NOT FOR QUOTATION
WITHOUT PERMISSION
OF THE AUTHOR

WORLD COMMODITY MODEL FOR FERTILIZER

The alternative long-term prognosis of the world fertilizer production, consumption and trade on the basis of an econometric model

S. Mészáros

January 1980
CP-80-1

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

S. MÉSZAROS is head of Department of Research Institute for Agricultural Economics, 1355 Budapest, 55. Pf. 5, Hungary

PREFACE

The Food and Agriculture Research Program at IIASA deals with the world's food problems on two fronts: firstly it analyses future food problems by building a system of national policy models and secondly, it studies production factors of agriculture aimed at improving technologies and solving the world's food problems. Fertilizers play an important role among the production factors in agriculture, and their growing use in the future will contribute to higher food level supplies both in developed and developing countries.

The fertilizer model presented here+ was constructed for alternative long-range projection, consumption, and world trade and can be linked to agricultural, industrial and global models. The author helped to develop the Hungarian national policy model++ on food production at IIASA and is therefore acquainted with the efforts, principles and methodological procedures used to develop both global models. He hopes that the publication of this document on future fertilizers problems by IIASA will contribute to a better understanding of world food problems in the future.

+ The model was constructed as a part of research work carried out by the Hungarian National Planning Institute under contract to UNIDO.

++ Modelling of Centrally Planned Food and Agricultural Systems: A Framework for a National Policy Model for the Hungarian Food and Agriculture Sector. C. Csaki, A. Jonas, S. Meszaros. IIASA, 1978, RM-78-11.

CONTENTS

THE PURPOSE AND CHARACTERISTICS OF THE FERTILIZER COMMODITY MODEL, 1

The purpose of the fertilizer commodity model, 1

The more important determinant factors of fertilizer consumption and production /the economic sphere modelled/, 3

The mathematical model, the solution and methods of prognostics, 8

DESCRIPTION OF THE ECONOMETRIC MODEL, 9

Equations of the sphere of the whole economy, 1o

Equations of the food economy, 13

The equations of fertilizer sphere, 16

The quantification of the model, 2o

ALTERNATIVE PROGNOSES

Scenario A /Basic/, 24

Scenario B, 33

Scenario C, 34

Scenario D, 35

Scenario E, 37

Simultaneous solutions, 38

Summary, 4o

References, 47

Appendix 1: Simulation models equations, 5o

List of variables and parameters of the model, 54

Results of Scenario A, 57

Results of Scenario B, 64

Results of Scenario C, 71

Results of Scenario D, 78

Results of Scenario E, 85

Simultaneous solutions, 89

WORLD COMMODITY MODEL FOR FERTILIZERS

S. Mészáros

THE PURPOSE AND CHARACTERISTICS OF THE FERTILIZER COMMODITY MODEL

The purpose of the fertilizer commodity model

The International Centre for Industrial Studies functioning within the United Nations Industrial Development Organization /further: UNIDO/ worked out the conception of a world model named UNIDO World Industry Co-operation with the purpose of analysing the problems of the realization of Lima target /UNIDO International Centre for Industrial Studies 1977/.

The world model consists of a series of models linked together, and within this system there is a difference between an inner layer and an outer layer. The models of the inner layer are closely related, and there is a flow of information in radial-direction among them. The models were prepared within UNIDO. The models of the outer layer are connected loosely in turn with the models of the inner layer, and there is no information link between the models of the outer layer therefore the models of the outer layer can be separately developed as well.

One of the inner layer models is the model which determines the international Trade Disaggregation. Its task is to disaggregate in the previous model in value determined foreign trade matrix at least into 7 product groups. The World Commodity Models are placed within the outer layer, deducing the expected export and import of the products in question from the demand and supply of country-groups and these results can be used for controlling and correcting the data given by the Trade Disaggregation Model. The task of the World Commodity

Models is to give long-range projections /up to the year 2ooo/ with respect to the demand and supply and international trade of the products in question.

The task of the final study was to provide for a conception of the World Commodity Model concerning the fertilizers. For the consumption of fertilizers a long-range prognosis up to 2ooo has already been prepared in the UNIDO International Centre for Industrial Studies, starting from the need of fertilizers presumed on the basis of the increase of population /UNIDO International Centre for Industrial Studies 1976/. Only one prognosis is provided by this study for the trend of fertilizer consumption in the developed and developing countries till the year 2ooo. However, the present generation of the prognosists refuses the preparation of a single long-range prognosis and alternative prognoses are prepared in the form of different suppositions, so called scenarios concerning the future /F.H. Sanderson 1977/. It was the desire of the preparators of the UNIDO World Model that the Fertilizer Commodity Model should give alternative scenarios concerning the production, consumption and international trade of fertilizers as well.

The requirements concerning the fertilizers and meeting the World Commodity Model requirements are the following:

- preparation of alternative long-range prognoses for the international trade of fertilizers should be realized

- the most important determining factors of the international trade of fertilizers should be satisfied by the model /demand, supply, price etc./

- the individual prognosis should be consistant in the light of equilibrium requirements, and the relation among different factors

- alternative suppositions should be made concerning the exogeneous variables which can obscurely be determined in long term or have the characteristics of quality from the point of view of fertilizers

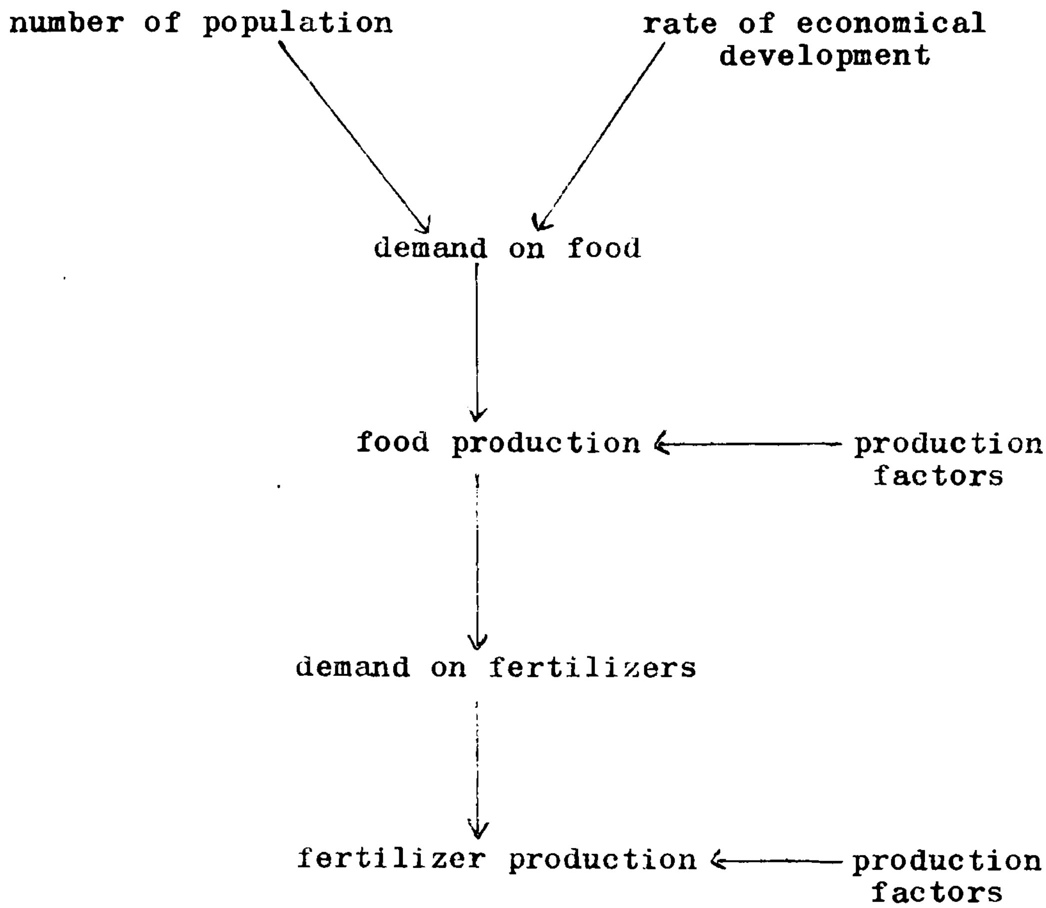
- the model should elaborately count with the world fertilizer production and consumption concerning at least the groups of developed and developing countries

- the model should be relatively simple, with respect to the ease of manageability and practical applicability of the results.

The most important determinant factors of fertilizer consumption and production /the economic sphere modelled/

For the formation of the fertilizer product model the determinant factors of fertilizer consumption and production, the connection of the fertilizer as a product with its environment must be considered. When forming the model the followings have been taken into consideration:

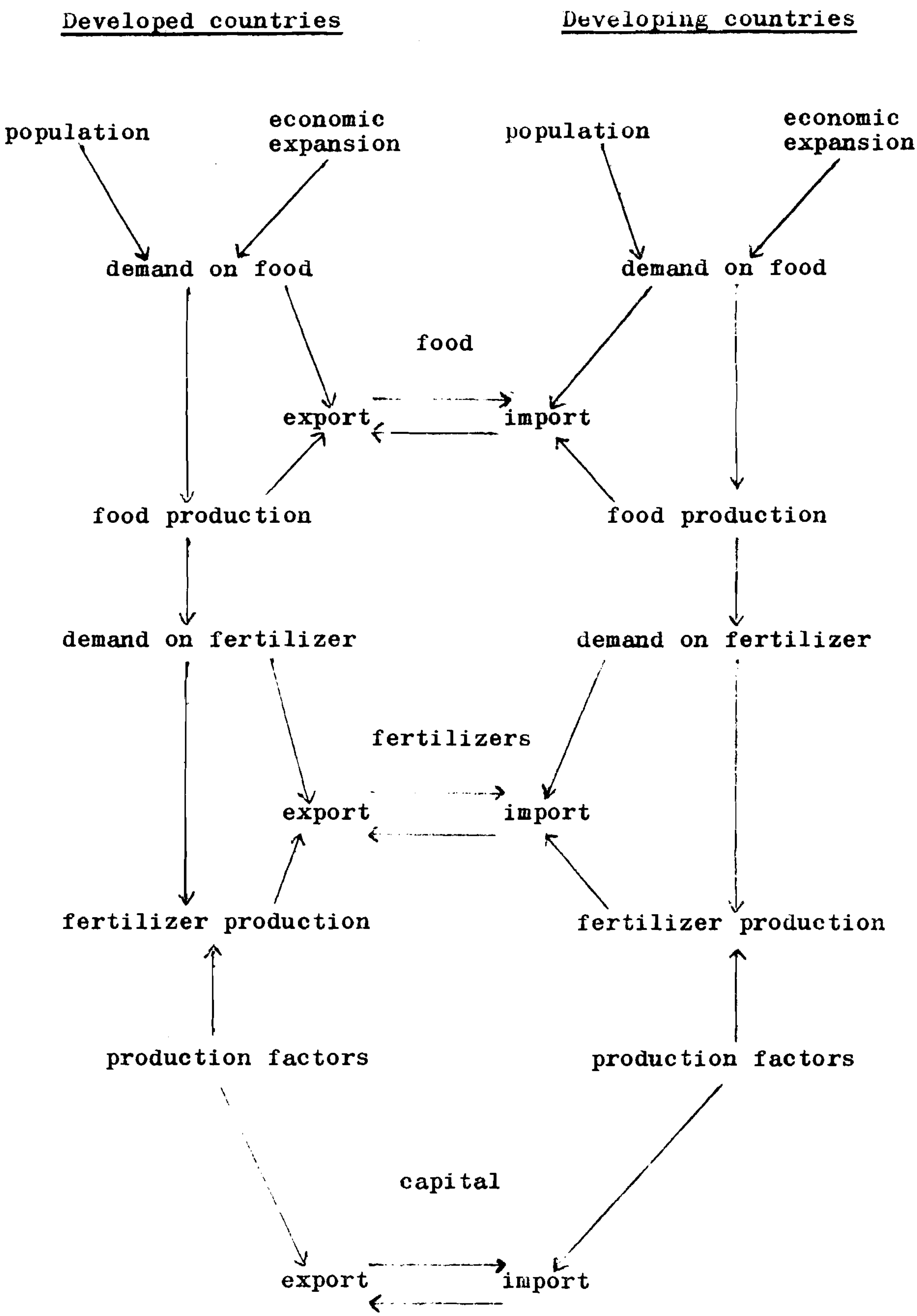
1. The conditions of the fertilizer production can not be made independent from the situation of other products, from the tendency of environmental factors: the demand on fertilizers basically depends on food production, especially on plant cultivation. However, food production is determined by the demand on food, the formation of which depends on the number of population and the rate of economic development. The production of fertilizers is determined mainly by the magnitude and utilization of manufacturing capacity and the availability of raw materials and energy sources. Consequently, for the preparation of alternative and consistant prognoses the modelling of concatenation can not be avoided even in that case when factors are modelled in a simplified way.



2. It is clear that the export supply and import demand on fertilizers can be deduced only by the comparison of the domestic fertilizer demand and production. Consequently, the country-group modelling of the previous concatenation is needed, in respect of the developed and the developing countries at least. At the same time it is obvious that in case of effort for consistant prognosis the fertilizer export supply of the developed countries and the fertilizer import demand of the developing countries can not be calculated independently from one another, but an equilibrium must be created between them because the import demands can be only as much as the production for exports. Not only this one /respectively in the case of three aliments, three/ equilibrium occurs among the models of the individual country-groups. Thinking over, in this respect the government of a developing country can choose among three alternatives in order to solve the problem of provision:

- to import food
- to import finished fertilizer
- to import capital /factory for fertilizer production or perhaps raw material/

The modelling of all the three possibilities should be made possible because the conversion into each other of the three possibilities can be realized more or less. Among the models of the individual country-groups with regard to the fertilizer commodity model a connection may be proposed in the following three cases:


Developed countries
Developing countries
population
economic expansion
population
economic expansion
demand on food
demand on food
food
export
import
food production
food production
demand on fertilizer
demand on fertilizer
fertilizers
export
import
fertilizer production
fertilizer production
production factors
production factors
capital
export
import

3. When the economic sphere for modelling is considered from the point of view of means for counterbalancing, two ones can reasonably be accepted for being modelled in this respect:

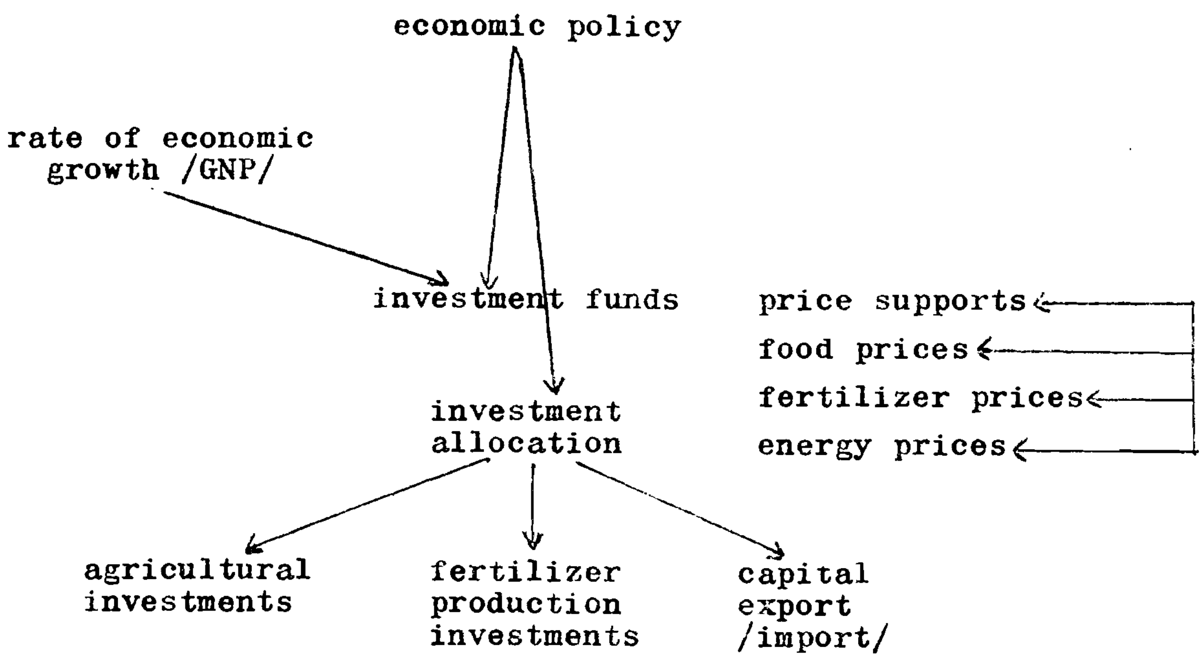
- the prices

- the investments

The change in the prices of food products and fertilizers could be the means of counterbalancing in the short run. In the long run the investments have a greater role in counterbalancing considering the investments of both agriculture and fertilizer industry. When the value of these investments in the gross national production /GNP/ shares with a constant rate, the volume of investment can vary depending on the alternatives of the rate of economic growth. When the ratio of investments in GNP is considered as policy variables, a possibility is given to create and examine alternatives in this respect as well /in the case of developed countries there is a possibility to have the investments of fertilizer industry in the form of capital export/.

Only the world market prices can be modelled from all the prices because there is no possibility to quantify the domestic prices in the case of country-groups. Besides, the short term changes in import demand and export supply; on the long run outer factors also effect on prices /e.g. on the prices of fertilizers, the prices of raw materials, energy and capital/, on the other hand, policy variable may also play a role in the form of international price agreements and price supports which can be handled as alternative exogeneous variables.

The means of economic policy on effecting counterbalancing and their influence are represented as follows:



4. The relatively simple and practical handling of the fertilizer commodity model cannot be realized without certain simplifications, especially in the food sphere.

