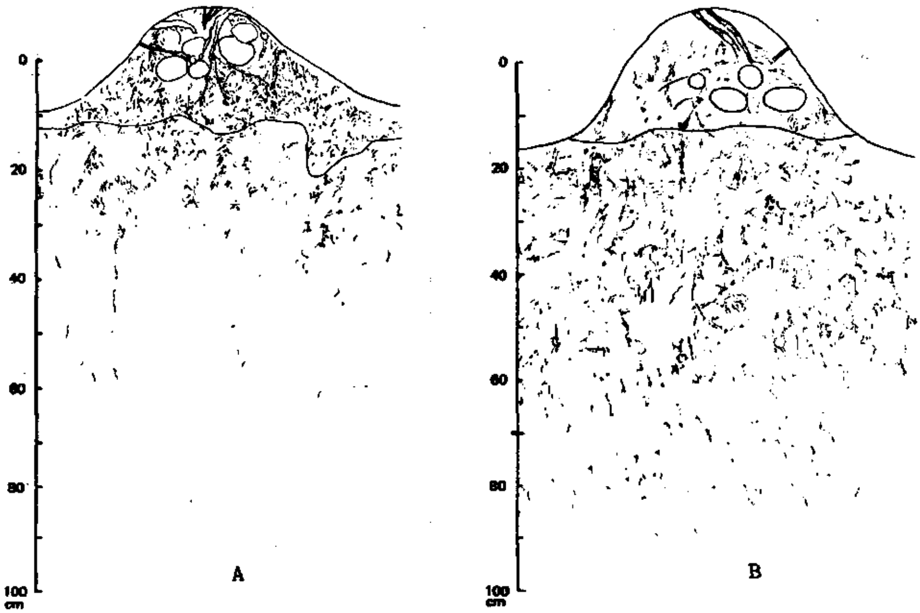

Figure 2. Root development of potato plants at Experimental Farm 'Westmaas' (A) and at PAGV, Lelystad (B) in August 1978 (data from STIBOKA, Wageningen)

At field capacity each cm layer of soil at Lelystad provides a total of 2.4 mm water available for plant growth and at Westmaas 2.1 mm. Furthermore, at Lelystad, given a medium rate of evaporation (e.g. 3 mm/day) about 50% of the water is readily available and at Westmaas about 45%. At high rates of evaporation (e.g. above 4 mm/day) water stress can occur already when 1/3 of the available soil water has been taken up by the crop. This means that at Lelystad a total of 192 mm water is available of which roughly speaking 70-100 mm is easily available and at

Westmaas the total is 84 mm of which 30-40 mm is readily available.
In summer in both regions the soil water table is at about 1.5 m. However, due to incomplete 'ripening' of the sub-soil in the new Polders the capillary rise of soil water is much stronger at Lelystad than at Westmaas, therefore, crops at Lelystad benefit much more from the soil water than at Westmaas. This difference applies to most crops in Oostelijk Flevoland and in the Zuid-Hollandse islands.
Table 3 shows that in June there is on average a water deficit of about 50 mm. Soils in Oostelijk Flevoland can easily supply this quantity of water, while the soils in the Zuid-Hollandse islands can barely do so, especially when root growth is not fast. In July there is an average deficit of 30 mm. Taken together with the figures for the previous months this is sufficient to cause water stress with an average rainfall in the Zuid-Hollandse islands, but not in Oostelijk Flevoland.
In 1979 the rainfall was low in July and August. The calculated evapotranspiration for these months was at Lelystad and Oudenbosch 180 mm and 177 mm respectively. The water deficit for these months was 95 mm at Lelystad and 87 mm at Westmaas. It is evident that, under these conditions, production at Westmaas in August could not be optimal. In fact the daily tuber growth was 50% higher at Lelystad than at Westmaas during that month. On the other hand the difference in evapotranspiration and rainfall in 1980 was small, largely due to the high rainfall in July (148 mm). Notwithstanding this, the difference in yield was considerable (Table 1). Such a high rainfall may do even more harm to crops on soils with hard compacted layers than a dry period as such layers hamper rapid drainage of the excess water after a heavy fall of rain. The consequence may be suffocation of the roots with the result that even in a short dry period after heavy rains water stress can occur.
From the foregoing it can be concluded that differences in the yield of crops grown in the new Polders and on the old land are mainly caused by water shortage. This shortage is caused by differences in the development and depth of penetration of active roots due to the presence of hard, obstructive layers in the soil. Such layers hamper root development and a fast drainage of excess water and so cause suffocation of roots. It is now increasingly realized that poor drainage due to obstructive layers is as harmful from the point of view of water supply to the crop as is the mechanical resistance of the obstructive layers

to root growth.
Another aspect is the root microflora. Very little is known about it and its effect on root development and activity. It may be that the root microflora of potato crops on the old land is different from that of crops on the new Polders. The scope of our knowledge in this field is so limited that we do not even know if there is a difference and if so, whether it can contribute to the observed yield differences. We dare not, however, exclude it!

Table 2 shows that the yield differences in seed potatoes are much smaller than those in ware potatoes. Several factors which may provide an explanation of this are:

a) a shorter growing period;
b) special growing techniques e.g. pre-sprouting and sprinkler irrigation;
c) regional effects.

The more favourable growing conditions found in the Noord-Oost Polder are partly offset by an earlier date of haulm killing in the Polder and less frequent pre-sprouting of seed tubers than in Noord-Friesland. Despite this, the yields of seed tubers are higher in the Polder than in Noord-Friesland.

3.2 Quality

Irregular water supply to the crop stimulates the formation of misshapen tubers, tubers with growth cracks and even second growth (Lugt, 1960). The number of tubers smaller than 35 mm depends on many factors such as soil structure, soil moisture in the ridge at tuber initiation and shortly thereafter and on second growth induction later in the season. It appears that in most years the higher percentage of non-marketable tubers on the old land is mainly due to an irregular water supply caused by shallow rooting.
The lower dry matter content of tubers from the Polders can be explained in part by better water supply and by the high potassium content of the young soils of the Polders. It is well known that a high potassium uptake can reduce the dry matter content.

In the N.O.P. and Oostelijk Flevoland the soil is very homogeneous. This in turn influences the homogeneity of the cooking and processing quality of potatoes from any one field, which is highly desirable.

4 Significance of the Polders for potato production in the Netherlands

As stated in the Introduction only a few comments on this subject will be made. Without the new Polders it would be difficult to grow the 80,000 ha of seed and ware potatoes on silt soils which are particularly suitable for potato production, in a crop rotation of 1 in 4 years as required for non-resistant varieties where the soil is not fumigated against potato cyst nematodes. This means that the present high level of exports of seed and ware could not be maintained except with the contribution made by the new Polders.

Although no data are available it is logical to assume that the quality characteristics of the ware potatoes from the new Polders have had a favourable effect on the export of ware potatoes and their processed products.

The foregoing makes it clear that the suitability of the new Polders for potato production has made a considerable contribution to the present strong position of the potato crop in the Netherlands.

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AGRICULTURAL MECHANIZATION AND PLOT DIMENSIONS IN POLDER DEVELOPMENT PROJECTS

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Introduction

The design process of polders with agriculture as an important sector, like in the IJsselmeerpolders, means: taking longterm decisions on the physical structure of the planned farming systems: the dimensions of the field plots, the location of the farm buildings and the location and structure of roads and water transport facilities.
The design of the physical structure for farming has long term effects on the economic results of farming as it influences both the yield levels as well as the costs of land use and other costs of production.
Van Iwaarden (2) lists the influencing factors as follows:

a) impact on yield levels
   - quality of drainage: maximum length of drainage system;
   - yield reduction on headlands, on strips along canals and ditches, on strips along plot and field sides;

b) impact on costs of land use
   - costs of construction and maintenance of canals and ditches;
   - costs of construction of public roads and farm roads.

c) impact on costs of agricultural production other than land use costs
   - costs of transport of men, materials and products;
   - costs of other field operations: turning on headlands, reduced work speed and extra work on field sides and headlands.

He defines the optimum design for field plot dimensions within the overall design of the project, as the one with the minimum total of

costs of a) to c).
The costs under a - c are influenced by the length and width of the plots and the planned farming system(s), including the (sub-)system of agricultural mechanization.
The objective of this paper is to discuss and to review the output of this planning for the third IJsselmeer Polder, Eastern Flevoland, with the main urban centre Lelystad, an area of 54000 ha.

Evaluation of the Planning with Special Reference to the Development of Agricultural Mechanization during the period 1950-1980.

In 1950 the IJsselmeerpolders Development Authority (IJDA) prepared a report on the most appropriate dimensions of farm plots in East Flevoland (4). The calculations were renewed in 1957 because of the increase of the cost level of the various components (5). In 1963 analogue studies were made to define the optimum design for the fourth IJsselmeer Polder, Southern Flevoland (7). These studies were based on crop farms with a grain/root crop ratio of 60/40, the technology level of 1963 and wage cost levels of 1963 and 25 resp. 50 per cent higher; the farm situated near the public road; the maximum plot width 500 m because of drainage requirements.
The results are given in fig. 1.
For a 30 ha farm the suggested dimensions were: 1000 x 300 m; for a 60 ha farm: 1200 x 500 m.

The problem for the planners was to make decisions on plot dimensions before the allocation of the land to the farmers took place. This latter decision process was substantially influenced by political considerations; in this process not only the variation of farm sizes was discussed but also the type of farming: crop farming, mixed farming, dairy and fruit farming.

In table 1 is given a summary of the farm and plot sizes as they were developed in the IJsselmeer Polders since 1930.

Table 1. Plot size and plot dimensions for grain/root crop farms in the IJsselmeer Polders.

Name of polder	Period	Main plot size (m)	Farm size (ha)	Average	Plot pieces per farm
Wieringermeer	1930-1941	800x250	10-72	42	2,1
Northeastern	1942-1962	800x300	12-48[2]	27	1,4
East Flevoland	1957-1976	1000x300[1]	18-60[3]	40	1,7
South Flevoland	1968-	1200x500			

[1]) Western part 1000x450m; [2]) and [3]) a small number of is larger: up to resp. 72 and 120 ha.

In this table we notice that since 1930 - the start of IJDA - the minimum size of the farms and the standard length of the plots have increased.

In this type of costs calculations the farming system including the level of agricultural mechanization is a variable component: When planning farm plot dimensions, road and canal systems, farm sites and farm buildings it is not yet known what developments in the farm system and the mechanization sub-system will take place.
Now, more than thirty years after the planning of the East Flevoland Polder, in this paper we will evaluate the planning results, in particular in relation to the high level of mechanization, that has been achieved during these decades.

Agricultural mechanization in its broadest sense means the introduction and increased application of any technical aid in agricultural operations and to these operations are considered all activities carried out on the farm level: land development, tillage, planting, irrigation, other crop operations during growth, harvesting, post harvesting, livestock operations and other farm activities, such as contract work, repair, maintenance and transport.

Agricultural mechanization influences both the yield levels, the costs of land use as well as the other costs of agricultural production.

Its influence on yield levels is achieved through:
- more timeliness of required operations;
- a better quality of the operations e.g. in tillage or harvesting.

In tillage it will lead to a better seedbed operation, in harvesting to a reduction of harvest losses;

- As higher mechanized operations are usually less time consuming they enable the farmer to intensify the cropping system.

A second area where mechanization influences the economy is the mechanization of construction of roads, canals, ditches as well as their maintenance, that results in lower land use costs for the farmer.
A third area where mechanization has an impact on the input/output ratio of farming is the mechanization of the agricultural operations themselves: the time requirements and costs of operating on the farm.
In this paper we will look more closely to this area.

In (4) the impact of plot dimensions on time requirements and operating costs is summarized in three points:

1) on farm transport of equipment;
2) on farm transport of personnel;
3) on farm transport of materials and products.

In that study of 1950 a farm model was selected of 24 ha land with 50 per cent grains, 30 per cent root crops and 20 per cent other crops; transport quantity 20,0 tons.ha^{-1}; field work requirements: 300 manhours. ha^{-1}; 1 tractor, 1 horse.
Hourly costs: labour 1,50 gld, tractor 2,- gld, horse 0,80 gld, transport costs per tonkm: 0,46 gld; cost capitalization factor: 25.
The costs were calculated based on the organization and operating methods, that were common in those years. The time requirements for transport for the tractor, the horse and a labourer were calculated at resp.: 0,01625, 0,075 and 1,5 hour per 100 m distance (= plot length + plot width : 2) and per ha.

Table 2. Annual time consumption, annual and capitalized costs of transport of men, equipment, materials and products per ha for a crop farm for a plot length of 600-1400 m.

Plot length (m)	Annual time consumption $h.ha^{-1}$			Annual costs of products etc $gld.ha^{-1}$	Capitalized costs $gld.ha^{-1}$
	tractor	horse	man		
600	0,08	0,38	7,5	4,6	408
800	0,098	0,41	8,3	5,1	448
1000	0,10	0,47	9,3	5,7	505
1200	0,11	0,53	10,5	6,4	571
1400	0,13	0,59	11,8	7,2	644

Table 2 shows an increase of the time requirements and costs when the plot length is increased, due to an increase of the average transport distance.

Also the construction and maintenance costs of the farm ditches including costs of reduced yields on the sides increase with the length of the plot. However the costs of the road and canal network in the polder decrease and the three together show an optimum traject around 1000 m length (table 3).

Table 3. Costs of construction and maintenance of roads, canals, ditches and on-farm transport (capitalized costs) ($gld.ha^{-1}$). Source: (4)

Plot length	Roads, canals	Ditches	Transport	Total
600	885	158	408	1451
800	680	192	448	1320
1000	565	230	505	*1300*
1200	490	269	571	1330
1400	435	315	644	1394

The report (4) also states that for farms smaller than 15 ha the plot length should be limited to around 800 m. And the comment is made that the ideal would be a different plot length for different farm sizes.

It was also stated that because of changes in cost levels, farm practices and technology it was not well possible to make solid estimates based on situations e.g. 25 years later.

From table 3 we notice that from the three cost elements the direct costs for the farmer are 28 to 46 per cent of the total costs and the percentage increases with the plot length: the reason why farmers who rent a farm prefer the shortest plot length available.
Another option: the location of the farms on a more central point of the plot, has been studied, but not applied. The cost savings in road and canal construction due to a longer plot are counterbalanced by extra costs of an additional farm road and extra costs of the facilities like water, gas and electricity. In the "old country" this farm location is often found. This option might deserve new attention, even in a breakeven situation, e.g. for reasons of landscape diversification.

Renewed cost estimates (5) led to the conclusion to increase the optimum plot length by an average of 100 m.

To define the plot dimensions for the fourth polder Southern Flevoland Smits et al. (7) renewed the studies with higher yields, higher wage levels (2,45, 3,06 and 3,68 gld): and a higher degree of mechanization. The time requirements were reduced from 300 to 175 $h.ha^{-1}$. The costs of a farm road along a ditch with a length of 5/6 L and turning costs on headlands (0,5 min. each) were added.
The method of calculation in (7) is also on some other points slightly different from the one published in (4) so that exact comparison of data is not possible. The results of these calculations are given in fig. 1. It shows that although the total minimum cost level (a-c) for a 24 ha farm with a 60/40 ratio increased from 1950-1963 from 1300 $gld.ha^{-1}$ to 4500 $gld.ha^{-1}$ *the optimum plot length remained the same.*
This is explained by the fact that the higher levels of technology in land development and farming compensated the higher unit costs and also the higher yield levels, that as such would require higher transport costs.
It is also remarkable that the most economic farm size for this farm type and technology level is around 90 ha with a plot length of around 1700 m. Larger farm units show an increase of total costs.

The next question is: Has this picture changed during the period 1963-1980 ?

To find the answer we look at the development of agricultural mechanization in Eastern Flevoland since 1963. From information collected by IJDA the tables 3 and 4 indicate the progress in agricultural mechanization during this period.

Table 3. Tractor population per 1000 ha on arable farms in Eastern Flevoland 1968-1980.

Tractor size (KW)	1968	1972	1976	1980
< 21	4,1	1,8	1,5	1,0
22 - 36		28,9	20,0	16,2
37 - 54	51,5		31,4	32,2
55 - 74		28,5	9,6	16,1
< 75			0,2	0,4
Total number	55,6	59,2	62,7	65,9

Source: IJsselmeerpolders Dev. Auth., Lelystad

Table 3 shows a further increase in mechanization, partly in the total number of tractors but mostly in the power size per tractor and the power level per ha. Also for most other kinds of equipment the change of numbers per 1000 ha land is not so impressive but much more the increased level of the capacity of the machines.

Table 4. Some selected equipment per 1000 ha in Eastern Flevoland.

		1968[1]	1978[2]
Field sprayers	< 15 m	6,9	0,1
	15 - 18 m	12,6	6,8
	18 m	0,1	13,4
Potato harvesters-loaders	1 row	6,0	1,8
	2-4 rows	1,8	8,6

[1]) appr. 15.100 ha

[2]) appr. 29.300 ha

Source: IJsselmeerpolders Dev. Auth., Lelystad

The increased power supply and capacity of equipment on the farms has led to a further decrease of the labour requirements for field operations. For a grain/root crop farm (60/40) the required labour was calculated at 300 in 1957 at 175 per ha and per annum.
In 1980 it is reduced to 32 per ha and per annum; the hourly costs for men and tractors however have increased very much (1980 level for both: 22 gld.h^{-1}).

Since 1966 IJDA has not published new data in crop farms; in 1972 a report was issued on grassland farms. The conclusions were almost equal to those in (7). As far as the influence of mechanization on time requirements and costs in farming is concerned since 1972 another method of calculation can be used. At IMAG, the National Institute of Agricultural Engineering, Wageningen, time and motion studies of farm operations have been carried out since 1948. From many thousands of these studies a databank on farm labour requirement data was set up in 1970 (3). The databank holds detailed information on labour requirements of all usual farm operations. The data files are specified for various kinds of operations, the equipment used, various working widths, work speeds and yields.

The IMAG data service is frequently applied to determine economic farm plot dimensions for land consolidation and other land development projects both on a national as well as on an international level. (For planning agricultural projects in developing countries it is unfortunate that for common practices in specific tropical crop production, especially for manual and animal drawn operation there is not yet a data bank that holds adequate information. Steps are taken to cover this).

For field operations the task time is split up in:
- the nett required time for the particular operation: e.g. effective ploughing time, adjustment of the plough, necessary rest;
- additional time, depending of field dimensions, with a time requirement per 100 m width and a time element per 100 m length of the field;
- additional time for operating on the field corners;
- additional time per 100 m distance for transport on the field and from the field to the buildings.

In table 5 the time requirements and costs of men and tractors are given per ha per annum of a 40 ha farm with a grain/root crop rotation of 50/50 and a common mechanization level anno 1980. The required time per ha for field operations has now been reduced to 32, including 10 hours for seed selection (1963: 175!). For the working direction on the fields the longest side is taken.

Table 5. Costs and time requirements for men and tractors on a 40 ha farm with a grain/root crop ratio of 50/50 for the various IJsselmeerpolders. Mechanization level 1980.

Polder	Plot dimensions m	Man hours per ha	Tractor hours per ha	Costs $gld.ha^{-1}$
Wieringermeer	800 x 250	32,0	11,9	937
N.E. Polder	800 x 300	32,6	12,5	991
E. Flevoland	1000 x 300	32,6	12,5	991
E. Flevoland-West	1000 x 450	32,3	12,2	978
S. Flevoland	1200-1600 x 500	32,6	12,4	989

Table 5 shows nearly no influence of the various plot dimensions on the time and cost requirements. For the Wieringermeer the favourable result can be explained by the fact that the 40 ha farm is optimal for this plot design. For the other polders 40 ha is not optimal.
The small differences of the dimensions of the 10 ha fields (length: 330-500 m, width 200 x 300 m, distance field corner - building 200-500m) have nearly any influence.
Only in the case of small fields (2 ha and less) plot dimensions and plot size show a remarkable influence like it is demonstrated in fig. 2 and table 6.
Fig. 2 gives the time requirement for a tractor plough (width 1,05 m; speed 5 $km.h^{-1}$).
Table 6 gives the results of an intensive grain/root crop farm with three field dimensions: A: 200 x 100 m; B: 250 x 200 m; C: 500 x 400 m, and two mechanization levels: I: 2 tractors of 40 kW; II: 1 tractor of 40 kW, 1 tractor of 80 kW.

Table 6. Labour requirements for field work ($hrs.ha^{-1}$). Source (1)

	AI	BI	CI	AII	BII	CII
Plant potatoes [1])	50	40	37	40	30	28
Sugar beets [2])	22	16	13	16	12	9
Grain (wheat) [3])	19	14	10	15	11	9

[1]) excl. soil desinfection

[2]) excl. planting and harvesting beets, but transport included

[3]) excl. combine harvesting, but transport included

In this context it should be stated that the individual farmers have adapted their mechanization system to the specific layout of their farm: in the selection of the content of bulk tanks, hoppers and trailers; in the construction of paved farm roads to increase transport speeds and loads.

Conclusions

An evaluation of the dimensioning of the farm plots in the IJsselmeer Polders from the viewpoint of efficient farming when increasing the degree of agricultural mechanization has shown that the plot dimensioning planned 20-50 years ago is still satisfactory.
By avoiding too much fragmentation, especially for the smaller farms (< 24 ha), the possibilities were favourable for mechanized farming on all farm size levels and increase of the farming scale was easily possible.

It means that in case of allotment of reclaimed land to small farmers it should be kept in mind that in the future possibly other sizes of farms and other mechanization levels may be desirable (of course this depends on the man-land ratio in each country and region).
In such cases sharing of two or more farms on one plot might be prefered in stead of one plot per farm.
At the other hand it is essential for plot design planning to know what farm types and sizes will be installed.

Final remarks

In this paper the subject of the aspects of agricultural mechanization in planning of polder projects has only been touched from one angle. For other information - especially for tropical conditions (irrigated farming) - it is recommended to consult relevant literature, e.g. "Mechanization of Irrigated Crop Production". FAO Agric. Serv. Bull. 28, Rome, 1977.

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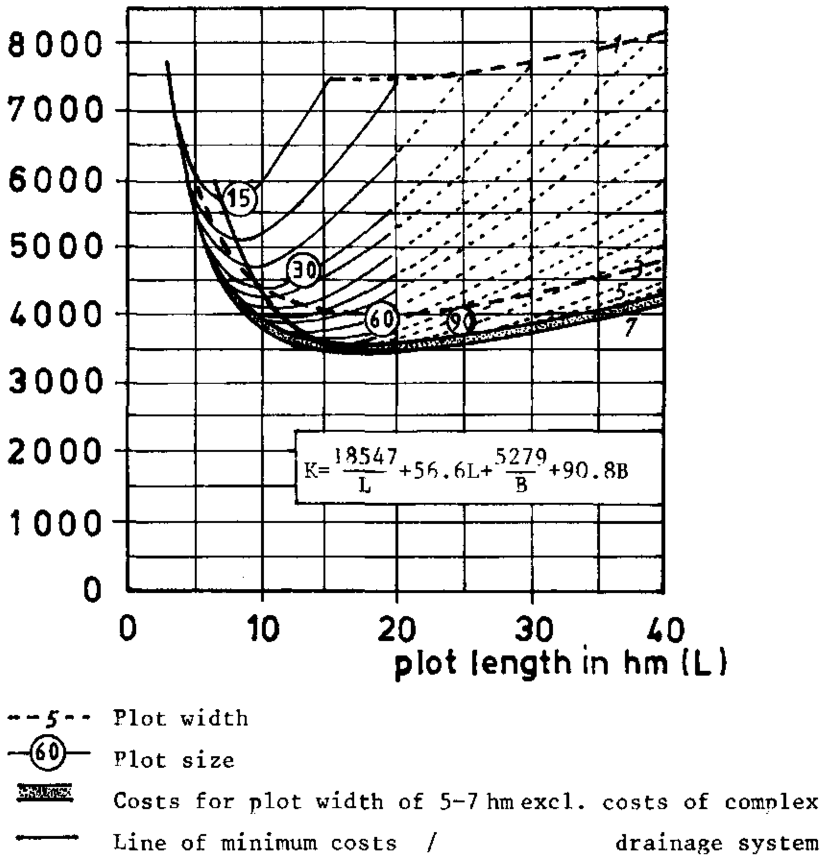

Fig. 1. Capitalized costs (gld.ha^{-1}) of a-c (see text) for various plot dimensions. (Source: van Iwaarden, 2).

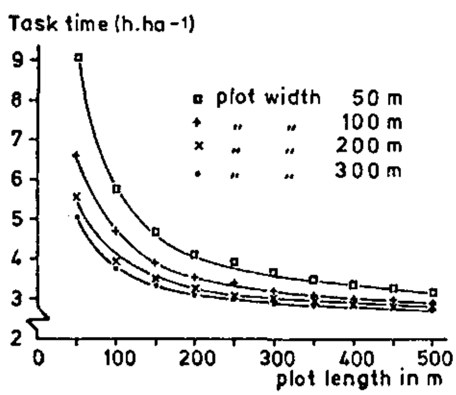

Fig. 2. Ratio task time - plot length for ploughing (width 1.05 m, speed 5 $km.h^{-1}$).

EFFECTS OF FRESH-WATER SUPPLY OF SCHOUWEN-DUIVELAND, THE NETHERLANDS

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Abstract

Upon completion of the Delta Works, parts of the Rhine estuary will become stagnant basins. Desalination of these basins create possibilities for additional water-supply to adjacent agricultural areas. The study, presented in this paper, was intended to provide arguments for the decision upon desalination of one of the basins: Lake Grevelingen. It evaluates the agricultural effects for one of the islands: Schouwen Duiveland of water-supply from either Lake Grevelingen or, in case of a saline Lake Grevelingen, from the nearby Volkerak. (Figure 1).
The paper treats three major aspects. The conclusions are:

- the increase of crop yield by additional water supply amounts to over 15% for potatoes, fruit trees and grass, between 10% and 15% for sugar beets, cereals, leguminoüs plants, onions, celeriac and bulbs; and less then 5% for chicory, winter carrots and leek.
- the maximum water demand for sprinkling and flushing amounts to 3.4 $mm.day^{-1}$. If areas with a strong saline seepage are excluded from flushing the demand decreases to 2.5 $mm.day^{-1}$.
- realization of a fresh-watersupplysystem requires an investment of about Dfl $20*10^6$. The extra investment in the case of a saline Lake Grevelingen amounts to 10% of the total investment. The net yearly profit of fresh-water supply amounts to between Dfl $3*10^6$ and Dfl $4*10^6$.

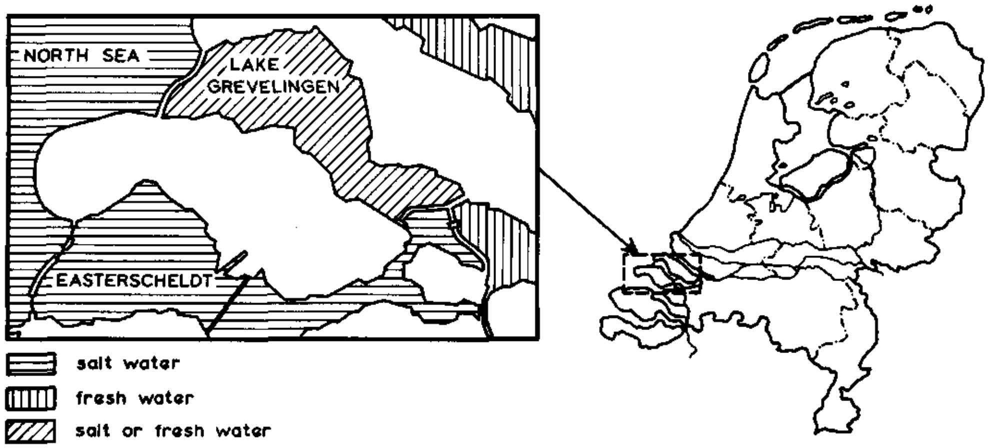


Figure 1. Location of study area

1 Increase of crop yield by fresh-watersupply

The crops on Schouwen Duiveland often suffer from an insufficient water supply. The reduction in yield corresponds with the magnitude of the occuring water deficiency. In this study the water deficiency has been determined as the difference between actual- and potential evapotranspiration. The actual evapotranspiration depends on meteorological conditions, crop type and soil characteristics. In order to account for variations in crop- and soil type Schouwen Duiveland was divided into square elements with an area of 25 ha. For each element a representative crop- and soil type was determined and the actual evapotranspiration was computed using historical data of meteorological conditions.

1.1 Method for calculation of actual evapotranspiration

Rijtema (1965) and De Laat (1980) presented a calculation scheme in which the transient vertical flow in a soil column is simulated by a

succession of steady state situations with a duration of 10 days. In the scheme the soil column is divided into a root zone, an unsaturated- and a saturated subsoil.
The rootzone is defined as the layer in which the crop withdraws the water. Because of the predominant influence of the water uptake by the crop on the flow, the presence of hydraulic gradients in the root zone is ignored in the scheme. Furthermore, water uptake by the crop equals potential evapotranspiration if the soil water pressure is higher than a certain critical value and equals zero if the soil water pressure is lower than -1600 kPa (pF 4,2). For values of the soil water pressure in the intermediate range the actual evapotranspiration is obtained by interpolation using a semi-logarithmic relation.
In the unsaturated subsoil only flow in the vertical direction is considered. Water storage is taken into account.
The saturated subsoil represents the upper part of the groundwater storage which can be fed and depleted by exchange with deep aquifers and the surface water system.
To execute such a simulation it is necessary to have data on the inital soil water content, the physical properties of the different layers in the soil and the fluxes through the upper and lower boundaries of the soil.

1.2 Data

Data were available on the free water evaporation and the precipitation in the study area during the summers (April-September) of the years 1933-1980. The potential evapotranspiration E_p for the different crop types in the summers mentioned has been derived from the free water evaporation E_0 using the formula $E_p=f.E_0$. Values for the crop factor f were taken from the literature.
From existing maps a representative crop type could be determined for each of the elements. The crop types distinguished are: potatoes, sugar beets, cereals, leguminous plants, onions, chicory, winter carrots, celeriac, leek, bulbs, fruit trees and grass. The total area of these crops amounts to about 15,000 ha. For each crop type the thickness of

the root system and the critical soil water pressure were used as input data.

Similary a representative soil type was determined for each element. The many different soil types on the soil map have been grouped to 11 units with corresponding physical properties. The relationships between the soil water pressure and the soil water content, and between the soil water pressure and the hydraulic conductivity were determined for each layer in the 11 units.

The flow between the saturated subsoil and the surface water system was simulated by a drainage function. The soils on Schouwen Duiveland are drained by pipes, situated at 0.9 m below surface. The discharge through the drains has been supposed to be proportional to the average depth of the groundwater table below the land surface; with a discharge equal to zero at a groundwater depth of 0.9 m and equal to 8 $mm.d^{-1}$ at a groundwater depth of 0.3 m. Infiltration of surface water through the drains will not occur because the drains are situated above the surface water-level. Direct drainage of infiltration from the surface water has been ignored because of the great distance between the ditches and the low transmissivity of the soil.

The flow between the shallow deep groundwater could be derived from the results of a geohydrological study.

The initial soil water content has been derived from the situation found in the field at the beginning of the summer; this means a groundwater depth equal to the average spring groundwater depth and an equilibrium moisture profile in the unsaturated zone.

1.3 Results

For each element the actual evapotranspiration for the summers 1933-1980 was calculated and compared with the potential evapotranspiration of the crop. The water deficiencies were averaged for the crop types distinguished over the different elements. Then for each crop the water deficiency was averaged over the 47 years. Expressed in percentage of average potential evapotranspiration the deficiency for the different crops amount to: potatoes 18%, sugar beets 10%, cereals 10%, leguminous

plants 15%, onions 12%, chicory 4%, winter carrots 3%, celeriac 13%, leek 2%, bulbs 10%, fruit trees 20% and grass 16%.
To transform the thus found water deficiency into a reduction in yield it was assumed that the interrelation between crop yield and actual evapotranspiration can be approximated by a linear function. If it is furthermore assumed that the application of sprinkling will reduce the water deficiency and the yield depression to zero, the presented percentages for water deficiency also indicate the increase of crop yield by additional water supply.

2 Water demand for sprinkling and flushing

Due to the continuous inflow of salt groundwater from the sea the surface-waters have become brackish. They will remain so when fresh water is supplied unless an extra amount of water is added for flushing.

2.1 Salt load on surface waters

Depending on the hydrological circumstances the chlorinity load may vary strongly in space and in time. In order to compute the amount of fresh water needed for flushing, a simulation model of the chlorinity load was prepared in two stages. In the first stage the areal distribution of the seepage was computed for stationary flow, using a finite element model. The second stage was devoted to the modelling of the temporal fluctuations of the salt load.

2.1.1 Areal distribution of seepage

The computation of the areal distribution of seepage was done with a standard computerprogram of the Delft Hydraulics Laboratory, GROMULA. (Broks and Dijkstra 1979). GROMULA is a Galerkin finite element program for flow in a multi layered system of aquifers. Figure 2 gives an impression of the element grid that was used for Schouwen Duiveland. The

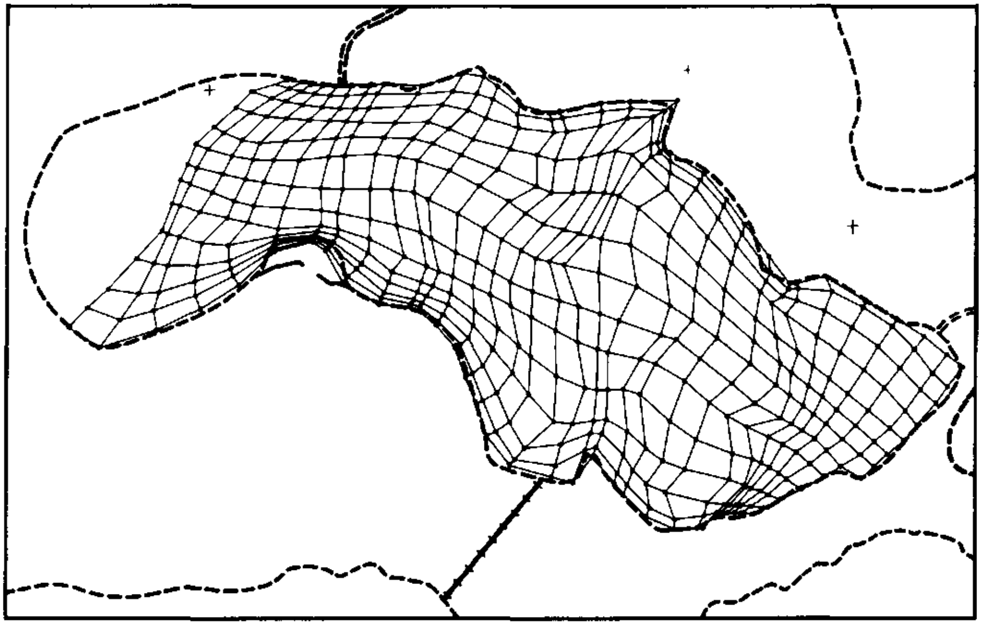


Figure 2. Element grid, Schouwen Duiveland

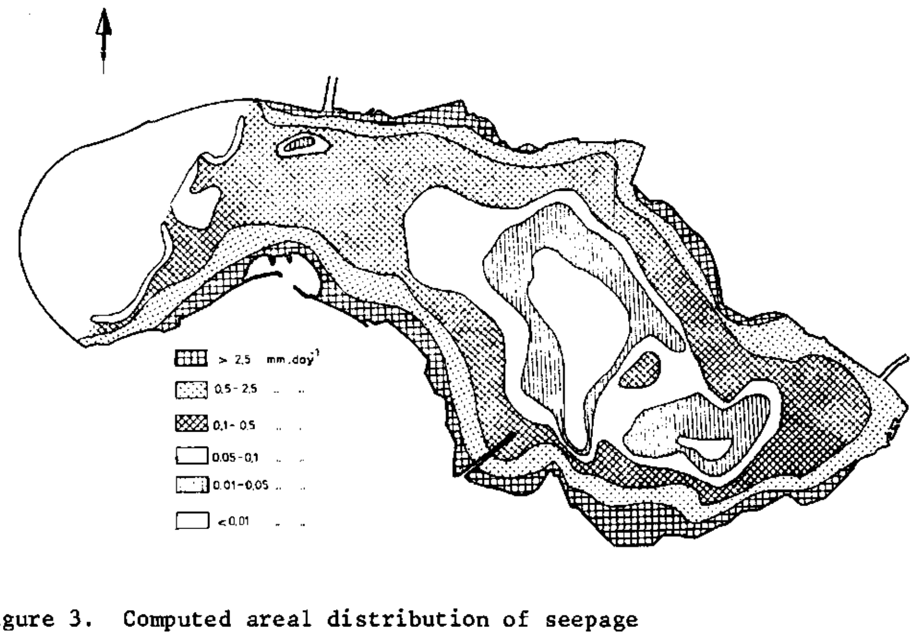


Figure 3. Computed areal distribution of seepage

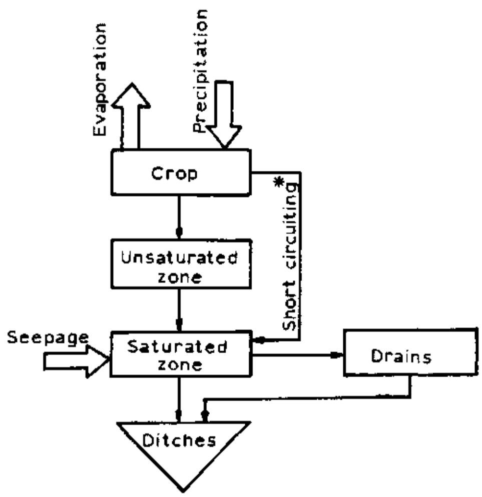
geohydrological scheme consists of two aquifers divided by a semi-pervious layer. On top there is also a semi-pervious layer, in which a constant polderlevel is maintained by means of surface water ditches. The boundary conditions consist of a constant waterlevel (mean sea level) along the boundary of the grid and a constant polderlevel in the upper semi-pervious layer.
Observed piezometric levels, available for both aquifers were used for model calibration. Moreover, the computational results could be verified against existing water balances over several years, available for the greater part of the isle. With the calibrated model the areal distribution of the stationary seepage was computed for a future situation. when ditch-levels may be adapted to decrease seepage. Figure 3 shows the computed seepage to the top layer.

2.1.2 *Temporal fluctuations of the salt load*

Whereas the inflow of salt groundwater from the sea is more or less stationary the exfiltration to the surface waters shows marked fluctuations in time. This phenomenon is attributed to the storage of salt groundwater in the semi-pervious toplayer during summer. There appears to exist a close relation between the fluctuations of the salt discharge and the effective precipitation. In order to formulate this relationship the computer program LINMOD has been develloped and applied to each element of the GROMULA model. Essentially LINMOD describes the discharge of water from the landsurface to the ditches through the saturated zone. As the problem doesn't require comprehensive knowledge of the processes in the plant-soil system both the crop and the unsaturated zone are modeled very schematically.
Figure 4 shows the lay-out of LINMOD. From field observation it was concluded that after each shower some rapid downward flow takes place, presumably through cracks. In the scheme this effect is indicated as "short circuiting". Discharge may take place either through the drains or through the subsoil. In both cases the relation between inflow and outflow of the saturated zone can be expressed in the form

$$F_{out}(t) = \int_{o}^{t} F_{in}(t-\tau).e^{-\alpha\tau}d\tau$$

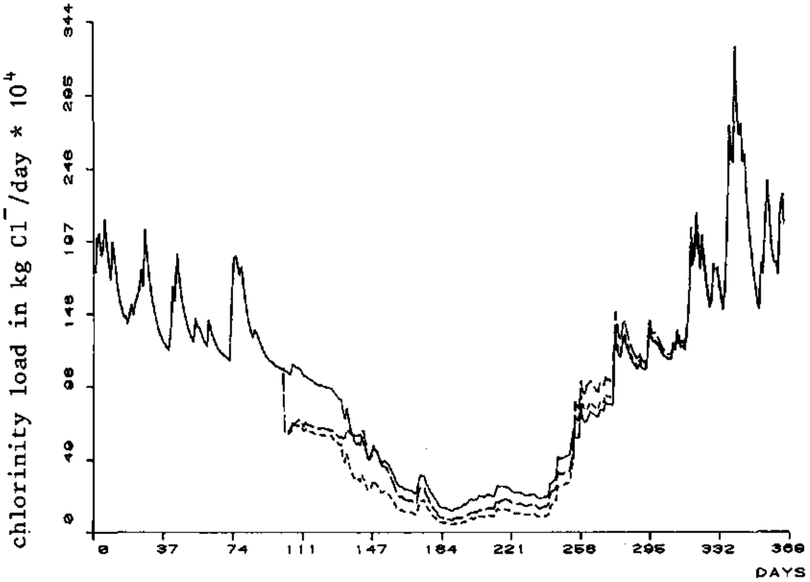
where α (reaction factor) takes on different values each time the phreatic level passes the drains.
To transform discharges to salt loads the drainwater-runoff is multiplied by the chloride content of the drainwater while the runoff from the subsoil is multiplied by the chloride content of the upper aquifer. For both parameters maps where available from earlier investigations.



* short circuiting:rapid downward flow of water through cracks

Figure 4. Lay-out of the computer program LINMOD

The model LINMOD has been calibrated for a sequence of years. Figures 5 and 6 show examples of the computational results. Figure 5 shows the time dependent chloride charge (summed over the area of investigation). The influence of certain watermanagerial measures is clearly seen: when the polderlevels are raised during the summer the discharge of salt decreases. The effect is partly conceled when sprinkling is applied.
Figure 6 shows the calculated spatial distribution of the salt load at the start of the growing season of 1976.



—— chlorinity load (present polderlevels)
--- chlorinity load (raised polderlevels)
– – chlorinity load (raised polderlevels and sprinkling)

Figure 5. Computed temporal distribution of the chlorinity load (1976)

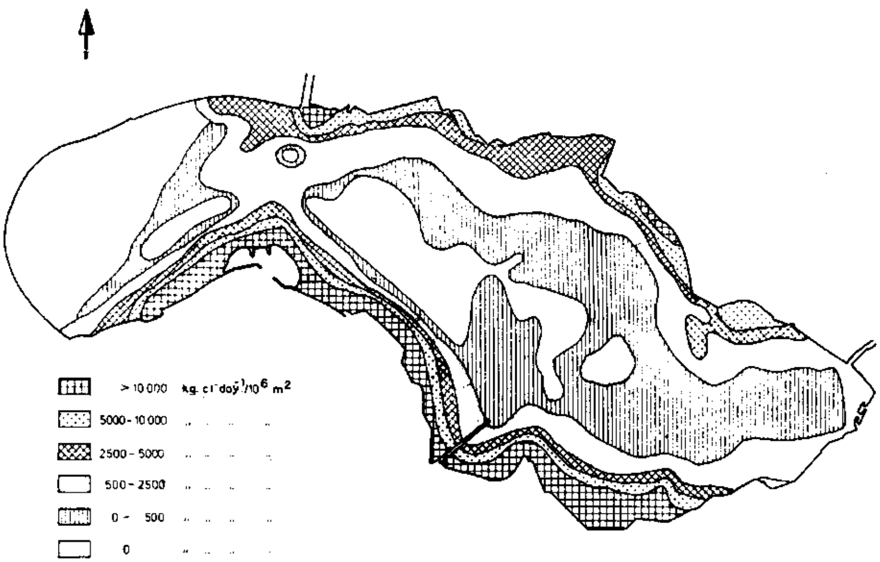


Figure 6. Computed spatial distribution of the chlorinity load (april/may 1976)

2.2 Demand of water for flushing

The most critical period of flushing appears to occur at the beginning of the growing season. Once the salt load at this time is known, the demand of water for flushing can be calculated in a relatively simple way. The calculation is based on the principle that irrigation takes place from side branches of the system and the optimal situation is reached when the required quality standard is just met at the confluence of the side branches and the collector branches. As the water needed for sprinkling also helps to combat salination, no discrimination is made between water for sprinkling and flushing.
The calculation is done for two different supply systems. One with a diffuse intake from the fresh Lake Grevelingen and the other with a concentrated intake for supply by pipe line.
In the most critical periods the following results are obtained: for both systems the amount of water needed for flushing and sprinkling is 3.4 $mm.day^{-1}$ of which 1 $mm.day^{-1}$ is used for sprinkling. When some very saline areas are excluded from flushing this amount may be lowered to 2.5 $mm.day^{-1}$. Compared to other coastal areas of the Netherlands the calculated amount of water needed for flushing is extremely high. However, the salination of Schouwen Duiveland is known to be extraordinary severe.

3 Investments and economic effects

3.1 Investments

The investments required for the realisation of a fresh water supply system mainly result from groundwork and constructions. For the main alternative in case of a fresh lake the investments amount to Dfl 22.3 $* 10^6$ which may be lowered to Dfl 18.4 $* 10^6$ by the exclusion of some very saline areas. The main alternative for a salt lake requires Dfl 24.3 $* 10^6$ which reduces to Dfl 20.0 $* 10^6$ when very saline areas are excluded (the pipeline needed to transport fresh water to the island, is not included in these figures). It can be concluded from these figures that the salt variant always requires a higher investment.

3.2 Economic effects

The economic effects (net yield) for the farmers on Schouwen-Duiveland are, as far as the agriculture and horticulture are concerned (90% of the cultivated land) accounted by an optimization model developed by the Research Station for Arable Farming and Field Production of Vegetables in Lelystad. The economic effects on fruit culture, stock farming and bulb culture, the remaining 10% of the cultivated land, are estimated in a different way.

For the computation four scenario's are considered:

PS- : Present situation without sprinkling

PS+ : Present situation with sprinkling

OPT- : Optimum situation without sprinkling

OPT+ : Optimum situation with sprinkling

The farm-plans for the two OPT scenarios are obtained from the optimization model, with the maximum net profit as an optimization criterion and farm size, labour force, tool cost, demands of crop rotation, yield reductions and crop prices as input data.

In order to quantify the effects of changes in the farm-plan due to fresh water supply the model is applied on farm-level. The cost of sprinkling, composed of fixed anual- and variable cost is input to the model. The capacity of the sprinkling installation is put at 30- or 60 $m^3.hour^{-1}$, and the annual cost at 20% of the replacement value. This 20% consists of interest, writing-off, maintenance and insurance. The variable cost, mainly cost of energy depend on the gross water gift, the capacity of the installation, the price of gas-oil and the sprinkled area. The accounted total sprinkling costs vary from 467-691 Dfl/ha, equally composed of fixed - and variable cost. From these figures and by comparison of actual and potential crop yield it can be concluded that sprinkling appears to be profitable for potatoes, onions, celeriac, sugar beets and chicory.

Table 1 shows the area used for agriculture and horticulture under the different scenarios as computed by the optimization model.

Table 1. Area used for agriculture and horticulture (in %)

scenario	PS- and PS+	OPT-	OPT+
agriculture	89	72	68
horticulture	11	28	32
Total	100	100	100

The shift in land use under the two OPT scenarios is obvious. Though on a national scale the indicated increase in horticultural area is not very likely, it is conceivable on a regional scale. Table 2 presents the net farm economic effects from sprinkling. The minimum effect is derived from comparison of the two PS scenarios, the maximum effect from comparison of the two OPT scenarios.

Table 2. Net-farm economic effects on Schouwen-Duiveland (in million guilders)

	minimum effect	maximum effect
Agri- and horticulture	2.50	3.10
Fruit culture	0.60	0.60
Stock farming	0.15	0.15
Bulb culture	0.01	0.10
Total	3.26	3.95

The presented minimum effect for agri- and horticulture of Dfl $2.5 * 10^6$ corresponds with an increased net yield of Dfl 4100.- for a 20 ha farm and Dfl 9800.- for a 40 ha farm.

The gross effect of sprinkling is obtained by addition of the sprinkling cost, which amounts to about Dfl $3.6 * 10^6$, to the presented net effect. Thus the gross minimum effect of sprinkling amounts to Dfl $6.9 * 10^6$ and the gross maximum effect to Dfl $7.6 * 10^6$.

The real economic effect will be higher than indicated by these figures, due to the so-called multiplier effect which has not been taken into account. Though introduction of sprinkling will lead to intensivation of the agriculture, the creation of extra employment is hardly to be expected, because of the occurence of idle time in the present situation.

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PEAT POLDERS IN THE WESTERN PART OF THE NETHERLANDS

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Abstract

There were extensive areas of fenland in the western part of the Netherlands in former times. From the middle of the tenth century onwards, much of this marshland was reclaimed and developed as arable land; this caused subsidence, and eventually made it necessary to build dikes. In the polders thus formed, high groundwater levels made the land progressively less suitable for arable farming, so that more and more land was turned over to grazing. Adequate drainage was ensured by frequent dredging of the ditches. The dredging led in turn to a shift in the proportion of water to land areas, and to changes in the composition of the topsoil and land use suitability. A distinction can be made here between peat polders with clayey topsoils and those with sandy topsoils. The sandy topsoils have been created in areas where mud was mixed with sandy stable dung. In the peat polders with sandy topsoils, which have a good workability, there is horticulture as well as grazing.

The grazing areas are used for dairy farming. This type of farming, however, puts such great demands on the bearing capacity of the topsoil and on drainage, that only the peat soils with a sandy topsoil are suitable. In the other peat polders intensive dairy farming is possible only if the water level in the ditches is lowered by between 0.3 and 0.5 metres. This lowering of the water level causes subsidence, however, resulting in progressive lowering of the peat surface.

1 Introduction

Between the strips of clayey deposits along the river banks and the drained lakes of the western part of the Netherlands there are extensive peat areas, known as peat polders (Figure 1). These peat areas have undergone a unique process of development, the results of which can still be seen clearly in the landscape, soil conditions and land use.

The following stages can be distinguished in the development of the peat polders:

- formation of raised bogs,
- reclamation of the bogs, resulting in subsidence (to some extent due to oxidation of peat) and increasing difficulty in controlling water,
- formation of peat polders by constructing dikes and dams, and by extending the drainage system,
- formation of lakes and open water as a result of cutting over the moss peat for fuel,
- constant adjustment of polder water levels as land levels gradually subside due to oxidation of peat,
- changing soil conditions and increase in water area proportionate to land as a result of dredging,
- adjustment and differentiation of land use as soil conditions and polder water levels change.

These developments are described in further detail in this article. The main emphasis will be on the continual subsidence and the resulting changes in soil conditions.

2 Formation of the peat polders

Around the eighth century the western part of the Netherlands consisted mainly of large areas of raised bogs which were drained naturally by rivers and streams. Clay soils and clay-on-peat soils occurred only in narrow strips along the banks of the water courses (Figure 1). Most of these have been assimilated in the peat polders, and no further reference is made to them in the present context.

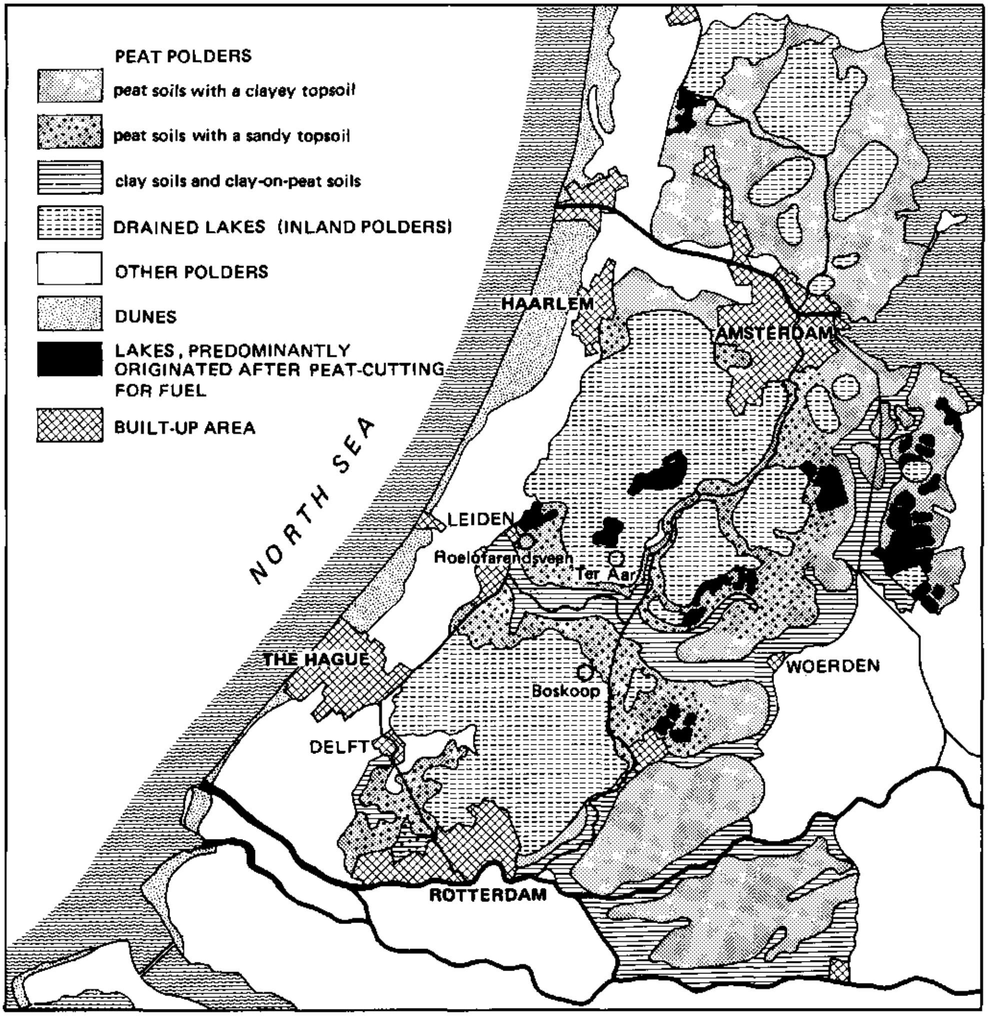

Figure 1. The peat polders in the western part of the Netherlands

Many of the bogs in the northern part of the peatland were brought into cultivation in the period between the middle of the tenth century and the beginning of the twelfth (Van der Linden, 1982). The existing pattern of small fen streams was followed as closely as possible, with the result that the fields are of irregular form and length. Similar irregular developments also occur in other parts of the fen area. Systematic reclamation of the central and southern areas of the peatland began in the eleventh century, starting from the rivers and fen streams (Van der Linden, 1982). A series of parallel ditches was dug, to form a regular pattern of cultivation in strips of approximately 110 by 1,250 metres. The fenland was rented out to the developer by the original proprietor under an agreement called a cope. The name cope, kop or koop can be found in many of the place names in this area (e.g. Teckop, Nieuwkoop, Boskoop). The youngest strips of cultivation were furthest away from the rivers and fen streams, and cut off from the older developments by wide ditches.

The fenland was originally high ground, drained by the rivers. After the land had been reclaimed and brought under cultivation, the peat began to oxidize more rapidly, and therefore to subside at an increasing rate. Dikes and embankments had to be built in order to protect the older, lower-lying and most subsided fields from river water and water draining from the more recently developed areas at a higher elevation.

This is the process by which, from about 1500 onwards, the peat polders came into being, contained by embankments and dikes and with controlled water levels in the ditches. Good drainage had to be ensured by digging main drainage canals, canalizing peat streams and extending the system of ditches. It was the introduction of water mills, in particular, which made the creation of peat polders a practicable proposition.

In many of the peat polders the moss peat was cut over for fuel. Most of the artificial lakes thus formed were later pumped dry (Figure 1: drained lakes).

3 Further development of the peat polders

In spite of peat polder development, the control of water levels became increasingly difficult. Arable farming eventually became impossible, and more and more land was turned over to grazing. The progressive soil subsidence, which according to Schothorst (1982) was due mainly to oxidation of the peat, made it necessary to have constant control over the water levels in the ditches. This meant that ditches - which were increasingly important as drainage channels - had to be kept deep enough. This was done by means of regular dredging (Van Egmond, 1971). The farmers were under obligation to dredge, and this was checked on annually. The mud from dredging was deposited on the adjacent fields.

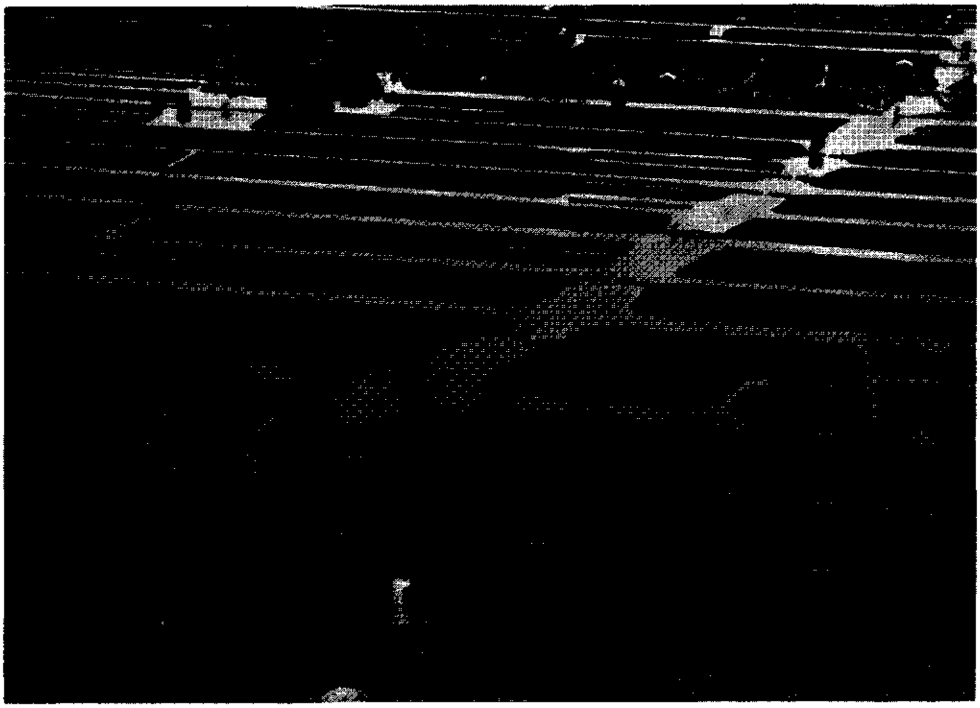

Figure 2. The wide ditches indicate the peat areas which have been subjected to prolonged dredging. (Photograph: KLM Aerocarto)

Where the land was used for grazing, poaching often caused considerable amounts of peat to disappear into the ditches. This material was put back on to the land by dredging, but the ditches nevertheless became wider and wider (Figure 2). Wide ditches and comparatively narrow strips of ground are therefore characteristic of much of the peat land used for grazing. Only the length of the original cope allocation remained unchanged.

4 Formation and properties of man-made topsoils

The constant dumping of mud on the plots of land has greatly affected the properties of the topsoil and land use suitability in the peat polders. The mud can vary quite considerably in composition, the clay or sand content being the main variables. In former times the mud was mixed with dung from the stables and spread on the land as dressing.

Sand rather than straw was often used as stable bedding. Much of this sand, which came from the dunes along the coast (Figure 1: dunes), eventually ended up on the land with the dung. Refuse from the towns was also used for mixing with the mud. Its organic components gradually oxidized and disappeared from the mud mixture, but the mineral additives, such as the sand, remained. Clayey or sandy topsoils were the result of whatever components had been added to the mud (Table 1, Figure 1).

Table 1. pH, organic matter content and particle size distribution of topsoils in peat polders

	Peat soils with a clayey topsoil	Peat soils with a sandy topsoil
Number of samples	31	49
pH	5.0 ± 0.4	4.9 ± 0.4
Organic matter[1]	33 ± 8	27 ± 7
Clay (<2 µm)[1]	31 ± 12	14 ± 5
Silt and fine sand (2-150 µm)[1]	29 ± 4	29 ± 5
Coarse sand (>150 µm)[1]	7 ± 5	30 ± 5

[1]In % of dry soil.

The clayey topsoils are 15 to 25 cm thick, are well moulded, have a high clay content and contain little or no coarse or fine sand. The use of mud encourages moulding of the peat. This causes a decrease in the organic matter content and an increase in the clay content.
The sandy topsoils are 20 to 35 cm thick and are also well moulded. The predominant mineral component is fine or coarse sand. The topsoils in the peatland which originally had a high organic matter content contain hardly any coarse sand naturally. When it occurs, it has been added through human intervention, sometimes in considerable quantities (Table 2).
Mixing stable dung into the mud causes the organic components to oxidize more slowly. Where sand or refuse from towns have also been mixed in, minerals have been incorporated as well, which has the effect

Table 2. Quantity of sand in peaty topsoils of 30 cm thick

Weight percentage of the fraction >150 µm	Quantity of sand (tonnes/ha.) in peaty topsoils with a bulk density of:		
	0.6 g cm^{-3}	0.7 g cm^{-3}	0.8 g cm^{-3}
20	432	504	576
35	756	882	1008
50	1080	1260	1440

of increasing fertility. Sand in the dressing mixture also makes for topsoil with a greater bearing capacity (Table 3). The favourable effects of these additives on the bearing capacity and fertility of the peat soils is borne out by the comparatively high (for that time) grazing density of 1.75 head of large livestock per hectare which pertained in some peat polders in the second half of the nineteenth century (Van Egmond, 1971).

5 Present land use

The peat polders in the Netherlands are used mainly for grazing. Extensive horticulture occurs only in polders with a sandy topsoil, the main types being cultivation of ornamental shrubs (around Boskoop) and glasshouse cultivation of vegetables and flowers (at Ter Aar and Roelofarendsveen, for instance). Peat soils are suited for these forms of cultivation if they have the following properties (Aendekerk, 1975):

- well moulded topsoil 20 to 30 cm thick,
- sufficient sand in the topsoil,
- organic matter content of 20 to 40%,
- good drainage potential and adequate moisture supply from groundwater.

About a third of the samples of sandy topsoils in Table 1 meets the first three of these requirements. Many peat polders with sandy topsoils have a subsoil of peat with a high permeability (sometimes wood peat) and a groundwater level in summer of between 0.60 and 0.80 metres

below surface and 0.3 to 0.4 metres below root zone. The last of the above requirements therefore does not usually present a problem for the various types of horticulture.
For dairy farming purposes the soils in the peat polders have limited possibilities as regards the form of the fields, topsoil bearing capacity and drainage.
The fields are long and narrow, especially where there has been a lot of dredging. Re-allotment could improve matters, but this would involve building new roads and moving farmsteads - a costly business on peat soils.
Intensive farming puts great demands on the bearing capacity of the topsoil and on drainage. The groundwater level must not be higher than 0.25 to 0.30 metres for any length of time, while penetration resistance, which is a measure of the bearing capacity of the topsoil, must be greater than 0.6 MPa (Table 3). Much of the land in the peat polders does not measure up to these conditions. Poaching damage has consequently been widespread. Only the peatlands with a sandy topsoil are to some extent suited to this type of farming.

Table 3. Penetration resistance and groundwater level of peat soils (April 1970)

Type of topsoil	Number of samples	Mean groundwater level (metres below surface)	Mean penetration resistance (MPa)
Sandy topsoil	7	0.21 $\pm$ 0.10	0.6 $\pm$ 0.09
Clayey topsoil	17	0.17 $\pm$ 0.06	0.4 $\pm$ 1.0

The bearing capacity of the topsoil in the peat polders can be improved without detriment to the production of grass through lowering the water level in the ditches by 0.3 to 0.5 metres. The peat soils with a sandy topsoil are at an advantage in this respect, in that the same result can be reached with comparatively higher ditch water levels. Lowering the water level in the ditches, particularly in peat soils without a sandy topsoil, will cause the organic matter to oxidize rapidly, and therefore lead to a large amount of subsidence (Schothorst, 1982). The ditches in the peat polders are still being dredged to keep them deep enough. The mud, however, is no longer being mixed with stable dung. Mud in areas with eutrophic and mesotrophic types of peat contains pyrite (FeS_2). Oxidation of mud will therefore nearly always lead to an increase in the acidity (Table 4).

Table 4. *pH of eleven mud samples from a peat polder*

	Fresh mud	Mud after slow oxidation during 90 days
Mean value pH	6.4	3.7
Range	6.2 - 6.6	2.0 - 6.5

Dressing the land with mud can cause problems if the mud contains more than 1 to 1.5% pyrite, or if the pH drops to below 4.0 after slow oxidation. Acidification is counteracted by using lime ($CaCO_3$), but large quantities are required.

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FORESTRY AND FORESTRY RESEARCH

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1 Introduction

Fifty years ago the barrier dike across the Zuiderzee was completed. Since that time the polders created in the IJsselmeer have been enriched with 50 million trees and other plantings.

From the outset, some of the reclaimed polder land was designated for afforestation. The initial setbacks encountered in this afforestation, and the lack of knowledge and experience of how to deal with this virginal land engendered a need for forestry research specifically directed to the conditions prevailing in the polders (unripened soils, exposed sites, etc.). The successful establishment of forest areas in the Wieringermeer Polder (drained 1930-1940) set a precedent for future afforestation in the polders.
In the period that the Noordoost Polder was being reclaimed (1942-1962) more experience was obtained about afforestation. At the end of this period the poplar began to be used on a large scale as a pioneer species and has become important in the design of forestry management plans.

2 The Wieringermeer Polder

In 1930, two years before the barrier dam from Wieringen to Friesland was completed and the IJsselmeer was created, the Wieringermeer Polder was drained. Because the polder was reclaimed directly from the sea its soil was very saline.

After the reclamation several plans were drawn up to make the polder habitable as soon as possible and to provide shelter by planting trees. These plantations were planned on soils unsuitable for agriculture. Information was already available on some of the problems of afforesting the IJsselmeer Polder soils: trees had been planted on the experimental Andijk Polder, reclaimed in 1923. Encouraged by the favourable results of these experimental plantings and using experience acquired during the afforestation of the Frisian islands, large-scale afforestation was begun in the Wieringermeer Polder in 1934. The species planted were Acer pseudoplatanus, Fraxinus excelsior and Quercus robur and, to a lesser extent, Populus spp., Betula pendula, Picea sitchensis and Pinus nigra.

Some years later, poorly growing species were replaced by more productive species, to ensure that the plantings were economically viable. The afforestation was done without any consideration being paid to the establishment of a normal age class distribution, even though this is desirable in the long term.

During World War II the Germans blew up the barrier dam, and the resulting inundation severely damaged the existing plantings. After the war the damage was repaired as best as possible. A layer of sandy material 1 metre thick had been deposited on the agricultural soil near the breaches in the dam: this land was subsequently designated for forestry.

3 The Noordoost Polder

In the Noordoost Polder (reclaimed in 1942), the land that was considered to be unsuitable for agriculture was earmarked for forestry. In all, 1895 hectares, distributed between 4 forest complexes, were designated for afforestation. The soils to be afforested consisted of boulder clay, loamy sands, preglacial sands and peat.

The planting was based on the planting schemes tested in the Wieringermeer Polder. Main tree species used were Acer, Fraxinus, Quercus and Populus, but also Larix, Picea and Pinus. In all plantings Alnus glutinosa was used as a secondary species: later, other species were used (Prunus avium, P. padus, P. spinosa, Crataegus monogyna, Sorbus aucupa-

ria and Quercus rubra). Many combinations of tree species in different mixtures and spacings were tried out. The growth of the species varied, according to the soil type. The advantage of mixing the species was that this reduced the risk of failure of the afforestation.
The Forest Research Station (Bosbouwproefstation) started work in the IJsselmeer Polders just after the war, in co-operation with the State Forest Service (Staatsbosbeheer).
In 1947 Alnus glutinosa was used as the only secondary species in a proportion of 4000 per hectare which proportion in 1950 was increased to 8000 per hectare.
All the planting schemes incorporated provisions for shade-tolerant species to be planted at a later stage.
In 1950 the first large-scale poplar stands were planted. They gave much information about planting, management, thinning and clone selection. Because these plantings showed, that poplar was an excellent pioneer species, this was the beginning of the large-scale use of poplar in afforestation in the polders.

4 Oost-Flevoland and Zuid-Flevoland Polders

At the beginning of the 1960s the multiple-use function of the forests became more important. This resulted in the forest area being enlarged, and to do this, soil suitable for agriculture was used.
At that time "De Dorschkamp" Forestry Research Institute, the State Forest Service and the IJsselmeer Polders Development Authority (Rijksdienst voor de IJsselmeerpolders) were all engaged in forestry and forestry research in the polders, and therefore in 1967 the Commission for Forestry Research in the IJsselmeer Polders (Commissie Onderzoek Bosbouw IJsselmeerpolders) was set up to co-ordinate the research. This commission, in which all three organizations are represented, deals with all research into the choice of tree species, the composition of stands, stand establishment, stand improvement, clone selection, forest protection and forest ecology. In the 1960s social conditions in the Netherlands were changing and this had a great influence on the way the Oost-Flevoland and Zuid-Flevoland Polders were developed. These social changes included:

- an improved economic climate, leading to more spare time and greater mobility
- more attention being paid to the welfare of the population
- mechanization and rationalization in agriculture and industry

In response to these changes the planners developed intensive and extensive recreation facilities on and around the peripheral lakes, and the forests became an important feature of these developments.
In the Oost Flevoland Polder, 6000 hectares of forest areas have been planted, mainly in 10 forest complexes. Some of the forest complexes in the west of the polder have been planted on very good soil. The forest area in Zuid-Flevoland Polder is still being laid out. In this polder the forest area has been combined within one large forest complex of 4000 hectares (2000 hectares have been planted so far). The integration between forest and city has been taken into account in the plans for the development of the city of Almere. It is planned to have 7600 hectares of plantings in the polder.

5 The role of the poplar in forest development of the polders

The poplar has been used to a great extent in the Oost-Flevoland polder: approximately 40% of the trees planted are poplar. The poplar is a fast-growing tree, a good pioneer species that soon builds up a favourable micro-climate and is economic attractive.
The need to develop normal forestry management in the polders has gradually become more evident. Most of the forests in the Oost-Flevoland Polder belong to one age class. To achieve a normal age class distribution, theoretically only 10% of the planting should be accomplished every ten years, assuming a rotation of 100 years. After 90 years the final 10% should be planted to give the forest a normal age class distribution. Obviously it is neither desirable nor practical to allow a large area designated for forestry to lie fallow for a long period and therefore stands should be planted temporarily and felled after a certain number of decades to make way for stands with permanent tree species. Poplar is an ideal species to use for such short-term plantings because already after 10 years it yields an acceptable harvest of wood, and can be converted to plantings with other species.

The ultimate aim of afforestation in the polders is to achieve a normal permanent forest at the end of the longest rotation. To do this, a development model is worked out for the planting of a forest complex. Using this model suitable tree species can be recommended. The most recent directives for the choice of tree species for afforestation in the polders were issued in 1979/80:

63% Populus species	: 65% P. euramericana
	10% P. nigra
	10% P. canescens
	12% P. trichocarpa and hybrids
	2% P. alba, P. tremula and experimental clones
4% Salix species	
8% Fraxinus excelsior	
6% Acer pseudoplatanus	
5% Quercus robur	
4% Fagus sylvatica	
10% other species, of which 4% are softwood.	

A model is drawn up for each forest complex to be developed and is used as the basis for the management plan. The trend nowadays is shifting away from a model design for the polder forests in general towards a plan for each forest complex that takes into account the ultimate forest type that is envisaged:

1. Forests on wet soils: Macrophorbio-Alnetum and species from the Alno-Salicetum and Salicetum-albae.
2. The next phase on only shallowly drained soils is: Fraxino-Ulmetum, Pruno-Fraxinetum and Anthrisco-Fraxinetum. On drier and sandier soils, species of the Violo-odoratae Ulmetum.
3. On well drained, riper, more developed soils: forest types related to the Fago-Quercetum.

It might be clear, that the development of the forest ecosystems to the forest types mentioned under 2 will take decades till centuries and to those mentioned under 3 even longer. During this time stands composed of pioneer species and species of phase 2 will make a considerable part of the total forest area.

SOCIO-ECONOMIC AND PHYSICAL PLANNING ASPECTS

DO POLDERS ADAPT TO THEIR ENVIRONMENT?

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1 Abstract and Introduction

Before a reclamation the borderline land - water is obvious. However, when after the reclamation the same line remains as clear and uninterrupted, for example through the difference in landuse, the question arises of whether the new land is really integrated into the existing landuse pattern. From the regional planning point of view it is sometimes considered a failure or a danger when a new "big" entity is not really (being) integrated such as a new building into a built up area, an industrial estate or recreational site near a city, an airport or a polder in the region.

It must be clear that a new entity, p.e. a polder, has got its own spatial identity and that is fully appreciated. But life can at any scale make social, functional and through these also spatial links between old and new, making old and new one divers but organic pattern.

Three examples are discussed:

par 2 the large scale plan for the reclamation of the Zuyder Zee

par 3 the medium-scale plan for an older and a recent polder in the Netherlands

par 4 the small scale plans of Singapore Marina City and Almere Harbour.

The conclusion is that the integration of a polder into the overall landuse pattern is possible, is necessary and is quite a challenge, both for policy makers and for those who live inside and around the polder. The clue is to transcend the one-sided technical and agricultural nature of the polder as such with planning items on the polder's scale and as varied as life. See also par 5.

All parties will, with different objectives, answer the question the title poses, with: "They should"

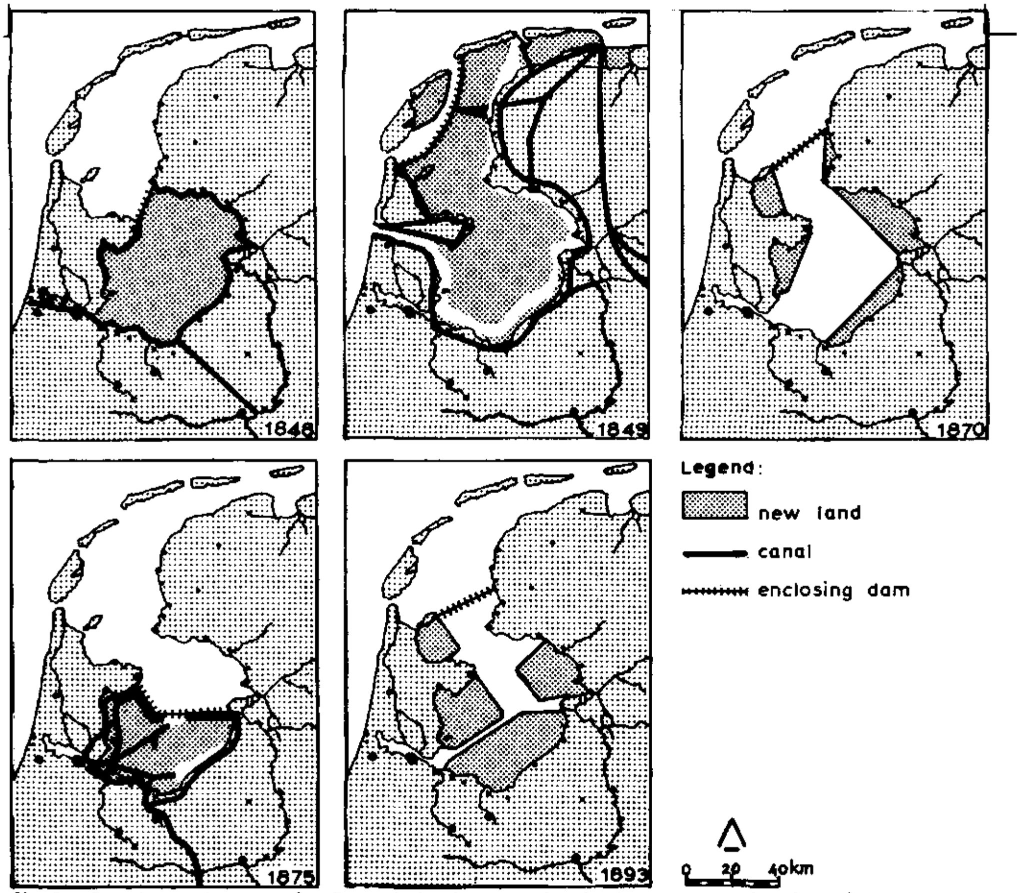


fig 1 In the schemes 1, 2 and 4 the emphasis is on new land and on water-system-control, in scheme 3 mainly on water-defence. None of the schemes is integrated into the environment; in scheme 2 the water-system-control rules the environment.

