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A CONCEPT OF THE AGRICULTURAL MODEL USED IN THE RESEARCH PROJECT 'ZUIDELIJK PEELGEBIED'

Projectgroep Zuidelijk Peelgebied 8

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Bepaalde nota's komen niet voor verspreiding buiten het Instituut in aanmerking.

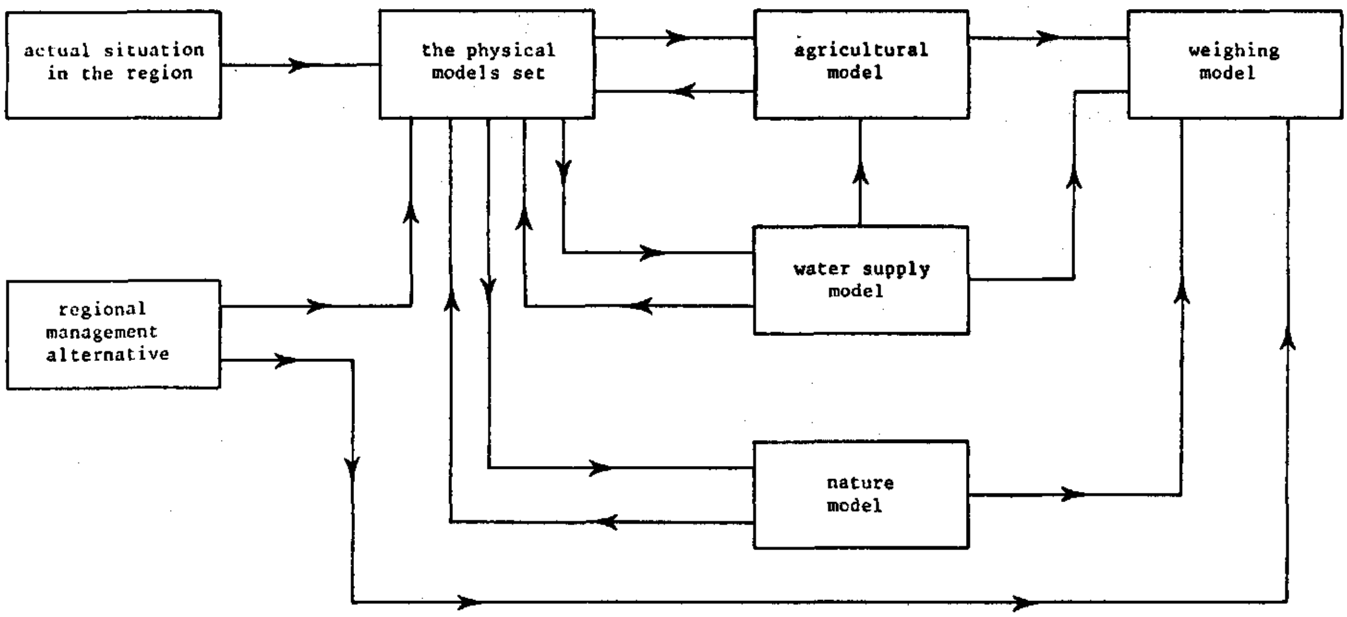
CONTENTS

1. INTRODUCTION[*]

The regional hydrological research project 'Zuidelijk Peelgebied' aims at developing an evaluation method for both the quality and quantity control of ground and surface water in regions where the users of the water have conflicting interests. The selected users of the water are agriculture, nature and water supply.[**]

The evaluation has to be made for a number of alternative strategies for the regional watermanagement. The alternative strategies are a priori specified. For each strategy the behaviour of the users has to be described for a range of years. In this paper it is indicated how this can be done for one of the users, agriculture.

In scheme 1, the position of the agricultural model in the whole complex of models is illustrated. The physical models give a description of the processes that take place in the ground- and surface water.



scheme 1

[*]This paper is a translation of a revised version of Vreke, 1980

[**]It is 'the industrial and public water supply', further refered to as public water supply.

The physical models are based on the actual situation in the region. Each management strategy is characterized by conditions concerning water quality and water quantity. The set of physical models transforms these conditions into restrictions for the users. For agriculture this means restrictions concerning the water and manure control by the farmers. The set of physical models also describes the interactions between the different users. This does not count for the damage claims paid by the water supply (indicated by the arrow between water supply model and agricultural model). The damage claims are the monetary compensations for the yield reduction of the farmers caused by the withdrawal of water.

