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FRAMEWORK OF A FIRST LEVEL MODEL FOR THE DEVELOPMENT OF AGRICULTURE

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contents

1. Introduction

The objective of the Policy Analysis System is to analyse the effect of (potential) measures in the field of regional water management, on the behaviour of the users of groundwater and surface water. Agriculture is one of these users. In order to describe the behaviour of agriculture two different approaches can be applied
- simulation of the behaviour of the seperate farms.
- analysis based on numbers of farms per farmtype and changes from one farmtype to another.

Both approaches have advantages and disadvantages. In the simulation aproach the existing farms are introduced to get a realistic variation between the seperate farms. For the interpretation of the results however the link with the existing farms has to be released. One of the advantages of this approach is that the variation between the farms that belong to one farmtype are taken into account. But this requires a lot of computation time.

The analysis based on numbers of farms per farmtype requires less computation time but the differences between the farms belonging to one farmtype are ignored.

Because it is expected that a lot of measures must be analysed the the first level model is an analysis based on numbers of farms per farmtype. This analysis is supported by the simulation approach as a second level model.

This report contains some remarks about the Policy Analysis System and its objectives (section 2). Section 3 presents an outline of the first level model which is based on numbers of farms per farmtype. The classification of the farms into farmtypes is the subject of section 4. This classification is important because the variation between the farmswithin a farmtype has to be small with respect to (among others) the effects of the measures applied by the RPMA. On the other hand it is important to have the number of classes as small as possible. The first level model and the classification of the farms has been the subject of a number of discussions with Sergei Orlovski and Paul van Walsum during my visit at IIASA from 18 through 22 february 1985.

2. Outline of the policy analysis system.

In th Zuid Peel research project a framework for a decision support system for the regional water management has been formulated. This system contains the following two-step procedure

- in the first step, the Scenario Generating System, a target state is generated. This target state is generated by maximizing income in agriculture conditional to the physical (a.o. hydrological) restrictions for the region and conditional to the required levels of environment, employment in agriculture and the extraction of groundwater by public water supply companies. The required levels are formulated by the RPMA (the Regional Policy Making Authority).
- in the second step, the Policy Analysis System, the effect of possible measures in the field of the regional water management, on the behaviour of the farmers (and eventually on environment and/or public water supply companies) is analysed. These measures can be applied by the RPMA in order to influence the behaviour in such a way that the target state is approximated.

The procedure is interactive. The generation of a target state is repeated until the RPMA is sartisfied. For each iteration one or more of the constraints with respect to environment, groundwater extraction and employment in agriculture are revised by the RPMA. If the RPMA is satisfied with the generated target state then the RPMA formulates a set of measures (a water management alternative). In the Poolicy Analysis System the effect of this set of measures on the development in the region is analysed. This results in an expected development for the region. This development is compared with the target scenario (by the RPMA). If the RPMA is not satisfied he can either formulate a new set of measures to be analysed in the Policy Analysis System or he can decide that the target state can not be reached and so it has to be revised. In this case the set of constraints with respect to environment, groundwater extraction and employment in agriculture are revised and a new target state is generated.

The Scenario Generating System and the Policy Analysis System have the same structure. They both consist of a relatively simple (linear) first level model and a number of second level models which may be more complicated. In the interactive procedure only the first level model is used. The second level models are used to calculate the coefficients of the first level model and/or to verify the results of the first level model (not necessarily after each run). In this way it is tried to keep the required computation time as low as possible. This is important for an interactive procedure.

In the remaining part of this chapter the Policy Analysis System is described in more detail. At this moment the

Policy Analysis System is (in fact) restricted to the analysis of the behaviour of the farmers. With respect to Public Water Supply and Environment it is assumed that the behaviour is known. The measures applied by the RPMA are changes in the hydrological structure of the region and/or measures to influence the behaviour of the farmers with respect to the use of water and to the application of manure. Some potential measures are

- regulation of the application of manure and/or the use of water
- subsidizing specific investments (for instance with respect to technologies that are 'new' for the region)
- introduction of minimum prices (or penalties) for certain technologies
- extension. By way of extension the RPMA tries to influence the decisions of the farmers.