2 Zuyder Zee; too large to integrate?

The numerous schemes for the reclamation of the Zuyder Zee (fig 1, 1840-1900) concentrate on the gain of land and on waterdefence; they regard the old land as good enough for digging canals for water control. (schemes 2 and 4).
Also the first (scheme for a) settlement pattern does not integrate the polders into the overall settlement pattern (fig 2, ± 1935). On the contrary, the proposed settlement pattern is an independent and introvert scheme; the polders seem to function as a try out for a recent scientific model (the Christaller-model).
A more recent plan is one (fig 3, 1965) which makes clear that not all proposals that just cross the dike automatically integrate old and new land. The national highroad network covers the whole country with a chessboard scheme, adapted as

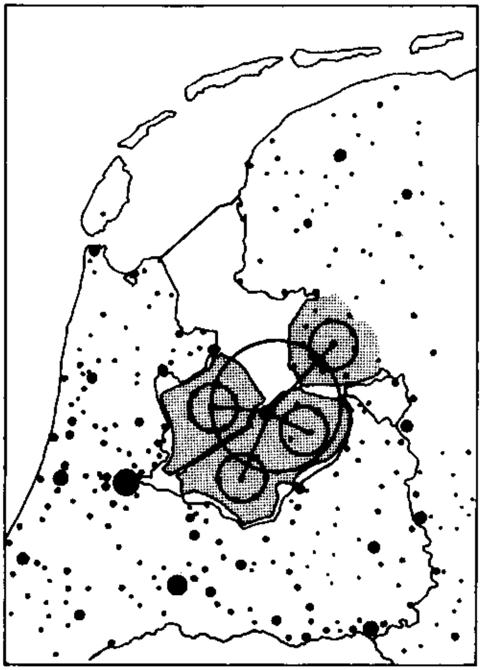


fig 2 The application of a newly found settlement model (+ 1935) in the polder area, regardless of the surrounding existing settlement pattern.

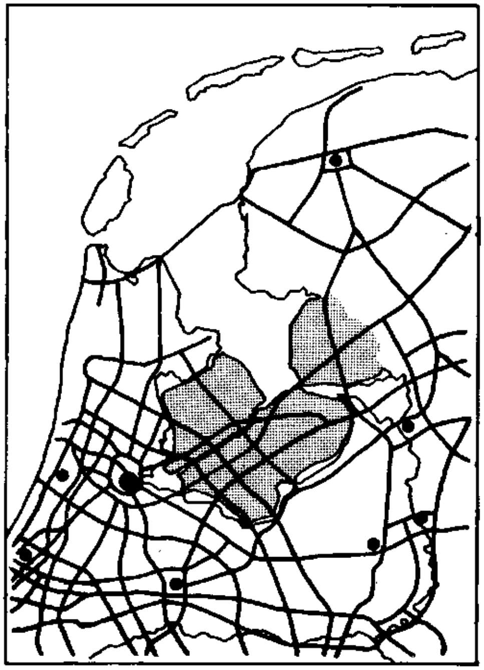


fig 3 The application of a squareboard highway network covering the whole land (1965) regardless both old and new topography underneath.

fig 4 A nationwide planningconcept with urban zones, open space and transportlines, integrating the polderarea into the adjacent landuse pattern.

little as possible to the existing urban and rural topography underneath. In fact this grid-system does not integrate but ignores both old and new land.

Finally a nationwide planning concept was attempted (fig 4, ± 1955), prompted by the need of more space in the larger cities south-west of the polders. This scheme is also a scheme rather than a design, but one that subjects the former sharp coastline and the agricultural landuse of the Zuyder Zee to national planninggoals, one that integrates urban and rural, transport and settlement at the scale of the polder or even at the scale of the larger cities of the country. Something as large as these polders needs integration into a really large environment.

3 Two polders; the older: stepwise integration the newer: unplanned integration

The Haarlemmermeerpolder (fig 5) was reclaimed in 1852. A rectangular parcellation and the location of two villages presented the polder as a big rigid entity within a highly differentiated environment.

The first signs of "integration" up until 1920 were no more than a few hamlets inside the ringdike, like answers to the villages outside. In worldwar I a military dike was created across the polder. When in 1920 Amsterdam needed an airport this was located on the Amsterdam-side of the still new polder. For many years these three steps made up all the integration that took place (fig 5a).

fig 5a Haarlemmermeerpolder: in eighty years just six hamlets and an airport, answers to direct out-side-the-ring-needs.

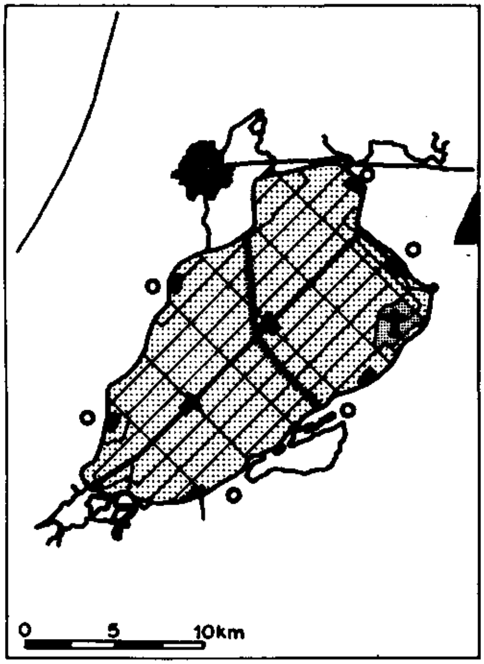
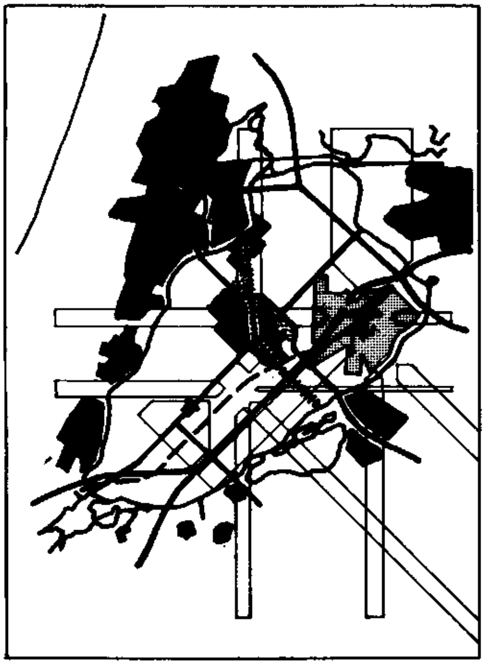


fig 5b Nowadays the transportsystem, and urbanisation- and commuting relations and regional ties relate the polder to the environment.



After worldwar II things began to change. (fig 5b) Employment in agriculture decreased and the airport grew into a national amenity, both resulting in considerable commutor flows in all directions. An airport requires these days a vast transportation system: highways and a railway line were constructed, crossing the dikes at many points. And though in the sixties the polder was declared large scale open space south of Amsterdam and Haarlem (which is also a way of functional integration), in the late seventies the suburbanisation pressure of these two cities was such that new residential areas were being planned in the polder, with the main village growing into a regional centre, of in many aspects no longer that dependent of the two big cities.

So after the three careful steps of integration undertaken in 80 years, five bold steps were taken over 50 years; the comparative large polder area had met with a variety of demands.

Now it may seem that merely the worldwide trend of scale-enlargment caused the process of integration of this polder into its environment. However, it is not the integration itself (scale-enlargment may be disintegrative in other situations); the next example will among others show this.

The second example of integration at this scale concerns the North-east polder, one of the polders in the Zuyder Zee, reclaimed in 1942. Initially (re par 2) the agricultural landuse prevailed and the independant (and introvert) settlement pattern was designed and that was that (fig 2 and 6a).

In this concept one aspect of scale-enlargment was already included: much larger agricultural parcels than anywhere else. However, employment in agriculture were expected to be more and the maximum distance between villages was expected to be smaller in comparison to recent standards. So too many villages were planned for too few people and the villages as a result did not grow as quickly and strongly as was planned. This was an unplanned and negative effect of scale-enlargment.

But other unplanned effects emerged. East of the polder the area is of poor agricultural value and poorly-populated, but of high touristic value. This caused the two woods along the east-border (on agriculturally less valuable grounds) to become centres for recreational activity (fig 6b).

Of the highroads, crossing the polder in the initial plan, one branch will not be built, in order to save that eastern nature area. A power station and recreational water sports were given opportunities along the waterfront.

Even more surprising is the fact that three villages in the south east section of the polder attract quite a few people, commutors, from the old land because they like

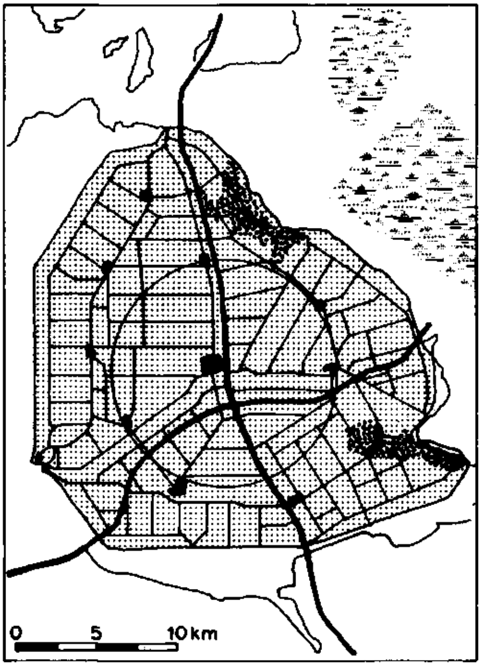


fig 6a the brand new polder, ten villages, a main village and crossroads.

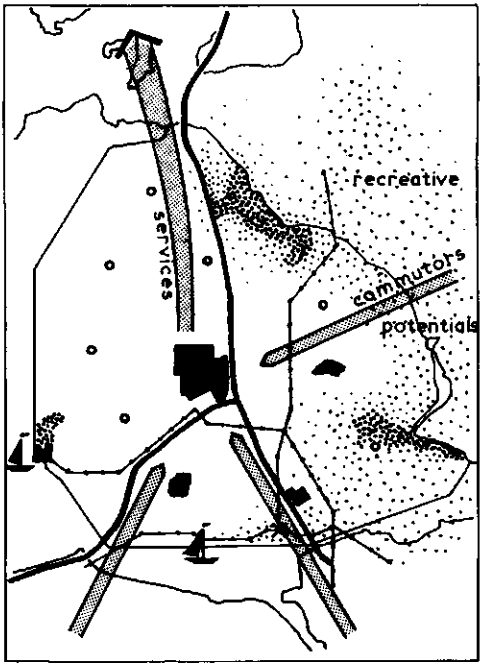


fig 6b After 35 years: functional and infrastructural links; unexpected residentional and recreational emphasize, backed by regional planning.

the atmosphere and the comparatively high standard of living. The effect of extra growth touches also the centre village: This one has grown to some 25.000 inhabitants with amenities at a "secondary level", which also serve the area north of the polder.

What we see here is that the form and the topography of the polder, through the comparatively high agricultural value of the soil and spacious parcellation, keep the polder distinct from its environment. But, over the years both the provincial government and the polder government did surveys and set goals with a scope that covered not just agriculture and water defence but the whole spectre of regional planning and not just the polderarea but the so called IJssel-valley. That's how, through quite a few functions old and new land mutually influence each other, thus integrating the polder in its environment.

4 Two small-scale examples with far reaching consequences. Singapore Marina City and Almere Harbour.

The Singapore seafront is being extended into the sea for the third time in history.

Through the impressive combination of a buildingboom, design skill and international touristic attraction, the waterfront is the main distinctive area: Singapore Rivermouth, Elisabeth Walk and the view they provide are unforgettable. However, the same boom has forced the city to extend its Central Area and to provide a new traffic-infrastructure along the coast, leading to a bold reclamation plan. Is this going to be the end of the unforgettable view?

The first sketches (fg 7a) show a reclamation along straight lines, a breakwater clearly visible in the plan, a highroad with three interchanges and a clear layout of the Central Business District and residential areas. Functionally all requirements have been met, all relations are there; the reclamation seems to be integrated. However, the question arises, at least at this scale, whether the integration will work, not only on paper and functionally, but also designwise and visually, from the touristic point of view.

A number of slight changes has therefore been proposed (fig 7 b).

For nautical reasons the rivermouth should not be symmetrical but bending north-east as is the present mouth of Singapore River.

For traditional and touristic reasons, the mouth of the Singapore River has been given priority above that of the Kalang River, the former emphasizing the urban quality, the latter continuing the quality of residential and open space.

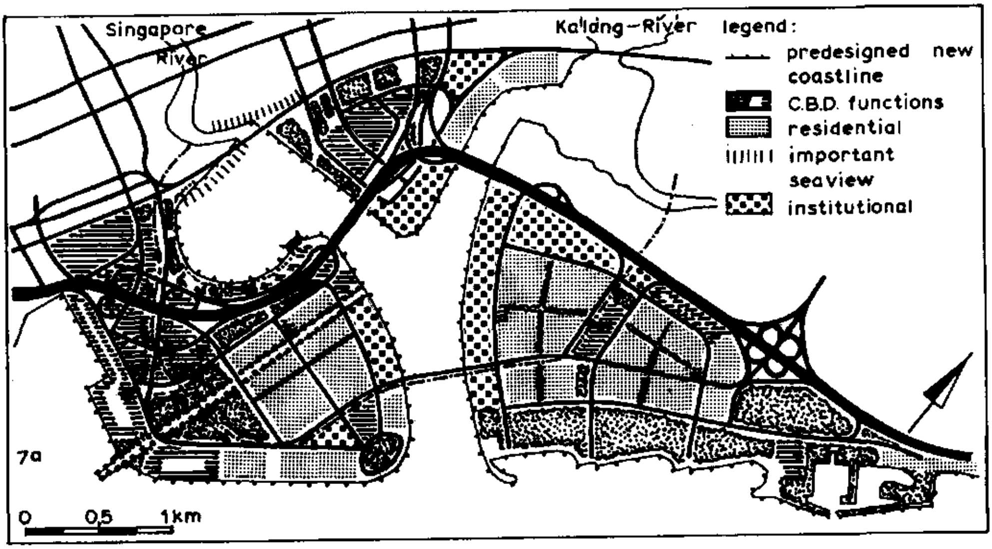
The "corridors" of CBD activity are being without any break continued into the new land, for the atmosphere of downtown is very sensitive to spatial interruptions. Prestigious pedestrian malls have been carefully planned at the most choicy locations.

The residential areas have been adapted to the (densities according to the) presence of the Mass Rapid Transit system and to the green-and-open-space-structure. Two important details of Marina South are that the breakwater is subject to the whole design and that a considerable amount of highrise buildings is proposed in order to "dwarf" the huge layout of the highroad from the viewpoint of the old (and remaining) prestegious seafront.

The sub-centres have effective slow-traffic lines and no-through traffic. The main traffic route is such that the three Marinas and the interchanges with the highroad are optimally connected and an open seaview is maintained.

On both sides of Kallang River the best accessible "national open space" seems to be optimally located.

In conclusion, where this reclamation was caused by the highly "urban" Central Area, it is completely subjected to the integration of new land with the old. Engineers and architect-planners should cooperate in such cases from the very



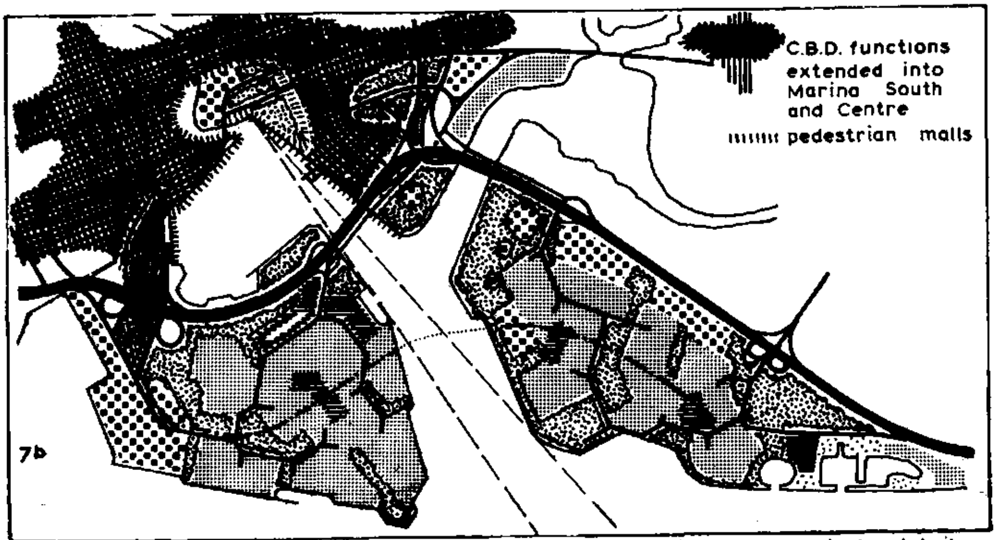


fig 7a new land with a design contrasting markedly (a o designwise) from landuse in central area.

fig 7b coastline not predesignd but a part of overall layout; the seaview is partly maintained. and CBD organically growing into new land.

beginning of the planning-proces.

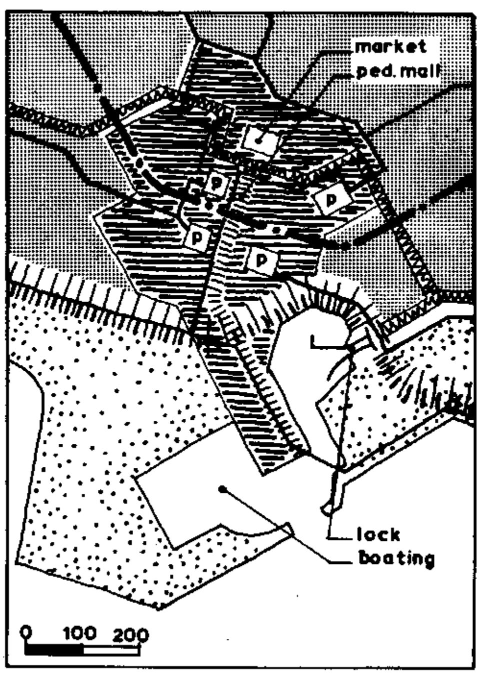
The last and also small-scale example, is again dutch: Almere-Harbour.
The realisation of the new town of Almere was started at Almere south, for the simple reason that a soil depot was available there. The designers considered that the main distinctive feature of this settlement should not be that of a "small

village behind a big dike" but to the contrary, the overpowering dike should, with all its technicalities be subjected to a human settlement of considerable size.
A choice was made to do three things (fig 8); a. the dike was slightly retraced; b. the lock was promoted from "ship entrance" to "city entrance", and (c), the city centre was designed with an extension across the dike. In this way the supremacy of the dike was thrice subjected to the urbanity of settlement.

5. Conclusion

In conclusion of this paper, we come back to a statement in the introduction. A reclamation scheme often has got a big scale in comparison to the environment and a one sided landuse in comparison to the adjacent landuse pattern.
These differences in scale and landuse are no objections. But planning items on the scale of the reclamation, such as urban zone, airport, commutor flows, CBD extension etc. and the variety life, including recreational attraction and new standards of living, can transcend the newness of a polder. It is a quality of human culture to accept this challenge.

fig 8 Almere Harbour: from the very beginning of the planningproces the polder dike was "transcended" by the human settlement.



MANAGEMENT AS A TASK POLDER-ADMINISTRATION AS A MEANS FOR AN INTEGRAL MANAGEMENT OF THE RURAL AREA

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Abstract

The principal tasks of Polder-administrations concern the management of dykes and embankments.
Polder-management may also be made serviceable to the management of nature, landscape and recreational joint-use.

1. Introduction

The Netherlands show a very intensive landutilization. Many forms of landuse lay a claim on the space that is scarce. All these forms of landuse make specific demands regard to lay-out and management of this space. Considering the variety of forms of landuse it may be expected that the relevant specific demands will be greatly divergent and sometimes even contradictory.
One of the most important functions in the rural area is agriculture. The working population engaged in agriculture has a direct control of the agricultural lands. Control of water quantity and water quality has often been handed to public bodies as there are among which the Polder-administrations.

Of old, these Polder-administrations have been directed towards agricultural interests, in the execution of their tasks. In this article possibilities are indicated to reach a more integral management in the rural area, which may lead to interweaving of joining of more forms of landuse in one place. Besides, polder management may also be utilized for nature management, landscape mangement and recreational joint use. In the proces, the existing types of organization and the present assignment of tasks of the Polder-administrations are taken as a starting point. It is not our intention to indicate in detail how the types of organization should develop in future. We aim at indicating a number of possibilities for integration of management tasks for situations in which various sector-interests are interwoven. Later, suitable solutions will have to be worked out that are based on the characteristics of these local situations.
This article is mainly based on a report that was published in 1979 under the same title, by the Cooperate Body "De Groene Long". Eleven polder-administrations participated in this Cooperate Authority, roughly comprising the polders between Alkmaar and Zaanstad in the province of Noord-Holland. The report was drafted by Ingenieursbureau 'Oranjewoud' B.V. After a brief explanation on the development of management in the rural area, we will enter into the relations between polder management nature management, landscape management and recreational joint use considered in the view of the management tasks of the drainage districts. At the same time the aspects of administration and finances will be dealt with.

2. Polder-management

For many centuries polder management in the Netherlands has been carried out by Polder-administrations. This task especially comprises the management of embankments, the fight against outside water and control of the water quantity, specially directed at the agricultural landuse and buildings. In a later stage care for the water quality was added to the tasks of a number of drainage districts.

A Polder-administration is a public authority with an organization in which the directly interested parties have a seat. By the extension of the tasks that the Polder-administrations went through, also persons that are not concerned with agriculture have got a seat on the board. With this gradually introduced change the significance of the polder-administrations has become more distinct to the community. To be able to carry out the present management tasks well, the Polder-administration have at their disposal a technical department, an executive department, pumping stations, equipment etc.
Financing of the activities has been arranged by means of a levy on built-on as well as on vacant properties in a polder. Besides Polder-administrations receive subsidies on works.

3. Polder-management and nature management

Various polderareas contain valuable areas of nature. Each area has its own ecosystem, which makes specific demands on the waterlevel control and the tolerance for fluctuations in this.
The larger nature areas are managed by organizations concerned with the preservation of nature. It is possible to institute a waterlevel control for these larger units that is directed towards the preservation and the development of the nature areas. In good consultation between the manager of the nature area and the Polder-administration, agreements can be made about the control of the water quantity. In polders also natural elements occur that are not managed by an organization for the preservation of nature. We may mention here bankstrips, reedlands, watervegetations and meadowbird areas. The value of these natural elements are directly influenced by the control of the water quality and the water qunatity. With this a direct relation to the management tasks of the Polder-administrations has been indicated. Also by means of the execution of the current management activities, such as reed mowing and cleaning ditches, Polder-administrations influence the development of flora and fauna.
The relation between polder-management and nature protection might be utilized in a better way if the Polder-administrations would base

the management activities on a management plan in which the natural values in the area would be taken into account. This management plan gives directions for the required waterlevel in a given period, mowing schedules for verges, reedlands and bankstrips and finally the required waterdepths and terms of cleaning.
Not enough is yet known about the relation between the control of the water quality and nature management. Research into the significance of the 'factor water' in an ecosystem is urgently required. The results of this research will give important indications for the nature management to be conducted.

4. Polder-management and landscape management

In the Netherlands agriculture is decisive for the outlook of the landscape of the rural area. Because the agricultural developments have a gradually taken place and because there are great soil scientific and hydrological differences among various territories a great variety of types of landscape exists in the Netherlands. These types of landscape contain a lot of culture-historical information. The landscape elements that contain this culture-historical information are sometimes called bearers of a picture of the time. In the past, the landscape elements fulfilled a function for agriculture. Trees supplied agricultural timber and were used as a bar for cattle and wildlife. The watercourses in the more watery areas often held an important function for transportation. In this way both use and management were controlled by the farmers. The landscape elements give a reflection of the technical possibilities and the economic requirements of agriculture. In the last decades the scale increase in agriculture has become more prominent. This economically required change has become possible by the technical improvement of the external conditions of production, namely opening up water control and land division. These improvements for agriculture were achieved in the framework of re-allotment. A consequence of these developments however was, that many landscape elements that were of old controlled by the farmers because of their practical use, gradually fell into decay.

In the recent years the idea has grown that the rural area not only has a function for the greater part meant for economic agricultural use. The townsman has discovered the rural area to be an attractive recreational area.

This attraction is especially determined by the presence of elements in the landscape with large culture-historical or geomorphological values. A balance between the demands that modern agriculture makes on the external factors of production and the demands that are made on the mangement and the development of the landscape form the general social function should be sought. The new Act on land division aims at the achievement of this required balance in the re-allotment of land. Regarding management no strong arrangement has been made yet. In the municipal organizations the departments concerned with public gardens occupy themselves with the management of green areas. This job is restricted to the municipal property and is concentrated especially in the residential areas.

The landscape elements in the rural area are threatened with decay because of lack of a responsible authority. In some cases agreements have been made with farmers for certain areas (management-agreements) or hedge banks are put up in the framework of employment programmes. This however offers no security in the long run, for management involves permanent maintenance. An enlargement of the activities of the Polder-administration regarding the management of landscape elements is quite sensible. The Polder-administrations are active regionally in a geographically connected area. They have at their disposal a management, administration and technical unit, because of which landscape management may be classed with an existing organizational structure. The Polder-administration is a public authority which - under supervision of the province - establishes orders and prohibitions.

Management of the landscape-elements should be based on a management-plan. This management-plan will cover the entire area for which the authority of the Polder-administration holds. The link up to the municipalities will be made by having the municipal designationplans and if there, a municipal landscape developmentplan, as starting points with the drafting of the management-plan.

5. Polder-management and recreation

To an increasing extent the rural area is being discovered by the townsman as a space for recreational activities. In this respect projects are meant that have not been laid out especially for recreational purposes but it concerns the use of facilities that have a different principal function. For this the phrase 'recreational joint-use' was introduced. Characteristics of 'recreational joint-use' are low numbers of visitors (extensive use) and a low level of lay-out (extensive lay-out). The most important activities meeting these requirements are walking, cycling, horseriding, fishing, canoeing and rowing. Often these activities can take place without the establishment of special facilities. Thus, cycling on the agricultural development roads is possible without any problem. For this no special planning is necessary.
Recreational joint-use in relation to other functions is specifically of interest with regard to planning and management, if by means of slight measures and slight expenses an obvious added value in recreation will arise.
This may best be illustrated with the aid of a number of examples.

- by providing an inspection path or a quay alongside a watercourse with a simple pavement attractive cycling possibilities will arise,
- by allowing access (on foot) opportunities for walking be realised and fishing water will become accessible,
- by providing a bank protection with a heavier construction for a length of 5 to 10 m, a launching place for canoes will be created,
- by providing bridges in polders with a litte extra height through-routes for skaters, canoeers and rowers will come into being.

From the polder-management the connection with recreational joint-use may be made in two ways. First of all this concerns the use of areas managed by Polder-administrations, by people seeking recreation.
The dykes, embankments and inspection paths can be made suitable with simple means for foot, cyling or bridle-paths. Watercourses may be utilized for fishing, rowing, canoeing and skating. The main restrictions are espically found in the legal field: walking rights, fishing rights etc. In the second place the Polder-administration can be involved with the management of recreational facilities in the rural area.

In this respect the management of cycling paths, picnic spots, fishing jetties and berths for watersports are in mind.
Especially in the western part of the Netherlands instances can be found of involvement of Polder-administrations with the management of facilities. Also assistance is rendered in various places in order to make recreational joint-use legally possible.
Developments in the field of recreation should be derived from a basic recreation-plan which should be considered as a regional management-plan. By means of this basic recreation-plan the connection is made with the Physical Policy which lies within the control of the provincial and municipal authorities.

6. Administrative and financial aspects

Polder-administrations already have an extensive experience in the field of various specific management tasks. The tasks are carried out based on public competencies. Today, again, we are justified in noting that the management tasks carried out by the Polder-administration are interwoven with practically all the functions that play a part in the rural area. These are the reasons for the suggestion to add a number of management-tasks as to nature, landscape and recreation to the tasks already existing.
The Polder-administration on account of direct and related tasks, as well as because of experience in the field of the execution of management based on public law, is the proper organization to take care of and coordinate the various management-tasks. Naturally, the composition of the board should be adapted to this broader field of tasks.
For this adjustment of the Board, however no ship-shape solution can be provided. It is to be expected that the extension of tasks will have financial consequences. With the institutions on whose behalf (also) these tasks are carried out, agreements will have to be made on the compensation. It is not possible however to apply the profit principle just like that. If for the maintenance of a nature area with its own management of watermarks seperate measures are needed, the question may be asked whether these measures have either become necessary because of altered requirements regarding environmental

management, or that they are caused by altered conditions in the environment. This may show that in spite of the many connections that exist between polder-management, nature management, landscape management and recreational joint-use many things yet remain to be settled.

THE IJSSELMEER AREA: THE PROTECTION OF A NATURAL FRESHWATER AREA OF INTERNATIONAL IMPORTANCE

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Abstract

Reclamation of the Markerwaardpolder - the last part of the Dutch Zuiderzee-project - is at the moment no longer a matter of course. The serious ecological damage to the IJsselmeer - a freshwater natural area of international importance - as a whole, and the changed opinions on physical planning in the Netherlands have led to a reorientation on the necessity of reclaiming the Markermeer (part of the IJsselmeer).
This reorientation is also evident from the results of the recent participation and advice procedure and from the recent opinions of the government and of political parties.
Opponents to the old plan plead: do not reclaim this area but manage it carefully as open water. In the discussion and the decision-making process this alternative plays an important role. It can be defined as the development and management of the IJsselmeer as a natural area with additional use by fishery, water-supply and recreation - in so far that they do not conflict with its function as a natural area.
Because of the many possible conflicts between the natural and other functions, and between the other functions themselves, there is a strong need for a comprehensive policy programme. Such a programme will clearly show how the manifold importance of the IJsselmeer as open water (without reclamation).

1 Klein IJsselmeer, Markermeer and IJmeer, together a natural area of international importance

After the completion of the Afsluitdijk in 1932, the IJsselmeer developed into a natural area of international significance again. The salt and partly brackish Zuiderzee with tidal movement changed into a fresh, stagnant inner sea with a surface of about 3500 km^2. Since the reclamation of several polders the IJsselmeer (divided into Klein IJsselmeer, Markermeer and IJmeer) covers 2000 km^2. It is one of the largest freshwater lakes in Western Europe.

The Netherlands with its many wetlands lie just between the breeding grounds and the wintering areas of many species of waterfowl. Its situation on an important migration route for waterfowl of the northern hemisphere and the mild winter climate makes our country very important for migrating, wintering and moulting birds. Especially the relatively large stretches of water, where birds can find great rest and an abundance of food are important. The Waddenzee, IJsselmeer and Delta-area all have their very own functions for waders, ducks and geese (Saeijs and Baptist 1978).

Recent research has given new information on the number and species of waterfowl in the IJsselmeer area. During several international conferences on the conservation of wetlands and waterfowl, standards have been set to denominate specific areas as being of international importance. These standards are called the IWRB-standards (International Waterfowl Research Bureau). A comparison of the bird-counts with these standards leads to the conclusion that the entire IJsselmeer, with the Wadden Sea and Eastern Scheldt are ornithologically of utmost international significance (De Molenaar en Müskens, 1979).

Within the IJsselmeer area the Markermeer has its own special place. It is of proportionally great significance to several species. The Markermeer is also very important as a feeding area for some species of breeding birds (especially the cormorant). Unlike the IJsselmeer with its mainly sandy bottom, the Markermeer has a clay bottom. The soil-fauna of the Markermeer is therefore proportionally rich, serving as food for the fish, and thus being directly and indirectly very important for waterfowl. The completion of the Enkhuizen-Lelystad dike favourably influenced the waterquality of the Markermeer

- partly thanks to the clay bottom (percentage of silt, capacity to combine with phosphate). The water-quality of the Klein IJsselmeer shows however a tendency to worsen - presumably caused, among other factors, by the lack of water exchange with the Markermeer.
Results of research of the dispersion of birds in the whole area lead to the supposition that there is a strong relationship between the Klein IJsselmeer and the Markermeer. Several factors such as food supply, weather conditions and differences in shelter play a role.
Finally, it has to be mentioned that the Klein IJsselmeer, the Markermeer and the IJmeer are important for other natural areas on the bordering 'old land' (including the already existing polders), e.g. the Naardermeer, Waterland and the Oostvaardersplassen. On the one hand the water is an important feeding ground for birds breeding on the old land (e.g. the cormorant) and resting and sleeping place for other birds (e.g. smew, tufted duck and many other species). On the other hand the Markermeer is an important resting area for species that feed on the old land.

2 International Commitments

The presence of natural areas of such great international importance within our country's borders, such as the Wadden Sea, Eastern Scheldt and the IJsselmeer (as a whole), brings with it of course international obligations. The moral obligation to handle carefully this 'common heritage of mankind' is laid down in international conventions. In this respect, especially the Convention on Wetlands of International Importance especially as Waterfowl Habitat - also ratified by the Dutch government - is of interest.
This so called Ramsar convention (1972) aims at the conservation, the careful management and wise use of wetlands (areas of marsh, fen, peatland or water - fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres).
The convention obligates the member states to:

- designate suitable wetlands within its territory for inclusion in a List of Wetlands that is registered with the convention's secretariat;
- announce to the secretariat intended changes of enlisted areas;
- compensate such changes elsewhere;
- establish reserve areas in wetlands, whether they are enlisted or not.

The Netherlands have designated six areas for the Wetlands List so far, unfortunately not including the IJsselmeer area. In a recent draft-policy scheme on nature conservation and landscape protection the government announced that it will consider designating the Klein IJsselmeer for the List of Wetlands, but it has excluded the Markermeer. On the contrary, there is the reclamation scheme for this lake.
In my opinion this is a clear violation of the Wetlands Convention, according to which the conservation and careful management of this wetland of international importance should prevail. It is amazing that so little attention is paid by other countries to the way in which the Dutch government fails to keep its international obligations.

3 Markerwaard polder: a serious threat to a fresh water natural area

Reclamation of the Markerwaard polder - the last part of the Zuiderzee project - will gravely affect this valuable natural area. The damage will be far more than the loss of 400 km^2 of feeding, moulting and resting grounds for waterfowl. Owing to the ecological relationship with other parts of the IJsselmeer and with other natural areas on the land, reclamation will also affect these areas. Very important is the fact that many species there have no refuge areas elsewhere.
This being so, it is not surprising that heavy protests arose when, in the early seventies, the Markerwaard reclamation scheme was put together in more detail. For the environmental organisations and action groups reclamation means unacceptable damage to this important natural area (Stichting Natuur en Milieu 1981; Vereniging tot behoud van het IJsselmeer, 1981).
There was also another reason for protest against the Markerwaard: the

serious doubts of the need for this polder in view of the developments in town and country planning during the past decades.

4 Changes in physical planning

During the implementation of the Zuiderzee project criticism of the spatial developments in Holland and its socio-economic and socio-cultural impacts became stronger and stronger.
Holland is a country with a high population density (1981: 419 inh./km^2). Between 1951 and 1976 the population increased by 37%. It is significant that in the same period total urban land use (in the broad sense) increased by 90%. Thus the urban area per inhabitant is strongly increasing (1951: 205 m^2/inh., 1976: 286 m^2/inh.). These figures indicate a process of urban sprawl with heavy negative impacts such as longer travelling distances, more car-use and deterioration of the quality of urban centres.
Due to increasing claims for space and the type of land use, this development has a most negative impact on natural and landscape values: deterioration and splitting up of the nature areas and precious scenery. Moreover, there are all kinds of environmental impacts (water, air, soil pollution, noise and waste of energy). In addition to these negative results, the expansion of urban areas tends to increase the competition for the scarce space between the other types of land use, for example agriculture, recreation and nature. In comparison, economically weak phenomena such as nature conservation are usually at a disadvantage. Continuing on this line leads to far greater quality problems for urban environment and for nature environment and landscape.
As a reaction to this development, therefore, a counter-movement arose. In short, this movement advocates a much stronger concentration of urban development, less growth of mobility (especially by car), and in general more linking up with existing urban centres.
Gradually this opinion was incorporated into the government policy on physical planning. At the moment major policy goals are to stop urban sprawl and to encourage a concentrated urban development.
In view of this development one can understand that serious doubts arise about the necessity and the impact of the Markerwaard polder. As

a result of increasing urban land use there are bottlenecks of all kinds on the 'old land'. The pursuit of solutions through the creation of new land according to the opponents of the Markerwaard only moves the problems. To build the new polder would be to fight the symptoms instead of the true reasons. It will also mean a free hand to the space-wasting process which increases the problems.
There is an urgent need to fight the sprawling urban development. Adding new land will frustrate the above-mentioned governmental goals and actions on physical planning and will therefore unbalance the overall policy. With respect to the very complicated and almost unmanageable features such as suburbanisation, an integral policy is of utmost importance. Reclamation of the Markermeer is therefore contrary to the government policy on physical planning.

5 Political developments

The decision of the government in 1976 to let the question 'Markerwaard yes or no' follow the procedure of national physical planning key-decisions can be seen as political recognition of the above-mentioned opinions on physical planning. This was decided although there was already available an extensive recommendation pro reclamation made by the Council of 'Waterstaat' (Public Works) - the main advisory board of the Minister for Traffic and Waterstaat (Raad van de Waterstaat 1976). After a long period of preparation due to diverging opinions, the cabinet produced in 1980 a draft decision: a proposal to reclaim the Markerwaard. The procedure of participation and advice on this draft decision is now nearly completed. At the moment of writing this paper only the consultation of provincial and local authorities has to be carried out.
The participation procedure shows an overwhelming amount of comments speaking out against the Markerwaard polder.
The Advisory Council for physical planning - the main advisory board in this procedure - delivered on April 28th. 1982 a profoundly divided advice. The smallest majority possible voted in favour of the governmental proposal, the other members present not approving the proposal for various reasons. Some are in favour of the Markermeer as an open water area, others want more information and are not (yet) convinced of the

necessity of the Markerwaard polder.
The Council for the Protection of Nature criticizes the draft decision because of the lack of alternatives. According to this advisory board the arguments of the government for reclamation show serious short-comings.
The Council of Waterstaat repeats its advice of 1976.
The design of the governmental draft decision has met serious criticism during the participation procedure and also from the several advisory boards. A major point of criticism is the lack of an elaborated alternative for the development of the IJsselmeer area without the Markerwaard polder. In the decision-making process the point now is: what is the most desirable development of the Markermeer in relation to the bordering 'old land'. Especially since the government itself states in its draft decision that an acceptable future development is possible with and without reclamation, the absence of this alternative is marked as a grave short-coming.
During the participation and advice-procedure an important political development took place. During the 1981 parliamentary elections, several political parties expressed themselves against the Markerwaard. An important political party of the centre took a neutral stand and wanted to await the results of the procedure of participation and advice. The coalition cabinet also wrote in the coalition-agreement (its political basis) a special statement on the Markerwaard issue. Summarized, it says that the present government is not convinced of the desirability of reclamation, that it will await the results of the procedure of participation and advice before a definite decision is made, and moreover that in the meantime, it will make a proposal for management as an open-water area.
The central political question is whether the results of participation and advice will be able to convince any government. I doubt it very much; I think the political fight will be on again. In that debate the missing alternative could play an important role. In the governmental agreement a proposal is mentioned for development of the Markermeer as an open water area. What should be the headlines of this proposal?

6 Conservation and development of the IJsselmeer as a fresh water natural area

The IJsselmeer (Klein IJsselmeer, Markermeer and IJmeer) is at the moment of significant value and performs a number of important functions. In view of the discussion on the Markerwaard, I should like to define the values of ecology, landscape and cultural history of this area as the basic values. Apart from these, this area has many other functions such as: water-management and supply, professional and recreational fishing, recreation (on water and on the banks), shipping as a mode of transportation, dredging and cooling-water supply for (conventional) electrical power plants. Some of these functions are very compatible with the basic values; others are in conflict with them. A short sketch shows the following.

6.1 Water-quality

A main problem in the IJsselmeer area is the water-quality, especially the level of eutrophication. The IJsselmeer, as a downstream basin in the delta of the River Rhine, receives highly nutritious water. Since the completion of the watershed-dike between Enkhuizen and Lelystad the eutrophication is especially a problem in the Klein IJsselmeer. Incidental algae bloom occurs, with possible negative impact on the ecosystem and on other functions such as swimming water and drinking-water-supply. When permanent algae bloom is established, these negative impacts will surely occur. Furthermore, the River IJssel carries a certain amount of pollutants to the IJsselmeer, among others heavy metals. The salt-percentage of the Markermeer and especially of the IJmeer may deteriorate in very dry years the quality as supply water, as a result of the discharge of the Flevopolders.

6.2 Water-supply

It was initially proposed for purposes of water-supply to construct a storage basin in the Markermeer/Klein IJsselmeer. Inquiries by a special committee proved that storage management can be also assured by regular alteration of the waterlevel of the lake itself. The decision to drop the storage basin-scheme is surely to the advantage of nature and landscape. Changes to the waterlevel of the lake itself - more than according to the present level-management - can, however, also damage the marshes and shallow waters outside the dikes around the 'old land'. These wetlands are important as breeding grounds and resource areas for birds. Further research is needed to find out if level-changes are needed and how the negative impacts can be mitigated.

6.3 Fishing and recreation

Of all functions, fishing and recreation are to some extent compatible with the functions as a natural area. However, a recreational boom, with new yachting harbours and other landing and overnight facilities, could affect the waterfront of the scenic, small towns along the former Zuiderzee, while it also means a heavy pressure on the natural functions as resting and moulting grounds for waterfowl and to the local waterquality. Windsurfing especially can be a source of disturbance because it penetrates up into the smallest corners of an area. In this field also lies a potential conflict between recreation and (professional) fishing.

Carefully guided development and zoning on the basis of the bearing capacity of the ecosystem - once further research has been done to establish this - are the key words.

6.4 Shipping

With regard to shipping, the problem lies with the environmental impact of possible accidents. On the main shipping route, Amsterdam-Lelystad-Friesland, there is much transport of dangerous substances such as liquid fuels and chemicals. Waterpollution as the result of a severe accident would be of severe damage to the other functions of this area.

6.5 Dredging

The dredging activities in the Markermeer, IJmeer and Klein IJsselmeer for sand for the building industry, have serious impacts on nature and fishing. The deep pits (up to 30 metres) that are left after dredging,

mean the loss of bottom-fauna. This decreases food-supply for fish and birds (diving ducks and perhaps also fish-eating birds). Moreover. the deep pits have a negative impact on water-quality.
Organized recreation, fishery and nature conservation strongly oppose these dredging activities. Although the government policy on dredging is said to be prudent, the organizations criticize the number of dredging permits as being far too many.

6.6 Energy

Energy production causes local problems because of the discharge of cooling-water from electricity powerplants. Transportation of electricity causes in the surroundings of the IJsselmeer bird casualties as a result of collisions with high tension wires.
Far worse is the threat of a proposed energy-storage-system, the so-called Plan-Lievense. This includes a water-storage-basin in the Markermeer with dikes of about 30 metres high. This basin is meant for storage and peak-shaving of electricity, especially from wind-turbines. Although wind energy is generally considered to be friendly to the environment this storage-basin means more serious damage to the nature values of the Markermeer. The basin, covering at the maximum stage 165 km^2, will also cause the loss of fertile bottom with negative impacts on fish and birdlife. It will form with the high dikes and high tension lines a barrier in the waterarea. This will lead to bird casualties and will affect the scenery. There are also serious doubts about the impact on water-quality; the inevitable changes in the waterlevel outside the basin will affect the nature areas on the banks of the lake, and the dredging of enormous amounts of sand for the construction of the dikes increases the existing problems that dredging for other purposes already presents.
Environmental organizations have serious objections against this proposal. They dispute the necessity and the rentability of this project. For the time being increasing amounts of electricity from wind energy can be delivered to the electricity network without the use of storage capacity. Should energy storage be needed in the long term there are alternatives to be considered such as quickstarting gas powerplants or other storage systems below surface level. This criticism is being made, by the way, by other people as well as environmentalists. At the moment,

it is very doubtful if this option in the Markermeer will be realised.

7 A policy scheme for the IJsselmeer area, an alternative for reclamation

These are, in a bird's eye view, the main possible choices in the IJsselmeer area, but are also the present problems. They need a coordinated and a comprehensive approach. Based on the qualities as an internationally accepted natural area, the main goal should be the conservation and development of the basic values (nature, landscape, cultural history).

Apart from this, some other functions can be developed within the limitations set by this main goal. I am especially thinking of water-management (improvement of the water-quality), fishing and recreation. With regard to shipping, some measures are to be taken to safen or to diminish the transport of dangerous substances, and to reduce the impact of calamities. Dredging is in conflict with most of the other functions and should be stopped, especially since dredging sand in the North Sea is - on a small scale - a useful alternative. An energy-storage-basin is incompatible with the above-mentioned main goal.

This combination of functions of nature, landscape, water-management, fishing and recreation will give this area - without reclamation - a great importance for society. A comprehensive government policy scheme is needed together with ways in which to prevent a creeping loss of quality as time goes by. Doing nothing means the continuation of a process of partial decisions and deterioration, with an inevitable worsening of this natural area in the long run. Careful management is needed for the conservation of this area and for the realization of its potentials.

Such a policy scheme is also needed if one wants to seriously consider the question 'reclamation, yes or no'. In my opinion, it is necessary together with every proposal for reclamation - wherever it may be in the world - to also seriously consider the alternative: development without reclamation. It may turn out that conservation of nature and the local and national community are far better served with careful management than with reclamation.

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DECISION CRITERIA: DIFFERENCES AND SHIFTS BETWEEN INSIDERS AND OUTSIDERS IN DUTCH POLDER-DECISIONMAKING

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Abstract

In our pluralistic society the insiders and outsiders, who are involved in Dutch polder-decisionmaking want power-resources in order to get access to the decision-takers and to affect the final decision.
Because these power-resources are directly related to the nature of and the possibilities for changing decision-criteria, there is a strong relation between the competition of individuals,groups and institutions for better power-positions and the decision-criteria which will be used in the final decision-taking.
This paper will give an illustration of this theoretical proposition. The history of the decision-making process concerning the Markerwaard-polder contains the information for such an illustration.

Preface

If we consider decision-making and decision-taking to be rational processes then we can use the concept of "decision criteria". Then the decision can be based upon clear and preferably quantitative criteria in such a way that the decision-takers are legitimated to implement the decision.
Preparing and taking decisions about large public works of dredging, draining and reclamation are long drawnout processes in the fields of politics and planning. Long-term processes can never be characterized as purely rational. In such processes key-decisions are only taken if the

power-balance-sheet between the individuals, groups and institutions involved has reached a relatively clear and stable position. Everyone, whether an individual or a member of a group or institution,uses decision criteria which reflect his interests, as closely as possible. Therefore decision criteria, concerning for instance the issue whether or not the contemplated final polder of the Zuyder Zee Project (ZZP) -the Markerwaard- is to be constructed can be considered as the verbal expression of the condition of the power-balance-sheet on that particular issue.
So long as the power-balance-sheet between individuals,groups and institutions involved is in an unstable condition, the decision criteria which will be used when taking the final decision are not known for certain and in fact are continually changing during the process of decision-making.
In the following sections in this paper we now try to justify those statements:

1) decision-criteria and the power-balance-sheet:some theoretical remarks;
2) insiders and outsiders in processes of decision-making;
3) decision-making about the Markerwaard;
4) decision-criteria: some illustrations of differences and shifts between insiders and outsiders in decision-making about the Markerwaard.

1 Decision criteria and the power-balance-sheet: some theoretical remarks

In the Netherlands the execution of certain large public works of dredging, draining and reclamation takes several decades. During these projects several key-decisions have to be made. This applies to the case of the Delta-Works (in execution since 1955) and to the separate decisions about enclosing the different estuaries in the south-west part of the country. This definitely applies to the Zuyder Zee Project (ZZP) too. This project concerns the closing off from the North Sea of an inner sea and the reclamation of parts of the newly created lake. The Dutch Parliament decided upon the execution of this project in 1918. However in the 1970's some outsiders (NB: for this concept see section 2) started a public debate about the desirability of making the contemplated final polder, the Markerwaard. In this paper the policy-making process around the Markerwaard will be used as a case-study for illustrating the aforementioned propositions.

It is the view of this author that the choice of decision-criteria is essentially a political one. Therefore it can be imagined that when considering decisions about large public works which are characterized by the involvement of many individuals, groups and institutions, very many relevant decision-criteria can be detected by the trained observer. In the Markerwaard case for example the following decision criteria, among others,have been used; the decision is good if it :

- follows the general policy which has been chosen;
- helps to achieve a financial return of investments;
- creates new employment in the area;
- safeguards the ornithological and ecological values of the area;
- supports economising on the use of scarce land in a densely populated country;
- supports fresh water fishing;
- furthers public decision-making based on the availability of all the relevant information, a consideration of alternatives reflecting real possibilities and after a serious participation procedure of the public and the relevant advisory boards;
- if it doesn't constrain or limit the choice open to future generations.

In the Markerwaard case it is impossible to take a decision which favours all these criteria. Therefore we would expect to be able to connect certain decision-criteria with certain interests. For the present we define decision-criteria as standards which can be used (objectively and subjectively) to further special interests during the process of decision-making and to evaluate specific public proposals and their expected effects both during decision-making and after decision-taking.

The individuals, groups and institutions involved interact with each other in such a way that they obtain easy access (formally or informally; directly or indirectly by successfully propagandising some of their ideas) to the decision-takers. Obtaining such access means that one has a good power-position. The ideal power-position is the one in which a non-decision-taker has such a relationship of mutual interdependence with the decision-taker that the formal position of the latter can only be maintained by taking that decision which has the highest priority of the non-decision-taker. Power-positions are the outcome of the permanent competition between individuals, groups and institutions for available power resources. As a result of

constant competition power-positions are continually shifting. These ever-changing power-positions form, with respect to each other, a power-balance-sheet which is always in an unstable state.
Power resources are the basis of power. It is possible to distinguish four categories of power resources. These are : control of the

1) means of production (for example: land, capital, labour force, machinery, distribution and rationing systems, public finance);
2) means of force (physical violence, weapons, police, army, prisons);
3) means of orientation (ideology, religion, science and scientific research, education, values, standards, symbols);
4) means of organization (control of organised loyalties in interestgroups, employer organizations and trade unions, groups and associations in society; ability to reorganize, (planning-)procedures, control of communication-networks).

It has to be recognised that the struggle for power resources is not a zero-sum-game: long-term policy-making processes in particular are characterized by new and constantly changing power resources. The aforementioned concepts are the basis of our definition of power. In our view power is a capacity which only has real importance when it is used in a relationship of mutual interdependence of individuals, groups and institutions.
Power resources, the basis of power, are used between mutually interdependent individuals, groups and institutions in a way that manipulates others into doing or not doing something which is either against their first preferences or against their direct interests. Such mutual interdependence exemplifies the fact that the execution of power always has its price. Therefore, studying the changing power-balance-sheet in long-term-policy-making requires that attention be paid to the ever-changing power-positions of insiders and outsiders with regard to each other and based on their continually changing control of different power-resources.
Having come to the end of this section we can now complete our conceptual scheme by relating what has been stated about decision-criteria to the power-balance-sheet. If an individual, group or institution or a coalition between them draws near to the ideal power-position, that is to say, the power-balance-sheet favours their interests, it is likely that the decision-takers will decide in accordance with the decision-criteria preferred by this individual, group or institution.

2 Insiders and outsiders in processes of decision-making

So far people involved in the process of decision-making about the Markerwaard have been called "individuals, groups and institutions".Although they control very divergent power resources and they therefore occupy different power-positions, in our view these people are (as far as they are concerned with the Markerwaard-issue) still mutually interdependent. However, for analytical reasons it would be useful to make a further distinction between these people, namely between insiders and outsiders. In accordance with an earlier paper (Goverde,1982) we use the nouns insiders, established and participants as synonyms, as we do with outsiders and marginals.

In this paper someone is an insider when he participates formally as the representative of a group or an institution in a particular public process of decision-making and decision-taking. If he is involved in the process of decision-making around that issue, but without a representative function as outlined above he is an outsider, a marginal.

Insiders in infrastructural policy-making are for example: the Cabinet,the Ministers concerned, top civil servants, the leaders of employers' organizations and Trade Unions, leaders of political parties, members of parliament (M.P.'s) with particular specialisations, administrators of regional and local government. All the participants together create a so-called "iron circle of decision-makers" in a particular policy-field (in this case urban and regional planning, planning of infrastructure).

Outsiders are for instance: members of and voters for political parties, members of social organizations, newspapers, radio and television, action groups, churches, public opinion research.

The insiders can be subdivided into people who participate in taking the final decision and people who only participate in the formal procedure of preparing this final decision. We see members of the Cabinet and particularly the Minister of Traffic and 'Waterstaat' [1] and the Minister of Housing and Physical Planning as the "decision-takers".

Insiders and outsiders interact in such a way that they obtain the best possible access to the decision-takers. In that case they hope to get a decision which favours their interests or which statisfies the decision-criteria they have chosen. Seen from this viewpoint insiders and outsiders are not separate groups.On the contrary. Just as the landowner and his peasants, two football-teams playing a match, two or more warring armies, insiders and outsiders form a so-called "figuration", i.e. a closely interconnected network of communications and social relations. Without outsiders insiders cannot exist and vice versa. Therefore the study of the power-balance-sheet and the relevant decision-criteria has to be directed to studying the structure of the communications and social relationships in such figurations (N.Elias,1969 en 1971). In such research some relevant questions are for instance:

- what is the formal procedure in the decision-making process studied ?
- who are the decision-takers ?
- which are the individuals,groups and institutions who control so many power resources that they can repeatedly operate in the formal procedure?
- who are the insiders and outsiders who are able to get access to the decision-takers and which power resources are used by them most ?
- what do in- and outsiders call each other ? what are the labelling words frequently used during the decision-making process ?
- is there a rapid changeover of individuals playing participatory roles during the process ?
- do some marginals become participants ? and vice versa ?

Answering these questions can give information about shifts in the power-balance-sheet. It is impossible to answer these questions within the scope of this paper. In the following sections only a few illustrations will be given in order to show that answers to these questions could be found in extended decision-making processes, especially in the decision-making process of the last part of the ZZP, the possible reclamation of the Markerwaard in the Netherlands.

At this juncture our theoretical point of view can be summarised in the following proposition. The greater the modifications in the use of power resources and labelling words, the mobility among insiders and between insiders and outsiders, the accessibility of the decision-takers to participants and marginals, then the more intensely power relationships change and the greater the chance that different decision-criteria will become important so that decisions will be taken other than would have been expected from an earlier stage.

3 Decision-making about the Markerwaard

In order to prepare ourselves for the Markerwaard-case some remarks ought to be made about the formal aspects of policy-making in the fields of physical (urban and regional) planning and the planning of infrastructure. Further some important historical data about the Markerwaard decision-making process will be given. For more detailed information, however,please see for instance van Grondelle'paper (1982) prepared for this symposium.

The contemplated reclamation of the Markerwaard is an infrastructural project. Infrastructure can be defined as technical works (mostly civil engineering and water management) which are necessary to make possible many different social activities. An infrastructural project is characterized by its need for a relatively large area of land, its long duration, its great influence upon the physical development of the country, its high capital costs and its need for public decision-making.
For some projects (for example land reclamation, airports, highways)special governmental sector-planning systems exist. By a"sector" we mean a branch of government usually coinciding with a ministry such as housing, agriculture, nature and landscape conservation, traffic and transport etc. Sector policy aims to ensure the smoothest possible course for that activity (Min.HPhP,1979) Characteristic of these sector-planning administrations is their involvement with both the preparation and the execution of the projects.
The main task of the national physical planning authorities (the Minister of Housing and Physical Planning and the National Planning Service) is to coordinate the physical effects of the different infrastructural projects. Because each planning system (the sector and the physical planning) has its own institutional and organisational framework, its own areas of competence and its own procedures for policy-making, the decision-making on infrastructure is basically twin track. Each track is followed to its conclusion but of course there are attempts at co-ordination.

The national government has created two new instruments to promote this co-ordination in policy-making for infrastructure. The first instrument is the Structural Outline Plan (SOP). The second is the procedure for key decisions in national physical planning (PKD-procedure).
A SOP (report with maps) relates to the main outlines and principles of

the long-term policy to be conducted (from 25 to 30 years) in a given sector of government policy which has important physical consequences.

(e.g. electricity supply,traffic and transport,...). SOP's go through the PKD-procedure. This procedure has been applied to decision-making about the Markerwaard as well. The PKD-procedure has the following main steps. The Council of Ministers decides whether the procedure will be instituted. After (inter-)departmental deliberations (among and between the sector- and the physical planning track) and negotiations in the Council of Ministers a policy resolution is published. As part of this procedure facilities are provided for democratic participation in this policy resolution. In practice these facilities are generally used to full effect. At the same time the government conducts consultations with lower authorities, generally the Provincial Councils and,if possible, also the Municipal Councils concerned. The government also invites recommendations from the Advisory Physical Planning Council (APPC) and, if necessary from other advisory boards as well. On the strength of the views expressed and the recommendations made in the course of the democratic participation and consultations with the administrators, the government reviews its policy resolution a second time and then publishes its decision. This government decision is presented to the Second Chamber, which has, for a period of six months, the opportunity of further discussion with the government on the decision. In the case of the PKD's presented so far, the Chamber has endeavoured, by inviting to the government to make certain changes, to influence the contents of the government decision. The use of SOP and PKD-procedure does not mean that all problems of coordination on the national level in this twin track decision-making about infrastructure have been solved. But these problems are not the main subject of this article and have been dealt with elsewhere (Goverde,1982,2). For the purposes of this paper, the procedures as related to the decision-making about the Markerwaard can be chronicled as follows:

1972 : The Minister of Traffic and 'Waterstaat'(sector-planning track) decides to publish a discussion-note concerning the Markerwaard.Six reclamation-options (including the non-reclaiming one) are presented. However all options demand big water management infrastructure. The Zuyder Zee Committee(ZZC), a sub-committee of the 'Waterstaat' Council (=the advisory body of experts serving the Minister of Traffic and 'Waterstaat') organizes a public participation procedure.

1974 : The Cabinet decides that the Markerwaard issue will go through the PKD-procedure(physical planning track).

1976 : The majority of the ZZC advises the reclamation of the Markerwaard. The 'Waterstaat' Council accepts this advice of the majority of its sub-committee. The minority of the ZZC (representatives of three ministries and one organization for nature and landscape protection) is not convinced of the desirability of the new polder and asks for the decision to be postponed for at least ten years.

1979 : On the physical planning track the National Physical Planning Committee (official interdepartmental advisory board of top-civil-servants preparing PKD's) advocates the Cabinet in an unpublished advice to construct the Markerwaard.

1980 : In January, the Cabinet asks for a more precise cost-benefit-analysis concerning the Markerwaard. June 20th, the Cabinet decides to publish a policy intention to reclaim the polder. That is the beginning of the public part of the PKD-procedure.

1981 : June 15th is the last date to submit recommendations to the APPC. Never before have so many people (17,500,most of them outsiders) used the facilities for public participation. These 17,500 people gave about 660 different responses to the government policy resolution People and organisations who asked for the polder (220) wished to see the new land used in the main for agriculture. About 335 organisations were against the new reclamation. About 100 respondents had no clear preference.

1982 : April 28th, the smallest ever majority of the APPC advices the reclamation of the last ZZP-polder in the Markerlake. The largest ever minority cannot accept the Cabinet's proposed policy.

It has to be recognised that all these steps in the formal procedure since 1972 have been accompanied, sometimes even influenced by the countless activities of the marginals. Discussions on the issue were organized and promoted in pubs, libraries, schools, neighbourhood centres,in the streets, in the newspapers, in radio- and TV-programmes. During its construction the dyke between Enkhuizen and Lelystad was occupied by some marginals for several days in 1973. Several books, pamphlets and research-papers were published.

The results of public opinion research were that in 1978 2/3 of the Dutch population had some opinion about the Markerwaard issue: 57% of these were

against the reclamation. This is a completely different result from the findings of a similar research project in 1972. At that time 23% of the Dutch people thought that the Markerwaard had been reclaimed already and the others did not realise that further reclamation could ever become an political issue.
Nowadays there is no longer general acclamation for the ZZP. At the Barrier Dam there is a monument on which is sculptured a famous slogan: "a nation that is alive, builds for its future". An ever-increasing number of people in the Netherlands now believe that more land-reclamation is not the only possible way to show their nations' vitality.

4 Decision criteria: some illustrations of differences and shifts between insiders and outsiders in decision-making about the Markerwaard

The theoretical focus of this paper was summarized at the end of section 2. A systematic research to verify or falsify the stated proposition concerning the Markerwaard-case has not yet been undertaken.
An earlier paper(Goverde,1982) tried to illustrate that in the decision-making about the Markerwaard, the insiders and outsiders, as mutual interdependent individuals, groups and institutions, were really competeting for the best power positions by trying to get and maintain control over the means of orientation and organization. The illustrations concerned access to and the use of scientific research, ideology, symbols, (planning-)procedures and communication-networks. The results can be summarized as follows. Insiders and outsiders who support the reclamation have the advantage in the control of

- scientific research (they can decide when and what research will be done and if the results will be published; they can systematically prevent having to make a master plan for the use of the fresh water area),
- symbols (sculptures of the founding fathers of the ZZP,buildings in modern architectural style for the offices of the polder project in the centre of the project, information centre,jubilees, scientific meetings) and
- (planning-)procedures (the civil servants most involved participate in

the whole decision-making process both on the sector-track and on the physical planning track).

On the other side in- and outsiders who are opponents of the new polder have made progress, especially in the last decade, in getting control over

- ideological aspects (new values such as for instance "don't spoil the physical environment", "don't pollute the last fresh water areas", "urban renewal gives more employment than reclamation" can compete politically with the "Dutch national tradition of the nation's struggle against the water"),
- some parts of the (planning-)procedures (in the public part of the PKD-procedure most outsiders appeared to be opponents of further reclamation; the present Minister of Traffic and 'Waterstaat' -one of the main decision-takers- cannot decide in favour of the Markerwaard without creating political difficulties for himself) and
- communication-networks (four of the seven national newspapers have chosen for the anti-reclamation side; some radio and TV-networks have an anti-Markerwaard point of view, others express doubts about going on with the project).

In general, the polder-promoting insiders'control over power resources is still strong but is diminishing. The developments in the last decade have forced both in- and outsiders to opt for other power resources. The outsiders first tried to get control over the means of communication in order to influence public opinion. Now they use research resources in order to give a better basis to their propositions and their decision-criteria.
Some pro-Markerwaard participants do not want to use more research resources. They would like to get a decision as soon as possible and therefore they use the introduction of new symbols in order to influence public opinion and the decision-takers. In summary, in the seventies the power-balance-sheet was slightly shifted towards the anti-Markerwaard position.

Looking at the developments of the control over power resources in the last decade it is not surprising that there are big differences in the decision-criteria used between polder-promoting and anti-reclamation in- and outsiders. For instance, the participants who want the Markerwaard emphasize "the continuity in the general policy already chosen" and "the creation of new employment in the area". The polder-promoting outsiders use "the creatior of new land for agriculture" as their main decision-criterion.

Insiders of anti-reclamation groups and organizations stress that a legiti mated decision is impossible if further research is not completed (master plan of the use of the fresh water area; employment-scenario's with or without reclamation). They use decision-criteria as "economising on the use of scarce land in a densely populated country", "safeguarding the ornithological and ecological values of the area", etc.
Anti-reclamation outsiders mostly use decision-criteria based on concrete interests of specific users: "the conservation of the landscape", "fresh water fishing", "the possibility of large scale water recreation in the area",etc.

As was pointed out earlier, systematic research into the basis of our whole theoretical framework has not yet been undertaken. However, some indications have been given above that there have been many changes in the use of power-resources.
Furthermore, to our knowledge, information is available about the development of labelling words ("do-people" versus "talking-people"), the mobility among insiders (some authorities from Amsterdam who promoted the Markerwaard in the beginning of the seventies still play an important role as advocates of the polder at different levels in the administration),the mobility between insiders and outsiders (some outsiders accepted positions in the main advisory board), the accessibility of the decision-takers to participants and marginals (of course insiders, especially civil servants, still have their formal access to the ministers involved, but the insiders of the anti-Markerwaard position have a fairly frequent access to them too).
So, after more systematic research, it is possible to make a case that power relationships in the Markerwaard issue are shifting fundamentally.
In this particular case, power relationships are changing in the direction of an anti-Markerwaard position. Therefore decision criteria used by the individuals, groups and institutions who favour this option will become more important. At the moment however the power-balance-sheet has not reached a stable anti-Markerwaard position.
In the formal procedure, after the APPC has published its advice, it is the turn of the Cabinet now. For the decision-takers, however, the present-day condition of the power-balance-sheet is an uncomfortable one. Therefore the most likely prospect for the near future will be a deliberate policy of non-decision-making.

Note

1 'Waterstaat': originally water management and protection of the land from the water. By extension it is also responsible for the construction and administration of roads and waterways.

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URBANIZATION IN DUTCH POLDERS; THE EVOLUTION OF THE RANDSTAD CONCEPTION

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Abstract

Since many centuries villages and towns have been built and expanded in the "Low Lands" on reclaimed land. In most cases valuable agricultural land had to be conversed into new residential area.
In the twentieth century, especially after World War II the urban expansion on surrounding area is quantitatively of considerable size. Because of economic and demographic reasons this development was most important in the western provinces. Within this part of the Netherlands the "Randstad Holland" is internationally known.
In the period 1960 - 1980 three subsequent reports on national physical planning have been published by the government, containing headlines and structureschemes of the wanted future development.
Since the end of the Fifties' the Southern-IJssellake region plays a crucial act in the Randstad conception. Two new towns with high targets, assessed by commitments between the state, the province and local authorities, are related to housing problems in the northern Randstad.
Between the Fifties' and the Eighties' spatial policy on urbanization is moving from emphasis on spreading and radiation to an increasing accent on contraction and concentration of urban functions within

restricted agglomeration areas. The paper stresses that hitherto Flevoland has been maintained as radiation zone of the northern Randstad. Elements within the contracting forces however may in future influence the functions of the Southern IJssellake polders (Flevoland and Markerwaard).

Introduction

Since it has been made clear elsewhere that the western provinces of the Netherlands are fot the greater part lying below sealevel, have to be drained artificially, we don't have a polder definitionproblem for this paper, dealing with urbanization structure and urbanization policy in the northwestern part of our country. So, except minor parts, the provinces of North-Holland and Utrecht, as well as the IJssellake polders are relevant as a subject for this congress.
Secondly, because of the role of the IJssellakepolders in the urbanization structure in the Netherlands, today and in future, we only describe this "new land" in the context of the already mentioned regions of North-Holland and Utrecht ("the old land"); so we have to neglect the importance of a wider geographical framework for urbanization processes in the densily populated western part of the Netherlands, as well as we cannot mention other functions of the IJssellakepolders.
A third general remark refers to a restriction within the IJssellakepolders: the older polders in the IJssellakeregion, the Wieringermeer and the Noordoostpolder (Northeastpolder) are not involved and probably will not be involved in urbanization processes (as far as we can foresee today). The settlements in these older polders can be defined as villages and, in the case of Emmeloord, as a little town with certain regional functions, providing a mainly agricultural surrounding area. Only Flevoland is since the (first) "Report on physical planning" (1960) earmarked as a region which will catch a considerable part of the population overspill from the conurbation of Amsterdam-Gooi.
To be concrete we mean the fastly growing new towns Lelystad and Almere, where housing production figures are related and will for a long time be related on housingproblems of especially Amsterdam, as long

as there are commitments between the State, the Province and the local authorities.

Randstad - Holland

Generally speaking the population growth in the first half of this century took place and had largely consequences in towns of middle and big size, which showed a high increase of the number of inhabitants.
In 1900 34% of the total Dutch population (=5,1 mln) lived in municipalities with less than 5.000 inh. and 22% in municipalities with 100.000 inh. or more. Fifty years later these figures were 15% and 31% of a total population of 10 mln. When we focus on the most urbanized western part of our country we must ascertain that just after World War II the provinces of North-Holland, Utrecht and South-Holland consisted of a mainly agricultural region with a number of widely dispersed towns of fairly limited size, except for the most important towns Amsterdam, Rotterdam, The Hague, Utrecht and Haarlem.
Within this part of the Netherlands the most urbanized area is internationally known as the "Randstad-Holland" (fig. 1).
To indicate shortly the urban character we compare the total average density in the three above mentioned provinces (900 inh./sq. km or 2.250 inh/sq. mile) with the average density within the urban "horse shoe" on fig. 1 (2.400 inh./sq. km or 6.000 inh./sq. mile).
The number of inhabitants within this "horse shoe" was about 4.200.000 in 1960.
Economic and societal developments after World War II, especially since the Fifties', caused fundamental changes in the growth rates of towns and villages, changes leading to a new urbanization pattern and a new spatial structure. Most relevant for urbanization processes were the decrease in capacity of urban regions and in relation to this development the suburbanization.
In a report of the National Physical Planning Agency, "The development of the West of the Country" (1958), the "Randstad" was indicated as an area, turning into as was called "a problem area" from the point of view of physical planning, caused by a continuation of the above mentioned

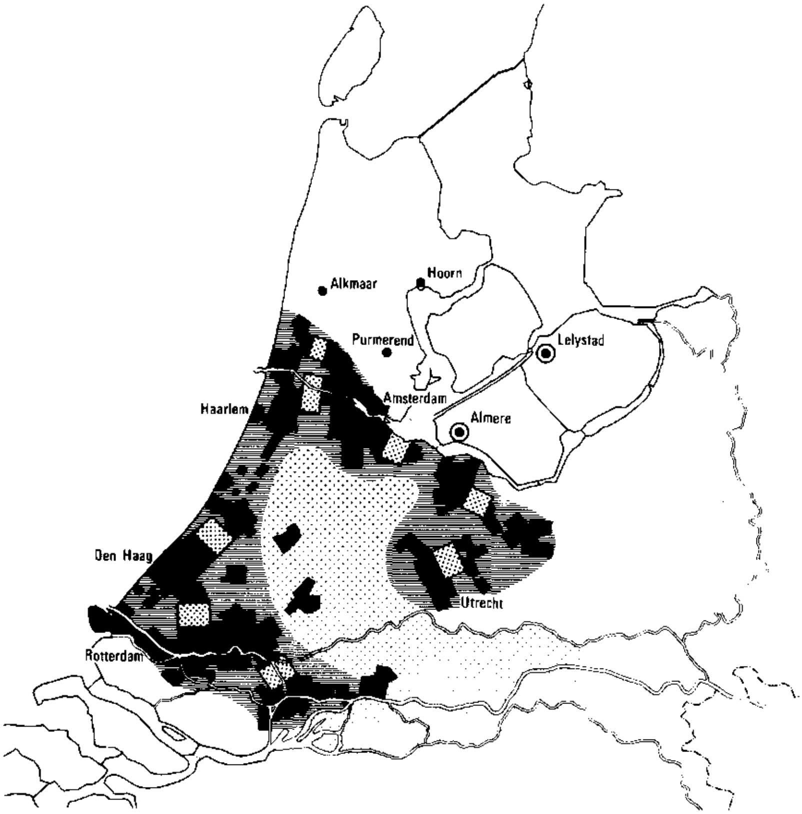

Figure 1. The "Randstad-Holland" and the IJssellake Region

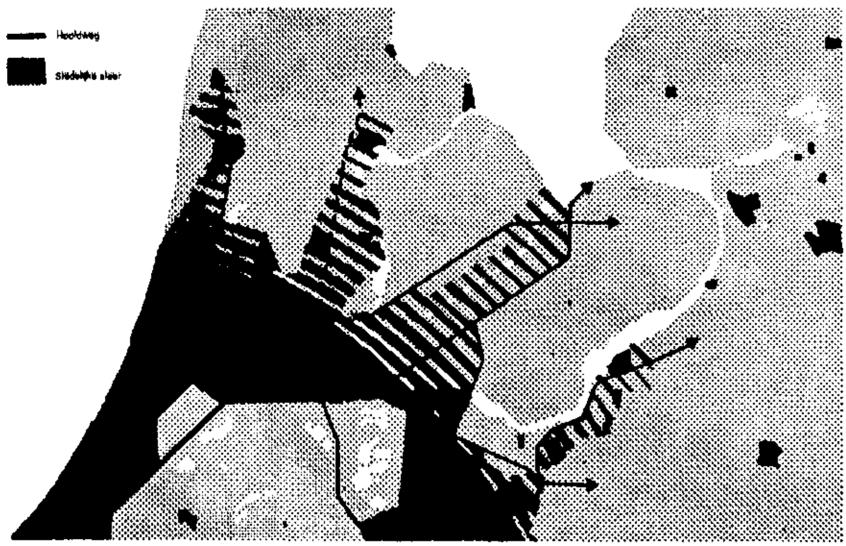

Figure 2. Expansion and radiation (A Structure Plan for the Southern IJssellake Polders 1961)

new developments. The significance of the problem analysis and the presented suggestions for a solution in this report and the (first) "Report on physical planning in the Netherlands" (1960) for the Dutch policy on physical planning and the vision on the urbanization structure in the next decades, can hardly be underestimated.
In the context of this paper we can describe briefly these visions as a warning against urban and spatial developments in the urban regions of London, Paris, some urbanized areas in the United States etc., taking into account an estimated population growth to about 13,5 mln in 1980 and 20 mln in 2000 (in 1958 ca. 11 mln) in the Netherlands.
Three basic principles had been formulated as far as the "Randstad" is concerned:

- Preserving the economic significance of the "Randstad" and offering possibilities for further growth in quantity and quality, as far as possible in spatial point of view, based on recognized potentials (accent was laid upon the seaharbour activities in the Rotterdam and the Amsterdam region).
- Preventing the "green heart" from being intensively involved in the expansion of the urban settlements surrounding this rural area.
- Maintaining the spatial separation between the agglomerations by zoning the "urban horse-shoe" in urban and rural parts.

Based on these principles the necessary new urban expansions should be realized if possible within the urban regions concerned; however because of the restricted spatial capacity this solution was considered as insufficient in relation to the spatial demands. New urban area should therefore be created outwards from the "Randstad", in "new towns" or "expanded towns", like the british did. The reports suggest a target for each of the "new towns" of no less than 100.000 inh. and a location not too far from the central town for the benefit of the inevitable mutual socio-economic interests, notwithstanding a necessary development of the new towns to a certain degree of independence. Besides, or better primarily, emphasis was put on urban renewal and reconstruction of old and bad neighbourhoods in the central towns of the agglomerations. The just mentioned necessity of new urban area must also be seen in relation to the losses of housing capacity in urban reconstruction areas.
In the first mentioned report, so already in 1958, Flevoland and

Markerwaard have been mentioned as to be involved in the "Randstad" conception as above has been pointed out, as far as the northern part of "Randstad" is concerned. Curious aspect was the assumption that the Markerwaardpolder should be drained as soon as possible (1968!) and afterwards Southern-Flevoland (1978!).
In fact the sequence has changed and the draining of the Markerwaard-polder has not reached the stage of ultimate decision until now (1982!). The reports mentioned Hoorn, Alkmaar and Purmerend (in North-Holland) and Lelystad (in Eastern-Flevoland) as new urban area at medium distance, whereas Almere (in Southern-Flevoland) at the time was indicated as "one of the new towns near the borderlake".