The most important simplification is that food production and plant cultivation will be represented by grain production in the model.

It has more reasons:

- the grain amounts to 6o % of direct calorie consumption amounts to 5o %,
- the grain amounts to 5o-6o % of the cultivated land of developed countries as well as in the developing ones,
- the grain receives approximately 5o-6o % of the total fertilizer utilization in the developed and the developing countries, too /R. Ewell 1976/,
- it is also an important point of view that we have long term prognoses for grain production developed by more organizations /see e.g. F.H. Sanderson 1977/ which can be utilized to control the operation of fertilizer commodity model.

In the case of food demand the needs in cereals, meats, milk and eggs will be taken into account and will be converted into food and feed grain demand. This method has already been applied in some world food models /e.g. G.F. Framingham 1974/.

Only the most important thing, the cultivation of new lands will be taken into consideration as agricultural investment having the ease of availability, especially in the developing countries. At the same time we do not take the account of e.g. the irrigational investments in this model, though their role in certain regions may be important.

But at the handling of fertilizers the three nutritive materials are taken into account separately; they are the nitrogen, phosphate and potassium fertilizers. This has more reasons as well:

- getting on in time the $N : P_2O_5 : K_2O$ relations in fertilizer consumption are changing,
- on the other hand, the raw material sources of phosphate and potassium are concentrated in different countries, therefore the conditions of export-import are varying for every nutritive,

besides, the capital and energy needs of manufacturing the three nutritives are different, so their world market prices responded indifferent way to the changes of energy prices.

The mathematical model, the solution and methods of prognostics

The satisfaction of requirements set for the model and the modelling of this economic sphere can only be realized with the help of econometric model consisting of more equations. To provide prognoses for different years an econometric model is being applied as a simulator in that way that the equations of the econometric model will be solved one after another for every prognosticated year /R.C. Meier, W.T. Newell, H.L. Pazer 1969/, but the results will be printed out for every five years only.

In the case of an econometric model the question arises whether there is some possibility of applying a recursive model where it is satisfactory to solve the individual equations in turn or a simultaneous model is needed where all the equations concerning the given year should be solved simultaneously. In the case of more country-groups the reason for the application of a recursive model can be given by the quantification of the model to be solved, and another reason is the necessity of taking into consideration the non-linear connections /e.g. in regard to the fertilizer portions and yields/. At the same time the application of prices as endogeneous variables and the modelling of their effect on demand and supply as well as the validation of equilibrium requirements would necessitate in a simultaneous solution.

The question is related to the problem of connecting the individual blocks of the individual country-groups with regard to the counterbalancing of the world market. Three methods of connections are known:

- "formal linking" - is a connection produced by the so called simultaneous solution,
- "non-formal linking" - it does not lead to perfect counterbalancing after a limited number iterative steps,
- "loose linking" - the handling of inconsistencies takes place only after the running of blocks which can only be an emergency solution /M.A. Keyzer 1977/.

According to our opinion the simultaneous one is the best solution in the case of two country-groups; namely, the application of "formal linking", thus the econometric model will be introduced accordingly. The solution will be carried out by the use of Moris-Normann program package allowing the application of non-linear equations as well.

Prognoses are carried out by the econometric model as follows:

- the values of exogeneous variables should be defined externally for all the years of the prognosticated period /in the form of a time sequences or trends/, and in alternative way, of course,

- in the case of lagged endogeneous variables their values must be given only for the starting year,

- the values of endogeneous variables for all the years of the prognosticated period will be calculated from the model in an alternative way.

In principle there is a possibility of calculating the so called "long-run multipliers" which show the effect of a single change of exogeneous variables on the final values of endogenous variables in the starting period of the system which converges to the equilibrium /see e.g. S. Reutlinger 1966/.

On one hand the forming of alternatives can be based on the trend alternatives of exogeneous variables /e.g. population GNP/ on the other hand on varying some parameters of the model or some complete equations of its. Each combination of the alternatives given for the parameters and for the different exogeneous variables means one scenario for the future. For the actual forming of scenarios see more details in the following chapters.

DESCRIPTION OF THE ECONOMETRIC MODEL

The econometric model is to be introduced in two different ways: with the description of the structure and of the equations of the model.

Figure No 1. shows the structure of the econometric model. Three spheres are to be distinguished horizontally within the system; the sphere of the whole economy, one sphere for food industry and one for fertilizers. One part of the sphere of the whole economic consists of exogeneous variables. The periods t and t+1 are situated vertically, within these periods some phases of reproduction period are to be found. The direction-signs described with continuous lines show the connections within a year and the ones described with dotted lines show the lagged effects. Thus the prices of grain and fertilizers for example have their influence on demand in the same year, while some effects on supply are already lagged, and will only be valid in the next year.

In the followings the equations of the model will be given in normal form without any numerical data. The numerical equations will be reported in the enclosure. The variables of the model are indicated by capital letters, and the parameters by small ones.

The following indexes are used in the description of the model:

/t/: upper index, it denotes the number of years, t = 1, 2, ..., 25

i : lower index, indicating food products /cereal, meat, milk and egg/

j : lower index indicating fertilizers /nitrogen, potassium, phophate/

k : lower index indicating country-groups /developed and developing ones/

Equations of the sphere of the whole economy

The number of population, the GNP and the prices of energy sources used for fertilizer production are exogeneous variables in the sphere of the whole economy. The price and investment policies are exogeneous factors, too. These have to be given for the model in external way; equations containing only endogeneous variables will be described in the followings.

The personal income of population will be deduced from GNP and the per capita income will be derived from the above:

$$TINC_k^{/t/} = f/GNP_k^{/t/}/ \qquad /1/$$

$$PCINC_k^{/t/} = TINC_k^{/t/} \;/\; POP_k^{/t/}, \qquad /2/$$

where:

TINC = the total personal income of the population

GNP = gross national production /exogeneous variable/

PCINC = personal per capita income

POP = the number of population /exogeneous variable/

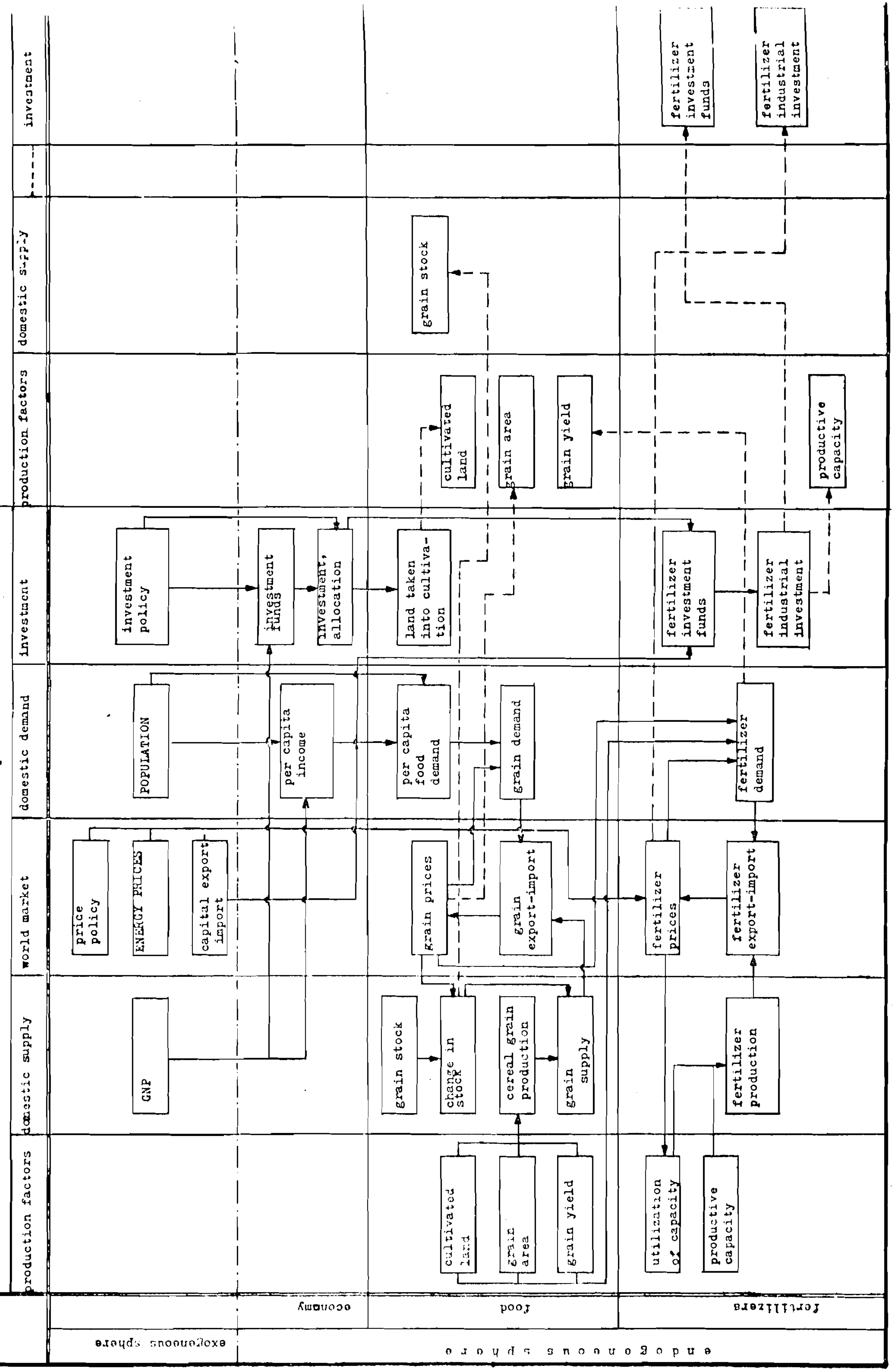
The available funds for the total investment will be derived from GNP as well. The ratio of available investment funds for the fertilizer industrial investments and for the increase of cultivated land is determined by the exogeneous investment policy:

$$TINVF_k^{/t/} = f \;/\; GNP_k^{/t/} \;/ \qquad /3/$$

$$LINVF_k^{/t/} = a_k \; TINVF_k^{/t/} \qquad /4/$$

Figure 1.

The Structure of the Econometric Model



$$FINVP_k^{/t/} = b_k \ TINVF_k^{/t/} \qquad /5/$$

where:

TINV = annual financial funds for investments in the whole economy

LINVF = the available financial funds for the investments in the agriculture, for the increase of cultivated land

a = parameter indicating the ration of agricultural investments /a parameter of exogeneous economic policy/

FINVF = the annual financial funds for investments in the fertilizer industry

b = parameter indicating the ratio of fertilizer industrial investments /a parameter of exogeneous economic policy/

For simplification reasons agriculture is supposed to utilize the total annual financial funds for investments for the purpose of expanding, the cultivated land which means that the prices of grain and land have no effect on the expansion of cultivated land. However, in the fertilizer industry the prices and investments are cyclical, therefore it is desirable to make it possible to influence the volume of annual investments by the fertilizer prices and accordingly it should be permitted to accumulate the annual financial funds for more years. The given financial funds for investments in fertilizer industry which is available in every country-group can be influenced by the capital export or import, the volume of which should also be defined as an exogeneous economic parameter.

Equations of the food economy

The per capita food demand can be expressed as the function of per capita income for grain, meat, milk and eggs separately:

$$PCFD_{ik}^{/t/} = f \ / \ PCINC_k^{/t/} \ / \qquad /6/$$

where:

$PCFD_i$ = the quantity of per capita food demand on food product i.

In the following equation all the food demand will be converted into grain demand and at the same time the grain demand will be made dependent on the world market price of grain:

$$PCGD_k^{/t/} = \left[\sum_i c_{ik}^{/t/} \quad PCFD_{ik}^{/t/} \right] \cdot d_k \frac{GPR^{/t/}}{GPR^{/t-1/}} \cdot e_k \qquad /7/$$

$$TGD_k^{/t/} = PCGD_k^{/t/} \cdot POP_k^{/t/} \qquad /8/$$

where:

PCGD = per capita grain demand /consumption/

TGD = total grain demand /consumption/

GPR = world market price of grain

c_i = a multiplier to convert the food-demand into grain demand on food product i

d = the price-elasticity for grain demand

e = multiplier for calculating the need of seed-grain

The land yearly taken into cultivation is calculated as the quotient of investment funds available for this purpose and of costs of taking land into cultivation pro hectare. The annually cultivated area is reduced for urbanistic purposes but at the same time they are expanded by the new lands taken into cultivation:

$$LINC_k^{/t/} = \frac{1}{fk} \quad LINVF_k^{/t/} \qquad /9/$$

$$L_k^{/t/} = g_k \; L_k^{/t-1/} = LINC_k^{/t-1/} \qquad /1o/$$

where:

LINC = new land taken into cultivation

L = cultivated land

f = cost of bringing into cultivation per hectare

g = the rate of annual reducement of cultivated land for the purpose of urbanization.

The quantity of grain production is calculated on the basis of cultivated land, the territorial ratio of grain and grain yield. The territorial rate of grain depends on the ratio of the preceding year and on the price of grain in the preceding year. But the grain yield depends on the fertilizer demand and yield-trend in the preceding year.

$$GP_k^{/t/} = L_k^{/t/} \cdot A_k^{/t/} \cdot Y_k^{/t/} \qquad /11/$$

$$A_k^{/t/} = f \; / \; A_k^{/t-1/} \, , \; GPR^{/t-1/} \; / \qquad /12/$$

$$Y_k^{/t/} = f \; / \; Y_k^{/to/} \, , \; t \, , \; FEDH_{jk}^{/t-1/} \; / \qquad /13/$$

where:

GP = the quantity of grain production

A = the ratio of grain within the cultivated lands

Y = the yield of grain pro hectare

$FEDH_j$ = fertilizer demand for 1 hectare on nutritive j.

The quantity of grain supply is deduced from the production and from the change in stocks. The forming of stocks is determined by the previous year stocks, storage loss and change in stocks. But the change in stocks depends on the volume of stock of the previous year, on the given annual price of grain as well as on the exogeneous variables expressing economic purposes in connection with the forming of stocks /e.g. ensuring the safety of world-provisioning may require the increase of grain stores in the developed countries:

$$GSP_k^{/t/} = GP_k^{/t/} + GSTM_k^{/t/} - m_k \, GP_k^{/t/} \qquad /14/$$

$$GST_k^{/t/} = h_k \, GST_k^{/t-1/} - GSTM_k^{/t/} + m_k \, GP_k^{/t/} \qquad /15/$$

$$GSTM_k^{/t/} = f \; / \; GST_k^{/t-1/} \, , \; GPR^{/t/} \; / \qquad /16/$$

where:

GSP = the quantity of grain supply

GST = the volume of grain stocks

GSTM = changes in the grain stock /the reaction of stock/, which can have a plus sign as well as a minus one /stock increase or stock decrease/

h = a parameter to express the loss in storage

m = parameter to express the economic purposes in connection with the volume of grain stocks /exogeneous parameter/

The quantity of grain getting into foreign-trade is calculated from the difference between the supply and demand. It means net export or import depending on the sign. The equilibrium of the quantity to be exported or imported is created by the equilibrium condition through the grain prices:

$$GTR_k^{/t/} = GSP_k^{/t/} - TGD_k^{/t/} \qquad /17/$$

$$\sum_k GTR_k^{/t/} = 0 \qquad /18/$$

$$GPR^{/t/} = f\ /\ GPR^{/t-1/}\ ,\ _k GTR_k^{/t/}\ / \qquad /19/$$

where:

GTR = the quantity of grain export /or import/.

The equations of fertilizer sphere

The level of fertilizer demand /fertilizer consumption/ on 1 hectare cultivated land is expressed in the form of a function of grain yield so the fertilizer-consumption is determined basically by the grain yield, but the actual degree of consumption depends on the prices of fertilizer and grain, as well as on their ratio. The fertilizer consumption may be calculated for nutritives separately or all together starting from the constant relation N : P_2O_5 : K_2O.

$$FEDH_{jk}^{/t/} = f\ /\ Y_k^{/t/}\ ,\ FEPR_j^{/t/}\ ,\ GPR^{/t/}\ / \qquad /2o/$$

$$TFED_{jk}^{/t/} = FEDH_{jk}^{/t/}\ .\ L_k^{/t/}\ .\ n_k \qquad /21/$$

where:

$FEPR_j$ = the world market price of fertilizer for nutritive j

$TFED_j$ = the total fertilizer demand /consumption/ from nutritive j

n = multiplier rate for fertilizer consumption for non agricultural purposes.