The agricultural model, the nature model and the water supply model describe the behaviour of the respective users.

The weighing model gives an evaluation of the development of a number of relevant variables conditioned to the restrictions imposed by each one of the management strategies. This results in the determination of the optimal water management strategy (conditioned to the objectives of the regional water management).

In this paper a preliminary concept of the agricultural model is described. In par. 2, some general remarks with respect to simulation models and to the agricultural model are made. Par. 3 gives a description of the production model. In par. 4 this production model is supplemented with other submodels to complete the agricultural model. In par. 5 some concluding remarks are made.

2. SIMULATION MODELS

Simulating a system is to apply a model which represents the system. Experimenting using the model has to be possible in those cases that experimenting with the original system is impossible, not practical or too expensive. Using the model leads to conclusions concerning the operation of the original system. The model may be a representation of the system at a different scale or with different materials. It also may be a representation using mathematical equations. In economics a simulation model is a set of either deterministic or stochastic mathematical equations describing the economic (sub)system. Influences from outside the system are brought into the model by using exogenous variables. The stochastic element can be brought into the model by using random generators.

The agricultural development will be described by a simulation model, based on the actual situation in the region. This simulation model consists of a number of mutual dependent sub models (this is illustrated in scheme 3, in par. 4). The submodels are:

- the production model;
- the income model;
- the investment model;
- the agricultural land market model;
- the changing of standard farm type model.

The agricultural model is a dynamic model, the output of year t is the input of year (t+1). In addition to these endogenous variables the model contains some exogenous variables. This concerns:

- the general economic development. The 'Zuidelijk Peelgebied' area is a rather small area, so the agricultural development in this area hardly influences the general (agricultural) economic development. By using different general economic scenario's, a sensitivity analysis of the model results can be performed;
- the restrictions concerning water and manure control by the farmers imposed by the regional water management. A number of management alternatives with respect to the qualitative and quantitative water management by the regional authorities have to be evaluated. Each of these alternatives imposes different restrictions concerning the water and manure control by the farmers. The agricultural development for each one of these alternatives has to be determined;
- the restrictions concerning water and manure control by the farmers imposed by the user 'nature'. A number of nature levels is defined. To maintain or to get at a certain nature level a sufficient quantity of water of a well-defined quality must be available. To guarantee such a situation, restrictions are imposed to the other users, agriculture and water supply.

- the damage claims paid by the public water supply. These claims are paid by the public water supply as a compensation for the damage caused by the withdrawal of water. The size of the claims is based on governmental regulations and is determined in the water supply model;
- the development of the employment in agriculture for the region. To make the model results mutual compatible, conditions are imposed to the development of employment. It is possible to consider different employment scenario's.

The agricultural model is linked up with the set of physical models (and with the other uses) by the production model. The production functions describe the yield of a number of crops as a function of physical variables. The income model links to agricultural model to the weighing model. An adequate measure for the development (and distribution) of agricultural income is not defined yet.