A Structure Plan for the Southern IJssellakepolders

Shortly after the publication of the (first) "Report on physical planning in the Netherlands" the above written urbanization policy was implemented in the long term planning of the IJssellake region in the form of "A Structure Plan for the Southern IJssellakepolders" (1961), published by the Zuiderzee Project Authority.
The radiation of the "Randstad Holland" was characterized as the decisive element of the structure of the Southern polders (Flevoland and Markerwaard); nowadays it is en vogue to translate radiation into expulsion, which must sound negative (another chapter will deal with this recent movement).
Figure 2 shows the just quoted structure principle of the Structure Plan, together with an important condition to realize it: the transport lines between the central town and the designed urbanization in the new land. The indicated parts of Flevoland and the southwestern part of the Markerwaard, nowadays indicated with less land, should be able to absorb about half a million people, a number regarded as sufficient in relation to the assumed need for new urban space till the end of century. The significance of the Structure Plan for the functioning of Lelystad can briefly be formulated as a radical change of the regional context; being designed as the regional centre of the Noordoostpolder, the Markerwaard and both parts of Flevoland (intended number of inhabitants 30.000), its

function and size had been put moreover in relation to the urbanization process in view in the northern Randstad (new target: about 100.000 inh.). Not having reclaimed the Markerwaardpolder until now, the least we can say is, that this spatial structure picture is partly still to be realised. Nevertheless much has been realised as will be pointed out later in this paper. On this point only one remark: it can not be denied that the statement in the Structure Plan as to allocate the south-western part of southern-Flevoland and the region of Lelystad catching the expanding urban and economic functions of the northern Randstad, is already of actual value in 1982.

Widening trends in Randstad policy

Both in the (first) "Report on Physical Planning in the Netherlands" (1960) and the "Second Report on Physical Planning in the Netherlands" (1966) one of the headlines of policy has been described as to concentrate urbanization in a number of "radiation areas" also functioning as development axes, outwards from the Randstad pointing into the periphery of the country. Apart from structuring the urbanization process, avoiding to diminish the quality and quantity of open space (for example the "green heart"), these radiation conception should stimulate the developments of peripheral provinces, with an unbalanced economy and nearly always higher unemployment figures. In concrete terms the radiation should become visible in migration of people and labourplaces out of the western part to the north, the east and the south. These goals of spatial policy (and regional-economic policy) have only been partly realized. In fact, generally speaking, the emigration (surplus) from peripheral regions diminished or disappeared, whereas as labour places are concerned, decentralization relatively did not occur at all. The economic structure in peripheral areas remained unbalanced and weak, as again turned out in the recent years.
Referring to the Randstad policy again one has to admit that it should become a nearly impossible task to stop the strong suburbanization movement, started already in the Fifties', and push it into the wished clustering within restricted areas and axes. After the publication of the

'Second Report on Physical Planning in the Netherlands" the warnings were manyfold, mainly with arguments as the increasing private and public prosperity in combination with increasing car ownership and a reduction of the daily and weekly labourtime. Moreover an important push-power was generated by the lack of adequate housing in the bigger towns, because of a very slow start of urban renewal and reconstruction. In the same time several small towns and villages, mainly outside direct influence areas of the agglomerations, were able to generate numerous housing projects, producing the popular categories of dwellings(family housing with gardens etc.), shortly mini-garden cities. The intended clustered deconcentration of industries and offices did not happen either; on the one hand the attraction (pull-factor) of Randstad-locations remained often stronger than problems of land shortages and/or congestion problems, on the other hand many enterprises choosed a relocation in rural area, partly near infrastructure (like main roads and the airport of Schiphol), partly in high status-area with attractive landscapes.
In this way the agglomerations were developing to "urban regions", covering edges of the above mentioned "green heart", and even growing to partly overlapping "urban zones", characterized by several agglomerations, towns and villages with intensive cross relations. So visually and functionally, the original polder landscapes were submitted to change into parts of urban zones and are withdrawn from our national cultural heritage.
To prevent misunderstanding we must ascertain (more than twenty years after the (first) "Report on Physical Planning"), that the terrifying picture of an megalopolis as Paris, London, or the north-east coast of the United States are far from being realized in the Low Lands; the Dutch scale and speed of urbanization is in a fairly large extent defined by a continuation of an existing dispersion (or better zoning) of functional entities within the Randstad provinces. One has to keep in mind, however, the flatness of our country, always causing a visual nearness of the neighbouring towns and villages, also when the concerned view is unattractive.
Besides the increase of the car-mobility, at the cost of the use of train and bus, required an expansion of infrastructure (but nevertheless caused traffic congestion) at the cost of rural qualities (including natural

values).
Shortly, the "clustering deconcentration conception" was only (and is only) partly a spatial reality. One may assume that without this official conception more or less a Belgium-like pattern would have arisen in the western provinces. It is plausible too that the development goals as concerns the urbanization structure did not have sufficient time and opportunity to be largely realized. Within the framework of planning procedures with an ambitious character, a period of 10-15 years is mostly too short to permit clear result. This will presumebly turn out to be true in the case of some recent suggestions on spatial developments of urban regions!)

Contracting trends in Randstad policy

After these remarks on elements of widening and spreading in planning policy and spatial reality, we have to deal briefly with some important changes in approach to spatial goals in general and urbanization in particular.
Started earlier as avant-garde issues, two societal movements were of increasing importance and relevance for spatial planning policy in the Sixties' and especially in the Seventies': a growing appreciation of nature and landscape and interest for ecological values, and a revival of appreciation of the economic, social and cultural values of city life and urban living conditions. Both movements are not exclusively Dutch. As in foreign countries they have relatively strong political influence and support. It is not quite clear whether they represent essential and major needs and feelings in society but indeed have sometimes good reasons for a fight against lacks, mistakes and threats, notwithstanding an excessive and often troublesome presence in decision making procedures.
In fact these two elements already were clearly present in the "Second Report on Physical Planning", but did not get an emphasis as nowadays. Partly the "ecological conception" is related to the general energy problem (since the start of the Seventies'), playing an important act in the mobility discussion. In the case of the attention for urban life it

is clearly recognized that urban renewal and reconstruction had a slow start and much is to be realized, however there are differences between for example Rotterdam and Amsterdam.
It is relevant too to put forward the general economic crisis, both influencing the expectations of the private household and the national economy (including budgets of government, provinces and municipalities). May be the future is too expensive, so why not "repairing on a small scale", in stead of an ambitious planning on the long run? (summarizing a not unimportant general feeling).
Last but not least physical planning, but not only physical planning, is confronted with an increasing uncertainty and lack of concensus about future goals and needs, creating a bad climate for the design and realization of plans (good or bad). Moreover a growing attention for instruments, how to realize the intentions, is drawing back the view on what is to be realized.
These factors have, directly or indirectly, much to do with contracting trends or resistance against spreading in the visions on urban structure, as well as these elements are visible in the recent reality of migration of people and enterprises. In the context of the (northern) Randstad these visions play an important act in the headlines of spatial policy until the end of the century, as can be read in reports and plans published by the government, provinces and important towns like Amsterdam.
On the national scale the "Third Report on Physical Planning in the Netherlands", published in three parts, is to be seen as a reaction on the developments and feelings pointed out above, by reconsidering the goals of spatial policy till 1990.
In the second part, the "Report on Urbanization" (1976), the development of the agglomerations got much attention, stronger than in the "Second Report"; the deterioration of the residential and living climate in urban regions, especially the oldest neighbourhoods, is presented as a crucial problem to solve as soon as possible. Besides the residential capacity of the towns and the urban regions will have to be increased, if possible, whereas population overspill from the cities to some new towns has been cut down, like for example Purmerend and Hoorn in the province of North-Holland. Lelystad and, still more emphasized, Almere retained its high

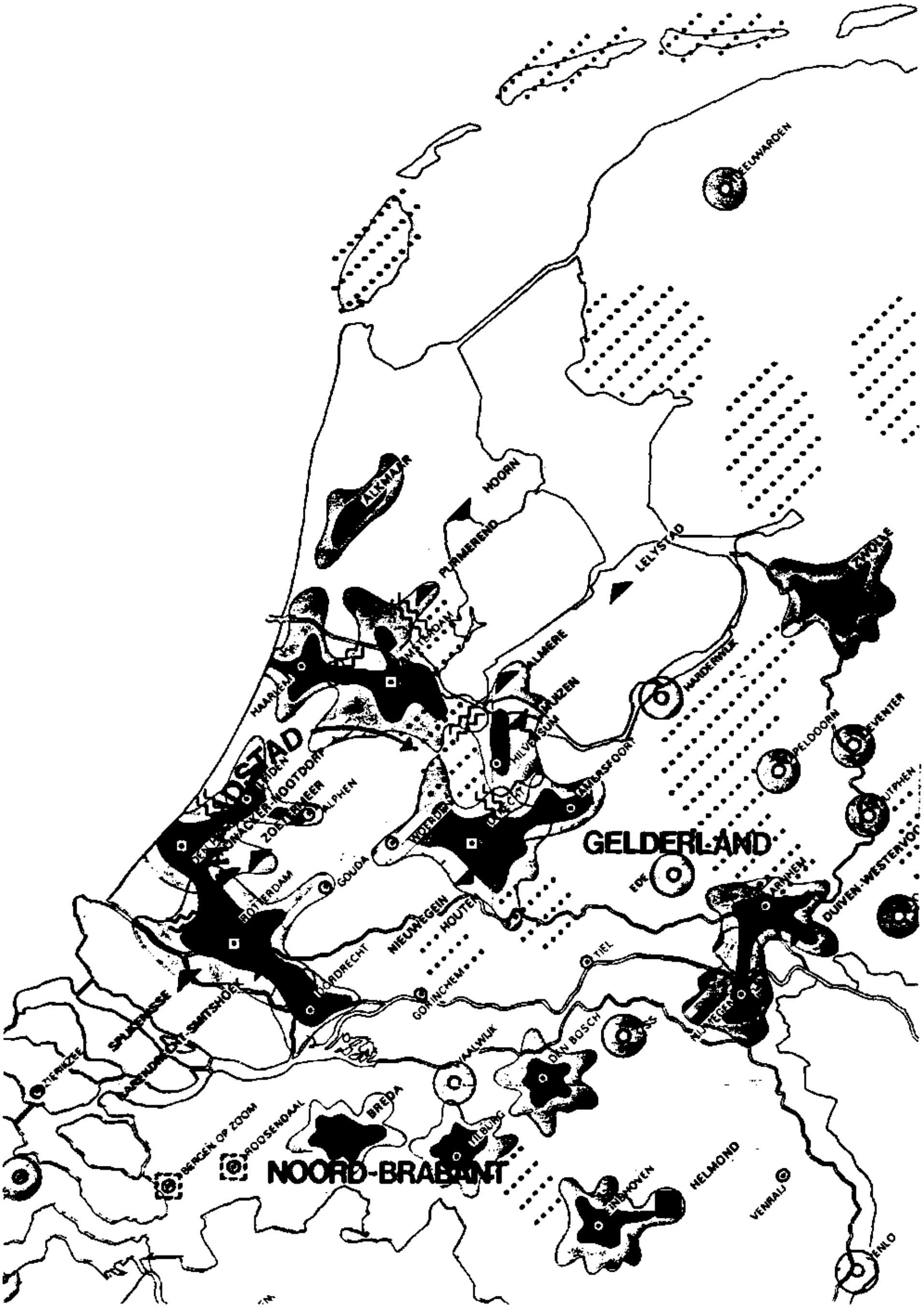

Figure 3 The "Randstad-Holland and other urban regions (Report on Urbanization 1976-1979)

housing production targets.
The report stressed the necessity of reducing the emigration surplus of North-Holland and recommended adequate housing production and urban renewal, so advertised more concentration of all urban functions within certain areas, the agglomerations and the near vicinity. Radiation to the North of North-Holland, as recommended in the Sixties', is less emphasized, whereas a new town development between Amsterdam and Haarlem, near Schiphol, must be pursued.
The wish to reduce the migration surplus to Utrecht and Gelderland is also based on the spatial pressure and diminishing capacity for urban expansion in these provinces, in connection with the quality of the threatened rural areas, in particular areas with high natural qualities, covering parts of these two provinces (including eastern parts of the "green heart").
Concentration of urban employment got more emphasis, ascertaining that relocation of jobs to new towns was not proportionaly to the migration of employed people to the new towns.
Illustrative is the emphasis nowadays on the regional economic significance of the national airport Schiphol (in the old Haarlemmermeer-polder, drained more than a century ago and being part of the "green heart"), in contradiction to the accent on seaharbour activities in the Sixties'.
In the provincial planning policy the new towns in North-Holland were recommended to stop functioning for Amsterdam, receiving new goals as regional centres in which as much as possible the regional need for housing and employment must be faced.
Figure 3 shows the vision on the Randstad as described in the "Report on Urbanization".

New towns on the bottom of the sea

After the publication of the "Second Report on Physical Planning in the Netherlands" a framework on administration level had been constructed, to make the commitments necessary to warrant the housing production in the northern Randstad (only for North-Holland). In 1970 commitments

till 1980 had been reached, resulting in targets for the new towns in North-Holland and Flevoland. Shortly we only deal with the targets for Lelystad and Almere, assessed on the calculated need in North-Holland, in particular Amsterdam, and a certain acceptable maximum for housing production pro year in new towns without initial social and economic infrastructure. In Lelystad and Almere about 80% of the production had to be assigned to inhabitants of North-Holland, especially Amsterdam, being 11.000 dwellings of a total production of about 14.500 in ten years. New town Lelystad had already been started in 1967, whereas the initial production in Almere had been expected after 1975.
When we evaluate the realization of these targets, we see that the intended production figures have been reached. At the end of 1979 the number of dwellings in Lelystad was 12.500 and in the first part of Almere (Almere-Harbour) more than 2.700 dwellings had been produced. The total population number at that time was more than 45.000.
In the context of the "Third Report on Physical Planning in the Netherlands" new targets for the period 1980-1990 were ordered: for Lelystad at least 14.000, whereas in Almere a minimum production of 24.000 has to be achieved, largely in parts of the designated area along the railline, planned to be completed till Lelystad before 1990 (again about 80% assignment for North-Holland). About 1990 Lelystad and Almere will have an estimated number of inhabitants of about 80.000 each.
In 1982 we find ourselves on the eve of the formulation of targets till the end of the century, on the occasion of the revision of the "Report on Urbanization". If and in what extent the above described contracting trends in urbanization policy will influence the targets for the new towns in Flevoland is a question we can not answer yet.

Final remarks

It may be useful to warn against overemphasizing the changes in the Randstad conception. Apart from some real evolutions, like the recognized seriousness of urban reconstruction (problems) and for example the implications of changing demographic forecasts, these changes seemed to be largely differences in accent. Moreover the

realization of new intentions, like raising the residential capacity of agglomerations, may be doubted (will it succeed in time and diminish sururbanization and really influence the future of new towns?).
Important question in this context is the cost/benefit relationship, financially and socially, concerning the location of new urban area and the character of urban reconstruction.
However it may be a serious mistake to underestimate the consequences of recent developments in planning policy. Taking into account the above mentioned political support concerning new visions on urbanization and housing policy, we might as well fear a real discontinuity, even before new urban plans will have shown to be realistic and desirable. For example, much has been invested in new towns in Flevoland (including private investment), investment which will only have maximal return (in the long run) if the (financial) policy contains continuity.
It is plausible to conclude that since the (first) "Report on Physical Planning" a continuing contest between contracting and widening forces is going on. May be the looser of the Sixties' will be the winner in the end. In the meantime there are losses in the quality of the space in the western provinces and a great deal of victimizing socio-economically.
As far as the reclaiming of the Markerwaard is concerned, the future developments on spatial policy and practice will influence deeply the functions of this last polder in the IJssellake region, designed in the 19th century, when it will be drained.

APPENDIX

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RECREATION IN NEW AREAS; THE IJSSELMEERPOLDERS AS CASE-STUDY

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Abstract

In the historical development of the Zuyderzee-project, the evolution of planning in the field of open-air recreation is a very interesting and curious one, in which time- and geographical aspects give a very important background. The paper tries to show to what extent open-air recreation is integrated in or isolated from the rest of the planning targets, based on the developments in the past decades and the geographical movements through the former Zuyderzee of the developments of polders, in contact to the surrounding "old land-areas" and the evolution of physical planning in the country as a whole.

Leisure is a part of our civilisation, although there are big differences in the importance and intensity, as well as in its level of integration in the daily life. That is also the case with open-air recreation as part of leisure, but directed to and taking place in the open air. It concerns a variety of activities in the towns and villages or outside the nucleus. In both cases the difference is possible to make between what could be called "following types" and "stimulating types" of open air recreation. The first group is part of the total local structure on a given place and serving as part of the accepted good life of the inhabitants, the "stimulating types" - apart of being to some extent part of the local or regional system - function as income - work - and activities-providing element seen on that local respectivaly regional level and are brought in from outside the local or regional area and

thus functioning for a bigger geographical area. It can be said, that the balance between both types can be different from town to town and from region to region. The balance also can differ in the course of time. In this sense geographical units as such can be described within a given area, which from the point of view of open-air recreation and the area as a whole are defined as more ore less "following" or "stimulating" in character. It also seems to be possible to influence the function of those regional situations by stimulating or restricting measures, taken by or under the influence of gouvernmental action.
The development of an area can also be seen in terms of the dichotomy "following" or "stimulating", as concerns open air recreation. So a purely agricultural region generally will not have an overwhelming "stimulating" system of open-air recreation but may nevertheless satisfy the daily recreational needs of its inhabitants. On the other side a wintersport-centre can be seen as an extreme development of a stimulating open air recreation region. In between an attractive (hilly) region can be a fine place to live and at the same time be functioning as a recreation resort for people from far away, during their vacation etc.
The potential qualities of a region can be a reason for the development of "stimulating" forms, caused by specific qualities of natural composition in relief, water, landscape, etc. But there seem to be necessary other elements to bring the recreational use of an area with these natural qualities beyond the level of "following" recreational use. It seems to me that some of the important elements are:
a) the geographical situation of the area among other regions as concerns its uniqueness in its natural qualities;
b) the need felt in the surrounding regions or countries to the qualities which the region under study can fullfill, seen from the spatial side and within the timelimits;
c) the level of individual mobility to bring an area in the reach of those who need its qualities, or the willingness to create public means of mobility;
d) the level of the need to look for new possibilities in open air recreation;
e) the level of capital-needs to satisfy these needs, in the private sector and in the public field; the willingness to invest and take

risks in this field;

f) the willingness and possibility to combine in a region different potencies in the field of open air recreation, to attract the maximum variation in recreation-lovers: a regional coordination problem;
g) the optimum combination possible between open air recreation forms and other types of land- and water-use, as for example nature, transport, agriculture, urbanisation;
h) the regional governmental and social organisation in their attitude and organisational power to develop and maintain the qualities of a region in its recreational development.

Although this number of factors is not complete, it nevertheless demonstrates that a situation where is not found a good combination of positive factors, will not lead to an optimal development of stimulating open air recreation. Some basis-factors may be so strong, that they even hinder the development as such. In other cases only a restricted development take place.

History of recreational development in the IJssellake-area

Before the closing of the Afsluitdijk in 1932, the North-Sea penetrated into a region, in which open air recreation existed only very incidental. Also just after the closing of the dam, when the tides were no longer present but the water not yet fresh, the use of the waters of the IJssellake was only incidental. In the Thirties there were some places where the use from the land surrounding the IJssellake is known, as for example Harderwijk, where people walked in the shallow water for long distances before reaching deeper water. Also there was some watersport-use of the area, and it may be accepted that also forms of sportfishing took place. Behind the coast some vacation-activities took place, but it was not of strong importance. Especially the use of the water in the IJssellake was very restricted, particularly to the happy few, who could afford sailing. The society as a whole saw no possibilities and had no other use in mind than professional fishing or aspects related

to this. Apart from shipping and the above mentioned activities, the Dutch Society lived with an attitude of defense against the shallow sea. The sewage system demonstrated this. Many towns and villages, rivers and streams transported the water unpurified in the open water.
Also with the start of polders in the former Zuiderzee, no attention was given to open-air recreation as a stimulating factor in regional development. Only in landscaping (among which forest on lands not usable for agriculture) and the opportunities given for sportfishing (drainage system) a basis was furnished for future development in this aspect. In the Wieringermeer however from the beginning elements were taken in the planning, to create open-air facilities for the own inhabitants. Studying the local town-plans from the three villages created before World War II one realises, that the central open spaces in the villages have specific recreational functions apart of specific social ones. Also the small forests and parks can be seen as elements of this. This tradition is continued in the North-East polder. The structureplan for this polder, developed in and after World War II, showed a number of villages and a regional servicecentre with a number of recreational facilities, in type, place and size adapted tot the agecomposition and life style of the own inhabitants: local forests, a number of facilities, often including sport facilities of different kinds, as local horse riding equipments, swimming pools, play grounds, parks and waters for small boating. Especially in Emmeloord the size and variety of provisions is important, but always meant as an aspect of local and regional function of the town. Outside the centres bicycle-pathes as well as roads give possibilities for driving for pleasure, canals invite for sportfishing, in a relatively big-scaled landscape. Forests are created only on those soils which only inefficiently could have been used for agriculture and therefore are situated on those places, without any direct connection to stimulate a strong development of open-air recreation. Nevertheless (as is the case in the Wieringermeerpolder as well) these forests gradually came in use for recreation in the form of routes for walking and bicycling, open spaces for day camping or specific camping sites and canals for throughpassing watersport. A geological and ship-archeological museum on one of the two prior islands was opened and received gradually a growing stream of visitors. An other island (Urk) maintained its professional fishing-port

function, which proved (in combination with the interesting traditional way of life of the inhabitants) to become a goal in touristic visits, for thousands of people from The Netherlands and abroad. Often this was and is combined with a visit to the polder-area, itself developing as a touristic goal. It should be taken in mind however that - apart of the museums and camping-sites - no stimulating-types of open air recreation were developed until recently. Even the fact that a number of out of use farm-labourers-houses became second-homes and that touristic visits to bulb-growing areas in different parts of the North-East polder and Wieringermeerpolder arose must be seen more as a consequence of structural changes in agriculture than as a really planned and stimulated development. Nevertheless in today-situation the regional tourist board now is using these and other aspects as means to stimulate tourism and open air recreation, the local and regional gouvernment try to stimulate a further development in the frame-work of regional and national schemes. And they can partly do so, because the different elements of the fysical and functional structure make it possible.

In Flevoland and the area of the future Markerwaard the situation is quite different or will be so. The start of it lies partly in the experiences in the North East Polder, partly in an interesting geographical factor. The latter lies not only in the geographical situation as such, but predomminantly in the fact, that it proved necessary to create lakes of different sizes between the adjacent "old land" and the polders, to prevent a dangerous lowering of the groundwater level on the "old land" and a constant seepage in the polders. In the very shallow lakes a canal for the communication between the different towns along the coast proved necessary and with the sand dugged out of the profile, a number of islands were constructed and long stretches of sand- areas were created on the outside slope of the dikes. These elements of fysical structuring of the area, in combination with the construction of roads on the dikes, were the first signs of changing attitudes and new visions to the possible use of the new area on both sides of the dikes. In combination with new forests along the dikes (although the first forest-area in the North-east of East-Flevoland had in its initial start the same background and functions as the forests in Wieringermeer and North-East polder: exploitation-forest on relatively bad agricultural soils), the infrastructural basis was laid and meant to receive people from other regions and other countries in their aim for

open air recreation.
Decisions in this direction were taken in the early Fifties, when the first signs of mass open-air recreation after the restauration-period following World War II, could be seen. They were developed in plans and brought to reality in the second half of the fifties, at once followed by a real explosion of visits to the beaches to an extent which was not foreseen. The pressure on the new facilities sometimes exceeded the created possibilities for beach recreation, the development of camping facilities had a same effect. People and organisations of different types discouvered the potential possibilities of the new created zone along the borderlakes of East Flevoland and insisted on facilities also on the "old-land" side. Boating gradually also developed, as well as driving for pleasure, sport-fishing etc. It led to a number of important decisions; taken in the early sixties and later on:

a) stimulating types of open-air recreation should become an integrated aspect of the structural development of the area under reclamation (East Flevoland), as far as this is still possible and capable for integration with other functions;
b) in future new polders (South Flevoland and Markerwaard) with their specific geographical position close to the centres of urbanisation, a further development of stimulating types of open air recreation should be furthered to a still higher degree and stronger integrated with other functions; also in urbanisation as such open air recreation should be more and more an integrated aspect of the planning.
c) the stimulating types of open air recreation not only should be situated in rural areas, but also should - as far as possible - become a part of the urbanisation system developing in the new urban centres of Flevoland and Markerwaard;
d) as a consequence the planning for stimulating types of open air recreation should be particularly concentrated in a broad zone along the borderlakes and strongly based on the interdependence of the areas on both sides of the dikes, but should also be developed as an aspect of the agricultural areas in the central parts of the polders, in the forests and - if possible - within the rural centres;
e) especially in East Flevoland, but also in the following polders, a high variety of provisions in each type of open air recreation should be made possible, as far as the fysical and financial conditions can

make it possible, to make the areas usable for all interested inhabitants of the country;

f) where realistic, with recreational developments one should take in mind that also nature has specific rights. Forms of integration should be accepted and even stimulated where possible;

g) the whole development should be integrated with developments in open air recreation for the country as a whole and especially be coordinated with the surrounding areas on the "old land" as far as necessary.

As a consequence of these decisions, taken within the frame-work of the State-Organisations charged with the development of the area and approved by the responsable minister, the further expansion of stimulating types of open air recreation took place to a far extent and as an accepted structural element in the total development of the new areas, in the above meant directions. Conditions for further developments were improved or created and a broad variety of recreational elements found a place. Under the more or less virginal conditions also (and even especially) new forms of open air recreation and especially expanding ones could be located. New lay outs could be developed, new technical aspects could be tried out, new views on open air recreation could be experimented. Some examples of these aspects are:

1) the optimal creation of a fresh-water beach could be tried out (and is evaluated);
2) among the almost 30 campings in Flevoland (ca. 30.000 places) much attention has been given to touristic places and to experiments on an optimal spatial structure for different types among them;
3) for hiking, special provisions were and are created;
4) second homes were created only in the form of complexes; no dispersed second homes were accepted;
5) for sportfishing a network of fishing-picnicplaces was made, to concentrate those who are willing to accept this and to spread those who want to fish alone, rather succesfully;
6) integration of forest-development and recreational development in forests took place, as well as forms of integration of recreation and nature;
7) the integration of stimulating types of open air recreation and urban developments started. In this case also the planned integration of

"following types" of open air recreation in a number of aspects is intensified and provided with a lot of experimental solutions, as for instance urban fringe developments;

8) in watersport the borderlakes are of specific importance for surfing. For the developments of other new types of watersport, for a save route between parts of the country.

The examples of new developments in a given time, demonstrate the advantage which a new area can have for itself and as an experimental situation for provisions which also can be used elsewhere. There also can exist a danger of misachievement, on the other hand, if the experiment becomes a faillure or if the developments in thinking on a higher gouvernmental level goes a different direction in a later period of the time. Therefore a good contact with the world outside the area is very important and a constant evaluation of all things created.

Analysis of the situation

It is too early for an end-evaluation: the proces of development in the given direction still is going on, the equipment of the area still underway or even not started, because of the fact that one of the polders has not yet been made. Therefore only a provisional analysis can be given, in general terms and in combination with an insight in the development of national visions concerning the country and the position of the new areas in it.

When the recreational developments in the IJssellakepolders started, no national developmentplan existed. The experiments with the development of fresh-waterbeaches along the coast of Eastern Flevoland and their big succes especially in the regional functions they developed, might have been of utmost importance to a later development of these beaches in other part of the Netherlands. In the zoned development of a variety of camping sites (as concerns their target-group mostly based on demand), created a lot of experience for further planning.

The interesting point also was, that they could be situated in combination with the landscaping of the area. The development of forests in the Sixties therefore also went more and more to a multifunctional use, i.e. for forest exploitation, development of nature and the structuring for

open-air recreation as for mobile and static aspects of day-recreation and vacation. In the agricultural parts of the polder a landscape was created of a large scale in which smaller recreational elements can be found in the form of bicycling pathes, sportfishing and picnic-sites, the reservation of walking-pathes for long-distance walks, etc. It means that - although the centre of gravity was laid in the recreational development of the zone along and in the borderlakes, also other parts of the polders were introduced in the interest of people from outside the area (and of course the growings stream of own inhabitants). In the season the day-visits in the Sixties should be seen in tenthousands, the number of overnight stays in hundredthousands. Not every element from the beginning was used to its maximum, but one can say that practically all of them proved to be very welcome. One should not forget to mention, that also the touristic function of a large scale developmentwork as the development of a polder is, the construction of villages and towns, the intensified visits to migrated members of the family etc. contributed (and still do) to the development of the recreational function of the area and its stabilisation. In all it meant that a good experience was built up in integrated planning, including open air recreation.
The recreational aspects of the development of the polders and borderlakes became (in the late Fifties) formalised as an integrated aspect of "A Structure plan for the IJssellakepolders", developed by the two responsible state-authorities. Some aspects of this rather general plan later have become part of the national recreation plans, thus accepting the area in principle as part of the future developments in The Netherlands. These national plans however more followed than guided the developments in the area, which however led to the obligation to continue, helped as far as possible by results of research in the area and outside it.
In the thinking about further developments in the IJssellake-area, the geographical situation and the order in time during which the polders and surroundings are developed are important. It is clear that especially in the densely populated areas of the Northern part of the Rim-City with their lack of space and recreation facilities the need for expansion in the direction of the IJssellake-area is the highest and strongly directed to day-recreation. This means that - generally speaking - the direct pressure on the new areas slows down with growing distance of the densely urbanised areas and gives more room for stay during vacation and

types of second homes. Thus from the point of view to give recreational function to the new lands and the lakes especially for the highest needs felt, a development of South Flevoland should have been the first, but because during the Sixties only East Flevoland could be used, the IJssel-lake-area only could be of help in a restricted way for the western part of the country. During the Seventies' gradually new possibilities came in view along the coast of South Flevoland and in this polder, which are in full development now, based on plans on a longer run and integrated in multifunctional structure-plans, comprising the polders and the areas around.

One of these plans is a development-plan for the borderlakes, created in the first half of the Seventies' and strongly based on an supra-regional level, with a forecasting in elements as beach-visit, watersport, sportfishing etc. The plan created on this whole, includes consequences in recreation-planning also for big parts of the surrounding old-land and tries to take care of other aspects of fysical planning. Although the forecasting needs some adaptation and a further integration in other aspects of fysical planning is needed, the zoning-aspects and general thoughts of the plan are usable for the further structuring of open air recreation and its development, in the long string of borderlakes and their direct surroundings. It could mean that this area will become of utmost importance for the further development of open air recreation in The Netherlands, based on a combination of watersports, amphibious forms of day recreation, camping, nature-aspects etc. The plan fits rather good in the new National Structure-scheme for open air recreation (which now is passing public discussion), which in the meantime also has been developed. It also will be used as a basis-element for a general recreation plan for Flevoland, which also is in its last stages of development and in many aspects it is and was yet taken in execution.

Other elements which contribute strongly to the general recreation plan for Flevoland are the structure-plans for the urban developments of Almere and Lelystad, as well as the structure-plans for the polders South Flevoland and East Flevoland. They all contain a number of stimulating types of open air recreation reserves: especially the structure plan for Almere may be meant here, also because it is clear, that in the choice between urban developments and regional recreational

functions a good balance has to be found, accepting that parts of the recreational pressure should be guided to other parts of South Flevoland and elsewhere.
The importance on the national level of planning for recreation, Flevoland and the area of the borderlakes also will have, is perhaps good demonstrated by the fact, that in the forecasting and general plans(1980) on the national level, a very important role will be given to the area in which the IJssellakepolders are (and perhaps will be) situated. In the mentioned Structure-scheme on open air recreation, 50% of all foreseen watersport-developments should take place in this area (including the area of the Markermeer), and ca. 30% of the growth in vacation-provisions (camping sites, second homes etc.) should be situated here. Although the question has not be answered in how far the existing (and perhaps future) area can fullfill these needs, it might be said, that the further integration of the area in the national whole will take place to a still further extent. The problem perhaps will be, not to overestimate and to find a good combination with other needs as agriculture, urban developments, forests nature etc. One should also take in mind, that the general position of long-distance open air recreation is strongly under discussion, in relation to the general life conditions of today and the future. This could be a hindrance in a strong overall day-recreational function.
Nevertheless it can be said that the new area within 20 years have developed from a hardly used area, to a region in which not only stimulating types of open air recreation have been accepted, but is seen as an area in which millions of stays can be made yet, along which and through which ten thousands of watersport-lovers pass on their way to other parts of the country or to a nice place in the area, over which many people fly and under which a basis has been laid for a strong integrated development of recreation, serving people from different parts of the country and abroad.

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QUALITATIVE SPATIAL PLANNING MODELS FOR NEW URBAN FRINGE AREAS

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Abstract

Almere new town in the southern Flevolandpolder near Amsterdam has a polynuclear lay-out. The open space around and between the urban nuclei will be structured according to a general development strategy, which is based on the principles : coherence and diversity. For the urban fringe areas this strategy has been further worked out by means of the construction of two qualitative spatial planning models.
One model is made with the help of a preference-budget game for already afforested areas with recreational purposes.
The other is based on the phenomenological orientation on the city and applies especially for areas with mixed functions. Both models are suitable for use outside Almere.

1 Introduction

The physical planning situation in the Northern wing of the Randstad Holland shows such a congestion, that the planning of an new urban area with the capacity of 300.000 inhabitants, Almere, is approached energetically. 185.000 inhabitants in 25 years implies an unprecedented growth rate. Partly to accomplish flexibility a polynuclear lay-out has been chosen for the urban area. Another reason is the short distance between the homes of the inhabitants and the green space outside the nuclei. Probably the relation between the townspeople and the country round the town gets stronger and the mobility of recreation decreases by this lay-out. It is true that there are already potential, natural attractions in the new polders, but all of these must still be brought to development. This strongly emphasizes the necessity of a good physical planning policy for open space between Almere's residential nuclei, the Buitenruimte (Outer Area).

2 General development strategy of the Buitenruimte

The open space should be able to function in various ways, e.g.:

- opportunities for recreation for the inhabitants of Almere, as well as for the regional population, with a wide range of activities, are needed;
- a productive agriculture and forestry might have a distinct place;
- natural scenery is undeniable of great importance for a new urban district.

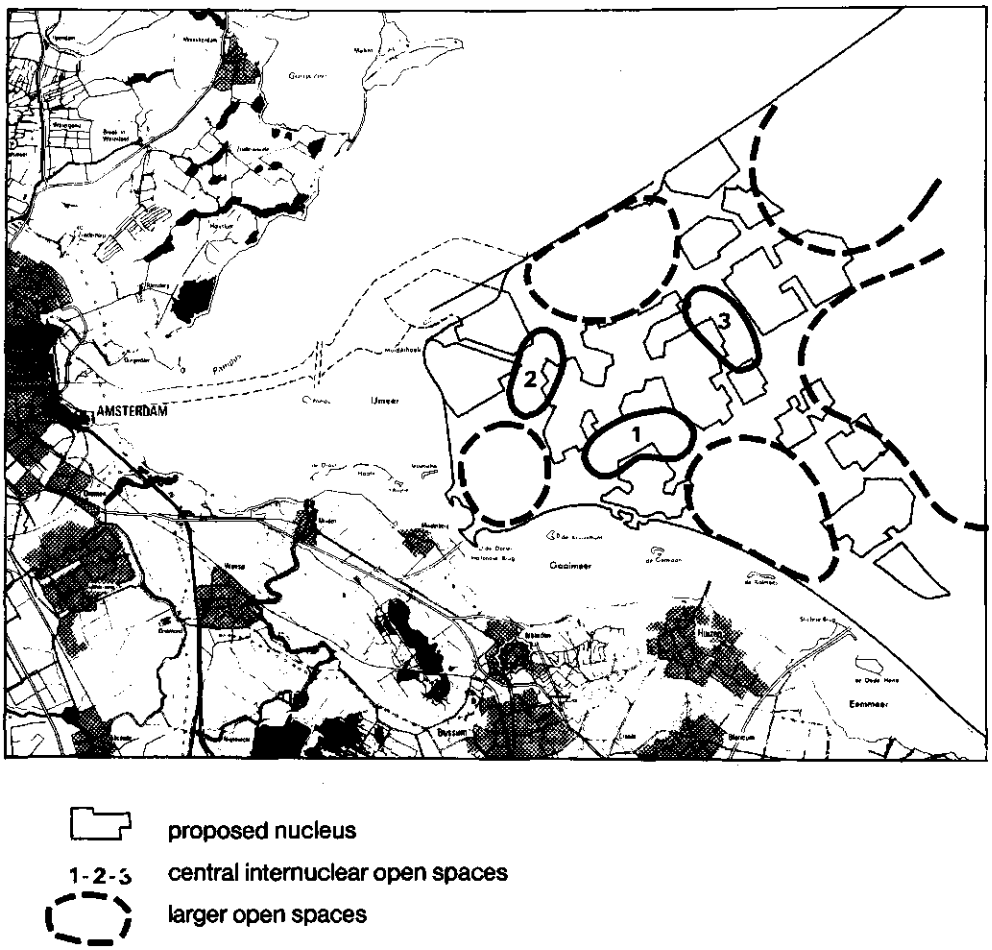
Furthermore it is desirable to anticipate the arrival of the inhabitants. However, the situation of the built-up areas and the principal network of roads and public utilities has important consequences for the development of the open space outside the built-up areas. Therefore, a two-folded general development strategy was set-up with the following objectives:

- it is desirable to strive after diversity in the lay-out of the open space; in this way feasibility will emerge for further differentiation. So far, designation of the Buitenruimte has been a continuation of the Government agricultural holdings that prevail throughout a new polder and is, among other things, a major factor in the cultivation of the unreclaimed polder soil.
- it is desirable to strive after coherence between the nuclei themselves and between the nuclei and the open space, in a physical as well as functional way.

The diversity will be dependent very much on the choice of large scale land-uses which may serve as components for the lay-out of the areas outside the intensive development zones. For this choice are several starting points at hand, like the fitness of a few spots for sand-digging with potentials for recreation lakes; agriculture and afforestation. This is why the Buitenruimte can be divided into a number of distinct areas (Fig. 1):

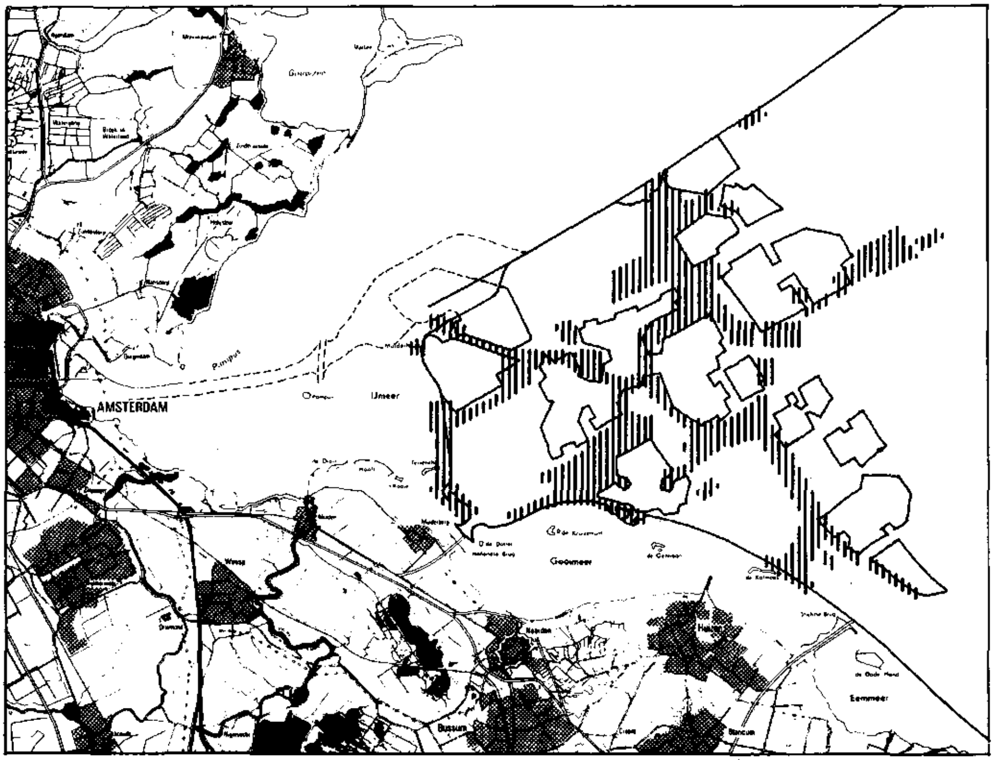
- the spaces directly between built-up areas. These are in easy reach from the main-roads and from the residential areas, and thus centrally situated for the inhabitants. In consequence these places evidently have a high potential for a very intensive and variated use.
- some large areas in a less central situation. For these areas there are possibilities for more extensive, large scale land-uses.

Figure 1: Open spaces in Almere New Town: the Buitenruimte.



The coherence will be furthered by stimulating the engagement of the inhabitants by an easy and direct access for cyclists and pedestrians to the Buitenruimte. Starting from the urban centers and the central internuclear open spaces with intensive development potentials, a radial network has been designed, linking up areas that may be used intensively in future. It runs through the open space and town parts, following existing and future local physical features like canals, dikes, edges. It is distinctly directed to attractive provisions, major landmarks and the points of access to Almere from the old land and the rural parts of Flevoland. This radial network is called the Landscape Development Zones - L.D.Z. (Fig.2). Given form in an very early phase they are the carrying environment for further developments.

Figure 2: Landscape development zones.



3 Specific character of urban fringe areas

Research pointed out that urban fringe areas are subject to at least two paradoxal tendencies:

- visual and functional clearly recognizable designation elements become blurred (levelling)
- the establishment of non-public, monofunctional designation elements of very big size, because of which the general usefulness and the penetrability of the area for visitors decreases (segregation of functions).

At the same time, however, the results of these tendencies lead towards a complex and rather chaotic transitional milieu which as such forms an ideal milieu for play and adventure (=recreation) for townspeople. Probably this is caused by the fact that one can give to these areas the meaning of being outside in the free open air and still being quite near the home and the town.
How to create such a recreational useful urban fringe area that also in the long run has enough complexity and a certain chaos, without getting to much segregation of functions and of levelling?
The general development strategy had to be worked out furthermore in this sense.

4 Simulation model of urban fringe landscape environments

The internuclear area no. 1 (Fig. 1) had been afforested since 1973 bearing in mind the arrival of the first inhabitants in 1976. To structure the area in a more detailed way a preference-budget game was played under the future inhabitants. So their involvement could be mobilized in an early stage.
Twenty landscapes that can be realized in a technical sense in Almere were realistic described by means of drawn material (in stead of photographs) (Table 1)

Table 1.

twenty landscape environments	large scale, multifunc-tional	small, multif.	large, monof.	small, monof.
activities restricted to water	a	b	c	d
activities restr. to quiet shores	e	f	g	h
activities restr. to crowded shores	i	j	k	l
activities restr. to quiet land	m	n	o	p
activities restr. to crowded land	q	r	s	t

Measuring the respondents' preferences for these environments took place by a preference-budget game. The advantage of this method above others is the fact that the respondent has to indicate priorities and also set himself restrictions in choosing these, because of his limited budget. In addition, it saves the respondent the necessity to put his preference into words. Finally, such a preference-budget game is extremely operational: it is easy to play and it yields data that can be processed at once. The respondents were presented the twenty above-mentioned environments, with the request to indicate for each environment what sort of activity they would like to do there. (In an empirical urban fringe study in 1979 it was found that they did indeed what they "promised" to do in the various landscape environments). Subsequently, the respondents selected the ten most attractive environments from these twenty and arranged them in order of attractiveness. Finally, they were asked to make an as realistic as possible choice between the urban fringe landscapes, because, for instance, a large, quiet recreation forest cannot be situated at five minutes' distance from the city centre full of facilities (main centre Almere-Stad). The respondent got an amount of 100 counters at his disposal. By means of this amount he could purchase one or more environments from the ten he had selected.
The rule was that an environment close to the house is more expensive than an environment farther away. The criteria that were used for

attributing counter-value per landscape:

1. the chances of realization in technical sense
2. intensity of use
3. scale of the open spaces in the landscape environment
4. distance from the home of the inhabitant.

On the whole, the respondents liked to play the game. Therefore, the game can be called a success. It can be stated that the landscapes that have been underlined in table 1 are the most favoured ones. For that matter, this is not to say that the landscapes scoring lower are less valuable; a value-judgment should not be passed until one of the landscapes would have scored zero, which is not the case.

To use the results in planning, not only the visual indications of the pictures should be taken into consideration, but also the distribution of space that the package of activities indicates for each landscape. Aids to determine, e.g. the area of the open spaces between the vegetation, are the description of the scale of each landscape and the indications sedentary, stationary and mobile as estimates of the space required for the activities.

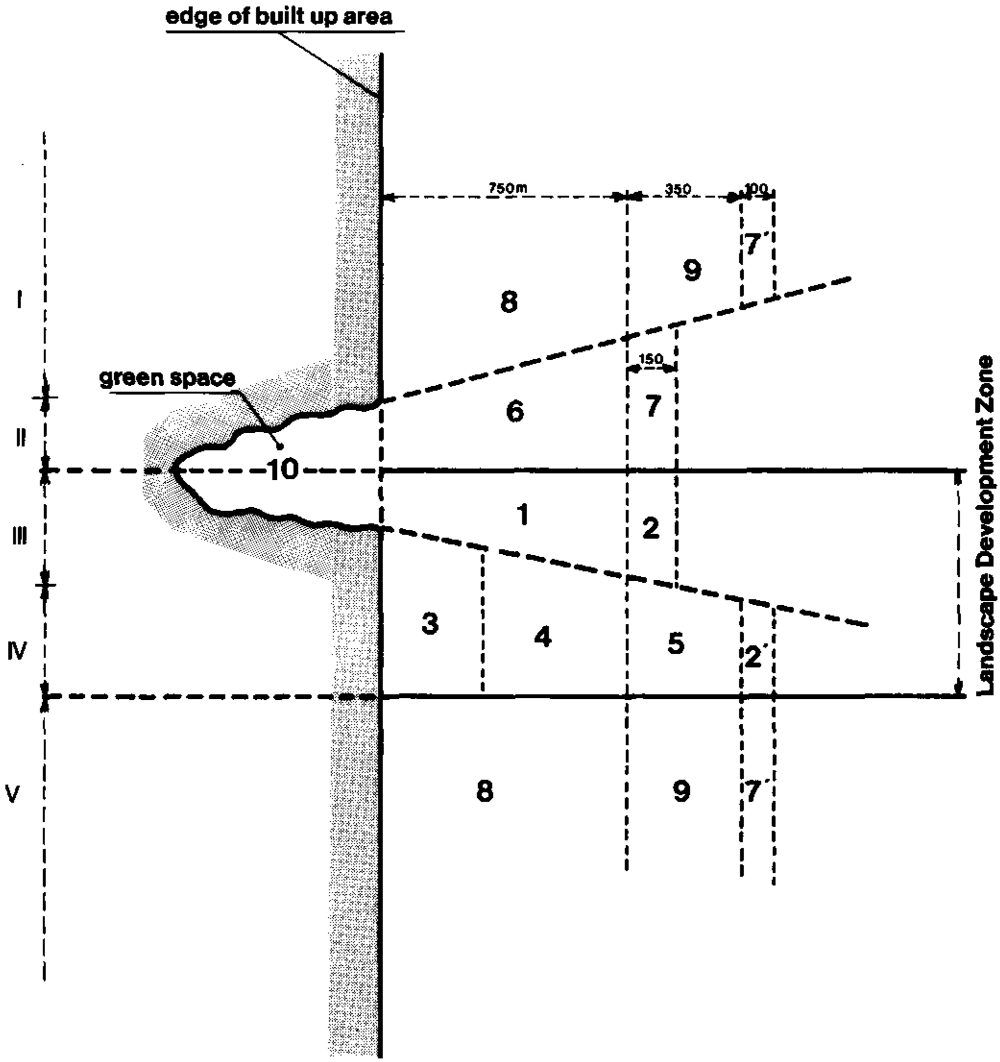
Thus the zoning principle from the general development strategy of the Buitenruimte was translated into concrete planning indications. First of all, for all landscape environments a range of distance to the home had been calculated. The maximum distance (as the crow flies) from the built-up area is 1.200 m. Furthermore at the distances of 300 and 750 m clear boundaries were found concerning the locational preferences of a number of activities in certain landscape environments.

Furthermore the extent of combinations per landscape environment with other environments could be indicated.

Table 2. Combinations of landscape environments

	often combined with other landscape environments	seldom combined with other landscape environments	not combined with other landscape environments
crowded	r, t, k, l and s	i, q and j	
quiet	m, n and p	e and f	g, o and h
water		a, b, c and d	

Figure 3: Theoretical visual content of fringe area.



I, V = urban fringe area

II = the same, near green space

III = the same, near green space and in the L.D.Z.

IV = the same, in L.D.Z.

1-10 = mix of landscape

So the theoretical "visual" contents of the fringe area could be designated (Fig. 3). This was translated into the real situation in the central internuclear open space no. 1 on account of the existing park-land forest and the existing and future relations between both adjacent nuclei (Fig. 4 and 5).
This method of model-building is also applicaple to situations outside the Almere-area.

5 A qualitative spatial planning model

For future urban fringe areas where not yet a development like afforestation took place, another elaboration of the general development strategy was handled. Reason for this was the preference budget game model being based upon certain recreation designations. It gives no clue for all possible urban fringe elements of non-recreational character. So a structural theme, a "leitbild", is needed. The following concept has been chosen: the phenomenological orientation with regard to the town. It has to organize the spatial planning on micro level. The base for this concept is the idea that cities are artifacts and worlds of artifice placed at varying distances from human conditions close to nature (Yi-Fu Tuan).
Transition zones in the urban fringe, then, may be ranked according to how far they depart from farm life, from the agricultural rhythm of peak activity in the warm half of the year, and from the cycle of work during the day and of sleep at night. Although the Buitenruimte of Almere is based upon an artificial polder-bottom, the life-experience of all new townspeople is yet benefitted if the area is structured as the more or less natural counterpole of town and citycentre. Through this the possibility of open-air recreation gets sense.
The urban pole is then characterized by the fact that it does not know how it is fed, that it comes alive in winter and that it slights the daily course of the sun. The phenomenological orientation with regard to the town has been divided in four milieus:

1. the milieu between the buildings of the urban built-up area;
2. the milieu right at the edge of the built-up area
3. the milieu just outside the edge of the built-up area

Figure 4: Sub-areas A-H in central internuclear open space no. 1.

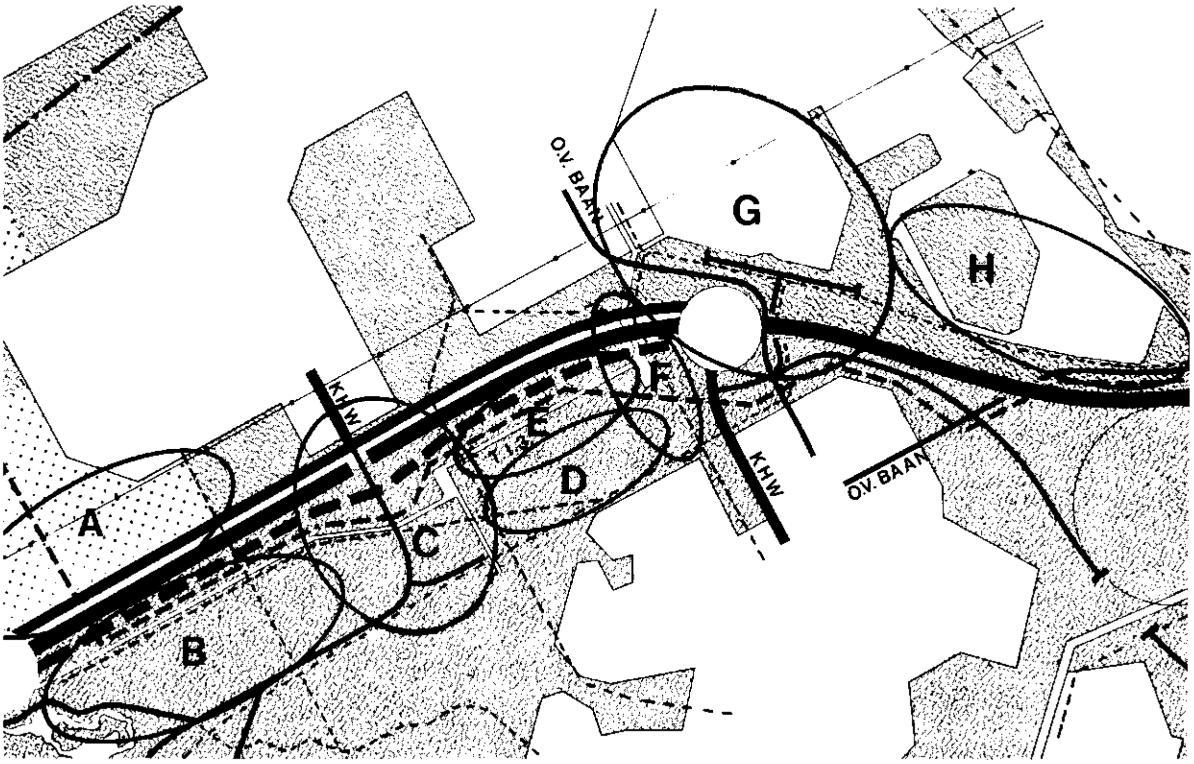
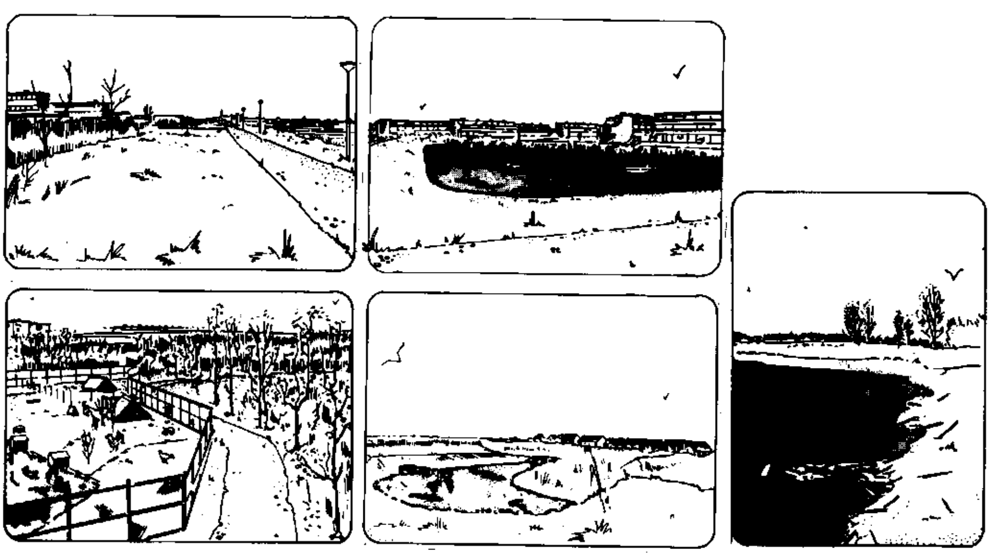


Figure 5: Landscape-mix of sub area D.

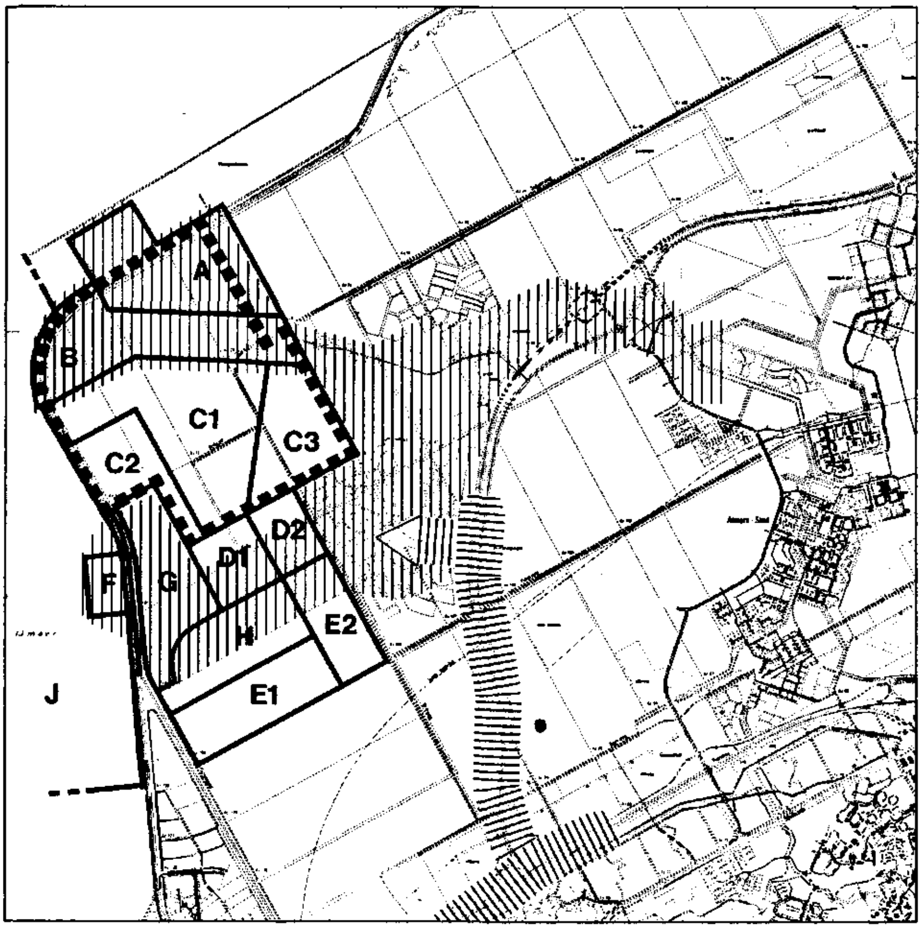


4. the milieu outside the town.
First, a Programme of Development for an area on a global level is needed to make the model work (e.g., local structure plan level). In the second place it is for Almere necessary to decide whether an area will ever be indicated as a L.D.Z. Starting-points for the model are furthermore the facts that milieu no. 1 in principle is always present and that everywhere where the milieus no. 2 and 3 aren't yet there, milieu no. 4 exists. In that case milieu no. 4 is contiguous to milieu no. 1 untill designation elements which belong specifically to milieu no. 2 or 3 with regard to their form, function, possible situation, external relations, etc., announce themselves. All possible elements are arranged towards:

- their presence in historical developed urban fringe areas.
- their fitness to belong to milieu no. 1,2,3 and/or 4.
- their fitness to be a part of a L.D.Z.

When an element emerges, first of all is checked if it fits into a designation mentioned in the Programme of Development. If so, secondly one looks at the fitness for being a part of a L.D.Z. in milieu no. 4. The criterion for this is public attraction (agglomeration effect on a small scale). If not,the element will be located outside the L.D.Z. An element of milieu no. 2 will be placed as near as possible to elements of milieu no. 1. An element of milieu no. 3 will be placed as near as possible to elements of milieu no. 2. When there are no such elements the element will be referred to another area,or it has to wait till no. 2 elements will have showed up. In first instance all space reservations for a latter phase of development are in milieu no. 4. In practice the development of the milieus no. 2 and 3 will decrease no. 4. After some development in time elements of no. 2 and 3 can change functionally within certain limits.
When a new element does fit in a L.D.Z. then it is situated in a logical way in the L.D.Z., without reckoning the adjoining milieus outside the L.D.Z.
In figure 6 the first phase in planning the western part of Almere is shown. The L.D.Z.'s are traced from the population centres to the coast of the Y-lake. This is the"target area"outside the town where in future people will go. In a latter phase of development the nucleus Almere-Pampus will shade this target area. By now the development of

Figure 6
Almere-West.



sub-area

L.D.Z. of local order (Almere)

supposes edge of built-up area in 2000 (nucleus Almere-Pampus)

L.D.Z. of regional order (from Amsterdam)

D2 sub-area code

this coast can not be taken in hand, so a temporary public attraction is foreseen in the central internuclear open space no. 2: a regional open recreation-sports area, the Pampushout. At present the L.D.Z. is not more than a linear area of attention; when Almere-Pampus or the Marina at the coast emerges the L.D.Z. will become a real carrying environment. A more exact position-finding of designation elements than their localisation in a certain still rather big sub-area is not possible with a Programme of Development. It is this qualitative spatial planning model that allows to arrange the various elements in a logical way within each sub-area, for all possible points of time in the future development. The model allows also the selection of the pioneer elements for L.D.Z.'s and the location of them in L.D.Z.'s. Figure 7 shows an example of the simulated future urban fringe area at the second point of time (t+1), just before the start of the nucleus Almere-Pampus. (next page).

An important advantage of the model is the possibility to read the exact timing of infrastructural works, e.g. roads, in order to make sure that the development of the Buitenruimte will be stimulated in the way of the general development strategy.

A lot of qualitative forecasting and social surveying and evaluating research is already done to program the development of recreational provisions in the nuclei and of the Buitenruimte of Almere new town. Nevertheless the need for qualitative spatial planning and design tools has always been felt. The described model has been tried out in four historical old land urban fringe areas. Because the model matches the real situation it can also be used outside the polders.

References

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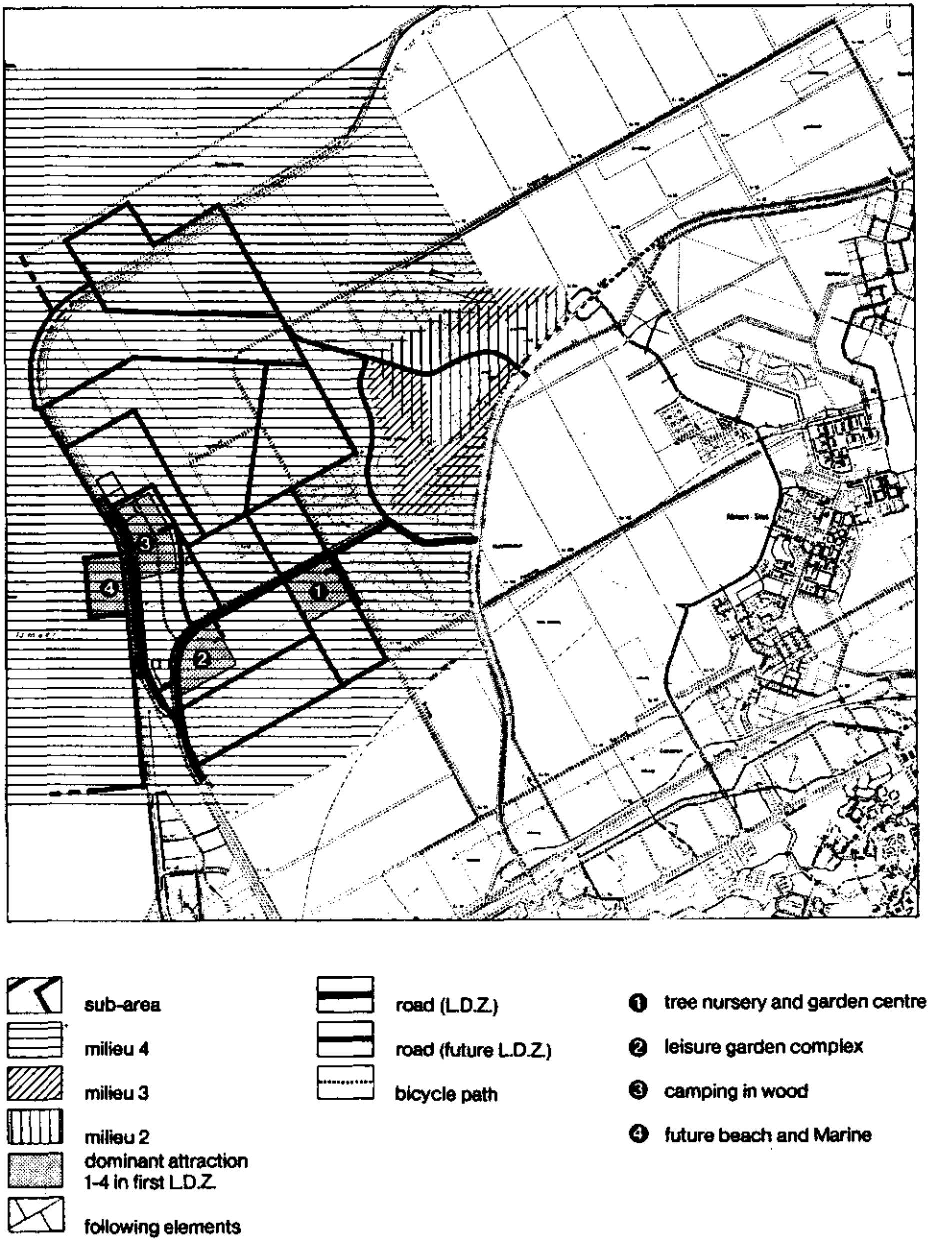
Figure 7
Almere-West at time t+1.



EMPLOYMENT PLANNING OF NEW TOWNS IN THE IJSSELMEERPOLDERS

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Abstract

Since 1942 the IJsselmeer Polders Development Authority has planned and developed two regional centres and a new town and is presently involved in the construction of the largest new town in the polder: Almere.

After having briefly discussed the polynuclear concept of Almere, the paper concentrates on the employment aspects of these new towns.

As employment planning on a national scale is already a hazardous task, on an urban scale it becomes even more difficult, especially when no former employment exists, as was the case here.

Changes in the economy and new insights as to the role of a new town may greatly influence the employment forecasts.

Emmeloord and Dronten, planned as agricultural centres amidst newly reclaimed land, both now show an employment structure where the service sector and manufacturing industry dominate.

Lelystad, started in 1967, had in the period of 1967-1972 more jobs than resident working people.

From 1973 onwards, Lelystad changed its position of new town, from economic regional centre to overflow town, with the result that employment fell behind.

Almere has been set up as an overflow town, to accommodate people and firms from the neighbouring Amsterdam and Gooi-regions.

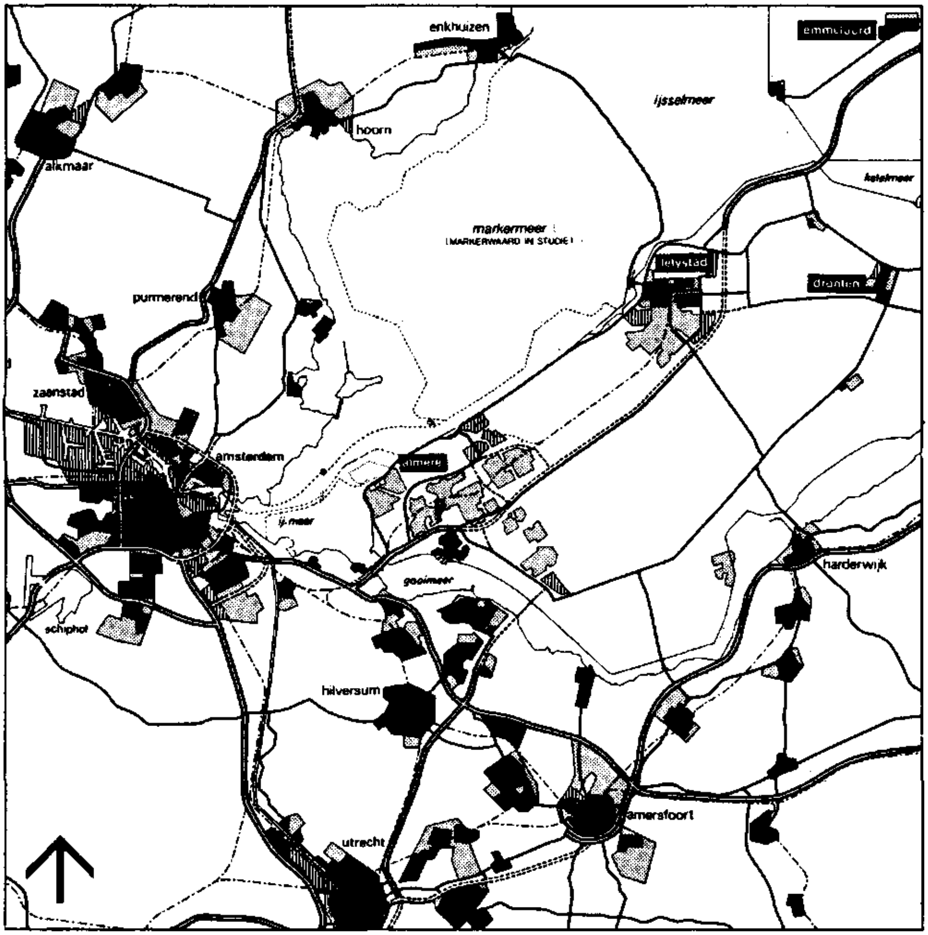
The employment targets set for Almere have been reasonably fulfilled up to 1981.

As to the short-term employment forecasts, Almere will probably find it much more difficult to attract employment.
It is predicted that Almere can face the long-term future optimistically, given its good industrial location and infrastructure.

1. The polynuclear concept of Almere

In 1970 it was decided that Almere should be built in order to house the population overflow and provide space for the factories of the overcrowded Amsterdam and Gooi-regions (Figure 1).
A target population of between 125,000 (minimum) and 250,000 (maximum) was set for the year 2000 and the polynuclear concept of Almere was accepted. This concept means that Almere should be composed of a number of nuclei of different sizes, each large enough to have a satisfactory degree of independence,together forming a town, with the largest nucleus (Almere-Stad) binding the centres together as a whole.
Between the nuclei open spaces will be preserved to be used for different purposes, varying from intensive recreational use to virtually natural or agricultural areas.
The polynuclear concept of Almere has the advantage that the final size of the town and the exact number of nuclei have not to be decided upon at this stage.
It also opens up the possibility of building at several places simultaneously or shortly after another, whereby mistakes made in one nucleus hopefully may be avoided in the following one.
Work on the first nucleus (Almere-Haven) was started in 1975. It has a present population of 14,000 and will ultimately accommodate some 20,000 inhabitants in 1985.
Almere-Stad, the largest nucleus, with a target population of 110,000 received its first inhabitants in 1980. Towards 1990 it should contain almost 45,000 people. The third nucleus (Almere-Buiten) is still at the drawing-board stage, but is planned to accommodate almost 16,000 people towards 1990 and 40,000 - 50,000 in its final state.
Further nuclei are being considered.
The planning and inplementation of the Almere plans is done by the IJsselmeer Polders Development Authority, the body which also built

Figure 1
Urban and regional development of Almere towards the year 2000



water

present and future nuclei and urban development

industrial estates

roads

railway

5 10 15 20km

Lelystad new town (ultimate population:100,000) and which built at an earlier stage Emmeloord and Dronten, both agricultural centres (all on reclaimed land).

2. Employment planning

2.1. Employment planning of Emmeloord and Dronten

It may be said that the planning or forecasting of employment of a new town in most town-planning publications hardly gets the attention it deserves.

This is not surprising as experience has shown that most employment forecasts for (new) towns do not come true.

A survey among employment forecastst for the Dutch new towns of Emmeloord, Dronten, Lelystad and Almere, as compared with the present actual situation clearly illustrates this point. Both Emmeloord (present population: 18,000) and Dronten (present population:11,000), started in 1942 and 1962 respectively, were planned as agricultural centres amidst newly reclaimed farming land. At present, both new towns show an employment structure where the service sector and manufacturing industry now dominate, whilst farming has lost its leading role. These agricultural centres have grown much faster than was originally anticipated and have already twice as many inhabitants as was foreseen.

The social-economic developments after the Second World War, with increasing farm mechanisation, even on modern planned farms operated more or less like a factory, have caused a redundancy of jobs in the farming sector. Other sectors of employment moved in to recuperate this loss, thus greatly changing the economic structure of these towns.

2.2. Employment planning of Lelystad

Lelystad, with a planned population of 100,000 (originally 30,000) and a present population of 44,000,was started in 1967. In the period of 1967-1972 it had more jobs than resident working people, resulting in a large daily influx of workers. Most people during this period came from eastern provincies. During this period Lelystad was a new town primarily with an economic function (regional centre with many government services).

The percentage of people who worked and lived in Lelystad at that time averaged around 80. From 1973 onwards it was no longer necessary to be economically tied to Lelystad in order to get a house there. The home building programme was gradually increased from 300 per year in the early seventies to 2,000 in 1981. Most of the newcomers in want of a house are now coming from the Amsterdam-region and the province of North-Holland, where most of them still have their work.
As a result, Lelystad became a commuter town or in other words: a town to accommodate the overflow of people from a densely urbanized part of the Randstad (central area in the ring of the following cities: Amsterdam, The Hague, Rotterdam, Utrecht).
The percentage of people who still work and live in Lelystad had fallen in 1981 to 49. The national planning policy to increase the housing programma of Lelystad new town, without compensating this with a yearly influx of government jobs, in fact meant that the employment forecasting of Lelystad had been upset.
In short, in the period 1967-1972 population from the eastern part of the Netherlands followed the employment to Lelystad, whereas from 1973 onwards employment gradually followed the population from the western part of the Netherlands, with a time lag of approximately 2 years.

2.3. Employment planning of Almere

Almere new town is primarily being built to accommodate the population overflow from the Amsterdam and Gooi-regions , neighbouring this new town.
Almere new town falls in the category of new towns built around London, Birmingham, Liverpool, Manchester or Glasgow to relieve pressure on overcrowding in big cities.
Almere can thus be classified as another category of new town than Emmeloord and Dronten, both towns being built to act as a regional centre in a rural area.
Lelystad changed its position of new town, as we have seen above from economic regional centre to overflow town, just as Almere.
Having thus classified the type of new town Almere will be, we will now look at the employment forecasting of this town.
The first report to deal with this matter dates from 1970. In this

report one foresaw a great commuting surplus to the Randstad up to 1980. After 1980 this surplus would rapidly decrease due to the increasing interest of firms to settle in Almere.
About 50% of employment would be in manufacturing industry and another 50% in the service sector in 1980, changing to 40% in manufacturing industry and 60% in the service sector in 1990.
In the next report, Almere 1985, one notices a shift of emphasis as regard employment in Almere.
One of the goals in this report is to keep the difference between the number of jobs and employed persons in Almere at no more than 10%. This, in order to keep commuting at the lowest possibel level.
The service sector is strengthened from 60 to 65% in line with Dutch national trends (overall decline of manufacturing industry).
A report dealing with the first nucleus of Almere, called Almere-Haven, appeared in 1974, two years before the first people moved into this nucleus.
The forecasts as regards the employment structure of Almere-Haven looked as follows: 40% manufacturing industry, 45% service sector and 15% construction. In the detailed subdivision of the service sector , for example, no allowance, was made for wholesale trade. As per January 1981 already 47 wholesale trade firms were established in Almere-Haven. This example clearly shows how employment forecasts may be upset by an unforeseen development in industrial migration.
Only a market study of the wholesale trade in the Amsterdam and Gooi-regions, where most of the wholesale trade firms come from, could probably have discovered this remarkable trend.
In the latest official report on Almere, appearing in 1978, most employment aspects have been revised again.
The following table gives an insight in the target number of jobs to be attracted to Almere over a great number of years.