The available investment funds for fertilizer industry are defined by the rest from previous year, by the annually forming funds and by the capital export-import. The capital export and import should counterbalance.

$$FINVFA_k^{/t/} = FINVR_k^{/t-1/} + FINVF_k^{/t/} - CAPTR_k^{/t/} \qquad /22/$$

$$CAPTR_k^{/t/} = v_k \; FINVF_k^{/t/} \qquad /23/$$

$$\sum_k CAPTR_k^{/t/} = 0 \qquad /24/$$

where:

FINVA = the available financial investment funds for the fertilizer industry

FINVR = the rest of financial funds from the previous year

CAPTR = the quantity of capital export /or import/ for fertilizer purposes

0 = coefficient to determine the ratio of capital export /only for the developed countries, exogeneous economic parameter/

The given annual actual volume of fertilizer industrial investments are calculated by functions. It is possible to give the minimum volume of investments pro nutritives and the maximum volume defined by the available funds in the function. The actual investment volume as well as its combination pro nutritives may vary between the minimum and maximum values, making also possible the formation of the rest of funds. The investment volume between the minimum and maximum values depends on fertilizer prices of the previous year:

$$FCIMI_{jk}^{/t/} = P_{jk} FEC_{jk}^{/t/} \qquad /25/$$

$$\sum_j FECI_{jk}^{/t/} \cdot r_{jk} = FINVFA_k^{/t/} \qquad /26/$$

$$FECI_{jk}^{/t/} = f \ / \ FCIMI_{jk}^{/t/}, \ FEPR_{j}^{/t-1/}, \ FINVFA_{k}^{/t/} \ / \qquad /27/$$

$$FINVR_{k}^{/t/} = FINVFA_{k}^{/t/} - \underset{j}{} \ FECI_{jk}^{/t/} \ . \ r_{jk} \qquad /28/$$

where:

$FCIMI_j$ = the minimum investment volume from nutritive j

FEC_j = fertilizer production capacity from nutritive j

$FECI_j$ = minimum of volume from nutritive j

P_j = coefficient to determine the minimum ratio for a unit of investment /exogeneous parameter/

r_j = coefficient defining the cost for a unit of investment /exogeneous parameter/

Fertilizer production capacities are annually updated by the selections because of amortization and by the investments from the previous year. The utilization of capacities depends on the starting value and the trend of utilization and it is also influenced by the fertilizer prices. So the fertilizer production is calculated from the capacities and from their utilization, the calculation does not depend on raw material /the raw materials will not be limiting factors up to the year 2000, see UNIDO International Centre for Industrial Studies 1977/. The fertilizer supply is received from the quantity, the losses are discounted:

$$FEC_{jk}^{/t/} = s_{jk} FEC^{/t-1/} + FECI_{jk}^{/t-1/} \qquad /29/$$

$$FECU_{jk}^{/t/} = f \ / \ FECU_{jk}^{/to/}, \ t \ , \ FEPR_{j}^{/t/} \ / \qquad /3o/$$

$$FEP_{jk}^{/t/} = FEC_{jk}^{/t/} . \ FECU_{jk}^{/t/} + u_k \ FEP_{jk}^{/t-1/} \qquad /31/$$

$$FESP_{jk}^{/t/} = v_{jk} FEP_{jk}^{/t/} \qquad /32/$$

where:

$FECU_j$ = capacity utilization by the production of nutritive j

FEP_j = fertilizer production from nutritive j

$FESP_j$ = fertilizer supply from nutritive j

S_j = amortization rate at the production capacity of nutritive j /exogeneous variable/

u = coefficient defining the ratio of other /not producted/ phosphates /exogeneous parameter/

v_j = coefficient defining the losses by transport and storage of nutritive j /exogeneous parameter/

The net export as well as the import of fertilizers are calculated from the difference of supply and demand. The quantity of net export and import will be equal in consequence of the counterbalance condition. The counterbalance will be realized through the fertilizer prices, though they are influenced by the exogeneous energy prices and by price supports. In order to receive the gross export-import data in the statistics and in UNIDO world model, the export within the individual country-groups should be added to the net export:

$$FENTR_{jk}^{/t/} = FESP_{jk}^{/t/} - TFED_{jk}^{/t/} \qquad /33/$$

$$\sum_k FENTR_{jk}^{/t/} = 0 \qquad /34/$$

$$FEPR_j^{/t/} = f\ /FEPR_j^{/to/},\ FESUP_j,\ EPR^{/t/} \qquad /35/$$

$$FEBTR_{jk}^{/t/} = w_{jk} FENTR_{jk}^{/t/} \qquad /36/$$

where:

$FENTR_j$ = the net export /or import/ of fertilizer from nutritive j

$FESUP_j$ = fertilizer price supports by nutritive j /exogeneous economic variable/

EPR = price index of energy sources for fertilizer industry /exogeneous variable/

$FEBTR_j$ = gross export /or import/ of fertilizer from nutritive j

w_{jk} = coefficient defining the ratio of export /import/ within country-groups /exogeneous parameter/

The model described here in a general form consists of 36 equations. The block of a country-group contains 65 equations taking into consideration the 4 food products and the 3 fertilizer products. The model consists of 124 equations in the case of 2 country-groups /developed and developing ones/ because the equilibrium requirements and price equations occur only once.

23 out of 65 equations of a country-group should be given in the form of a function the other 42 express only either certain operations between the variables or 1-2 coefficients should be given only to the equation.

There are 63 variables in the equations of a country-group from which 57 are endogeneous variables and 6 exogeneous variables /population, GNP, energy-price index, fertilizer price support/. There are yet 3o constant coefficients in a country-group block which are not changing in time, they are parameters expressed in exogeneous way, but there are 4 between them which are economic policy parameters, that is why they should be defined in an alternative way /the relations of investments in GNP, the ratio of capital export, the objectives in connection with grain stocks/.

The quantification of the model

The first phase of our quantification work was the collection of statistical time series for the years 196o-1975 concerning the endogeneous and exogeneous variables of the model with respect to the developed and developing countries and the world total separately. Data were collected for individual countries in the fields of the consumption of fertilizers, the yield of grain, the personal per capita income and food consumption as well; we did it for 2-3 occasions within the period of 15 years.

The second phase was the estimating of functions needed by the model on the basis of time series of the period 1964-1974, i.e. it was based upon 11 years time sequences. In the experimental period we had to consider several types of alternative functions and variables. Data from individual countries were applied for the calculation of functions expressing the relation between the consumption of fertilizers and the yield of grain as well as the relation between the per capita income and the food consumption. Two criteria were taken into consideration when making our choice among different alternative functions:

1. the function must reflect appropriately the factual values of the base period 1964-1974

2. the function should result in a reasonable prognosis for the forecast period /by the substitution of data from advanced countries/. Accordingly, for example, the consumption of cereals, meat, milk and eggs were described by different types of functions in a proper way with regard to the developed or developing countries.

The third phase was the creation of simultaneous equations on the ground of the functions previously described. The individual equations were grouped according to their blocks as well, i.e. whether they were contained by a recursive, a simultaneous or postsimultaneous ones.

The fourth phase was meant by the estimation of factual values of the base period of 1965-1974 years with the help of all simultaneous equations effecting as a simulator. It was carried out in the following way: first, the annual ones were calculated independently /started with the factual values of the previous year/ and this was followed by the calculation of the sequence of years /started with the factual values of 1964 year/. The model was not applied for the purpose of prognostics until it has resulted in satisfactory estimation for the base period.

The fifth phase was the application of the simulation model for prognostics of the years 1975-2ooo.

Our greatest intention was to solve the model in simultaneous way. At first we didn't succeed in the formation of price-equations being capable of providing dynamic counterbalance within the system for a long period of 25 years where conditions seem to vary too often. That was why the price-equations were neglected and simultaneous equations were solved in recursive way and the counterbalance was established by the final calculation of variants where some role was assigned to the counterbalancing effect of grain and fertilizer stocks as well. The prognosis-alternatives A-E of the following chapter were based on recursive solutions of this type.

Some simplifications were allowed compared with the primary description of the model. As the program available for us was not able to operate with inequalities, limitations on the financial funds of investments in fertilizer industry as well as the capital export were disregarded. Because of the imperfectness of price equations the price support of fertilizers was not considered either. The lack of data concerning fertilizer production capacities made it impossible for us to define the degree of utilization as a function of price, thus the production capacity was handled in an exogeneous way. The forming export surplus /the quantity above import/ was considered to increase stock in the cases of grain and fertilizer and that's why grain stocks in the case of increase differ from the ones in the computer output list.

The analysis of the five scenarious resulted in the simultaneous solution as well, where the prices of fertilizers and grain are defined by the model. As respects the results of the scenarios - except the prices, they do not differ essentially from the ones of the recursive solutions and consequently, they will be represented only in the form of examples.

ALTERNATIVE PROGNOSES

The results of our prognostic activity will be presented in the following chapters in the form of written evaluation and tables enclosured. In order to interprete the results properly some information is needed:

1. The Grouping of Countries: The following countries and territories were enlisted into the group of developed countries: USA, Canada, Western-Europe, Eastern-Europe, the Sowjetunion, Japan, the South Sea Islands /Australia, New-Zealand etc./. The following continents belong to the category of developing countries: Asia /except Japan/, Africa, Latin-America. Thus our grouping somewhat differs from the standard regional groups of UNO but it seems to be more reasonable for the purpose of fertilizers. The same categories were used in Mr. Ewell's study /R. Ewell 1976/ as well.

2. The Concept of Grain: All kinds of grain crops are understood by the concept of grain, allones registered and accumulated by the statistical year-books of FAO. Therefore food grain includes rice as well, while feed grain contains maize; and the category of grain includes both food and feed grain.

3. The Concept of Fertilizers: Fertilizers are meant by their effective substance, according to this N is the effective substance for nitrogen, P_2O_5 for phosphate and K_2O for potassium.

4. The Character of Prognoses: our intention was to provide a consistant, so called "counterbalancing" prognosis in each case. They are in accordance with each other from three points of view /it is only partially true in the case of scenario E/. They are as follows:

- an accordance in time: the prognosis started with data from 1974-1975 years and is annually calculated up to 2ooo year /however, results are published for every five years only/,

- an accordance in place: prognoses considering the groups of developed and developing countries are in accordance with regard to the grain and fertilizers export and import,

- an accordance in economic spheres: the growth of population and the development of economy, the grain production and consumption, the fertilizer production and consumption are accorded with one another within the country-groups.

5. The Alternatives of Prognoses: the calculation of prognoses was carried out in some versions. The alternatives are connected with different presumptions for the future; one group of alternative presumptions is considered to form one "scenario", or one future "image". The results of prognoses with the further scenarios are described in the followings:

Scenario A: a moderate growth rate of population and economy and the presumption of unchanged /for the year 1976/ world market prices of grain and fertilizers.

Scenario B: a more intensive growth rate of population and economy, a moderate rise in world market prices of grain /1 % per year/.

Scenario C: a more intensive growth rate of population and economy, and the developing countries increase their cultivated area.

Scenario D: a more intensive growth rate of population and economy, the developed countries have increased the grain yield instead of increasing the cultivated area, there is a rise in world market prices of fertilizers /2 % per year/, the utilization of productive capacity is increased to some extent as well.

Scenario E: a more intensive growth rate of population and economy: higher grain yield than in the developed countries, though the efficiency of the utilization of fertilizers is reduced.

One part of the individual scenario-elements /like the growth of economy and population forms a version of different prognoses from the point of view of demand on grain /an indirect demand on fertilizers/ while the other ones like the rate of growth of cultivated land and grain yields do the same from the point of view of grain production /a direct demand on fertilizers/, and the rest /the world market prices of fertilizers, the percentage of the utilization of productive capacity/ operates from the point of view of fertilizer production.

The above scenarios result in an ever increasing fertilizer consumption and according to this in an ever increasing fertilizer production as well. The fertilizer consumption and production of Scenarios E and D have reached the level forecast in the study of UNIDO /UNIDO International Centre for Industrial Studies 1976/. The trade of fertilizer between developing and developed countries does not show an increase accordingly to the letters of the alphabet for a greater extent of equalization can be observed within the country-groups between fertilizer consumption and production.

The results of prognoses belonging to the first scenario, Scenario A will be discussed in details so that the way of calculations, the reasons for the results could easily be understood. When presenting the results of the rest of scenarios we stressed the essence, the difference among them, therefore they are discussed in a shorter way. By the end of evaluation a table will be given including the most characteristic features of prognoses belonging to the individual scenarios.

Scenario A /Basic/

It is characterized by a moderate growth of population and economy, unchanged world market prices.

The Factors of Grain Consumption

Taking into consideration the number of population the basic scenario had the lowest variant. This prognosis corresponds to the "medium" variant defined by Population Division of UNO in 1975, and at the same time it is considered to be the more reasonable one because the latest prognosis published in Monthly Bulletin of FAO in March, 1978 contained a variant close to the above one. By this version, the annual development rate in developed countries - o,8 % in the years 197o-1975 - will be reduced to o,6 % by the years 1995-2ooo, and the same in developing countries will be reduced from 2,3 % to 1,9 %. Accordingly, the total population of the world will increase from 4 milliard in 1975 up-to 6,25 milliard by the year 2ooo.

In the field of the economic growth we had the lowest variant again in the basic scenario. This variant takes into account the moderate rate of growth of gross output /GNP/ for each year. The annual rate of growth in developed countries - 5,3 % in the years 197o-1975 - will be reduced to 3,8 % by the years 1995-2ooo, while in developing countries it will be reduced from 6,1 % to 4,4 %. Accordingly, the gross output of the world - in the value of 3886 milliard dollars in 1975 - will be exactly three-times more by the year 2ooo /based upon the value of dollar in 197o/.

"Individual consumption expenses" were considered to be the per capita income of the population. This name occurs in FAO Commodity Projection as well. Its relation within GNP had a fairly constant value, 59 per cents in developed countries and 7o per cents in developing countries within the period 1965-1975. Therefore the per capita income was calculated from these relations from the actual value of GNP. The per capita personal income was deduced by simple division not considering the interrelations of the growth rate between the population and economy. Accordingly, the per capita personal income will increase from 1749 $ of the year 1975 to 4274 $ by the year 2ooo in developed countries, while in developing countries from 155 $ up to 319 $. With regard to the great importance of these index-numbers some comparisons were made with other authors' prognoses as well. Blakeslee-Heady-Framingham in their publication entitled: "World Food Production, Demand and Trade" /Iowa State Univ., Ames 1973/ provided their prognoses for 96 countries individually. On the basis of this work the index-numbers of personal income in the "medium" version related to the year 196o are represented by the following data in percentage /with the exception of China/:

	1985	2ooo
developed countries	235	345
developing countries	165	213
world total	186	249

In the case of our prognosis these index-numbers - related to the year 196o - are as follows:

	1985	2ooo
developed countries	273	452
developing countries	2o9	31o
world total	216	311

According to our prognosis, the growth rate of personal income is more intensive, but the two kinds of prognoses do not differ essentially, both are acceptable.

With the help of the forecast values of personal income the per capita consumption of cereals, meat, milk, and eggs were calculated in the recent paper. We made use of the consumption by quantified functions for both country-groups and time series.

The consumption of cereals /including rice/ is reduced heavily in parallel with the increase of personal income: the consumption of 156 kg in 1975 will become to 57 kg by 2ooo. This reduction may seem a bit extreme but its reality is proved by the fact that the per capita cerals consumption in the USA, in 197o amounted to 65 kg, while the per capita personal income was approximately 3ooo $. However, the cereals consumption will increase in the developing countries up to the year 2ooo: the consumption of 133 kg will amount up to 158 kg by 2ooo, the rate of changes is not extremely intensive but will increase up to the present consumption rate by developed countries.

The meat consumption increases to a great extent in the developed countries: from the level of 79 kg in 1975 up to 133 kg by 2ooo. This level of consumption can be observed now only in Australia and New-Zealand, but the one in the USA is close to it. Meat consumption even in the developing countries has an increasing tendency; it rises from the annual volume of 14 kg in 1975 up to 26 kg by 2ooo, though an important lag is apparent compared with the one of the developed countries.

The milk consumption /including milk products corresponding in value to milk/ was considerable in developed countries even in 1975 - 333 kg per head - and this will increase up to 426 kg per head by 2ooo. This consumption level has been reached by some European countries recently, for example by the Scandinavian countries: Moreover, there are two countries overcoming essentially this consumption level /in Finland and in New-Zealand the per capita consumption of milk and milk products varies between 6oo-7oo kg/.

The egg consumption in developed countries will increase from 13,4 kg in 1975 up to 2o,4 kg per head by 2ooo. The egg consumption in the USA, New-Zealand and Israel is about this level. This consumption will increase from 2,4 kg in 1975, up to 4,2 kg by 2ooo in developing countries.

The per capita /food and feed/ grain consumption was calculated from the consumption of the four above mentioned food products by the following index-numbers taking into consideration the modificative effect of changes in grain prices as well. /These index-numbers were deduced from the factual values of the years 1964-1974/:

	developed countries	developing countries
cereals	1,1	1,2
meat	2,1	3,o
milk	o,7	1,2
eggs	3,o	4,o

In developed countries the per capita consumption of grain was 582 kg in 1975; this will increase up to 7o3 kg by 2ooo because of the rise in grain demand. The grain consumption in developed countries increases from 249 kg in 1975, up to 354 kg by 2ooo. In this way the world total consumption of grain in 1975 - 341 kg - increases up to 391 kg by 1985 and up to 427 kg by the year 2ooo. Therefore our prognosis is in accordance with the forecast in Mr. Sanderson's study. This is shown by the following comparison:

	World total consumption of grain, kg per head		
	197o	1985	2ooo
Sanderson	333	392	45o
Mészáros, Scenario A	335	391	427

The total consumption is calculated by the multiplication of the above values and the number of population. Therefore the world total consumption of grain was 1353 million metric tons in 1975. This value will increase up to 1883 million by the year 1985 and 2672 million metric tons by 2ooo. The estimation for the year 1985 is in correspondence with the prognoses of other sources available for us:

	World total consumption of grain, millions of metric tons
	1985
FAO	1725
USDA/ERS	177o
Sanderson	1894
Mészáros, Scenario A	1883

It should be noted that the above value of grain consumption was calculated on the basis of unchanged world market prices from the year 1976 in the basic scenario. The average world market price of grain /the weighted average of wheat, rice, and maize, etc./ amounted to 71 $ per ton in 197o, it increased significantly from the year 1973 and it reached the maximum value of 17o $ per ton in 1974 and decreased to a lower level by 1976. In accordance with this the unchanged price for this period had the value of 13o $ per ton.

The Factors of Grain Production /fertilizer consumption/

The volume of cultivated area of the world amounted to 15o6 million hectares; it was increased by 85 million hectares in the period of 1o years. The volume of cultivated area in 1975 was assumed to be unchanged in developed countries in the basic scenario as previous calculation versions had shown that the increase of the volume of cultivated area would result in an extra surplus of grain - under the conditions of the presumed growth rate of population and economy. On the contrary we had to take into account the increasing tendency of expanding the cultivated land in developing countries and that is why the volume of cultivated area of the world amounts to 1893 million hectares by the year 2ooo. This value does not approach to the volume of potential cultivated area of the world amounting to 31oo-36oo million hectares /D. Norse 1976; J.De Hoogh, M.A. Keyzer, H. Linnemann, H.D.J. Van Heemst 1977/. This increasing rate of cultivated area is fixing the 9,5 % of the investment funds of national economy. The cost of taking into cultivation per hectare amounts to 12oo $ /G. Galoppin 1974/.