For a part these measures can be transformed into changes in prices and/or in expected income. Other measures try to influence the behaviour of the farmers in an other way (for instance by extension). However the effect of both types of policies has to be taken into account in the first level model.

The first level model not only describes the behaviour of agriculture but it also requires a description of the physical system including the interactions between agriculture, groundwater extraction and environment. This is schematized in scheme 2.1.

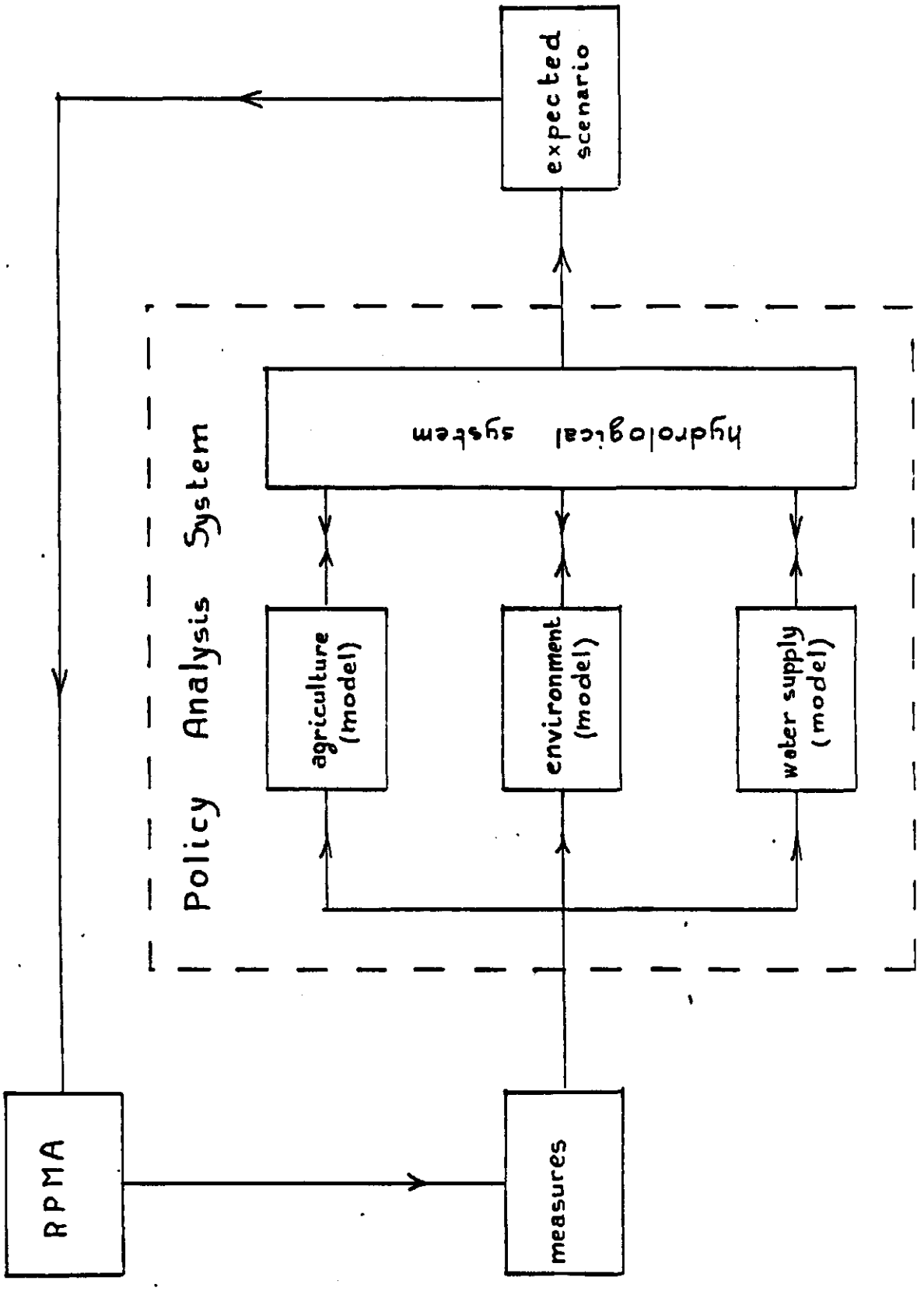
scheme 2.1

In scheme 2.2 the important aspects with respect to agriculture are indicated. Here it is shown that the policies applied by the RPMA, the limitations of the physical system and some exogenous factors (prices, restrictions with respect to employment) influence the development of agriculture.