Table 1. Target number of jobs in Almere, according to sector, 1980-2000

Year	Primary sector		Construction		Manufacturing industry		Research and development		Other services		Total	
	abs	%	abs	%	abs	%	abs	%	abs	%	abs	%
1980	100	3	600	15	1,500	40	100	3	1,500	39	3,800	100
1985	450	3	2,000	13	5,900	39	750	5	6,100	40	15,200	100
2000*											68,400	

*For the year 2000 no division per sector has been made.

In the year 2000 the ultimate target number of jobs in Almere is 68,400, corresponding with a target population of 163,000 and a working population of 69,500 (economic activity rate 42%). An equilibrium is considered to be established when the number of jobs is no more than 10% lower than the working population.
This arrangement seems sound, considering the fact that in the nearby Amsterdam and Schiphol airport-regions the opposite is the case.
Great emphasis is placed in the 1978 report (and also in former reports) on the facilities to be provided for employment.
Experience has shown that the supply of readily available industrial estates, connected with a good transport network to the Randstad is vital for the successful attraction of employment. An employer looking for a site in Almere, can choose out of four types of industrial estates, namely: (Figure 2)

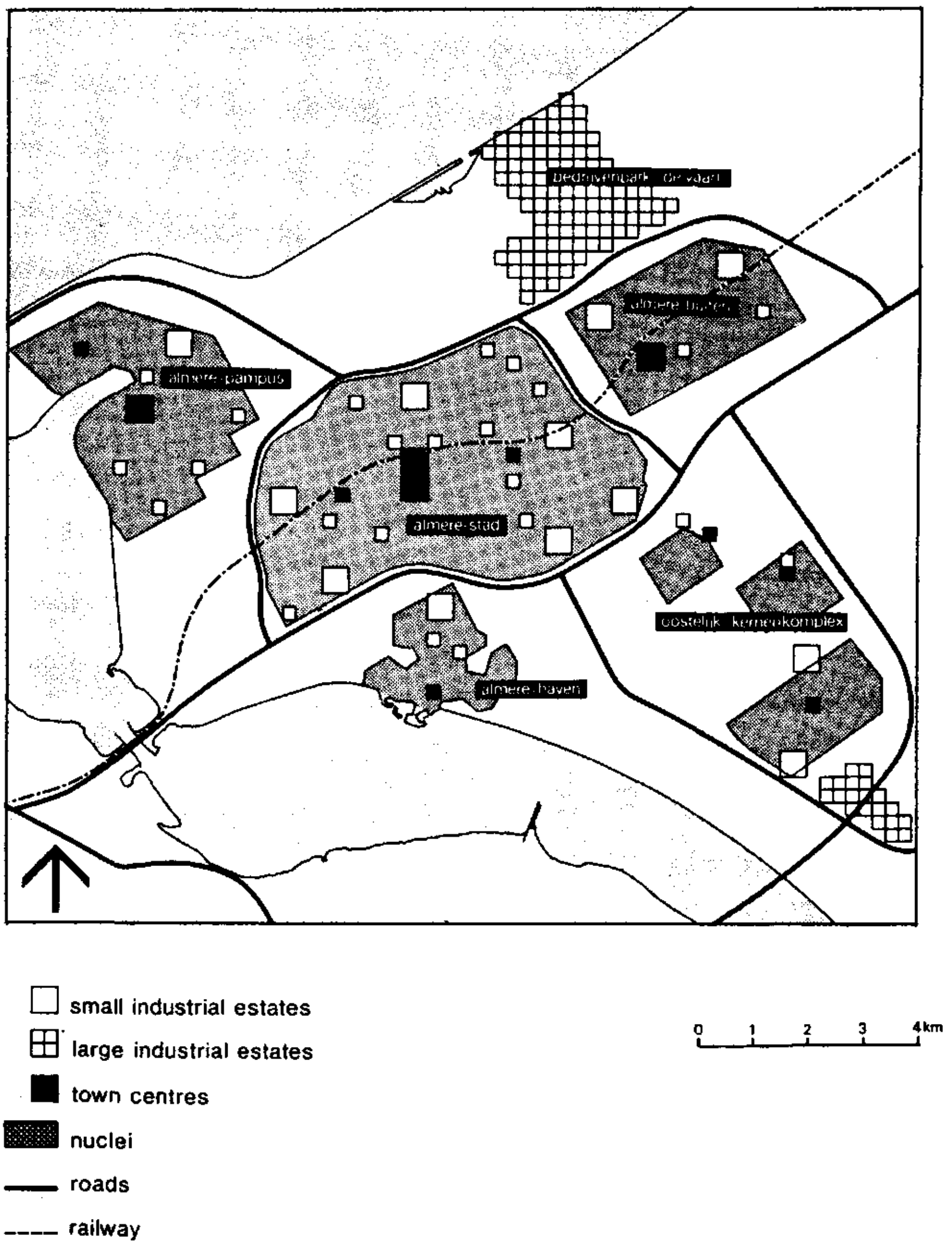
1. scattered small sites in or near residential areas;
2. small estates (< 10 ha) near residential areas;
3. estates, ranging from 30 to 50 ha, located on the outskirts of the nuclei;
4. large estates along waterways and along trunk-roads (from 60 to 200 ha);

and two other central locations:

5. locations in the town centre of the nuclei;
6. the main town centre of Almere in Almere-Stad (being developed).

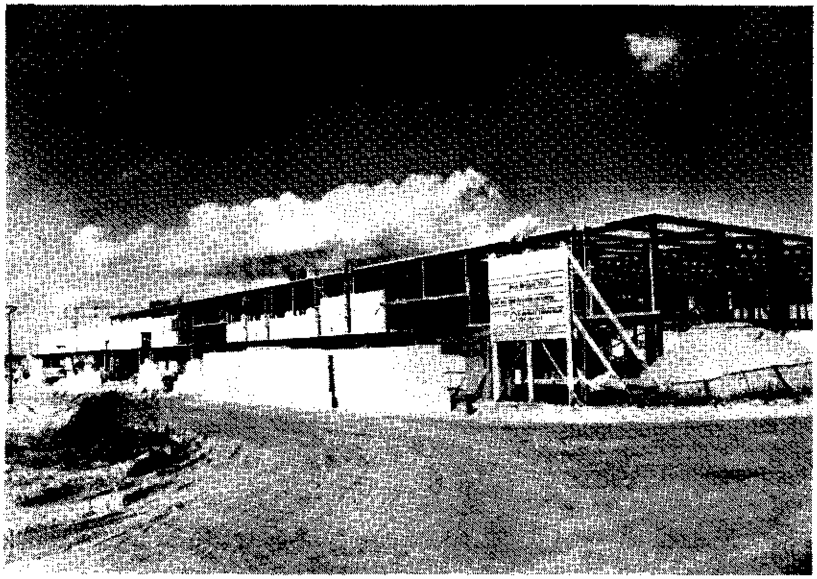
On the estates, advance-factories and nursery units have been built

Figure 2
Types of industrial estates and town centres in Almere towards the year 2000



to house entrepreneurs who have no time or money to build their own accommodation. (Figure 3).

Figure 3. Construction of advance-factories on the "De Steiger" industrial estate, Almere-Haven.

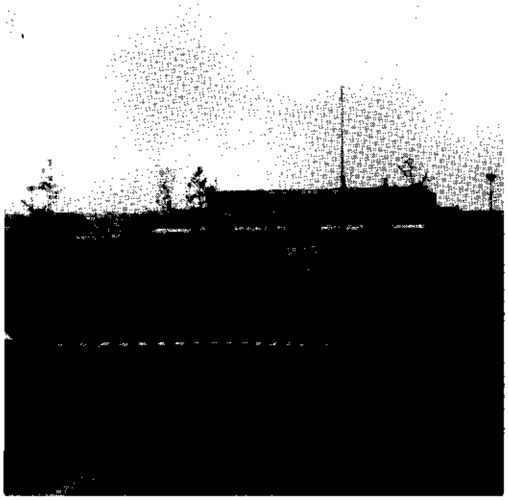


Newly established firms, with little capital, usually rent the nursery units, which are being let at a low rent in order to stimulate industrial development.

Advance office accommodation has also been built in the centre of Almere-Haven and in Almere-Stad.

Another type of facility built for the business community is a service centre on a large industrial estate (De Vaart) on the urban fringe. This service centre includes services such as a restaurant, a small bank, rooms to rent for business purposes and an information office. Planned are a postoffice and a petrol station as additional services. The provision of these above-mentioned facilities is a fairly recent development as regards the housing of industry in the Netherlands (Figure 4).

Figure 4. Service centre on the "De Vaart" industrial estate



The feasibility of a wholesale trade centre and a transport centre for road transport firms is under consideration.

Finally, although not necessarily part of employment forecasting, something will be said here about the financial incentives to settle in Almere, as this is an important item of the relative attractiveness of a new town to invest there.

From the start, Almere itself had no special financial investment premiums to offer, contrary to Lelystad. The reason being that Almere was so favourably located near Amsterdam and the Randstad and could offer fairly low industrial land prices, so that it probably would not need any.

In the years 1977/1978, the Dutch government introduced a series of investment premiums to stimulate investment in new towns, growth centres and other areas in need of industrial development. These premiums, which also apply to Almere, are called;

W.I.R. (Investment Account), R.O.T. (Additional premium for town and country planning purposes,)Kleinschaligheidstoeslag (additional premium for small scale enterprises) and Grote Projectentoeslag (Additional premium for major projects). All these premiums offer various grants, depending on the investment and the location.

3. Comparison between planned and actual number of jobs in Almere, as per 1980

As per 1st January 1980 there were more than 3,900 people employed in Almere. The target number of jobs on that date was 3,800.
Table 2 gives the detailed comparison per sector of industry.

Table 2. Comparison between planned and actual number of jobs, per sector, as per 1980

Sector	Target number of jobs	%	Actual number of jobs	%
Primary sector	100	3	420	10
Construction *	600	15	1,406	36
Manufacturing industry	1,500	40	739	19
Research and development	100	3	1,374 (Research and development + Other services)	35 (Research and development + Other services)
Other services	1,500	39		
Total	3,800	100	3,939	100

* Including construction not resident in Almere.

From this table it appears that the target number of jobs has been more than reached. The actual number of jobs per sector, however, did not correspond with the number of jobs planned.
Manufacturing industry was more difficult to attract to Almere than originally expected. This sector has been shrinking in the Netherlands for more than a decade, and most firms in this sector are reluctant to move in these hard economic times.
The primary sector, on the other hand, is very well represented in Almere. However most of the jobs in this sector are not found in the town of Almere itself, but in the rural area near Zeewolde, neighbouring Almere. For statistical reasons this area has been added to Almere.
The number of construction jobs in Almere is more than expected. At the moment, two nuclei Almere-Haven and Almere-Stad are being built

simultaneously, involving the construction of houses, offices, factories, schools and other facilities, all needed to make an urban environment. A large number of construction workers commute from neighbouring areas to Almere every morning.
The total industrial area available amounted to 153 ha, of which 76 ha had been distributed. This brings the average space per employee at roughly 200 m^2.
This chapter will be concluded with some remarks on commuting to and from Almere.
In the chapter on employment planning, is was stated that one of the goals had been to keep the difference between the number of jobs and employed persons in Almere at no more than 10%.
As per 1st January 1980, the number of people commuting to Almere amounted to 2,918 persons, most of whom came from the Amsterdam and Gooi-regions. The total number of commuters travelling from Almere each morning reached 1,418.
These large commuter streams into and out of Almere resulted from the fact that the total number of jobs in Almere (3,939) outnumbered the working population (2,499) of this new town, the difference (1,440) being 37%.
Allowance should be made however, when evaluating this aspect of employment planning, for the fact that these figures only relate to the first four years of employment in Almere. When the new town matures, it is likely that the difference between the number of jobs in Almere and its working population diminishes, although probably never completely. In other words, Almere is not likely to become a self-contained town in future, due to its proximity to Amsterdam (25 km).
This is clearly shown by the percentage of people who work and live in Almere, which was 41% in 1980 and 40% in 1981.

4. Employment prospects of Almere

As per 1st January 1981, the total number of jobs in Almere increased to 5,348, an increase of 1,409 jobs in one year.
The population at that time totalled 12,213 and the working population increased to 4,440. The difference between the number of jobs and employed

persons thus fell in one year to 19%, a remarkable change. As a result of this, the outgoing commuter traffic increased drasticallly to 2,497 (the year before: 1,418).

Incoming commuter traffic increased to 3576 (the year before: 2918).

The greatest increase in jobs occurred in the sector other services (519 jobs), followed by the sub-sector wholesale trade (306 jobs).

Employment in manufacturing industry increased by 153 jobs.

The percentage of women of the total number of jobs rose from 13% in 1980 to 16% in 1981. Most women work in the sectors wholesale trade and in other services. This increase is a sign that Almere is becoming a "normal" town, where office work is also represented.

The year 1980/1981 thus was a very good one for Almere, as far as employment is concerned.

Most of the increase in employment resulted from the migration of firms from the Amsterdam and Gooi-regions. In the Netherlands, as in Great Britain and elsewhere, industrial migration mostly takes place over a limited distance in order to keep markets and personnel (the average distance is 30 km).

As it takes approximately two to three years from the first contact made with these firms to the time they become operational in Almere, it is reasonable to argue that this large increase in employment in 1980/1981 was the result of efforts made to attract industry to Almere in 1978. At that time the recession with accompanying high interest rates had not yet hit the Netherlands.

Nowadays, firms are generally much more reluctant to move as a result of the depressed economy and high interest rates.

The latter are crucial in financing new buildings.

Some firms, which had already decided to move to Almere, cancelled this decision in 1981.

For the short-term period ahead, it is probably reasonable to argue that it will become more difficult for Almere to fulfil its employment targets.

This may be illustrated by the fact that as per 1 January 1982, the number of jobs increased by 1,071, as compared with an increase by 1,409 jobs the year before.

The employment prospects for Almere for the long-term look reasonably bright. With its central location in the Netherlands, near Amsterdam and

Schiphol, its efficient road network and future railway connection with the Randstad, its various types of industrial estates, advance factories and offices and the main centre of Almere-Stad for the greater part completed in 1986, Almere is equipped with all the necessary industrial infrastructure to face the future optimistically.

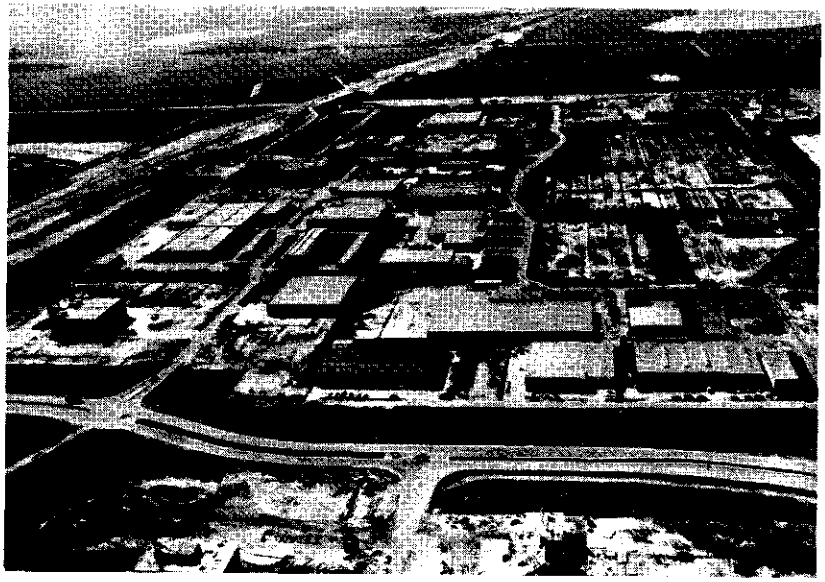


Figure 5. Aerial view of the "De Vaart" industrial estate

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NEW STRUCTURES IN NEWLY RECLAIMED LAND?

THE DEVELOPMENT OF SOCIAL STRUCTURES IN FLEVOLAND (IJSSELMEERPOLDERS) THE NETHERLANDS

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Abstract

The social and political reasons to create a new polder often have an intentional aim of improving the quality of life (q.o.l.) for the occupiers. The social structure has to be better than people are used to in the villages and towns they come from.
Sociologically a new society is developing but the elements of this society: individuals and families are not new. They take with them their "social luggage"; social structures and institutions they are used to. Are new social structures developing in the new land? Yes and no. Sociological research in the "IJsselmeerpolders" in the Netherlands proves that several attempts were made to change social structures. Some of the research gives answer to the question why attempts are successful and others are not. Most recent research in Almere indicates that the speed of development has a great influence on the development of social structures. This concernes both old and new structures, but the new ones are more sensible. The direction of the association will be clear: the faster the population grows, the less easy social structures will appear. The creation of facilities and of social structure are very

important instruments to improve the q.o.l. and to enlarge the feeling of belonging to the community. When the inhabitants themselves can influence the process they feel more "at home".
Sociological research is very useful to find out what kind of facilities and social structures are needed by the future inhabitants. This ought to be an integrated part of the planning of a new polder. If not, than it is probable that the new land does not improve the q.o.l. of those for whom the polders is reclaimed.

1 New land - new people?

Making a polder means: reclaiming land, creating something new. The word "new" is fascinating everybody concerned with the creation of it. The technician wants to create a better system of watercontrol in the polder. The farmer expects a better piece of land than he had before. He also expects higher yields. Modern infrastructure can be made. Economic structures can also be improved. In many cases the changes in social structures are a result of changes in economic aspects or of agricultural innovations. These innovations are seldom spectaculair because they must be supported by the inhabitants in the polder. Although the polder is a specific piece of land, the connections with the surrounding areas are obvious. So, even if it is political desirable, it is almost impossible to select people to live in a new polder in an entirely closed community. The new inhabitants in the polder also bring with them their own traditions and social structures; their "social luggage". This can be a mixture of structures that are common to different groups that settle in the polder, but they can seldom be radically changed in a certain direction.
Economy, agriculture and settlements are higly dependant on social structures. For instance, it is impossible to start a completely mechanised large-scale project in a polder when all inhabitants are used to a subsistence way of life. This is not only because they have a lack of knowledge, but also because economic and aften social structures are not ready for a big change.
Another conditions for social change is the homogeneity of the new settlers. They must be positive about changes and will have to support

them. Innovations can not be realised from the outside.
The immigrants must also be able to understand and to manipulate the social structures of which they are members. They must at least have at their disposal an élite to stipulate the changes.
In the case of a growing community the colonists must be able to make clear what new structures mean to the community. They must stimulate the new immigrants to cooperate.
One of the most important means to create new structures, of which we hope they will be an improvement, is the creation of a good quality of life. In this paper will be described what happened in Flevoland, especially in the new towns Lelystad and Almere.
Sociology as a science has three main tasks in the process of building and development of a polder and the improvement of the q.o.l.:

- Making a thorough study of the intentions and aims of the polder, in connection with the social structures of the future population.
- Advising in land use and service-building in the new polder to improve the quality of life.
- Evaluation of the q.o.l. and studying, describing and explaining the social changes that occur.

According to the three main tasks of sociology, the following questions will be answered in the second part of this paper:

- What are the aims of the polder, especially the new towns Lelystad and Almere?
- Which social structures can be expected?
- What are the means of the planning authority to stimulate and direct the development and to improve the q.o.l.?

In the third part will be evaluated what happened in Lelystad and Almere, the two new towns in Flevoland, one of the IJsselmeerpolders.
In part four conclusions will be drawn and the role of sociology in the planning proces will be evaluated.

2 A new polder is made for people by people

In 1957 the reclamation of Eastern Flevoland was finished and in 1968 Southern Flevoland was dry enough to start the development. We will mention to the two polders as "Flevoland". Lelystad has nearly 50.000 inhabitants and Almere has 22.000 inhabitants. Besides the new towns, Eastern Flevoland has three villages and in Southern Flevoland one village is under construction.

One of the main reasons to construct polders in the middle of our country was the need of land for agricultural purposes. In the sixties the need was added for more land for recreation and town building. The northern part of the "Randstad", especially Amsterdam needed a lot of space to build new houses as substitution for the old -and often very small- houses in the Capital. So, many inhabitants of Flevoland new towns are immigrants from Amsterdam (± 55%). Lelystad will have 100.000 inhabitants in the year 2000 and Almere will have 125.000 to 250.000 in the year 2000[1]. With this and more detailed information it is possible to answer the first question: for whom is the polder made and what are the social structures that can be expected?

In Flevoland the most important characteristics are:

- Room at last for different purposes: agriculture, recreation, nature and new towns.
- For Lelystad and Almere: presenting a good alternative for sub-urbanisation in the "Randstad".
- Possibility for everyone to rent or to buy a good house.
- Very fast development.
- Integrated planning: The government is responsible for demographic aspects, for town building, building, construction of amenities, infrastructure, agriculture, recreation etc.

The majority of the inhabitants of Lelystad and Almere will be immegrating from Amsterdam. Research in the Capital among 8000 families who were interested in moving to Lelystad or Almere learned that:

- they wanted a better house and neighbourhood than they were used to.
- they wanted a safer neighbourhood, both concerning vandalism and traffic.

- they wanted less noise and more and better outdoor recreation facilities.
- People that are most interested in moving to Flevoland were from upper lower class and lower middle class. A majority was between 20 and 40 years old.

The new towns in Flevoland had to face a structural problem. The reasons to leave Amsterdam are much stronger than the reasons to move into the new towns. Lelystad and Almere are, on the other hand, almost the only alternative to obtain a better q.o.l. The immigrants don't have the intention to build a new society in the new land. It can be expected that Flevolanders will like to create the same social structure they are used to in Amsterdam. They are focused on the single-family house and their own privacy. They expect to find good provisions in the new town and often do not realize that the provisions are dependent of the number of inhabitants. Social structures will be private-centred, more than community-centred.

In his book "The village in the IJsselmeerpolders"[2] Constandse describes the desirable characteristics of new rural culture in general. He states that town and country are both parts of one and the same global culture, but each forms its own subculture. He concentrates on the country, while we will concentrate on the town. But we can follow the main analytical process Constandse has taken, although he is far more comprehensive than we can be in this paper.

According to what we described above, the desirable characteristics of the urban culture in Flevoland, the "Leitbild" for planning, can be constructed. Town people must be offered a better quality of life than they are used to in their present settlements. All services must be available in the town itself. People must be able to work, to live and to relax there.

Social structures have been treated as a result of the planning proces. They have seldom been an important aim or goal by themselves. New social structures will not be offered. In part 3 will be analysed whether that was right or not.

3 Lelystad and Almere

3.1 Lelystad

Evaluation of what happened to social structures in Lelystad has been done on the basis of sociological research data.[3] The colonisation of the town area started with a lot of support of civil servants from the development "corporation" (Rijksdienst voor de IJsselmeerpolders; R.IJ.P.) and from those who were working at the electricity-plant that was built near to Lelystad. Many of them were directly concerned with development of the town itself and they were very active in starting community life. They felt "the colonists". Both in their working-time and in their leisure-time they were occupied in the development of their own town. The participation rate was very high. New initiatives were critically looked at from outside the polder. Very few of these initiatives were citically looked at from outside the polder. Very few of these initiatives were successful in the end.
The atmosphere changed when the immigrants from Amsterdam settled in Lelystad. Most of them were less interested in development of social life in the town. Many of them did not work in Lelystad, but had to t travel every day between their living- and working-place. Their participation rate is lower than that of the colonists. Despite this tendency to less participation in social structures, many of them changed their habits because of the new situation. Most of the change was a result of the better housing in Lelystad.
This tendency to less participation must not be interpreted very negatively. It was not very bad for the development either, because social structures were already settled and also the new inhabitants still produce enough support to what is established in Lelystad. But still, there are big differences between the two groups of inhabitants.

3.2 Almere

Almere consists of several nuclei, of which "Almere-Haven" has about 16000 inhabitants and "Almere-Stad" about 6000.
Before the first inhabitants settled, several groups were occupied in

preparing the new community. The groups consisted of colonists and advisors of universities, churches and professionalists, in particular social workers. They were very active during the first two years and started a lot of activities such as sporting clubs, churches, social work, etc. During this period they had a great influence in starting social structures which still exist. The first 100 inhabitants of Almere-Haven held 80% of the committee members in the first two years. After five years their influence has diminished, but the social structures they made are still there. One of the experiments they started was building one church and creating one structure for both Protestants and Roman Catholics. This was an experiment in the Netherlands, a pilarized country. The church functions quite well in the community but the structure is at moment less integrated than was the intention at the start. It changed under pressure of the religious inhabitants themselves.

At the start of the second nucleus, "Almere-Stad", no real colonists- people who prepared and started social structures- settled. Many provisions in the first nucleus were meant to be for both Almere-Haven and Almere-Stad, although the distance is about 5 kilometres. This does not mean that there were no provisions, but especially the non-physical provisions were settled in Almere-Haven. Therefore the start of community life was much more difficult than was the case in Lelystad or Almere-Haven. In Almere-Stad from the start most of the immigrants came to the new town for the reasons described in part two of this paper. Their intention was, and still is, to get a good house in a quiet surrounding and not to be active in community building. Without going into details, because this can be read in the reports of sociological research concerned,[4] conclusions can be formulated.

4 Evaluation and conclusions

In the process of preparing a polder for future inhabitants, it is very useful to formulate aims and goals concerning social structures: what kind of people are going to live in the new polder. The expectations of future inhabitants are concerning a better quality of life than they are used to. So, knowledge of the q.o.l. before immigration is essential and

sociological research can formulate in what directions the future inhabitants want to improve the quality.
Sociological research is able to advise in the planning process and must be part of it. A new polder attrackts new people, but they are only new in the sense of achieving a new community. People themselves are not new. They bring with them their own "social luggage" and so, their social structures. Experiments in (partly) new social structures are only successful if they are thoroughly prepared by the first colonists. When immigrants do not have the intention to help in starting community life, it is very difficult to get settled social structures.
The experience in Lelystad and Almere is, that improvement of the q.o.l. can be successful on one hand -better houses, better neighbourhood, safe and healthy living conditions- but on the other hand attention must be paid to non-physical aspects.
It is very important that people feel included in the new community. Especially when planning and construction are in the hands of one organisation, as is the case in Flevoland, attention must be paid to the development of social structures. When the speed of the development is as fast as in Almere (up to 2500 dwellings per year) unexperienced inhabitants are not able and often are not interested in developing social structures. Those who are able and who are interested in starting community life, often get into trouble because of too many different persons within the bureaucratic organisation. They have to take care of too many aspects of the very fast growing community. The speed of the development is too high for the volunteers.
The solution can be found in stimulating participation and involvement of the population:

- A small group of "first settlers" must be stimulated to prepare thoroughly on their moving to a new settlement. They must know exactly what will be the situation when they arrive and what can be expected in the future.
- The planning and creation of many of the provisions must be dependent of what the inhabitants actually want. In their effort to get a community-house or a children's playground they will have to work together to get the provisions they need badly.
- The development organisation must place at the disposal of the inhabi-

tants a small team of specialists with permission to decide about what can be done by the inhabitants. They can decide about both provisions for the community and about non-physical aspects of community life.
New social structures can only survive in newly reclaimed land if they are the result of what the inhabitants themselves want to create.

Notes

[1]For a map of Flevoland and its surroundings see the paper of: Spierings, M. "Urbanization in Dutch polders; the evolution of the Randstad conception".

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SHOPS AND SHOPPING CENTRES IN THE IJSSELMEERPOLDERS

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Abstract

One of the tasks that the IJsselmeerpolders Development Authority fulfills in colonizing the polders is the planning and realisation of shopping facilities. The method of planning and realisation of shops in the polders since 1930 indicates that there has been a notable development as well in national legislation as in the practical application on this field in the polders.
However these developments did not follow the same track. In fact it can be stated that the developments in the polder were, forced by the special circumstances and the experiences from the past, far ahead of the developments in this field on national scale.
For instance, in 1972 an act became operative by which it became necessary to carry out a distribution research when a structure plan or land use plan was to be made. The IJsselmeerpolders Development Authority used this kinds of research already when in the Forties the planning and design of the North-east Polder was at hand.
There are not only set rules in relation to the location, number and size of the shops in the new polders. Also the composition of branches is closely analysed and kept in sight, especially at the start of the developments in the centres of the new towns and villages.
When the size and number of the different branches people need is

fixed, shopkeepers are selected and they get a contract for a special branch of shopping. And without agreement of the Development Authority it is not permitted to deviate from that branch in the first years of the existance of the shop.

1. The situation of retail trade in general until 1937

Personal freedom and tolerance have always been main characteristics of mentality in the Netherlands. This is for instance expressed in the liberal spirit in which private initiative and free enterprise played an important part. Interference from the side of the government in this field was seen as something bad. However this 'laisser faire' principle could lead to undesirable situations in which governmental authorities were forced to intervene in order to prevent chaos in the economic household of society.

A good example in this matter is to find in the development history of retail trade. Until 1937 anyone who wished to do so could start a shop, when and where he wanted to. There were no conditions set to that. During the depression that started in 1929 this lack of conditions had a disastrous impact on the general structure of retail trade. The enormous unemployment combined with the low standards of social security caused great masses of people who had hardly any income. A lot of them tried to bring their income on a higher level by starting a shop of some kind.

Most of them did this without any knowledge on the basic principles of retailing and without enough money to create a sound economic basis for their business activities. As a result most of these shops did not last very long; they disappeared and others took their places for even such a short time. But in the mean time they did great damage to the established retail trade. These 'real shopkeepers' suffered from the (mostly false) competition of all those dabblers and sometimes could not hold out.

In 1937 the government wished to make an end to that situation because it wrecked the whole structure of retail trade. A law was enacted that set conditions to people who wanted to start a shop. It was an indirect way to set bounds to the quantity (and quality) of shops because the act did not apply to the shops itself. It conditioned only future shopkeepers in the sence that they had to have professional knowledge of the branch, enough commercial knowledge in general and they had to be sufficiently solvent. In no way there were rules set to the number, size or allocation of shops because, as was stated in the Parliament, that would contravene the principle of personal freedom.

2. The first polder

In those years and under those circumstances the first of the IJsselmeerpolders, the Wieringermeerpolder, was reclaimed in 1930. At that moment the Act on the establishment of small businesses of 1937 was not yet in operation.

So retail trade in the Wieringermeerpolder was free. The only statement that was to be found on the allocation of shopping facilities in the new polder said that it was to be expected that settlements of people would arise on the main crossings of roads and canals and that possibilities had to be created for the establishment of shops. And that was all there was said to it.

For the government, represented by the Development Authority, the most important goal was to create a polder in which farmers could live a good life and all aspects of colonization were subordinate to that goal. There were hardly any plans made concerning the building of villages and there were no plans concerning the building of schools, medical provisions, shops and all the other amenities we nowadays concern elementary. It was thought that when there was a need for some amenity or another it would establish itself.

As far as shopping facilities are concerned that proposition worked too well. Under the pressure of the economic crisis of the thirties a lot of people came to this new part of the Netherlands to try their luck by starting a shop. Everybody had the right to do so and the government had to give the opportunity.

After a short period of time there were in the Wieringermeer a great number of shops of all sorts and types and most of them without a reasonable basis of existence: apart from the fact that a lot of the shopkeepers did not have enough professional knowledge of their branch, the number of shops was not in the least in proportion to what the people living there needed. As a result many of those shops went bankrupt in no time and for a long period of time there was a chaotic situation during which supply and demand were completely out of balance.

3. Development in national legislation

The act of 1937 by which conditions were set to individuals who wanted to start a shop, was followed in 1954 by a new one. But in this act also nothing was said about the element of supply and demand to set limits to the number and size of shops in a certain area or region. As far as that was concerned it did not differ from the 1937 act. And the law that was enacted in 1974 did not mention the element of need and supply either. That act did not apply to small business in general but specifically to retail trade.
However in the meantime it had become more and more clear that it was necessary to guide and regulate developments in retail trade regarding quantity and allocation. And according to the principle of need and supply. In a defined area or region the total amount of square metres had to be in balance with the demands people living in that area or region had. Developments had to be planned in order to keep them within certain limits and had to be guided along set lines.
After the Second World War the authorities in the densely populated and almost overcrowded Netherlands were continually confronted with the task to regulate the use of the scarcely available space. In 1962 that task resulted in the Physical Planning Act. A special Decree in relation to that act was promulgated in 1965 and it stated that (on a local level): 'burgomaster and alderman shall institute an inquiry into the existing conditions and into the possible and desirable developments of the community in the interest of the proper utilisation of space in the areas occupied by that community'. And on that basis the local government will produce plans for what is likely to take place in the community and will draw up structure plans and land use plans.

The development in national legislation made it possible form 1976 on to make plans in which the establishment of retail trade facilities depended on the elements of need and supply. For from then on the Decree proscribed an inquiry into the necessity and volume of shopping facilities and, based on the research results, in the land use plans defined areas were designated in which it was allowed to establish shops. And it forbade to realise shopping facilities outside these designated areas.

4. Developments in the polders since 1945

Although the North-east Polder fell dry in 1942, the real colonisation started not before World War II was ended. The experiences in the Wieringermeerpolder had learned that the colonization policy had to be radically changed. The circumstances in the new polders were obviously quite different as they were on the 'old land'. Establishing and organizing totally new communities had to be planned very carefully. That also applied to the establishing of retail trade. From that moment on the method of planning and realisation of shopping facilities in the polders deviated principally from what was usual and allowed elsewhere in the Netherlands. But because of the very special circumstances in the polders the national government which carried the ultimate responsibility did not oppose this planning policy. In short this method concerned the application of demand and supply through which shopping facilities were established. Of course at that time it was a rather primitive method because there was hardly any know-how available on the field of distribution planning, but on the other hand one must not forget that it was put into practise some 20 years before it was common use in the Netherlands. And the planning may have been simple and not quite perfect, it was effective in the sense that the chaotic and unbalanced situations of the Wieringermeer did not exist in the North-east Polder and that developments could be kept in sight and could be to a great extent regulated.
Because the establishing of retail trade could not be regulated according to public law, the Development Authority used the private contract with the individual shopkeepers as a planning instrument.

Establishing shopping facilities went as follows: as soon as the building of villages started and people settled down the first shops were established. The shops were built by the Development Authority and let to thoroughly selected shopkeepers. And only those shops were realised which fulfilled the most elementary needs of the inhabitants. For instance a grocery, a butcher, a bakery, a green-grocer, a dairy-shop, a mechanic (annex blacksmith in those days), a shop for domestic utensils and a general textile-shop. Because the number of inhabitants increased only gradually, in the starting period the extent of sales were too low compared to the costs. So at first no profits were made at all. The shopkeepers who wanted to rent a shop were, among others, selected on the condition that they had a sufficient financial background to hold out untill sales were at a profitable level. From the side of the authorities established shops were protected against competition. There were no shops in the same branch accepted untill the number of inhabitants was great enough to make both shops profitable in the exploitation. So the number of shops and the total amount of square metres was sufficient to meet the need of the inhabitants on the one side and, after a starting period, guaranteed the shopkeepers a reasonable income on the other.

At first this method of planning and realising amenities was only based on general experiences in practise. The theoretical side of it would be developed as time went by and it took quite some years before it was shaped into the distribution planning theory we work with today.

In fact the theory was built from the practical experiences of shopkeepers and their customers. That was the starting period of distribution research. The accountancies of the shopkeepers were evaluated in order to get some knowledge of the developments in sales and the turnover per square metre shop-space. Surveys were held among retailers and inhabitants of the polder in order to get knowledge of shopping habits and the amount of money people spent in shops; and where they spent it.

The results from those surveys, when confronted with the economic results of the established shops gave insight in the accuracy of the establishment policy in retail trade.

In the fifties such surveys were for instance carried out by A.K. Constandse and the Economic Institute for the Small and Middle-sized Businesses.

As a conclusion it can be stated that during the colonisation of the North-east Polder gradually a policy was developed to establish retail trade facilities in a responsible way based on theoretical principles.

5. Distribution-planning and distribution-research of today

In order to be able to draw up a policy it is necessary to construct theoretical models by using the results of evaluating research. And to project these models on future situations. During the period that the policy is carried out research has to be done in order to test the validity of the theoretical models in practice and to make adaptions when necessary.

During the colonization of Eastern Flevoland and the realisation of Dronten and Lelystad a theoretical model on the establishing of shopping facilities was used which was based partially on own research results and partially on nationally known figures.

This model contains the following elements:

- the number of inhabitants living in a defined area;
- the average amount of money that is annually spent in shops per head;
- the percentage of that amount that is annually spent in shops in the own town or village (the purchasing-power-percentage);
- the annual turnover per square metre shop-space that is necessary for a shop to function profitably.

In this model a distinction is made between food shops and non-food shops. With assumptions on growth or decline of the elements above it is possible to determine at any moment in the future the amount of square metres necessary for shopping facilities in the defined area.

To complete the model there are two more steps to take. First the allocation of the shops and the size of the different concentrations of shopping facilities. And second, in close relation to the first step, the determination of the different types of branches and kinds of shops.

With the help of the above constructed model it is possible to carry out a policy in which the realisation of shopping facilities will be in the right proportion to the size and structure of the population; at any time and any place.

So to recapitulate there are two planning instruments at hand in the establishing of retail trade:

- the described model with which it is possible to determine the floorspace;
- the structure plans and land use plans in which the sites where building of shops is allowed, are indicated.

Planning shopping facilities in new towns is a very complex and difficult matter. Especially in the newly reclaimed polders because it is not possible to refer to comparable situations elsewhere. It is not know beforehand what the structure of the new population will be, how they will act in the new situation and for what time their relation to the former place of residence will be so strong that it influences their shopping habits. And apart from that there are a number of independent variables which can cause a difference between shopping habits in the old and the new situation: mostly housing rents are higher in the new towns, more money is spent on travelling, economic developments in general can play a part (as is the case in these days). All that facts can lead to a lower shopping budget in the new situation and that will have consequences for the planning of shopping facilities in new towns. The only way to get some grip on the situation is by evaluating regularly the results of the planning policy. In the IJsselmeerpolders that is done for instance by means of surveys every two or three years. Experiences of inhabitants, customers and shopkeepers are gathered to see if up to that moment the planning targets are reached.

When new towns are growing fast (as is the case in Lelystad and Almere) the time between the surveys has to be relatively short in order to get a continuing and reliable picture of the way amenities are used and judged by people. So much the more because changing or adjusting the plans does take time. That is inherent to the way in which shopping facilities are realised: not one shop after another but in large proportions and mostly as (important) parts of large-sized and complex multi-functional town centres. The planning and realisation of such amenities normally takes three years or more and so do changes in planning.

In Lelystad since 1974 four surveys are carried out to evaluate the functioning of shopping facilities in town (1974, 1976, 1978 and 1982). In 1974 there were about 12.000 inhabitants and some 10.500 square metres

of shop-space; in 1982 there were 48.000 inhabitants and about 45.000 m2 of shop-space.
The results of those surveys show a certain line of development concerning shopping habits. For instance in the amount of money people spent in shops outside Lelystad: in 1974 that was in the food-branch 31% and in the non-food branch 56%. Reasons were to find in the fact that, with a population of just over 10.000, the level shopping in Lelystad was not yet very high. No big department stores and no speciality shops. And another reason was that in the first period after moving people tend to have still a strong relation to the old place of residence. And when they go back to visit friends and relatives, they also go shopping in the shops they know. The fact that most of the out of town shopping was done in Amsterdam stated that conclusion: as a result of the overspill policy many of the inhabitants of Lelystad come originally from Amsterdam and they visit Amsterdam frequently or go there every day because they work in Amsterdam. The results of the surveys carried out in 1976 and 1978 indicate that the amount of money people spent in the local shops increased: in the food-branch up to 93% in 1978 and in the non-food branch up to 63%. The percentage of purchasing power that drained away decreased but it is remarkable that the position of Amsterdam stayed on the same level. Unfortunately the results of the most recent survey are not yet available, but it is expected that as far as the non-food branch is concerned the trend is to be continued and the food branch has reached the maximal level of binding. In the non-food branch the drainage will decrease as a result of an increase in shopping facilities quantitatively as well as qualitatively. Amsterdam will probably hold a strong position in the orientation of shopping, but less strong as before, among others as a result of the economic depression of this moment.
In general the results of the surveys indicate that the policy concerning the establishing of retail trade was relatively successfull. And that the users of these facilities judged likewise.
In Almere, the new town in the most recently reclaimed polder (Southern Flevoland) surveys were held in 1979, 1981 and 1982. The results point into the same direction as is the case in Lelystad: a decreasing of drainage in shopping as the available shop space increases. In general need and supply of shopping facilities are in balance and when people complaint about a shortage of shops or low service levels that is

because their expectations are too high strung. It is not reasonable to expect very specialized shops or big department stores when the number of inhabitants does not meet certain standards.

6. Conclusion

Developing and realising a planning policy in retail trade can only be successfull when the original starting points are constantly tested and evaluated by means of distribution research. Especially in completely new situations the experiences of the users of shops are of great importance for the planners. Because that is the every day reality they will have to take into account. And to which they will have to direct the plans.

Since the late forties the Development Authority in the IJsselmeerpolders do evaluate their plans and is using research as a planning instrument. The distribution planning research with its long tradition in the IJsselmeerpolders has proved to be a very useful instrument with which the needs of the present and future population can be fulfilled in a flexible and efficient way.

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THE REGIONAL ECONOMIC POLICY IN THE NEW TOWNS ALMERE AND LELYSTAD

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Abstract

The main function of Lelystad and Almere is to relieve the overcrowded conditions of the Randstad by offering housing-facilities. This goal however is not to make dormitory towns, but to create a living environment that can meet both the housing and the job needs of the growing populations. To date efforts to increase the employment-base have focused on attracting existing firms from the old land to the polders. Two developments however have forced the authorities to reconsider this policy. First, firms willing to relocate to the polders require different job-skills than those of polder-residents. The failure to match jobs and skills forces polder residents to commute to the Randstad for jobs. Second, general poor economic conditions make it very costly for firms to move from one place to another.
Therefore the polder-authorities have to find new ways to create a balance between working and living in the new towns. Our primary focus at the moment is the structure and situation of the Dutch economy and to find implications for the regional economic policy. If we look at the comparative advantages of industry in Flevoland, the introduction of highly specialised knowledge in the production process is possible and of great value. Especially, small and medium sized enterprises have a major task in the economic development and employment of the polder region.

1 Introduction

For social and economic reasons an important starting-point of Dutch physical planning for the last 10 years is to reduce the distance between residential and work-areas and to limit further rise of population-mobility as much as possible. This starting-point recurs in the growth-centre policy. In the selection of the location for growth-centres, attention is paid to the access of existing or new means of public transport (travel time should be no more than 25 minutes) and the infra-structure to create a sufficient amount of employment.
This policy implies a short distance between the donor-cities and the growth-centres and a good climate for economic development. Map 1 shows the present situation of the economic core and fringe areas in the Netherlands.

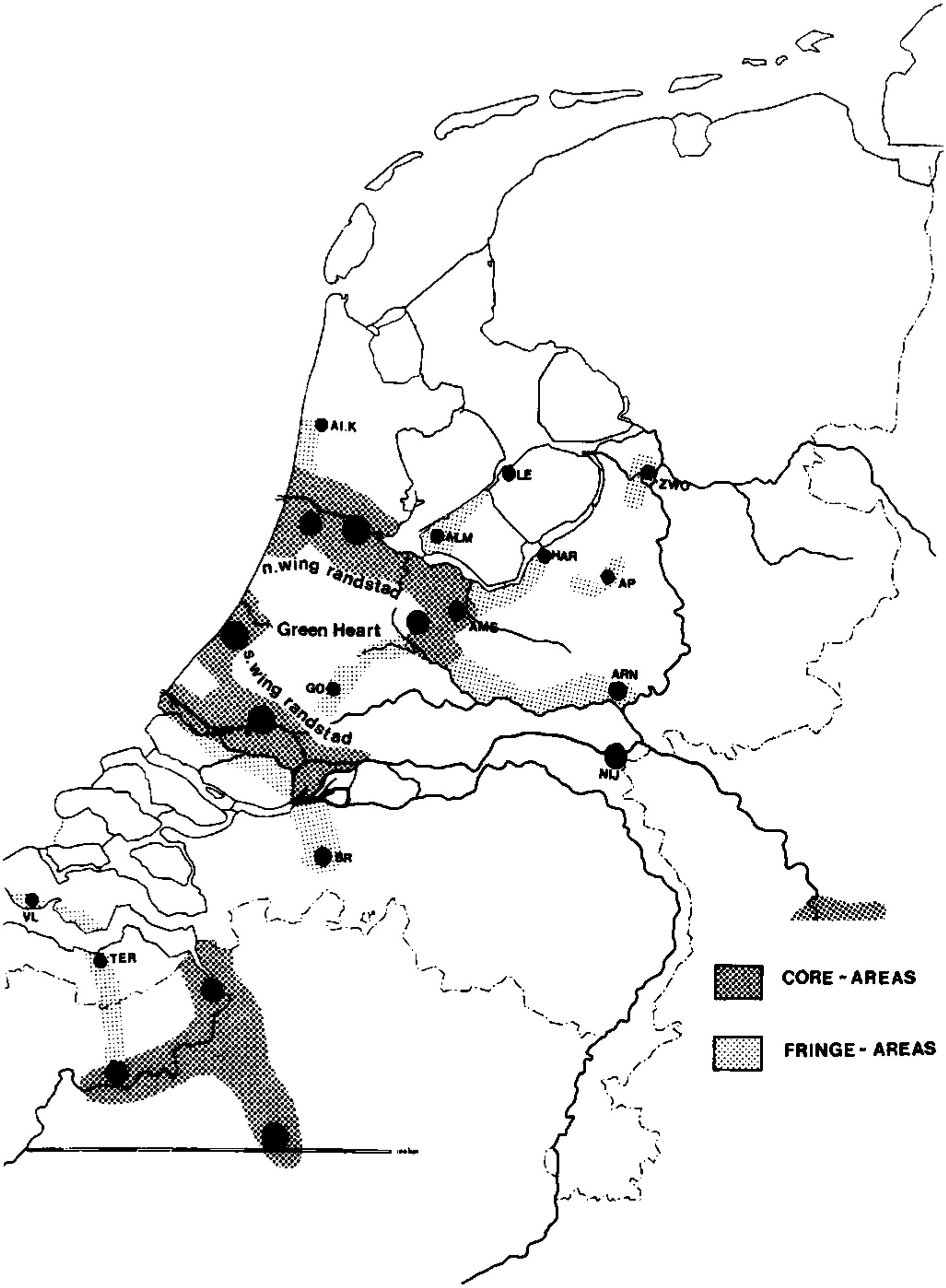
On the base of above principles the designation of Almere as a growth-centre is obvious. The distance to the donor-cities in the northern wing of the Randstad is about 20 km. Although the distance of Lelystad to the same donor-cities is about 60 km, it still lies within the Randstad sphere of influence. For that reason the contribution of Lelystad to relieve the Randstad of the considerable housing-problems is important.

In this paper the economic consequences will be analyzed. The present situation will be described as well as the conclusions for the regional and economic policy for the short and longer term.

2 The present economic situation of Lelystad and Almere

To create a sufficient amount of employment Lelystad and Almere up till now strongly relied on the shift of enterprises from the old land, in particular from the Randstad. For years this policy was very successful. Shortage of space, congestion and a huge restrictive regional and local business-policy led to a situation in which expanding firms were forced to look for new sites outside the Randstad. Due to their social, economic and spatial amenities Lelystad and Almere became attractive alternatives.

Map 1 Present economic core and fringe-areas in the Netherlands



However, the last few years, the willingness of the entrepreneurs to set-up an industrial firm in the polders has declined. Some reasons for this can be mentioned.
First of all the economic recess and the unfavourable prospects. They have contributed in reducing the urge of making great investments on new sites considerably. Secondly the collapse of the real-estate market due to which the opportunity of getting a good price for the old premises has become little. Finally the fear of most donor-cities to affect the production level. This fear is expressed in offering new industrial set-up facilities against better conditions than before within the local-bounds.

This development has consequences for the population-employment equilibrium.
Table 1 shows the difficulty to maintain this equilibrium. In Lelystad a negative relationship occurs since 1977. Up till now the balance for Almere was still stable but likely Almere will also face with negative figures in 1982.

Table 1. The development of labour-force and employment in Lelystad and Almere during the period 1-1-1971 till 1-1-1981

	Lelystad		Almere	
year	labour-force	employment	labour-force	employment
1971	1.317	1.840	-	-
1972	1.946	3.177	-	-
1973	2.633	4.498	-	-
1974	3.488	4.575	-	-
1975	4.483	5.177	-	-
1976	6.355	6.517	-	-
1977	7.980	7.407	27	723
1978	9.747	8.024	583	1.486
1979	11.828	8.770	1.525	2.139
1980	12.951	10.037	2.499	3.939
1981	14.355	10.437	4.440	5.348

Due to this quantitative stay-behind in the development of employment, commuting between above two cities and the Randstad appears. Although extensive streams of commuters characterize Lelystad and Almere from the beginning.

Initially, this was a result of qualitative descrepancies between supply and demand of labour. This originates in the essential task of the growth-centres Lelystad and Almere, viz. paying a contribution to solve the housing-problems in the Northern wing of the Randstad. Only a small part of the available houses is directly reserved annually for the employees of the companies removed from the over-flow areas.
Table 2 shows the commute-balance for Lelystad and Almere.

Table 2. Incoming and outgoing commute in Lelystad and Almere during the period 1-1-1971 till 1-1-1981

	Lelystad		Almere	
year	incoming	outgoing	incoming	outgoing
1971	1.050	500	-	-
1972	1.682	370	-	-
1973	2.184	270	-	-
1974	1.732	565	-	-
1975	1.855	1.233	-	-
1976	2.427	1.926	-	-
1977	2.699	2.980	696	-
1978	2.660	3.990	1.325	392
1979	2.680	5.222	1.532	866
1980	3.230	5.648	2.918	1.418
1981	3.330	6.306	3.576	2.497

Above situation occurs in most growth-centres in the Netherlands (see appendix 1).

The economic characteristics are the main reasons why the advantages of the growth-centre policy is increasingly questioned, although targets never have been set in this respect. Speaking of Almere, this development should not be considered as critical, thanks to the short distance to be overbridged to the industrial areas in the central cities. As far as Lelystad concerns the situation is less favourable but this town achieved the targets with respect to the primary housing function.
Terminating the growth-centre function of Lelystad would be unwise at the moment. Apart from the great investments made and the continuing need for houses which hardly can be fulfilled elsewhere, there are some hopefull aspect. Firstly the growing population trough which the labourmarket becomes more differentiated. Secondly the possible reclamation of the last polder in the area: the Markerwaard. Finally the assignment of Lelystad as capital town of Flevoland no doubt this will have a positive effect on the employment situation in Lelystad.
Further on the main reason for the present situation is the economic recess. A study, which was published recently shows that both centres have an attractive business set-up climate, compared to other towns with overspill characteristics near the Randstad. Eleven cities (appendix 2.1) were researched on the aspects relevant to in-coming companies. By multiplying the weights given to these aspects by the chosen firm categories with the seperate characteristics under each heading for each town (appendix 2.2) and adding the results a town league table was constructed (appendix 2.3). Each seperate characteristic scored on a rating of - 1(-), 0(0), 1(+), 2 (++) or 3(+++). Although there are some imperfections in this approach it might be clear that the business-climate in the polders is very good. The town-table places Almere as the best location for every group, while Lelystad usually forms part of the top-four.
No doubt the pressure in Flevoland will increased after the recovery of the economy.
However a re-consideration of the business promotion-policy on short and medium notice is an asset. The growing need for employment, especially among the young people forces the local government to create more jobs. Lelystad makes it it's aim to limit the difference between population and employment to 15%. This policy means creating more than 1700 jobs every year. Before going further into what will or can be done, attention will be paid to the possible importance of Lelystad and Almere

on the long term.

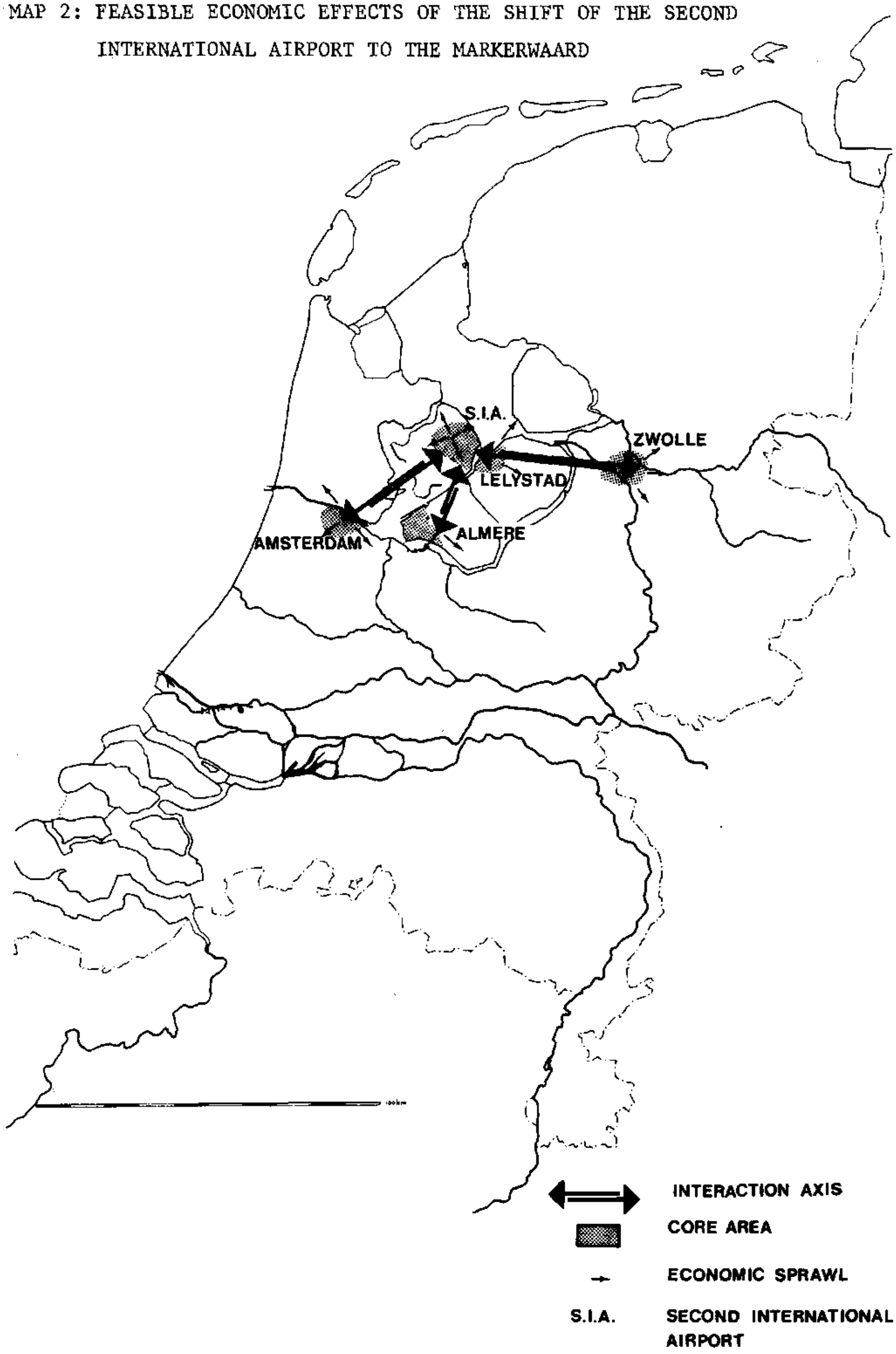
3. Regional-economic prospectives of Lelystad and Almere

The structures of the polders in Holland are strongly determined by the bottle-necks experienced on the old land, especially in the west. This will also be valid for the Markerwaard.
One of the bottle-necks for which the Markerwaard can contribute to a solution is to secure the economic position of the Randstad. To secure this position, consolidation, re-structure and modernizing the production-possibilties are obliged.
The answer, whether this can be fully realized within the present urban zones in the Randstand is uncertain, taking into consideration the lack of space and limited capacity of the environment. This mainly applies to the large-scale activities, such as expension of the international air-port Amsterdam-Schiphol. Shifting large-scale activities from the Rand-stad inwards (Green Heart) conflicts radically with the policy of not involving the open central areas of the Randstad in the urbanisation. This is one of the reasons why the Markerwaard is pointed out by the Government as a location for an eventual new international airport. Realization in the Markerwaard means maintenance and furtherance of the concentration of employment in the Randstad and growth-centres outside of the northern wing.
Another reason is the location of the Markerwaard with respect to the structually weak regions in the north and east of the Netherlands. One of the targets of regional economic policy is also strengthening the economic position of those regions. By the construction of large-scale activities in the polders, like this airport, Flevoland and its centres Almere and Lelystad could become valuable stepping-stones. On map 2 cartographic explanation of the subject is given.

4. Regional-economic policy on the short and medium range: From the shift to the development of enterprises

Due to the current economic situation western economics - like the

MAP 2: FEASIBLE ECONOMIC EFFECTS OF THE SHIFT OF THE SECOND INTERNATIONAL AIRPORT TO THE MARKERWAARD



Netherlands - are forced to change their economic policies. Maintenance of the level of prosperity necessitates the manufacture of technologically highly advanced products. Only methods which acquire highly specific knowledge open new prospects. Especially small enterprises which concentrate on highly specialised products and small markets offer good perspectives. Also on a regional level a change in economic policy is needed. More strictly than in the past Almere and Lelystad should put emphasis on the potentials of the polders, instead of the shift of enterprises from the overcrowded Randstad, because - especially in a period of stagnation - this has no significance what so ever from a macro-economic point of view. Until now the use of regional resources has been neglected. The first steps into a new approach have been made. For instance, the co-operation between the section Research and Business Settlements is a fact.

An effort is being made to stimulate business activities by means of so called action-research. The main comparative advantages which could be developed with action research are:

- space available, in the economic heart of the country;
- the highly specialised knowledge which is on hand in several institutions in the polders; and
- the dynamic growth of the population.

The "Rijksdienst voor de IJsselmeerpolders" has expertise in the field of building, town planning, development of agricultural areas and the establishment of enterprises. This expertise has already been used in international projects in which the Rijksdienst takes part. In the past the Rijksdienst due to its extensive and many sided research-apparatus attracted highly qualified enterprises.

In the area of bio-technology this concerned among other things the laboratories of the Agricultural University Wageningen.

Industrial application of the results can be expected in the near future. Another example of an area of technology acquiring highly specific knowledge is the proto-type project which at the moment is being developed in co-operation with T.N.O. in Delft. A third development is connected with the favourable location of Flevoland in relation to the Randstad. At the moment preparations are made for the establishing of a

trade centre for computers in Almere. In this centre all know-how on hard- en software is brought together. In this project the Rijksdienst co-operates very close with the Dutch computer industry.
Finally: a business-centre has been founded in Almere by the Rijksdienst in co-operation with a bank of commerce. In this centre some thirty small enterprises will be established; supervised by an expert manager with regards to starting-up problems. In the frame-work of improvement of the causes of survival of newly established enterprises a course for new undertakers will be designed.

5 Conclusion

The Rijksdienst for the IJsselmeerpolders tries to stimulate an regional economic development which agrees with the desired structure of national economy in the future. In this structure these are the enterprises with good outlook and which can create and maintain employment. Instead of the shift of enterprises selection has to take place, according the before mentioned criteria.

REVIEW ECONOMICALLY ACTIVE POPULATION, EMPLOYMENT CAPACITY AND COMMUTING (In/Out).

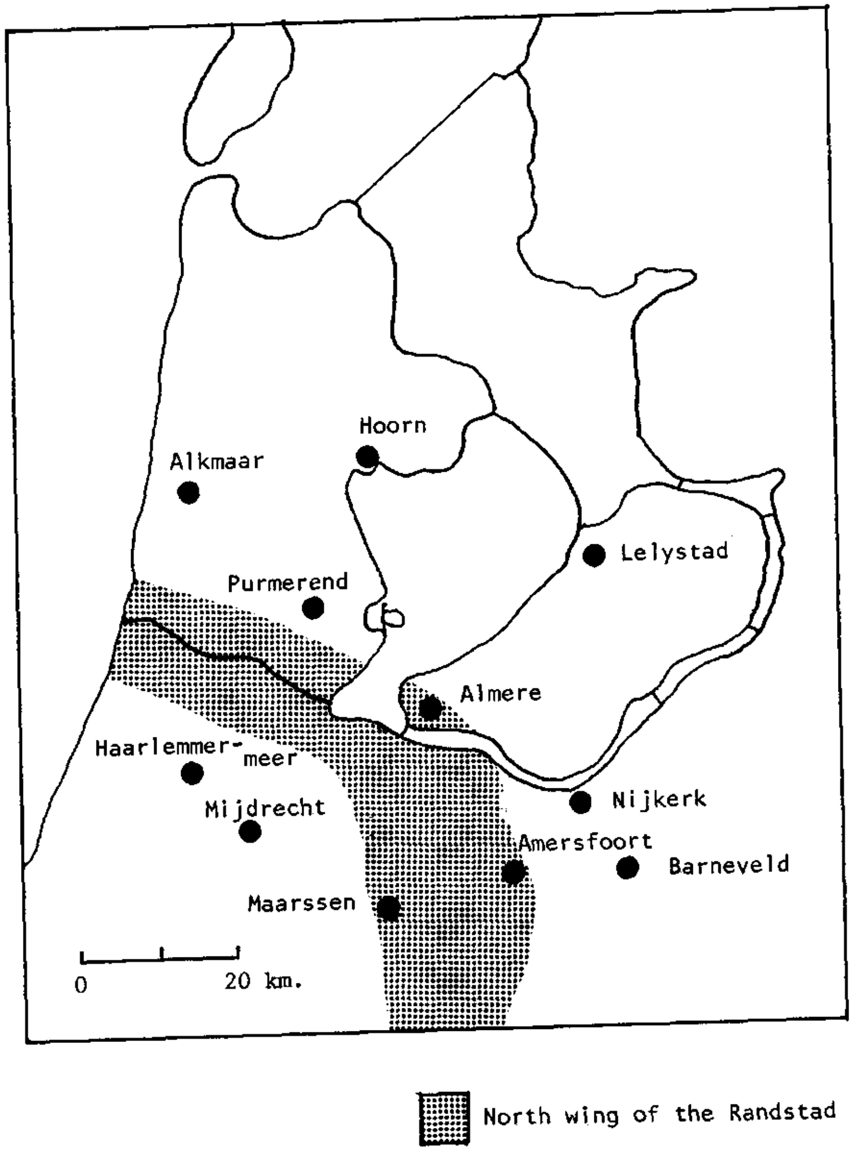
GROWTH CENTRES AND GROWTH CITIES

Municipalities	Year	economically active population	emloyment capacity	commuter flows			
				outgoing (o)	in %	incoming (i)	balance
Growth centres:							
Alkmaar	1978	27,500	21,500	10,000	36	11,000	1,000 (I)
Hoorn	1978	13,130	13,133	5,859	45	5,862	3 (I)
Purmerend	1978	12,800	6,600	8,700	68	2,800	5,900 (O)
Almere	1978	577	1,486	386	67	1,325	939 (I)
Lelystad	1978	11,800	8,800	5,200	44	2,700	2,500 (O)
Huizen	1978	11,100	6,250				appr. 4,600 (O)
Nieuwegein	1978	13,400	6,178	10,562	79	3,370	7,192 (O)
Houten							
Capelle a/d IJs.	1978	16,000	appr. 6,000	10 to 11,000	63	(small)	10,000 (O)
Spijkenisse	1978	12,600	7,000	7,300	63	1,900	5,400 (O)
Hellevoetssluis	1978	6,500	appr. 3,400				2,900 (O)
Zoetermeer	1978	20,000	9,000	13,000	65	2,000	11,000 (O)
Growth cities:							
Groningen	1976	56,000	69,000	12,000	21	25,000	13,000 (I)
Zwolle							
Breda	1976	appr. 22,000	50,231				
Helmond	1977		appr. 14,000				appr. 500 (O)

Source: Growth-centres and growth-cities, Ministry of Housing and Physical Planning, 1981.

APPENDIX 2.1

LOCATION OF THE EXAMINED MUNICIPALITIES



APPENDIX 2.2.

MATRIX OF LOCATION FACTORS:	Weightings given by: Printing Industry	Metal Industry	Wholesale Trade	Services	Small Firms	medium-sc. firms	large-sc. firms	Valuation gained by the municipality of: Alkmaar	Almere	Amersfoort	Barneveld	Haarl. meer	Hoorn	Lelystad	Maarssen	Mijdrecht	Nijkerk	Purmerend
LABOUR MARKET	4,2	4,9	3,5	3,7	3,7	3,6	5,0											
-size of labour force	3,6	3.1	2,2	3,2	2,5	2,6	3,3	+++	+	+++	++	+++	++	++	+	+	+	++
-% employed females	2,4	1,7	2,1	3,0	2,0	2,3	2,2		+++	+++	+	+	+++	+	++	+		++
-% resident-commuters	2,7	2,4	1,4	3,2	2,2	1,9	2,3	++	+++	+	+	++	++	++			++	+++
-% unemployed	1,9	2,1	1,9	1,3	1,9	1,8	1,9	+++	++	+++	+++	+	+++	++	+	+	++	++
INDUSTRIAL SPACE	4,9	4,9	5,4	4,1	5,3	5,1	4,5											
-available space for sale	4,2	4,3	3,9	-	4,1	4,1	3,8	+++	+++	o	++	++	+++	+++	++	+	+	o
-office space available	-	-	-	4,7	-	-	-	++	++	+++	+	+	++	++	+++	o	+	+
-long lease contracts	1,5	1,8	1,4	1,3	1,4	1,5	1,5	o	o	o	o	o	o	o	o	o	o	o
-purchase price ind. space	4,6	4,6	4,5	-	4,6	4,6	4,3	++	+++	+	+	+	+++	+++	+	+	+++	
-rents office space	-	-	-	3,9	-	-	-	++	+	++	+	++	++	++	++	o	+++	++
-proximity rail station	3,1	2,6	2,7	3,7	3,0	2,7	2,9	+	o	+	+	+	+	o	+	o	+	+
-communications by bus	3,7	3,4	3,4	4,2	3,5	3,4	4,0	++	+++	++	++	++	+	+	+++	++	o	+++
PUBLIC POLICY & INCENTIVES	3,9	4,0	3,8	3,4	3,9	3,8	3,5											
-grants (WIR,ROT,SOL)	4,1	4,5	4,1	4,6	4,4	4,1	4,1	++	++	+	+	++	++	+++	+	+	+	++
-levies (SIR)	2,7	2,4	2,4	1,7	2,3	2,7	1,8	o	o	-	-	-	o	o	-	-	-	-
-attitude towards business	4,4	4,1	4,1	3,7	4,2	4,1	4,1	++	++	+	+	+	++	++	+	+	+	++
-duration set-up procedures	4,5	4,3	4,0	4,4	4,3	4,1	4,2	++	+++	+	+++	+		+++	++	+++	+++	+++
-temporary premises available	2,4	1,8	2,1	1,6	1,8	2,2	2,5	+	+	o	o	o	o	o	o	o	o	o
COMMUNICATIONS	3,9	2,6	4,6	4,4	4,1	4,5	3,5											
-Randstad	4,4	3,5	3,1	3,7	3,5	3,3	3,3	+	+	+++	++	+++	+	+	+++	+++	++	++
-rest of the Netherlands	3,0	2,5	3,3	3,4	3,1	3,2	2,9	+	++	+++	+++	++	+	++	+++	++	+++	+
-international airport	1,6	1,7	2,5	2,7	2,3	2,3	2,4	++	++	++	+	+++	++	+	++	+++	+	+++
-Amsterdam	4,0	2,3	2,4	3,0	2,6	2,7	2,8	++	+++	+	+	+++	++	+	+++	+++	+	+++
AMENITIES	3,0	3,5	2,4	2,6	2,3	2,8	3,8											
-housing production	4,3	3,6	3,5	3,9	3,7	3,6	3,9	+++	+++	++	+	++	++	+++	+	+	+	++
-housing assignments to staff	4,7	4,3	4,2	4,1	4,2	4,2	4,4	++	++	+	+	++	++	++	+	+	+	
-recreation facilities	4,0	3,6	3,4	3,4	3,5	3,3	4,0	++	++	+	++	++	+++	+	++	+++	+	+
-socio-cultural facilities	3,6	3,6	3,2	3,4	3,4	3,2	3,6	++	+++	++	+	+	+++	+	+	++	+	++
-landscape amenities	3,3	3,0	2,7	3,3	3,0	2,6	3,4	+++	+	+++	+++	++	+++	+	++	++	++	++
-vocational schools	3,0	3,6	1,9	3,0	2,3	2,4	2,4	+++	++	+++	+	+	+++	++	o	++	++	+

Source: Jan van Oudheusden et all. Bedrijfsverplaatsing en produktiemilieu, University of Utrecht, 1981.

APPENDIX 2.3.

LEAGUE TABLE FOR TOWNS WITH OVERFLOW FROM THE NORTHERN WING OF THE RANDSTAD

	Printing industry	rank	Metal industry	rank	Wholesale trade	rank	Services	rank	Small-sized firms	rank	Medium-sized firms	rank	Large-scale firms	rank
Almere	712	1	650	1	607	1	566	1	626	1	630	1	671	1
Alkmaar	660	2	633	2	538	2	554	2	560	2	561	2	650	2
Hoorn	625	3	598	2	522	3	538	5	536	3	543	3	614	3
Lelystad	572	4	546	4	491	4	466	8	508	4	509	4	540	5
Purmerend	564	5	495	5	464	5	554	2	464	7	467	7	478	8
Haarl. meer	547	6	464	6	461	6	510	6	473	6	476	6	515	6
Maarssen	522	7	420	10	459	7	424	10	482	5	483	5	546	4
Amersfoort	509	8	453	7	421	9	550	4	428	10	439	8	508	7
Mijdrecht	496	9	415	11	426	8	489	7	430	9	439	8	464	10
Barneveld	488	10	440	8	419	10	425	9	432	8	428	10	471	9
Nijkerk	459	11	423	9	394	11	346	11	410	11	406	11	433	11
Max. score	898		816		763		786		785		791		854	

Source: Jan van Oudheusden et al., Bedrijfverplaatsing en produktiemilieu, University of Utrecht 1981.

FROM SPONTANEOUS SETTLEMENT TO INTEGRATED PLANNING AND DEVELOPMENT

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Abstract

The reclamation of new land, which is uninhabited, involves internal colonization implying the establishment of a new society. In the beginning the reclamation projects were carried out by private corporations and there was no clear settlement policy. Even when in the 19th century the State took responsibility for the operations no settlement policy of any importance was developed. During the execution of the IJsselmeerpolders-project in this century a planning and development system was built up, however, that takes care of detailed integrated plans, takes responsibility for the preparation of the land, for settlement patterns, for construction, for the guiding of immigration, the creation of jobs, and the harmonious integration of the plan in the national planning goals.

The origin of polders is to be found in the human attempts to protect land against flooding, with the aim to make land that could be used temporarily only, into land that could be occupied permanently and safely. In the Netherlands these attempts started about one millennium ago.

Why these heroic efforts with primitive tools in such a dangerous half-drowned country were made is an interesting question, but will not be answered here. Not the causes but the effects are relevant in this context. Out of this co-ordinated moving of earth which enabled the people to control the moving of water, technical as well as organizational skills were developed, which created a selfconsciousness in matters of watercontrol that formed the necessary basis for the development of plans for drainage of new land, land that was not occupied before. In small-scale reclamations this did not always imply new human settlement: the reclaimed land was just used to enlarge the existing farms or estates. In the North of the country it is usual, up to the present, that the borderlines of a farm, standing perpendicularly on the coastline, are elongated into the water and all the land that will eventually be reclaimed, lying between those lines, belongs in principle to that farm. Even if a concerted effort was necessary, such as the drainage of a lake, for which windmills had to be built for pumping the water out, it might well be that the reclaimed land was farmed by the people living on the border of the former lake.

When the drainage projects became larger and technically more sophisticated, considerable investments where necessary, which could not come from local sources. As a consequence the projects came into the hands of managers, planners, and were considered as ends in itself. Farms were established, villages came into existence, people from elsewhere were moved in, sometimes from adjoining areas, sometimes from larger distance, sometimes individually, sometimes in groups.

Although the inhabitants of the new land did not come from very far, most often from within the Netherlands, which is a rather small country, a fact is that these people came together in new circumstances, where everything had to be built up from scratch, where a new society had to be formed. As such, the name 'internal colonization' which has been given to such processes is quite adequate. Also the name 'pioneer' attributed to the first settlers was not an exaggeration, because the life of the first and sometimes even the second generation was not an easy one. In the 17th century the companies which undertook the works were formed by merchants, urban people, who wanted land but who did not know how to work it and sometimes appointed unskilled people to continue the exploitation of the land after drainage. Furthermore the land was often badly drained, as a consequence bad harvests came about.

People were struck by diseases, like malaria, in unhealthy conditions at the beginning.
In the 19th century, when some large drainage schemes, with modern techniques (steam engines instead of windmills) were carried out by the State and not by private companies, the living-conditions for the people were not at all good in the beginning. The State carried out the works for reasons of safety-protection of the areas surrounding the lakes - and was not interested in the exploitation of the land. After initial drainage and a rough parcelization the acquired land was sold as soon as was possible and no attention was given to what happened further. This was the case with one of the largest developments in this country, the Haarlemmermeer, an area of 20.000 ha, in which now Schiphol-airport is located. Prosperous as the region is now, very poor it has been in the first twenty years of its existence, because of bad drainage, lack of good organization of the building of the new society, resulting in bad health-care, formal education, housing and transportation.
When in this century the Dutch government decided to carry out the largest reclamation project ever undertaken, it was understood, on basis of the aforementioned experiences, that as the goal should be to develop not only new land, but also a prosperous and harmonious society, it should take full responsibility for the development process as a whole, not only for the technical, but also for the social and economic aspects. This idea of more intensive intervention by the State was not only inspired by the idea that the mistakes of the previous century should be avoided now, but was also an expression of the coming of the welfare-state.
The State had to play in this way a dual role. As owner of the new land, developed with public funds, it had the duty to strive after good economic management of the area. It should, just as any private entrepreneur try to make profit. As guardian of the welfare-state it had to protect the inhabitants against misfortune and to promote public welfare. These two roles are not always easy to combine.
The first role was in the beginning considered as the most important one. The land was made ready for normal cultivation by the Development Authority. A land allocation plan was made, with fixed sizes and types

of farms. The land remained property of the State, the farm buildings were constructed by the State. The farmers were carefully selected in order to be sure that a very capable group of people would till the land in the new area. If the main aim of a reclamation project is to increase the agricultural production, then this is a good policy. It is the same policy as would be applied by a private landowner: try to find the best tenants. This policy made it unnecessary to make extensive educational and training programmes for the settlers. They were ready for the job. This is stated so expliciteIy because in many foreign cases the main problem is how to teach people to make the best use of the new opportunities. In those cases the people are not selected: they are the ones who are entitled for some reason to receive a piece of land.