The proportion of grain land to the total volume of cultivated land is described in the model by equations which defined the given annual proportion of grain land and grain prices from the previous year. As the grain prices were presumed to be constant ones in the basic scenario, consequently, the proportion of grain land increased only very little; in developed countries the growth rates are: 44 % in 1975 and 46 % by 2ooo; while in the case of developing countries: 54 % in 1975 and 53 % by 2ooo.

By calculating grain yields the continuation of tendencies having their validity for the years 1964-1974 was observed in the forecast period in our basic scenario. In developed countries the growth of grain yield is 14,4 kg, and in addition 13 kg annual trend effect was calculated for the increase of 1 kg mixed fertilizer effective substance, while in developing countries the efficiency of fertilizer application was 13,6 kg, and the annual trend effect amounted to 8 kg. Thus the grain yield in developed countries will increase from 2,25 tons per hectare in 1975 up to 3,85 tons per hectare by the year 2ooo, and in developing countries it will increase from 1,53 tons up to 2,5o tons per hectare. The prognosis in Mr. Ewell's study /R. Ewell 1976/ somewhat differs from the above mentioned value because in his opinion the grain yield will be 5,2 tons per hectare by the year 2ooo and the value of 3,67 tons per hectare will be reached by 1985 as to the developed countries. This has only little probability according to the present trend, all the more because there are only 7 years left up to the year 1985. In case of developing countries Mr. Ewell seems to have a pessimistic prognosis; they will reach the value of 1,97 tons per hectare only by the year 2ooo.

The total grain production of the world increases above the doubled value of the one in 1975 by the year 2ooo. The estimated volume of grain production is essentially more than the one in Mr. Ewell's prognosis, who presented an essentially lower proportion of grain land:

	World total grain production, million metric tons				
	198o	1985	199o	1995	2ooo
Ewell	1575	1745	1914	2o84	2253
Mészáros, Scenario A	1678	1914	2173	2469	2817

The grain production forecast by us makes possible for the trade of grain to develop in a proper manner. The net /between developed and developing countries/ grain export and import respectively, will increase from 49 and 43 million tons in the year 1975 up to 216 million tons by the year 1995, and it will decrease a little - in connection with the growth rate of grain production in developing countries - by 2ooo.

Besides, the forecast grain production grain stocks will increase significantly in developed countries as well. Though the earlier high level of stock will be reached by 199o only, in the following decade stocks will have a considerable increase amounting to 644 million tons by the year 2ooo. This represents the two-thirds of the annual consumption in developed countries; this volume of stock is sufficient for 8 months and thus it contributes to the safety of food provision for the world significantly. The stock in developing countries seems to be unchanged and on a low level which can be understood because of their import demand.

The fertilizer consumption per hectare was calculated in the model from quantified functions on the basis of factual values in the period 1964-1974. In these functions the value of fertilizer consumption per hectare is deduced from the relation of grain yield to the fertilizer grain prices in the case of each nutritive. In order to reach increase in 1 ton of grain yield the following quantities of effective substance were needed in developed countries: 27,o kg N, 11,5 kg P_2O_5 and 13,5 kg K_2O; it totals up to 52 kg mixed effective substance. As the level of significancy of the coefficients was very high and the earlier calculations based on data from individual countries did not resulted in essential non-linear effects, these coefficients of fertilizer demand were applied for the period of prognosis in the basic version. According to our prognoses the application of mixed effective substance will increase from the annual value of 92 kg per hectare in 1975 up to 164 kg per hectare by 2ooo, the 1:o,65:64 NPK-relation will change into a 1:o,56:o,57 one on developed countries. Thus the application ratio of nitrogen will increase. In developing countries the annual application of effective substance will increase from 25 kg per hectare in 1975 up to 8o kg per hectare by 2ooo; the annual NPK-relation 1:o,39:o,23 will change into 1:o,42:o,26.

The total fertilizer consumption will be the following takint into account the above-mentioned values. The world consumption of nitrogen will increase from 4o million tons in 1975 up to 11o million tons by 2ooo; the world consumption of phosphate will increase from 23 million tons up to 54 million tons and, potassium from 2o million tons up to 45 million tons. In the study of UNIDO on fertilizers /UNIDO International Centre for Industrial Studies 1976/ an essentially higher fertilizer consumption was forecast: 165 million tons of nitrogen, 76 million tons of phosphate and 66 million tons of potassium. On one hand this surplus can be explained by their presuming a non-linear /quadratic/ relation between the number of population and the fertilizer consumption. On the other hand, the comparison with the values of Mr. Ewell's study shows that the difference comes rather from the different forecast grain yield than from the different relation of fertilizer grain. This can be observed mainly in the case of developed countries. He has forecasted the volume of grain yield reached by the application of fertilizer forecast for 1985 as we did for the year 2ooo:

	Grain yield	N	P_2O_5	K_2O
	tons per hectare	application kg per hectare		
Ewell, 1985 Developed countries	3,67	76	42	42
Mészáros, 2ooo Developed countries	3,85	77	43	44

It must be mentioned that reaching the value of grain yield 3,67 tons per hectare by the year 1985 seems to be critical according to the values of the last 15 years.

In order to have more possibilities for comparison the prognosis of Blakeslee-Heady-Framingham will also be presented. This one does not contain values concerning China. However, even including these data this prognosis approaches to our one:

Fertilizer consumption in 2ooo,
million tons

	Version A /2:1:1 NPK relation/			Version B /1:1:1 NPK relation/		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Developed countries	45,5	32,8	28,1	36,5	37,3	32,7
Developing countries	12,2	6,7	4,9	1o,7	7,5	5,7
World total	57,7	39,5	33,1	47,2	44,8	38,4

It must be noted here as well that the calculation of fertilizer consumption was carried out assuming unchanged world market prices of fertilizers from 1976 on, in the basic scenario. Fertilizer prices between 1973-1975 had the same price relations as grain prices, and they reached the normal level by 1976. From this time on we calculated the following prices of effective substance: 25o $ per ton in the case of nitrogen, 2oo $ per ton with phosphate and 12o $ per ton with potassium.

The Factors of Production and Trade of Fertilizers

The fertilizer productive capacity. Values of the productive capacities of fertilizers for 1975 will be published on the basis of data of Commission on Fertilizers /Commission on Fertilizers 1976/, with the exception of phosphate where the values of the wet process are included only.

The productive capacities of 1975 year were increased by the investments and decreased by 3 % value of annual amortization rate in the period of prognosis. The volume of investments is described in the model by equations calculating the given annual volume of investments as a function of the volume of investments and the fertilizer prices from the previous year. These functions were quantified on the basis of factual values of the period 1964-1974. The world market prices of fertilizers - as we have mentioned before - are unchanged in the basic scenario but compared with the period 1964-1974 they are on a higher level. Thus both in the developed and developing countries a gradual development of productive capacities takes place in the case of all 3 nutritives in the period of prognosis. The nitrogen productive capacity of the world will increase from 75 million tons in 1975 up to 131 million tons by the year 2ooo, the phosphate productive capacity from 48 million tons up to 68 million tons and the potassium one from 31 million tons up to 75 million tons. The development of fertilizer productive capacities had the following values of the estimated investment funds of their economy in the period 1964-1974: o,8 % in developed countries and 2,3 % in developing ones. Concerning these relations in the period of prognosis, there is some shortage in financial funds in the first 6 years, but later on a considerable residue is formed from the investment funds of fertilizer industry. This will mean the accumulation of funds of 9-lo years by 2ooo /it means in the form of investment costs 1ooo $ per ton for nitrogen, 6oo $ per ton for P_2O_5, and 2oo $ per ton for K_2O/.

The satisfaction of a relatively low level of fertilizer consumption of the basic scenario needs only a relatively low productive capacity utilization. The N-productive capacity utilizations reach 86 % in developed countries and 83 % in developing ones by 2ooo. There is a lower rate of phosphate capacity utilization: 8o % and 78 % respectively. The utilization of potassium productive capacity seems to be 66 % in developed countries and 97 % in developing ones /assuming a constant capacity utilization in case of potassium, and an increasing one in cases of nitrogen and phosphate/.

Fertilizer production is determined by the extent and utilization of productive capacities. In case of phosphate the production of raw phosphate is added. The cost of its direct application shares 4,5 % of the application of finished phosphates in developed countries and 6 % in developing ones. In this way the N-production of the world will increase from 42 million tons in 1975 up to 112 million tons by 2ooo, that is almost three times more. The phosphate production will increase from 24 million tons in 1975 up to 56 million tons, and the potassium production from 2o million tons up to 5o million tons by the year 2ooo. The increase in production amounts to 2,5 times in cases of phosphate and potassium. The volume of world fertilizer production equals approximately the one of consumption.

The net export/import of fertilizers can be calculated as the difference between the consumption and production of fertilizers in a given country-group reducing the losses. In case of nitrogen 5,%, phosphate 4,3 % and potassium 8,3 % was the loss and the utilization for other purposes calculated on the basis of data obtained from FAO. The necessity of equality of net export-import /between the country-groups/ was prescribed, and the stock was increased by the occasional surplus. Thus the net export of nitrogen will increase from 4,6 million tons in 1975 up to 28,1 million tons by 2ooo, i.e. the measure of increase is above six times. The net export of phosphate increases more slowly, from 1,9 million tons up to 6,7 million tons. The net export of potassium shows a dynamic increase of 13,6 million tons as well by the year 2ooo.

The gross export-import of fertilizers involves the trade between the individual country-groups as well. These values were deduced from net export-import by estimating the net-gross relations and their trends in the period of 1964-1974 years and were used as a basis for the period of prognosis. Gross values first of all in developed countries differ essentially from net ones for there is a considerable trade activity among the countries. In the group of developed countries first of all the export of potassium is significant it totals up to six times more than the volume of its net export. The gross export of nitrogen and phosphate to some extent overcomes only the values of net export.

Certain quantity of fertilizer stock has been accumulated while counterbalancing dynamically between the net export-import and the consumption and production among the individual country-groups. Its volume is not considerable; it will amount to the value of one year's production by 2000 in developed countries.

Scenario B

It is characterized by a more intensive growth rate of population and economy, and a rise in world market prices of grain.

In the case of the number of population the "intensive" growth rate was defined as a slightly decreasing one in developed countries /from 0,8 % to 0,75 %/ and as a constant one - 2,4 % per year - in developing countries. Thus the population of the world would have an increase from 6,25 milliard inhabitants calculated in the basic scenario up to 6,52 milliard inhabitants by the year 2000.

The growth rate of economy was considered to be "intensive" when the growth rate of GNP had a constant increase amounting to 5 % in developed countries and to 6 % in developing ones.

According to the previous presumptions a change can be observed by the year 2000 in per capita personal income as it follows:

	Scenario A	Scenario B	Index
Developed countries	4274	4896	115
Developing countries	319	367	115

The expected greater demand on grain was supposed to counterbalance with grain production by the rise in world market prices of grain. An annual 1 per cent of rise in prices was presumed, thus the price of grain in 1976 - 13o $ per ton - amounted to 165 $ per ton by 2ooo.

The more intensive growth rate of population and economy - in spite of the rise in world market prices of grain - resulted in an increase of the world total consumption of grain by 2ooo; it increased from 2672 million metric tons of the basic scenario up to 2889 million metric tons.

Under the influence of an intensive growth rate of economy and a rise in prices of grain, the production of grain increases too, as a result of a moderate increase in grain yield and in the rate of cultivated area. Therefore the total world grain production will increase from 2817 million metric tons of the basic scenario to 2975 million metric tons.

The more intensive grain production causes an increase in fertilizer consumption by 2ooo as well /million tons of effective substance/:

	N	P_2O_5	K_2O
Scenario A	11o	54	45
Scenario B	115	56	48

This rate of fertilizer consumption can be satisfied by the productive capacities and the percents of utilization mentioned in Scenario A, and only the accumulation of fertilizer stocks have a moderate increase. However, the increase in fertilizer consumption will lead to a further increase in net export-import of fertilizers. In case of nitrogen it will reach 31,6 million tons, in case of phosphate 8,3 million tons and in case of potassium 15,1 million tons by the year 2ooo. Naturally, the values of gross export will increase accordingly.

Scenario C

It can be characterized by a more intensive growth rate of population and economy, an increase of cultivated area even in developed countries.

Presumptions concerning population and economy are the same as in Scenario B.

The counterbalance of grain production and consumption is intended to be realized by the increase of cultivated area even in developed countries and not by the rise in world market prices of grain. Cultivated area in developed countries increased from 658 million hectares in 1964 up to 694 million hectares by 1974. This increase of cultivated area fixed approximately o,8 per cents of the annual investment funds of national economy. Only the half of this value was accepted in Scenario C for the period of prognosis, thus their cultivated area will amount to 8o4 million hectares by 2ooo.

The increase of cultivated area results in a higher production of grain than the rise in grain prices in Scenario B. The world total production of grain amounts to 3o49 million metric tons by 2ooo.

Accordingly, grain stocks will also increase considerably in developed countries, especially during the following 1o years. This will increase up to 1149 million tons by 2ooo, that is to more than one year's grain consumption of the developed countries.

This causes an increase in the world total consumption of fertilizers increasing up to the following values /million tons effective substance/ by 2ooo year.

	N	P_2O_5	K_2O
Scenario A	11o	54	45
Scenario B	115	56	48
Scenario C	12o	59	5o

In order to satisfy this rate of fertilizer consumption, the utilization of N productive capacities should be increased in developed countries in relation to Scenarios A and B reaching 88 per cents of the utilization by the year 2ooo.

The values of net export-import of fertilizers can be found between the forecast values of Scenarios A and B.

Scenario D

It can be characterized by a more intensive growth rate of population and economy, a more intensive grain yield.

Presumptions concerning population are the same as in Scenario B.

The counterbalance of grain production and consumption is assumed to be realized by a more intensive, fast growth rate of grain yield in developed countries in relation to the basic scenario /but neither by increasing the cultivated area, nor by a rise in world market prices of grain/. For this purpose the parameter of fertilizer efficiency was left unchanged but the trend-coefficient was given a higher value, namely an annual increase of 27 kg instead of 13 kg supposing a faster wide-spread use of scientific achievements. /The value of

27 kg was calculated from the results of analysis of relations in each country./ It resulted in a possible maximum growth rate of grain yield, namely, the yield of 5,2 tons per hectare - that is Ewell's calculation - can be reached 3-4 years earlier.

	Grain yield in developed countries /tons per hectare/				
	198o	1985	199o	1995	2ooo
Scenario A	2,79	3,o7	3,33	3,59	3,85
Scenario D	3,48	4,o6	4,57	5,o6	5,54

This fast increase in yield - supposing an unchanged proportion of area - causes a higher increase in grain production compared with the ones of other scenarios. The world total production of grain is supposed to amount to 3321 million metric tons by 2ooo year leading also to a considerable increase in grain stock in developed countries. Grain stocks sufficient to satisfy the demand on grain for 8 years are supposed to accumulate in developed countries by 2ooo. This can be accepted as a reasonable thing only in that case if the greater part of it would be distributed to the developing countries in the form of an assistance in the period of 1976-2ooo years /above the consumption defined on the basis of income/.

Considering fertilizer consumption its level approximately equals the one estimated in the study of UNIDO:

	Fertilizer consumption of the world in 2ooo /million tons of effective substance/		
	N	P_2O_5	K_2O
UNIDO	165	76	66
Mészáros, Scenario D	137	64	57

It must be noted that the consumption levels per hectare are approaching to each other as far as the cultivated area estimated by Ewell is used for reference basis.

In order to satisfy this level of fertilizer consumption an annual rise of 2 per cents was needed in the world market prices of fertilizers. Therefore the following prices are expected by 2ooo: the price of nitrogen amounts to 4o2 $ per tons, the same with phosphate will be 322 $ per tons and with potassium it increases up to 193 $ per tons. These prices are almost equal the factual ones of 1975.

Besides, a more effective utilization of productive capacities is also required. The world average of capacity utilizations amounts to 97 % for nitrogen, 86 % for phosphate and 76 % for potassium by the year 2ooo.

Under these conditions the world total production of fertilizers are as follows by the year 2ooo: 143 million tons of nitrogen, 68 million tons of phosphate, 73 million tons of potassium.

With regard to the fact that the fertilizer production in developing countries is approaching more closely to the increase in consumption in this scenario, lower values for the net export-import of fertilizers that is lower values for the trade between the developing and developed countries can be defined as the ones in the above scenarios. Moreover, this scenario results in a moderate decrease in net export-import for phosphate.

Scenario E

It can be characterized by an intensive growth rate of population and economy, a faster increase in grain yield and some decrease in the efficiency of fertilizer application in developed countries.

Presumptions for population and economy are the same as in Scenario B.

The grain yield of developed countries was calculated also by the trend-coefficient of 27 kg annually, but considering the higher grain yields and the rate of fertilizers respectively, the efficiency of fertilizer application was reduced: a value of lo,8 kg for efficiency of fertilizer application was accepted, that is the 75 % of the basic coefficient. In accordance with this fact the quantity of nutritives needed for 1 ton of grain yield was increased by 25 per cents in equations /System Control Inc. 1977/. The decrease in the efficiency of fertilizer application caused a somewhat lower grain yield than the one in Scenario D: 5,14 tons by 2ooo. This value approximately equals the value estimated by Ewell.

Accordingly, a lower level of accumulation of grain stocks can be observed than in Scenario D, equalling the consumption of 5-6 years in developed countries by 2ooo.