3. THE PRODUCTION MODEL

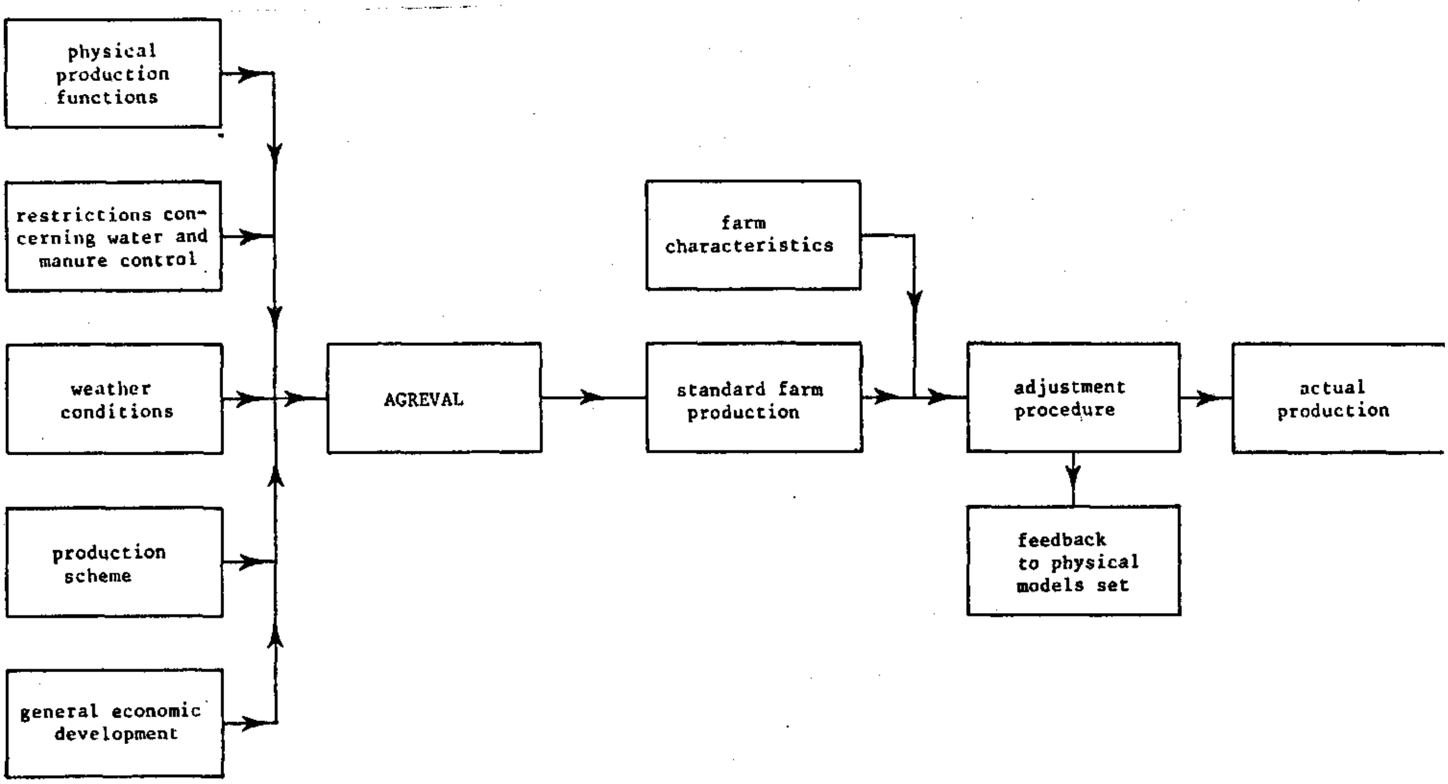
3.1 Introduction

The production model is the link between the agricultural model and the physical models set. Physical production functions are constructed for a number of crops. A physical production function describes, at farm level, the yield of a crop as a function of the quantities of labour, non-factor inputs, water etc. used in the production, conditional to hydrological and soil characteristics. The calculations concerning the production are executed for a number of standard farms. Before a classification of the farms in a number of standard farm types is made, an inventarisation of all the farms in the region has to be made. The standard farm production is calculated for each standard farm type conditional to weather conditions. To get the farm production of the individual farms, the standard farm production is adjusted. This leads to a variation in the production of the farm's belonging to the same standard farm type conditional to weather conditions. In reality, this variation is observed too. It is caused by, among others, differences in (the quality of) the farm management.

Using an approach giving a variation in the farm production, leads to a better description of the consequences of the water management alternative as is got by using an approach without a variation in the farm production. This concerns:

1. The description of the development of agricultural income. Next to the development of the mean income, the income distribution among the farms is of great importance.
2. The description of the consequences of the agricultural development for nature and for water supply. The variation in farm production and the location of the farms are important factors in describing this influence.

In scheme 2 the calculation of the production (including labour inputs, water use etc.) for the farms belonging to a certain standard farm type is illustrated. In the next paragraph this is treated in more detail.



scheme 2

3.2 Calculation of the standard farm production

For each standard farm type the production of the standard farm has to be calculated (conditional to the weather conditions). This is the standard farm production. Simultaneously with the standard farm production some inputs are determined. These inputs are:

- the quality of the production factors labour and capital (including cattle) used in the production;
- the used quantities of non-factor inputs;
- the water used in the production. The quantity of water obtained by sprinkling irrigation using ground and/or surface water has to be specified;
- the quantity of manure used in the production. This includes the quantity of manure dumped to get rid of it.

In the remaining part of the paper these inputs are included in the standard farm production.