The second role, being the guardian of welfare, is less easy to describe. Even on the matter of the farms itself, the basis of the economy, there were next to economical also socio-political factors that played a role in decision-making. From a purely economical viewpoint it would have been possible to calculate which type of farm would give the highest profit. But this would not give necessarily the highest socio-economic advantage on the national level. For that reason a rather complicated system was developed, resulting in a mix of smaller and larger farms, giving opportunities to different kinds of farmers.

But outside the direct sector of farming the planning became also more 'human', more directed to the building of a society than to the economic development only. The farming population should not only have good farms, but there should be also service-centres, good housing for the workers, there should be shops, schools, churches, medical services, recreation facilities, libraries. And all the personel employed in these services should have a good basis for existence and the services should have a good quality.

In retrospect this sounds logical and simple. At the time of the first development in the IJsselmeerpoldersproject, half a century ago now, it meant that all kinds of relations between social facts had to be studied and quantified: how many customers does a baker need to make a living; how often does an average person borrow a book and how many kilometers he will travel to get such a book; young lovers need some wood to make walks in: how many hectares of wood should be planted to

satisfy the needs of a certain quantity of lovers?
This did not only provoke research needs, but it also encouraged, even necessitated, government-interference in a number of fields that had always belonged to the private sphere. Standards and norms had to be found for a number of immeasurable things.
Of course research and normsetting had imperfactions, not in the last place because social change remained for a large part unpredictable, but an advantage of all this research-work and striving after integrated, comprehensive planning was, that the understanding about interdependencies in matters of societal development was improved and that because of that better planning systems could be designed.
From the single goal, how to keep the area dry and safe, the goal to make profit from agriculture, now the goal was to give people a good life.

As agricultural areas the polders could be considered as being an end in itself. Of course the internal colonization had also as a goal to solve problems on the main land: farmers leaving for the polders freed space for other forms of landuse, or for improving the farm-structure in overcrowded areas. The policy of selection of applicants for a farm in the polders was in later years even geared to that purpose. But the developments within the project were nevertheless happenings in a more or less closed regional-economic system.
Because in other parts of the world, in many or most cases, polders are developed for agricultural purposes, some more attention will be given to that part of the history of the IJsselmeerpolders.
If agriculture is the main source of production, the changes in agriculture have far-reaching influences on the socio-spatial system. In our case the main change was that the response of agriculture to the cost-price squeeze was the replacement of labour by machines, which meant that there were less people on the land. Less people on the land means a lower demand for services.
This lower demand for services was quite problematic, because it was only quantitatively lower, qualitatively it became higher. Good schools were wanted, shops with a variety of wares were requested. This problem could within the closed system only be solved by reducing the number

of central places and accepting the larger distances from the periphery of the catchment areas to the core. Because of the fact that the farmers were in the position that they could possess one or more private cars the increase in distance was acceptable, but of course not ideal.
The remarkable thing about the project of the IJsselmeerpolders is that it is possible to see the effects of socio-economic change and of development in planning, real life, because the polders have been constructed one after one, with time-lags long enough to see change clearly: years of drainage being 1930, 1942, 1957 and 1968. In the first polder the main effort has been put into a good landuseplan for agriculture: rectangular lots, good roadconnections, in some parts even waterconnections. But a plan for a balanced settlement pattern was not made. It was expected that like in the past at roadcrossings services would spring up. Of course this would have happened, but not in the orderly way and without personal dramas as was the norm in this era. Therefore, later the government took care of the establishment of villages. In the second polder the lesson was taken at heart: next to the careful planning of the agricultural landuse, the settlement pattern was designed on basis of extensive studies on catchment areas of different kinds of functions and on distances from the periphery of a village area to the centre which would be acceptable. The result was a hierarchical pattern of a regional centre in the geographical point of gravity and a circle of ten villages around it. Already during the period of execution of the plan it became clear that the dynamism of societal development was underestimated and that the system was too static: the villages remained too small, the services could not function in the proper way for that reason, and because of an immense increase in private motorization distances counted much less as a limiting factor, which caused that the regional centre grew faster than was expected. A parallel of this way of planning in a closed system can be found in the Lakhish region in Israel (not a polder but a former desert). The same hierarchical pattern set up in about the same time and now a prospering regional centre - Kyriat Gat - has grown while the villages have hardly a function.

In the third polder the results of the changes are clearly demonstrated. Again a regional centre was planned. The number of villages was, in comparison with the former polder, greatly reduced, four instead of ten and of these four only two would be built. The average size of the farms was increased, the number of people employed in agriculture went down and down and soon it was realized that the system of enlargement of scale could not go on forever. The closed system was broken up by the decision not to build houses for local demand only in the two villages that were realized, but just to build and allow people from elsewhere, who were not economically tied to the area, to buy or rent a house. Because of a shortage of houses and the desire of many people to live outside the big cities in a quiet rural environment, this policy was quite success-full.

It would be interesting to know how this process would have developed in the following polders if agricultural use would have been remained the main function.

But this was not so. Around the year 1960 the period of the IJsselmeer-poldersproject as an isolated agricultural project ended. The polders coming nearer to the urban concentrations in the West of the country (the Randstad or Rim City) were more and more regarded as a compensation for the scarcity of space in the urban areas. The borderlakes, designed at first for geohydrological reasons only, became in a short time recreation-areas of national importance, for swimming, for sailing, developing a demand behind the dykes for areas where campings and holiday-bungalows could be built.

Of much more importance has been the decision to choose the polders as the location of two new towns. The first one, Lelystad, could be regarded as an expanded town because the polders would have needed a larger centre, a kind of provincial capital, anyway. Without the 'task' to grow out to 100.000 inhabitants, some 30.000 would have lived in the place if the regional system had remained closed.

The second one, Almere, designed for 250.000 people, is a pure satellite of Amsterdam, but is playing role of course in the polders.

In a rather short period changes have taken place which have a tremendous effect. Where as a continuation of a thousand years old tradition the agricultural space of the Netherlands would be increased with about 10 percent, now the region is seen as the habitat for half a million of people.

In the Dutch terms half a million of people is a sufficient number for

forming a new province, but this is probably not of great interest for a foreign audience.
Of more importance may be that the agricultural function, which has been the most important during the period of reclamation, is now being attacked by a third new element: nature. In this crowded, urbanized and industrialized country there is a general fear that natural areas, typical for the lowlands, will disappear. Therefore, there is a strong (political) movement that wants to keep parts of the drained land as it is after reclamation and does not want that the fifth and last polder is made, because as a lake this part of the territory has more value than as land.
Some people state that not doing things, not transforming the environment is the ultimate wisdom after a period of ruthless destruction in order to make profit. Others think that this attitude is the result of a state of such high prosperity, that people think they can afford to leave things as they are. Probably there is some truth in both statements. Anyway, it is a curious phenomenon to see that there is such a resistance to the attempt to create new space for human life so near to an area where six million people live and who have a shortage of space. Of course the water as such is also space for human use and this is recognized by the fact that the borderlakes of the polders are designed wider than is necessary for hydrological purposes.

So, as has been said: each polder is an expression of the time in which it has been constructed, even the last one by not being constructed yet! It shows that the main value of this technique of draining is the acquisition of space, which can be used for many purposes. This is demonstrated in the Netherlands very clearly, because this is such a densely populated country. Also the older polders, which have originally been made for the acquisition of agricultural land, are often used now for other purposes: industry, residential quarters of the town, or airports. The fact that these polders are so clearly a product of their time is probably typical for polders as such, because polders are flat, are rather undifferentiated, have hardly any historical landmarks, and give therefore the planners a high degree of freedom for designing. This is in itself fascinating, but it gives also a heavy responsibility and the absence of guidelines present in the existing environment, causes decision-

making to be often laborious.
On the other hand the freedom of the planners is limited by the wishes and needs of the immigrants. If improvements of a certain kind are wanted, then they can be realized - within reason - in the new polders, but if the immigrants want to maintain or reproduce their culture in the new environment, then there will be no fundamental innovation. Although there is much societal change, this change attracts so much attention and is described at such lenght, that there is hardly any awareness of continuity. If one studies the so-called new society on the new land than it is surprising to see how much continuity there is. For a part this will be because a number of cultural elements function so well that there is no need for change; for another part it may be explained by tradition (which can be rational as well). Remarkable is the continuity in the system of agriculture. There is an enormous change in techniques, the production and the productivity have grown, but the types of farms, even the size and form of the farms show a resemblance which is striking, whether one looks in the sixteenth century Beemster, the eighteenth century Haarlemmermeer or the present days IJsselmeerpolders.
This internal logic of the design and development of the first polders disappeared with the coming of the new towns. The number of inhabitants was no longer the result of the productivity of the land, but became a target in itself and the result of decisions and developments outside the region. This made the planning process more complicated and more a part of the national planning.
The task of the developer was no longer only to equip a region with the necessary system of services and amenities, but also to promote and create the resources for making a living as well: by replacement of activities and jobs from elsewehere (overspill from the cities) or establishment of new activities. Although this building of new towns was started by the same organization that developed the polders as a whole, this activity is in fact no longer typical for polders, except that the start had to be made from scratch: no infrastructure of any kind available in the beginning. Because these new towns with their fast growth involve a large building activity, new ways of financing had to be found, the funds coming from different and mostly private sources. This meant that more people and institutions were going to

participate in the decision-making process. This made matters more complex and the timing in the system of networkplanning more vulnerable.
As building of highways, construction of a railway, the budget for housing etc. are all subject to different spheres of decision-making and have their own sequences of priorities, regional comprehensive planning becomes difficult.
Looking at this complex situation it becomes all the more clear what the adventages are of the formula of the IJsselmeerpoldersproject: ownership of the land, planning, development and management in the initial stage in one hand.
Of course a good organization is not a guarantee for success in all respects. The general economic situation in a country, the political climate, the changes in value-orientation, have quite an influence, especially on long-term planning and a development-organization has to take these factors as data. This can be seen in the present: it is possible to build a new town, to develop a new society on new land, but if unemployment is growing in the country and in neighbouring countries also, it cannot be avoided that this phenomenon occurs also in the new towns. But the interesting fact remains that polders as such, by providing space, have always a value. That is true for the old polders, it will also be true for the new. It is quite possible that there will be no need for more new towns in the future. Then it is good to realize that we did not make polders in order to have space for new towns, but that we found a place for new towns because there were new polders. It is quite probable that in the last polder to be made, agriculture will form the main activity. In that case we can under again new circumstances, with new techniques perhaps, but with old experience, continue this work that started over 1000 years ago.

THE ZUIDERZEE PROJECT IN THE NETHERLANDS

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Abstract

Creation and financing of large scale polders in the Netherlands is a matter for central government.
Establishment of local and regional government in polders causes special problems.

1 Introduction

This paper describes the reasons behind the Zuyderzee project which was embarked upon after 1900 and the establishment of local and regional government, i.e. the municipalities and provinces. It was decided in this period that the creation and financing of large-scale polders was a matter for central government, but that there was a point at which local government was needed to structure the polders and populate them.
Initially a special form of local government operated in each of the four polders, with the Minister for Home Affairs acting -as is still partly the case- as Provincial Supervisor.
The normal mode of local and regional government has not yet been established in all the polders.
The question of whether to reclaim the final polder in the Zuyderzee Project is still under discussion. The present reorganisation of local and regional government will affect the form it takes in the present and future polders.

The paper begins with a brief description of administrative organisation in the Netherlands (2), followed by a presentation of the reasons behind the polder project (3).
Next, the various ways of creating 'normal' administrative arrangements in the various Zuyderzee polders are discussed (4). There is then resumé of the current reorganisation of the administrative structure, with some discussion of the division of the country into provinces and the problems that have arisen with regard to polders (5). Finally, attention is devoted to the ultimate completion of the Zuyderzee project (6) and the paper ends with some conclusions (7).
One final point to note is that it would be beyond the scope of this paper to attempt more than a brief outline of the various points covered. It is simply intended to show that the creation and administration of polders is something which brings its own particular problems in its wake.

2. Administrative organisation

The Netherlands is a decentralised unitary state, which means that the constitution decrees that the highest authority is concentrated at central level, with regulatory and administrative powers allocated to lower-level bodies.
The lower-level bodies are divided into territorial bodies -provinces and municipalities- and those that exist for a specific purpose, e.g. the water control boards which together with the municipalities constitute the lowest tier of administration.

The municipalities, some 800 in number, are territorial bodies, towns and villages with their own administration. The law allows them to pass ordinances required for the management of the municipality, and to this extent they are autonomous. Over and above this, the constitution requires them to cooperate in implementing the law, in other words to share the task of government.

Water control boards were set up for specific purpose; their sole responsibility is water control. This subject is examined at length in another paper prepared for the symposium.

Under the Dutch system of government, there is another tier between the municipalities and the water boards on the one hand and central government on the other, namely the provinces, now 11 in number. Apart from supervising the municipalities and water control boards, they have their own autonomous powers and responsibilities for sharing in government.

Finally, the constitution allows for public authorities to possess the statutory power to pass ordinances, but the legislator have made little use of this provision. Nevertheless, it has had a major impact on the polders.

3. Reasons for embarking on the polder projects.

Up to the last century the construction of polders had its origins in either private initiative or interest on the part of the local authorities. This situation changed in the second half of the nineteenth century. The experience gained with the Haarlemmermeer polder, which was reclaimed in 1849, prompted discussion on whether the creation of polders in the Zuyderzee should not after all be financed and carried out by central government. It was decided that this should be so, whereupon the Zuyderzee Project had to be regulated by law, for central government's competence and responsibilities in the matter could only be established by legislation. The net result was the Act of 14 June 1918 on the enclosure and reclamation of the Zuyderzee (the enclosure activities will not be considered in this paper). In brief, the Act stipulated that work required to close off the Zuyderzee and to reclaim parts of it was to be carried out in a manner to be determined by or on behalf of the government, which was also to finance the project. Government agencies entrusted with the implementation of the work (the Zuyderzee Project Authority of the Ministry of Transport and Public Works is responsible for constructing polders, and the IJsselmeer Polders Development Authority for their further development).

The Wieringermeerpolder was reclaimed in 1930, the Barrier Dam was completed in 1932, the North East Polder was reclaimed in 1942, the eastern part of Flevoland in 1957 and the southern part in 1968. All that now remains is the last polder in the Zuyderzee Project, the Markerwaard, which will be discussed later in this paper.

4. Administration in the IJsselmeerpolders.

The constitution prescribes that new municipalities and provinces may be formed by legislation and that powers to pass ordinances may be vested in other public bodies. Once a polder is reclaimed and inhabited, the need for regulation increases in proportion to the growth of the population.

Obviously a municipal organisation can only be established once there is a sufficiently broad base for it. Moreover, it must be borne in mind that in a newly reclaimed polder the role played by the government still largely determines how it will develop.

In view of the difference between government involvement on the one hand and the creation of a minicipality on the other, the legislator not surprisingly consider it necessary for a temporary administrative authority to be established in the initial phase of settlement as a precursor to one or more municipalities. The constitution makes provision for such an authority and this measure has been adopted in all the polders of the Zuyderzee Project. The first separate authority to be created (an innovation in the Dutch system of government) was the Wieringermeerpolders (see diagram 1 for data on the reclamation, the establishment of the authority, the creation of the municipality and the control board, and assingnment to a province. The diagram also shows the number of persons resident in each polder on the date which it became a municipality).

The administration of the Wieringermeer Authority, as it was called, was exercised by a council and a board which were responsible for settlement, management and water control (central government services), together with a steering committee, an executive committee and a chairman for municipal affairs. The Wieringermeer formed part of the province of North Holland, as it still does today.

In this case Parliament was not called upon to approve the establishment of a new municipality owing to the different system of law obtaining during the occupation of the Netherlands in the Second World War. It came into being by decree of the national authority of that time, a decree which remained in force after the war. Water control in that period was regulated by specially institued board, while an authority as described above was set up for the area covered by the North East Polder, the second polder in the Zuyderzee project.
Unlike the Wieringermeer administrative structure, a Commissioner with extensive powers was appointed to act as sole manager.
National authority remained in the hands of the State, again in contrast to the Wieringermeer. The powers and responsibilities which are normally vested in the municipal council (an elected body), the municipal executive (comprising the Burgomaster and Aldermen) and the Burgomaster (appointed by the government and who acts as Council Chairman), were concentrated in the hands of the Commisioner. The powers and responsabilities at provincial level relating to municipalities were retained by the Minister for Home Affairs. This offered a pragmatic solution which was democratically justifiable while the polders still had only a handful of inhabitants.

As soon as the population had reached a sufficient size, however, it was felt a municipality ought to be created. Twenty years after the establishment of the authority referred to above the North East Polder had reached this stage. At the same time the area was assigned, albeit provisionally, to the province of Overijssel. Water control has been only partially regulated:
a purification board is responsible for water quality, while water defences and volume are still the province of central government.

In 1955, the Southern IJsselmeer Polders Authority was set up by Act of Parliament. This was on the lines of the North East Polder structure, including that the powers and responsibilities at provincial level relating to municipalities were exercised by the Minister for Home Affairs. In 1972 part of Flevoland, Dronten, became a municipality, with provincial responsibilities for the municipality again being retained by the Minister for Home Affairs; the municipality itself, however, is free to introduce provincial ordinances. The municipality of Lelystad came into being on the same line in 1980. Now only Almere and Zeewolde in Flevoland have still to become municipalities, while the matters of water control and the allocation of Flevoland to a province have also to be regulated.

DIAGRAM I	Reclaimed	Authority instituted under Section 162 of Constitution	Year of attaining municipal status	Number of inhabitants at time of becoming municipality	Allocation to province	Water controll
Wieringermeer	1930	1937	1941	approx. 5,300	1942	1942
North East Polder	1942	1942	1962	29,352	1962*	1969**
East Flevoland	1957	1955	Dronten -1972	Dronten 13,314	?	?
			Lelystad -1980	Lelystad 43,256	?	?
South Flevoland	1968	1955	Almere ca.-1984	Almere ?	?	?
			Zeewolde" -1985	Zeewolde ?	?	?

* Provisional

** Responsible for water quality only

5. Incorporation of the polders in provinces and reorganisation of the administrative structure.

Diagram I shows that with the exception of the Wieringermeerpolder (which became part of the province of Holland) the majority of the polders in the Zuyderzee project are not yet incorporated in a province although this is provisionally the case with the North East Polder.

In the context of the Second World War it was an obvious move to allocate the Wieringermeerpolder to the province of North Holland.
When it came to the North East Polder, however, consideration was given to the possibility of creating a separate province comprising the North East Polder, Flevoland and the Markerwaard. As the matter has still not been decided, the North East Polder has been only temporarily incorporated in a province, and Flevoland not at all.

When Dronten and Lelystad, which form part of Flevoland, became municipalities explicit allowance was made for the plans to reorganise the administrative structure which had been devised in the previous decade. We shall not dwell on the discussion of this point, but simply report that the plans for reorganisation were designed to achieve further functional decentralisation and a reduction of scale at provincial level. It is a project which will require many years to complete.

At the initial stage of the reorganisation plans, Flevoland was to become a separate province; subsequently , after thoughts turned to a less extensive reduction scale, the plans moved in the direction of dividing Flevoland among a number of provinces and incorporating the North East Polder once and for all in the adjacent province of Overijssel. Now, however, the intention is to create a polder province comprising Flevoland and the North East Polder. In 1986 has been fixed as the year of decision in whatever form it ultimately takes, for it is in that year that elections to the Upper House of the Dutch Parliament will be held; up to now the inhabitants of Flevoland have been no say in the composition of the Upper House of the States General (the National Assembly comprises two Chambers; the Lower House is directly elected, the Upper House indirectly through the Provinces).

A separate problem was that of the exercise of provincial authority in areas with municipal status but which were not part of a province. When the Bill on the Southern IJsselmeer Polder was before Parliament in 1954-1955, it was commented that the allocation of provincial authority to the Minister for Home Affairs would be at variance with the constitution, in which provincial supervision of the municipalities is rooted. The problem was resolved bij adding an article to the constitution to the effect that supervision of municipalities in areas obtained by reclamation and which as yet did not form part of a province was to be regulated bij law (Article VII);

As stated above, the separate Acts creating the Southern IJsselmeer Polders Authority, the Municipality of Dronten and the Municipality of Lelystad stipulated that supervision was to be exercised by the Minister for Home Affairs. A salient point here is that the autonomous provincial responsibilities (see section 2) were not separately regulated and it would seem erroneous to assume that fall under the heading of supervisory responsibilities as the text does not seem compatible with this interpretation. Since the two Acts creating the municipalities decreed that the power of the provincial authorities were to be vested in the Minister for Home Affairs, i.e. including their autonomous responsibilities, the statutory provisions are in fact at variance with the constitution. However, as the constitution itself does not permit review of the constitutionality of legislation for the law is inviolable - this has not become an issue.

6. Completion of the Zuyderzee Project : the Markerwaard.

As stated in Section 3, it was decided that the Zuyderzee Project would be implemented and financed by the State. The final part of the project, the Markerwaard, is however the subject of often heated discussion. Although the government possesses the power to construct the polder, pursuant to the aforementioned Act of 1918, it felt that there should be broad consultation before the decision to go ahead was taken, and consequently the government's plan to reclaim the land was published in 1980. It is now passing through the procedure of what is termed a 'crucial planning decision', a procedure which has been followed in numerous branches of administration in the past few years and is shortly to acquire statutory force by inclusion in the Physical Planning Act.

There is no doubt that government concern has grown considerably in many social areas since 1918, the year in which the Zuyderzee Project got under way. The Physical Planning Act, for example, allocated municipalities major powers in the area of physical planning. Legislation on environmental protection is also of recent date in most cases. Encroachment on natural environments is subject to the approval by the various competent authorities, often involving protracted procedures. In these circumstances, it is likely that the construction of the final polder, if the green light is given, could become a very lengthy business on account of the complexity of the numerous procedures that would now have to be followed. One means of saving time would be to regulate the implementation of the project by statute.
Whether this should be done by amending the existing Act of 1918 or by rescinding it and passing a new Act is not under discussion at present. A statutory arrangement for the construction of the Markerwaard would, however, offer several other benefits apart from a satisfactory rate of progress, including financial guarantees. Such an arrangement could also lay down procedures for the establishment of one or more municipalities and assingnment to a province.

Finally, if research were to show that the construction of the Markerwaard might cause damage, a compensation provision could be included in the Act. This would offer the public greater legal security, especially with regard to the procedures to be followed.

7. Conclusions.

1. The magnitude of the Zuyderzee Project and the accompanying expense mean that the project can only be carried out by central government

2. The matter of administration has invariable been the last item on the agenda in the Zuyderzee Project

3. The normal administrative structure has been established only in the first polder, which was reclaimed in 1930.

4. The constitution has been influenced by the polder project

5. Statutory provisions have still to be made for the last polder of the project

POLICY AND SETTLEMENT ASPECTS TIDAL SWAMP LAND DEVELOPMENT IN INDONESIA

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Abstract

In opening up tidal swamp lands in the Outer Islands for rice production by mobilizing landless farmers from Java and Bali, the Indonesian Government faces a number of policy choices and development options. The cost per ha of the option selected will not influence the level of basic services to be provided to settlers, but will determine the speed with which they will start producing for the market and reach adequate income levels.

1 Introduction

Since ten years Indonesia has been engaged in a programme for development of tidal and coastal swamp lands in an effort to make this last vast land resource productive in its drive towards self-sufficiency in food grains.
As these swamp lands are mostly uninhabited, manpower needs to be mobilized elsewhere in the country to cultivate them after reclamation. This ties in with the need to find land for the ever-growing numbers of landless peasants from Java and Bali, for whom settlement areas are being sought in the Outer Islands through the nation-wide transmigration programme.

2 The National Perspective

2.1 The tidal swamp land resource

So far, over 7 million ha has been identified in Indonesia as a potential for tidal swamp land development (out of 35 million ha of such land in the whole country). This means that these swamp lands are the only remaining important land resource of the nation, available for agricultural development.
Programmes are under way to map and open up these lands, so that 25 % of this land potential will be available for productive use by the end of the fifth Five-Year Development Plan (in 1994). In practice this means a target of roughly 100 000 ha of new land to be reclaimed annually for the remainder of this century.

2.2 Human resources

Between 50 and 60 % of the Indonesian labour force is engaged in agriculture, but the man/land ratio is unfavourable (and further deteriorating) in over-populated Java and Bali, where population growth is exceeding agriculture's absorption capacity. Hundreds of thousands of landless farmers have therefore registered for settlement in the Outer Islands, where relatively abundant land is available.
Should tidal swamps be developed at the rate of 100 000 ha per year, then this land resource could - at 2 ha per family, being the minimum farm size for transmigrant families - accommodate 50 000 families per year, which is only a fraction of Java's annual population growth. As tidal swamp lands are comparatively suitable for rice cultivation and as this type of agriculture is labour-intensive, it is obvious that developing the tidal swamp land resource in the Outer Islands by mobilizing human resources in Java and Bali - where rice cultivation is traditional - is an attractive and logical policy choice.

2.3 Rice consumption and production

With a national rice production of well over 20 million tonnes per year

now, Indonesia is reaping the benefits of intensification efforts in recent years to increase the production of the nation's staple food. But intensification has its limits and it could not on its own cater for rice consumption growing at a rate of 3.5 to 4.0 % per year. Newly developed production areas (such as tidal swamp lands opened up) will be needed to contribute to ever-growing food grain needs. It is estimated that at least 120 000 ha of new rice production areas are needed each year to make up for rice deficits on a national scale, if Indonesia is to remain successful in avoiding further rice imports, as it was able to in recent years.
An over-production of rice is not very likely yet, but should it occur, then parts of tidal land areas could be converted for growing upland crops, such as coconut, an other much-needed food crop in the archipelago. Spontaneous transmigrants, such as the Buginese, have systematically done that for many years by converting their rice fields into coconut plantations.

3 Policy choices

In determining priorities for bringing tidal swamp lands into production as well as implementing its transmigration programme, the Indonesian government faces various policy coices, which may be competing or conflicting. The following options may serve to illustrate this dilemma:

- if a fast certain increase in the Outer Islands' rice production is aimed at, implementing it through transmigration of small farmers - used to subsistence production - may not be the appropriate solution. Possibly estate-wise production should then be preferred.
- if transmigrant farmers should obtain a maximum income from their 2-ha farms within a given period, rice may not be the most profitable crop in the end. It is likely that such cash crops as oil-palm or coconut would present better choices for income maximalization.
- if the implementation of transmigration programme targets should get priority, the government would aim at maximalizing the numbers of settlers. It is clear, however, that in that case food grain production for the market is not likely to occur soon, while incomes will also remain low for a number of years.

- if development cost per ha is to be kept at minimum levels, marketable rice surpluses will not be realized at an early stage nor will farmers' incomes rise to acceptable levels in the first years of project development.

From this presentation it may be clear that choices have to be made, as one may not expect to realize the various options simultaneously. In practice it appears that cost considerations will primarily determine scope, method and speed of tidal swamp land development and hence its meaning and success as factors in attaining food grain self-sufficiency and a more equal income distribution.

4 Development options

Based on development cost per ha, there are several options for opening up tidal swamp lands and bringing these areas into production.

4.1 High-cost development

If high development costs per ha are acceptable, newly reclaimed land can be developed intensively and sizeable crop surpluses can be anticipated within a few years. This in turn will result in a high income per ha. If the farm size is geared to a targeted income, the planned farm size can be small and consequently, a large number of settlers can be accommodated. In this case, quite a few policy objectives can be met simultaneously.

There is, however, one factor which disturbs this positive picture: as nearly all transmigrants originate from the over-populated islands of Java and Bali, where they are used to a subsistence economy, they tend to reduce risks which may affect their lives and use a system of mutual cooperation and assistance. The optimum use of intensively developed farms, which is required to produce marketable surpluses, demands a profit-oriented mentality.

Adapting the farmers' mentality will take a long time, during which the farmer will not be able to benefit adequately from the large investments made to develop his land intensively.

4.2 Low-cost development

If budgetary constraints require low development costs per hectare, newly developed land can be developed extensively only, and marketable surpluses will materialize later. The subsequent lower returns per hectare will require larger farms to generate reasonable farm incomes which will still be in the region of the target income.
Besides budgetary advantages, low-cost development offers some attractive advantages in future absorption capacity of the projects. Under low-cost development the productivity of the soil can still be increased in future when funds become available for further investment. In other words, the area to be developed will still have the capacity to absorb future generations of farmers.
One disadvantage of the low-cost option is that it may not be compatible with the ever-increasing pace of the transmigration effort in Indonesia, taking into account the targets set for the current Five Year Development Plan, under which 500 000 families are to transmigrate through the government-sponsored programme.
Further, the country is gradually using its more remotely located land resources, at steadily increasing investment costs per hectare. Whether under low- or high-cost development, it can less afford to have projects which do not yield benefits quickly if a certain equilibrium between costs and benefits is to be maintained.

4.3 Quickly maturing projects under low-cost development

To speed up low-cost development, the use of the investment and the human resources involved could be improved. Although this will raise development cost to some extent, the increase in benefits, both in terms of money and food production, will be still greater.
To increase the production potential of the lands to be reclaimed, the following measures can be carried out:

- improving the water management infrastructure, thus eliminating certain risks which lower-cost solutions would entail for farmers;
- clearing all of the farm land so that the transmigrants will be able upon arrival to start producing the crops the nation needs (the

common practice so far is to clear half of the land, leaving the other part for the farmer himself to clear later);

- facilitating farmers' access to inputs and markets by a concentrated programme of agro-supporting services, to be operational upon the arrival of the transmigrants and geared to a situation in which farmers themselves take responsibility for such services through their own organizations as soon as possible.

A second step might be to select only experienced farmers as transmigrants. Only this category of applicants is able to benefit fully from larger project investments and from more intensive agro-supporting services in the initial years of project development. Such a step would require tightening up of selection procedures, as quite often now half of the prospective settlers do not have farming experience.

A third way of making better use of human resources in tidal land development is by adapting and modifying management input in transmigration projects. If investments are enlarged and selection criteria altered, project management is only necessary for a concentrated effort during a limited period. Under such a system, the transmigration service and the other agencies involved in project implementation would make available their project management capacity through a system of roving task forces, dealing with a particular project only during the period it takes to get farmers to the level where they temselves are in control of their situation as self-reliant agricultural producers. If this period could be reduced - other conditions mentioned being met - a project management group would not need to stay more than two to three years in any one area.

5 Settlement aspects

5.1 The tidal land setting

Settlement planning in tidal lands differs from that in upland areas in that the topographical condition hardly determines the selection of settlement locations. Most land is flat and featureless and allows for a certain freedom of plan design, both for the drainage infrastructure and for the settlement pattern. Nor do soil conditions play a role in this respect. Most tidal soils have rather uniform characteristics and it is seldom necessary to locate settlements on poorer soils in order to save better land for cultivation. This leaves the natural drainage system and the projected drainage infrastructure as the determining factors for tidal land settlement planning.

Tidal lands are usually situated in remote areas without easy access to the service structure of adjacent regions. Therefore, the physical planning of the project's service structure has to be rather 'independent' from the one existing in neighbouring areas.

For transmigration projects in Indonesia, basic settlement units (blocks, hamlets) need to be identified, in which a leadership pattern may develop, once the newly arrived transmigrants have settled. Such basic units, usually called hamlets in tidal land areas, should have not less than 20 and not more than 40 families. Although such a hamlet does have certain communal functions, it is too small to serve as the basic service delivery unit. Such a unit in Indonesia comprises about 500 families and is the village ('unit desa'). Thus, groups of 12 to 16 hamlets together form one village unit and the service superstructure is built up from there. Services, such as education and health care are delivered through village centres, usually located centrally in the area of hamlets served.

Less specific, because much more dependent on the existing structure in the area, are the requirements for secondary service levels. As there is hardly any service structure in tidal land areas, service areas of between 8 000 and 10 000 families are desirable. This means that in settlement and service planning one service centre of a higher level (secondary service centre) is usually planned for every 16 to 20 villages.

For larger schemes it may even be necessary to consider the design of a main service centre with a service level adequate for the needs of a population of between 20 000 and 30 000 families.

5.2 Criteria for settlement planning

Assuming that drinking-water facilities are found near the dwelling, then the main yardstick for determining the optimum location of the farm house in any settlement scheme is the distance which has to be covered to perform the daily production and to reach the basic general and social facilities for leading a decent life in transmigration areas. A further criterion, relevant for the planning inside the basic settlement unit, is the distance between farmers' dwellings, on the one hand ensuring possibilities for social interaction and on the other hand providing a certain privacy for each family.

With regard to the distance between the farm house and the farm land, this should not be larger than the distance which can be covered by half an hour's walking. Hence the farm land should not be more than 2 km away from any farmer in a scheme. Within that distance he should be able to reach all of his land, which preferably should be allotted to him in a single plot.

The same distance is regarded as the maximum to be covered between the dwelling and the service delivery point (the village centre), where farm families go for educational and health facilities, agro-supporting services, marketing, etc.

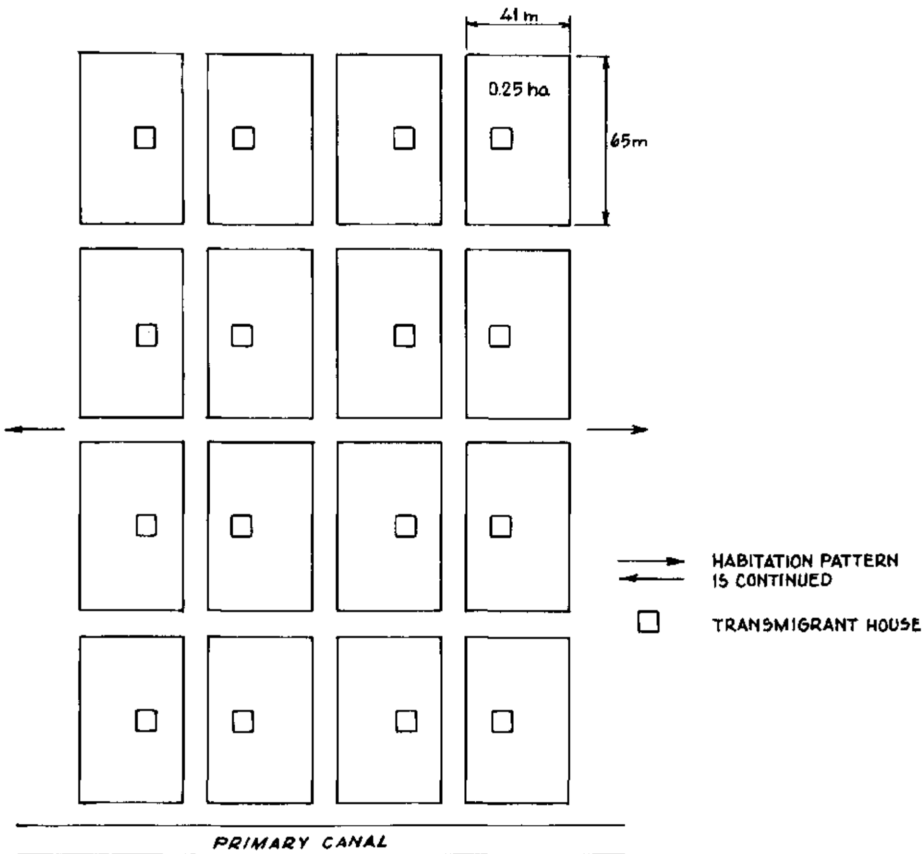
With regard to the distance between farm houses, this should be between 15 m as a minimum and 50 m as a maximum.

Balancing such settlement criteria calls for a compromise. Nuclear settlements, situated around the service centre, provide easy access to facilities, but will involve rather long distances to the fields for quite a few farmers. Dispersed settlement, such as when each farmer has his dwelling on his farm plot, will reduce the distance to the work area to a minimum, but results in long distances to the village centre and will not help creating farming communities.

Considering this, Euroconsult has developed a settlement pattern for tidal land projects, with farm houses situated in rows of 4 alongside primary canals, each on 0.25 ha of home yard. Hamlet areas are designed strip-wise with village centres at distances of not more than 4 km from each other (see Fig. 1).

The distances for such a model work out as follows:

- between dwelling and farm land (provided in one lot): maximum 1.8 km;
- between dwelling and service centre: maximum 2.0 km;
- between dwellings (situated on home yards with dimensions of 41 x 65 m): 15 m.



(AT OTHER SIDE OF PRIMARY CANAL ONE FINDS THE SAME CONFIGURATION)

6 Provisions and services

Provisions and services to transmigrant settlers in Indonesian agricultural resettlement projects in general (and hence also in those situated in tidal land areas) can be divided into:

- basic facilities, without which settlers could not lead a normal life in the Outer Islands;
- additional provisions, enabling transmigrants to reach service levels similar to those enjoyed by other sections of the population.

6.1 Basic facilities

As basic facilities are regarded:

- transportation from the area of origin to the new settlement site (increasingly this facility is provided through air transport);
- a farm area with a minimum size of 2 ha, out of which 0.25 ha is reserved for the home yard and the farm house. Usually 1 ha is cleared upon arrival of the transmigrant;
- a simple house, built of locally found timber, with a ground area of 36 to 42 m^2, a corrugated iron roof, and a covered latrine at a distance of 15 m from the house;
- two steel drums for collection of rain-water from the roof (capacity 200 l);
- agricultural tools and household utensils;
- seeds;
- subsistence rations for a period of up to 18 months;
- basic health care facilities;
- primary school facilities.

6.2 Additional provisions

At the level of the primary service centre (the village unit) the following facilities are provided to the settler community:

- agricultural extension and credit;
- assistance in establishing cooperatives;
- village communal halls and storage;
- post office;
- market facilities;
- places of worship.

INNOVATIVE POTENTIALS AT KAINJI LAKE BASIN FOR FADAMA FARMING: A STUDY OF THREE RESETTLEMENTS

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Abstract

The building of the Kainji Dam for a hydro-electric power resulted in the resettlement of 44,000 people along the banks of the Kainji Lake in 1968. These people belong to three different geo-political areas bordering on the lake. Their traditional farmlands called fadamas were inundated, but the lake regime at present provides a draw-down area of about 19,000 hectares. The resettlement policy encouraged primary innovations first. After about seven years of successful resettlement, secondary innovations meant for community development are being introduced. The various adoption responses of the three resettlements representing the three geo-political areas bordering on the lake are discussed in detail and compared. Factors responsible for success and failure are analysed in terms of Planned Change Theoretical model, and recommendations are then made along the suggestions of the World Bank Training and Visit approach.

Introduction

The resettlement policy for the Kainji Lake basin was unique in the sense that it did not adopt any of the existing policies anywhere in the third world. The policy ensured that the people to be resettled were not forced out of their old homes, and that having agreed to leave, they would suffer minimum interference in their socio-cultural systems.

Thus only basic innovations such as houses, water-supply, new sites, etc. were introduced in almost all the resettlments. (Oyedipe, 1977). Altogether some 44,000 people in 239 villages and towns were resettled in 141 villages and towns. Anfani, Yumu, and Zamare are three of such resettlements. The assumption underlying the resettlement policy was that developmental innovations should not be confused with the basic ones so that the resettled people would be able to cope with the initial problems of adjustment. A study of the resettlement in 1972 revealed that the people have attained 66.7% high adjustment level. (Oyedipe, 1977). Research findings at the Kainji Lake Research Institute have also shown that the many innovative in-puts in agriculture, fisheries, etc. can now be introduced to them. Agricultural researches have revealed that the draw-down area which is seasonally exposed and the tributary rivulets to the lake provide opportunity for dry-season farming in March. (Amaugo, 1977: 161). The rains start in May, but some crops especially rice, okro and vegetables can be lucratively cultivated before the rainy season; especially since there is no competition for labour during this period and there is possibility of early harvest for good market.
The Socio-Economic and Extention Services Unit of the Institute intends to build on the favourable climate of successful adjustment by these resettled people to teach the new technology of draw-down/fadama farming using the approach of the Training and Visit to teach the farmers.

This paper describes the resettlement villages, the Training & Visit approach as adapted by Kainji Lake Research Institute, and then discuses the theoretical implications of our approach.

Anfani

Anfani is one of the first resettlements; five villages were merged together to form the present Anfani. It is about 25 km. from the Institute headquarters, at New Bussa. (Figure 1).
The population of Anfani in pre-resettlement days was 136 but now it is 1364; an increase of 829%. The population comprises 669 (49.1%) males and 695 (50.9%) females. The dominant age group is that of 5-10 years.

Altogether, those below 35 years in age are 811 (59.4%). Those who are 50 years and above are 93 (6.8%).
Literates are 609 (44.6%) while 357 (26.2%) are underage for schooling.

Gungawa 972 (51.3%) and Kamberi 157 (11.5%) are the dominant ethnic groups in Anfani. There are 87 farmer families giving a total population of 239 (17.5%). Traders are 418 (30.6%). Only 85 (6.2%) declared themselves as unemployed while 581 (42.6%) are children. 1,124 (82.4%) have no urban experience. A school, and a market provided after the resettlement are fully utilized.
The attitudes of their women have changed considerably especially in terms of sending children to school, and trading, inspite of wife-seclusion practices. They desire 'expensive' marriage for their children. Thus the population is virile, sufficiently heterogenous, and activiely exploiting advantages in its rural environment. Their proximity to New Bussa provides a market for all they can produce. That they still rural in orientation indicates that they will continue to remain at the resettlement to adopt the innovations if properly introduced.

Zamare

Zamare is situated on the north-eastern bank of the lake near Yelwa, its divisional headquarters in Sokoto State. (Figure 1). It originally comprised five settlements which were merged together at the resettlement. Its population on the eve of resettlement was 514, but by 1982, the population had increased by 114.9% to 1105.
The population comprises 560 males and 545 females. Children of under 4 years are dominant with a population of 230 (20.8%) followed by young men of age 21-34 who are 200 (18.1%). Age group 35-49 years is 110 (9.9%) and those of 50 and above are only 5.1%. Thus 95% of the population is virile.
Literates are 475 (42.9%) and almost all are Muslims (1050 or 95%). The dominant ethnic groups are Hausa and Gungawa. Farmers are 280 (25.3%), made up of 72 farm families. Traders are 200 (18.1%, and fishermen 180 (16.3%). The farmers are traditional onion growers utilizing traditional

irrigation methods. (Roder 1970: 9-14). As high as 80.5% of them have no urban experience even though they are less than 20 kilometres from Yauri.

This population is also virile and rural oriented. They are much more inclined to adopt innovations especially with such high rate of literacy. Some of them had bought corn-mills, outboard engines for their fishing canoes while most of them utilize the government Health Centre provided after resettlment. The presence of so many traders indicate high potential for ready markets for agricultural produce. Indeed many traders come there from Yelwa. That they are Muslims means they can easily get co-operation of Zarkin Noma (Head of farmers) and will have hardly any taboos against the innovations.

Yumu

Yumu is a resettlement town on the western bank of the lake in Shagunu District of Borgu Division (Kwara State). It comprised seven smaller resettlements in pre-resettlement days, with a population of 378. In 1982, it had increased by 150% to 945.

Males are 525 and females 420. The dominant group is 5-10 years which is 245 (25.9%). The young men of age 21-34 are 174 (18.4%) but those in the range of 35-49 years are only 90 (9.5%). Those above 50 years were only 60 (7.4%).

Literates are 431 (45.6%) and only 104 (11.0%) claimed to worship traditional gods. Kamberi and Gungawa are the dominant ethnic groups. Farming is the primary occupation of 208 in 48 farm families. Traders numbered 180 (19.1%). About 885 (93.7%) claimed to have no urban experience.

A school has since been introduced in the resettlement, and the farmers are used to hiring tractor for their farm operations. The Kamberi are noted for their ability to cultivate relatively large farms using both male and female labour extensively. The Gungawa are also noted for their traditional irrigation farms for onions.

In pre-resettlement days, the villagers never cultivated onions on any large scale; but with the good market for onions these days, all the farmers claimed to be growing onions during the early dry season.

Thus this population is also virile, heterogenous, and actively exploiting the resources in its environment. Again the influence of Islam in making them respect leaders like Zarkin Noma is potentially high.

Chief Farmer (Zarkin Noma)

The traditional role of the Chief Farmer (Zarkin Noma) is that of being a leader in many respects to the community. He is appointed by the District head as a result of his proving to be the best farmer. Once appointed he holds the title for life.

He proves to be the best farmer by having more large farms with variety of crops than other farmers. He has to even show interest in livestock. Thus throughout the year, he has enough foodstuffs to sell or even give away. Many of his farmer-friends depend on him for seeds to plant in the next year.

Once appointed he makes sure he never falls below expectation. These days of annual agricultural shows, he makes sure he wins. Thus it is assumed that if he is unable to provide foodstuff or seeds in any particular season, then no other farmer in the village is likely to.

He is respected and often called upon by the agricultural extension worker in the village before any other farmer. He is supposed to be friendly and kind to all.

Any farmer who feels he can do better only has to bid his time until the death of the current chief to get the title. Thus others keep on doing their best and in course of time get recognized as good farmers and potential chiefs.

The Training and Visit System

This system of extension services recommended by the World Bank means directly teaching the farmers in a systematic programme with frequent visits. The Extension Worker is trained to visit the groups of farmers in his charge fortnightly in rotation and this affords close supervision. (Benor & Harrison 1977: 19).

The Extention Worker is guided, trained and supervised by the Extention Officer at the Headquarters. The later in collaboration with the Agronomist specialist had charted out the details of what is to be done forthnightly.

In each of the three villages selected, the farmers have a chief farmer who by tradition plays leadership roles to his colleagues. He and four others will be selected as imitable farmers, who will in turn select friends. The Extension Worker visits each imitable farmer and his 'friends' per day, and rotates for the others. In each group, the imitable farmer allows experiments in his farms and encourages others to visit and copy from him. Group discussions are also held, and any problems are brought to the headquarters for solution.

He visits the five groups during the week and comes to New Bussa, to meet his research specialists in the following week for more instructions. By Saturday he is back in his station to begin next Monday's work. The system aims at a comprehensive re-training of the farmers in better land preparation (because of erosion), improved seed bed and nursery maintenance, use of good seed, seed treatment, timely operations, weeding, proper spacing of plants, etc.

The Officer at Anfani would operate from New Bussa base, while those in Zamare and Yumu will operate from Yelwa and Shagunu bases respectively. (Figure 1). The Institute's out-stations in these areas will reduce problems of distance. By mid May, the lessons would have been thoroughly learnt and the farmers can go to farm uplands. Fears of failures need not arise since the farmers are required to practise these new techniques on a smaller scale in the first year, and progress in subsequent years. It is estimated that Anfani, Zamare and Yumu have 150 ha., and 100 ha. of draw-down areas respectively to cultivate.

Theoretical implications and Conclusions

The concept of Planned Change has acquired global implications since 'western influence' has affected communities in the Third World and caused changes in their traditional institutions. Even within national boundaries in these countries, national development plans affect rural communities politically and economically such that meaningful change for development has to come from outside the rural areas.

To successfully apply 'systematic and appropriate knowledge in human affairs for the purpose of creating intelligent action and change' (Bennis et. al. 1970:4) arguments have been adduced to the effect that the client system should have as much understanding of the change as possible; while the change effort is made to appear as self-motivated. Other factors are that the change programme should include emotional, and cognitive elements, as well as psychological support from change agent. (Bennis 1970: 77-8). Yet not much attention has been paid to the processes of crucial change involving intensive interaction between change agent and client system voer short periods at different intervals. This provides breathing space for the client system.

In the Kainji Lake basin the resettlement exercise gave much room for client system to understand as much as possible what was involved such that their participation and cooperation was easy. Psychological supports were provided and adjustment became easy. But it appears a significant factor in easy adjustment was the carrying capacity of the client system for the innovations. If innovations were too much at the time, the results would have been different. The same principle is now being encouraged for the Training & Visit scheme.

Within a period of only six to eight weeks, active training of farmers will be undertaken annually for the draw-down cultivation. Twice or thrice repeated, this approach is bound to succeed; and once successful in three resettlements, the spread to neighbouring ones is very likely.

For national plans, it appears, effectively implemented innovations for short periods have great potentials with minimum costs for both Change Agents and Client Systems.

Acknowledgements

My sincere gratitutde goes to the Director of the Kainji Lake Research Institute for allowing me to present this paper. My colleague Dr. A. B.

Chaudhry also deserves my thanks for his critical observations. Finally my assistants Messrs Alamu, Toyin, Rafiu, Odubiyi, Samson and Abubakar, and others are acknowledged for their invaluable contributions.

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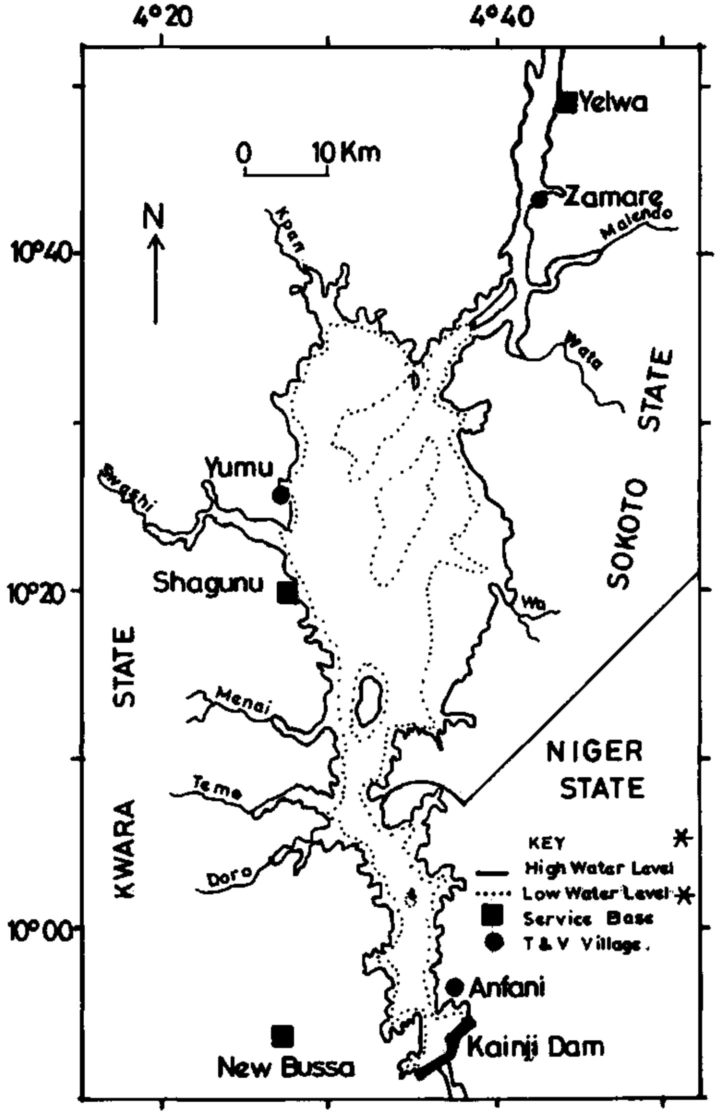

* The land between low and high water marks is the draw-down land (Fadamas)

Fig. 1. Map of Kainji Lake Showing The Three Resettlement Villages for T.&V. Services.

SOCIO-ECONOMIC ASPECTS OF WATER MANAGEMENT OF SALINITY CONTROL AND RECLAMATION PROJECT NO. 1 IN PAKISTAN : A CASE STUDY

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Abstract

The objective of SCARP-I (Salinity Control and Reclamation Project No. 1), was to eradicate waterlogging and salinity and to increase agricultural productivity in the project. To achieve these objectives, two thousand high capacity tubewells varying in discharge from 3(84 l/s) to 5 cusecs (140 l/s) were installed in the project. The quality of tubewells water varied from good to marginal and hazardous. It was estimated that tubewells would last for more than 30 years and that the groundwater table would be lowered to the pre-irrigation period to make groundwater mining as a possible proposition for supplementing canal irrigation. The experience of the last twenty years of the operation of the project however, shows that the discharge capacity and the specific capacity of these tubewells reduced to 50 percent within a few years after the operation of tubewells and that the groundwater level was stabilised at 5 metres below the ground surface. In fact it has started to rise in late seventies. Various strainer materials, such as mild steel, stainless steel, PVC,brass and fibre glass were tried to prolong the life of tubewells but in vain. Analysis of available data on the performance of tubewells has shown that brass strainer is the best . The problem lies with the design and construction of the gravel pack around the wells and not with the encrustation and corrosion of strainer materials. Because of the deterioration of performance of tubewells, the operational and maintenance cost has increased considerably whereas there was comparatively very small increase in revenue from the project. Consequently

the expected rate of return was not obtained. It was only 6 percent in 1981.

1. Introduction

The project is situated in the northern part of the Indus Plain between rivers Ravi and Chenab (Figure 1).

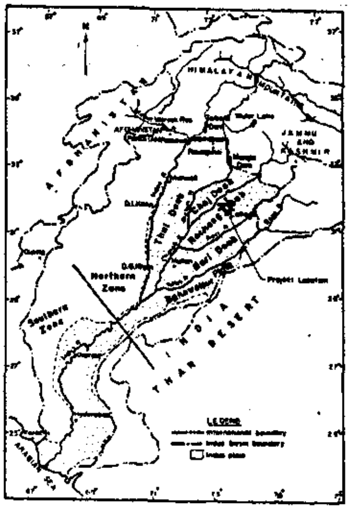

Figure 1.General location of the Project within the Indus Plain

The project has been divided into twelve units (Figure 2)

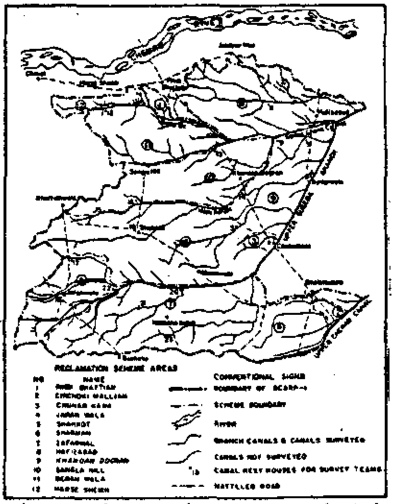

Figure 2. Project Area showing twelve units and canal network

and is irrigated with four canal system. It extends over 0.5 million ha (1.21 million acres) out of which 82 percent is culturable. It lies in the semi-arid part of the country (Figure 3)

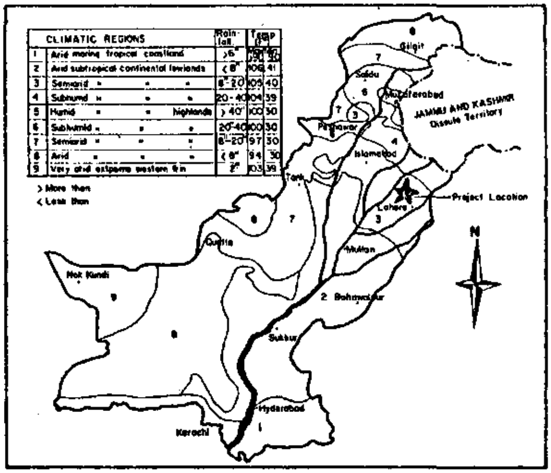

Figure 3. Climate of the Project

The project area is underlain by an alluvial complex consisting of fine to medium grained sand, silt and clay. The groundwater in the aquifer is not sweet everywhere, The upper 40 meter of strata is filled with sweet water which is underlain by saltwater. The thickness of fresh water is maximum near rivers to almost nill in the central part of the area between rivers (locally called Doabs). The groundwater quality therefore varies from useable to hazardous. The whole of the Indus Plain is covered with a vast network of weir controlled canal irrigation system. Before the introduction of the weir controlled irrigation system, the groundwater table was more than 35 metres deep over most of the Indus Plain and was in dynamic equilibrium with inflow being equal to the outflow (Figure 4). The dynamic equilibrium of groundwater was disturbed because of the irrigation system. As a result the water table started rising at the ratio of 15 cms to 75 cms per year. By late 1930's and early 1940's the water table had risen over most of the irrigated area very close to the ground surface creating waterlogged condition. Evaporation from the high water table gave rise to accumulation of salts in the upper soil strata and hence salinity problem in the root zone of crops. The process of salinization accelerated in areas where irrigation supplies were inadequate to leach down the salts.

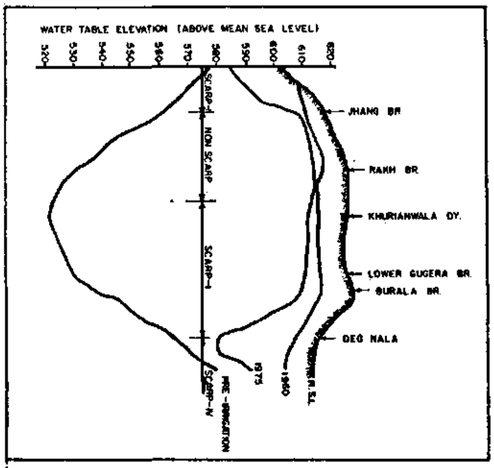

Figure 4. Water Table rise in the Project since irrigation started

Waterlogging and salinity engaged the attention of engineers and scientists ever since 1930's. The first step proposed to control waterlogging and salinity in 1931 was to provide additional irrigation supplies at the rate of 28 l/s per 10 hectares to wash down the salt during June to August when abundant river supplies are available due to Monsoons. The reclamation supplies were restricted to areas with water table deeper than 3 - 5 metres below the ground surface. This measure, however, did not produce the desired results because a number of areas which were declared as having been reclaimed deteriorated again due to salinity. This rendered doubtful the effect of reclamation supplies as permanent measure. Other measures adopted to control waterlogging and salinity were the construction of seepage drains along the major canals, lining of main and feeder canals, frequent canal closures and lowering of canal water levels. These measures did not prove effective. The solution of the problem was, therefore, considered to lie in providing vertical drainage of groundwater by means of tubewells.

After independence in 1947 the efforts to eradicate waterlogging and salinity were intensified with the assistance of the United Nations and its subordinate organizations. This was followed by an era of foreign technical assistance culminating in a ten year programme of waterlogging and salinity control in 1961. This programme was reviewed by the U.S Panel of experts in 1964. The Panel recommended to extend the scope of SCARPS to integrated agricultural development covering irrigation,drainage fertilizers, seeds, pests and- disease control, better agricultural and irrigation practices. Agricultural development in Pakistan was proposed to be achieved by an integrated application of all the factors of agriculture with a sustained human efforts to communicate modern agricultural techniques to the farmers, to improve these techniques through research, and to create the economic conditions that would motivate the farmers to help themselves. It was also recommended to concentrate development effort on limited project areas of about 0.4 million hectares managed by an organization based on area than on function to permit a coordinated attack on all aspects of agricultural production. This was called the 'Project Approach', which was an integrated approach combining irrigation, agriculture, tubewell operation, cooperatives under onr project Director.

2 Objectives of the Project

Although SCARP-1 was in its final stages of development, its management strategy was reviewed to incorporate the recommendations of the U.S Panel. The Project covered an area of 0.5 million hectares and was managed by one Project Director who was responsible for all development factors mentioned above. The objectives of the project were to preserve/restore/improve and develop the land and agricultural water resources for national welfare through:

a) Tubewells: to lower watertable and to provide more water for extensive and/or intensive agriculture.
b) Reducing salinity hazard; by leaching, adding amendments; increase cropping intensity but avoiding land deterioration by hazardous tubewell water.
c) Helping the farmers by:
   1) extension of recent technical information to them;
   2) removing their financial hurdles through loans, subsidies etc; and
   3) ensuring correct return for agricultural produce sent to markets.

The targets set to achieve the above objectives were as follows:

a) To increase cropping intensity to 150 percent
b) To increase crop yields/hectare three times the one that existed during the pre-project period.

c) To reclaim an effected area of 0.17 million hectares.

3 Pre-Project evaluation

Investigation in the late fifties focussed attention on the above targets. In these cases there was need for additional irrigation water which was limited by the available river flows and existing capacities of the irrigation system. The major thrust was on the estimation of irrigation demand for intensive cropping and for reclamation through salt leaching and drainage. It was therefore, proposed to increase water allowance from 5 hectares per litre/sec (350 acres/cusec) to 2 hectares per litre/sec (150 acres/cusec). In practice the irrigation system was supplying one litre/sec of water to 7 hectares instead of the designed allowance mentioned above. This figure has been used to show shortage of canal supplies and the progressive deterioration of good lands due to salinity in the absence of downward leaching. The figure also implies that major cause of waterlogging could then be due to seepage from irrigation network rathern than infiltration from the fields. This is also clear from the fact that average canal supplies equivalent to 78 cms at the heads of water courses were available during the pre-project period as against 144 cms required for crop consumptive use on the basis of Blaney and Criddle formula. In fact some experts quoted 174 cms as the delta for the project. This indicates the importance of groundwater development through tubewells to meet the shortage of water from canals.

4 Post-Project Evaluation

The completion of SCARP-1 was followed by the development of six other SCARPS in Pakistan. This project was therefore, taken as a pilot project to provide design and operational information for other SCARPS. Therefore, this project was monitored continuously in the last two decades. Data was collected on tubewell performance, canal and tubewell discharge soil salinity, cropping pattern , cropping intensity, and yields of crops, the operation and maintenance expenditure on tubewells and the revenue received from the project. The Project has also been evaluated a number of times, more from the point of view of technical and administrative organizations than from the basic social and economic factors that were inhibiting the targeted agricultural growth. This paper is part of a comprehensive study (1981) which the authors conducted for the United Nations University in 1981. The objectives of this study were:

a) To collect and analyse field data on the project performance since its completion with a view to determine the effective use of existing knowledge for the solution of technical, social and economic problems in increasing agricultural productivity of the project area.
b) To identify critical gaps in knowledge or in the dissémination of knowledge to the project managers and the farming community.

This paper is only a small part of the above comprehensive study and is based on data collected from various organizations and through a field survey. In this survey 947 farmers were interviewed on 144 watercourses and data was collected on status, rolè, value, attitude, perception and family characteristics of farmers, farm characteristics, pattern of social interaction and agricultural data. Distribution of farmers along watercourses is given in Table 1.

Table 1. Distribution of number of sampled farmers according to watercourses reach and land holding

Land holding (ha)	Head	Middle	Tail	Head-Middle-tail	Total
<2	0.8	2.5	0.3	0.1	3.8
2 - 10	16.8	26.4	22.5	4.5	70.5
>10	0.5	8.2	7.8	4.6	25.7
TOTAL	22.7	37.1	30.6	9.2	100.00

5 Analysis of Data

5.1 Project Tubewell Performance

The detailed analysis is given in another paper (1982). However, it would suffice here to mention that the consultants had assumed 30-40 years as the tubewell life. On the contrary the economic life has been observed to be 12 years during which the tubewell discharge reduces to less than 50 percent of its initial discharge. In the past the major cause attributing to this was believed to be corrosion and encrustation of strainer material. Consequently a number of strainer materials such as miled steel, brass, PVC, coir rope and fibre glass were used without making a concerted effort to study the basic cause of such a deterioration to suggest remedial measures.

Analysis of data on tubewell performance (Figure 5) in the past several years has shown that fibre glass has not performed better than the less costly materials such as mild steel, brass, and PVC.

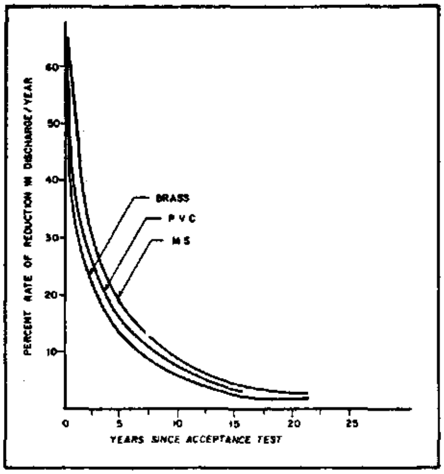

Figure 5. Percentage reduction in discharge of public tubewells with various tubewell materials.

It has been observed that maximum discharge reduction in all strainers occurs during the first two years. The rate of decline in discharge progressively decreases with time untill it is almost 3 percent/year after 15 years. In terms of performance, brass is the best followed by PVC and mild steel. Corrosion and encrustation cannot have such a rapid effect. It is therefore, believed that it is design and construction of the gravel pack which has a predominant effect in the deterioration of performance of tubewells.

5.2 Social impact of tubewell locations

The consultants had considered that the nature of the project aquifer was such that high capacity tubewells could be used any where. Therefore the tubewells were located in the following manner:

a) Where one tubewell served one watercourse, it was located at the head of the watercourse to facilitate mixing of tubewell water of marginal quality with the canal water.

b) Where two or more watercourses were served by one tubewell, it was located near the head of the upstream outlet on the side of the canal with the largest command area. This eliminated construction of extensive channels to convey water back to the heads of water courses.

Both of the above locations created social problems on the utilization of water. First the high capacity tubewells necessitated remodelling of water courses. This was the responssibility of the farmers who took long time with the result that wastage of water had increased. Farm efficiencies had further reduced. Moreover, heading up of water in the head reaches of water courses due to high tubewell discharges did not permit the authorised discharge from the watercourse outlet as it depends on the head difference tubeween the outlet and the distributary.

In situations of one tubewell serving more than one watercourses, disputes arose where water was conveyed across a distributary through syphons which generally get choked. Disputes also arose when one water course served several villages and the water never reached the tail end due to cuts by the upstream users, especially when the watercourses are several kilometres long (more than 6 Km). These social problems could have been eliminated had the tubewells been of small capacity and dispersed over the whole length of a water course. In fact the farmers have reacted to shortage of water and have installed low capacity small tubewells of their own. Farmers opinion about adequacy of water-supply is given in Table 2 below. It is clear from Table 2 that only 7% of the farmers are satisfied with irrigation supplies while 93% are not getting enough water. The distribution of private tubewells is shown in Table 3.

Out of the total number of private tubewells 64 % were diesel operated and 36 % electrically operated wells. This would give an indication how difficult it is to get an electric connection for a tubewell. In spite of all that the shortage of irrigation water has forced the farmers to install costly diesel operated tubewells.

Table 2. Farmers opinion about irrigation supplies

Landholding(ha)	Tubewell (Private) farmers reporting%				
	No shortage	Total	T/well water	canal water	Both
< 2	-	-	-	-	-
2 - 10	1.6	98.4	10.1	11.7	76.6
>10	0.2	99.8	14.4	11.0	74.4
Mean	0.9	99.1	12.3	11.3	75.5
	All farmers reporting %				
Project Average	7.0	93.0	15.6	16.9	60.5

Table 3. Distribution of private tubewells

Landholding(ha)	Percent of farmers having private tubewells
< 2	0.0
2 - 10	48.0
> 10	52.0

Serious shortage of irrigation supplies has been caused by the frequent breakdowns or stoppage of public tubewells. Figure 6 indicates the reported number of hours lost in various years. This has partly been due to frequent project reorganizations. The project started with an integrated approach or ' project approach' with irrigation, agriculture and cooperatives all under one Project Director. In 1970 these Divisions were separated and merged with their respective Departments. From then onwards, the responsibility of the Project Directorate was only irrigation. In 1977 canal water distributipn was handed over to their respective canal divisions and the project Directorate was responsible only for the operation and maintenance of tubewells. As a result of farmers have to run to various organizations for various problems. This has created frustation among them. Consequently they cast doubts on public services in the project.

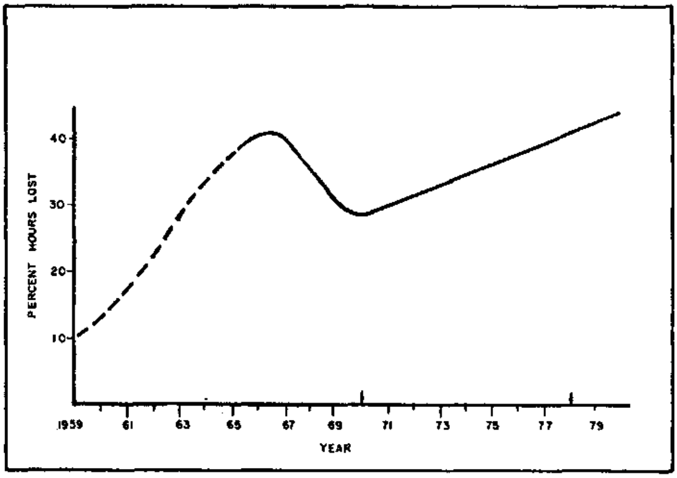

Figure 6. Total percent hours lost due to various tubewell defects

5.3 Effect of shortage of irrigation supplies on cropping pattern and yields

Analysis was carried out to determine the difference in cropping pattern of the farmers reporting ' shortage ' and ' no shortage ' of irrigation supplies. The cropping pattern as a percent of the cropped area is given in Table 5.

Table 5. Comparison of cropping pattern of farmers reporting 'shortage' and 'no shortage ' of irrigation supplies

Crop	Cropping pattern (%)	
	Full supply	short supply
Wheat	36.8	47.7
Rice	26.8	19.2
Sugarcane	7.5	4.5
Maize	1.7	2.3
Fodder(K)	11.2	8.8
Fodder(R)	10.3	9.7
Other crops	5.7	8.3

The difference in crop yields is shown in Table 6

Table 6. Comparison of yields (Kg/ha) of farmers with adequate and inadequate supply

Crop	Adequate supplies	Inadequate supplies
Wheat	2,170	1,604
Rice	1,980	1,604
Sugarcane	30,565	29,901

There is a substantial reduction in the yields of wheat and rice as a result of inadequate irrigation supplies. Fertilizer application in both cases has been observed to be the same.

5.4 Economic Analysis

The natural outcome of frustation in farmers and the shortage of water was that the project did not produce the desired economic returns. The crop yields reached their highest in 1968-69 when abundant water was made available and there were no operational problems. Thereafter the yields declined and continued to show a declining trend untill 1981 (Figure 7) when this survey was conducted.

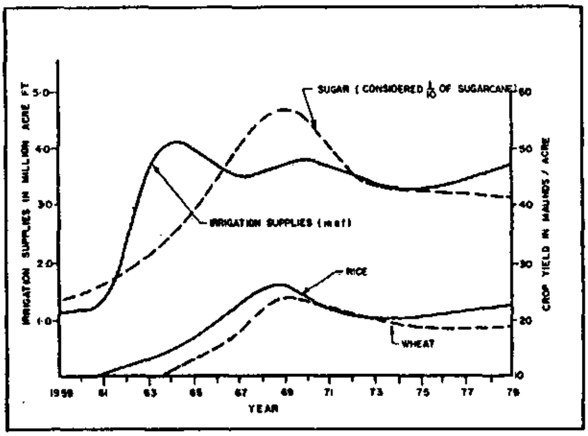

Figure 7. Water Supply crop yield relationship

The yields in 1981 were 50 - 60 percent of the target of major crops. The cropping intensity however, exceeded the target as shown in Table 7.

Table 7. Cropping intensity 'with' and 'without' Tractors and private tubewells

Landholding (ha)	Cropping Intensity (%)					
	Project Average	Tractor with	Tractor without	Private T/well with	Private T/well without	Both
<2	152.4	-	-	-	-	-
2 - 10	136.6	143.2	126.8	145.5	125.5	156.9
>10	125.0	127.0	120.1	127.4	118.6	131.2

The increase in cropping intensity can be attributed to private tubewell development and farm mechanization. There is however, an imperative need to focuss attention to increasing crop yields/ha by maintaining proper salt balance, and groundwater table level through leaching and drainage. It may also be emphasised here that there is an urgent need to develop a criterion for land productivity viz-a-viz yeild, salinity status and drainage. At present the land is considered to have been reclaimed if the water table is lowered below 3 m from the ground surface, irrespective of its salinity status and its yield potential. Land productivity should be classified keeping in view soil-water-plant relationship.
On the economic side the farmer is concerned directly with increased and sustained crop yield in return for the labour and material inputs. His motivation is related to the benefits he derives from his inputs and his skill in using them. Data was, therefore, collected on market prices of inputs, outputs, the labour involved in farm management and the water rates that the farmers are paying for various crops. Results of analysis of farm budgeting are presented in Figure 8 for two main crops. The points where the curves cut the yield axis represent the yield at which the farmer have no gains under the prevalent costs. These yields are 934 and 1131 Kg/ha (10 and 12 maunds/acre). All crops show diminishing return indicating thereby that the land has not reached its maximum production level and requires increasing cost to get more yields.

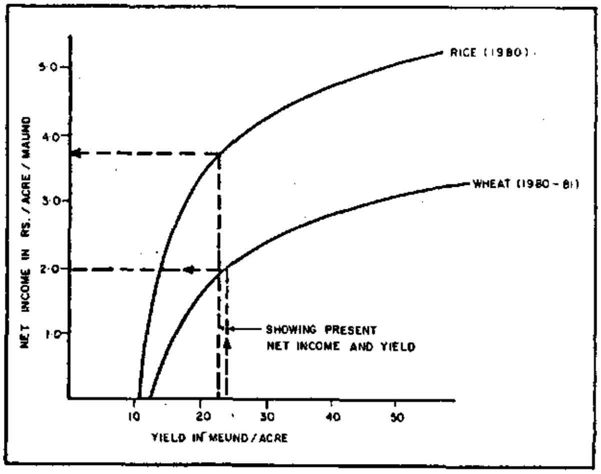

Figure 8. Farmers net income - yield relationship

It is interesting to note that farmers are paying only 14.5 and 11.8 percent of their net income as water rates to the Government, in spite of the fact that these are twice those of the Non - SCARP areas.

The results presented above may present a very bright picture on the economic returns that the farmers in the project are receiving in relation to the water rates they are paying for the facilities provided to them . In this situation one should not ignore the large variation in yields from the average. For example, a large number of farmers have wheat fields of 15 maunds/acre (1415 Kg/ha);there are others who are obtaining 31 maunds/acre (2924 Kg/ha). For these farmers water rates are 32 and 12 percent of their net income. These are the low yield farmers who have to stand greater impact of any increase in water rates. The low yield farmers are generally those with affected lands. Since they have to face the brunt of any increase in water rates, they canot invest on the improvement of their lands, There are many low-yield farmers who have been reported to be paying water rates by getting loans from the market brokers or by selling their animals.

On a macro level the objective of the economic analysis was to evaluate the economic performance of the project, especially the economic returns brought about by the high investment cost on the public tubewells. The purpose of the public tubewells was first to reclaim the project and bring it at par with the adjoining non-SCARPS. After the improvement is achieved, the project yields must exceed those of non SCARPS because of the availability of additional quantity of water from the public tube-wells. In this economic analysis, therefore, the economic concept of 'with' and 'without' project has been used. The 'without' project is the one which has the same agricultural environment as this project, but has no public tubewells. For this purpose an adjoining area having similar soil salinity and watertable conditions was selected. Data regarding cropping pattern, intensities, crop yields, tubewell pumpage - both public and private - in the project area and the adjoining Non-SCARP area was collected and used in the economic analysis. It was undertaken according to two parameters of investment criteria; i.e. Benefit Cost ratio and the Internal Rate of Return. The results of economic analysis are given below:

Benefit Cost Ratio	=	0.99 : 1
Internal Rate of Return	=	5.7 %

The above results indicate that the project operation has been inefficient.

6 Acknowledgement

This study was sponsored by the United Nations University. Their financial assistance is thankfully acknowledged. The study was conducted by a team consisting of engineers, agriculture scientists, sociologists, statisticians and economists at the Centre of Excellence in Water Resources Engineering, University of Engineering and Technology, Lahore, Pakistan.

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THE ORIGIN AND EARLY STAGES OF THE HERMAN-GÖRING-POLDER (TÜMLAUER KOOG) IN SCHLESWIG-HOLSTEIN, GERMANY

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Strengthening the peasantry played an important ideological rôle during the period of National Socialism in Germany, and one of the important policy instruments for pursuing this goal was establishing new settlements in Germany itself (called the Siedlung policy). Before the time of National Socialism this policy was concentrated on those parts of Germany to the east of the Elbe, where estates in financial difficulties were split up into farms. There, the aim was to extend the number of German-speakers in districts with large Polish-speaking minorities.