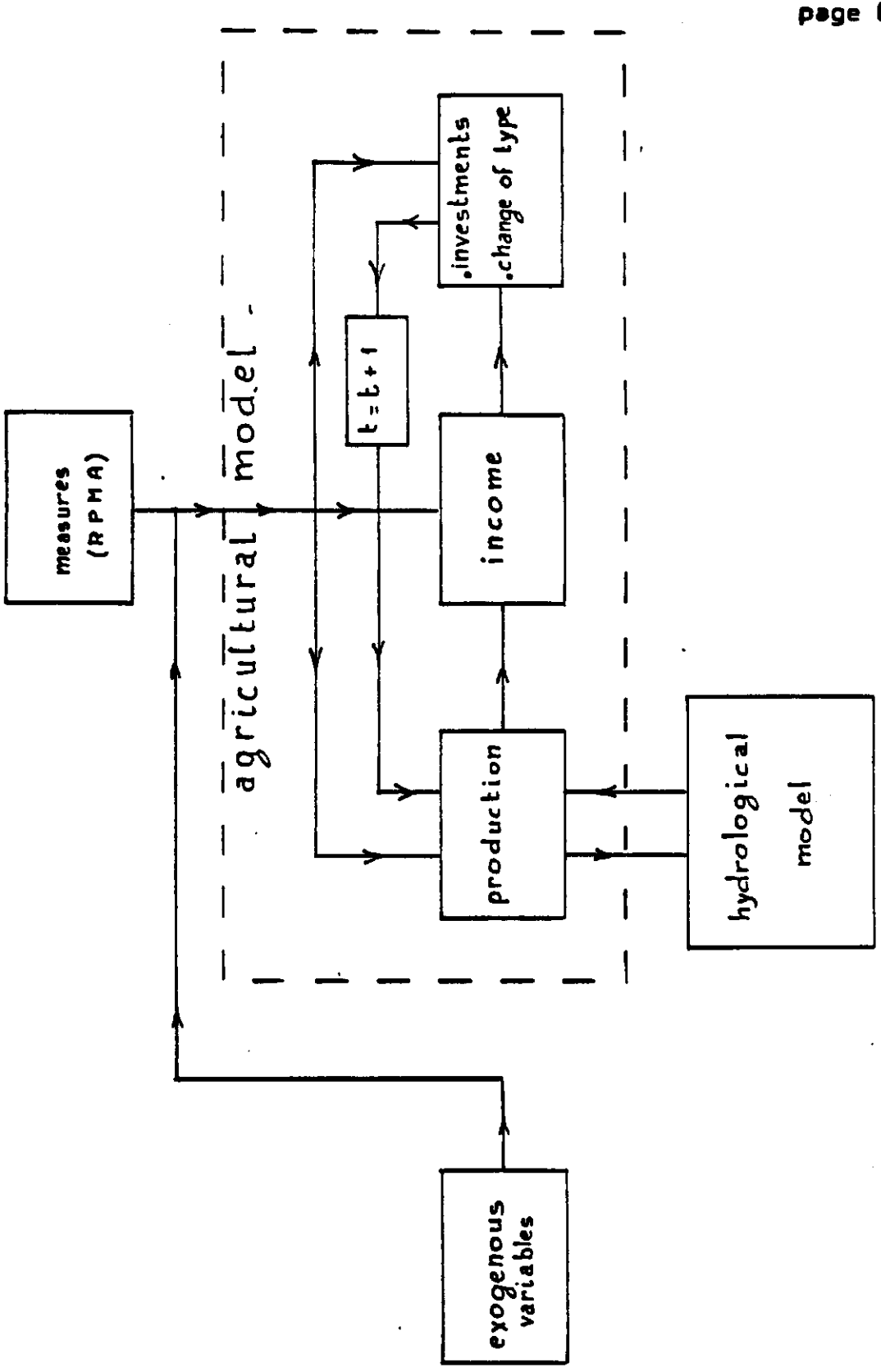
scheme 2.2

It has been stated that the Policy Analysis System contains both first level models and second level models. These second level models will mainly be the same models as in the Scenario Generating System, but some of these models will be new. One of these new models is the simulation model with respect to the development of agriculture. This model is based on the development of the seperate farms. These farms are introduced into the model as a representation of the variance between the farms within a farmtype. The (agricultural part of the) first level model will be based on this simulation model.

For the (agricultural part of) the first level model an approach based on numbers of farms per farmtype is followed. This is a rather simple approximation which requires a large number of farms in each farmtype. With respect to the classification of the farms into farmtypes some severe conditions can be formulated (for instance with respect to the use of water and manure). This is discussed in section 4.



schema 2.1 The Policy Analises System.



scheme 2.2 The schematised framework of the agricultural model.

3.Outline of the first level model

The first level model describes agriculture in terms of numbers of farms per farmtype and in (year to year) changes in these numbers. These changes can be caused by the entering of new (starting) farms, by farms changing from one farmtype to another or by terminating farms. For these changes probabilities have to be estimated.

For each farmtype a representative farm is defined. In the model it is assumed that all farms belonging to a farmtype are equal. This means that they don't differ in farmsize, income, cropping pattern, manure applications, water requirements, labour requirments, etc.. For the representative farm the development (in time) of these characteristics is described. The mathematical representation of the first level model is stated in the following equation.