In calculating the standard farm production, one has to account for:

- the characteristics of the standard farm type. This includes the equipment, production scheme and the size of the standard farm;
- hydrological and soil characteristics. These characteristics determine the physical production (crop yield) that can be reached;
- the restrictions concerning water and manure control by the farms imposed by both the regional watermanagement and nature.

For the calculation of the standard farm production the model AGREVAL is used. AGREVAL is a linear calculation program that calculates the production and the income out of labour for the individual farm. The program is built to analyse the effect of landdivision characteristics such as parcellation and opening up on labour inputs and on the size of production. Hydrological and scenery characteristics can be accounted for. For a short description of AGREVAL, see RIGHOLT, REINDS (1980).

If AGREVAL is used, the production scheme has to be known. The production scheme gives a detailed description of the crops that are grown, of the size and the composition of the live stock and of the

actions that are taken and of the tools (machinery) that are handled. This includes for instance a description of the way the farmer gets rid of the manure (e.g. by transport to a manure depot). For each standard farm type a number of variants for the standard farm production scheme may be defined. These variants may differ in for instance the possession of a certain capital good such as a sprinkling plant.
In defining the production scheme, the general economic development, especially the development of the prices of agricultural products, may play an important role. The weather conditions are accounted for by calculating the standard farm production for some variants with respect to the weather conditions. It is assumed that weather expectations do not influence the choice of the production scheme.

3.3 Calculation of the actual production (methodology)

In practice a variation in the production of the farms belonging to one standard farm type is observed. This variation concerns the quantities of factor and non-factor inputs and the crop yield. In the research project 'Zuidelijk Peelgebied' both the crop yields and the inputs for the production are of great importance. Therefore, the variation has to be built in in the agricultural model. This will be done by adjusting the standard farm production of the individual farms. It results in the actual production of the individual farms.

The variation in the production of the farms belonging to one standard farm type is caused by a large number of factors. Some of these factors are:

1. The size of the farm. This concerns both the total area of cultivated land and the effectively used area of cultivated land. The effectively used area is determined by, among others, the shape of the parcels and by border characteristics (e.g. hedges).
2. The parcelling and the opening up.
3. The hydrological and soil characteristics
4. The production scheme.
5. The capital stock (buildings, cattle, machinery and tools). This is closely related to the production scheme.

6. The non-factor inputs that are used.
7. The possibilities for water control and the way in which these are used.
8. The quantity (and the quality) of labour that is available.
9. The quality and the objectives of the farm management. One of the reasons to mention the objectives of the management is to focus attention to farmers for pleasure and to farmers with the intention to terminate farming within a relatively small number of years.

Next to the mentioned farm characteristics, the variation in the farm production is influenced by the weather conditions. This is caused by the fact that not all farms (are able to) react to the weather conditions in the same way.

The factors that cause the variation in the farm production among the farms belonging to one standard farm type, can be divided in factors concerning:

a. the production scheme;
b. the weather conditions;
c. the farm management (and the farm characteristics).

ad. a. For each standard farm type the calculations will be made for a number of variants with respect to the production scheme (the production scheme variants).
This is necessary because there are differences between the farms in the possibilities of water control, in the availability of equipment etc.

ad. b. The weather conditions are generated outside the agricultural model. For each of the production scheme variants, the production is calculated for all the selected weather alternatives (the weather variants).

ad. c. Another important factor is the farm management. Large differences in the yield exist between farms having the same production scheme and operating under the same circumstances. These differences are caused by the management. It can be brought in into the model by constructing some variants of the standard farm production conditional to the production scheme and the weather conditions (the management variant) or by using an adjustment procedure for each individual farm. In the adjustment procedure some farm characteristics also may play an important role.

Concluding it can be stated that the mentioned variants of the standard farm production belong to different levels. Each higher level can be divided in all lower levels. The different levels are:

level 0 - the standard farm production

level 1 - the production scheme variants

level 2 - the weather variants

level 3 - the management variants

This means that in calculating the actual production of an individual farm, the following steps can be recognized:

STEP 1 - select the standard farm type the farm belongs to;

STEP 2 - find out the production scheme variant the farm belongs to;

STEP 3 - choose the weather variant. This depends on the weather conditions generated outside the agricultural model;

STEP 4 - determine the production of the individual farm by bringing in the management factor. This can be done in two different ways. If a management variant is constructed, the production of the individual farm is known when a management variant is assigned to the farm. The second possibility is using an adjustment procedure. At this time the second approach is chosen.