The decrease in the efficiency of fertilizer application causes a further increase in the level of fertilizer consumption in developed countries in spite of a lower level of grain yield. Thus the world total consumption of fertilizers can be shown in the followings in the year 2ooo /million tons of effective substance/:

	N	P_2O_5	K_2O
UNIDO	165	76	66
Mészáros, Scenario D	137	64	57
Scenario E	152	7o	65

This value of fertilizer consumption approaches the most to the one in the prognosis of UNIDO.

From the point of view of fertilizer production no perfect counterbalance has been realized by the application of this model - neither applying the recursive nor the simultaneous simulations -, despite calculating a high rate of capacity utilization in the case of Scenario D, moreover, the world market prices of phosphate and potassium have been increased not by 2 but by 3 per cents annually in the case of the recursive simulation.

Naturally, this does not lead to the fact that the fertilizer consumption of Scenario E cannot be satisfied at all; it is impossible only considering the presumptions of the model. In developed countries the production of 112 million tons of nitrogen in 2ooo is satisfactory for their own consumptions, but it is not sufficient for the satisfaction of import demand in developing countries. It is on the contrary in the case of phosphate because the trade between the two country-groups has an opposite direction: developing countries produce more phosphate than it is required for their own needs and they cover the demand on phosphate of developed countries. Some surplus of potassium is produced in these countries. In order to counterbalance first of all the increase of investments in N productive capacities would be needed both in developed countries and in developing ones. It is required in the form of capital export of the latter.

Simultaneous solutions

The results of simultaneous solutions hardly differ from the ones of recursive solutions. A more significant difference can be observed in the case of variants having some influence on the counterbalance; these are the prices, the stocks, and the values of export-import. That is why these data will be published for Scenarios A, D, E.

In all three scenarios a tendency of decrease can be shown in the case of the world market prices of grain. This is in accordance with the accumulation of grain stocks in developed countries /the export surplus of developed countries was considered to increase stocks/. The decreasing prices of grain had no possibility to prevail the accumulation of stocks /that is to provide a perfect counterbalance of grain export-import/ because it is caused wholly or partially by external factors /the increases in cultivated area, in yield/. The decrease in prices reaches its highest value in that scenario where there is the greatest accumulation of grain stocks /in Scenario D the grain prices will decrease to 88 $ per ton by 2ooo, and the greatest extent of accumulation of world total grain stocks can be observed, namely, 4386 million tons. Compared with the recursive solutions there is an essentially lower accumulation of grain stocks /in Scenario D the world total grain stock would amount to 4386 million tons in 2ooo instead of the value of 7411 million tons/, that is why the counterbalance of simultaneous solution is a more perfect one.

The value of net export-import of grain are approaching to the values of recursive solutions. This amounts to 193 million tons by 2ooo in Scenario A - in cases of a moderate growth rate of population and economy - while it amounts to 47o and 471 million tons respectively, in Scenarios D and E - in cases of an intensive growth rate of population and economy.

The world market prices of fertilizers show an increasing tendency /compared with the relatively low prices in 1976/ in all three scenarios, though in the beginning or in the middle of the period of prognosis temporary decreases in prices may occur. A more intensive increase can be found in Scenario E where the world market prices will approach to or reach the high level of the year 1975 /however, they will not reach the 2 or 3 per dents of growth rate respectively, being calculated in cases of nitrogen, phosphate and potassium respectively, of the recursive solution/. This suggests that counterbalancing of fertilizer consumption and production becomes more difficult on one hand as time passed and, on the other hand in the case of the following scenarios where conditions are getting more complicated /fertilizer demands are increased/. The counterbalance in Scenario E cannot be considered as a perfect one.

In cases of net export-import values of fertilizers for simultaneous solutions differences of the values of export-import /that is the formation of stock was not considered/ were not corrected in order to see clearly how much the counterbalance was realized by the simultaneous simulation. A fairly fine counterbalance is realized in Scenarios A and D, but there is some lack in nitrogen and potassium in Scenario E by the simultaneous solution. Deduced from all three scenarios it is obvious that the trade of nitrogen will be the bigger followed by potassium and finally the smallest volume will belong to phosphate in the trade of two country-groups /that is in the net trade/. It is very interesting that in Scenario E the lack in the trade of phosphate will have an opposite direction: developing countries will export it into developed ones /naturally, this would be fully justified considering all the other conditions of the model/. It is also a remarkable tendency of the results that the volume of scenarios started from A going to E shows some decrease, that is the demand on fertilizers /fertilizer consumption/ is increasing more intensively, faster in the developed countries and more moderately in the developing ones than the fertilizer production /this is restricted again to the conditions of the model and the price elasticity of the investments of fertilizer production/.

The gross export-import values of fertilizers were calculated from the original net ones, thus they include the differences of net export-import values as well. These results will not be published in Scenario E because of the imperfectness of the counterbalance, and in the case of phosphate because of the minus values.

Summary

It was our intention to provide counterbalancing prognoses for the world total consumption, production and trade of fertilizers up to the year 2ooo. They were supposed to counterbalance from the points of view of time pattern, trade between the two country-groups and in accordance with the economic spheres being modelled. We wished to develop these prognoses in alternative ways for the cases of series of different presumptions concerning the future /scenarios/. The present paper deals only with the results of prognoses for five different scenarios, though these five scenarios were chosen in order to represent the formation of variants from the points of view of demand on grain /direct demand on fertilizers/, grain production /indirect demand on fertilizers/, and fertilizer production. Results will be summarized on the basis of values for the year 2ooo as follows:

Grain consumption /the consumption of food grain and the demand on feed grain/ is determined in the model through the personal income and the consumption of cereals, meat, milk and eggs respectively, by the growth rate of economy and the number of population. The per capita grain consumption in developed countries will amount to 7o3-717 kg depending on the growth rate of economy by 2ooo, the same one will be 354-373 kg per head in developing countries. Thus the world average consumption per head varies between 427-443 kg /this is in correspondence with Sanderson's forecast value of 45o kg/. The world total grain consumption will be 2672 million metric tons supposing a moderate growth rate of population and economy and 2892 million metric tons presuming an intensive growth rate of population and economy. This is true when supposing the world market price of grain in 13o $ per ton /this approximately equals the one in 1976/.

Grain production in the model is specified by the cultivated area, the proportion of grain land to total cultivated area, the level of grain yields. The increase in cultivated area in the period of 1964-1974 was taken as a basis for forecasting calculation in developing countries. In developed ones no increase in cultivated area was considered - with the exception of Scenario C - as it was not needed. Consequently, the world total cultivated area will increase from 15o6 million hectares in 1975 up to 1893-1923 million hectares by the year 2ooo. The proportion of grain land to the total cultivated area will be 46-48 per cents in developed countries, and 53-54 per cents in developing ones depending on the world market price of grain. A lower level 3,85-3,92 tons per hectare and a higher one /5,14-5,54 tons per hectare/ of grain yield were supposed in developed countries and the same has the value of 2,35-2,54 tons per hectare in developing countries depending on the prices of grain and fertilizers. Thus the world total grain production will vary between 2817 and 3321 million metric tons overcoming the quantities of consumption in all scenarios.

A reasonable development of the trade of grain can also be observed in the case of the grain production mentioned above. The volume of net trade, that is the trade between the developing and developed countries will amount to 19o-44o million metric tons by 2ooo depending on the various conditions of individual scenarios, whereas the value of export-import trade was 49 and 43 million tons respectively, in 1975. Beside this the model accumulates also a considerable volume of grain stock in developed countries which is justified to some extent on one hand from the point of view of security of food provision, and on the other hand grain stocks can be partially utilized for providing assistance. This purpose was not taken into account in the model. The biggest volume of grain stocks would amount to the grain consumption of 8 years in developed countries, however, it is reduced to the value of 4-5 years by the simultaneous solution.

Fertilizer consumption in the model depended on the cultivated area, the level of grain yields, the relation of world market prices of grain and fertilizers. The connections of fertilizer utilization and grain yields of the period 1964-1974 served as a basis for the period of prognosis as well - with the exception of Scenario E, where the efficiency of fertilizer application was decreased by us. An increasing consumption of fertilizers can be found in the five different scenarios in the direction of A to E. The quantity of mixed effective substance will vary from 164 to 292 kg per hectare of cultivated area by 2ooo in developed countries. The same will vary from 68 to 83 kg in developing countries; in both cases depending on the grain yields and the world market prices of grain. Thus the world total fertilizer consumption will be the following in the year:

	The quantity of effective substance, kg per hectare of cultivated area	Total effective substance, in million metric tons
N	58-79	11o-152
P_2O_5	28-36	54- 7o
K_2O	24-34	46- 65
Total effective substance	11o-149	2o9-287

In the study of UNIDO on fertilizers /UNIDO International Centre for Industrial Studies 1976/ the prognosis for fertilizers overcomes to some extent the upper limits /165 million tons of nitrogen, 76 million tons P_2O_5 and 66 million tons K_2O/.

Fertilizer production in the model depends on one hand on the world market prices of fertilizers having an influence on the development of productive capacities and on the other hand on the percentage of capacity utilizations supposing an improving tendency in time. Capacity utilizations will have the following world average values by 2ooo: 85-97 % N, 79-86 % P_2O_5, and 67-76 % K_2O depending on the various conditions of individual scenarios. The world production of fertilizer will vary as follows in 2ooo /million metric tons of effective substance/:

	Developed countries	Developing countries	World total
N	82-112	3o-4o	112-152
P_2O_5	38- 46	18-25	56- 71
K_2O	48- 71	1,5-1,7	5o- 73
Total effective substance	168-229	5o-67	218-296

In the period 1964-1974 developing countries have made use of o,8 %, and developing ones 2,3 % of their investment funds for the purpose of developing of fertilizer productive capacities. If these relations of percentage are taken into account for the period of prognosis there will be a smaller lack of financial funds in the years 1975-198o and some surplus accumulated during the last 5-1o years.

The values of the net export-import of fertilizers in the model are calculated as a difference in the fertilizer consumption and production in the case of a given country-group. Losses and utilizations for other purposes are deduced from the production having the following estimated values: nitrogen 5 %, phosphate 4,3 %, and potassium 8,3 %. The net export of developed countries and the net import of developing ones were intended to counterbalance in the solution. We did not succeed in a perfect counterbalance in Scenario E. The volume of net trade of fertilizer is bigger in the case of nitrogen in all scenarios - 17-32 million metric tons of effective substance - followed by potassium having the value of lo-15 million metric tons, and the lowest volume can be observed in the net trade of phosphate, namely o,4-8 million metric tons. It becomes apparent from the comparison of the results of the different scenarios that the volume of fertilizer trade is decreasing from Scenario B to Scenario E, that is the efforts to satisfy the increasing fertilizer consumption point rather into the direction of autarchy than to an increase of trade between the country-groups.

The gross export-import of fertilizers involves the trade between the country-groups as well, consequently, the values of developed and developing countries are not needed to be equal. The volume of gross trade in the model was deduced from the one ot net trade as follows: in the case of potassium this value is a constant index-number, in the cases of nitrogen and phosphate it is a function containing the changes of index-numbers in time as well. Thus the world total gross trade of fertilizers will vary according to the following values in 2ooo /million metric tons of effective substance, on the basis of recursive solutions of Scenarios A, B, C, D/:

	Gross export of developed countries	Gross import of developing countries
N	21,6-28,7	18,6-32,1
P_2O_5	4,4-1o,3	1,9-1o,o
K_2O	6o,7-76,2	1o,3-15,3
World total of effective substance	86,7-115,2	3o,8-57,4

The gross export of developed countries in mixed substance amounts to almost 5o % of their fertilizer production while the gross import of developing countries amounts to 5o-66 % of their fertilizer consumption.

The world total values for the year 2ooo obtained by recursive simulations of the five different scenarios are arranged in a row in the table enclosed for the purpose of the ease of availability.

World Total Values in 2000

Variables	Unit of measure	Scenarios A	B	C	D	E
I. Scenario elements:						
1. Population	million inhabitants	6253	6519	6519	6519	6519
2. GNP	milliard dollars	11790	13733	13733	13733	13733
3. Cultivated area	million hectares	1893	1923	2032	1923	1923
4. Grain yield	tons pro ha					
developed		3,85	3,92	3,85	5,54	5,14
developing		2,50	2,54	2,50	2,38	2,35
5. Capacity utilizations	%					
N		0,85	0,85	0,87	0,97	0,97
P_2O_5		0,79	0,79	0,79	0,86	0,86
K_2O		0,67	0,67	0,67	0,76	0,76
6. Grain prices	$ per ton	130	165	130	130	130
7. Fertilizer prices	$ per ton					
N		250	250	250	402	508
P_2O_5		200	200	200	322	407
K_2O		120	120	120	193	193

Variables	Unit of measure	Scenarios				
		A	B	C	D	E
II. Results of prognoses:						
1. Personal income	$ per head	1152	1289	1289	1289	1289
2. Grain consumption	kg per head	427	443	443	443	443
3. Grain production	million tons	2817	2976	3049	3321	3175
4. Grain stocks	million tons	666	581	1171	7411	5456
5. Fertilizer consumption	kg pro ha					
N		58,4	60,1	59,2	71,4	79,0
P_2O_5		28,5	29,4	29,1	33,5	36,3
K_2O		23,9	24,9	24,8	29,6	33,7
6. Fertilizer production	million tons					
N		112,0	112,0	113,9	142,8	152,0
P_2O_5		56,5	56,5	56,5	67,7	71,7
K_2O		49,7	49,7	49,7	73,0	73,0
7. Net trade of fertilizers	million tons					
N		28,1	31,6	29,6	16,8	
P_2O_5		6,7	8,3	7,3	0,4	
K_2O		13,6	15,1	13,9	10,2	

World market prices were considered exogeneous variables in the recursive simulations and only the effects of their changing could be observed. The world market prices in simultaneous simulations became endogeneous variables being annually defined by the model as counterbalance prices. The grain prices had a decreasing tendency in all scenarios and that is in accordance with the accumulation of grain stocks, and prices are supposed to be 88-122 $ per ton by 2ooo. The fertilizer prices show an increasing tendency in all scenarios /or at least to the relatively low prices in 1976/. A more intensive increase can be found in Scenario E where the world market prices of fertilizers will approach to or reach the high level of 1975 /the world market prices will be the following: nitrogen 432 $ per ton, phosphate 312 $ per ton, potassium 155 $/. It can be said that counterbalancing the fertilizer consumption and production will be more difficult on one hand as time passes and on the other hand as demand on fertilizers increases from Scenario A to Scenario E.

We had no possibility to examine the effects of all important factors in our present calculations. A more intensive examination of the effects of the following factors is recommended for further calculations:

- consideration of different possible N:P:K relations,
- other versions of fertilizer applications in developing countries,
- a more profound consideration of the effects of fertilizer investments on the world market prices,
- the effect of increasing investments of fertilizer industry in developing countries, in the form of capital export.

REFERENCES

Constructing the UNIDO World Industry Cooperation Model. /1977/ A progress report. UNIDO International Centre for Industrial Studies 24:130.

Draft world-wide study of the fertilizer industry: 1975-2ooo. /1976/ UNIDO International Centre for Industrial Studies 22:267.

Sanderson, F.H. /1977/ World Agriculture: Reassesment of trends and policies. In: MOIRA: Food and agricultural model. Proceedings of the Third IIASA Symposium on Global modelling, Sept. 22-25, 1975. G. Bruckmann, ed. IIASA, Laxenburg.

Ewell, R. /1976/ Fertilizer use and food production. UNIDO International Centre for Industrial Studies. Manuscript.

Framingham, G.F. /1974/ The world food needs of the 198o's. Canadian J. of Agric. Econ., Ottawa, 218-241.

Keyzer, M.A. /1977/ Linking national models of food and agriculture: an Introduction IIASA Research Memorandum -77-2. Laxenburg.

Reutlinger, S. /1966/ Analysis of a dynamic model, with particular emphasis on long-run projections. Journal of Farm Economics, 48:88-1o6.

Meier, R.C., Newell, W.T., Pazer, H.L. /1969/ Simulation in business and economics. Prentice Hall, Inc.

Single - year population estimates and projections for major areas, regions and countries of the world, 195o-2ooo. /1975/ Population Division, United Nations, ESA/P/WP. 56. New York.

Agricultural commodities-projections for 1975 and 1985. /1966/ FAO, Rome.

Income elasticities of demand for agricultural products. /1972/ FAO, Rome.

Income elasticities of demand for agricultural products. /1976/ FAO Draft.

Norse, D. /1976/ Development strategies and the world food problem. Journal of Agric. Econ. 1:137-158.

De Hoogh, J., Keyzer, M.A., Linnemann, H., Van Heemst, H.D.J. /1977/ Food for a growing world population. In: MOIRA: Food and agriculture model. Proceedings of the Third IIASA Symposium on Global modelling, Sept. 22-25, 1975, G. Bruckmann, ed. IIASA.

Clapham, W.V., Shook, T., Warshaw, M.V. A regionalized food model for the global system. Proceedings of the First IIASA Symposium on Global modelling, Apr. 1974, Band B: 5oo-554, Laxenburg.

Commission on fertilizers: Current situation and longer-term outlook. Third Session, 8-11. June 1976. FAO, Rome.

Annual fertilizer review 1975. /1976/ FAO, Rome.

Suarez, C.E. The long-term evaluation of the prices of energy. In: Latin American World Model. Proceedings of the Second IIASA Symposium on Global modelling, Oct. 7-1o, 1974, G. Bruckmann, ed. IIASA, Laxenburg.

On Boll Weewil Eradication, An analysis of a proposed policy using AGRIMOD. System Control Inc., 1977.

Galoppin, G. The food sector. In: Latin American World Model. Proceedings of the Second IIASA Symposium on Global modelling, Oct. 7-1o, 1974, G. Bruckmann, ed. IIASA, Laxenburg.

Allen, G.R. /1976/ Some aspects of planning world food supplies. Journal of Agric. Econ. 1:97-12o, Reading.

