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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(b) Kroeze, G.H. Six years of IMAG Data Service, p. 284-291.
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Reference is also made to another paper of the symposium:

Hoeve, H. 1982. Allocation of Land to Agricultural Use in the Dutch IJsselmeerpolders. (Farm Settlement Policy). R.IJ.P., Lelystad.

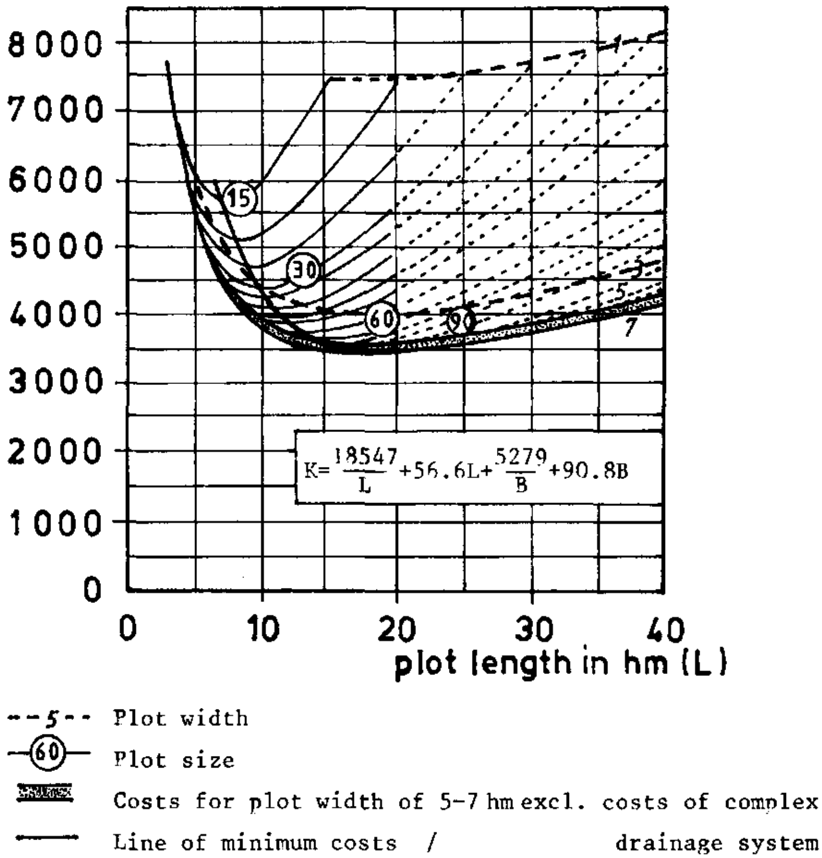

Fig. 1. Capitalized costs ($gld.ha^{-1}$) of a-c (see text) for various plot dimensions. (Source: van Iwaarden, 2).

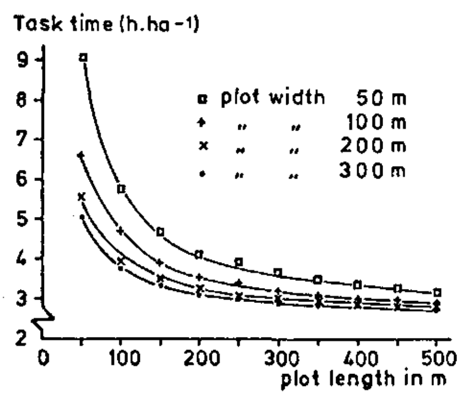

Fig. 2. Ratio task time - plot length for ploughing (width 1.05 m, speed 5 $km.h^{-1}$).