Let N(r,i,t) - the number of farms of (farm) type i in region r at the start of year t (i=1,---,M)

P(r,i,j,t) - the probability that a farm of type i in region r changes to type j in year t (i,j=1,---,M ; i=/=j)

P(r,i,0,t) - the probability that a farm of type i in region r terminates farming in year t (i=1,---,M)

P(r,0,j,t) - the probability that a new farm of type j starts in region r in year t (j=1,---,M)

ND(r,i,j,t)- the number of farms in region r going from type i to type j in year t (i,j=0,1,---,M; i=/=j)

g (---) - the function that calculates P(r,i,j,t) as a r,i,j combination of some variables that are not specified at this moment.

XF(r,i,t) - the size (area) of the representative farm of type i in year t in region r

For region r the number of farms belonging to farmtype i is stated in equation (3.1).

$$(3.1)\quad N(r,i,t+1) = N(r,i,t) + \sum_{j} (ND(r,j,i,t)-ND(r,i,j,t)) + ND(r,i,0,t) - ND(r,0,i,t)$$

The number of farms going from farmtype i to farmtype j is equal to the number of farms of farmtype i multiplied by the probability that a farm of type i changes over to type j. This is stated in (3.2). In (3.3) it is indicated that this probability is a function of some farmtype characteristics of both the old farmtype (i) and the new farmtype (j). These characteristics are not specified yet. The approach is feasible when the number of farms belonging to farmtype i is large. If this number is to small the multiplication can be replaced by using random generators in the selection of the

ND(r,i,j,t). In this case the random generators are based on the probabilities.