Commission on fertilizers, Possible price stabilization measures, Third Session, 8-11. June 1976. FAO, Rome.

Csáki C., Jónás A., Mészáros S. Modelling of centrally planned food and agricultural systems: A framework for a national policy for the Hungarian food and agriculture sector. IIASA Draft, Sept. 1977, Laxenburg.

Enzer, S., Drobnick, R., Alter, S. World food prospects. A preliminary report of the second Twenty Year Forecast Project. Prepared for a conference on Systems assesment of new technology: International Perspectives, July 1977 at IIASA, Laxenburg. Center for Future Research-Graduate School of Business Administration - Unov. of Southern California, Los Angeles.

Meadows, D.H. /1977/ A conceptual overview of agricultural models. In: MOIRA: Food and agriculture model proceedings of the Third IIASA Symposium on Global modelling, Sept. 22-25, 1975. G. Bruckmann ed. IIASA.

Mészáros S. /1972/ A műtrágyázás hatékonysága és optimumai. /Economic efficiency and optima of fertilizers./ Akadémiai Kiadó, Budapest.

Quance, L., Food and agriculture. USDA/ERS. Draft, Dec. 1976.

Quance, L., Plato, G., Smith, A. US agricultural outlook updata and projections for the West to 1985 and 2ooo. Paper for a Conference in Fort Collins, Colorado, July 1976.

Reynolds, T.M., Heady, E.O., Mitchell, D.O. /1975/ Alternative futures for American agricultural structure, policies, income, employment and exports: A recursive simulation. Iowa State Univ., CARD Report 56. Ames.

Wangh, F.W. /1964/ Cobweb models. Journal of Farm Econ. XVVI. Nov.

Womach, A. /1976/ The U.S. demand for corn, sorghum, cats and barley: An ecnoometric analysis. Univ. of Minnesota, Economic Report 76-5. St. Paul.

Blakeslee, Heady, Framingham /1973/ World food production, demand and trade. Iowa State Univ., Ames, Iowa.

APPENDIX 1: SIMULATION MODELS EQUATIONS

	Developed countries	Developing countries
1	$TINC_1^{(t)} = 0.59\ GNP_1^{(t)}$	$TINC_2^{(t)} = 0.70\ GNP_2^{(t)}$
2	$PCINC_1^{(t)} = \left(TINC_1^{(t)}/POP_1^{(t)}\right).1000$	$PCINC_2^{(t)} = \left(TINC_2^{(t)}/POP_2^{(t)}\right).1000$
3	$TINVF_1^{(t)} = 0.20\ GNP_1^{(t)}$	$TINVF_2^{(t)} = 0.15\ GNP_2^{(t)}$
4	$LINVF_1^{(t)} = a_1 TINVF_1^{(t)}$	$LINVF_2^{(t)} = a_2 TINVF_2^{(t)}$
5	$FINVF_1^{(t)} = 0.0085\ TINVF_1^{(t)}$	$FINVF_2^{(t)} = 0.0233\ TINVF_2^{(t)}$
6.1	$PCFD_{11}^{(t)} = e^{\left(26.9642-3745.61/PCINC_1^{(t)}\right)}\left[PCINC_1^{(t)}\right]^{-2.6363}$	$PCFD_{12}^{(t)} = e^{\left(5.2379-55.6923/PCINC_2^{(t)}\right)}$
6.2	$PCFD_{21}^{(t)} = -354.94+58.406\ \ln PCINC_1^{(t)}$	$PCFD_{22}^{(t)} = -49.96+13.1266\ \ln PCINC_2^{(t)}$
6.3	$PCFD_{31}^{(t)} = -363.84+94.537\ \ln PCINC_1^{(t)}$	$PCFD_{32}^{(t)} = 0.4071\left[PCINC_2^{(t)}\right]^{0.8613}$

	Developed countries	Developing countries
6.4	$PCFD_{41}^{(t)}=-38.31+7.027 \ln PCINC_1^{(t)}$	$PCFD_{42}^{(t)}=-6.67+1.8856 \ln PCINC_2^{(t)}$
7	$PCGD_1^{(t)}=\left[1.1PCFD_{11}^{(t)}+2.1PCFD_{21}^{(t)}+ +0.7PCFD_{31}^{(t)}+3.0PCFD_{41}^{(t)}\right]\cdot\left[1.1-0.1\frac{GPR^{(t)}}{GPR^{t-1}}\right]$	$PCGD_2^{(t)}=\left[1.2PCFD_{12}^{(t)}+3.0PCFD_{22}^{(t)}+ +1.2PCFD_{32}^{(t)}+4.0PVFD_{42}^{(t)}\right]\cdot\left[1.1-0.1\frac{GPR^{(t)}}{GPR^{t-1}}\right]$
8	$TGD_1^{(t)}=\left(PCGD^{(t)}\cdot POP^{(t)}\right)/1000$	$TGD_2^{(t)}=\left(PCGD^{(t)}\cdot POP^{(t)}\right)/1000$
9	$LINC_1^{(t)}=\frac{1}{1.2} LINVF_1^{(t)}$	$LINC_2^{(t)}=\frac{1}{1.2} LINVF_2^{(t)}$
10	$L_1^{(t)}=L_1^{(t-1)}+LINC_1^{(t-1)}$	$L_2^{(t)}=L_2^{(t-1)}+LINC_2^{(t-1)}$
11	$GP_1^{(t)}=L_1^{(t)}\cdot A_1^{(t)}\cdot Y_1^{(t)}$	$GP_2^{(t)}=L_2^{(t)}\cdot A_2^{(t)}\cdot Y_2^{(t)}$
12	$A_1^{(t)}=0.1073+0.7273 A_1^{(t-1)}+ +0.000144 GPR^{(t-1)}$	$A_2^{(t)}=0.5961-0.2002 A_2^{(t-1)}+ +0.000288 GPR^{(t-1)}$
13	$Y_1^{(t)}=1.04+z_{11}+z_{12}\left(\sum_j FEDH_{j1}^{(t-1)}\right)$	$Y_2^{(t)}=1.14+0.008t+0.0137\left(\sum_j FEDH_{j2}^{(t-1)}\right)$
15	$GDT_1^{(t)}=GST_1^{(t-1)}+GSTM_1^{(t-1)}$	$GST_2^{t}=GST_2^{(t-1)}+GSTM_2^{(t-1)}$
16	$GSTM_1^{(t)}=75.78-0.5287 GST_1^{(t)}- -0.1848 GPR^{(t)}+m_1GP_1^{(t)}$	$GSTM_2^{(t)}=26.24-0.6595 GST_2^{(t)}- -0.0924 GPR^{(t)}+m_2GP_2^{(t)}$
17	$GTR_1^{(t)}=0.9846GP_1^{(t)}-TGD_1^{(t)}-GSTM_1^{(t-1)}$	$GTR_2^{(t)}=-0.9846GP_2^{(t)}+TGD_2^{(t)}+GSTM_2^{(t-1)}$

19 $$GPR^{(t)}=150.0-0.3192\left[GTR_1^{(t)}-GTR_2^{(t)}\right]$$

	Developed countries	Developing countries
20.1	$FEDH_{11}^{(t)}=-24.68+26.98\ Y_1^{(t)}-$	$FEDH_{12}^{(t)}=-36.45+33.79\ Y_2^{(t)}-$
	$-\ 1.0FEPR_1^{(t)}/GPR^{(t)}$	$-\ 0.30FEPR_1^{(t)}/GPR^{(t)}$
20.2	$FEDH_{21}^{(t)}=1.50+11.47\ Y_1^{(t)}-$	$FEDH_{22}^{(t)}=-14.86+14.23\ Y_2^{(t)}-$
	$-1.5\ FEPR_2^{(t)}/GPR^{(t)}$	$-0.50FEPR_2^{(t)}/GPR^{(t)}$
20.3	$FEDH_{31}^{(t)}=-5.38+13.45\ Y_1^{(t)}-$	$FEDH_{32}^{(t)}=-8.69+9.52\ Y_2^{(t)}-$
	$-2.9\ FEPR_3^{(t)}/GPR^{(t)}$	$-2.9\ FEPR_3^{(t)}/GPR^{(t)}$
21.1	$TFED_{11}^{(t)}=FEDH_{11}^{(t)}.L_1^{(t)}/1000$	$TFED_{12}^{(t)}=FEDH_{12}^{(t)}.L_2^{(t)}/1000$
21.2	$TFED_{21}^{(t)}=FEDH_{21}^{(t)}.L_1^{(t)}/1000$	$TFED_{22}^{(t)}=FEDH_{22}^{(t)}.L_2^{(t)}/1000$
21.3	$TFED_{31}^{(t)}=FEDH_{31}^{(t)}.L_1^{(t)}/1000$	$TFED_{32}^{(t)}=FEDH_{32}^{(t)}.L_2^{(t)}/1000$
22	$FINVFA_1^{(t)}=FINVR_1^{(t-1)}+$	$FINVFA_2^{(t)}=FINVR_2^{(t-1)}+$
	$+FINVF_1^{(t)}-CAPTR_1^{(t)}$	$+FINVF_2^{(t)}+CAPTR_2^{(t)}$
23	$CAPTR_1^{(t)} = o_1 FINVF_1^{(t)}$	

24
$$CAPTR_1^{(t)}-CAPTR_2^{(t)} = 0$$

	Developed countries	Developing countries
27.1	$FECI_{11}^{(t)}=1.5688\ -$	$FECI_{12}^{(t)}=0.9000+0.0025FEPR_1^{(t-1)}$
	$-0.2274\ FECI_{11}^{(t-1)}+$	
	$+0.0121\ FEPR_1^{(t-1)}$	

	Developed countries	Developing countries
27.2	$FECI_{21}^{(t)}=1.2818 - 0.1099\ FECI_{21}^{(t-1)} + 0.0024\ FEPR_{2}^{(t-1)}$	$FECI_{22}^{(t)}=-0.1594+0.0055FEPR_{2}^{(t-1)}$
27.3	$FECI_{31}^{(t)}=-1.2944 - 0.4020\ FECI_{31}^{(t-1)} + 0.0492\ FEPR_{3}^{(t-1)}$	$FECI_{32}^{(t)}=0.0085+0.0005FEPR_{3}^{(t-1)}$
28	$FINVR_{1}^{(t)}=FINVFA_{1}^{(t)}-1.0\ FECI_{11}^{(t)} - 0.6FECI_{21}^{(t)}-0.2FECI_{31}^{(t)}$	$FINVR_{2}^{(t)}=FINVFA_{2}^{(t)}-1.0\ FECI_{12}^{(t)} - 0.6FECI_{22}^{(t)}-0.2FECI_{32}^{(t)}$
29.1	$FEC_{11}^{(t)}=0.97FEC_{11}^{(t-1)}+FECI_{11}^{(t-1)}$	$FEC_{12}^{(t)}=0.97FEC_{12}^{(t-1)}+FECI_{12}^{(t-1)}$
29.2	$FEC_{21}^{(t)}=0.97FEC_{21}^{(t-1)}+FECI_{21}^{(t-1)}$	$FEC_{22}^{(t)}=0.97FEC_{22}^{(t-1)}+FECI_{22}^{(t-1)}$
29.3	$FEC_{31}^{(t)}=0.97FEC_{31}^{(t-1)}+FECI_{31}^{(t-1)}$	$FEC_{32}^{(t)}=0.97FEC_{32}^{(t-1)}+FECI_{32}^{(t-1)}$
30.1	$FECU_{11}^{(t)} = 0.60 + 0.01\ t$	$FECU_{12}^{(t)} = 0.44 + 0015\ t$
30.2	$FECU_{21}^{(t)} = 0.54 + 0.01\ t$	$FECU_{22}^{(t)} = 0.42 + 0.014\ t$
30.3	$FECU_{31}^{(t)} = 0.76$	$FECU_{32}^{(t)} = 0.97$
31.1	$FEP_{11}^{(t)}=FEC_{11}^{(t)}\ .\ FECU_{11}^{(t)}$	$FEP_{12}^{(t)}=FEC_{12}^{(t)}\ .\ FECU_{12}^{(t)}$
31.2	$FEP_{21}^{(t)}=FEC_{21}^{(t)}\ .\ FECU_{21}^{(t)} + 0.045\ FEP_{21}^{(t-1)}$	$FEP_{22}^{(t)}=FEC_{22}^{(t)}\ .\ FECU_{22}^{(t)} + 0.06\ FEP_{22}^{(t-1)}$

	Developed countries	Developing countries
31.3	$FEP_{31}^{(t)} = FEC_{31}^{(t)} \cdot FECU_{31}^{(t)}$	$FEP_{32}^{(t)} = FEC_{32}^{(t)} \cdot FECU_{32}^{(t)}$
33.1	$FENTR_{11}^{(t)}=0.950FEP_{11}^{(t)}-TFED_{11}^{(t)}$	$FENTR_{12}^{(t)}=TFED_{12}^{(t)}-0.950\ FEP_{12}^{(t)}$
33.2	$FENTR_{21}^{(t)}=0.957FEP_{21}^{(t)}-TFED_{21}^{(t)}$	$FENTR_{22}^{(t)}=TFED_{22}^{(t)}-0.957\ FEP_{22}^{(t)}$
33.3	$FENTR_{31}^{(t)}=0.917FEP_{31}^{(t)}-TFED_{31}^{(t)}$	$FENTR_{32}^{(t)}=TFED_{32}^{(t)}-0.917\ FEP_{32}^{(t)}$

35.1 $$FEPR_1^{(t)}=6.53+59.59EPR^{(t)}-35.0\left[FENTR_{11}^{(t)}-FENTR_{12}^{(t)}\right]-FESUP_1^{(t)}$$

35.2 $$FEPR_2^{(t)}=49.87+65.35EPR^{(t)}-53.56\left[FENTR_{21}^{(t)}-FENTR_{22}^{(t)}\right]-FESUP_2^{(t)}$$

35.3 $$FEPR_3^{(t)}=42.97+8.41EPR^{(t)}-16.23\left[FENTR_{31}^{(t)}-FENTR_{32}^{(t)}\right]-FESUP_3^{(t)}$$

	Developed countries	Developing countries
36.1	$FEBTR_{11}^{(t)}=1.50+0.98FENTR_{11}^{(t)} + 0.14\ t$	$FEBTR_{12}^{(t)}=0.25+0.92FENTR_{12}^{(t)} + 0.0766\ t$
36.2	$FEBTR_{21}^{(t)}=1.02+0.82FENTR_{21}^{(t)} + 0.12\ t$	$FEBTR_{22}^{(t)}=0.06+1.02FENTR_{22}^{(t)} + 0.0392\ t$
36.3	$FEBTR_{31}^{(t)} = 5.95\ FENTR_{31}^{(t)}$	$FEBTR_{32}^{(t)} = 1.0070\ FENTR_{32}^{(t)}$

List of variables and parameters of the model

POP	=	population
GNP	=	gross national product
TINC	=	total personal income of the population
PCINC	=	per capita income of the population
TINVF	=	total yearly investment funds
LINVF	=	annual investment funds for taking land into cultivation
FINVF	=	annual investment funds in fertilizer industry

a	=	proportion of annual investment funds in agriculture
b	=	proportion of investment funds in fertilizer industry
$PCFD_i$	=	per capita demand on food products
PCGD	=	per capita demand on grain /consumption/
TGD	=	total demand on grain /consumption/
GPR	=	world market prices of grain
c_i	=	index number of demands on grain and food products
d	=	price elasticity of grain demand
e	=	index number of needs in seed
L	=	cultivated area
LINC	=	taking into cultivation of a new area
f	=	cost of taking one hectare of land into cultivation
g	=	annual decrease of cultivated area because of urbanisation activities
GP	=	grain production
A	=	proportion of grain land to cultivated area
Y	=	grain yield
GSP	=	grain supply
GST	=	grain stocks
GSTM	=	changes in grain stocks
h	=	loss of storage
m	=	economic policy purposes in connection with modifications of grain stocks
GTR	=	/net/ export-import of grain
$FEDH_j$	=	fertilizer demand /consumption/ on one hectare cultivated land
$TFED_j$	=	total fertilizer demand /consumption/
$FEPR_j$	=	world market prices of fertilizers
n	=	index-number of fertilizer consumption for non-agricultural purposes
FINVA	=	available investment funds in fertilizer industry
FINVR	=	residue of the funds from the previous year
CAPTR	=	capital export-import for fertilizer industry
o	=	parameter defining the relation of capital export /for developed countries only/
FEC_j	=	fertilizer capacities
$FECI_j$	=	volume of investment

$FCIMI_j$ = minimum volume of investment
p_j = coefficient for defining the minimum volume of investments
r_j = costs of a unit of investment
$FECU_j$ = utilization of capacities
FEP_j = fertilizer production
$FESP_j$ = fertilizer supply
s_j = amortization rate
u = relations of other phosphates
v_j = losses because of storage and transportation
$FENTR_j$ = net export-import of fertilizers
$FEBTR_j$ = gross export-import of fertilizers
$FESUP_j$ = price support for fertilizers
EPR = price-index for energy
w_j = proportion of export-import within country-groups

Values of exogeneous parameters

	A	B	C	D	E
			Scenarios		
a_1	o	o	o.oo42	o	o
a_2	o.o959	o.o959	o.o959	o.o959	o.o959
z_{11}	o.o13	o.o13	o.o13	o.o27	o.o27
z_{12}	o.o144	o.o144	o.o144	o.o144	o.o1o8
m_1	o	o	o	o	o.o1
m_2	o	o	o	o	o
o_1	o	o	o	o	o

Scenario A. Moderate growth rate of population and economy, unchanged world market prices