From 1933, more emphasis was given in this new settlement policy to increasing food production. Consequently, the emphasis changed from dividing up estates - the result of which having been a shift towards cattle products rather than an overall increase in the amount - to the colonising of new land. This was the context within which the newly enclosed land behind the dykes along the coastal mudflats of Schleswig-Holstein was settled, especially from 1933 onwards.
In this paper we shall investigate the realisation of one of the polders on the west coast of Schleswig-Holstein, the Hermann-Göring-Koog, and in so doing we shall demonstrate the influence of the ideology of National Socialism on this process. We shall discuss in particular the antecedents of the polder, the process of building the enclosing dyke, the land-using planning and architectural design, the selection of the settlers, and some of the developments during the National Socialist period. We

shall start with a few words about the overall plan for the west coast of Schleswig-Holstein, as part of which plan the land was won.

1 The plan to enclose the land

The main aims of the regional plan for the west coast of Schleswig-Holstein were to shorten the coastline by enclosing silted-up land behind dykes and to improve the water management of the adjacent mainland. Farming villages were to be established on the new polders, and the land was not to come into the possession of the farmers on the old land nearby, as is customary on - for example - the coastal mudflats in the north of the Netherlands (van Welsenes, 1980, p. 74).
The contents of the plan were published as early as 1931, by a cooperative association of waterboards, the 'Freie Arbeitsgemeinschaft der Deichverbände an der schleswig-holsteinischen Westküste (Denkschrift 1931, p. 31). In 1933, the National Socialists adopted this plan almost without modifications: from then on, they began to put the stamp of the new doctrine on it. In order to emphasise that, the plan was named after the 'Gauleiter" of Schleswig-Holstein, Hinrich Lohse. At the same time, typical National Socialist aims were added to the existing plan-objectives - to increase the number of farmers with 'highly valued racial characteristics' and to improve the supply of food (Martens 1935, p. 31; Schow 1938, p. 1). And because the plan was incorporated within the national town and country planning system, there would be no conflicts about areas of competence so it should be possible to implement the plan more quickly. However, the division of responsibilities within the town planning system was unclear, and that led to disunity between the planning agencies and the national ministry of agriculture. Moreover, the central authorities remained dependent on the expertise of the waterboards, while these latter had been relieved of their powers (Schow 1938, p. 11).
A considerable part of the plan had been realised before 1945: seven mudflat polders were brought behind dykes, varying in size from 500 to 1300 ha. Of these, the best known were the Adolf-Hitler-Koog and the Hermann-Göring-Koog, both initiated in 1935 by the men who had lent them their names. The execution of the Lohse plan began straight away in 1933,

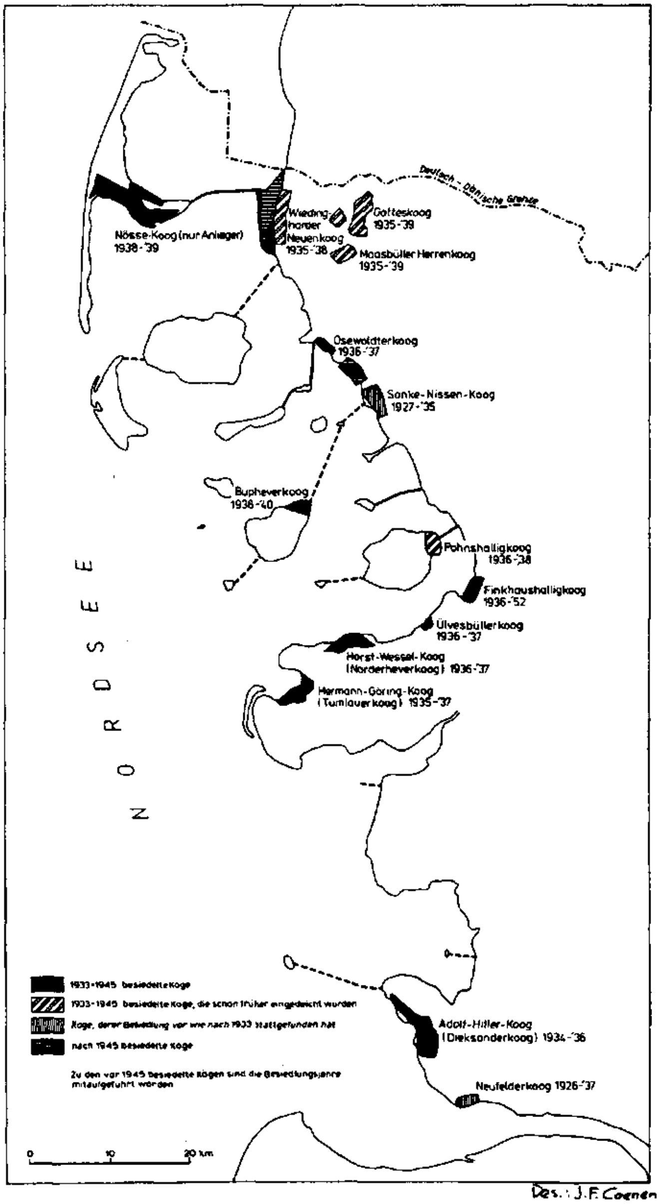

Fig. 1. The Lohse-Plan for the west coast of Schleswig-Holstein.

everything having already been prepared. In that same year, work began on the Hermann-Göring-Polder, although an early enclosure of that area was not in the original timetable.

2 The history

The Hermann-Göring-Koog is situated in a bay in the northwest of the Eiderstedt peninsula, on what is called the Tümlauer Bucht.
Before its enclosure, the area was used for extensive sheep grazing. The exposed mudflats around the Eiderstedt peninsula are relatively small in area compared with the rest of the coastal mudflats of Schleswig-Holstein, because currents prevent much silt being deposited either on the north or the south of the peninsula. It is for this reason that not a single new sea polder - called a 'koog' in Schleswig-Holstein - had been created since 1862. On the Tümlauer Bucht, however, it was considered feasible in the 1920's to enclose an area of land, because an extensive foreland had accumulated over the years, protected by the bay. But a request made in 1924 by the then administration 'Kreis Eiderstedt' to build an enclosing dyke was rejected, on the grounds that the land was not yet ready for impoldering, by the standards of that time. In addition, a number of channels would have to be enclosed, and that would not yield any useful land.
When the National Socialists took power in 1933 they pushed to one side those objections to building the dyke. They considered that constructing a polder on that side could serve as a model project for improving the pattern of agriculture on Eiderstedt. For in that area, the fattening of cattle was the principal agricultural activity, and on leasehold farms, neither of which were acceptable to the ideals of National Socialism: fattening-up cattle was too speculative and contributed too little to the food requirements of the area, and the system of leasehold did not strengthen the ties of the peasant to his land (Denkschrift Hermann-Göring-Koog). But although experts established that not all of the ground was suitable for impoldering, construction of the dyke nevertheless began in 1933 (Pakusa, Rüttgers 1936).

3 Building the enclosing dyke

Each stage of the realisation of the Hermann-Göring-Polder was accompanied by differences of opinion between the parties involved, and the building of the dyke was no exception. Discussions over the line of the dyke were still in full swing when the dyke was begun in 1933. Against the idea of keeping the dyke as short as possible, it was argued that a longer dyke would be better, as then more of the gullies and channels could be kept outside the dyke. The dyke which was eventually finished at the end of 1934 was 5.2 km long, a comprise between the two possibilities. The polder had an area of 580 ha, giving a ratio of 106 ha for every 1000 m dyke: this was a little better than the then minimum norm of 100 ha for every 1000 m dyke (Pakusa, Rüttgers 1936). However, the decision to run the dyke through several channels was not without consequences: towards the end of the construction, the dyke collapsed where it had been laid in a channel. The reason given was the poor load-bearing capacity of the ground. Up till then, all work on the dyke had been by hand, as part of the job-creation programme, but reparing the dyke had to be done with the help of machines.

4 Laying out the new land

A settlement company (a 'Siedlungsgesellschaft') was given the task of developing the polder and selecting the settlers. This company was a private organisation in which the state had some influence by virtue of a considerable shareholding and representation in the supervisory council (Aufsichtsrat). The settlement work of these companies was overseen by a regional technical farming authority, the 'Kulturamt'. During the period of National Socialism, the various agricultural interest groups were co-ordinated by an organisation called the 'Reichsnährstand', and the local representatives of that organisation were also able to exercise some influence on the settlement process. But while the first two agencies (the settlement company and the Kulturamt) had clearly defined rôles, the rôle given to the Reichsnährstand was vague. In our opinion this was deliberate: it allowed the state, and especially the central ministry for agriculture, to influence the course of events more or less unnoticed.

From 1933, the settlement company lost its capacity to operate independently, for the co-ordinating organisation (Reichsnährstand) and the state acquired a deciding vote in the supervisory council. It appeared that such state control would be sufficient to guarantee a quick and flexible execution of decisions. But the question of powers and responsibilities which was important at the national level also arose in a local context. That is clear if we look, for example, at the lay-out plans for the polder.

The 'Kulturamt' supported by the local branch of the Reichsnährstand, designed a sub-division plan; at the same time, the local settlement company (the Schleswig-Holsteinische Höfebank) was also working out a plan, which could count on the support both of the national town and country planning authority and, in particular, of Göring himself. In all these activities, Göring was an important figure because Hitler had given him responsibility for the 'Erzeugungsschlacht', a campaign to increase the level of food production nationally, and had also charged him with the task of winning new land on the west coast of Schleswig-Holstein.

Two plans were therefore prepared, and from each can be deduced, more or less, the aims of the plan-makers. In the design of the Kulturamt, the ideal of community was foremost. For that reason, there was to be a concentrated settlement, this was to be a local government unit (Gemeinschaft) at the lowest level, and it would be dependent on the surrounding area of the old land. There were, as a result, very few communal services planned for the new village. In the design of the settlement company, agricultural production was central. Consequently, the settlement pattern was to be dispersed: each farm stood in the middle of its own land. And, so that the new community could be used as a model and example, it was to have a number of facilities such as a school and a cafe. Moreover, the polder was to be an independent local government unit.

Göring got his way, in this as well as subsequent matters. A closer examination of the plan chosen reveals farms built beside a road running the length of the polder and also alongside several roads going across it (Figure 2).

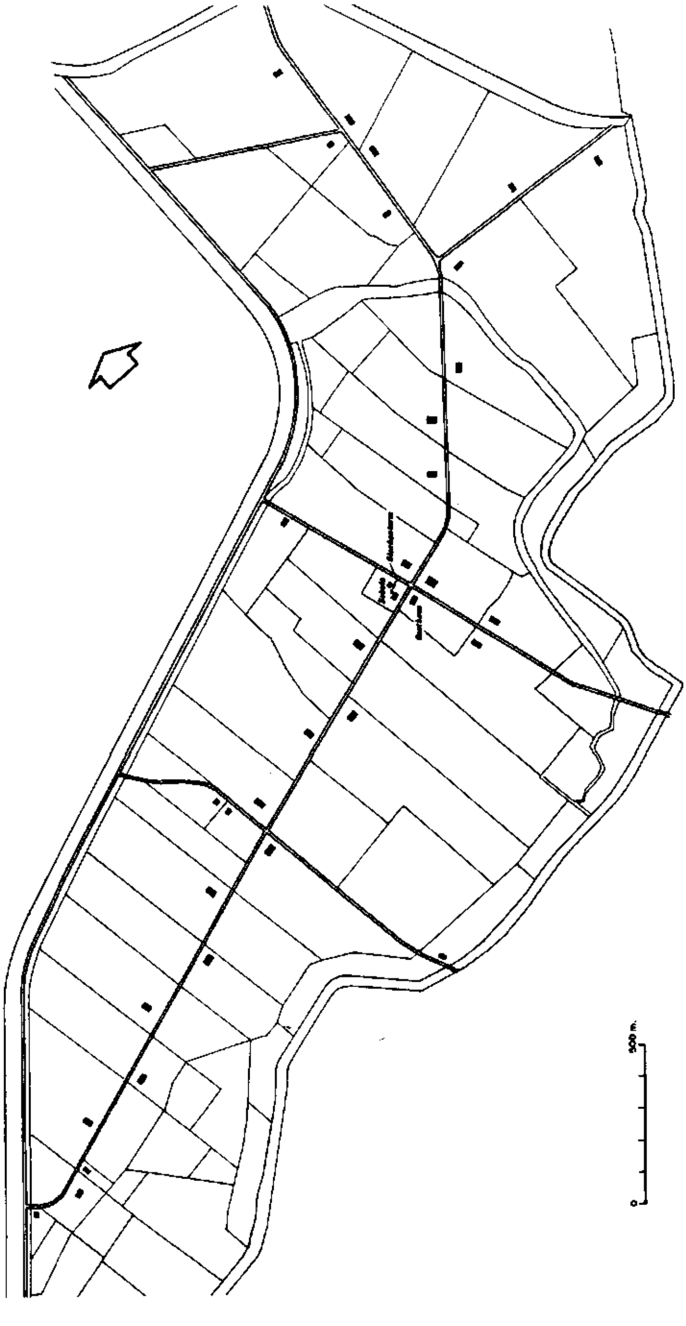

Fig.2. Hermann-Göring-Koog 1935.

Where the main road and the lateral road to Tating cross, a sort of centre was to arise, because here were to be concentrated facilities such as the school, the cafe with a community hall, and the bell tower. The function of the bell tower was to symbolise the character of the village as a farming community: that can be read from the inscription 'The peasantry is the bloodstock of the German race' (Das Bauertum ist der Blutsquell des deutschen Volkes) which is at the same time a declaration of the relationship of the village to the nation.
Incidentally, the design of the village centre was less impressive than had been intended: from the road out of Tating the bell tower could not be seen, whereas the toilet block could be seen from a long way off.
Initially, 32 farms were established on the new polder. On the basis of their size, these could be divided into two groups: one of 22 farms between 10 and 27 ha for full-time farmers, and one of 9 farms between 2 and 5½ ha for part-time exploitation. The chairman of the Kulturamt had raised objections to creating 'part-time' farms, because he considered that it would be impossible to find sufficient non-agricultural work in the surroundig area. On the other hand, it was argued that all the part-timers had other work on the polder: 5 were dyke workers, 2 farm labourers, one a cafe owner and one a carpenter. The farms for part-timers were dispersed between the farms for full-timers, in order to create a community of farmers and labourers, as in other new polders (Denkschrift Adolf-Hitler-Koog).
Because the farming units were dispersed throughout the polder, the number of plots per farm could be kept down to a maximum of 3. As time went on, most farms were able to cultivate crops, although it was obligatory to keep a small area of pasture land in order to prevent too much specialisation. There were, incidentally, 6 farms to the north of the polder which, because the land was so heavy, had to be wholly or for a large part sown with grass. (Denkschrift HG-Koog, Wohlenberg 1939).

5 The architectural design

A lot of attention was given to the style of the buildings, not so much out of a consideration for business efficiency, but more because of the symbolism. In order to point out the connection between the polder and the agricultural past of Eiderstedt, when agriculture had been arable, the houses and the farm buildings were built in the form of the so-called 'Haubarge', which had been the farm style on Eiderstedt (it is not unlike the 'Stelphoeve' in Friesland). The roof was of thatch. But the school and the cafe were also built in this style, and even the bell tower had a thatched roof. There was a lot of propaganda for this style of building in the time of National Socialism, and up until 1945 it was not permitted to erect buildings in any other style. Only one man, a farmer in the north of the polder and a party boss, was allowed to deviate from that style in order to achieve a more efficient set of buildings. The farms were put up as 'Ausbausiedlungen': only the bare essentials provided. Later, if the settlers were able to enjoy the record harvests that were expected of them, they might be able with their own resources to expand and further equip their buildings.

Although officialdom showed itself to be very satisfied with the new farms, the settlers themselves were less content. They complained about the impracticable building style, the impossibility of expanding the buildings cheaply, and the poor quality. The principal reason for the latter was the haste with which the building was accompanied, in order that everything should be ready for the inauguration in October 1935. Another result of building with such speed was new differences of opinion between the Kulturamt and the Höfebank, for the Höfebank had started building without waiting for the permission of the Kulturamt.

6 The selection of the settlers

Theoretically, the settlers were to be chosen for their supposed favourable racial characteristics and their professional knowledge. In practice, political affiliation and relationships with important party officials played a significant, sometimes a decisive, rol. Those who had been members of the NSDAP before 1930 could count upon financial support if

they obtained a place on the polder. Non-party members who were nevertheless selected had to find their own finance. (Incidentally, if you were not a member of the party, you could only be selected if you were sound financially). Of the 27 new-comers to the polder (the other 5 farms were taken by dyke workers or small farmers already working there) there were, on arrival, 5 members of the SS, 3 members of the SA, and 6 who had been party members before 1930.
Before they went to the polder, all had worked in agriculture.

Examing where the settlers had come from shows that relatively few were from the direct surroundings. Of the 34 settlers who finally came, almost half were from the east of Eiderstedt, where Kreisbauernführer Hönck lived, an important figure in agriculture in Eiderstedt. Those few settlers who came from outside Eiderstedt obtained important public positions on the polder, such as mayor or the Ortsgruppenleiter SS, which would indicate that they had been deliberately attracted to the polder.

7 The inauguration

The polder was officially inaugurated by Hermann Göring on 20 October 1935. There was a strong wind with occasional rain. The ceremony took place on the outer dyke and demonstrated how important the enclosing of the mudflat polders on the west coast of Schleswig-Holstein was for propaganda purposes at this time. As well as Göring, the national Minister for Agriculture Darré and Gauleiter Lohse were present. Relationships at national level were made clear. Göring gave the longest of the opening speeches, was made godfather of the first boy to be born on the polder (bud did not attend the christening which had been especially organised for that day by the church at Tating), declared that 25,000 RM would be made available for settlers who experienced financial difficulties, and promised that a community hall would be added to the cafe. The part allotted to Darré was much more modest: he gave only a short opening speech and was allowed to nominate the local representative on the Reichsnährstand, the 'Ortsbauernführer'.
The opening ceremony emphasised clearly the dominant position of Göring with respect to Darré.

After the school had been opened in 1936, attempts were made to stimulate an intensive community life, in which the farmers in particular were to take part. The initiatives came mainly from the party and from the school teacher who had been appointed in 1936. However, before that time the farmers had already learnt to be dependent on each other. Before their houses had been finished they had lived under primitive conditions in wooden huts, and that together with the laborious farming methods which had to be used had thrown them on their own resources. After the work had been completed, the cohesion of the farmers, both ideological and economic, remained. They were kept on their toes by the hostile attitude of the people living in nearby Tating: most of the enclosed land had been previously used for sheep grazing by the farmers from Tating.

The first years on the polders were particularly difficult economically for the farmers. The ground was much heavier than they had expected, which made cultivation very laborious. The record harvests which they had been led to expect were not forthcoming, and in 1937 about 200 ha (about 40% of the land) were not yet fully in use. The wet weather in the first years was blamed for the disappointing results, but it became clear in 1937 that the structure of the ground was poor. Some authorities began to admit that the polder might have been enclosed prematurely. The circumstances were particularly unwelcome for the settlers, especially for the good party members who had little financial room for manoeuvre. The central government was not so much concerned with the fate of the settlers, however, but more with the propaganda-object falling into discredit. For that reason, the settlers were granted even more subsidies, even though they had already enjoyed the financial relief promised by Göring in 1935. Further, a start was made in 1938 with draining the ground and with the addition of 'blue sand' in order to improve the soil structure.

In spite of all those difficulties, almost all the settlers remained on the polder, an indication of their strongly developed solidarity. Before the end of the Second World War, only one farmer had had to leave his farm for financial reasons. However, the War itself had a strong effect on the village community, because the many party members

and SS'ers ended up at the Front, in the lower ranks. In all, 12 men were killed, more than 6% of the 192 residents (in 1939).
For the inhabitants, the war was the first of the unfortunate consequences of the special relationship between the polder and the National Socialist system. There were further consequences after the war - which for the people living on the polder had the wrong ending - they lost their priviledged position and the ideological basis of their existence and perseverance in economically hard times.
In 1945, the rumour went the rounds that all the inhabitants would have to leave the polder because of their NS-sympathies. In practice, only two farmers were removed, the schoolteacher was not allowed to exercise his profession until 1948, and everyone was 'denazified'.
The ideological upheaval had further effects. After the first generation of farmers had handed over to their successors in the course of the 1950's, about half of them left the polder and settles down elsewhere on Eiderstedt, and of those who remained few stayed on their own farms; most moved into new houses, often built at some distance from the farm, there to live out the rest of their days. From many conversations we have had, it would appear that discussion between the generation about the NS period was taboo.
Although the first generation of farmers scattered themselves over a large part of Eiderstedt, it appeared that they kept up a lot of contact with each other, idealising the past and rejecting the present.

If we examine the changes in the number of people and of farms, then we find the population stagnating and the farms merging and growing bigger. Between 1939 and 1975, the population fell by 17% to 160: between 1942 and 1977 the number of farms fell by 21%, from 33 to 26 (Historisches Gemeindeverzeichnis, Meier).
The farms remaining show a strong tendency to expand, and in 1977 they had 75% more area in cultivation than had all the farms on the polder in 1942. In that period, the average farm size grew from 13.8 ha to 30.6 ha, caused mainly by leasing additional land both on the old land and in the new polder. We see, therefore, that the remaining farms on the polder have a tendency to adapt themselves to the pattern of farming on the old land. The same is true for changes in the use of the land: whereas in 1943, 57% of the land belonging to the farms on

the polder was arable, in 1977 that had dropped to no more than 35%.

It is clear therefore that the ideological character, both social and economic, of the polder has disappeared. For that to have happened, however, the first generation had had to be replaced: to the end, they have remained faithful to the past and they would have preferred to have the circumstances pertaining then restored. And because that did not appeal to the younger generation (until a few years ago, at least) there was nothing for the older generation except isolation, an isolation in which they could live on the memory of the time when they had been regarded as an elite.

9 Traces from the past

In spite of those changes, one can still detect traces of the past. For example, the Tümlauer Koog, as the polder was renamed in 1945, is still a local government unit on its own, although its population is only 160 (in 1975). Most of the buildings are still in their original condition and most still have their thatched roofs. The village scene has changed little, because only a few houses have been built since 1945. Even the belltower is still there. Some of the buildings, however, now have a different use. The school has become a second home, because since the 'schulreform' of the 1970's all the children have to attend a central school in the neighbouring seaside resort of St Peter and the resident schoolteacher has moved to Garding. Many of the farms have lost their agricultural function, but their appearance has made them attractive to people wishing to spend a holiday 'down on the farm'. A lot of these people said they were very taken by the beautiful buildings in the Eiderstedt style, but they had no idea that those farms were little more than 40 years old. At the present day, at least 13 of the farms display the notice 'a holiday on the farm', and several other farms boast a holiday apartment. It is only that the farms look attractive: the development of tourism on the polder also owes much to the location nearby of the bathing beaches of Westerhever and St Peter.

A number of things have become clear from the above.
First, we have been able to see that objectives with a clear ideological basis have influences the settlement policy and its spatial expression. When the polder was enclosed in 1933, it brought success for National Socialism in the short term while the disadvantages which were to appear in the longer term (resulting from the poor ground conditions) were overlooked. The way in which the polder was laid out and inaugurated shows clearly that the NS-regime wanted to present itself als a united power, but that nevertheless different power positions could be detected within the regime. The fact that the use of power was unsupervised makes the rationale of the decisions unclear. Further, the physical planning of the polder was not so much the outcome of a consistent ideology as of the confrontation between two power positions at the national level (Göring vs. Darré) played out by actors at the local level (Siedlungsgesellschaft vs. Kulturamt). The architectural design and the selection of settlers demonstrated the conflict between wanting to use the settlement to improve the racial characteristics of the German people and wanting to increase food production nationally.
The heavy ideological content of the approach had specific consequences for the course of later developments. When the effects of enclosing the land too early became clear, it was necessary to spend a lot of money on corrective works because the project was being used as a model. The residents of the polder felt honoured to have been chosen, and they cooperated actively in order to ensure their future and to have the face of the regime in this respect. That meant that the disenchantment was all the more painful when the ideological content was removed in 1945. To the present day, it is still not apparent to that first generation that there was no clear ideological aim, and that it was more a case of establishing power positions.
The case presented here is of a modest size. The question must therefore be asked: to what extent is this case representative of developments more generally?

In answer, it must be pointed out that the project was implemented as part of the regional plan for the whole coastal mudflat area of Schleswig-Holstein, and that on the other polders constructed within the Lohse plan similar developments are evident. Other polders also, the Adolf-Hitler-polder (now called the Dieksander Polder) on Dithmarschen among them, were also built on ideological foundations. It must be said that the entire project enjoyed only a temporary limelight. The peak of its achievement was the completion of three polders in one year (the Hermann-Göring-, the Adolf Hitler-, and the Maasbüller Herren Koog on the Danish border, all in 1935). Thereafter, interest fell away quickly, and the other polders were given much less publicity, especially as patriotism had to be whipped up for other matters, such as the war preparations.

It must also be pointed out that other regional plans besides the Lohse plan were being prepared for other areas of Germany at this time. There were, for example, the Emslandplan, the plan for the Hessische Ried near Darmstadt and the Rhönplan (called the Dr. Hellmut-plan). In all those cases, the recently worked out ideas about national physical planning were applied to rural areas, where food production had to be increased by reclamation, drainage and 'Siedlung'. In addition to that aim, there were always other objectives, often specific to the region.
Seen in that light, the settlement of the Hermann-Göring polder does not stand on its own but is one component of the physical planning of the NS Period. That physical planning was applied elsewhere in Germany too, but most of the plans never came to fruition. After the war, a number of them (albeit with a different ideological content) were taken further, such as part of the Programm-Nord in Schleswig-Holstein.

Notes

1 The material of this paper have been bleant form many different sources not mentioned specifically in the course of the text. These were:
- Akten Landesarchiv Schleswig
- Akten Bundesarchiv Koblenz

- Akten Schleswig-Holsteinische Höfebank (renamed in 1936 in Schleswig-Holsteinische Landgesellschaft), Kiel
- Privatarchiv Thiesen, Garding
- Kirchenchronik Tating
- Bodennutzungserhebung Part 1 and 2, 1977.

Other useful sources were the interviews with first-generation-settlers and officials such as the mayor, the schoolteacher, etc.

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POLDERS AND LANDFILLS AS ALTERNATIVE SITES FOR MAJOR AIRPORTS

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Abstract

One of the biggest problems facing airport planners is to find enough land to meet the needs of new or expanding airports. For cities near water it might be worthwhile to consider polder and landfill sites. Studies have been done to build new airports in polders in the Great Lakes near Chicago, Cleveland, and Toronto. Polder and landfill airports have been considered for Copenhagen, London, Amsterdam, and Hong Kong. Polders are very expensive to construct, generate environmental concerns, and may have weather problems. Alternative land based sites may be too far from the city, may cost too much, may have other more valuable uses such as agriculture, and may lead to severe noise impacts on the population.

1 Introduction

Many of the major cities of the world are located adjacent to bodies of water, for example: Toronto, Vancouver, Boston, New York City, Miami, Washington, Chicago, Cleveland, New Orleans, Los Angeles, San Francisco, Copenhagen, Amsterdam, London, Hong Kong, Singapore, Seoul, and Osaka. It has been estimated that 75% of the population in the U.S.A. lives along ocean coasts or the Great Lakes area and that of out of the 15 largest metropolitan areas are adjacent to these bodies of water, Harza (1970). Land reclaimed from water may be a viable alternative for the airports of some of these cities.

2 Polder and Landfill Concepts

Two alternatives can be considered for reclaiming land for airport use. One is the traditional landfill alternative, and the other is the polder concept.

2.1 Landfill Concept

The landfill method of creating new land from water is to simply fill in with earth or rock the area required. This method is particularly suitable for airports located adjacent to water. Often the landfill area becomes an extension of the land based airport. The new land is usually elevated above the high water mark.

Numerous airports around the world are built on landfill, for example, San Francisco, Hong Kong, New York (JFK), Boston (Logan). New airports and extensions to airports have recently been built on landfill. The new Changi Airport in Singapore, opened in July 1, 1981, is built on 1,663 hectares of land of which 921 hectares are reclaimed land. The airport is 6.5 m above sea level, Goh Keng Chew (1981). At Nice, a runway at the Cote d'Azure Airport has been extended on landfill. Other airports are planning to build on landfill. The new proposed airport for Hong Kong will be built at Check Lap Kok. The airport will need about 800 hectares of which 485 hectares will be claimed from the sea, Clark (1981). In St. Thomas the only way to create land for expanding the airport is to extend the land into the sea for about one kilometre into 27 metres of water. The result will be 2.4 kilometres of new shoreline. It will require 7.7 million cubic metres of fill, Clark (1981). And at Vancouver Airport, Transport Canada proposes to extend a runway into the Strait of Georgia requiring 1.5 million cubic metres of fill, Transport Canada (1976).

Feasibility studies for landfill type airports have also been made for a number of major world airports. In Cleveland, NASA proposed to build an airport on landfill 1.5 kilometres offshore in Lake Erie. The first phase would cover 425 hectares in about 14 metres of water and require 66 million cubic metres of fill, Harza (1970). A similar project was proposed for New Orleans. Here the new airport would be located in Lake Pontchartrain, 40 kilometres from the city. The first stage would see a 964 hectare island in 1.8 metres of water, Harza (1970). And on the west coast of the U.S.A., San Diego conducted a study to investigate the feasibility of constructing a new airport in the Pacific Ocean, Lord (1973). The planners recommended a fill and dike method of construction as shown in Figure 1. Due to the steep continental slope and deep water, the airport would have to be located close to the shoreline. In England, during the search for a Third London Airport, a study was made of a site at Maplin, located 80 kilometres from London. The airport would become part of combined development of air, sea, oil, and industry terminals on 7,200 hectares of reclaimed land. An estimated 330 million cubic metres of fill would be needed, Harza (1970).

2.2 Polder Concept

The polder concept can be used where the depth of water, or the availability of fill precludes the construction of a landfill alternative. In the polder concept the operating surface of the airport will be well below the level of the water. To-date the polder concept has not been used to create land exclusively for airports. However a number of feasibility studies have been conducted for major world airports.

In 1972 Transport Canada explored the feasibility of constructing a new airport for Toronto in a polder in Lake Ontario. The airport would require 810 hectares and have two 3,660 metre parallel runways separated by 1,520 metres as shown in Figure 2. The runways were placed parallel to shore, one 2,500 metres and the other 4,000 metres from the shoreline. The polder would be 12 kilometres long and be enclosed by a 60 metre high perimeter dike of 32 kilometres. The dike would be designed to accommodate 15 metre waves (once per 1,000 years). The depth of water at the proposed polder site varies from 35 to 45 metres, Transport Canada (1973).

In the U.S.A., at least two polder concepts have been explored. In its

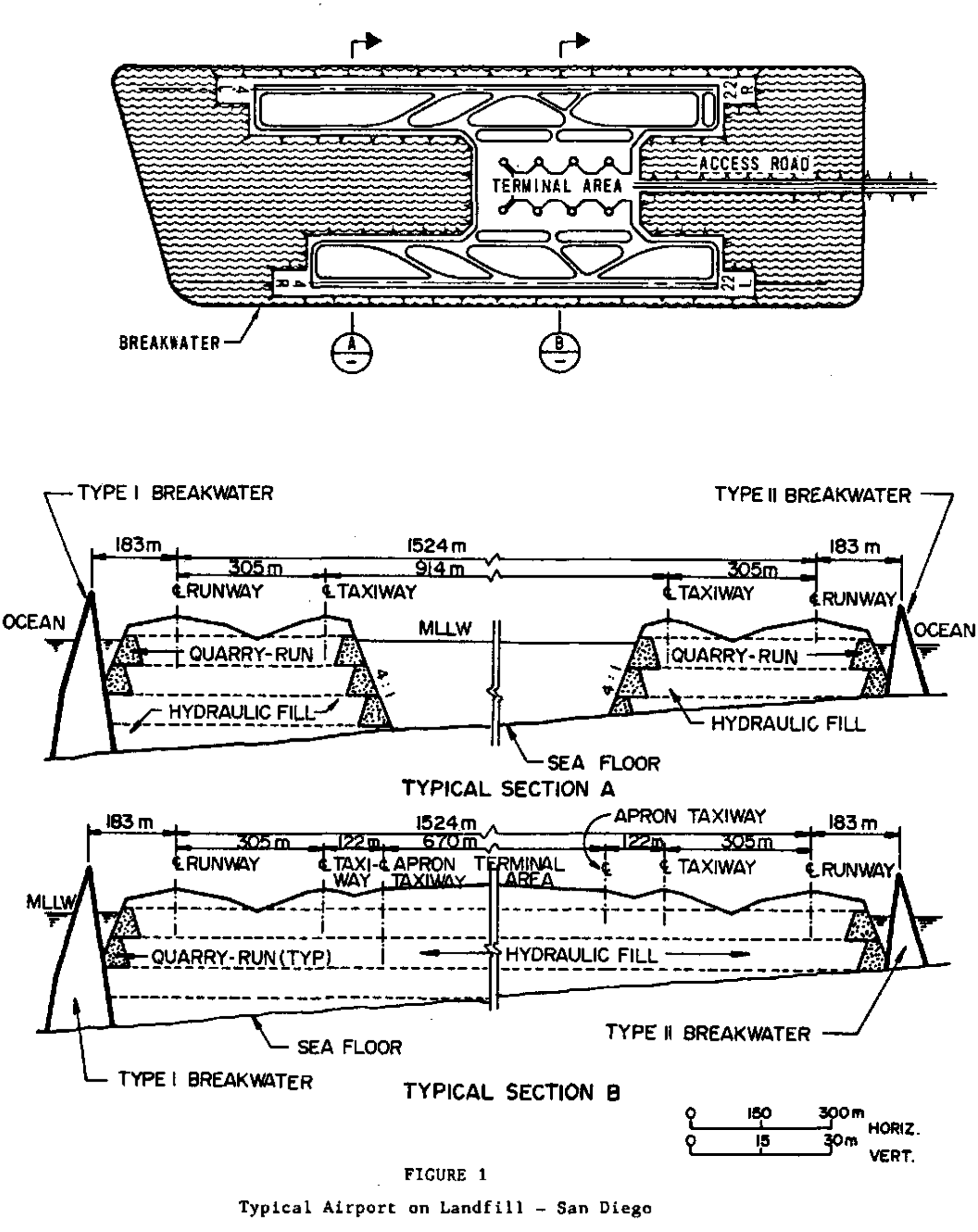

FIGURE 1

Typical Airport on Landfill - San Diego

SOURCE: Lord (1973)

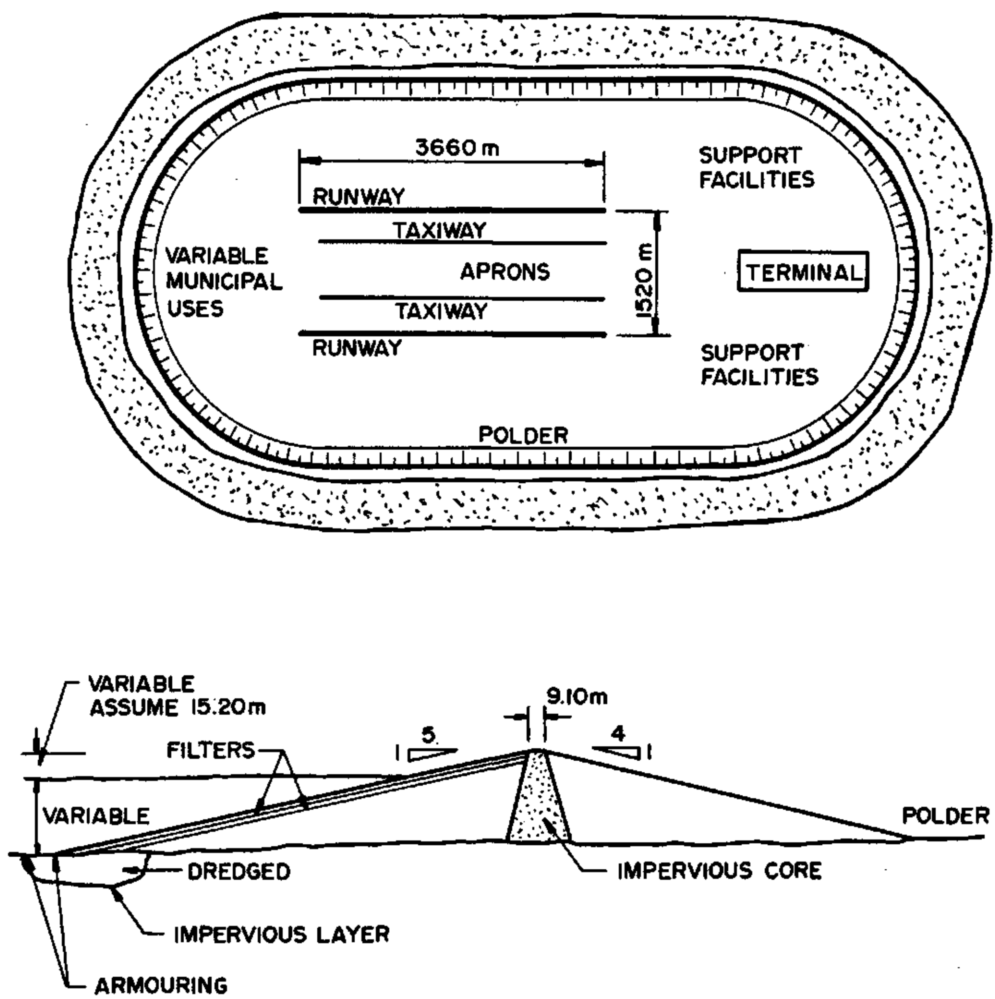

FIGURE 2

Typical Airport in Polder - Toronto

SOURCE: Transport Canada (1973)

search for a site for a possible third airport Chicago investigated a polder concept in Lake Michigan. The polder would be located 13 kilometres from the city in a depth of 15 to 20 metres of water. The polder would be circular in shape, with a 8 kilometre radius resulting in 4,450 hectares of land, Wheby (1973). New York City has also explored the feasibility of building an offshore airport using the polder concept. A polder measuring 8 kilometres by 13 kilometres has been proposed, Lerner (1973).

In Europe, both Denmark and the Netherlands have explored the possibility of constructing polders for airports. Copenhagen has identified the tidal-flats near the island of Saltholm as a possible site for a new airport. A semi-dike-polder method was suggested as the speediest and cheapest construction method, Harza (1970). In the Netherlands, a study has been underway since 1968 to consider the feasibility of constructing a second airport. In 1971 the Falkenhagen Commission, which had undertaken the study, presented its report to the government. Among its recommendations was one to make a more detailed study of five possible sites - two of which were land based sites at Dinteloord and Leerdam, and three were polder sites at Markerwaard, Maasvlakte, and Goeree.

3 Evaluation Criteria

In assessing the viability of using polders and landfills as alternatives, two sets of criteria were developed. The first set applies to airport site selection criteria in general and is shown in Table 1. The second set applies specifically to offshore airports and is shown in Table 2.

4 Assessment of Polder and Landfill Concepts

In the light of the evaluation criteria a summary is presented in Table 3 of some of the advantages and disadvantages of polder and landfill sites for airports.

Table 1. General airport site evaluation criteria

Criteria	Factors to consider
1. Airspace	• large amount required
	• other airports
2. Obstructions	• protected airspace
3. Atmospheric conditions	• fog, haze, smoke
4. Birds	• lakes, rivers, coastal areas
	• migratory routes
5. Topography	• open, flat land
	• drainage
6. Soil	• structural support
7. Environmental impacts	• aircraft noise
	• air and water pollution
8. Proximity to demand	• minimize ground time
9. Ground access	• automobile access
	• rail access
10. Utilities	• water, natural gas
	• oil, electric power
	• telephone, fuel
11. Availability of land	• purchase, lease
	• shape of parcels
12. Cost	• land
	• construction

Table 2. Offshore airport site evaluation criteria

Criteria	Factors to consider
1. Safety	• rescue facilities for water
	• water or ice from spray
	• corrosion of salt water
	• dike failure
2. Water	• depths of 10 to 15 m feasible
	• drainage water must be pumped
	• change in offshore hydraulics
	• loss of navigable and recreational water
3. Landing aids	• airport lighting
	• instrument landing system
4. Shipping	• obstructions of masts
	• interference with ILS
5. Area of land	• polder needs more land
6. Soil	• structural support
	• availability of fill
	• settlement of fill
7. Ecology	• sensitivity of marine ecology
8. Cost	• polders cheaper than landfill
	• Wheby (1972) estimated that landfill is 4 to 6 times more expensive than polder

Table 3. Advantages and Disadvantages of Offshore Airports

Advantages	Disadvantages
General:	
1. valuable land spared	1. impact on marine biology
2. noise impact minimized	2. fog could impair flying
3. room to expand	3. birds could be a hazard
4. located close to city	4. rescue may be difficult
5. no urban encroachment	5. high capital investment
6. land can be taxed	6. large quantities of material needed
7. obstructions minimized	7. specialized engineering required
8. plenty of airspace	8. ground access expensive
9. land for other uses	9. challenge to install landing aids
Landfill:	
1. maximum structural safety	1. very expensive to build
2. well suited for airports adjacent to water	2. requires sufficient low cost material
3. proven method of construction	3. fill will settle
4. easy to expand	
Polder:	
1. cheaper than landfill	1. dike failure will be a concern
	2. much larger area needed than for landfill due to flight path over dikes
	3. drainage water must be pumped out for life of polder.

5 Conclusions

1. It has become most difficult to find suitable land for new and expanding airports in the major cities of the world.
2. For cities located close to water the use of polder and landfill concepts offer the airport planner an alternative to land based sites, especially if the waters are relatively shallow, i.e., less than 10 metres.
3. The construction of offshore airports appears to be technically

feasible. The studies at Cleveland, New Orleans, San Diego, London, Toronto, Chicago, New York, Copenhagen, and Amsterdam corroborate this. Technical feasibility is however site specific.

4. Landfill concepts appear to be favoured over polder concepts in the studies examined to-date.
5. Offshore airports bring with them environmental impacts. Although the impact of aircraft noise is reduced over human habitation, impacts on marine biology and hydraulic action on adjacent shorelines needs to be further investigated.
6. Economically, offshore airports appear to be difficult to justify. They require huge capital investments. In the light of the current economic state of the world it is therefore not surprising to note that very few offshore airports have been built.

Acknowledgement

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ENVIRONMENTAL ASPECTS

THE OOSTVAARDERSPLASSEN, THE DEVELOPING OF MARSHY ECOSYSTEMS ESPECIALLY FOR WATERFOWL

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Southern Flevoland was the fourth polder reclaimed in the IJsselmeer. During the years the original purpose of the reclaimed areas has changed remarkably. From an almost exclusive agricultural use in the beginning, there is now multiple usage of the area for town-building, outdoor recreation, forestry, agriculture and even nature reserves. An example of the last mentioned use is the Oostvaardersplassen (figure 1).

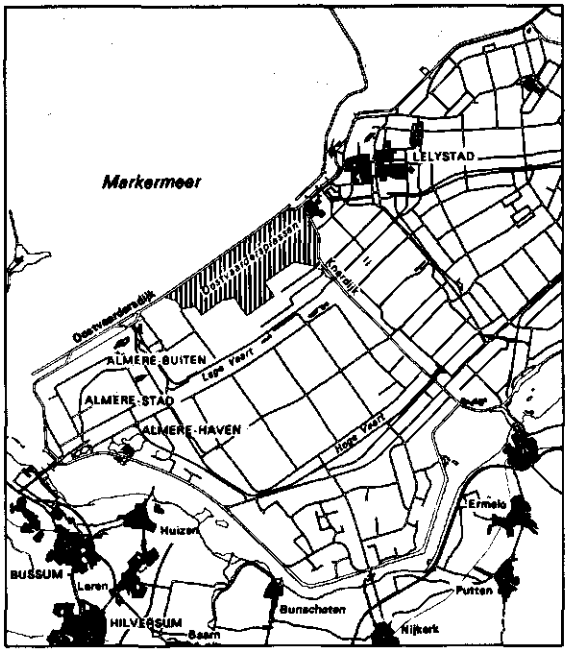


Figure 1. The location of the Oostvaardersplassen

After the construction of the dike and the period of pumping out the water, generally reed is sown from aircraft. Reed stimulates the preparation of the soil for planting. To germinate reed a muddy substract is needed with a very thin sheet of water and an only slight water movement. At that time there was in parts of the stretch along the Oostvaardersdijk a lot more water so that reed sowing did nog take place.

When constructing a dike, the first work is to dig out part of the clay underheath and to replace this with sand. That is why the sand pits in the Oostvaardersplassen are partly filled up with clay. Also clay depots were made there. In addition, in the shallow water, the wind stirs up much silt, which will be deposited elsewhere and as a consequence small differences in level will arise. On the higher spots, seeds of marsh fleawort (Senecio congestus), reed mace (Typha spec.), reed (Phragmites spec.), willow (Salix spec.) etc. germinate and these plants catch silt so vegetation extends. If such an area falls dry in a summer with a large evapotranspiration surplus, the vegetation extends massively. If there is a large precipitation surplus, the water level will rise and more silt will be stirred up.

The area of the Oostvaardersplassen has developed in a few years into a large-scale area with water pools and expanses of vegetation greatly varying in size. The main structure became that of a zone of open water along the dikes partly bordered by a mosaic of reed mace, reed and open water and partly by a close vegetation of reed and some willow. In the transition zone of the open water a natural bank has been formed at some places.

The abundance of food, the variation in biotope and the peaceful environment brought the area to the stage of an important resting, foraging and breeding area for numerous species of birds. The growth of populations in some species of birds during the years 1968 to 1970 can be seen in figure 2. These numbers concern only observations in the northeast section of the area. Comparing these figures with well known waterfowl areas in the Netherlands the result was so astonishing that it is quite understandable that the idea originated to preserve this part of Southern Flevoland.

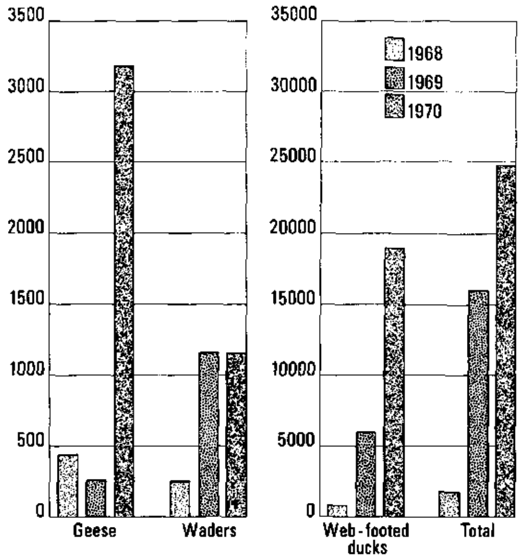


Figure 2. Number of birds counted during 1968/1970 in the area Oostvaardersdijk/Knardijk

As the reclamation of the adjacent area started with the digging of lateral canals and ditches a decision was needed whether or not to preserve this area for waterfowl. Connecting the laterals with the thin sheet of water in the Oostvaardersplassen would have drained almost the whole area and would have initiated the end of the natural development. It was then decided to preserve and further develop about 3.650 hectares for the benefit of the waterfowl.

The first job was to embank the area to prevent the water from running off. To determine the height of the embankment, one has to know the height of the water level that has to be maintained. Therefore one has to know the species of birds that will make their home there. And then the conditions of the specific biotopes are needed. As standard water level, the level of 3.9 m minus Amsterdam Ordnance Datum was chosen. A water level below this standard means, that a larger part of the Oostvaardersplassen will emerge.

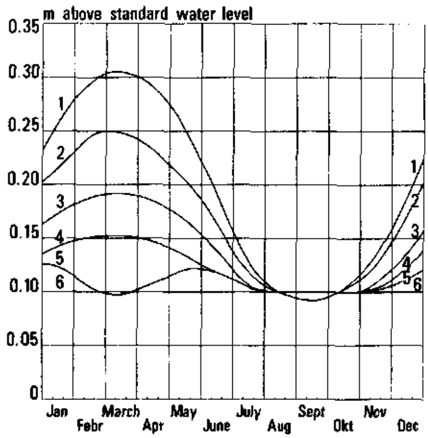
Another important factor is the distribution of precipitation and evapotranspiration in the course of the year. In the region of the Oostvaardersplassen there is on average a precipitation surplus of 240 mm in the winter and an evapotranspiration surplus of 199 mm in the summer.

But the deviations from the average can be rather considerable. In the dry summer of 1976 the evapotranspiration surplus was 458 mm. In the wet summer of 1965 it was only 22 mm. This means that the height of the water level in these years deviates from about -0.26 to +0.18 m from the avarage. To maintain a similar course of the water level in different years, provisions for the supply and the discharge of water are needed.

More than one computation technique was set up to find out the relation between the assumed course of the water level during the year, the pumping capacity, the discharge capacity, the effect of precipitation and evatranspiration and the deviations of the target water level. The most recently applied computation technique indicates (by means of a computerized programme) the course of the water level per decade for the previous 40 years, assuming a maximum and minimum limit of the water level and given a certain pumping and discharge capacity.
Figure 3 shows a set of variants of courses of the water level. A large difference in water level in winter and summer means a large reserve of water to compensate for the shortage of water in summer and a small pumping capacity for water supply. The pumping capacity is denoted in mm water sheet over the whole of the area. One mm water means a supply of 36,500 cubic metres, i.e. a pumping capacity of 90 mm per month means a capacity of about 4,500 cubic metres per hour.
From the computated sub and transgression of the target water level, it can be deduced whether or not the pumping of discharge capacity has to be adapted. Figure 4 illustrates, for a discharge capacity of 120 mm per month, the effects of differences in pumping capacity on the subgressions of the target water level.

The question still remains, which variant will be the best for an adequate functioning of the area. The answer is not given so easily because of the interaction between water level and functioning. The areas short history has already revealed striking examples.

In the first years of development of the Oostvaardersplassen, low water levels occurred especially in spring due to the weather conditions and the lack of water management facilities. Large areas of silt emerged due to water movement by wind. This attracted a large number of waders because of the good feeding conditions. However, vegetation expanded and drought in some years caused epidemics of botulism. The latter was probably caused by fish that died when parts of the area fell dry. The



Nr. variant	pumping capacity (mm/month)
1	60
2	70
3	75
4	90
5	100
6	110

Figure 3. Some variants of water levels

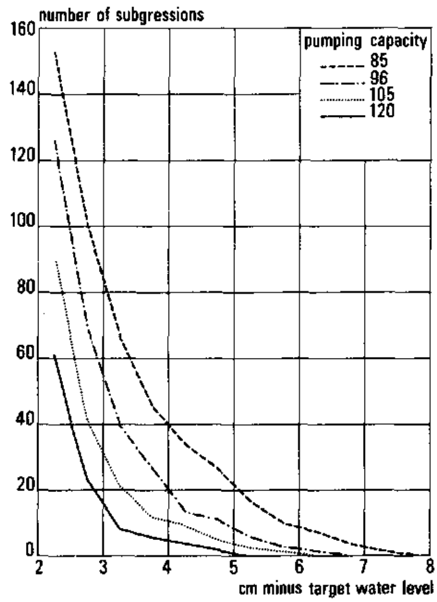


Figure 4. The subgression of the target water level (variant 4) at different pumping capacities and a discharge capacity of 120 mm/month

very large quantity of protein that then was set free is an excellent medium for the development of botulism. A counter measure is to raise the water level or to excavate watercourses to give the fish opportunities to escape. Excavation, however, is a big job so that in the first instance the water level was raised.

High water levels in winter and spring have many consequences. Firstly, there appeared to be much more silt movement. Erosion and deposition occured at places where it was undesirable. Secondly, previously dry spots had a higher water level with the result that, for instance, willows died of. And thirdly, the fish stock expanded heavily since chances of surviving in winter and spring were enlarged. That is why the food supply, especially for birds feeding on fish, increased enormously, which resulted in foraging on a large scale of, for instance, spoonbills. A water level of at least 5 to 10 cm in summer and autumn provided a suitable biotope for moulting, foraging and breeding of greylag geese. The presence of the greylag geese has been of great importance. The natural development of a pioneer vegetation in such a marshy area would be a filling up with plant growth. This filling up can be influenced by the management of the water level, but the presence of the greylag geese with their foraging on reed and reed mace has even diminished the actual vegetation, so the preservation of the young stage of succession in the Oostvaardersplassen has become much easier.

Balancing these kinds of advantages and disadvantages has led to the lowering of the average water level in winter from at most 0.3 m in 1975 to 0.15 m in 1980. The water level in summer has remained at 0.1 m above standard level.

This does not mean that in this respect the last word has been said. Within this main framework of water management, solutions have to be found regarding the prevention or at least restriction of botulism in all parts of the Oostvaardersplassen, the nesting of birds in trees, the breeding of birds on bare grounds, the distribution of the supplied water over the whole area.
A common point here is the necessity for difference in surface level or, in other words, the distribution of dry and wet spots.
A possible solution recently investigated is to combine these kinds of provisions with the borrowing of sand and clay in or nearby the Oostvaardersplassen. In the sand pits, the cover of clay has to be removed and, after the borrowing of the sand, the deep pits have partly to be filled up with clay. The remaining deeper water will create possibilities for the survival of the fish in the winter and for the foraging of birds searching their prey in deeper water. The lay-out of the sand pits can be used as a central part of a nesting area for cormorants. Sand can be used to create sparsely grown dry spots. Clay deposits can be used to establish grasslands for geese, to enable the cultivation of trees for nesting purposes or even to create conditions for the development of swamp forests.

On a smaller scale, there are possibilities for various developments by digging water courses as needed to supply isolated pools with fresh water at a low water level.
The starting point of such measures always has to be that the value of what is being made, exceeds the attendant damage. It has to serve the functioning of the reserve.

Often the question is posed whether or not all these investigations and activities have made sense. Would not a natural development have had at least as good results? A quite legitimate question. As to the Oostvaardersplassen, the answer is quite clear: without embankment, the area would only have a small water retaining section and, without water management, a situation would arise in which high water levels and emergence would alternate at random. This means that the functioning completely depends on weather conditions in a certain year and especially for the more threatened bird species, continuity no longer exists and in reality no contribution is made to their survival.

For the functioning of the Oostvaardersplassen the stage of development of Southern Flevoland is essential. Preliminary trenches, ditches and lateral canals provide foraging conditions for spoonbills (Platalea leucorodia) and several species of herons. The mixture of reedlands, shrubs, young plantations and arable land is favourable for breeding and foraging of the marsh harrier (Circus aeruginosus), the hen harrier (C. cyaneus) and the Montagu's harrier (C. pygargus). The vastness of the state farming area with rape and cereals offers such a quiet environment and abundance of food that thousands of geese and ducs are foraging there.
With the progress of the reclamation the trenches are replaced by subsoil drains, the ditches etc. are cleaned up, the reedlands and bushiness disappear and the farming system changes when the land is handed over to private farmers. The consequence will be quite a diminishing of the number and the species of birds. With that there will be a fall down in the functioning of the Oostvaardersplassen.

Therefore several studies have been carried out to answer the question what should be done to ensure the functioning of the Oostvaardersplassen.

It is quite clear that as the living conditions for the birds within the reclamation area are to disappear the answer could be to concentrate that kind of biotopes in a zone close to the Oostvaardersplassen in order to sustain the functioning of the system. That sounds easy but the problem is to translate it into practicable work.

A first approach has been to estimate the acreage needed for some key species of birds. As key species have been regarded the greylag geese (Anser anser), the spoonbills and several species of herons.
For the greylag geese the foraging conditions in spring especially have been considered as critical. To ensure enough feeding conditions for about 12.000 greylag geese in spring an area of 1200 to 1500 ha of grassland is needed.
For spoonbills also the spring is the most critical period to get enough fish to feed themselves and their young ones. Based on the presence of sticklebacks in ditches with shallow water it can be calculated that about 200 ha of shallow water is needed to feed a 100 pair of spoonbills with each four young ones within the period from their arrival up to mid june.
Regarding to the herons, the breeding and feeding conditions of bittern (Botaurus stellaris), little bittern (Ixobrychus minutus), night heron (Nycticorax nycticorax), squacco heron (Ardeola ralloides), great white heron (Egretta alba), little egret (Egretta garzetta), common heron (Ardea cinerea) and purple heron (Ardea purperea) are quite specific for each species and it is hard to determine what area is needed. Therefore it has been stated on the same area as calculated for spoonbills (200 ha).
Within the Oostvaardersplassen it is from the three species of harriers only the marsh harrier that finds a suited biotope there. Hen harrier and Montagu's harrier prefer land-conditions. These species are characteristic for the stage of reclamation. The consequences of creating living conditions for these species within the zone close to the Oostvaardersplassen are considerable. Based on the spatial pattern of breeding and foraging areas in Flevoland a ratio of acreage needed for marsh harrier, hen harrier and Montagu's harrier can be calculated as 7:3:2. When the 3650 ha of the Oostvaardersplassen are normatif for the living conditions of the marsh harrier, an acreage of 2650 ha is needed for the

other species. The harriers can also use the area calculated for the greylag geese. Therefore the net acreage could be about 1100 to 1400 ha. This approach leeds to an area close to the Oostvaardersplassen of about 3100 ha. This way of calculation pays only attention to some elements of the total system and can only be used as an aid to estimate the range of size for such an area.

Another approach has been based on the relations between the living conditions of birds and the different types of areas. Within a zonation of open water, marsh, transition area and farming area it has been calculated where which species of birds can be found. Open water stays for a system like the IJsselmeer, marsh for the Oostvaardersplassen and farming area for the usual pattern of arable land and grasslands in Flevoland. As a transition area has been considered a type of area such as can be found originally along marshes: several types of grasslands badly to moderately drained with a lot of shallow water as a transition from the marsh system to the well drained uplands.

Figure 5 shows one of the results of this approach. It is based on the calculation of the first choice of the different bird species for one type of area or a combination of types of areas. Very simplified it could be concluded that a zone close to the Oostvaardersplassen should have largely the type of a transition area.

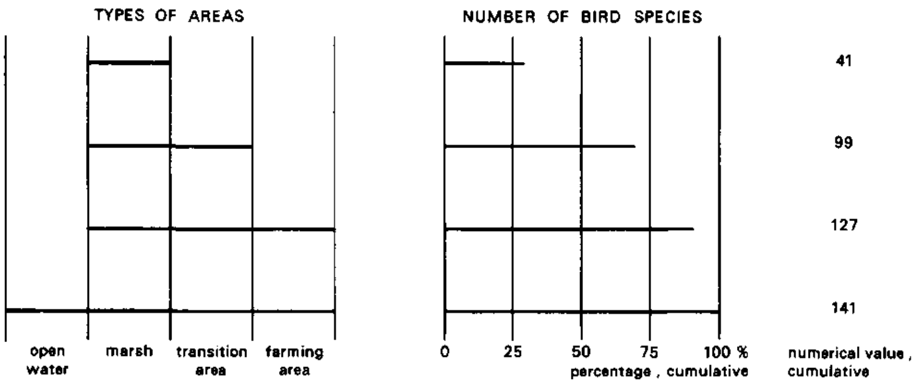


Figure 5. Distribution of the number of bird species based on the first choice for one type of area or a combination of types of areas

After such theoretical approaches a confrontation with the situation in the field is needed. Between the Oostvaardersplassen, the dike between Eastern and Southern Flevoland - Knardijk -, the main canal - Lage Vaart - and the urban area of Almere the maximum gross acreage available is about 2400 ha. Except some 300 hectares, where clay from the digging of the canals and from soil improvement in favour of the construction of the dikes has been deposed, the surface is very flat, After that the conclusion could be that the available area is too small and there is no motive for variation in groundwater level or potency for shallow water. Furthermore a railway from Almere to Lelystad has to be constructed through this area.
To start with the last point the original alignment of the railway just along the Oostvaardersplassen has been diverted to the main canal, the Lage Vaart. The remaining acreage between the Oostvaardersplassen and the new alignment of the railway is about 1850 ha. It is this area that will be designated for a nature reserve.
Within this - according to the calculations relative small - acreage of 1800 ha it is a challenge to develop a system that on one side could bear a large carrying capacity and on the other side could give living conditions for a large number of bird species. After a lot of discussions it has been chosen to develop the area from two starting points.
The first is the developing of the area of the soil depots with the spontaneous grown vegetation by way of an extensive grazing with - in the first instance - cattle. This semi-natural process will lead to a mosaic of bush, roughness and grasslands with a broad margin of living conditions.
The other starting point is to develop the already reclaimed area into different types of grasslands where also shallow water - ditches, ponds - will be constructed. The first accent lies on food supply. To reach a shift in food supply and living conditions especially in spring a system of different levels of groundwater and open water will be laid down. Near the Oostvaardersplassen the groundwater level will be high - p.e. 0,3 meter below surface - with a lot of shallow water and near the new alignment of the railroad the groundwater level will be lower and no open water will be constructed. The differences in water control and water management will lead to different types of grasslands. Furthermore

the character of the different types of grasslands can be strongly influenced by a grazing management. This type of area concerns about 900 ha.

There is very few experience with this way of managing. Therefore field-experiments will be started to get knowledge about the processes going on and about the effectiveness of the purposed strategy.
That is also why about 500 ha are hold outside the first phase of developing activities. Dependent on the results of the field-experiments and the processes going on in the area a way of developing will be decided on a later date.

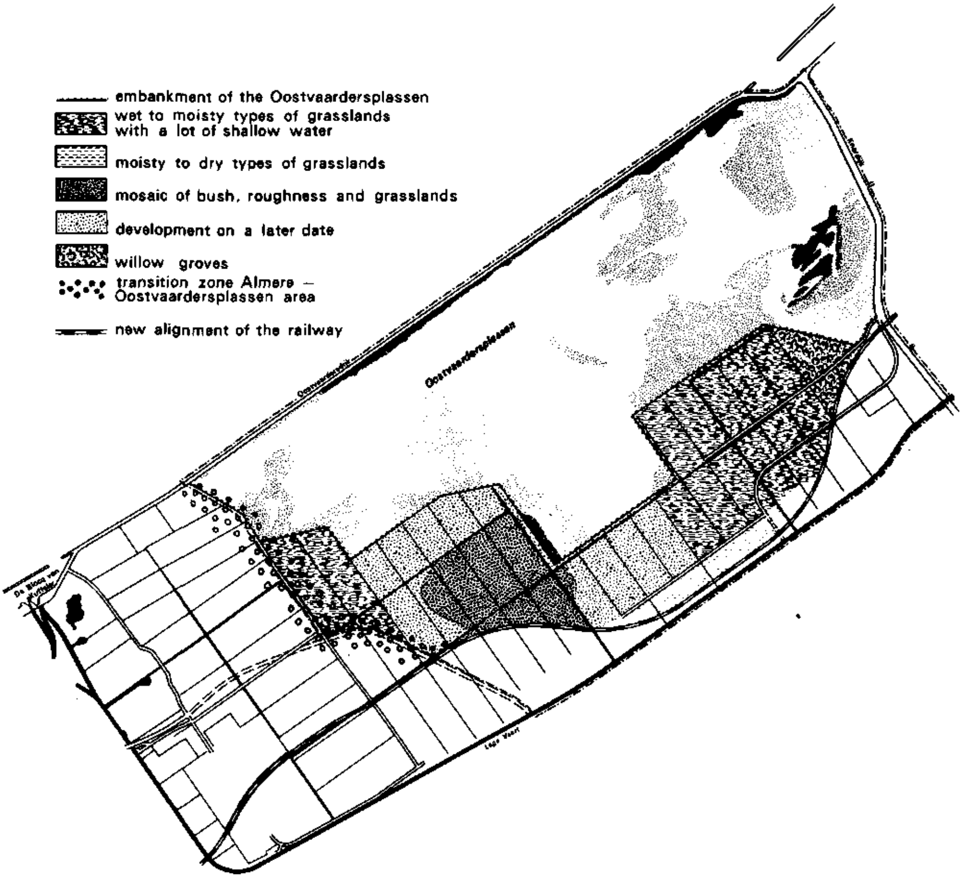


Figure 6. Starting plan for the development of the area close to the Oostvaardersplassen

Figure 6 shows the starting plan for the development of the area. About 100 ha of spontaneous grown willow groves will be unaffected. Along the border of the urban area of Almere and the Oostvaardersplassen area a transition zone has been stated to emphasize the necessity to tune the different spheres of influence.

A carefully and differentiated way of developing will be needed to reach the promising level of functioning of the whole system of the Oostvaardersplassen area as now - about 5500 ha - as now theoretically has been contried.

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FLYING OR CREEPING: THE IMMIGRATION OF ORGANISMS BETWEEN RECLAMATION AND CULTIVATION

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Abstract

The embankment and subsequent drainage of an area initiates a large number of simultaneous or successive processes that are often interdependent. Migration of organisms into and within a new polder leads to the development of dynamic distribution patterns offering excellent opportunities for studies of colonization by plants, animals and microbes.
Management measures, based on experiences in similar regions and on the local conditions, can be utilized to assist the development of, or maintain, valuable "natural" characteristics in areas selected for nature conservation.
In the biological literature a strong predominance of Dutch polders was found, indicating a need for more research elsewhere in the world, especially in view of the opportunities to establish new "natural" areas.

1 Introduction

Biologically speaking the emergence of an area of land does not represent a particularly exceptional situation; many plant species are equipped for a rapid exploitation of newly available space. Small annuals, rapidly completing their life-cycle in (seasonal) vegetation gaps and "nomadic" trees of the tropical rainforest form only two examples from a whole range of plants. The special significance of polders lies in the extent of the new area. Naturally occurring situations that are comparable in this respect are the emergence of land areas, due to volcanic activity or sediment accumulation, but also the introduction of foreign species. Invasions, especially of pests and disease organisms,have often drawn much attention, due to the often disastrous effects of such new elements in the invaded area. In quite a number of cases, however, the population stabilizes at a low level or even disappears after an initial explosion.

Similar development patterns can be observed in new polders; in the huge relatively virgin area where even soil formation still has to start, at least the pioneer species can utilise their full ecological potential. In stable ecosystems the ecological range of many species is restricted by competition. The realization of the potential of a species may occur over a period of time, as even in stable situations a constant change in individuals and their location takes place (Müller 1974). The effect of competition can only be determined by experimental ecological work, which has a number of obvious limitations. Hence the importance of the huge open air experiments provided by the hydraulic engineers.
A survey of biotic and abiotic changes, induced by impoldering, and of nature management options is presented in this paper.

2 Literature search

In order to obtain an insight into the range of literature on the biological aspects of polders an online search was made using the data bases of the European Space Agency (ESA) in Italy, Lockheed Dialog in California and Samsom Datanet, the Netherlands, via the terminals of the Central Library of the Technical University in Delft.

3 Soil formation and microflora transformation

3.1 Soil genesis

The drainage of polder initiates a number of physical, chemical and biological processes in the sediments. This complex of rapid or gradual changes occurring simultaneously and interacting with each other is called ripening. Topography and composition of the parent material determine to a major extent the soil-development, although burrowing activities of animals prior to reclamation may also have a distinct effect (Andriesse et al. 1973, Kooistra 1981). Three major types of parent materials can be distinguished (Pons and van der Molen 1973): organic, calc reous and non-calc reous.

Dehydration, desalination and oxidation of the sediments result in a differentiation in the originally waterlogged sediments in which, apart from a thin oxidized layer in the upper part, anaerobic conditions prevailed.

Shrinkage with development of cracks, and eventually soil structure, influences the hydrological conditions by increasing permeability and causing additional height differences. In the well-drained sandy soils desalinations by leaching proceeds rapidly, but at the same time nutrients are removed. This effect is accentuated when the capillary rise is insufficient to reach the soil surface. Under such conditions a crust of lichens, mosses and algae may develop (Skujinks & Klubek 1978).

The limited capillary rise in sandy soils gives the possibility to create gradients in moisture supply in order to increase environmental diversity in habitat building (Polman 1978). Accumulation of salt occurs in the upper layer of sediments with a fine texture during dry periods by movement of water of the soil surface to meet evaporative demands (Carter 1975).

3.2 Microbial development

Microbes play an important role in the chemical changes during the ripening process. Although the microorganisms of saline soils are insufficiently known (Chapman 1975) it seems likely that a change from a saline anaerobic 2-phase system to a 3-phase system will cause massive changes in the microbial populations. On a micro-scale the situation will be very complex and since anaerobic processes occur mostly in favourable micro-environments such as the rhizophere (Dommergues 1978) the short term effects can be a stimulation of, for instance, denitrification by plant roots (Woldendorp 1963, Bailey 1976). Also higher temperatures lead to higher rates of denitrification although the populations of denitrifiers may decrease (Doner & McLaren 1978). Decaying organic material and sites containing sulfides or hydrogen may also sustain some denitrifying species (Dommergues 1978). Perhaps the most clear-cut example of the effect of microbial activity in soil is the oxidation of pyrite in which bacteria of the genus Thiobacillus play an important role (Rasmussen & Willems 1981). The production of sulfuric acid may result in the development of acid suphate soils. Although microbes are the first organisms that establish populations in a new environment, few overall studies of their colonisation have been made (Müller, 1975). Due to the complexity of the microenvironment, the rapid changes occurring in microbial populations, the fact that most bacteria are inactive most of the time (Macfadyen 1978) and since it is relatively simple to study the natural succession of microorganisms in small-scale experiments, the investigations are usually aimed at a limited group of organisms. Soil fungi are among the most frequently investigated microorganisms (Pugh & van Emden, Tichelaar & Vruggink 1975). As the microbial imbalance in the new soil may allow a rapid development of pathogens, attention has to be given to the development of the soil microflora. The possible introduction of parasitic fungi with seeds is of special importance in this connection; Tichelaar & Vruggink (1975) list 26 species of fungi isolated from reed seeds.

The presence of mycorrhizal fungi can be an important factor, especially in soils poor in nutrients. In a soil poor in bacteria the development of Rhizobium spp. and Azotobacter spp. can be influenced by the predation by some species of protozoa (Sasdeshpande et al., 1975). The conspicuous fruiting bodies of a number of fungi enable surveys of the colonization over large areas (Daams & de Vries 1981, Van der Laan 1978, van der Aa, 1978, de Cock Buning 1977, Tjallingi 1977, Bas 1978).

4 Vegetation development

4.1 Dispersal

As developing and mature plants are essentially immobile and moreover form conspicuous elements in the landscape, they are excellent objects

for the study of distribution patterns; every individual can be included in a survey which may even be carried out sometimes by aerial photography or other remote sensing techniques. At the same time useful information about environmental conditions is obtained from the presence of indicator species. The establishment of plants can be seen as the result of two independent factors; the dispersal of diaspores and the spatial differentiation in the polder. The second factor determines the dispersion of seeds and the possibilities for germination and successful seedling establishment. The occurrence of "seed-traps" will affect the initial distribution,especially of wind-dispersed species. Wet areas with puddles but also places with a "rough" surface, due to an accumulation of mollusc shells or plant material, are sites where seeds fall out or are deposited after transport over the surface of dry regions. Seeds in remaining waterbodies and seeds transported after arrival by sheets of water blown across the polder during rainstorms accumulate in drift-lines. A third location where seeds can become lodged in big numbers are cracks developing in clay sediments. In very flat regions footsteps or tracks left by vehicles may provide a focus for seed accumulation. In such a situation the associated soil compaction may also play a role. Artificial or natural drainage channels may represent important migration routes with passive transport by pumping or by wind induced flow (Lijklema & van Straten 1978).
The size and the morphology of the seeds determines in principle whether a species can easily reach a new area (v.d. Pijl 1972). Nevertheless it must be realised that appearances can be deceptive as, for instance, shown by Bakker (1960). External factors that play a role in the realisation of rapid colonisation are the presence of barriers(esp. forests act as a seed trap) and the distance from the parent population to the new polder.
In this connection the prevailing wind during the drainage of a polder can have a marked effect. Birds are often mentioned as important dispersal agents and although it is probable that freshwater algae and invertebrates are transported by birds, their importance for successful plant dissemination,at least during the initial colonization period,is limited (Löve 1963).
As the production of seeds and germination are often periodical phenomena, differing for different species, there is a selective effect of

the moment of substrate availability on the composition of the pioneer vegetation, although persistent seeds may have remained viable in the aquatic environment.

4.2 Establishment

While seeds may be stress-tolerant, seedlings are often more sensitive than older plants; even oblique halophytes need reduced salinity for germination (Chapman 1975). The sorting effect of water transport may lead to aggregates of seedlings of a single species, in locations determined by size and weight of the seeds.

In saline areas only halophytes or halotolerant plants are found, but on relatively high, well-drained sites desalination can take place very quickly and salt-susceptible species can establish themselves (Joenje 1974). Among the pioneers in such areas bryophytes can play a prominent role (Joenje & During 1977). The high temperature optimum for growth in some bryophytes may be important for their success in the exposed environment (Grime 1979). The abiotic changes are ameliorated by the development of a plant cover, this is accompanied by a change in the composition of the vegetation from stress- and disturbance-tolerant plants to competetive species and a shift toward vegetative expansion.

The initial vegetation is characterized by wind-pollinated or self-pollinating species since pollinating insects are scarce in the first stage of development. *Phragmites australis* is an example of a species that can compete successfully in both stages; it has very light wind-dispersed seeds that germinate rapidly; once established it can attain dominance within a few years by its tall stature and vigorous vegetative expansion. In the Netherlands and Japan (Iwata & Ishizuka 1967) sowing of reed has been practised in order to ameliorate the mud soils by increased evapotranspiration and to exclude species adapted to exploit temporary gaps in a disturbed vegetation cover by vegetative regeneration from rhizomes or stolons and hence represent troublesome weeds in the future arable fields.

It is interesting to note the parallel between this management measure and the strategy of a number of plants and animals producing enormous numbers of seeds, eggs or larvae in order to ensure the establishment of suitable genotypes in all available locations. Once a more or less continuous vegetation cover has been established the conditions in the new polder are less extreme: lower wind velocities near the ground, more stable soil surfaces and reduced evaporation by an accumulation of plant debris, nutrients are recirculated.

Salt may still accumulate by capillary transport combined with evapotranspiration although the accumulation in halophytes with subsequent removal by grazing or by the annual shedding of organs as in Juncus maritimus (Chapman 1975) may contribute to the desalination process. Progressive reclamation activities will usually interfere in most of the area with the natural succession of plants, animals and microbes. Road verges may than offer suitable areas for a subsequent study of the spatial dynamics of various species (Haeck, Hengeveld & Turin 1980). At the same time road verges provide routes for organisms migrating by diffusion,defined by Pielou (1979)as gradual movement of populations across hospitable terrain for a period of many generations. Introductions by human agency are also likely to appear especially along roads.

5 Immigration of animals

Since most animals have,in contrast with plants,at least some degree of mobility during their adult life, it is somewhat surprising to find that, in general, plants spread more readily than animals (Pielou 1979). In many insects,dispersal is a byproduct of flight activity associated with feeding and oviposition (Emmell 1976). The study of Meyer (1979) indicates that the immigration of Carabids into a new polder is mostly accidental.

The element of choice that plays a role in the mobility of animals means that,although presence of an individual is proof of dispersal,it does not necessarily indicate colonization. Schultz & Meyer (1978) investigated the immigration of leafhoppers into a new polder and conclude that of the 13 species observed probably only one succeeded in establishing a resident population.