(3.2) $ND(r,i,j,t) = P(r,i,j,t) * N(r,i,t)$

(3.3) $P(r,i,j,\$) = g(r,i,j,t)(------)$

Corresponding with the changes in the numbers of farms per farmtype there are changes in the area occupied by the farmtypes. In a region the area supplied has to be equal to or greater than the area demanded. In (3.4) the landmarket for region r is stated.

$$(3.4) \quad \sum_{i} \{[ND(r,i,0,t)-ND(r,0,i,t)]*XF(r,i,t)\} + \sum_{i,j} \{ND(r,i,j,t)*[XF(r,i,t)-XF(r,j,t)]\} \geq 0$$

In this equation it is assumed that the farmsize of the representative farms is constant in time. If there is some development in time this has to be introduced into (3.4). When (3.4) is not met, it is the demand exceeds the supply, then the number of farms changing to another type and the number of entering farms is reduced. The labour inputs are modeled in the same way. The employment situation in the region is the limiting factor for the labour inputs. For water requirements and manure applications things are more complicated. Here the limitations are caused by the physical system and/or by policies applied by the RPMA. So, at least for a part, the modeling has to be over the regions and may be even including Environment and Public Water Supply.

In table 3.1 the number of farms per subregion in the Zuid-Peel area is presented for the year 1982. From this table it becomes clear that it is very likely that for the Zuid-Peel project an approach with random generators will be required.

table 3.1 The number of farms per region in the Zuid-Peel (1982)

region number	number of farms
1	27
2	93
3	27
4	44
5	71
6	26
7	64
8	24
9	120
10	0
11	44
12	29
13	55
14	94
15	47
17	68
18	218
19	138
20	18
21	74
22	24
23	97
24	127
25	57
26	43
27	21
28	189
29	67
30	88
31	61

the total number of farms in the Zuid-Peel region is 2055 (in 1982)

4. The classification into farmtypes

For a model based on numbers of farms per farmtype the classification of the farms into farmtypes is important. This classification has to be such that the number of classes is as small as possible still taking into account all relevant aspects. To find these relevant aspects the following questionshave to be answered:

- What will be done with the output of the model?
  The output of the model is used to determine the use of water and the application of manure for agricultural purposes in each subregion, taking into account the interactions between Agriculture, Environment and Water Supply (via the physical system). The model has to be run for a number of alternatives with respect to the regional water management. For each alternative the forecast for the development will be compared to the target state generated in the Scenario Generating System.
- What are the important inputs for the model?
  Important inputs are the current situation (in agriculture) in the region, the policies applied by the RPMA and employment constraints, prices etc..

Based on these answers the following provisional list is made with aspects that can be taken into account in the classification

- the intensities of the technologies. The technologies differ among others in the water requirements, in the application of manure and in labour inputs.
- the farmsize (both in standard farm units and in ha)
- the age of the farmer or his successor
- the fact if the farm is increasing or decreasing
- the financial position
- the soiltype
- the availability of a sprinkler installation
- the ratio own land / rented land
- the availability of manure handling equipment
- the available 'local' labour
- the education of the farmer or his successor
- the consumption pattern of the farmer
- the attitude of the farmer towards environment

Most of the aspects are on the list because they influence the behaviour of the farmer and his reaction to the policies. Taking into account all of these factors leads to a number of classses that exceeds the number of farms in the subregions. In that case it would be more convenient to work with the seperate farms. As a consequence only a few of the factors can be taken into account in the classification. As a start it is decided to base the classification on the intensities of technologies (measured in standard farm units). A further classification will be based on the results of the second level model (with seperate farms).

The classification with respect to intensities of technologies goes as follows. Each technology is valued in standard farm units. A standard farm unit is the dimension in which both the economic size of a farm and the size of the seperate directions of production within a farm are measured. A standard farm unit is a normative amount for the value added calculated for an efficient farm management under normal conditions. A direction of production consists of one or more technologies, for instance dairy farming is the combination of grassland with cows and maise. The farmtypes are defined in percentages for each direction of production. For instance a farm belongs to the farm type diary farming if more than 70 percent of the standard farm units is in (the direction of production) diary farming. The remaining 30 percent are free. It is also possible to discriminate between diary farming in combination with pigs or chicken and diary farming in combination with arable land. This assumption puts a claim on the remaining 30 percent.