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
1.	Number of population	dev.ed	POP_1	million inhabitants	1o52	1o97	1145	1192	1237	1278	1317
2.		dev.ing	POP_2		2558	2869	3229	3624	4o43	4464	4936
3.		world									
4.	Gross national product	dev.ed	GNP_1	milliard $	2516	3252	415o	5222	6476	7917	934o
5.		dev.ing	GNP_2		471	634	848	1114	1435	1814	225o
6.		world			2987	3886	4998	6336	7911	9731	1179o
7.	Personal per capita income	dev.ed	$PCINC_1$	$ per head	1411	1749	2139	2585	3o89	3635	4274
8.		dev.ing	$PCINC_2$		129	155	184	215	248	283	319
9.	Per capita cereals consumpt.	dev.ed	$PCFD_{11}$	kg per head	162,5	156,4	148,1	121,6	96,3	74,6	57,3
1o.		dev.ing	$PCFD_{12}$		125,9	133,6	139,1	143,3	15o,5	154,7	158,1
11.	Per capita meat consumpt.	dev.ed	$PCFD_{21}$	kg per head	69,8	79,1	92,9	1o4,o	114,4	124,2	133,4
12.		dev.ing	$PCFD_{22}$		13,6	13,9	18,5	2o,6	22,4	24,2	25,7
13.	Per capita milk consumpt.	dev.ed	$PCFD_{31}$	kg per head	324,3	332,8	361,o	379,o	393,8	411,7	426,o
14.		dev.ing	$PCFD_{32}$		26,2	29,9	36,3	41,6	47,1	52,7	58,o
15.	Per capita egg consumpt.	dev.ed	$PCFD_{41}$	kg per head	12,4	13,4	15,6	16,9	18,2	19,3	2o,o
16.		dev.ing	$PCFD_{42}$		2,1	2,4	3,2	3,5	3,7	4,o	4,6

Scenario A.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
17.	Per capita con-	dev.ed	$PCGD_1$	kg per	565,3	582,4	657,5	666,1	677,7	669,1	702,5
18.	sump. of food	dev.ing	$PCGD_2$	head	241,0	249,0	278,6	299,8	319,3	337,2	353,9
19.	and feed grain	world			335,5	341,1	377,8	398,9	403,3	415,3	427,3
20.	Consump.of food	dev.ed	TGD_1	million	595	639	753	797	838	881	926
21.	and feed grain	dev.ing	TGD_2	tons	616	714	899	1086	1291	1512	1746
22.	Total	world			1211	1353	1652	1883	2129	2393	2672
23.	World market price of grain	world	GPR	$ per ton	71	167	130	130	130	130	130
24.	Cultivated	dev.ed	L_1	million	680	695	695	695	695	695	695
25.	area	dev.ing	L_2	ha	795	811	854	911	985	1079	1193
26.		world			1475	1506	1549	1606	1680	1774	1893
27.	Proportion of	dev.ed	A_1	between	0,43	0,44	0,46	0,46	0,46	0,46	0,46
28.	grain land	dev.ing	A_2	0 and 1	0,52	0,54	0,53	0,53	0,53	0,53	0,53
29.	Grain yield	dev.ed	Y_1	tons per	2,13	2,25	2,79	3,07	3,33	3,59	3,85
30.		dev.ing	Y_2	ha	1,44	1,53	1,74	1,93	2,12	2,31	2,50
31.	Grain	dev.ed	GP_1	million	610	675	693	985	1070	1153	1236
32.	production	dev.ing	GP_2	tons	603	682	785	929	1103	1316	1581
33.		world			1213	1357	1678	1914	2173	2469	2817

Scenario A.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	127	172	205	216	190
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	127	172	205	216	190
36.		dev.ed	GST_1		139	89	97	105	138	271	644
37.	Grain stocks	dev.ing	GST_2	million tons	30	38	-17	22	22	22	22
38.		world			169	127	80	127	160	293	666
39.	N-consumption	dev.ed	$FEDH_{11}$	kg per	34,1	40,0^{+}	48,7	56,2	63,3	70,2	77,2
40.	for one	dev.ing	$FEDH_{12}$	ha	10,8	15,4^{+}	21,8	28,2	34,6	41,0	47,4
41.	hectare	world			21,6	26,8^{+}	33,9	40,3	46,5	52,5	58,4
42.	P_2O_5 consump-	dev.ed	$FEDH_{21}$	kg per	24,5	26,2^{+}	31,2	34,4	37,4	40,4	43,3
43.	tion for	dev.ing	$FEDH_{22}$	ha	4,3	6,0^{+}	9,1	11,9	14,6	17,3	19,9
44.	one hectare	world			13,4	15,3^{+}	19,0	21,6	24,0	26,3	28,5
45.	K_2O consump-	dev.ed	$FEDH_{31}$	kg per	22,1	25,5^{+}	29,5	33,2	36,7	40,2	43,7
46.	tion for	dev.ing	$FEDH_{32}$	ha	2,1	3,5^{+}	5,2	7,0	8,8	10,6	12,4
47.	one hectare	world			11,3	13,6^{+}	16,1	18,4	20,4	22,3	23,9

$^{+}$Calculated values.

Scenario A.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
48.	NPK consump-	dev.ed	-	kg per	8o,7	91,7+	1o9,4	123,8	137,4	15o,8	164,2
49.	tion for	dev.ing	-	ha	17,2	24,9+	36,1	47,1	58,o	68,9	79,7
5o.	one hectare	world			46,3	55,7+	69,o	8o,3	9o,9	1o1,1	11o,8
51.	N-consumption	dev.ed	$TFED_{11}$	million	23,2	27,8+	33,9	39,1	44,o	48,8	53,7
52.	total	dev.ing	$TFED_{12}$	tons	8,6	12,5+	18,6	25,7	34,1	44,3	56,8
53.		world			31,6	4o,3+	52,5	64,8	78,1	93,1	11o,5
54.	P_2O_5 consump-	dev.ed	$TFED_{21}$	million	16,6	18,2+	21,7	23,9	26,o	28,1	3o,1
55.	tion	dev.ing	$TFED_{22}$	tons	3,2	4,9+	7,8	1o,8	14,3	18,6	23,9
56.	total	world			19,8	23,1+	29,5	34,7	4o,3	46,7	54,o
57.	K_2O consump-	dev.ed	$TFED_{31}$	million	15,o	17,7+	2o,5	23,1	25,5	28,o	3o,4
58.	tion	dev.ing	$TFED_{32}$	tons	1,7	2,8+	4,4	6,4	8,7	11,5	14,9
59.	total	world			16,7	2o,5+	24,9	29,5	34,2	39,5	45,3
6o.	World market price of N	world	$FEPR_1$	$ per ton	1o9	434	25o	25o	25o	25o	25o
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	1o1	433	2oo	2oo	2oo	2oo	2oo
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	12o	12o	12o	12o	12o

+Calculated values.

Scenario A.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
63.	Annually formed	dev.ed	$FINVF_1$	milliard	.	5,5+	7,1	8,9	11,o	13,5	16,2
64.	investm. funds	dev.ing	$FINVF_2$	$	.	2,2+	3,o	3,9	5,o	6,3	7,9
65.	in fertilizer ind.	world			.	7,7+	1o,1	12,8	16,o	19,8	24,1
66.	N-productive	dev.ed	FEC_{11}	million	43,9	56,4	7o,2	77,9	84,5	9o,2	95,1
67.	capacity	dev.ing	FEC_{12}	tons	1o,o	18,7	24,2	28,o	31,2	34,o	36,4
68.		world			53,9	75,1	94,4	1o5,9	115,7	124,2	131,5
69.	P_2O_5 productive	dev.ed	FEC_{21}	million	3o,3	37,9	4o,4	42,1	43,7	45,o	46,1
7o.		dev.ing	FEC_{22}	tons	3,1	6,7	13,3	15,9	18,1	19,9	21,6
71.	capacity	world			33,4	44,6	53,7	58,o	61,8	64,9	67,7
72.	K_2O productive	dev.ed	FEC_{31}	million	21,o	3o,2	42,4	52,o	6o,1	67,1	73,1
73.		dev.ing	FEC_{32}	tons	o,4	o,6	o,9	1,1	1,2	1,4	1,5
74.	capacity	world			21,4	3o,8	43,3	53,1	61,3	68,5	74,6
75.	Residue of in-	dev.ed	$FINVR_1$	milliard	.	-5,8+	-1,7	12,1	36,o	71,4	12o,o
76.	vestment funds in fertilizer	dev.ing	$FINVR_2$	$	.	-2,4+	-o,9	6,1	18,3	36,7	62,3
77.	industry	world			.	-8,2+	-2,6	18,2	54,3	1o8,1	182,3
78.	N-capacity	dev.ed	$FECU_{11}$	between	.	o,61+	o,66	o,71	o,76	o,81	o,86
79.	utilizations	dev.ing	$FECU_{12}$	o and 1	.	o,45+	o,53	o,6o	o,68	o,75	o,83

+Calculated values.

Scenario A.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
8o.	P_2O_5 capacity	dev.ed	$FECU_{21}$	between	.	o,55+	o,6o	o,65	o,7o	o,75	o,8o
81.	utilizations	dev.ing	$FECU_{22}$	o and 1	.	o,43+	o,5o	o,57	o,64	o,71	o,72
82.	K_2O capacity	dev.ed	$FECU_{31}$	between	.	o,66+	o,66	o,66	o,66	o,66	o,66
83.	utilizations	dev.ing	$FECU_{32}$	o and 1	.	o,97+	o,97	o,97	o,97	o,97	o,97
84.		dev.ed	FEP_{11}	million	28,6	33,4+	46,4	55,3	64,3	73,1	81,8
85.	N-production	dev.ing	FEP_{12}	tons	4,4	8,3+	12,9	16,9	21,2	25,7	3o,2
86.		world			33,o	41,7+	59,3	72,2	85,5	98,8	112,o
87.		dev.ed	FEP_{21}	million	18,5	21,3+	25,3	28,7	32,o	35,3	38,6
88.	P_2O_5 production	dev.ing	FEP_{22}	tons	2,2	3,1+	7,1	9,7	12,3	15,1	17,9
89.		world			2o,7	24,4+	32,4	38,4	44,3	5o,4	56,5
9o.		dev.ed	FEP_{31}	million	17,4	19,4+	28,o	34,3	4o,o	44,3	48,2
91.	K_2O production	dev.ing	FEP_{32}	tons	o,4	o,6+	o,8	1,o	1,2	1,3	1,5
92.		world			17,8	2o,o+	28,8	35,3	41,2	45,6	49,7
93.	Net export of N	dev.ed	$FENTR_{11}$	million	3,9	4,6+	6,4	9,6	14,o	19,9	28,1
94.	Net import of N	dev.ing	$FENTR_{12}$	tons	3,8	4,6+	6,4	9,6	14,o	19,9	28,1

+Calculated values.

Scenario A.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
95.	P_2O_5 net export	dev.ed	$FENTR_{21}$	million	1,o	1,9+	1,o	1,6	2,5	4,2	6,7
96.	P_2O_5 net import	dev.ing	$FENTR_{22}$	tons	o,8	1,9	1,o	1,6	2,5	4,2	6,7
97.	K_2O net export	dev.ed	$FENTR_{31}$	million	1,5	2,3+	3,7	5,5	7,6	1o,2	13,6
98.	K_2O net import	dev.ing	$FENTR_{32}$	tons	1,3	1,o+	3,7	5,5	7,6	1o,2	13,6
99.	N gross export	dev.ed	$FEBTR_{11}$	million	6,3	6,1+	8,6	12,4	17,4	23,9	32,6
1oo.	N gross import	dev.ing	$FEBTR_{12}$	tons	4,3	5,4+	7,4	1o,8	15,2	21,o	29,o
1o1.	P_2O_5 gross exp.	dev.ed	$FEBTR_{21}$	million	2,6	2,7+	2,5	3,6	5,o	6,9	9,6
1o2.	P_2O_5 gross imp.	dev.ing	$FEBTR_{22}$	tons	1,1	2,5+	1,7	2,5	3,7	5,6	8,4
1o3.	K_2O gross exp.	dev.ed	$FEBTR_{31}$	million	9,4	13,7+	22,o	32,7	45,2	6o,7	6o,9
1o4.	K_2O gross imp.	dev.ing	$FEBTR_{32}$	tons	1,3	2,3+	3,7	5,5	7,7	1o,3	13,6
1o5.	N-stocks	dev.ed		million	.	-o,6+	17,9	37,2	54,7	63,8	54,1
1o6.		dev.ing		tons	-	-	-	-	-	-	-
1o7.	P_2O_5 stocks	dev.ed		million	.	o,2+	6,7	15,6	25,9	35,o	38,8
1o8.		dev.ing		tons	-	-	-	-	-	-	-
1o9.	K_2O stocks	dev.ed		million	.	-2,2+	1,o	13,1	28,9	43,o	49,4
11o.		dev.ing		tons	-	-	-	-	-	-	-

+Calculated values.

Scenario B. Intensive growth rate of population and economy, increasing world market prices of grain

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
1.	Number of	dev.ed	POP_1	million	1052	1097	1145	1192	1237	1232	1327
2.	population	dev.ing	POP_2	inhabit-	2358	2669	3231	3637	4095	4611	5192
3.		world		ants	3610	3967	4376	4829	5332	5893	6519
4.	Gross national	dev.ed	GNP_1	milliard	2516	3252	4150	5297	6761	8628	11012
5.	product	dev.ing	GNP_2	$	471	634	848	1135	1519	2033	2721
6.		world			2987	3886	4998	6432	8280	10661	13733
7.	Personal per	dev.ed	$PCINC_1$	$ per	1411	1749	2139	2622	3224	3971	4896
8.	capita income	dev.ing	$PCINC_2$	head	129	155	184	219	260	309	367
9.	Per capita ce-	dev.ed	$PCFD_{11}$	kg per	162,5	156,4	148,1	119,5	90,5	65,0	44,7
10.	reals consumpt.	dev.ing	$PCFD_{12}$	head	125,9	133,6	139,1	145,9	151,9	157,2	161,8
11.	Per capita	dev.ed	$PCFD_{21}$	kg per	69,8	79,1	92,9	104,8	116,9	129,1	141,3
12.	meat consumpt.	dev.ing	$PCFD_{22}$	head	13,6	13,9	18,5	20,8	23,0	25,3	27,6
13.	Per capita	dev.ed	$PCFD_{31}$	kg per	324,5	332,8	361,1	380,3	399,9	419,6	439,4
14.	milk consumpt.	dev.ing	$PCFD_{32}$	head	26,2	29,9	36,3	42,1	48,9	56,7	65,8
15.	Per capita	dev.ed	$PCFD_{41}$	kg per	12,4	13,4	15,6	17,0	18,5	19,9	21,4
16.	egg consumpt.	dev.ing	$PCFD_{42}$	head	2,1	2,4	3,2	3,5	3,8	4,1	4,5

Scenario B.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
17.	Per capita con-	dev.ed	$PCGD_1$	kg per	565,3	582,4	656,8	668,2	679,6	695,3	716,9
18.	sump. of food	dev.ing	$PCGD_2$	head	241,o	249,o	278,2	3o1,6	325,o	348,8	373,3
19.	and feed grain	world			335,5	341,1	377,3	392,1	4o7,3	424,1	443,2
2o.	Total consump.of	dev.ed	TGD_1	million	595	639	752	796	841	891	951
21.	food and feed	dev.ing	TGD_2	tons	616	714	899	1o97	1331	16o8	1938
22.	grain	world			1211	1353	1651	1893	2172	2499	2889
23.	World market price of grain	world	GPR	$ per ton	71	167	135	142	15o	157	165
24.	Cultivated	dev.ed	L_1	million	68o	695	695	695	695	695	695
25.	area	dev.ing	L_2	ha	795	811	854	911	988	1o91	1228
26.		world			1475	15o6	1549	16o6	1683	1786	1923
27.	Proportion of	dev.ed	A_1	between	o,43	o,44	o,46	o,47	o,47	o,47	o,48
28.	grain land	dev.ing	A_2	o and 1	o,52	o,54	o,53	o,53	o,53	o,53	o,54
29.	Grain yield	dev.ed	Y_1	tons per	2,13	2,25	2,8o	3,o9	3,37	3,64	3,92
3o.		dev.ing	Y_2	ha	1,44	1,53	1,74	1,94	2,14	2,34	2,54
31.	Grain	dev.ed	GP_1	million	61o	675	896	1ooo	1o99	1199	13o1
32.	production	dev.ing	GP_2	tons	6o3	682	787	94o	1127	1365	1675
33.		world			1213	1357	1683	194o	2226	2564	2976

Scenario B.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values 1970	Factual values 1975	Prognosticated values 1980	1985	1990	1995	2000
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	124	172	220	263	289
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	124	172	220	263	289
36.		dev.ed	GST_1	million	139	89	103	172	273	394	564
37.	Grain stocks	dev.ing	GDT_2	tons	30	38	21	20	19	18	17
38.		world			169	127	124	192	292	412	581
39.	N-consumption	dev.ed	$FEDH_{11}$	kg per	34,1	40,0$^+$	48,9	56,9	64,5	72,0	79,5
40.	for one	dev.ing	$FEDH_{12}$	ha	10,8	15,4$^+$	21,9	28,7	35,5	42,3	49,1
41.	hectare	world			21,6	26,8$^+$	34,0	41,0	47,4	53,9	60,1
42.	P_2O_5 consump-	dev.ed	$FEDH_{21}$	kg per	24,5	26,2$^+$	31,4	34,8	38,1	41,4	44,6
43.	tion for	dev.ing	$FEDH_{22}$	ha	4,3	6,0$^+$	9,2	12,1	15,0	17,9	20,7
44.	one hectare	world			13,4	15,3$^+$	19,2	21,9	24,5	27,0	29,4
45.	K_2O consump-	dev.ed	$FEDH_{31}$	kg per	22,1	25,5$^+$	29,7	33,7	37,6	41,4	45,2
46.	tion for	dev.ing	$FEDH_{32}$	ha	2,1	3,5$^+$	5,3	7,4	9,4	11,4	13,4
47.	one hectare	world			11,3	13,6$^+$	16,3	18,7	21,0	23,1	24,9

$^+$Calculated values.