Birds may represent a group of "commuters" utilizing a new polder only as a (temporary) breeding or feeding site (Veen 1980). Survival in the rapidly changing polder environment can be achieved by a capacity to tolerate the effects of the changes or by active avoidance of such effects. Most changes affect the ground-level species most directly; an example of avoidance behaviour is given by the mass migrations of insects and mites during seasonal inundations in the Amazon and Congo regions (Müller 1974). Migration over short distances also takes place when, after passive transport into the area, an active search for a favourable site is carried out, as for instance in . phids (Dixon 1976). Among the early arrivals in new polders beetles and spiders are conspicuous by the number of species involved (Meijer 1980). Only a minority manages to establish a population which, for Carabid beetles, may be due to sensitivity to changes in microclimate (Neumann 1975). Organisms of which the populations can expand rapidly in a suitable environment are obviously at an advantage in a new polder. A well known example is the asexual reproduction of aphids by means of which a single female of a favoured genotype can found a population of genetically uniform individuals (Grime 1979). Subsequent habitat changes may however have a strong effect on such genetically limited populations. The populations of pioneers are slowly supplemented or replaced by other species during the consolidation of the new environment. Perhaps the last ones to arrive are soil-inhabiting animals having a low dispersal rate. Some work has been done on the development of earthworm populations after their introduction (van Rhee, 1969a, 1969b, 1970, 1977). Also nematodes have been investigated because of their importance as plant parasites and their possible dispersal by human agency (Kuiper 1977). The colonization of the IJsselmeerpolders by moles (Haeck 1969) presents a good example of immigration by diffusion.

As the polder environment will maintain a special character for a long period of time, several species may appear that are rare or absent in the surrounding region. This has been found in widely differing organisms such as ferns (Bremer 1980), birds (Zijlstra et al., 1978) and fungi (Daams & de Vries 1981, van der Laan 1978, de Cock Buning 1977, Gams 1980).

6 Nature conservation and managment

Population growth, industrialisation and economic development of a

country determine the needs and the possibilities for nature conservation and nature-engineering or habitat-building.
Industrialisation also decreases the relative importance of agriculture. Thus the function of land reclamation for agricultural purposes has decreased in the successive polders in the IJsselmeer. Perhaps the best opportunities for nature-technique are found in reclamation and embankment projects where land gain is not the primary aim. Examples in the Netherlands of such areas are the Lauwerszeepolder,the Grevelingen basin and the Markiezaatsmeer.
In those cases a detailed inventory prior to the embankment, such as the report by Saeijs & the Jong (1982) on the Markiezaatsmeer, or a survey of the natural development in the area as a result of the embankment forms the basis of management planning aimed at maintaining or improving the actual and potential biological value (e.g. Reitsma 1981). Maps of the distribution and morphology of the sediments are important tools in the partitioning of the area. In land reclamation schemes for agriculture the marginal areas are most often designated for nature conservation. Although early planning is the most important tool for the realisation of natural areas,there must be sufficient flexibility to adapt the plans according to the actual development in order to achieve optimum results. Regular surveys with help of remote sensing techniques are important tools to follow the transformations occurring over large areas. Management measures may vary from non-interference via mowing, cutting, burning or grazing,to sod cutting, in order to perpetuate or to stimulate species or communities. Earth moving may be applied to create a more varied topography.
In this connection it must be realized that in Europe even the most natural seeming areas have to some extent been influenced by man. In the past this resulted in a diversification of flora and fauna by providing a range of habitats as opposed to the uniformity imposed by modern practices. In order to re-create or maintain such habitats, similar forms of exploitation are therefore necessary. Developments are derived by extrapolation or by using the situation in similar areas with a long history as a reference frame. The second approach will also provide information on suitable management (exploitation) methods. A new polder offers good opportunities for experiments with management strategies since most biological values, in contrast with existing nature reseves,

are only potential and therefore allow a certain margin for errors.

Conclusions

New polders offer extraordinary possibilities for research on the development and the relationships of populations of plants, animals and microbes, this potential seems to be under-exploited outside of the Netherlands. Conservation and management measures can be applied successfully to recover some natural values. Such considerations should however be seen in the right perspective; reclamation frequently destroys very valuable ecosystems, often with a considerable economic importance, for instance as breeding or nursery area for fishes and shrimps. Therefore environmental impact studies should be carried out whenever a reclamation project is intended.

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QUANTIFYING THE LOSS OF FUNCTIONS OF A NATURAL AREA AS A MEANS OF IMPACT ASSESSMENT FOR RECLAMATION PROJECTS

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Abstract

In the early seventies the township of Den Helder wished to reclaim part of the Balgzand tidal flats (Wadden Sea) for the development of a deep sea harbour and adjacent industrial area. Because it was recognized that the Wadden Sea fulfils a number of functions for human society which might be affected, the Netherlands Economic Institute did an investigation into the socio-economic aspects of the plans and the Research Institute for Nature Management investigated the environmental aspects. Already during the early planning phases a close contact existed between economists, planners and ecologists, and after a preliminary study it was concluded that only a minor development situated on an island might be economically and ecologically feasible. In the environmental study the fulfilment of the production functions, support functions, information functions, regulation functions and strict conservational aspects without harbour development were quantified. On the basis of a factor train, biological effects of the development were quantified, and the fulfilment of the functions was again quantified with the development taken into account. The results of the ecological study were taken into account in the cost-benefit analysis, and on the basis of both economic and environmental considerations the decision was taken to abandon the plans for reclamation.

1 Introduction

The effects of developments strongly depend on the size and place of a proposed polder or reclamation. Each specific site will have specific effects, and the effects on the ecosystems will be quite different in, for example, either a salt marsh, intertidal mud flat, mangrove forest or subtidal area. From a biologist's point of view it is interesting to study and describe the effects of one particular development on the environment. In this symposium however there will be a great deal of interest in the approaches and methods which can be used in order to quantify the effects of any development.
It is widely recognized that the environmental impact should be described in such a way that decision making authorities can use the information from the ecological study while making decisions on the acceptability of the project. Therefore the environmental aspects should be described in such a way that they can be compared with socio-economic aspects.
In this paper a general description of the approach and method which tries to reach this objective will be given. Then a case study where this approach has been used will be reviewed, and some general conclusions will be drawn.

2 The functions of a natural area

Most natural areas fulfil a number of functions for the human society. According to the General Ecological Model of The Netherlands (Van der Maarel & Dauvellier, 1978) a function of a natural environment can be defined as 'The possibility of the fulfilment of social needs, so far as this results from the properties of the natural environment'. In addition to the functiongroup enumerated by Van der Maarel & Dauvellier (l.c.) it is important to recognize one function group which falls outside the direct need of human society, viz. the functions which the natural environment fulfils for the sake of the survival of species, communities and landscapes. These functions are not based on social motives, but are ethically, esthetically or culturally motivated.
In this paper I will restrict myself to the Wadden Sea. This is an area

with extensive intertidal sand and mud flats along the Dutch, German and Danish coast, separated from the North Sea by a row of barrier islands. At present this area fulfils the following functions (Wolff, in manuscript).

I. Production functions

1) supply of water desalination plants and of process water for factories
2) supply of cooling water
3) supply of natural gas
4) supply of sand, clay and shells
5) supply of biomass to fisheries
   a. Wadden Sea fisheries on fish, shrimps, crabs, cockles and worms
   b. Nursery function for young fish and shrimps which are later caught by North Sea fisheries
6) supply of biomass to mussel culture and fish culture

II. Support functions

7) support of shipping routes and harbours
8) support of cables and pipelines
9) support of hydraulic engineering works such as dykes, jetties, piers
10) support of areas for military training
11) support of areas for recreation (yachting, swimming, diving, tracking and flying)
12) acting as dumping ground for dredged material
13) receiving fresh water from sluices and rivers
14) receiving waste- and cooling water
15) receiving air pollution

III. Information functions

16) opportunity for recreational experience of nature and landscape
17) signal function, indicating possible deterioration of the environment
18) opportunity for scientific studies and education

19) a genetic reservoir

IV. Regulation functions

20) influence on climate in coastal regions
21) influence on the carbon dioxide and oxygen economy of the atmosphere and coastal waters
22) possible biotic regulation, i.e. preventing diseases and pests among organisms, and acting as a parameter in the population dynamics of North Sea fish species
23) mineralization of organic compounds and subsequent release of soluble nutrients

V. Functions which are based on the ethical and esthetical values of the environment

24) conservation of plants, animals, communities and processes which occur in coastal regions naturally, and those which use the area on migration routes
25) conservation of typical estuarine landscape

Functions nrs. 16-25 are directly dependent on the natural environment and may therefore be taken together as strict ecological functions.
In most areas state and local governments have planning regulations which determine which functions are most important when conflicts arise between functions. For the Wadden Sea the main objective of the Dutch government policy is the Wadden Sea as a natural environment. However, according to the Government a number of functions mentioned before should, and can, be fulfilled as long as they do not come into conflict with the main objective. These functions are the ones which the Wadden Sea fulfils at present except nrs. 3 and 12.
A number of these functions, e.g. 1, 2, 5b and 7 have little effect on the strict environmental functions while others, e.g. 4, 5a, 6, 16 and possibly 11 have a clear impact but they are strongly dependent on an optimally working ecosystem. A third group are the functions which have a clear impact on the natural environment, but they are not dependent on a Wadden Sea as an ecologically healthy system. The first group of

functions can be realized without contravening the main aim of the government policy. The second group has a negative feedback, but the government will have to regulate to prevent one particular function to be overexploited at cost of other functions. In the third group the government will have to decide which scale of influence on the main aim is still acceptable, zero influence being one of the alternatives.

In planning science, the method of 'strategic choice' is becoming popular (Friend & Jessop, 1969). It means that when complicated planological problems arise, one does not try to lay down all future uses of an area, but one leaves a final decision until one has looked carefully into the consequences of each possible choice. Also one takes an option which leaves the major features of an area unchanged, so in future all other options are still open. Bearing this in mind it seems wise to follow a policy in the Wadden Sea which leaves the area intact so it can fulfil all the functions which are important at present.

For example it would be easy to taken one function and maximize its use. One could maximize function nr. 23 (mineralization) and change the Wadden Sea into a gigantic sewage treatment plant. This would result in the decrease or even disappearance of the majority of other functions. Similar things would happen if any of the other functions was maximized. This holds not only for the Wadden Sea as a whole, but also for specific areas within the Wadden Sea. This makes clear that one should not aim for a maximalization of one particular function if other functions are considered important or might be important in future. An optimalization of a number of functions seems a better approach. However, it is a governmental decision to state which functions are the most important, and which other functions should be allowed as long as they do not impair the more important one, and a scientist can only advice the government. The foregoing information is essential for anyone who wishes to write a report on environmental impact. The decision making authorities can only judge the presented information if it is collected and presented in such way that it can be compared with the planning regulations (see also Dankers, 1981).

3 The study and description of the environmental impact

A general description of the methodology which proved to be fruitful will be given in this chapter while a worked out example will be treated later.
When reporting and predicting environmental impact it is essential that a good description of the area is given. In an estuarine system both geology, morphology, hydrology and ecology should be described extensively. But also the expected development without human impact should be predicted. Especially in an always changing estuarine environment this is important.
A simplified food web can be used to describe the ecosystem. In this way interrelations between organisms (plants, animals and bacteria) can be described, but also environmental processes such as water currents, light penetration and physico-chemical factors can be taken into consideration. When this information has been collected it should be possible to describe and quantify the functions of the area.
The next step is to describe the effects of the proposed development. Environmental effects are seldom restricted to only one physical or chemical factor. Generally one can recognize two main groups. These are:

a) primary, mainly physical, effects which occur as a direct response to the environmental changes
b) secondary and tertiary effects which occur later and often at some distance as a response on the primary effects. Often these are chemical and biological effects.

This parade of effects can be called a factor train (Darnell 1976), and can be schematically presented. The description of the specific biological effects can then be left to a number of specialists who do not have to spend much time in trying to understand in detail the whole background of the development. When all relevant questions which arise from the factor train have been answered one can again quantify the fulfilment of the functions of the area. A comparison of the functions before and after the proposed development can be used by the decision making authorities in order to decide whether the development is in conflict with the planning regulations.

4 The environmental effects of a proposed harbour on the Balgzand tidal flats

In 1978 a report 'Een haven op het Balgzand?' was published in cooperation between the Netherlands Economic Institute and the Research Institute for Nature Management.
In this report both an economic and ecological evaluation of the proposed project was made. In the following chapter a summary of the ecological evaluation will be given.

4.1 Description of the area

The Balgzand is an intertidal area in the Dutch Wadden Sea. It is situated in the westermost part of the Wadden Sea along a major tidal inlet (Marsdiep) which connects the Wadden Sea with the North Sea (Figure 1). This means there is a strong marine influence because most

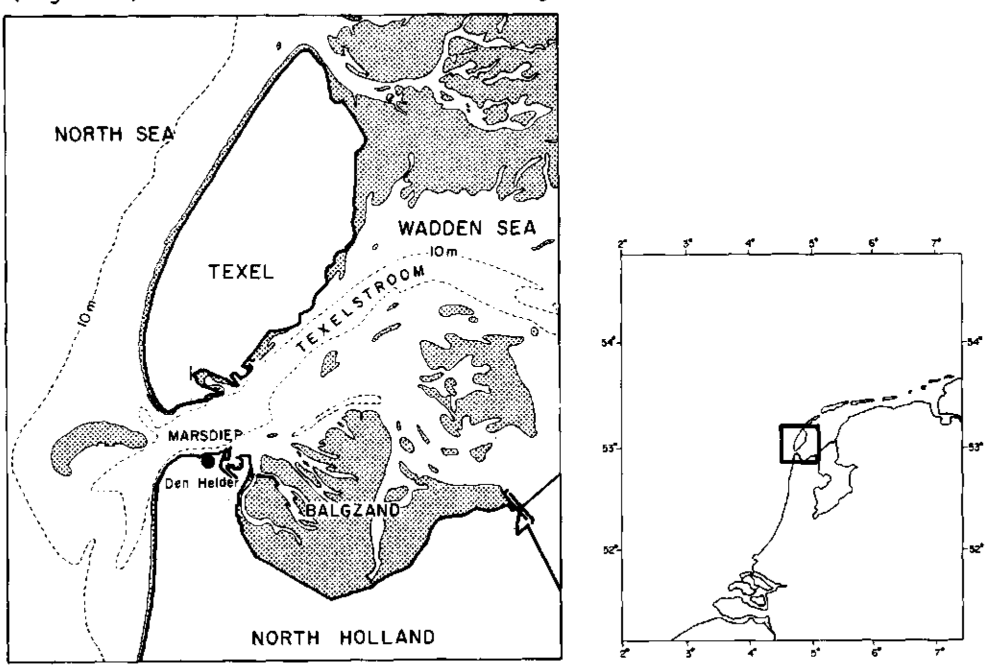

Figure 1. The Balgzand tidal flats

floodwater comes directly from the North Sea. The Balgzand shows an intricate pattern of gully systems and intertidal flats with gradients from fresh to saline and silty to sandy, and some salt marshes along its edge.

The recent geological history is well documented. Because of strong sedimentation the area of intertidal flats has increased from 3400 ha to 5350 ha during the last 30 years. Because the Balgzand has been studied in great detail by the Netherlands Institute for Sea Research the distribution and abundance of flora and fauna is well known. Therefore it was possible to calculate direct losses due to reclamation with great accuracy.

In figure 2 a simplified food web is presented. The ecological processes which can be described on the basis of this foodweb are strongly influenced by the large quantities of sea water that flow between the Balgzand and the adjacent Wadden Sea and North Sea.

These tidal currents are responsible for import and export of organisms, eggs, organic and inorganic suspended matter and nutrients. An unrestricted supply of eggs and larvae is essential for the role of the Balgzand as a nursery area for North Sea fish. The food web scheme also

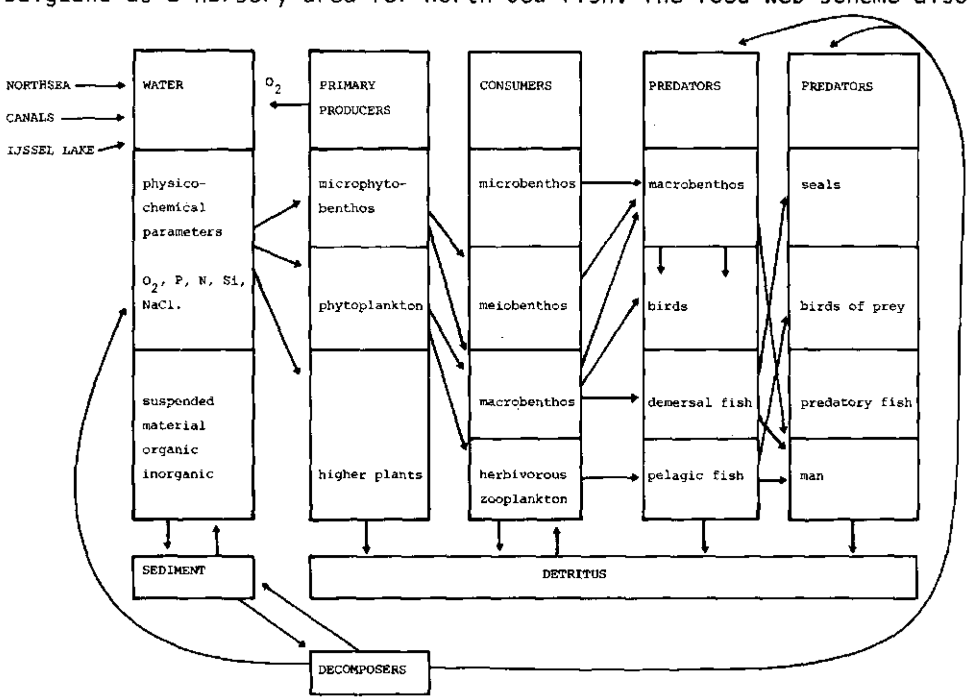

Figure 2. Foodweb in an estuary

makes clear that, for example, changes in the production of phytoplankton can have an effect on fisheries.

4.2 The functions of The Balgzand

Based on the description of the food web the production can be quantified. It should be kept in mind that the term production as used in the GEM is not the same as biological production. In the GEM only production of biomass which can directly be used by humans is of importance (e.g. marketable fish, mussels etc.). In the biological sense also formation of biomass by bacteria, micro- and macrobenthos and phytoplankton can be called production.

As has been mentioned before, the productivity of the lower organisms can have an influence on the biomass of marketable fish via the food web.

The productivity of the primary producers benthic algae (diatoms) and phytoplankton amounts to 280 g organic matter/m^2/year. For the whole Balgzand this means 16500 tons of organic matter is produced per year. The production of macrobenthic animals (shellfish, worms, crustaceans) has been estimated at 20-30 g organic matter/m^2/year.

Especially for migrating predators (fish) the Balgzand is more important than is indicated by the amount of fish produced.

When these animals spend their 'childhood' in the area (e.g. crab, shrimp, plaice, etc.) they do not have large weights, but they occur in great numbers and return to the North Sea to grow up. Without this nursery they may not stand a chance against the predation in the North Sea. There are indications that between 50% and 80% of the North Sea stock of plaice, sole and shrimp grows up in the Wadden Sea (Waddenzee-commissie 1974), and approximately 3% of the North Sea plaice have grown up on the Balgzand tidal flats.

A great number of bird species frequent the Balgzand, and many species are present with many individuals. However, although they consume a considerable part of the macrobenthos, most of the energy they obtain from their food is used for respiration, restoration of fat content for migration, and reproduction. Therefore, the increase in biomass of birds (or any other adult animal) is low.

An important aspect of the production function of the Balgzand is fishing for mussel seed. In 1975 1200 metric tons of juvenile mussels were collected from the Balzand tidal flats. In other areas these mussels are 'seeded' and grow up to approx, 6000 metric tons of consumption mussels.
The Balgzand did and does not have a great importance for the other production functions mentioned before, and the area did and does not have much importance for the support functions either.
Information function nr. 16 (recreational experience of nature and landscape) can only be valued psychologically, but each year between 20,000 and 50,000 mandays are spent in the area by sportfishermen. For educational purposes more than 750 mandays are spent annually and for scientific research 3000 mandays per year are spent in the area.
The most important regulation function is the mineralisation of organic compounds. Detritus is broken down by the group of decomposers (bacteria, micro and meiofauna). Their work can be compared to a two-stage sewage treatment plant, and the nutrients produced can again be used in the North Sea food chain by the primary producers (phytoplankton). It has been calculated that each hectare of the Balgzand breaks down an amount of organic matter which is equivalent to the waste treated by a sewage plant for 700 person equivalents.
It can be shown that the nature conservational value of the Balgzand is high (function 24). For at least 9 birds species the area can be regarded as internationally important according to the Ramsar convention, and archeologically and geologically the areà is of national importance.

4.3 The proposed development

Originally there were plans for extensive reclamations and harbour works. On economic grounds these plans were abandoned. In 1977 several smaller alternatives were designed (Figure 3), and after consultation with ecologists it was decided that the exchange of water between North Sea and Balgzand should not be restricted, and that, in order to prevent pollution of the Balgzand, the harbour should not be of the flow-through type (alternative c). During the progress of the economic study it became clear that a harbour of the proposed size would not be feasible,

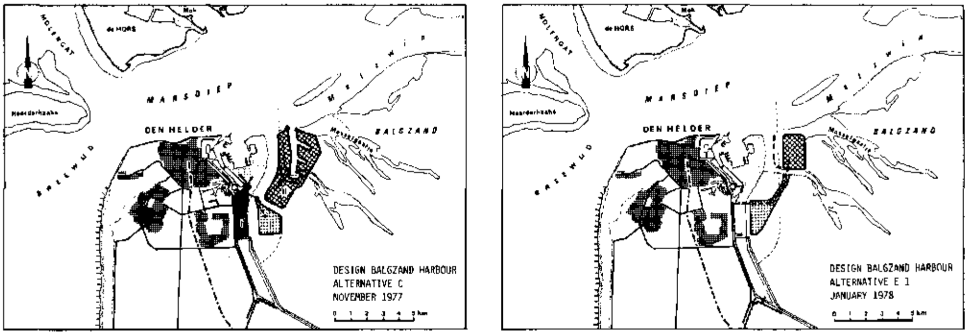

Figure 3. Some alternatives for a harbour development on the Balgzand

and therefore other designs were made (for example alternative E2); These were constantly adjusted on indications of economists and ecologists as well, in order come to an economically and ecologically optimal design. Both alternatives which are presented in figure 3 leave the main gullies which transport water unaffected.

4.4 The effects of the harbour works

The factor train which has been mentioned before has been presented in figure 4. I will not treat all possible effects in great detail. The majority of the biological effects which can be seen in figure 4 have been described in the report of 1978 (Dankers 1978). After the description of the biological effects the losses of each function were described. Two levels in the prediction of function losses should be distinguished. Direct effects can be predicted by comparing a map of proposed reclamations with the distribution of organisms. It can be concluded that organisms occurring on the proposed site will disappear. It should be kept in mind, however, that with this method function losses are quantified for the present situation because the possible distribution of organisms in future is hardly predictable. The prediction of indirect effects is much more complex, because it requires a good understanding of the physical, chemical and biological processes that take place in the area. However, the general conclusion was that with all alternatives the fulfilment of all environmental functions

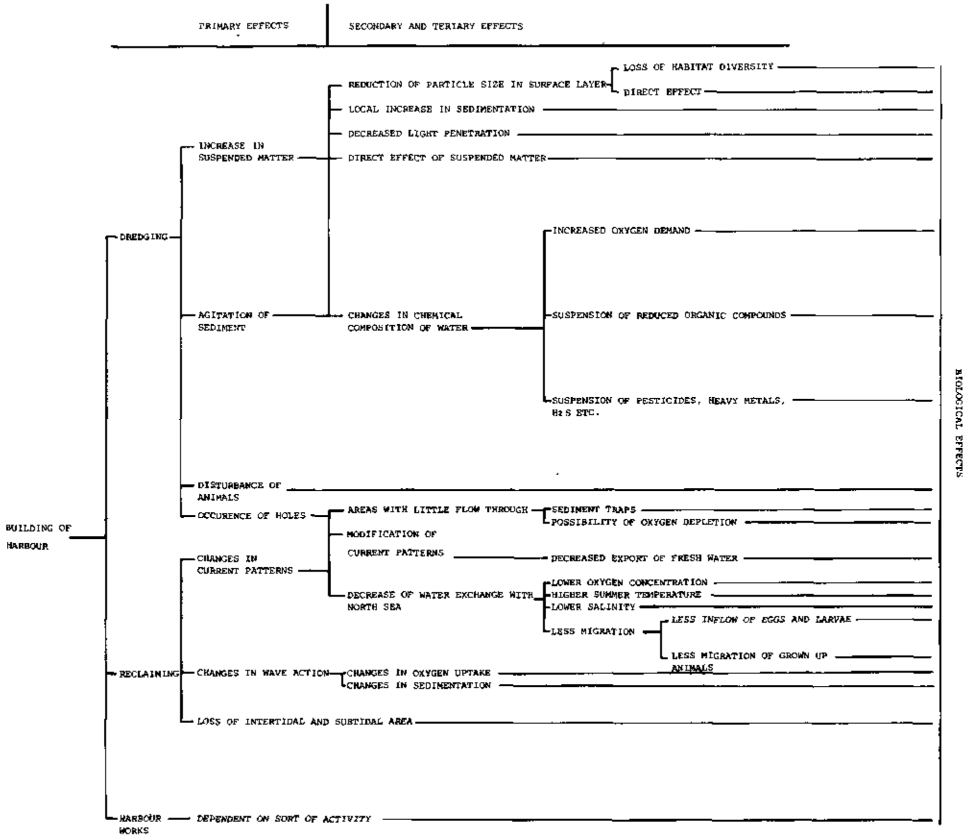

Figure 4. Factor train, indicating the effects which can be expected when reclaiming land for a harbour in an estuary

would more or less decrease. It also became clear that in alternatives in which the gully which transported water to the larger part of the Balgzand was kept unaffected, the detrimental effects would be kept to a minimum. Therefore, alternatives in which the harbour was situated on an island with a bridge connection to the mainland were favoured from an ecological point of view.

5 Conclusions

From previous experiences it was clear that it is important to consider ecological factors already during the early design stages of a proposed development. Changing a design at a later stage when much money has been spent often proves impossible. There are examples of proposed major developments which have been delayed and possibly abandoned because of political pressure which was based on ecological considerations e.g. the Dollard harbour (Bergman & Dankers 1979). When that harbour had been designed taking into account the value of the Dollard nature reserve, the political aversion certainly would have been considerable less. Another important aspect, which became clear during the experiences with environmental impact assessment, is that preferably all environmental functions as well as the function losses are quantified.

This gives the best opportunity for the decision making authorities to come to a good decision. It also gives the opportunity to include positive and negative effects in a macro-economic cost-benefit analysis. However, it is important to note that the functional approach should not be rigidly adhered to. For some areas it would be a lot of work to quantify a certain function, while it is clear beforehand that a particular function will be relatively little affected, or is of minor importance. Therefore, it is essential that before environmental effects are described, discussions have been made with specialists in order to prevent long descriptions of relatively unimportant aspects while omitting relevant matters.

It should be stressed that lack of knowledge or information should be clearly indicated. Most decision making authorities have little knowledge of ecology, and often think (or hope) that professional ecologists know everything about the environment. When the ecologists stress that there are uncertainties in their predictions then the decision making authorities can take this into account.

On the other hand the ecologist should be aware of the uncertainties in the predictions of other disciplines. In the case of the proposed Dollard harbour (Bergman & Dankers 1979) it was predicted originally that the salinity of a major part of the Dollard area would decrease by 10 0/00. This means that a major part of the Dollard would become a freshwater area. The conclusion of the ecologists was that this would cause the disappearance of a great deal of the marine and estuarine bottom - living organisms and wader birds. However they also mentioned that the effects would be less severe if the salinity decrease would be less extreme. This prompted the hydrographers to recalculate their findings and in subsequent physical reports the salinity decrease was predicted to be considerably less. This could then be translated in less severe biological effects.

Acknowledgement

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CUMULATIVE ECOLOGICAL CONSEQUENCES OF DIKING PROJECTS IN THE WADDEN SEA AREA

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Abstract

In the past extensive parts of the original Wadden Sea have been reclaimed, step by step, for cultivation, in the process of which especially the higher situated salt marshes disapeared from the Wadden Sea area. At the foot of the dike a new salt marsh was often formed, which after sufficiently high sedimentation, would be reclaimed later. By means of reclamation techniques an attempt was made to encourage the sedimentation in order to quicken the process. This state of affairs seems to have discontinued in this century. At present there are only a few places in the Wadden Sea area where the natural or artificial formation of salt marshes still take place, while the mud accumulation generally amounts to very little. the still existing salt marshes and mud flats, which are therefore practically irreplaceable, cover in comparison to earlier times, only a very small part of the Wadden Sea area. They are nonetheless of very great significance to the biological life. The importance of these areas is found amongst other things, in their function as feeding and breeding grounds of international significance for marsh and water birds, and as a nursery for many species of bethic fauna, which are so indispensable to birds and fish. These biologically very important borders of the Wadden Sea area are threatened with extinction due to planned diking projects. In the development of future polders the cumulative ecological consequences of projects should be considered seriously so far as their totality and mutual connection are concerned.

Outline of recent diking projects in the Wadden Sea area

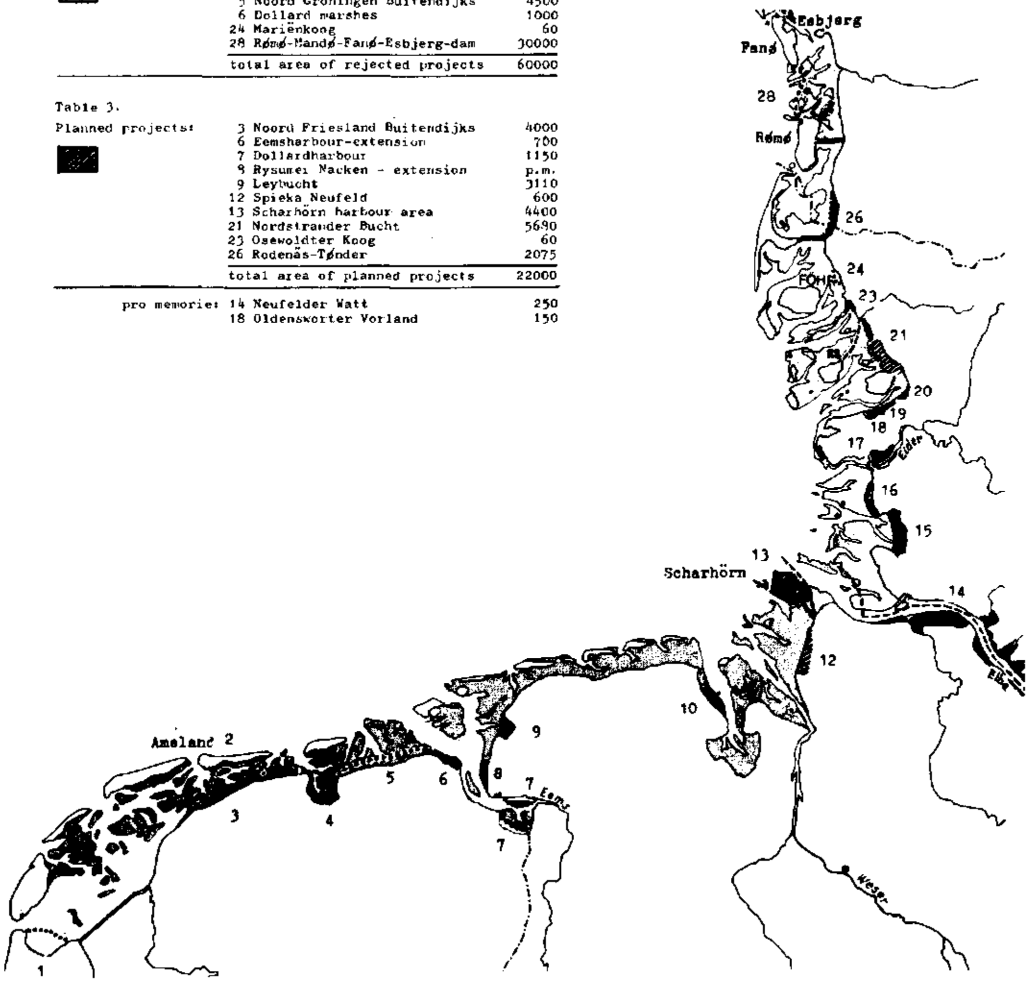
Especially since 1963 a stimilus of bringing about of diking projects was provided. A number of harmfull storm floods made it quite obvious that a heightening and a reconstruction of the existing dikes along the Wadden Sea coast was necesarry. It became possible now to gain land through the construction of a new, more seaward situated dike, for which funds were available which otherwise would have been used for threngthening the existing sea dikes. Table 1 gives an outline of diking projects after 1963. The reclamation of ca 116.000 ha has seriously been considered since 1963; up till 1979 the embankment of ca 34.000 ha has been completed in reality, the proposed poldering of 60.000 ha was rejected and more than 22.000 ha is still threatened by planned diking projects.

Functions of the threatened tidal areas as part of the ecological unity of the Wadden Sea area

The entire Wadden Sea area must be viewed as one whole[1] . In the first place it is a unity in itself, it is one ecosystem of which all parts influence each other. The water forms the connecting link in processes as erosion and sedimentation and the exchange of species due to tidal currents. In the latter case it does not only concern micro-organisms and larvae of, for instance, worms, cray fish and mussels, but also fish like plaice and herring. Mutual influence between the various parts is also furthered by birds in motion and the distribution of plant seeds by the wind. Secondly the Wadden Sea area is one with its environment. It is functionally and lastingly connected with areas outside it. Thus events in the Wadden Sea determine the number of some kinds of fish in the entire North Sea . As regards a great number of bird species, this influence is felt in wintering areas in Africa and breeding grounds in Siberia. It is therefore obvious that the seaward area of the dike cannot be considered as a number of isolated unities at all. On the contrary,the tidal areas perform a number of essential functions, the removal of which,due to poldering, has important consequences. We state here the following functions [2] :

Table 1. and Map 1. Outline of diking projects after 1963 in the Wadden Sea area of Denmark, Germany and the Netherlands. Source: 3 - 9.

			area (ha):
Table 1.			
Completed projects:	4	Lauwerszee	9000
	6	Eemsharbour	800
	8	Rysumer Nacken	600
	10	Voslapperwatt	1500
	14	Nieder Elbe	15000
	15	Meldorfer Bucht	4800
	16	Norderdithmarshen	930
	17	Eider	1280
	18	St. Peter Süderhöft	60
	19	Tetenbüllspieker	140
	20	Finkhaushalligenkoog	190
		total area of completed projects	34300
Table 2.			
Rejected projects:	1	Balgzand	8100
	1	Balgzandharbour	350
	2	wadden area of Ameland	17000
	5	Noord Groningen Buitendijks	4500
	6	Dollard marshes	1000
	24	Mariënkoog	60
	28	Rømø-Mandø-Fanø-Esbjerg-dam	30000
		total area of rejected projects	60000
Table 3.			
Planned projects:	3	Noord Friesland Buitendijks	4000
	6	Eemsharbour-extension	700
	7	Dollardharbour	1150
	8	Rysumer Nacken - extension	p.m.
	9	Leybucht	3110
	12	Spieka Neufeld	600
	13	Scharhörn harbour area	4400
	21	Nordstrander Bucht	5690
	23	Osewoldter Koog	60
	26	Rodenäs-Tønder	2075
		total area of planned projects	22000
pro memorie:	14	Neufelder Watt	250
	18	Oldensworter Vorland	150



1) production of bio-mass
2) regulation of the silt balance
3) biological purification
4) regulation of the oxygen cycle
5) nature observation, -education, scientific studies and signal function
6) genes reservoir
7) fisheries and agriculture
8) recreation
9) coastal defence
10) habitat for plant- and animal communities

The functions 1, 2, 3, 7, 9 and 10 will be discussed in this article in relation to the planned diking projects.

Production of bio-mass

Important is that the bio-mass production in these areas benefits a much larger area. On the one hand this is because many organisms from outside these areas come here to feed - i.e. birds, fish and cattle, and on the other hand many animals, concentrated in large numbers, spend their youth here, after which they disperse over the Wadden Sea area and North Sea. This nursery function is of importance to mud loving benthic fauna such as the smeew (Macona balthica), sea centipede (Hydrobia ulvae) and several worms, shrimps and crabs and also to fishsuch as plaice, flounder, sole, herring, sprat and others (Pleuronectes platessa, Pleuronectus flesus, Solea solea, Clupea harengus, Clupea sprattus a.o.). The disappearance due to diking projects, of the bio-mass production from areas on the seaward side of the dike, means a deterioration for the fauna covering a much greater area, especially for the bird species concerned, while also the reduction in the above mentioned organisms will be perceptible in the Wadden Sea and the North Sea.

Regulation of the silt balance

Due to their sometimes sheltered and mostly elevated position, a regular and continious sedimentation of in the water suspended silt and dead organic matter takes place in the areas on the seaward side of the dikes. The settling of the silt is aided by the action of diatoms and other benthic organisms. This function as sedimentation basin is of great importance so far as the silt balance in the Wadden and North Sea is concerned. The silt emanates partly from the Wadden Sea, the North Sea an rivers, as does the dead organic matter, including the refuse of towns and industry. Deposition of this suspended matter prevents a greater turbidity of the sea water which should decrease the growth of algae and as a result of this also the production of animal life including the spawning of fish. Moreover, a considerable amount of heavy metals is bound up with this silt. This is deposited with it and as a result is less likely to interfere with the feeding cycle of the Wadden Sea and the North Sea.

Biological purification

Organic waste which accumulates in this manner is disintegrated here by bacteria and other micro organisms into carbonic acid, water and organic salts, which are soluble in water, after which they serve as food for the primary production. Suspended useless and sometimes even harmfull organic refuse is thus transformed into soluble, useful nourishment. This process of mineralisation is of vital importance for the ever continuing production of bio-mass in the Wadden Sea area and the North Sea. With the tidal currents a vaste amount of nutrients is transported to the North Sea, where they contribute considerably to the production of fytoplancton. In the North Sea the nutrients are a limited factor for the primary production and the mineralisation factor is 10 to a 100 times smaller than in the tidal areas of the Wadden Sea [2]. Loss of these tidal areas, through embankment, means a direct loss of biological purification capacity; a capacity which can be compared with that of a water purification plant. This loss is estimated to be about 625 inhabitant equivalents (i.e.) per annum per ha tidal area [10]. Extrapolating, this means, for the plans being considered here, a loss of biological purification capacity of about 9 million i.e. per annum. The value of this can be expressed in cash terms by counting the cost of a two stage sewage works with a comparative purification capacity. These costs are stimated to be about 800 milion guilders as initial expences and 63 milion guilders per annum to cover exploitation costs.[2,10].

Fisheries

For fisheries the removal of the functions mentioned above, due to diking projects, means a direct loss of yield concerning species such as: mussel, shrimp, crab, eel, smelt, flounder and the brackish water gudgeon (Mytilus edulis, Natantia, Brachyura, Anquilla, Osmerus eperlanus, Pleuronectus flesus and Gobius microps). Besides these the North Sea population of specie , i.e. plaice, sole, herring and sprat (Pleuronectes platessa, Soleasolea, Clupea harengus and Sprattus sprattus) are also striken, all fish which, when young, spend an important part of their life in the area for trophic reasons.For instance it has been estimated that even a relatively small embankment of 2000 ha mudflat would cause a loss of more than half a million guilders as far as the plaice catch in the North Sea is concerned[11]. The diking plans considered here are estimated to have a ten times greater effect. This annual loss of about five million guilders only covers the plaice haul while even the expected industial pollution from the Dollart-harbour and the Scharhörn area has not even been taken into consideration.

Coastal defences

From experience it is known that a high foreshore in the form of salt marshes at the base of a sea dike can withstand a great part of the wave impact which at high tides threatens the sea dikes. The best coastal defence is obtained by elevating and strengthening the existing dikes and in maintaining the extant outer dike areas. In some cases however, this means that the decrease of the total dike length will not be at its maximum.

Plant communities

The botanical significance of the outer dike areas is based on the fact that these grounds form a irreplaceable habitat for the indigious salt marsh vegetation, algae and sea weed. Both in Zeeland and in the Wadden Sea area these vegetations have in the past been much decreased due to diking and blocking of the tides. Along the coast of the mainland of Denmark, Germany and the Netherlands there still exist about 50 more or less isolated habitats, which in most cases are already smaller than 500 ha. This is the minimal dimension needed for the development and survival of this type of ecosystem. Not all salt marshes are identical. Each area has been formed under different circumstances, so that unmistakable differences in geomorphology and vegetation can be distinguished. To maintain this diversity forms an important starting point for nature conservation and management. Recent scenic and botanical descriptions of tidal areas along the mainland coast of the Wadden Sea have been compiled by Dijkema[12]. He distinguished four groups of plant communities which correspond with four stadia in the salt marsh formation. On the basis of a map compiled by Dijkema an outline is given of the vegetation in the areasthreatened by embankment, see table 2.

Table 2. Surface distribution of vegetation zones (ha) spread over the tidal areas threatened by the planned development of polders.

Area	Vegetation zones				
	highest salt marshes and summer polders	high salt marshes	low salt marshes	mud and salt flats	id.without vegetation
3. N.Friesland	1100	300	600	600	1200
5. Eemsharbour	-	-	-	350	350
9. Leybucht	290	60	520	160	10
12. Spieka Neufeld	600	-	-	-	-
21. N.strander Bucht	-	-	1460	740	540
23. Osewoldter Koog	-	60	-	-	-
26. Rodenäs-Tønder	20	300	540	410	460
Total	2010	720	3120	2260	2560

Source: global estimation based on map (1:100.000) of Dijkema .

The above estimated salt marsh vegetation would be entirely lost through damming and blocking of the tides. It would be replaced by plant communities which all represent those inland ones found in high-trophic fresh water areas. The value of this, botanical-wise, would be greatly dependent on the use and management of the habitats concerned, but would be almost negligible in comparison with the original outer-dike situation. Concerning each vegetation zone the planned projects would cause the elimination of considerable areas. Relatively the most affected areas are the older and higher situated salt marshes and summer polders. Also by earlier embankments, especially these types of areas were lost. One should note that the number of areas, where an entire zoning of salt marsh vegetations still exists, would be reduced even further. Broadly estimated 1/3 part of the 34.000 ha tidal areas which have been poldered since 1963,would have been covered by higher plants. This means a loss of 11000 ha of vegetation ; due to the present planned projects another 8.000 ha of plant communities will be lost, once they are carried out.

Animal communities i.e. birds

The Wadden Sea is of vital importance to the annual cycle of many wad and water fowl. For a great part these species breed in arctic, subarctic and boreal climate zones of the Northern hemisphere. The breeding season is short, no more than two month. The rest of the year these species depend on the tidal coasts and adjacent areas, from Western Europe to South Africa. The total area of the ornithologically most important coastal wetlands in Western Europe comprises 1½ million ha[13]. The Wadden Sea is the largest, i.e. 660.000 ha and also the most important, with a roughly estimated number of on an average, 1½ to 2 million birds, which gather there simultaneously . The function as feeding ground for meat eating species depends a great deal on the enormous production of benthic fauna in these tidal areas, due to the ample mud content. Although these mud rich biotopes only account for a very small percentage of the total surface area, a great part of the food for birds is produced here[14]. The plant eating birds, such as geese and duck, forage here on the salt marsh vegetations. Almost all species, present in the late summer or autumn, endure there their seasonal moulting, either completely or in part. This process, by which their flight capacity decreases or even temporarily ceases entirely, is a great drain on their strength. During this period their fat reserves are reduced too. So at a time like this, peace and quiet during their search for food and their rest is of great importance. Too much interference deteriorates their physical condition and their chance of survival during the winter[13]. The tidal areas discussed here provide tranquillity and shelter during high tide, as well as feeding grounds nearby. According to international norms,which result from the in Iran organised "wet land convention" (Ramsar 1971), all the planned diking project areas are of the utmost importance for a great number of migratory bird species.

The relative tranquillity and the attainability of feeding areas decide amongst other things the importance as breeding place. In the outerdike areas considered here, great numbers and densities of species breed, which in other areas of Western Europe only occur scarcely or even decline in numbers. Taken globally two groups of birds breed in the outer dike areas. The one group is chiefly found in the summer polders. this comprises meadow birds such as godwit, common redshank, ruff etc. (Limosa limosa, Tringa totanus, Philomachus pugnax etc.). The other group breeds mainly on the salt marshes and comprises various species of ducks, terns, avocet (Recurvirostra avosetta), belonging to the class of littoral birds.

Considering 14 bird species which were taken into account, the estimated loss of tidal area, due to the planned polder development, would cause the elimination of allready more than 10.000 breeding pairs. In most of these areas about 20 to 30 species breed, so that the real number will be much higher. Moreover, a huge food source in the form of benthic organisms and salt marsh vegetation will disappear as well. Roughly estimated, it has been found that each hectare of this kind of area contains the food supply for 25 dependent birds[15]. This means that, due to the loss of feeding grounds only (22.000 ha), more than half a million birds would also vanish.

Embankment works and exploitation of harbour and industrial areas result in disturbing the peace and quiet which is sure to have an adverse effect on the possibilities for birds, also outside the reclamation area. Furthermore a decline can be expected in the production of marine organisms as a consequence of the increasing turbidity due to dredging and pumping works and the increasing pollution. These effects are difficult to estimate but seem to be rather serious. Also a change in salinity can diminish the production of benthic fauna which will indirectly cause a decline in the numbers of meat eating species of birds.

Various authors and researchers[16,17,15] have come to the conclusion that outside the Wadden Sea no permanent alternative territories exist for the due to embankment, ousted birds. In the Wadden Sea and probably also in comparative areas elsewhere, the food produced in the form of benthic organisms, is always entirely used up. Moreover, also elsewhere extensive regional diminution has taken place, i.e. in the Dutch Delta area. The stop-overs which form a chain along the migration route cannot serve as substitutes for each other; rather they must be regarded as each other's complement.

In the case of North Friesland, Eemsharbour and Leybucht it can hardly be expected that a spontaneous formation of new salt marshes will occur[4,17,18]. at the base of the new dike. In some cases the position is not quite clear (Nordstrander Bucht and Rodenäs-Tønder). The accretion of new land outside the dike can be stimulated artificially by means of reclamation. However the suitable places for accretion have already vanished, so that new efforts will never provide areas comparative in quality with what has been lost. Moreover any accretion will go very slowly; too slowly to replace the lost habitat. As an example serve the efforts, since 1959 in the German Nord Friesland, for the Hauke Hayenkoog. In spite of reclamation works no accretion of any importance has taken place[6]. As things are, we must therefore accept that the new situation outside the dike will not provide any suitable areas to accomodate the displaced birds. The future perspectives of land within the dike will differ according to project and species. Concerning the projects taken into account here only a little compensation of breeding locations can be espected. Even more difficult will it be to compensate the feeding and roosting localities, which the tidal areas provide for these species.

Table 3 gives an outline of the expected cumulative impact of 8 planned diking projects on birds. For nearly all of the 22 bird species discussed several resting zones will be lost - a great part of which concerns the most important refuges they have in the Wadden Sea area. Besides this, the largest breeding colonies of Recurvirostra avosetta, Sterna hirundo and S. paradisea will be lost and important breeding grounds will be disturbed of 7 other species. The heaviest losses will be suffered by the Avocet (Recurvirostra avosetta); with this species the greatest part of the population is in jeopardy; the survival of the entire N.W.European population is at a risk. Losses up to 1/3 of the N.W.European population of the Sheld Duck

(Tadorna tadorna) and the Spotted redshank (Tringa erythropus) are expected and about 1/5 part of the Barnacle goose (Branta leucopsis) and Curlew (Numenius arquata). Roughly 1/10 part of the N.W.European population is endangered concerning 8 other species (see table 3). Concerning 5 species the loss is estimated to be 5% or less.

Table 3. Expected decrease in number of resting and breeding birds as a result of diking projects

	species	1%-norm	expected decrease in % of the N.W. - European population per region , as a result of the disappearance of the migratory function								exp.decrease no.breeding pairs	I
			3	6	7	9	12	13	21	26		
d	C. alpina	15000	•		o	o			o	o		10
d	P. squatarola	450	O	·	o	·		·				10
d	L. lapponica	3000	o	·	o	·	·	·	•	•		5
b	R. avosetta	250	(20)	o	(35)	O			o	o	3000	75
b	T. tadorna	1250	O					O	(20)	O	100-200	30
d	T. erythropus	?	O		O					·		30
b	H. ostralegus	5600	o	·	·	•	·	o	·	·	- 1000	5
b	N. arquata	1600	(18)	·	•	·	·	·	o	•		20
b	L. limosa	800	·	·	·	·	·	·	·	·	350-700	5 ?
b	T. totanus	2500	O	·	•	•	·	·	•	·	- 1600	10
b	Ph. pugnax										100-200	?
b	S. hirundo										- 2600	10
b	S. paradisea										- 400	10
b	Ch. niger										40-60	?
b	A. clypeata										- 100	-
d	A. penelope	4000	O	·	·	·	·	·	•	·		10
b	A. acuta	500	·	·	O	o	·		O	·		10
d	A. brachyrhynch.*)	120							•	(90)		75
d	A. albifrons	1350							O	·		-
d	B. leucopsis	470	o							o		20
d	B. bernicla	1100	o		·	·			o	o		10

Legenda:
- · < 1 %
- • 1% - 2.5%
- o 2½% - 7½%
- O 7½% - 12½%
- (35) f.i. 35%

b = regular breeding bird
d = regular migrant and/or winterguest

I = total expected decrease per bird species in % of the N.W.-European population.

Regions: see map 1 : 3=Noord Friesland Buitendijks, 6=Eemsharbour-extension, 7=Dollardharbour, 9=Leybucht, 12=Spieka Neufeld, 13=Scharhörn harbour area, 21=Nordstrander Bucht, 26=Rodenäs-Tønder.

*) In calculating the here presented decrease of A. brachyrhynch., the unknown transition possibilities have not been taken into account.

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ENVIRONMENTAL DEVELOPMENTS IN TWO OF THE BORDERLAKES OF THE IJSSELMEERPOLDERS IN THE NETHERLANDS

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Abstract

The paper deals with the environmental developments in two of the borderlakes of the IJsselmeerpolders by means of a historical survey. Drontermeer (lake Dronter) and Veluwemeer (lake Veluwe) will by dealt with. These shallow lakes with an area of some thousands of ha consist as a closed watermanagement unit since 1956.
An indication will be given of the ecosystem of the lake IJssel area. The closing off of the lakes under review has originally led to a rich and varied plant and animal life due to the specific abiotic environment of these lakes. In the middle of the sixties deterioration began to set in, at first slowly, later more rapidly. Especially the increase in the drainage of agricultural and domestic waste matter played an important part in the downward development.
Since the second half of the seventies steps were taken to improve the situation, special attention was paid to deter the accumulation of phosphate. The results of the various steps taken will be considered.

1 Introduction

With the completion of the Barrier Dam in 1932, the Zuiderzee changed from an inland sea to a lake; lake IJssel. In the time space of a few years the saltish water of the Zuiderzee had been changed to fresh water caused by the inflow of the river IJssel and other rivers and streams. Thus an environment was created which proved optimal for the development of higher plant life. Seaweed (Zostera Marina) disappeared and Pondweeds (Potamogetonaceae) took its place.

Since lake IJssel had turned into a fresh water habitat, parts were separated by the making of polders. These parts, called borderlakes, have been designed for the following watermanagement purposes:

- the prevention of drying out of the adjoining existing land because of substantional lowering of the water-table in the new polders.
- to serve as a catchment area as a substitute for the former Zuiderzee.
- to sypply good quality water for flushing oversalted polder water.
- to maintain shipping connections to towns along the former Zuiderzee.

These arguments formed the basic for the diversity in size and width of the borderlakes. Other aspects such as recreation, the winning of sand, and the development of nature, played an incidental and subordinate role. The two lakes under discussion (which came into existence in 1956) were selected because not only do they present a good example of original reaction of the environment to the closing off works, but also of the environmental developments in relation to other extern factors.

2 General description of the lakes

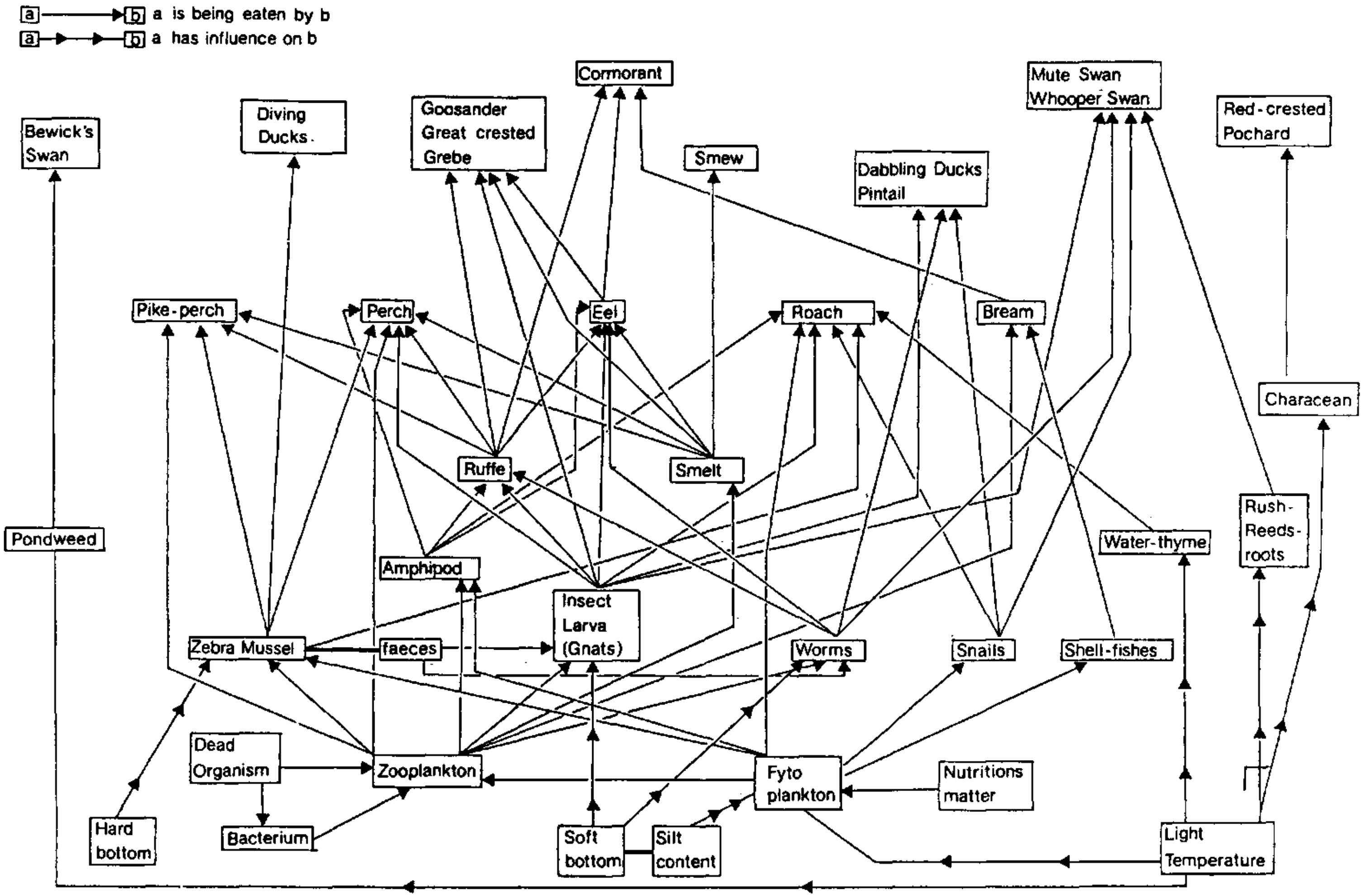
After the closing of the dike of Eastern Flevoland and the construction of the Harder locks and the Roggebot locks, a closed watermanagement unit came into existing which consists of two lakes interconnected at the town of Elburg.

The distance between both locks is 27 km, the width varies between 200 m and 2,6 km. The total area amounts to 4300 ha and the average water depth is approximately 1 m, except in the shipping channel where the depth is 3,5 m.

The lakes receive surplus water from the adjoining coastal areas via 22 streams ans 2 canals, the effluent from the waste water treatment plants at Elburg and Harderwijk and percolation water from the Veluwe. Surplus water from the lakes is mainly discharged via the Roggebot locks. Along the coast of the polder Flevoland loss of water occurs by percolation. In dry periods in summer the water level in the lakes is artificially controlled by letting in water from polder canals in order to prevent

figure 1

Relation of foodchain lake IJssel / border lakes



the lowering of subsoil water along the old (Veluwe) coast.

3 Description of ecological system

Figure 1 gives a diagrammatric view of the interconnecting food and influence chains which (can) take place in lake IJssel and the borderlakes. This diagram is no indication of a static situation, the emphasis lies on the situation which existed at the time of and just after the creation of lake Dronter and lake Veluwe. Some interconnections will be closer examined:

a) Type of soil. The Southern part of the former Zuiderzee floor consists mainly of clay; in the area of lake Veluwe and lake Dronter however sand submerges. This is especially relevant for the Zebra Mussel (Dreissena Polymorpha), an important link in various foos chains. This mussel is being eaten by Diving Ducks and fishes but in addition this little animal secretes a certain form of pseudo-faeces, which create a good breeding ground for insect larva and worms.
b) Waterdepth. In reality the whole of lake IJssel is shallow, but especially the borderlakes under review are particularly shallow and nowhere deeper than 2 m. Indeed along the old coast wide strips exists which are even shallower than 1 m. These latter strips are especially suitable for the growth of various water plants, at least by adequate transparancy (light!). These waterplants constitute a very important food source for bottom animals, fishes and birds (e.g. Bewick's Swan) and also create an excellent breeding environment for fishes.
c) Light and temperature. These factors play an important role in the growth of fytoplankton and waterplants. Growth can be limited by the increase of the silt contents. In turn the silt contents is defined by the type of soil and waterdepth, but also by wind velocity, an other additional abiotic factor.
d) Quantity/composition of food matter. The quantity of nitrates and phosphates is of particular importance for fytoplankton. In weak eutrophic water, the original condition of lake IJssel, the quantity of food matter is a limiting factor in the growth of fytoplankton.

Table 1. Development of a number of environmental indicators in lake Veluwe and lake Dronter since their closing off in 1956 (compiled from a great number of sources)

	Period		
Indicator	1957 - 1961	1964 - 1969	1972 - 1975
Fytoplankton	Green algae Diatoms, Desmids, Characeans, incidental Blue-green algae	no information	domination of Blue-green algae Characeans Desmids disappeared
Bottom animals	various insects, Zebra Mussel Zebra Mussel	many Amphipods, fewer Zebra Mussels	Zebra Mussel disappeared, limited diversity
Water plants	3 species of Pondweeds, Milfoil, Water-thyme	deterioration of all water-plants	2 species of Pondweeds, remainder disappeared
Fishes	many species, Smelt disappeared	deterioration: Pike Perch Roach	Pike disappeared, Bream and Eel increased
Birds	Diving Ducks, Dabbling Ducks, Bewick's Swan Red crested Pochard	general decrease numbers	disappeared: Red crested Pochard, Cormorant, Smew
Transparancy	1.0 m	no information	0.2 m

4 First reaction of the ecological system

Closing off of the lakes innitially created the following consequences:

a) On the one hand the change from brackish water to fresh water continued, on the other hand disturbances took place caused by incidental inflow of brackish water in summer.
b) A decrease of the environmental dynamics occured caused by the decrease of the length of wind sweep. This in turn created conditions for a greater variation in kinds of water plants, bottom animals and water birds and also meant a lower silt content (increased transparancy).
c) The influence of seepage, containing iron originating from the Veluwe area, increased due to lack of exchange and mixing with other parts of lake IJssel. This caused the deposit of the phosphate contents of the water whereby less phosphate became available for fytoplankton.

These factors contributed independently, as well as in relation to each other and in addition to other abiotic components, to a rich and varied plant and animal life. A summaray of which is presented in the second column of tabel 1 (period 1957 - 1961).

5 Eutrofication as a new problem

According to the third and fourth column of tabel 1, the original diversity of flora and fauna during the sixties and seventies decreased and transparancy deteriorated. This was mainly caused by the pollution originating from the discharge of domestic and agricultural refuse. Domestic refuse enters the lakes mainly via the direct discharge of refuse-water by waste water treatment plants and sewerage drains. This originates from urban settlements and in summer time from campings. Human faeces and domestic detergents play an important role; faeces are broken down in purification works by means of biological purification to phosphates and nitrates. Detergents are an important source of phosphate. Agricultural refuse-water consists mainly of manure; especially from manure surpluses which are being drained into streams and furthermore of manure which is being washed away from agricultural land.

This manure contains a rather high phosphate and nitrate level.
As the problem of the character of water pollution was not recognized in time, reliable measurements were not available of the quantities of refuse-water and its phosphate contents until the sixties. Table 2 is based on estimates.

Table 2. Estimated phosphate load on lake Veluwe and lake Dronter during some years in the period 1960 - 1975

	Phosphate load lakes	
Year	Tons/year	Grams/m^2 water area/year
1960	22 à 44	0.5 à 1.0
1967	97	2.2
1970	110	2.5
1972	119	2.8
1975	160	3.7

In 1967 approximately 75% of the phosphates originated from waste water treatment plants, the remainder came from streams.
The increasing trend in the phosphate load has, in addition to the population growth two important causes:

- an estimated 40% in the phosphate load is due to the increasing use of (chemical) detergents
- the concentration of a great number of intensive agricultural farms (pigs, calves and chicken farms) on the adjacent land. These farms produce more manure than required for the fertilization of agricultural land, resulting in an estimated 30% of the phosphate load.

The first effect of enrichment was that the content of food matter not any longer acted as the limiting factor in the growth of algae.
Consequently the mass of algae increased and the light intensity decreased. Thus an environment came into existence which became favourable for the development of Blue-green algae Oscillatoria agardhii, as this species grows more rapidly than others by low intensities.
The result is an intensive growth in Blue-green algae in summer thus

severely limiting the life possibilities of other plants and animals. The results are already indicated in table 1.
Because of dying off of algae in autumn and winter by which the phosphates got assimilated to the silt, a substantial quantity of phosphates accumulated in the bottom (in 1972 already estimated from 500 to 1000 tons).
Research has indicated that under specific conditions phosphate can be released again. This creates an additional complicating factor in trying to limit or eliminate the annual growth of Blue-green algae.

6 Steps taken to improve the situation and their effects

The yearly occuring growth of Blue-green algae can be prevented by limiting the load of phosphates and nitrates in such a way, that one of these nutrients again becomes the limiting factor in the growth of algae. Preference in thereby given to phosphate because not only is the supply of nitrates more difficult to control (nitrogen in precipitation binding nitrogen from the air by Blue-green algae), but the elimination of nitrate is aldo technically difficult to realize. The aim is to limit the phosphate load from o.5 to 1.5 grams per m^2 per annum. The most important stepts to be taken in order to realize this aim will be put forward, if possible with mention of their effects.

a) Dephosphating of waste water treatment plants.
   By adding iron or aluminium compounds phosphates are deposited. This process takes place at Elburg since 1973 and at Harderwijk since 1980. The result shows a limitation of the phosphate load from 80 to 90 %. Related to the lakes this means a reduction of the phosphate load to 1.2 - 1.9 gram per m^2 per annumn.
b) After-purification by means of reed fields.
   This method has been applied as a test at the waste water treatment plant at Elburg since 1978. During this process of after-treatment there is evidence that the nutrients are assimilated and tied by the growth of reed. The initial results are that approximately half of the refuse water (already dephosphated by the treatment plant).
c) The approach to eliminate the phosphate sources (detergents and

manure surpluses).
The aim of the Dutch Government is to prohibit the use of phosphate in detergents as from 1985. In relation to lake Dronter and lake Veluwe this does not mean a substantial limitation of the phosphate loas as most phosphates have already been removed in both waste water treatment plants.
Manure surpluses can partly by disposed off via manure banks and have partly to be purified in special installations (e.g. calves manure). As a result of the substantial expenses connected with these methods, and also because maize is able to absorb a high percentage of manure poisons, over-manuring of agricultural land still takes place.

d) Because of a certain balance between the phosphate supply on the bottom of the lakes and the phosphates dissolved in the water, it is possible by means of removal of the dissolved phosphate in combination with the algae which occur in the water, to lower the quantity of phosphate at the bottom. Therefore the lakes have been flushed with ferrugious water with a low phosphate content originating from the polder Flevoland during the past three winter periods.
This had led to an improvement in the transparancy of the water in the beginning of summer. The growth of Blue-green algae could however not (yet) be prevented.

HIGH WATER IN VENICE

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Abstract

A statistical model capable of forecasting high water and low water in Venice is discussed. Using atmospheric pressure and sea levels, measured up to 30 hours before, as input to the model, a short term flood warning (about 6 hours in advance) is possible. The city authority is currently using the model to warn the population and to set-up a system of raised wooden walkways before the flood hits the city. Other protective measures are foreseen by the installation of breakwaters, baffles and movable locks at the three inlets to the Lagoon.
A deterministic model is described which will also be employed in forecasting high and low water in Venice. The model can estimate sea levels as long as it is fed with pressure and wind fields over the Adriatic Sea, covering the last days: if predicted (hence future) weather parameters are given, the scheme can be used to predict sea levels. It uses as a boundary condition the sea level of Otranto (the southern inlet) where the oscillations of the Adriatic have a node. This model has been tested up to now by hindcasting three years of data. Daily weather forecasts, instead of previous data, will be shortly applied to the model to predict high and low water.

1 Introduction

An introduction to the Venice flooding problem is given by briefly recalling the historical origin of this place, with its world of tiny polders. The tribes that fled onto the Lagoon mudflats to escape the violence of the barbarians looked for places where the tide itself could help as a defense: as Cassiodorus wrote,

> 'they live like marsh birds, in nests of reeds raised on poles, to protect themselves against the waters...
> and the boats are tied to the walls like animals.'

In the intertidal plains where the town was built, in spite of the reasonable effort to have streets and homes high enough over the water level, unusual high tides could easily prevail. Severe floods occurred dozens of times in the life of Venice, before this century: now things are worse, as it will be seen.

It is worth mentioning that sometimes the reports of the old floods are frightening, with fatal accidents to people or severe damage to the precious water "wells" (elaborate underground rainpools), the only water supply other than ferrying tanks from the mainland.

A look at the map shows that Venice is at the center of the Lagoon (the "Venice moat") which communicates with the Adriatic Sea through three inlets.

When left in a relatively uncontrolled condition, the inlets opposed a substantial frictional resistance to the water motion, so that the tidal range was smallér in the Lagoon than in the northern Adriatic. The river inflow in the Lagoon itself can be disregarded, since it was diverted to the open sea with a huge technical effort during three centuries.

Modern requirements for shipping and industrial activities brought about a deepening of the inlets and the Lagoon canals: as a result, the town is less protected from sudden Adriatic surges.

A parallel effect was given by the construction of polders and dams for fish farming, which have reduced the expansion area for tides.

The only protection of the Lagoon can be seen now in the delay (about 1 hour) for the tidal wave from the sea to Venice.

Another dramatic effect of the human intervention was the sinking of the town, which topped its rate with about 5 mm/year near the middle of this century. The cause was the intensive water extraction from the subsoil for industrial purposes: needless to say, sinking the town is equivalent to increase the sea level - and the number of floods as well. Subsidence was essentially stopped early in the 1970's: but most of the damage is irreversible.

2 Physical environment

As it should be clear from the above remarks, the peculiar conditions that give origin to a flood should be studied in the sea: the Lagoon is just the receptor of the phenomenon.

The Adriatic is a long, narrow bay communicating with the Mediterranean. About one half of it, the northern part, can be seen as a continental shelf, shallow and with a gentle slope: the place is ideal for the generation of storm surges. Indeed, a glance at the map shows that south-easterly winds, blowing along the axis of the Adriatic, can pileup water towards the dead end of the sea, where towns like Venice and Trieste are located. But the freeboard is very reduced only for Venice (and a few other Venice-like hamlets) and this is the core of the problem.

Usually flood occurs when a storm surge (lasting normally 4-6 hours) comes in phase with the ordinary high tide: the range of the latter is more than one meter (in spring tide), which is a very high figure in the Mediterranean. A relevant feature of the Adriatic is the "seiche", or free oscillation of the sea. Easily expected as related to the resonance of the Adriatic as a bay, it is unexpectedly persistent, showing little energy loss both for friction and for external radiation. Its period, slightly less than 22 hours approximately, is significantly close to the diurnal tidal period: the Adriatic turns out to be a resonant cavity for tides, which accounts for their large range.

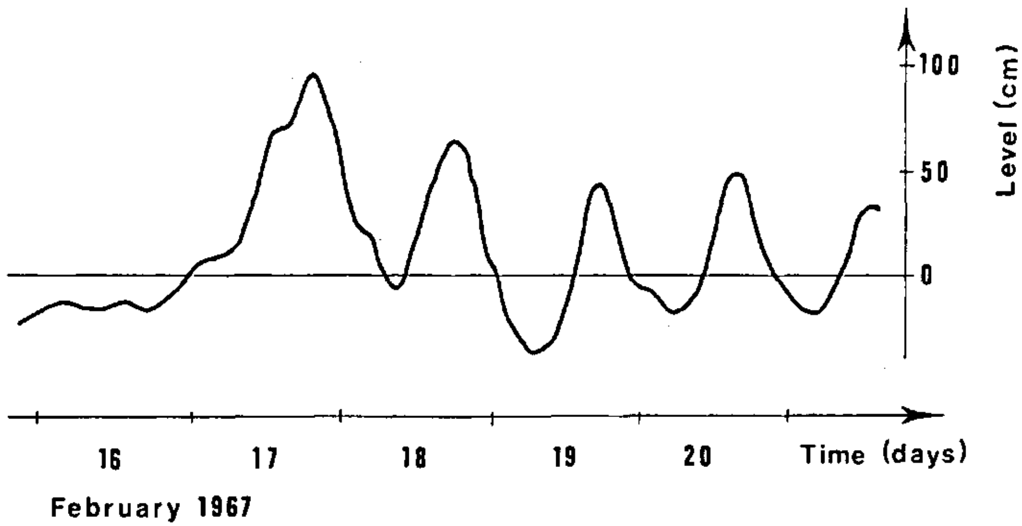


Figure 1. The free oscillations of the Adriatic: after the surge of February 17, 1967, "seiches" were observed for many days. (Ordinary tide was subtracted before plotting)

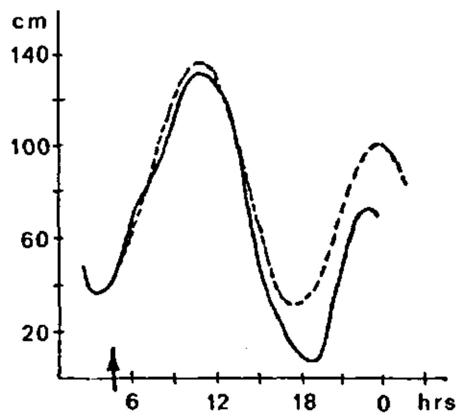


Figure 2. An example of tide prediction using statistical schemes. On October 25, 1980, a severe flood occurred in Venice (solid line, observed tide). The forecast given six hours before the peak (arrow) is shown by the broken line. It is adequate for this short term warning and poor for the following trend of the tide

3 The statistical model

It has been a common experience in many fields to face a problem using deterministic models, with dynamic equations and energy balance, and eventually to use, for practical analysis or forecast, numerical schemes to be defined as statistical or empirical.
The two approaches have usually much more common points than it could appear at a first glance: the statistical method requires a careful selection of the parameters to be used, and the physical insight coming from the deterministic study is precious. Also in the Venice case there was a preliminary work with storm surge equations (not to be confused with the deterministic model presented below). Then it became clear that, in order to have a short term forecast of the surge by a little amount of calculation, a few local observations were sufficient, and all this was the ideal starting point for a warning service: more complex schemes could follow with reasonable efforts for technical upgrading and personnel training.
An advantage of the statistical approach is that it can really consider some parts of the problem as black box: the details of weather evolution, for example, are avoided, taking profit of certain seasonal regularities of the weather pattern. To a mean degree of accuracy, simply the atmospheric pressure in Venice, as measured in the last 30 hours, as well as the hourly observed sea levels for the same time, are used as predictors. The latter input, Venice sea level, does not come as a surprise, since every time series will allow some kind of self-prediction. But one should stress that in this case the possibility of "seiche" makes it particularly interesting. Frequently, oscillations that were already started in the sea are the dominant factor for the time to come - yet they are embedded in the last hourly values.
Formally, the estimate of the sea level in Venice at the future time t, s_t^* , is obtained by inner products of vectors of observation and of filter weights:

$$s_t^* = \underline{s} \cdot \underline{f_1} + \underline{p} \cdot \underline{f_2}$$

The vector $\underline{s} \equiv s_{t-T}, s_{t-T-1}, \ldots, s_{t-T-n}$ contains sea levels observed up to T hours before the predicted time, and the pressure vector $\underline{p}$ is similar. The weights $\underline{f_1} \equiv f_{1,0}, f_{1,1}, \ldots, f_{1,n}$ and $\underline{f_2}$ are coefficients that were found as optimal from a many-year sample of the past. As mentioned above, their efficiency is improved by allowing different seasonal statistics, giving origin to season-dependent weights. The numerical scheme described above has been implemented and operationally exploited using very little electronic facilities.

The results were encouraging, and further trust stems from the previous experience of more complex statistical schemes. It was shown by Sguazzero et al. (Centro Scientifico IBM and C.N.R.-Grandi Masse, Venice) that another predictive scheme gives very accurate results on a six-hour prediction:

$$s_t^* = \underline{s} \cdot \underline{f} + \underline{P_1} \cdot \underline{F_1} + \underline{P_2} \cdot \underline{F_2} + \ldots + \underline{W_1} \cdot \underline{G_1} + \underline{W_2} \cdot \underline{G_2} + \ldots$$

where $\underline{P_i}$ refer to atmospheric pressure measurements from other stations on the Adriatic coast and $\underline{W_i}$ are nonlinear combines of some pressure values, simulating the wind stress on selected points of the sea. $\underline{F_i}$ and $\underline{G_i}$ are weights.

The future effort will tend to find a compromise between high accuracy of the projection and parsimony of input, not in order to cut people's work but mainly to reduce the dependence on remote-coming information. A promising perspective is also to include pressure data from places that are on the preferred track of storms: forecast should be available for longer lags.

4 Deterministic model

A deterministic model for the variation of the sea elevation due to storm surges and variations of the atmospheric pressure has been built to forecast both high and low water in Venice. Both situations are important for the city and the Lagoon. Presently the model is in its preliminary stage since it has been calibrated and tested by hindcasting 3 years of hourly data. Only the northern Adriatic basin was modeled by assuming the shape of a curved line. To further simplify the hydrodynamic equations, the linearized shallow water approximation was assumed. This assumption is justified because the wavelength due to storm surges is much longer than the depth of the Adriatic Sea, and the change in sea level is much shorter than the depth.