Simultaneously and consistent with the yield the quantities of the inputs are calculated. Obviously these inputs differ from the input quantities used at the standard farm.

3.4 Adjustment procedures

There is a large number of possible adjustment procedures. For simplicity reasons a rather simple procedure is chosen. The weather variant of the standard farm production is multiplied by an adjustment factor to get the actual production of the (individual) farm. Each farm has a different adjustment factor. The adjustment factors can be calculated in alternative ways, for instance:

1. Determine the adjustment factor for the individual farm conditional to the observed situation and consider it to be a constant during

the relevant time period. Take for instance the quotient of the actual production of the farm and the calculated standard farm production (weather variant) as the adjustment factor. This approach is easy to handle but has as a disadvantage that it is inflexible. It assumes that changes in for instance the farm equipment do not influence the production.

2. Determine the adjustment factor for the individual farm as being the weighted sum (or the weighted product) of a limited number of farm characteristics. The weighing factors may be constant or variable in time and may either be estimated or based on theoretical considerations. If this approach is used, changes in for instance the farm characteristics directly influence the value of the adjustment factor (and the calculated production).
3. Determine the adjustment factor purely at random. This can be done by drawing a number out of a symmetric or asymmetric probability distribution. The disadvantage of this approach is that the value of the adjustment factor does not depend on the farm characteristics.

The approaches mentioned can be stochastic or deterministic (with exception of number 3, of course). As we use the stochastic version of the approaches one and two, one (or more) of the parameters of a probability distribution are calculated in the indicated way. By using a random generator, a figure is drawn out of this distribution. This figure is the value of the adjustment factor for the farm.

3.5 An example of the calculation of the actual production

It is already mentioned that in calculating the actual production of a farm four steps can be recognized. In this paragraph an example in which the standard farm type (STEP 1) and the weather conditions (STEP 3) are assumed to be known, is described. This means that the attention is focused on the selection of the production scheme variant (STEP 2) and on the determination of the adjustment factor (STEP 4).

As selection criteria for the production scheme variant are chosen:

- the availability of certain (a priori defined) capital goods;

- the (physical) possibilities for water control (water use);
- the restrictions imposed by the regional water management and by the nature with respect to the water and manure control.

For each production scheme variant the standard farm production (weather variant) can be calculated by using AGREVAL.

The adjustment factor is determined by using the deterministic version of approach number 2 (mentioned in par. 3.4). It is assumed that the adjustment factor depends on:

- the ratio between the area of cultivated land of the individual farm and the area (of cultivated land) of the standard farm;
- the size and the composition of the live stock population. The livestock population has to be classified and each class must be represented by a parameter. The parameter is a measure for the intensity of the landuse by cattle farmers. For arable farming it is also necessary to define a measure for the landuse intensity;
- the parcellation and the opening up. With respect to these factors a classification has to be made too.
- a management factor. To give a concrete form to the management factor, further investigations are needed. However, it is possible to include the management factor in a stochastic term.

The value of the weighing factors will depend on further investigations. If the adjustment factor is determined, the actual production is found by multiplying the standard farm production by the adjustment factor. It will be clear that this example is only preliminary. It tries to illustrate the way in which the actual production has to be calculated. During the investigations it will appear that a lot of changes are necessary.