The following differential equations were solved:

$$\frac{\partial Z}{\partial Z} = - \frac{\partial U}{\partial x}$$

$$\frac{\partial U}{\partial t} = - \mu U - g\,h \frac{\partial Z}{\partial x} - \frac{h}{d}\frac{\partial p}{\partial x}$$

where Z is the change in the elevation of the sea after subtracting the astronomical contribution, with reference to the actual mean level of the Mediterranean Sea as measured at Otranto; U is the velocity of the water integrated vertically over the depth; x is the curvilinear coordinate along the curved Adriatic basin; μ is a damping constant; g is the acceleration of gravity; h is the average depth of the northern Adriatic Sea; d is the density of the sea water; p is the atmospheric pressure p_a, or the equivalent wind pressure p_w. Wind pressure is derived from wind velocity by the equation:

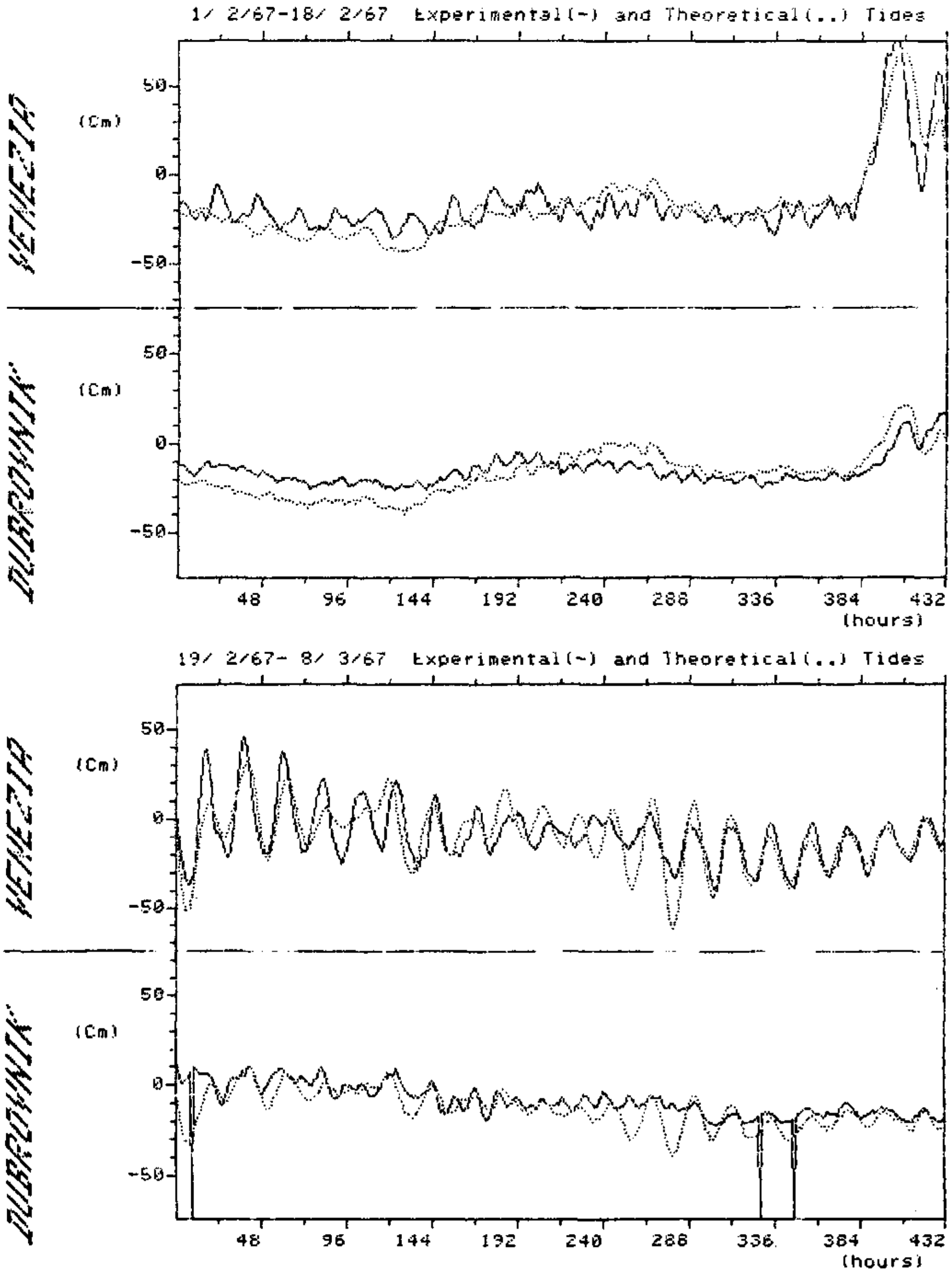
$$- \frac{h}{d}\frac{\partial p_w}{\partial x} = K \frac{d_a}{d} \cdot |v_1| \cdot v_1$$

where K is a dimensionless constant ($\sim 2 \cdot 10^{-3}$); d_a is the density of the air; v_1 is the component of the wind velocity along the basin.

The atmospheric pressure $p_a(x\,t)$ and the wind driving force $-(h/d)(\partial p_w/\partial x)$ as function of x have been approximated using only a few harmonic terms, having as a fundamental wavelength, the curvilinear length of the northern Adriatic Sea (up to Otranto). The harmonic amplitudes are assumed to be stochastic functions of time. Such an assumption allows an easy use of the meteorological fields measured or forecasted over the Adriatic Sea.

The change of the sea elevation in the previous equations is a periodic function of x. As a function of t it is a damped periodic wave having a period of 21.5 hr, i.e. the typical oscillation period of the northern Adriatic Sea. If the driving forces have a very long wavelength (zero

order harmonic) the solution is a damped aperiodic wave.
Figure 3 shows the theoretical and experimental sea level changes in Venice and Dubrovnik from February 1 up to March 8, 1976. During that period typical phenomena were present: moderate low water due to a high pressure field followed by high water and damped oscillations due to a spike-like storm surge, and other oscillations caused by moderate winds. In the future, current meteorological data, such as those from the European Centre of Medium Range Weather Forecasts, will be applied to the model.


1/ 2/67-18/ 2/67 Experimental(-) and Theoretical(..) Tides
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0
-50
48 96 144 192 240 288 336 384 432
(hours)
19/ 2/67- 8/ 3/67 Experimental(-) and Theoretical(..) Tides
(hours)

Figure 3

ECOLOGICAL IMPACTS OF POLDERCONSTRUCTION IN SURINAME

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Introduction

The Suriname Government is planning to reclaim large areas for rice and other agricultural purposes. The polders are projected in the coastal region. The main ecosystems that occur in the coastal area are: mudflats and beaches; salt- and brackish-water estuaries; sand ridges; brackish- and fresh-water swamps. Natural resources of these habitats include fish, shrimp, timber, game and honey. Poldering will have a strong impact on the ecology of the reclaimed area itself and its surrounding environment.

Impact in the polders

- The intention of poldering is to turn a natural, complex ecosystem into a more simple system, e.g. rice. Consequently, the natural vegetation in the polder will be lost, and natural productivity such as fish, timber, game, and waterfowl will be depleted.
- In order to maintain a simple and artificial ecosystem, several messures need to be taken, including application of fertilizers and pesticides. These chemicals will have a negative effect on water quality. Pesticide analysis of collected birds and fishes in the Wageningen Rice Area showed substantial residue levels of persistent, toxic pesticides (Vermeer et al, 1974). Since local communities are to a certain extent dependent on fishing and hunting for their

protein requirements, this pesticide contamination might effect the health situation of these communities.

- Management of surface water is necessary in the polders, especially for rice it is essential, but may cause outbreaks of vector pests such as mosquitoes (Malaria) and snails (Schistosomiasis).

Impact on the surrounding environment

A vast supply of fresh water is needed for irrigation purposes, either obtained directly from a river or fresh-water swamp, or drawn from a man-made storage basin. Most agricultural activities in Suriname are planned in the coastal area, where rivers and swamps are under influence of sea water fluctuation. Drawing fresh water from these rivers or swamps will bring the salt water influx inward. Vegetational changes will be caused by salination of the water supply. Major irrigation problems are to be expected especially along the Nickerie River, due to salt water influx. Damming up river or fresh swamp water to form a storage basin for irrigation purposes will decrease seasonal water fluctuations downstream. Under natural circumstances the forests bordering the rivers and swamps are flooded during the rainy season. Adult fishes migrate into these flooded forests to lay their eggs and remain there to feed on local food items such as fruits and insects. The juvenile fishes also remain in the forests until the water recedes. Fitness of fish populations shows a correlation with fluctuations in water level. During the rainy season food is abundant in the flooded forest environment, thus allowing the fish to build up fatty deposits, which are used as a metabolic reserve for the dry season when food supply is limited (vari, in prep). A migration pattern, similar to and possibly correlated with fish migration, is observed for the Giant Otter Pteronura brasiliensis, an endangered species (Duplaix, 1980). Due to fur trade, this species ia almost extinct in Brazil although it does occur in stable numbers in Suriname. A less extensive or (diminishing) flooding of the forests will reduce the time that adult and juvenile fishes can feed on local food items. This will have a negative effect on the overall fitness conditions of the whole fish population and the breeding possibilities of the adults. (Vari, in prep.). Marsh forests, such as the valuable Virola stands, are especially adapted to this seasonal flooding. These stands will also be affected if no flooding occurs. A decrease in the run-off of dammed-up rivers or creeks will also bring the salt water influx inward. A good example can be observed along the main road to Wageningen. Damming up of the natural creeks caused by the road, decreased fresh water run-off from Coronie Swamp. Salt water influx was brought inward, which can be detected by the change in vegetation. North of the road salt and brackish water swamps exist, while south of the road a fresh water swamp can be seen. Similar effects can be expected after damming up water for irrigation purposes. When the level of the water in the storage basin is too high for too long a time, the forests in the basin will be drowned. After the forests disappear, a new vegetation will develop, possibly herbaceous. Peat growth will be a consequence of vegetation successions, which will reduce the storage capacity of the lake.

Water quality

In Suriname local communities are directly (for water supply) and/or indirectly (for food supply) dependent on surface water. Drainage water contaminated with pesticides is therefore hazardous for these communities. Samples of animals and plants collected in 1979 and 1980 around the polders of Nickerie and Wageningen were analysed on pesticide residues. Endrin, Mercury, and NaPCP levels in some fishes and birds seemed alarmingly high (Fyfe and De Jong, in prep.). After pesticide spraying in the Nickerie Rice Area, thousands of dead fish were observed in the drainage canals flowing directly into the Corantijn and Nickerie Rivers (Fyfe, pers.comm. and writer's obs.). The fish market of Nickerie is supplied by fish from the Corantijn and Nickerie River estuaries. Also seafood export is very important, in particular shrimp. Juvenile shrimps seem very sensitive to pesticide intoxication. Since the Corantijn and Nickerie River estuaries are a major nursery and reproduction area for many economically important fishes and shrimps, pesticide contamination will certainly affect seafood export.

Conclusions and recommendations

The estuarine zone of Suriname has a high natural productivity and is in general considered a multiple-use environment. As such it is a very important food source in Suriname, providing fish, shrimp and wildlife and also has a good potential for cultivated crops, i.e. rice. However, reclamation of the area is necessary for cultivated crops in order to maintain controlled water management. This affects the natural production of the surrounding environment. Before planning a reclamation effort, effects of poldering on the ecology of the environment should be identified. The following measures should be taken to avoid depletion of natural production potentials:

- Nonvaluable natural production areas should be selected (if possible) for poldering and should preferably be projected where enough irrigation water is available (e.g. a large river system). Drawing water from a large river will avoid considerable disruptions of natural water level fluctuations. When it is necessary to construct a storage basin for irrigation purposes, it is important to maintain the natural fluctuations downstream of the dam so that the forests are flooded, in order to protect the fish populations. It is also important in the storage basin itself to prevent drowning of the forests because these forests possess high water storage capacity. To prevent drowning of the forests it is necessary to decrease the waterlevel during the dry season so that the forest soil dries out. In other words, these types of forests require both a period of inundation and a period of dehydration.
- Application of persistent, toxic pesticides should be avoided as much as possible in order to prevent contamination of important food sources. Use of less persistent, selective pesticides is recommended. Important predators of pests should be fully protected. At the moment the Limpkin, Aramus guarauna is still only partly protected although it is known as an important predator for snails (Haverschmidt, 1968) in rice fields. Other pest controlling possibilities for Suriname should be studied, i.e. fish in rice fields. At the moment the pesticide legislation is not enforced in Suriname. A pesticide commission has been formed to advise the Government concerning pesticide legislation, control, and use, etc.

The importance of the estuarine zone for Suriname is also being recognized. The Suriname Forest Service proposed to the Suriname Government to designate the whole estuarine zone as a Special Management Area. A Management Authority has yet to be established to maintain this area, after approval of the Government.

The conflict of possibilities in the coastal area is recognized in Suriname. An evaluation of the planning is strongly recommended so that natural and cultivated production potentials can be realized in harmony.

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MODELING EUTROPHICATION PROCESSES IN A POLDER AREA

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Abstract

The polder area Rijnland comprises a central network of canals and lakes (boezem) and a number of polder systems with canals, ditches and sometimes lakes with a lower water level. Eutrophication in boezem as well as polder lakes has reached such an extent, that recreational interests are being prejudiced and the ecosystems have been deteriorated. Modeling research has been initiated to enlarge insight in the dominant factors for phytoplankton growth and the effect of phosphate removal from waste water with respect to eutrophication. For the modeling of eutrophication processes in the lakes a coupled version of a chemical model CHARON and a phytoplankton model BLOOM II is used. The results for one particular lake, the Westeinder Plassen, will be presented in terms of phytoplankton and nutrient concentrations.

1 Introduction

The polder area studied is called Rijnland and is situated in the mid-west part of the Netherlands. The water system of the polder area consists of two different types of networks. The central network of canals and lakes is called boezem and has a water level, that is elevated above the polder land. The boezem encloses a rather large number of polder networks, that have a lower water level and consist of canals, ditches and sometimes lakes. The boezem provides water for the polders in dry periods and drains water in wet periods. It is also flushed with water from the River Rhine to combat salt intrusion from the North Sea.

As a result of high loads of nutrients from domestic and industrial waste water and from Rhine water boezem as well as polder lakes have become eutrophicated to such an extent, that recreational interests, that have great importance in this area, are being prejudiced and the ecosystems have been deteriorated. These problems stimulated the Water Authority of Rijnland to initiate an extensive research concerning eutrophication. Within this framework the modeling of eutrophication processes plays an important role. The objective of the research is to enlarge insight into the dominant factors for phytoplankton growth and to assess the effects of phosphate removal from waste water.

Presented is the modeling of one of the Rijnland lakes, the Westeinder Plassen. The lake, that is part of the boezem, covers an area of 9 km^2 and has an average depth of 2.9 m (Figure 1). The bottom consists of a mixture of clay, sand and peat. The organic carbon content is about 25% on a dry weight basis. The lake is flushed with water from one of the main canals of the boezem. Generally the water flows from its southern branch through the lake to its northern branch. The flow rate is on the average approximately 2 m^3/s. The average residence time is 5 months.

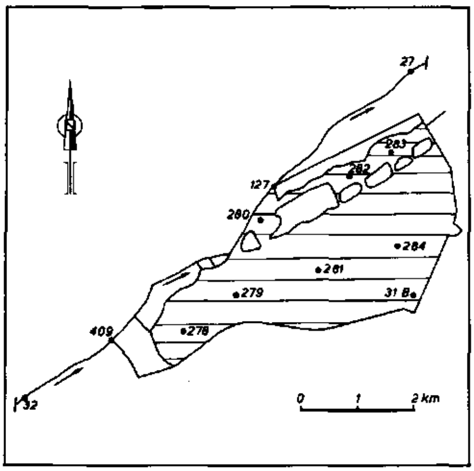

Fig. 1. Map of the Westeinder Plassen. Measurement locations are indicated with code numbers.

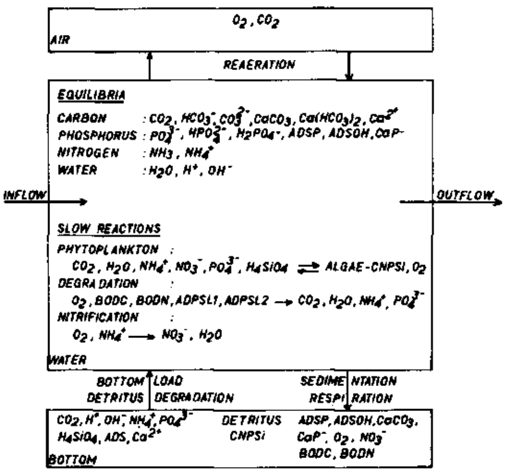

Fig. 2. Outline of the system definition for the Westeinder Plassen.

Besides from this inflow the Westeinder Plassen receives nutrient loads from unpurified domestic waste water (houses and ships), that can be very substantial during the recreational season in the summer.
The eutrophication model used computes both nutrient concentrations and phytoplankton levels on basis of nutrient loads, processes and meteorological parameters. The loads were calculated from inflow (concentration times flow rate) and diffuse sources. The flow rate of incoming water was calculated with the model ABOPOL, which was developed for water quantity calculations for a water system such as the Rijnland system on basis of boezem intake and outlet, precipitation and evaporation (Grijsen et al. 1982).

2 The eutrophication model CHARON-BLOOM II

The model used is a coupled version of the models CHARON and BLOOM II, both developed on assignment of the Environmental Division of the Delta Department (Dutch Ministry of Public Works). It is not possible to give extensive elucidation of the models here. Such can be found in several detailed reports (Bigelow et al. 1977, Clasen 1965, Los 1982, de Rooij 1982, Shapley et al. 1969).
CHARON is a chemical model, which calculates the chemical composition of a natural aquatic system on basis of mass balance, mass action law and process kinetics. BLOOM II is a phytoplankton model, which calculates the potential biomass maximum in steady state under given constraints of available nutrients and energy (irradiation and temperature). The models have been developed, calibrated and verified on data of three enclosures in a drinkwater reservoir De Grote Rug, located in the southwest of the Netherlands. They have been successfully applied separately as well as coupled to several Dutch lakes in a number of eutrophication studies (Los et al. 1982, de Rooij et al. 1982).
The chemical composition, calculated by CHARON as the result of loads, exchange with air and bottom, internal processes and outflow, does not only include the relevant chemical species in several phases (liquid, gas and several solids) but also phytoplankton. The species are made up out of components, unequivocal combinations of atoms. That is to say, no component can be written as a linear combination of other components. A

simple example of this concept can be given by the dissociation of water.

$$H_2O \Leftrightarrow H^+ + OH^- \qquad (1)$$

The components are H^+ and OH^-, the species H_2O, H^+ and OH^-. A system with more species can be described by means of addition of other components.

The species are divided in fast reacting equilibrium species, slow reacting species and phytoplankton compartments. To calculate the concentrations of these species the model has been provided with three modules: an equilibrium module, a slow reactant module and a phytoplankton module (de Rooij 1980).

The equilibrium module calculates the distribution of components among the equilibrium species according to mass balance and mass action law. The mass balance delivers:

$$\Sigma_j a_{ij} . x_j = b_i \qquad (2)$$

in which a_{ij} is the stochiometric coefficient referring to component i in species j, x_j is the quantity of species j and b_i the quantity of component i both in moles.

The mass action law refers to thermodynamics. It can be derived that the total Gibbs free energy of the system is equal to:

$$F = \Sigma_j x_j (c_j + \ln xf_j) \qquad (3)$$

in which c_j is a dimensionless relative Gibbs energy parameter of species j and xf_j its molefraction.

F strives for its minimal value and reaches it when the system is in chemical equilibrium. The equilibrium concentrations are computed by minimizing equation 3 while satisfying equation 2 with a log-linear programming technique (Clasen 1965, Shapley et al. 1969).

The slow reactant module calculates the change of the concentrations of slow reactants during a timestep. The change can be brought about by microbial degradation or conversion but also by inflow, outflow, sedi-

mentation, reaeration and bottom release.
The components that are released from or taken up by the slow reactants are assigned to or removed from the equilibrium system. The rate of change of the concentrations of the slow reactants is described with first and zero order kinetic formulations. The general equation can be written as:

$$\frac{dSR_1}{dt} = k_1 . C_j + k_0 \qquad (4)$$

SR_1 is the concentration of the slow reactant 1. k_1 and k_0 are the first and zero order temperature dependent rate constants.

One of the rate constants may have a zero value if the reaction is not applicable. C_j can be the concentration of the slow reactant itself or an equilibrium species or the difference between the actual and saturation concentrations of a chemical equilibrium species. The latter applies for instance to the exchange of oxygen and carbondioxide between air and water.
The phytoplankton module has three functions. First of all it takes care of the communication between CHARON and BLOOM II. On the one hand it transfers the concentrations of available nutrients, extinction and the growth limit constraints for all phytoplankton species from CHARON to BLOOM II. On the other hand it transfers gross primary production of phytoplankton species and the mortality rate from BLOOM II to CHARON. Secondly it calculates the magnitudes of the four phytoplankton compartments: living phytoplankton, suspended detritus, sedimented detritus and refractory detritus buried in the bottom. Thirdly it calculates the quantities of components, that have been taken up or released by the phytoplankton compartments during a timestep.
The module distinguishes two living phytoplankton compartments: phytoplankton present at the start of the timestep and phytoplankton produced during the timestep. The change of the former can be described for species j with:

$$\frac{dxs_j}{dt} = - (M + U).xs_j + I_j \qquad (5)$$

in which M is the mortality rate, U the outflow rate and I the inflow.

The change of the concentration of produced phytoplankton can be described by:

$$\frac{dxp_j}{dt} = - M.xp_j + \Delta xp_j/\Delta t \qquad (6)$$

$\Delta xp_j/\Delta t$ is the production of species j computed by BLOOM II.

The total amount of living phytoplankton at Δt is computed from the sum of the solutions of the equations 5 and 6. The three detritus compartments can be calculated from analogous differential equations, in which processes such as mineralisation and sedimentation are included.
In the coupled version BLOOM II calculates the maximal gross production during the timestep in stead of the potential maximal biomass. The production is distributed among a number of defined species. It is fed with the available nutrients and energy (irradiation), that have not been taken up by that part of the phytoplankton from the preceeding timestep, that is left over at Δt. So the production can be limited by five constraints (available N, P or Si) and two energy constraints (available light as result of irradiation and extinction, maximal growth as result of temperature and the maximal uptake of light).
BLOOM II uses two basic equations, the mass balance for the nutrients and the growth equation for each species, and two basic inequalities, one for the growth limits and one for the extinction intervals. The mass balance is represented by:

$$\Sigma_j a_{ij}.xp_j + e_i = b_i \qquad (7)$$

a_{ij} is the stochiometric constant of nutrient i in species j, e_i the surplus of available nutrient and b_i the total amount of available nutrient.

The growth equation is equal to:

$$\frac{dxp_j}{dt} = (Pg_j - M - R).xp_j \qquad (8)$$

in which Pg_j is the species dependent growth rate, M the mortality rate and R the respiration rate.

Pg_j is a function of temperature, irradiation, light extinction and depth. M and R are functions of temperature only. Equation 8 is used to assess what species may take part in the production. For those species the value of the differential must be positive. The integrated version of equation 8, extended with inflow and outflow, is used by CHARON for the calculation of the growth limit constraint for each species, which says that biomass production may never exceed an certain upper limit.

$$xp_{j,\Delta t} \leqq xlim_{j,\Delta t} \tag{9}$$

The extinction inequality is:

$$kmin_l \leqq \Sigma_j k_j . xp_j + kb \leqq kmax_l \tag{10}$$

where k_j is the species specific extinction and kb the background extinction.

This inequality says that the extinction must be within a certain interval l. In the case of only one species positive net production only occurs within the interval between $kmin_l$ and $kmax_l$. Below the former the species is light inhibited. Above the latter there is to little light for net production.
The optimal production for each extinction interval is found with a linear programming technique applied to 7, 9 and 10. The maximal production is determined as the highest value among those for the separate intervals.

3 System definition and input for the model CHARON-BLOOM II

The definition of the system falls apart into a chemical part for CHARON and a biological part for BLOOM II. The former concerns the description of the chemical composition of the phases air, water, suspended solids and bottom, and of the processes the chemical species are subject to. The latter concerns the description of the phytoplankton species composition and the properties of the species with respect to their chemical

Table 1. The chemical composition of the Westeinder Plassen.

Phase	Species	Components and stochiometric constants							
WATER	H+	1.0	H+						
	OH-	1.0	OH-						
	H2O	1.0	H+	1.0	OH-				
	O2	2.0	OH-	-2.0	H+	-4.0	EL-		
	CO2	1.0	H2CO3	-1.0	H+	-1.0	OH-		
	CO3--	1.0	H2CO3	-2.0	H+				
	HCO3-	1.0	H2CO3	-1.0	H+				
	NH3	1.0	NO3-	6.0	H+	-3.0	OH-	8.0	EL-
	NH4+	1.0	NO3-	7.0	H+	-3.0	OH-	8.0	EL-
	NO3-	1.0	NO3-						
	PO4---	1.0	PO4---						
	HPO4--	1.0	PO4---	1.0	H+				
	H2PO4-	1.0	PO4---	2.0	H+				
	H4SIO4	1.0	H4SIO4						
	CA++	1.0	CA++						
	CACO3	1.0	CA++	1.0	H2CO3	-2.0	H+		
	CAHCO3	1.0	CA++	1.0	H2CO3	-1.0	H+		
	ADSOH	1.0	ADS	3.0	OH-				
	ADSP	1.0	ADS	1.0	PO4---	1.5	OH-		
	CAP-	1.0	CA++	1.0	PO4---				
CALCIT	CACO3S	1.0	CA++	1.0	H2CO3	-2.0	H+		
BODC	BODC	1.0	H2CO3	-2.0	OH-	2.0	H+	4.0	EL-
BODN	BODN	1.0	NO3-	-3.0	OH-	6.0	H+	8.0	EL-
ADPSL1	ADPSL1	1.0	PO4---	1.0	ADS				
ADPSL2	ADPSL2	1.0	PO4---	3.0	H+				
ALGAE	CARB	1.0	H2CO3	-2.75	OH-	2.75	H+	5.5	EL-
	NITR	1.0	NO3-	-3.0	OH-	6.00	H+	8.0	EL-
	PHOS	1.0	PO4---	3.0	H+				
	SILI	1.0	H4SIO4						
AIR	O2A	2.0	OH-	-2.0	H+	-4.0	EL-		
	CO2A	1.0	H2CO3	-1.0	OH-	-1.0	H+		
SEDIM	SEDIM	0.08	NO3-	0.02	PO4---	0.02	H4SIO4	4.76	H+
		-3.80	OH-	8.96	EL-	2.36	H2CO3		
		0.3	CA++	0.018	ADS				

composition, specific extinction and process rates. Only an outline of the system definition will be given here (Figure 2).

The species for CHARON have been chosen on behalf of their relevance for phytoplankton growth and oxygen and nutrient budgets (Table 1). The presence of most species is obvious. However, some of them require further explanation.

Phosphate is adsorbed to iron (III) hydroxide (ADSOH), producing adsorbed phosphate ADSP. The adsorption is pH-dependent, which is the main reason for calculating the pH. Both equilibrium species ADSOH and ADSP are sub-

ject to sedimentation. Phosphate can also form a complex with calcium-carbonate CAP-, which is sedimented too.
The species BODC, BODN and ADPSL2 all refer to biodegradable organic matter and indicate its contents of carbon, nitrogen and phosphate respectively. ADSPSL1 is a inorganic phosphate fraction, which is very tightly bound to suspended sediments and can be released very slowly. The phase ALGAE has four species, one for each nutrient including carbon. The amount of each species is the sum of the amounts of the relevant nutrient in the four phytoplankton compartments. The amounts of the species are therefore subject to production, mortality, respiration, mineralisation and sedimentation. Notice that the electron (EL-) is considered as a component too. It plays a role in all redox reactions and its presence makes the calculation of the redox potential possible. The temperature dependent decay of the slow reactant SEDIM represents the internal load from the bottom to the overlying water. Its stochiometry and decay rate has been determined from measurements of interstitial water concentrations (Meijer 1981, Kroon 1981) and by model calibration.
The processes that are incorporated in the model can be distributed among two groups: equilibrium processes and slow reactions. To the former belong acid-base reactions (carbonate, phosphate and water equilibriums), precipitation-dissolutions (calciumcarbonates and -phosphate) and adsorption-desorptions (iron(III)hydroxiphosphate). To the latter belong inflow and outflow, reaeration, bottom load, decay processes, nitrification, denitrification and sedimentation. For all processes rate constants and temperature dependencies are specified (Smits 1980).
The phytoplankton species are specified in BLOOM II by means of their chemical composition and specific extinction (Table 2). All major species as far as Dutch lakes are concerned are included in the system definition. The value of C/CHL is rather high and found by regression of particular nitrogen against chlorophyll. The background extinction used was equal to 2.4/m for 1977/78 and to 2.05/m for 1979/80. These values are the averages found by means of linear regression of reciprocal Secchi depth against chlorophyll. There is no solid explanation for the sudden steep decrease of the background extinction in 1980.
Besides these constants process information has to be fed into BLOOM II. It concerns the rate constants and temperature dependencies for processes

Table 2. Stochiometric constants a for nitrogen, phosphorus and silicon (mg/mg dryweight), specific extinction coefficients k (l/m/mg drw/m^3), carbon/chlorophyll and dryweight/carbon ratios for all defined species.

Species	a-nitr.	a-phos.	a-sili.	k	C/CHL	DRG/C
Asterionella	0.024	0.0032	0.22	7.00E-05	80	3.0
Melosira	0.040	0.0026	0.15	5.20E-05	80	3.0
Cryptomonas	0.072	0.0046	0.0007	5.21E-05	80	2.3
Volvox	0.076	0.0070	0.0007	5.21E-05	80	2.3
Scenedesmus	0.058	0.0052	0.0007	5.21E-05	80	2.3
Ceratium	0.064	0.0046	0.0007	6.00E-05	80	2.3
Anabaena	0.070	0.0057	0.0007	2.66E-04	80	2.5
Aphanizomenon	0.068	0.0043	0.0007	2.35E-04	80	2.5
Microcystis	0.0531	0.0057	0.0007	1.20E-04	80	2.5
Oscillatoria	0.0530	0.0046	0.0007	1.75E-04	80	2.5

such as mortality and respiration. It also includes efficiency curves, that give the relation between light intensity and production.
The geometry of the lake has to be specified with surface area and mean depth. The latter only serves as an initial condition. In addition to the system definition given sofar the coupled version of the two models needs the following input, which was almost completely provided by the water Authority of Rijnland and has to be specified for each time-step (a week):

- Phytoplankton biomass concentrations in the inflow distributed among the ten species (derived from measured chlorophyll);
- Concentrations of some slow reactants and all equilibrium species in the inflow for calculation of the loads;
- The flow rates of inflow and outflow for calculation of the loads;
- Windspeed (reaeration), water temperature and irradiation;
- The measured space-averaged concentrations of the relevant water quality parameters of the lake itself for graphical comparison with calculated values.

4 Calibration and validation results for the Westeinder Plassen

The model was calibrated on the data of the years 1977/78. Only few adjustments of the previously used system definition (de Rooij et al.

1982) were necessary. They mainly concerned the mass exchange between bottom and overlying water. First of all the denitrification rate had to be enlarged to about twice its original value. Some of the stochiometric constants of the components in the species SEDIM had to be changed too. The values of those for H2CO3, OH-, H+ and EL- had to be enlarged. The result of this is that the bottom releases more carbondioxide and absorbes more oxygen. This could all be expected for a lake with such a high organic matter content of the bottom. The oxygen balance is completely dominated by primary production (85% of the gain terms) and bottom respiration (66% of the loss terms). Obviously the mineralisation of peat contributes to the bottom oxygen demand. The calibration results are satisfying in general (Figures 3 to 8). The space-averaged measurements are indicated in the figures as bars, that enclose twice the standard deviation. The standard deviation is a measure for the variability caused by lake inhomogeneity, sampling method and analyses. Generally measurements are averaged over eight locations. However phytoplankton biomass was measured as chlorophyll at two locations only (Figure 1: 279 and 284).

The total phytoplankton biomass (Figure 3) shows overprediction in each second quarter of the year. This indicates that in the model results the diatom bloom in the first quarter is followed too quickly by flagellates, greens and bluegreens. The species composition closely matches measurements. Diatoms (Melosira) dominate in each first quarter, while bluegreens (Microcystis) dominate each second half of the year. The model indicates silica, light and growth limitation in the first 25 weeks, followed by growth limitation in the next 10 weeks and light limitation during the rest of the year. In 1978 there is also nitrogen limitation from week 85 till week 90.

The pH (Figure 4) fits the measurements quite well indicating that the computed gross production (0.9 kg C/(m^2.y)) approximates its real value. The ammonium concentration (Figure 5) tends to be to low in summer. The measurements in summer may be questioned though, because some ammonification of particular nitrogen may easily have preceeded the actual analysis of the samples. Nitrate (Figure 6) tends to be somewhat to high during the nitrate depleted periods.

Orthophosphate (Figure 7) shows an example of the 'explosive bottom flux' in the summer of 1977. The phenomenon occurs in shallow eutrophic lakes

Model calibration results and measured data for 1977/78:

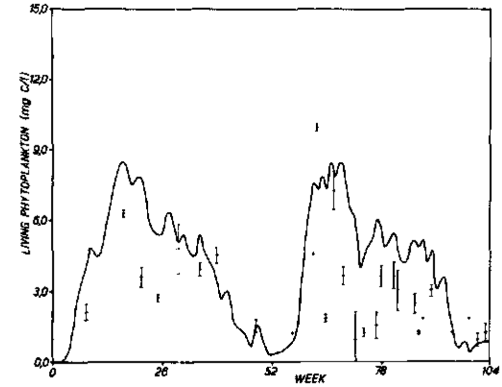

Fig. 3. Living phytoplankton

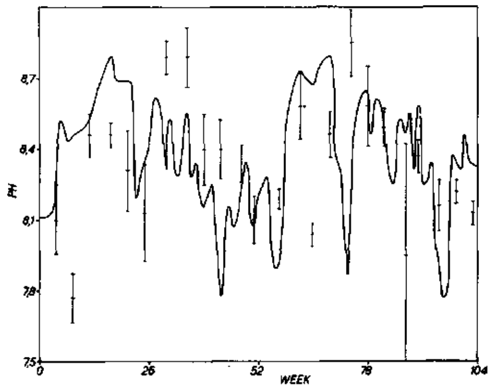

Fig. 4. pH

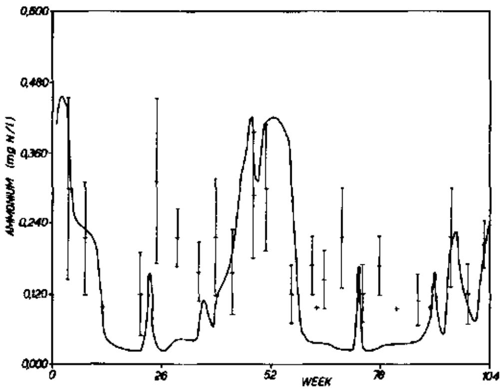

Fig. 5. Ammonium

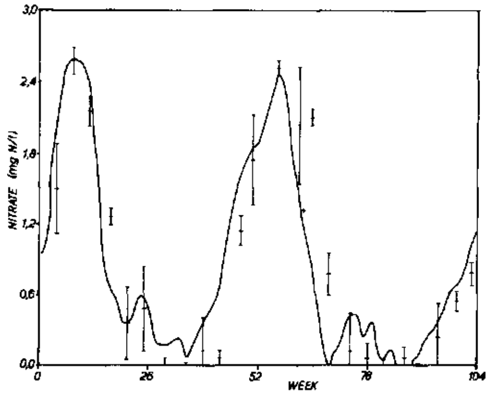

Fig. 6. Nitrate

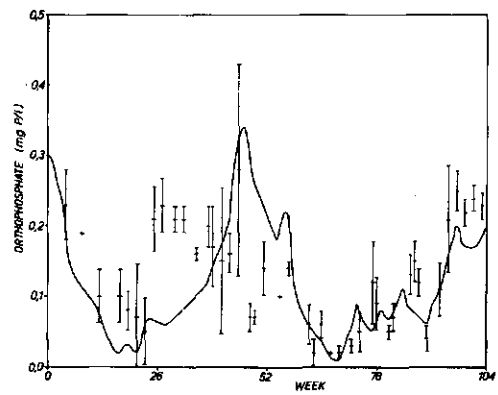

Fig. 7. Orthophosphate

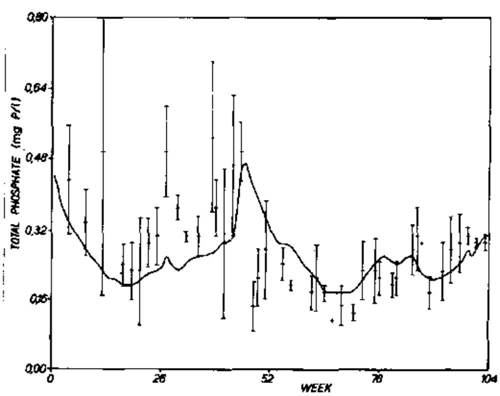

Fig. 8. Total-phosphate

when the surficial sediment becomes anaerobic due to high organic matter sedimentation, high water temperature and low windspeed. It is not incorporated in the model and cannot be simulated for that reason. To a lesser extent it can also be discovered in the total-phosphate picture (Figure 8). The incidental steep fluctuations in this parameter are beleaved to be due to fast resuspension and sedimentation, a process for which the model is not equipped either. It is thought however (in contrast to de Groot 1981) that the resuspended matter is not very reactive. No clear correlation between extreme values of orthophosphate and total-phosphate measurements can be found. The external phosphate load is calculated as 4.87 $g/(m^2.y)$. This is about 60% of the total load. The remaining 40% is the internal load from the bottom. The main phosphate removal process is inorganic sedimentation, which contributes 63% of the loss terms. Organic sedimentation (phytoplankton) and outflow contribute 14 and 23% respectively.

The validation was done on the data of 1979/80. The results were very similar. On the average the model performance is as good as for the calibration. However model results as well as measurements show a slight increase of phytoplankton biomass, due to a smaller background extinction, and a decrease of nitrate. This results in the occurrence of nitrogen limitation during the summer.

5 Discussion

The model generally simulates the water quality of the Westeinder Plassen quite satisfactory despite of the simple way the mass exchange between bottom and overlying water is included. In reality mass exchange will be a function of the depth of the oxidized sediment layer and the wind driven dispersion and not of temperature only. This means that the model is capable of simulating situations, that do not deviate too much from the present one. A substantial change in external nutrient loads may cause a change in water quality as well as bottom fluxes. In that case the model is unable to predict fluxes and the resulting water quality.

The accuracy of the model results is affected by a number of aspects. Omissions in and shortcomings of the data used for the calculation of the loads contribute substantially to inaccuracy. The concentrations of the parameters in the inflow were measured monthly and had to be interpolated. A number of parameters were only available for 1980 and had to be extrapolated to the other years (Si, Ca and HCO3-). As stated before the water inflow was calculated by a model. The water balance was checked with the aid of the chloride balance, which indicated that the calculated flow rate data were not perfect, especially for 1978 and 1979. Fast and incidental processes, such as resuspension and explosive flux, are not included in the model but do cause differences between measurements and calculations. Another source of inaccuracy will be the assumption of constant values for model parameters such as background extinction, phytoplankton stochiometry and carbon/chlorophyll ratio, that may all vary substantially with time.

It must also be stressed that the measured water quality, with which the model results are compared, may be quite inaccurate too. Errors are introduced by the sampling procedure, the analyses and inhomogeneity of the lake. All these remarks lead to the conclusion that the model cannot fail to be inaccurate to a certain extent. However the order of magnitude of the calculated concentrations and fluxes will be quite reliable.

The calculations show that nutrient limitation presently is not that important in the Westeinder Plassen, although nitrogen tends to become limiting. Phosphate is far from limiting during most part of the year. This is the result of high external loads from inflow and diffuse sources (habitation and recreation) as well as high internal load from the bottom.

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THE ASSESSMENT OF THE LAND CONSOLIDATION PROJECT EEMLAND

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1 Introduction and abstract

The area of Eemland is situated in the centre of the Netherlands on the coast of the Zuydersea; it encloses seven polders, the seize of 75,00 ha. The area has important values on nature (meadow birds) and landscape (open and large). The dairy farming is in a bad position with regard to income and working conditions.
To improve the agriculture structure the local farmers organization have applied for a land consolidation project. The preparation of that started in 1977.
The most important of this land consolidation scheme will be the tranfer of farms to the open polders in combination with reallotment and the lowering of the polder water level by improvement of the water management. Because of the fact that the government policy is aimed at both improvement of agriculture structure and at conservation of nature and landscape, a careful and weighted planning is necessary.

An important help for decision-making is the planning and assessment of a number of alternative plans, which are different in the measure in which regard is paid to the safe-garding of nature areas and the conservation of the landscape. By the assessment an insight is got in the effects of the different plans for agriculture, nature and landscape. In addition the internal rate of return of the investments are calculated.

The method of planning and assessment in Eemland is the subject of this paper. Previously some information will be given about:

- the instrument land consolidation
- the relation between land consolidation and physical planning
- the assessment system

2 The instrument of land consolidation

a. The four main objectives for land consolidation policy in the Netherlands are:

- the improvement of agrarian structure
- realisation of green area in urban agglomerations
- preservation of natural environment and landscape
- improvement of housing and living conditions

b. In general land consolidation projects include measures in the next fields:

- improvement of parcellation and distribution of plots by joining

- improvement of opening-up by building new roads and the reconstruction of existing roads
- improvement of watermanagement by for example construction or renewal of pumping plants, the digging or enlargement of water conduits and ditches.

c. Land development by land consolidation project is done according to the Land consolidation Act of 1954, which prescribes the procedure and guarantées the rights of landowners and users. This act acknowledges only an agriculture goal.
Nevertheless in practice land consolidation has became a multi-purpose instrument.
Besides improvements in the fields of agriculture the objectives of land development now include for instance the preservation of the natural environment, existing landscape and the restoration, if necessary, of the landscape.

3 Physical planning and land consolidation

a. In the framework of the government policy with respect to physical planning the soil-usage in the rural area is regulated.
In main lines three ways of soil-usage can be distinguished: regular agricultural management, nature management and areas in which both regular agriculture and nature management are mixed.
Here it should be mentioned that the Dutch government has created a long-term plan to designate about 10% of the agriculture land for natural areas and regulated agriculture.

b. Physical planning is determined on three levels of administration: State, Provinces and Municipalities.
The provincial regional plans prepared by the Provincial Government are a further working out on Regional scale of the policy on physical planning by the State Government.
On the third level the Municipal Council lays down the allocation plan which forms a refinement of the provincial regional plans.

c. The Provincial Regional Plan gives the frame-work in which land-consolidation schemes are envolved.
In this connection consolidation projects can be conceived as an instrument to develop rural areas in accordance with functions allocated to them within the frame-work of government policy on physical planning.

d. For the land consolidation project Eemland the provincial region plan Utrecht-West is in force.
In this regional plan the next functions are allocated in Eemland:

- agrarian management	6465 ha
- nature management	35 ha
- agrarian and nature management and landscape protection	750 ha
- landscape protection and agrarian management	250 ha

4. Assessment system

A new system for the evaluation of land consolidation projects has been developed by the Government Service for Land and Water Use. The effects of land consolidation are numerous and of very different character
In consequence the units in which there effects can be measured vary likewise. For example money and numbers of birds.
Its objective is first to make a thorough comparison between proposed land consolidation projects and secondly to make possible a comparison between several variants of schemes within one project. In this way the assessment is a help to envolve the best scheme.
The last mentioned application of the assessment system is the subject of this paper.
The assessment system offers the possibility to measure the effects of a land consolidation project on the next aspects:

- the economic effects especially for agriculture
- the effects on values of nature
- the social effects, especially those on working and living conditions of the rural population
- the effects on landscape
- the effects on road network improvement
- the effect on outdoor recreation.

The effects of a landconsolidation project are measured with regard to the so-called autonomous development.
In the land consolidation project Eemland the most important aspects are agriculture, nature and landscape.

5. Problem Set

5.1. Agriculture development

A very large number of the farms lies locked up in the center of the villages or in a ribbon building. In consequence most of these farms have no or scarcely any land near their farm buildings. Only about

25% of the lands lies near the farm buildings. The largest part of the grazing season most of the farmers have to milk their dairy cattle in distant pasture fields. This causes loss of time and insufficient care of land and cattle.
This problem can be solved by the transfer of a sufficient number of farms to the uninhabited open polders in combination with reallotment, so that 60% of the farm area lies near the farm buildings. In that case the dairy cattle can be milked all year near the farm buildings and it is also paying to invest in modern housing and milking systems, which are saving on costs and labour. As the area of most of the farms is too small the resettlement takes place in combination with farm enlargement. For this purpose the government purchases land during preparation and execution of the project.

The opening-up of the agriculture area is as a result of earlier land consolidation projects sufficient. However the road surfacing has to be improved and to be widened in view of the increased axle load and traffic intensity in the rural area.

The drainage of the ground is insufficient: 65% of the area has during the period sept.-april an average ground water level within 20 cm below surface. Consequently of this the bearing capacity is insufficient for cattle and field operations. This causes losses of grass yield. during the utilization of pasture. Moreover the grass yield stays behind caused by the unfavourable growing conditions.
This problem can be solved by lowering the polder water level in combination with the replacement of 5 new pumping plants by modern ones and the improvement of the main conduits and ditches.

5.2. Natural value

The natural value of Eemland is connected with the importance of the area for meadow birds. During the last ten years the number of meadow birds has falled sharply. In view of the social and agricultural developments it is expected that the decrease will continue.

Particularly of the scarce meadow birds such as common redshank and ruf.
The execution of a land consolidation plan would accelerate this fall if not at the same time measures are taken for the protection and development of natural values.

The negative effects of polder level lowering and resettlement in the open area on the number of meadow birds however can be compensated by the forming of sanctuaries for these bird.
The water-control and pasture management in this sanctuary will be aimed at optimal conditions for meadow birds.

5.3. Landscape value.

The openess and vastness is the most important value of Eemland from the point of view of landscape conservation. Transfer of farms from skirts of the area to the open polders might affect the openess.
The position of the transferred farms should be chosen in such a way as little as possible damage is done to the openess of the area.
Other characteristic elements of the landscape are the villages and the river Eem.

5.4. Problem set.

From the analysis appears that the considered measures to improve the structure and the production conditions of the agriculture affect the natural and landscape values of the area. By the forming of a natural sanctuary the natural values of Eemland especially in connection with meadow birds can be safe-guarded.
The situation and area of the sanctuary are affecting the possiblities of resettlement and with that at the same time the openess of the area Moreover the realization of a sanctuary by land acquisition is competitive with the need of enlargement of the farms.

The above mentioned leads to the conclusion that the government policy aimed at the promotion of diverge interest in the rural areas has a consequence a complex pattern of mutual relations in the frame work of land consolidation.
In an early stage of the planning it is most efficient to pay attention at first to the most important relations, namely:

- the effect of resettlement on the openess. This effect can be approached from different points of view; for example by giving priority to agriculture of to preservation of openess of the scenery.
- the effect of resettlement and improvement of water control on the natural values especially of meadow birds.
- the effect, the location and area of a sanctuary have on the possible number of farms which can be transferred.

6. Planning and assessment.

It has appeared that the problem set is complex with several factors, that each can be put variable. By combination of each of the factors a great number of alternative land consolidation schemes can be made
In order to limit the number of alternative schemes planning and assessment is divided into 3 phases.

1. The first step in the planning has been the working out of the agricultural desires for improvement of the structure of Eemland in a concrete scheme. For that purpose use has been made of a number of 5 schemes with an increasing improvement level. On account of the results of the agricultural assessment of these schemes a agrarian scheme is made with the following characteristics.
   - resettlement of 69 farms;
   - polder water level lowering from 40 - 60 cm below surface down to 90 - 110 cm below surface;
   - reconstruction especially of those roads along which new farms will be situated.

After that two sets of alternative schemes are envolved.

2. Set 1 are the sanctuary variants.
   By evaluating of these variants it can be ascertained how far the desire for an agricultural optimal structure bears to the desire to safeguarde the natural value of the area by establishing sanctuaries.

   An important starting-point was that transferred farms should be situated at a distance of 500 m up to the sanctuary. This means a loss of potential building sites. In view of this the relation between an increasing area of sanctuary and the number of possible farm transfers was studied by introducing three areas of sanctuary namely 135 ha, 195 ha and 535 ha.
   It has appeared that in spite of the increasing area preserved for sanctuary sufficient alternative building sites were available.

3. Set 2 are the landscape variants.
   From the measurement of the effect of the transfer of 69 farms has appeared that the valuable open character of the scenery of Eemland would get lost as a result of the next spatial effects of resettlement:
   - the large open areas are divided into several small ones, by which a levelling appears in the spatial structure;
   - the north-south directed perspectives get lost;
   - the unbuilt sky line is partly lost.

At this moment the conclusion could be drawn that a weighting between the interesting of agriculture and landscape was necessary. To bring information for the decision-making on resettlement and opennes two landscape variants are envolved and measured on their effects on agriculture and landscape. When filling up the number of farm transfers, marginal conditions are introduced, which are aimed at the conservation of those parts of Eemland, which are essential from the point of view of landscape.
This working method gave two land consolidation schemes with 46 and 59 farms transfers.

7. Result of the measurements of the sanctuary variants and landscape variants on landscape, nature and agriculture

7.1. Preliminary remarks.

When measuring the effect of a land consolidation scheme in Eemland on nature the following values are important:

a. the significance as breeding area for meadow birds;
b. the significance for the communities connected with groves and belts
c. the significance for (ditch) water communities;
d. the significance for communities of wet and not or less manured grass lands
e. the significance as temporary residence for birds during the winter period.

The significance as breading area for meadow birds is the only aspect lending itself to a prudent quantitative approach. Moreover the meadow bird is from the point of view of government policy the most important exponent of natural system of Eemland. This is why the presentation of effects of land consolidation on natural values will be limited to the number of meadow birds in the different schemes.

The effect of land consolidation schemes on agriculture will be measured in the increase of the farmers renumeration.
The increase of renumeration is especially the effect of:
- improvement of parcellation by replotting and resettlement;
- improvement of water management aimed at lowering the ground water level.

Finally it should be remarked that the internal rate of return of the investments is an important criterion when making the final decision on the execution of the land consolidation.

7.2. Results of the sanctuary variants.

In table 1 a survey is given of the results of the evaluation of sanctuary variants with the smallest and the largest area preserved for meadow bird sanctuary.

Table 1: Number of meadow birds, increase of renumeration and internal rate of return for two sanctuary variants both with 69 resettlements and a lowering of polder water level of about 50 cm in agrarian area.

	Number of meadows birds			
area of sanctuary	without land consolidation scheme	with land consolidation scheme	renumeration	internal rate of return
135 ha	190-950	300-1020	Dfl 930	11,7%
535 ha	240-190	950-1780	Dfl 870	10,4%

In the scheme with a sanctuary of 535 ha the average increase of renumeration per ha is Dfl 60 less and the internal rate of return 1,3% less than the scheme with a sanctuary of 135 ha's.
This is caused by the fact that the productive area for agriculture is smaller and the number of plots is higher after execution of the land consolidation scheme and realization of sanctuaries.
For the avifauna means that enlargement of the sanctuary up to 535 ha results into the redoubling of the number of meadow birds.

7.3. Results of the landscape variants

In table 2 a survey is given of assessment of landscape variants (46-59 resettlements) and the optimal agrarian scheme (69 resettlements).

Table 2: Increase of renumeration, internal rate of return effects on opennes of the scenery for two landscape variants with lowering polder water level of about 50 cm and area of sanctuary of 190 ha

number of resettlements	increase of renumeration	internal rate of returns	effect on opennes
46	Dfl 670	12,2%	opennes remains an important characteristic
59	Dfl 810	11,0%	opennes remains in parts of Eemland important characteristic
69	Dfl 900	10,9%	opennes is lost

It appears that the increase of renumeration of a scheme in which there are 69 transferred farms is obviously higher than of a scheme in which there are 46 transferred farms.
On the other hand in case of execution of a scheme with 69 transfers as mentioned before, the opennes of the scenery will get lost, because mostly all of the open areas are used for resettlement. Further it appears that in spite of the fact that priority is given to the preservation of the opennes still 46 or 59 transfers can be filled in the scenery.
From an economic point of view it can be mentioned that although a obvious increase of renumeration appears the internal rate of return is decreasing. This is a result of the fact that the use of open area for resettlement requires high investments in the reconstruction of roads and the installation public utilities.

8. Final remark.

The preparation of a land consolidation project in Eemland is a complex problem. On several fields there are contrary interests between agriculture, nature and landscape. It is possible to envolve a lot of alternative schemes. To limit the number of schemes the planning and assessment in this project is divided into 3 phases.
It has appeared that in this way the assessment gives an important contribution to the decision-making on the land consolidation project.

A WATER BALANCE MODEL APPLIED TO THE PROBLEM OF MAINTAINING A SWAMP NATURE RESERVE IN AN AGRICULTURAL AREA

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Abstract

A water balance model, including precipitation, evaporation, storage, drainage to ditches, artificial recharge and groundwater flow, is formulated. Parameters of the model are estimated for a swamp nature reserve with weekly observed water levels, piezometric levels, precipitation and evaporation data, during a one and a half year period. The calibrated model is used to calculate the water balance of the swamp nature reserve under natural conditions, and under modified hydrological conditions, which would result from possible engineering works in the surrounding agricultural area.

1 Introduction

The nature reserve "De Zegge" is a peat swamp area of about 100 ha, situated in the valley of the river "Kleine Nete", in the province of Antwerp, Belgium (Figure 1).
The valley has gradually been developed for agriculture during the last 30 years, threatening the existence of the nature reserve. High water levels are required in the swamps, in order to maintain the precious flora and fauna, while lower water levels are needed in the surrounding area for agriculture.
In the north, between the nature reserve and the river, water levels are

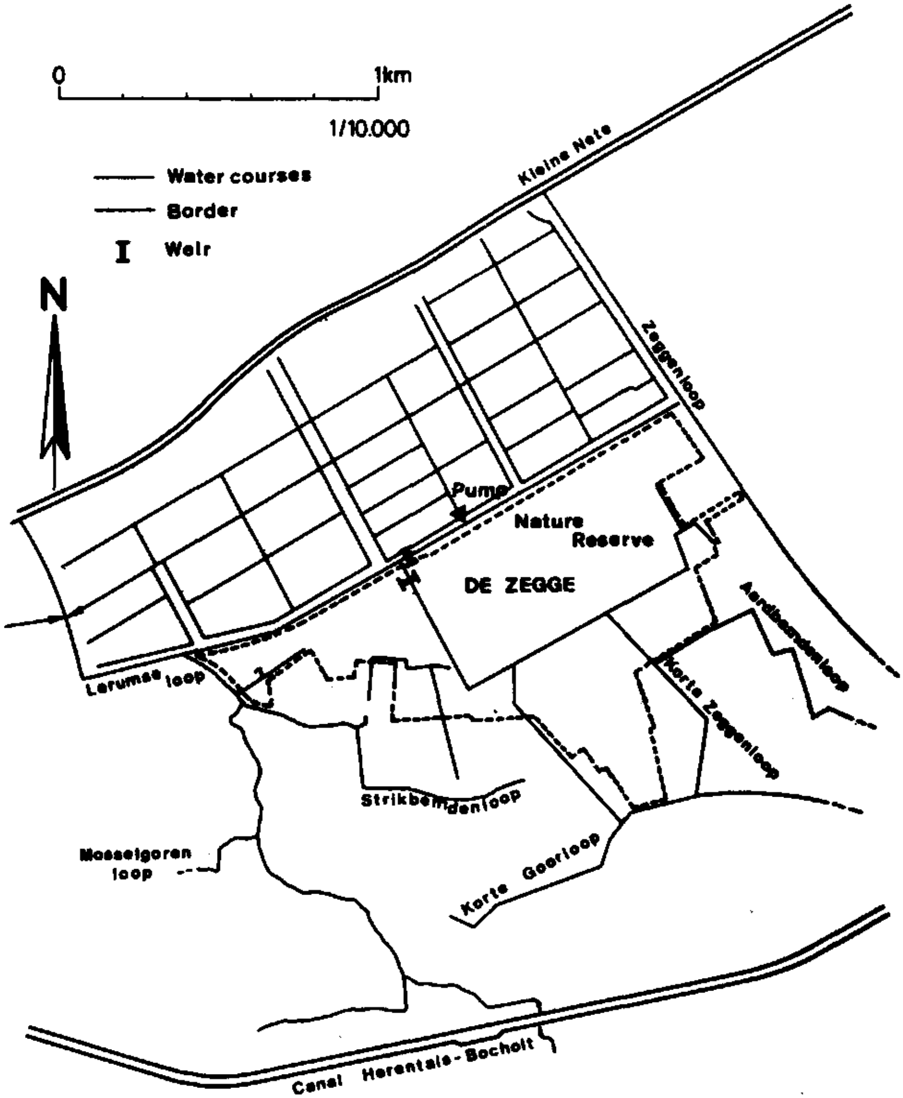

Figure 1. Situation plan

maintained about 1 m below natural levels. About 50 ha is drained by an Archimedean pump, delivering the water at the north side of the nature reserve.
In the south of the nature reserve, engineering works are planned in order to drain the high water table, which is probably induced by seepage from a nearby canal, having a water level about 4 m above the surrounding land.
Higher than normal water levels are maintained in the nature reserve, by means of weirs, ponds and a small pump on the south west border, pumping water from a local ditch into the nature reserve.

2 Measurements

In order to investigate the different terms of the water balance of the nature reserve, the following instruments were installed. The locations are indicated in Figure 2.

- a tipping bucket rain-gauge
- a water level recorder, installed on the major water course "Larumse loop"
- 31 water gauges, of which 16 installed in water courses and 15 in ponds
- 11 piezometers, installed at depths of about 1 m
- a piezometer installed at a depth of 15 m, at the east border.

Measurements were taken every week from December 1979 until July 1981. Evapotranspiration values for this period were calculated from pan evaporation data of a nearby climatological station. It was not possible to take measurements of the water amounts delivered by the pump at the south west side.
The observed surface and groundwater levels were inter-correlated. It was found that, in zones between ditches, the water levels and piezometric levels fluctuated very identically, such that three independent hydrological units could be identified, denoted as zones I, II and III in Figure 2. For example, the water level fluctuations at gauge 16, and piezometers 6 and 7, all located in zone III, are represented in Figure 3.

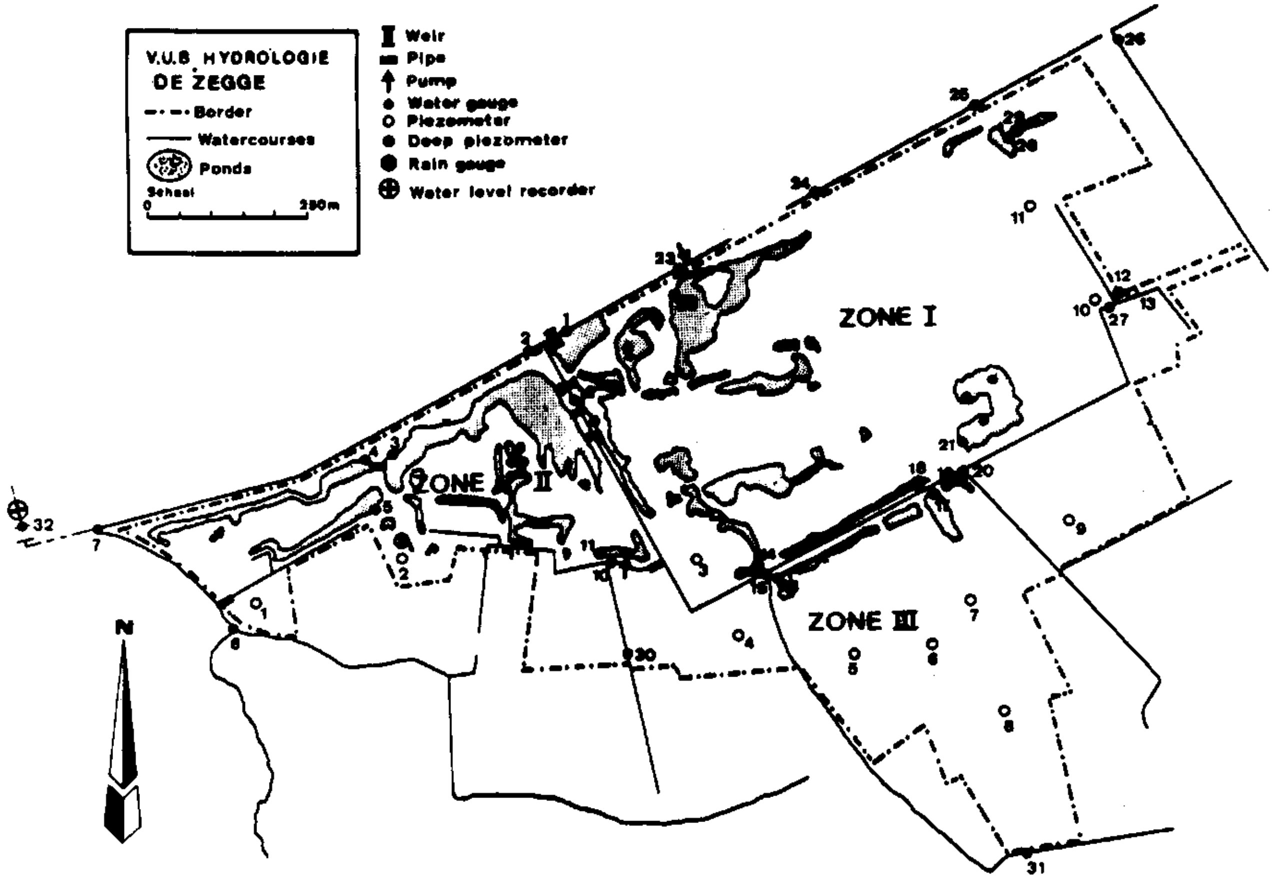

Figure 2. Location of measuring equipment

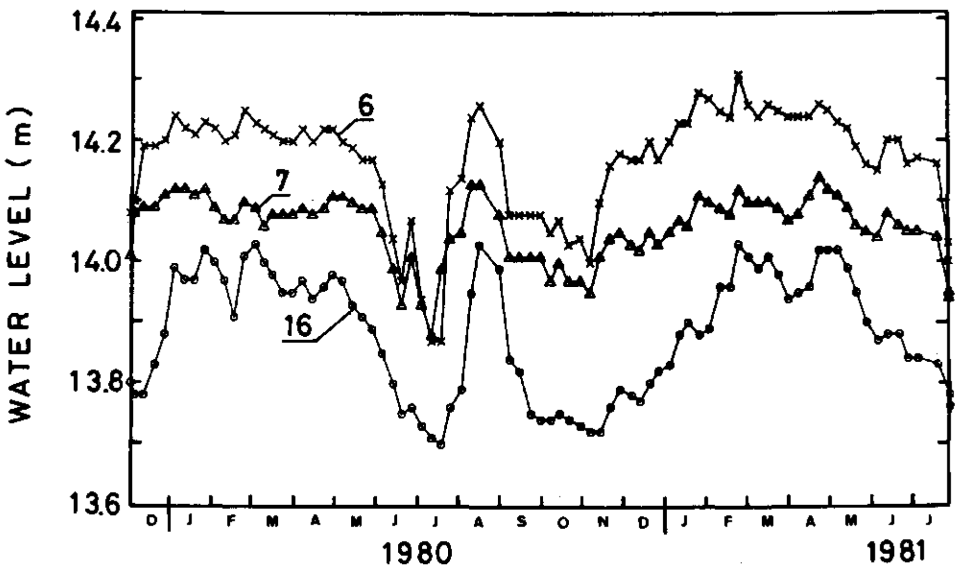

Figure 3. Observed water levels at water gauge 16, and piezometers 6 and 7

3 The model

3.1 Theory

For every zone the water balance can be expressed in terms of the average level of the water in the ponds and the groundwater in the soil

$$\mu \frac{dh}{dt} = p - e + q - g - a(h-h_d) \tag{1}$$

where

- h = average water level
- h_d = average water level in the ditches surrounding the zone
- μ = storage coefficient
- p = precipitation
- e = evapotranspiration
- q = artificial recharge
- g = groundwater loss
- a = discharge coefficient

The term on the left side of equation (1) represents the change in storage. Storage coefficient μ depends upon the area of ponds and the effective porosity of the soil. The last term on the right side represents the loss of water through drainage by the surrounding ditches (Figure 4).

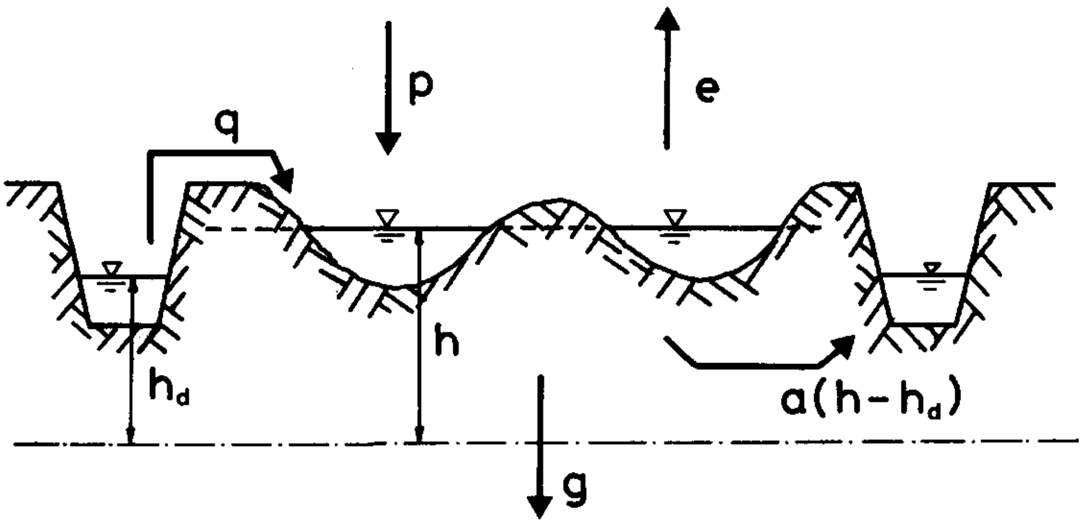

Figure 4. The water balance model

Groundwater loss, g, is only applicable for zone I, where at the north east border water will seep to the lower agricultural area. This loss is considered only at that site, because there is no ditch with an independent water level, as is the case for the remainder of the north border of the nature reserve.
Artificial recharge, q, is considered only in zone II, because of the pump. In zone I, the water delivered by the Archimedean pump is considered to be a negative drainage to ditches, because this water is first pumped into a ditch, and is partly lost at the weir, located at water gauge 1.

3.2 Calibration of the model

The average water levels in the zones and in the surrounding ditches can be estimated from the observed water levels. The changes in water levels can be calculated for every weekly period between observations. Precipitation and evaporation values are also known, such that only the parameters μ, a, q and g remain to be estimated in equation (1). This was accomplished by means of statistical techniques, in particular linear regressions. First μ and a are estimated, while q and g are considered to be zero. Then the residuals of the linear regression are analysed, for identifying the term q or g. For instance, it was found that in zone II, the artificial recharge occurred only in Spring and Summer, when the water level in the ditches is low. Results of these analyses are shown in Table 1. The estimated average values are presented with the standard deviation values given between brackets.

Table 1. Calibration results

	Zone		
	I	II	III
μ	0.435 (0.024)	0.229 (0.022)	0.480 (0.048)
a (day^{-1})	0.0058 (0.0012)	0.0060 (0.0007)	0.0017 (0.0004)
q (mm/day)	0	1.53 (0.37)	0
g (mm/day)	0.32 (0.21)	0	0

Notice, that most of the coefficients have been significantly estimated. The final statistical analyses of the residuals showed that all conditions for valid linear regressions were satisfied.

Now, the water levels in the zones can be calculated for given values of precipitation, evaporation and water levels in the ditches, by discretization of equation (1), with time steps Δt of one week.

$$h^{t+\Delta t} = \frac{p - e + q - g + a\, h_d^{t+\Delta t/2} + (\mu/\Delta t - a/2)\, h^t}{\mu/\Delta t + a/2} \qquad (2)$$

Figure 5 shows calculated and measured water levels in zone I, and

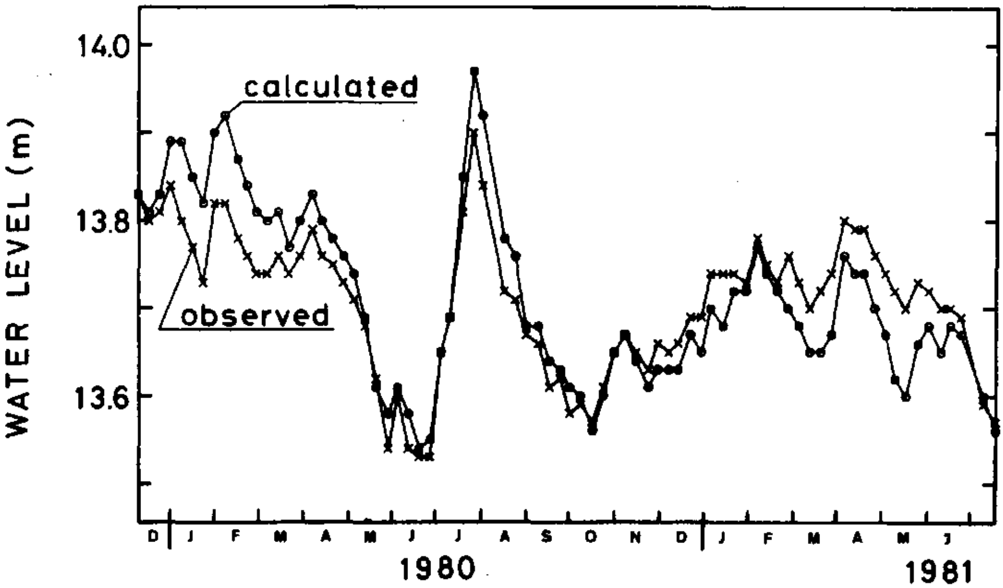

Figure 5. Observed and calculated waterlevels in zone I

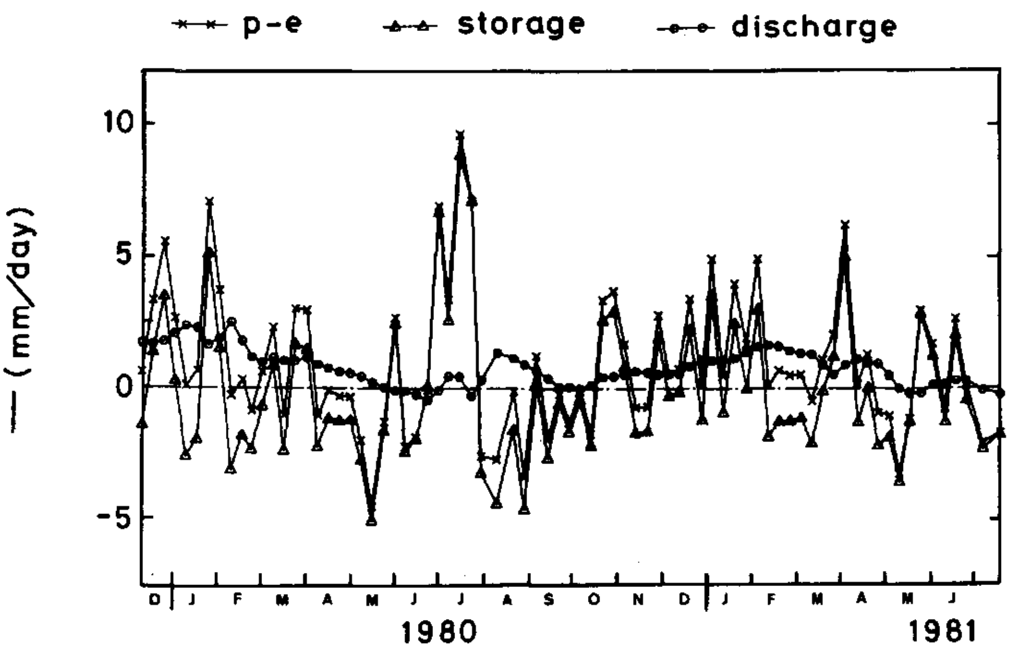

Figure 6. Water balance terms of zone I

Figure 6 shows the different terms of the water balance in zone I : netto precipitation, p-e, drainage to the ditches and storage. The difference between these three terms is the constant groundwater loss, g (not shown).

3.3 Predictions

The calculated terms of the water balance for the calibration period cannot be used for estimating the future hydrological situation, because 1980 and 1981 are wet years and the calibration period is too small anyway in order to contain all possible climatological conditions, such as extreme wet or dry periods.

Instead, the climatological evolution of the last thirty years, period 1950-1980, was assumed to be representative for the future conditions. Monthly precipitation and Penman evaporation values, for this period, were taken from a nearby climatological station. The water level in the ditches, however, were taken equal to the average level recorded in 1980, as no other alternative was available. The monthly water levels of the three zones, during the period 1950-1980, were simulated, using equation (2), with Δt = 30 days. The resulting classified water level values were considered to be accurate estimates of the future hydrological situation, provided that the hydrological conditions in the area remain unchanged. For instance, in Figure 7, the solid line shows the predicted water level distribution for zone I. One can notice that 80% of the time the water level will be lower than 13.80 m, which is the optimal level for aquatic flora and fauna, and 50% of the time the water is estimated to be lower than 13.60 m, below which survival of the nature reserve becomes problematic. Besides these classified water levels, all other terms of the water balance can be evaluated and interpreted.

The impact of modifications of the hydrological conditions, resulting from engineering works in the surrounding agricultural area, can be estimated similarly. For instance, when the weir at gauge 12 should disappear, the water level of the ditches becomes lower. The resulting drop of the water level in zone I is shown by the broken line in

Figure 7.

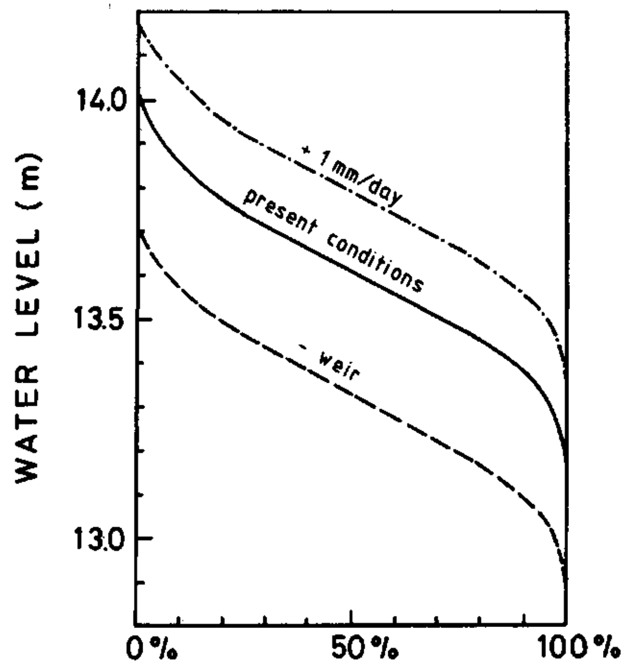

Figure 7. Predictions of classified water levels in zone I

This prediction shows that the nature reserve would be lost under these conditions.

As another example, the dotted line in Figure 7 shows the results when a pipe line would deliver 1 mm/day from the water course "Zeggeloop" to the east part of zone I. A very benificial average water level increase of 18 cm would result.

Similar calculations have been made for the other zones, such that the influence of the different engineering works could be evaluated.

4 Conclusions

A simple water balance model was defined, calibrated and used for prediction of the hydrological situation in "De Zegge" nature reserve, under present and future hydrological conditions. The technique is very easy to apply and the results are believed to be very reliable.

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