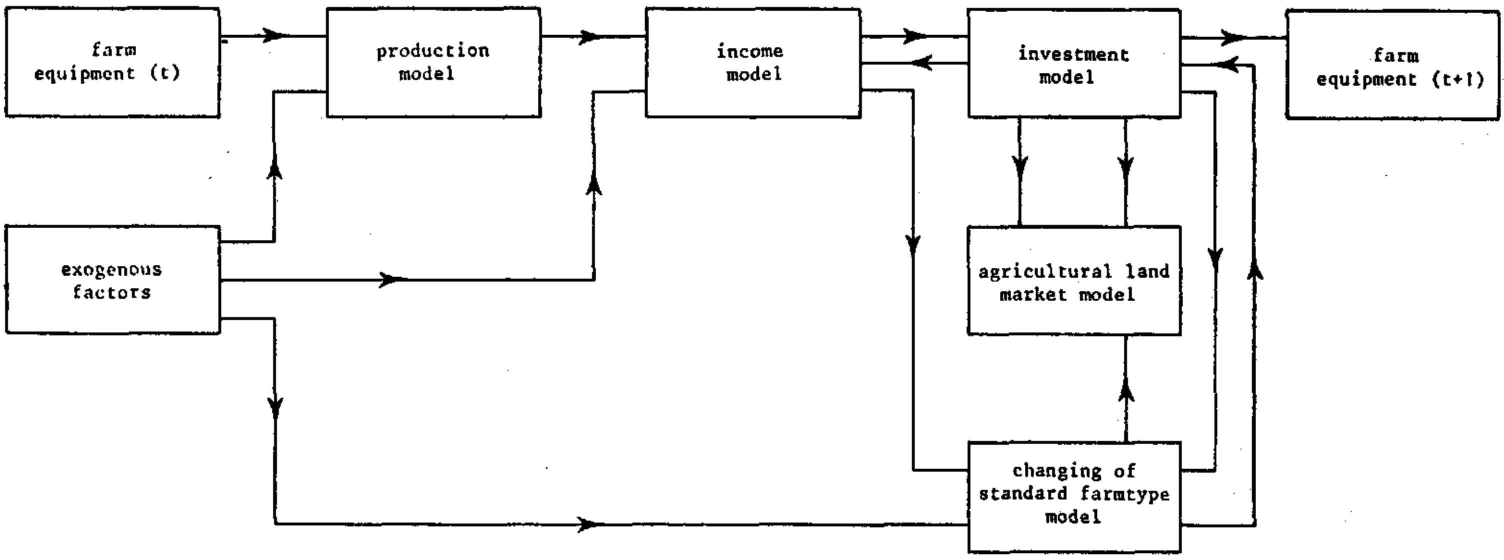
4. THE AGRICULTURAL MODEL

4.1 Introduction

The objective of the agricultural model is to describe the development of agriculture in the 'Zuid Peelgebied' area conditional to water and manure control restrictions. The development will be represented by the development of the mean income in agriculture and by the distribution around this mean. Important subjects treated in the agricultural model are:

- the linkage between the economic model and the physical models concerning crop yields. This enables an evaluation of the consequences of decision of the farm management for nature and water supply;
- the influence of the water and manure control restrictions on the farm management of the individual farms.

The model is divided in a number of mutual dependent submodels as is illustrated in scheme 3. This scheme gives the model for an



scheme 3

individual farm. For each farm in the region the calculations have to be made for a range of years. When all the calculations are made, the results with respect to income are taken together and will be transformed into one or more measures for the development of income (these measures are not defined yet).

The agricultural model is linked up with the set of physical models by the production models of the individual farms. Exogenous factors are, as is already stated in par. 2:

- the general economic development;
- the restrictions concerning water and manure control by the individual farms;
- the damage claims paid by the public water supply;
- the development of the employment in agriculture in the region.

In par. 3 the production model is treated, the other models are described in the following subparagraphs.

4.2 The income model

The income model describes the transformation of the physical production into income, the income from outside agriculture and the way in which the income is spent. As an illustration of the variables acting in this model a preliminary version of the model will be described. Because it is only a preliminary version some equations are not specified (further investigations are needed) and the value of the parameters is not given.

The model consists of an income equation

$$(4.1) \qquad Y = PQ + PL + PK - CN - CM - CW + POV + PDC$$

a consumption equation

$$(4.2) \qquad C = C\ (Y, T, \ldots)$$

and a tax equation

$$(4.3) \qquad T = T\ (Y, \ldots)$$

with

$$(4.4) \qquad PQ = \Sigma_i\ p_i\ Q_i$$

$$(4.5) \qquad PL = \Sigma_{L \epsilon E}\ w_l\ L_l - \Sigma_l\ w_l\ L_l$$

$$(4.6) \qquad PK = \Sigma_k\ cc_k\ KU_k - \Sigma_k\ c_k\ K_k$$

(4.7) $$CN = \Sigma_j \; pn_j \; N_j$$

The (possibly negative) savings are computed with eq (4.8)

(4.8) $$S = Y - C - T$$

The description of the cost of water control, the cost of manure control and the income not stemming from agriculture are subjects which have to be investigated.

The variables in the equation (4.1) - (4.8) are

Y - income before taxes;

PQ - the monetary value of the production;

P_i - the price of product i;

Q_i - the quantity of product i;

PL - the costs of labour;

w_1 - the wage of labour of category 1, LεE concerns the labour by the farmer or by the members of his family;

L_1 - the quantity labour of category 1;

PK - the costs of capital;

cc_k - the revenues of capital of category k;

e_k - the costs of capital of category k;

KU_k - the quantity of own capital in category k;

K_k - the quantity of capital in category k used in the production;

CN - the costs of the non-factor inputs;

pn_j - the price of non-factor inputs of category j;

N_j - the quantity of non-factor inputs of category j used in the production;

CM - the cost of manure control;

CW - the cost of water control;

POV - the income from outside agriculture;

PDC - the damage claims paid to the farmer (this is an exogenous variable).

4.3 The investment model

The investment model describes the capital stock of the farm, the changes in the capital stock and the capital costs. This results in a description of the farm equipment, an important factor in the production model.

The investment model contains the following variables:

- the monetary value of the capital stock (including the cultivated area);

$$K(t) = K(t - 1) + I(t) - D(t) \tag{4.9}$$

with

$K(t)$ - the monetary value of the capital stock in year t

$I(t)$ - the investments in year t

$D(t)$ - the depreciation in year t

The capital goods are divided in a number of categories. The classification will depend on the production model. For each capital category an equation of the same type as equation (4.9) has to be constructed. Equation (4.9) is the sum of the separate equations;

- the total capital minus the debts. This includes next to the capital stock, the capital outside agriculture. The total capital $V(t)$ is described in equation (4.10)

$$V(t) = V(t - 1) + S(t) - I(t) \tag{4.10}$$

The total capital $V(t)$ can be positive or negative. It is not clear yet if some restrictions concerning $V(t)$ have to be built into the model;

- the depreciations, this needs further investigations;
- the investments. An investment function has to be constructed. This concerns not only the amount of the investments but also the distribution of this amount among the categories of capital. Complicating factors in constructing the investment function are:
  1. the buying of land. Land can only be bought if it is assigned to the farm in the agricultural land market model. This may not

correspond with the investment pattern described by the investment function.

2. The investments caused by a changing of standard farm type. The decision to go over to another standard farm type may have enormous consequences for the investments in one or two years. This is caused by the fact that the new standard farm type may differ completely from the old one. For instance changing from cattle breeding to horticulture asks for a completely new farm equipment. The decision to go over to another standard farm type is described in the changing of standard farm type model.

- the farm equipment. The farm equipment can be considered as the physical representant of the investment model.

4.4 The agricultural landmarket model

In the agricultural landmarket model the demand and supply of land are treated. The supplied land mainly consists of the land stemming from terminating farms. The main subject of this model is the distribution of the supplied land among the demanding farms.

The agricultural landmarket model will be developed along the lines indicated in FILIUS (1980).

4.5 The changing of standard farm type model

This model describes whether or not a farm changes over to another standard farm type (this includes to terminate farming). One of the consequences of imposing water and manure control restrictions may be the necessity to change the farm management. In the worst case the changes needed make it impossible to go on farming at the present way. The resulting decision is to change over to a completely different standard farm type or to terminate farming. This changing over possibly may be guided by subsidizing and/or by providing information.

In this model the consequences of imposing restrictions concerning water and manure control for the farm management have to be made clear. These consequences (the decisions of the farmers) determine a large part of the agricultural (income) development. However, a lot of investigations are needed to get some insight into these matters. These investigations can be split up in investigations concerning the decision to terminate farming and in the decision to change over to another standard farm type. The model describing the decision to terminate farming will be developed along the lines indicated in FILIUS (1980). For the remaining part of the model further investigations are needed.

5. CONCLUDING REMARKS

This paper describes the framework of the agricultural model. The described (sub)models still have to be developed or must be adapted (AGREVAL) and the data still have to be collected. The framework only tries to indicate the subjects that need further investigations.

Looking at the objective of the research project Zuidelijk Peelgebied the changing of standard farm type model and the production model are the most important parts of the agricultural model. At first instance the investigations have to be concentrated around these subjects.

Before the investigations can be started an inventarisation of the farms in the region is necessary. This inventarisation has to be completed with some farm characteristics.

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