Scenario B.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
48.	NPK consump-	dev.ed	-	kg per	80,7	$91,7^+$	110,0	125,4	140,2	154,8	169,3
49.	tion for	dev.ing	-	ha	17,2	$24,9^+$	36,4	48,2	59,9	71,6	83,2
50.	one hectare	world			46,3	$55,7^+$	69,5	81,6	92,9	104,0	114,4
51.	N-consumption	dev.ed	$TFED_{11}$	million	23,2	$27,8^+$	34,0	39,6	44,6	50,1	55,3
52.	total	dev.ing	$TFED_{12}$	tons	8,6	$12,3^+$	18,7	26,2	35,1	46,1	60,3
53.		world			31,8	$40,3^+$	52,7	65,8	79,7	96,2	115,6
54.	P_2O_5 consump-	dev.ed	$TFED_{21}$	million	16,6	$18,2^+$	21,3	24,2	26,5	28,8	31,0
55.	tion	dev.ing	$TFED_{22}$	tons	3,2	$4,9^+$	7,9	11,0	14,8	19,5	25,5
56.	total	world			19,8	$23,1^+$	29,7	35,2	41,3	48,3	56,5
57.	K_2O consump-	dev.ed	$TFED_{31}$	million	15,0	$17,7^+$	20,6	23,4	26,1	28,8	31,4
58.	tion	dev.ing	$TFED_{32}$	tons	1,7	$2,8^+$	4,6	6,7	9,3	12,3	16,5
59.	total	world			16,7	$20,5^+$	25,2	30,1	35,4	41,3	47,9
60.	World market price of N	world	$FEPR_1$	$ per ton	109	434	250	250	250	250	250
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	101	433	200	200	200	200	200
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	120	120	120	120	120

$^+$Calculated values.

Scenario B.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
63.	Annually formed	dev.ed	$FINVF_1$	milliard	.	5,5[+]	7,1	9,0	11,5	14,7	18,7
64.	investm. funds in	dev.ing	$FINVF_2$	$	.	2,2[+]	3,0	4,0	5,3	7,1	9,5
65.	fertilizer ind.	world			.	7,7[+]	10,1	13,0	16,8	21,8	28,2
66.	N-productive	dev.ed	FEC_{11}	million	43,9	56,4	70,2	77,9	84,5	90,2	95,1
67.	capacity	dev.ing	FEC_{12}	tons	10,0	18,7	24,2	28,0	31,2	34,0	36,4
68.		world			53,9	75,1	94,4	105,9	115,7	124,2	131,5
69.	P_2O_5 productive	dev.ed	FEC_{21}	million	30,3	37,9	40,4	42,1	43,7	45,0	46,1
70.		dev.ing	FEC_{22}	tons	3,1	6,7	13,3	15,9	18,1	19,9	21,6
71.	capacity	world			33,4	44,6	53,7	58,0	61,8	64,9	67,7
72.	K_2O productive	dev.ed	FEC_{31}	million	21,0	30,2	42,4	52,0	60,1	67,1	73,1
73.		dev.ing	FEC_{32}	tons	0,4	0,6	0,9	1,1	1,2	1,4	1,5
74.	capacity	world			21,4	30,8	43,3	53,1	61,3	68,5	74,6
75.	Residue of in-	dev.ed	$FINVR_1$	milliard	.	-5,8[+]	-1,7	12,5	38,0	77,9	136,2
76.	vestment funds in fertilizer	dev.ing	$FINVR_2$	$	.	-2,4[+]	-0,9	6,3	19,5	40,7	72,6
77.	industry	world			.	-8,2[+]	-2,6	18,8	57,5	118,6	208,8
78.	N-capacity	dev.ed	$FECU_{11}$	between	.	0,61[+]	0,66	0,71	0,76	0,81	0,86
79.	utilizations	dev.ing	$FECU_{12}$	0 and 1	.	0,45[+]	0,53	0,60	0,68	0,75	0,83

[+]Calculated values.

Scenario B.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
80.	P_2O_5 capacity	dev.ed	$FECU_{21}$	between	.	0,55+	0,60	0,65	0,70	0,75	0,80
81.	utilizations	dev.ing	$FECU_{22}$	0 and 1	.	0,43+	0,50	0,57	0,64	0,71	0,78
82.	K_2O capacity	dev.ed	$FECU_{31}$	between	.	0,66+	0,66	0,66	0,66	0,66	0,66
83.	utilizations	dev.ing	$FECU_{32}$	0 and 1	.	0,97+	0,97	0,97	0,97	0,97	0,97
84.		dev.ed	FEP_{11}	million	28,6	33,4+	46,4	55,3	64,3	73,1	81,8
85.	N-production	dev.ing	FEP_{12}	tons	4,4	8,3+	12,9	16,9	21,2	25,7	30,2
86.		world			33,0	41,7+	59,3	72,2	85,5	98,8	112,0
87.		dev.ed	FEP_{21}	million	18,5	21,3+	25,3	28,7	32,0	35,3	38,6
88.	P_2O_5 production	dev.ing	FEP_{22}	tons	2,2	3,1+	7,1	9,7	12,5	15,1	17,9
89.		world			20,7	24,4+	32,4	38,4	44,3	50,4	56,5
90.		dev.ed	FEP_{31}	million	17,4	19,4+	28,0	34,3	39,7	44,3	48,2
91.	K_2O production	dev.ing	FEP_{32}	tons	0,4	0,6+	0,8	1,0	1,2	1,3	1,5
92.		world			17,8	20,0+	28,8	35,3	40,9	45,6	49,7
93.	Net export of N	dev.ed	$FENTR_{11}$	million	3,9	4,6+	6,5	10,1	14,9	21,8	31,6
94.	Net import of N	dev.ing	$FENTR_{12}$	tons	3,8	4,6+	6,5	10,1	14,9	21,8	31,6

+Calculated values.

Scenario B.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
95.	P_2O_5 net export	dev.ed	$FENTR_{21}$	million	1,o	1,9+	1,1	1,8	3,o	5,o	8,3
96.	P_2O_5 net import	dev.ing	$FENTR_{22}$	tons	o,8	1,9+	1,1	1,8	3,o	5,o	8,3
97.	K_2O net export	dev.ed	$FENTR_{31}$	million	1,5	2,3+	3,8	5,8	8,2	11,2	15,1
98.	K_2O net import	dev.ing	$FENTR_{32}$	tons	1,3	2,3+	3,8	5,8	8,2	11,2	15,1
99.	N gross export	dev.ed	$FEBTR_{11}$	million	6,3	6,1+	8,7	12,9	18,3	25,8	36,1
1oo.	N gross import	dev.ing	$FEBTR_{12}$	tons	4,3	5,4+	7,5	11,2	16,o	22,7	32,1
1o1.	P_2O_5 gross exp.	dev.ed	$FEBTR_{21}$	million	2,6	2,7+	2,6	3,8	5,4	7,6	1o,9
1o2.	P_2O_5 gross imp.	dev.ing	$FEBTR_{22}$	tons	1,1	2,5+	1,8	2,7	4,2	6,4	1o,o
1o3.	K_2O gross exp.	dev.ed	$FEBTR_{31}$	million	9,4	13,7+	22,6	34,5	48,8	66,6	89,8
1o4.	K_2O gross imp.	dev.ing	$FEBTR_{32}$	tons	1,3	2,3+	3,8	5,8	8,2	11,3	15,3
1o5.	N stocks	dev.ed		million	.	-o,6+	17,4	33,6	44,o	4o,3	9,5
1o6.		dev.ing		tons	-	-	-	-	-	-	-
1o7.	P_2O_5 stocks	dev.ed		million	.	o,2+	6,1	13,3	19,7	22,3	15,6
1o8.		dev.ing		tons	-	-	-	-	-	-	-
1o9.	K_2O stocks	dev.ed		million	.	-2,2+	o,7	1o,4	21,3	27,6	22,7
11o.		dev.ing		tons	-	-	-	-	-	-	-

+Calculated values.

Scenario C. Intensive growth rate of population and economy, increase of cultivated area even in developed countries, unchanged world market prices of grain

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
1.	Number of	dev.ed	POP_1	million	1o52	1o97	1145	1192	1237	1282	1327
2.	population	dev.ing	POP_2	inhabit-	2558	2869	3231	3637	4o95	4611	5192
3.		world		ants	361o	3967	4376	4829	5332	5893	6519
4.	Gross national	dev.ed	GNP_1	milliard	2516	3252	415o	5297	6761	8628	11o12
5.	product	dev.ing	GNP_2	$	471	634	848	1135	1519	2o33	2721
6.		world			2987	3886	4998	6432	828o	1o661	13733
7.	Personal per	dev.ed	$PCINC_1$	$ per	1411	1749	2139	2622	3224	3971	4696
8.	capita income	dev.ing	$PCINC_2$	head	129	155	184	219	26o	3o9	367
9.	Per capita ce-	dev.ed	$PCFD_{11}$	kg per	162,5	156,4	148,1	119,5	9o,5	65,o	44,7
1o.	reals consumpt.	dev.ing	$PCFD_{12}$	head	125,9	133,6	139,1	145,9	151,9	157,2	161,8
11.	Per capita	dev.ed	$PCFD_{21}$	kg per	69,8	79,1	92,9	1o4,8	116,9	129,1	141,3
12.	meat consumpt.	dev.ing	$PCFD_{22}$	head	13,6	13,9	18,5	2o,8	23,o	25,3	27,6
13.	Per capita	dev.ed	$PCFD_{31}$	kg per	324,5	332,8	361,1	38o,3	399,9	419,6	439,4
14.	milk consumpt.	dev.ing	$PCFD_{32}$	head	26,2	29,9	36,3	42,1	48,9	56,7	65,8
15.	Per capita	dev.ed	$PCFD_{41}$	kg per	12,4	13,4	15,6	17,o	18,5	19,9	21,4
16.	egg consumpt.	dev.ing	$PCFD_{42}$	head	2,1	2,4	3,2	3,5	3,8	4,1	4,5

Scenario C.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
17.	Per capita con-	dev.ed	$PCGD_1$	kg per	565,3	582,4	657,5	668,8	68o,3	696,o	717,6
18.	sump. of food	dev.ing	$PCGD_2$	head	241,o	249,o	278,5	3o1,9	325,3	349,1	373,6
19.	and feed grain	world			335,5	341,1	377,7	392,4	4o7,5	424,6	443,6
2o.	Total consumpt.	dev.ed	TGD_1	million	595	639	753	797	841	892	952
21.	of food and	dev.ing	TGD_2	tons	616	714	9oo	1o98	1332	161o	194o
22.	feed grain	world			1211	1353	1653	1895	2173	25o2	2692
23.	World market price of grain	world	GPR	$ per ton	71	167	13o	13o	13o	13o	13o
24.	Cultivated	dev.ed	L_1	million	68o	695	7o8	724	744	77o	8o4
25.	area	dev.ing	L_2	ha	795	811	854	911	988	1o91	1228
26.		world			1475	15o6	1562	1635	1732	1861	2o32
27.	Proportion of	dev.ed	A_1	between	o,43	o,44	o,46	o,46	o,46	o,46	o,46
28.	grain land	dev.ing	A_2	o and 1	o,52	o,54	o,53	o,53	o,53	o,53	o,53
29.	Grain yield	dev.ed	Y_1	tons per	2,13	2,25	2,79	3,o7	3,33	3,59	3,85
3o.		dev.ing	Y_2	ha	1,44	1,53	1,74	1,93	2,12	2,31	2,5o
31.	Grain	dev.ed	GP_1	million	61o	675	9o9	1o25	1145	1278	1429
32.	production	dev.ing	GP_2	tons	6o3	682	785	929	11o6	133o	162o
33.		world			1213	1357	1694	1954	2251	26o8	3o49

Scenario C.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	127	183	243	3oo	345
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	127	183	243	3oo	345
36.		dev.ed	GST_1	million	139	89	119	239	425	7o1	1149
37.	Grain stocks	dev.ing	GST_2	tons	3o	38	22	22	22	22	22
38.		world			169	127	141	261	447	723	1171
39.	N-consumption	dev.ed	$FEDH_{11}$	kg per	34,1	4o,o$^+$	48,7	56,2	63,3	7o,2	77,2
4o.	for one	dev.ing	$FEDH_{12}$	ha	1o,8	15,4$^+$	21,8	28,2	34,6	41,o	47,4
41.	hectare	world			21,6	26,8$^+$	34,o	4o,6	46,9	53,1	59,2
42.	P_2O_5 consump-	dev.ed	$FEDH_{21}$	kg per	24,5	26,2$^+$	31,2	34,4	37,4	4o,4	43,3
43.	tion for	dev.ing	$FEDH_{22}$	ha	4,3	6,o$^+$	9,1	11,9	14,6	17,3	19,9
44.	one hectare	world			13,4	15,3$^+$	19,1	21,8	24,5	26,8	29,1
45.	K_2O consump-	dev.ed	$FEDH_{31}$	kg per	22,1	25,5$^+$	29,5	33,2	36,7	4o,2	43,7
46.	tion for	dev.ing	$FEDH_{32}$	ha	2,1	3,5$^+$	5,2	7,o	8,8	1o,6	12,4
47.	one hectare	world			11,3	13,6$^+$	16,2	18,6	2o,8	22,9	24,8

$^+$Calculated values.

Scenario C.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
48.	NPK consump-	dev.ed	-	kg per	80,7	91,7+	109,4	123,8	137,4	150,8	164,2
49.	tion for	dev.ing	-	ha	17,2	24,9+	36,1	47,1	58,0	68,9	79,7
50.	one hectare	world			46,3	55,7+	69,3	81,0	92,2	102,8	119,0
51.	N-consumption	dev.ed	$TFED_{11}$	million	23,2	27,8+	34,5	40,7	47,1	54,1	62,0
52.	total	dev.ing	$TFED_{12}$	tons	8,6	12,5+	18,6	25,7	34,2	44,8	58,2
53.		world			31,8	40,3+	53,1	66,4	81,3	98,9	120,2
54.	P_2O_5 consump-	dev.ed	$TFED_{21}$	million	16,6	18,2+	22,1	24,9	27,8	31,1	34,8
55.	tion	dev.ing	$TFED_{22}$	tons	3,2	4,9+	7,8	10,8	14,4	18,8	24,5
56.	total	world			19,8	23,1+	29,9	35,7	42,4	49,9	59,3
57.	K_2O consump-	dev.ed	$TFED_{31}$	million	15,0	17,7+	20,9	24,0	27,3	31,0	35,1
58.	tion	dev.ing	$TFED_{32}$	tons	1,7	2,8+	4,4	6,4	8,7	11,6	15,3
59.	total	world			16,7	20,5+	25,3	30,4	36,0	42,6	50,4
60.	World market price of N	world	$FEPR_1$	$ per ton	109	434	250	250	250	250	250
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	101	435	200	200	200	200	200
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	120	120	120	120	120

+Calculated values.

Scenario C.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
63.	Annually formed	dev.ed	$FINVF_1$	milliard	.	5,5+	7,1	9,o	11,5	14,7	18,7
64.	investm.funds	dev.ing	$FINVF_2$	$	.	2,2+	3,o	4,o	5,3	7,1	9,5
65.	in fertilizer ind.	world			.	7,7+	1o,1	13,o	16,8	21,8	28,2
66.	N-productive	dev.ed	FEC_{11}	million	43,9	56,4	7o,2	77,9	84,5	9o,2	95,1
67.	capacity	dev.ing	FEC_{12}	tons	1o,o	18,7	24,2	28,o	31,2	34,o	36,4
68.		world			53,9	75,1	94,4	1o5,9	115,7	124,2	131,5
69.	P_2O_5 productive	dev.ed	FEC_{21}	million	3o,3	37,9	4o,4	42,1	43,7	45,o	46,1
7o.		dev.ing	FEC_{22}	tons	3,1	6,7	13,3	15,9	18,1	19,9	21,6
71.	capacity	world			33,4	44,6	53,7	58,o	61,8	64,9	67,7
72.	K_2O productive	dev.ed	FEC_{31}	million	21,o	3o,2	42,4	52,o	6o,1	67,1	73,1
73.		dev.ing	FEC_{32}	tons	o,4	o,6	o,9	1,1	1,2	1,4	1,5
74.	capacity	world			21,o	3o,8	43,3	53,1	61,3	68,5	74,6
75.	Residue of in-	dev.ed	$FINVR_1$	milliard	.	-5,8+	-1,7	12,5	38,o	77,9	136,2
76.	vestment funds in fertilizer	dev.ing	$FINVR_2$	$	.	-2,4+	-o,9	6,3	19,5	4o,7	72,6
77.	industry	world			.	-8,2+	-2,6	18,8	57,5	118,6	2o8,8
78.	N-capacity	dev.ed	$FECU_{11}$	between	.	o,63+	o,68	o,73	o,78	o,83	o,88
79.	utilizations	dev.ing	$FECU_{12}$	o and 1	.	o,45+	o,53	o,6o	o,68	o,75	o,85

+Calculated values.

Scenario C.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
8o.	P_2O_5 capacity	dev.ed	$FECU_{21}$	between	.	o,55+	o,6o	o,65	o,7o	o,75	o,8o
81.	utilizations	dev.ing	$FECU_{22}$	o and 1	.	o,43+	o,5o	o,57	o,64	o,71	o,76
82.	K_2O capacity	dev.ed	$FECU_{31}$	between	.	o,66+	o,66	o,66	o,66	o,66	o,66
83.	utilizations	dev.ing	$FECU_{32}$	o and 1	.	o,97+	o,97	o,97	o,97	o,97	o,97
84.		dev.ed	FEP_{11}	million	28,6	34,5+	47,8	56,9	65,9	74,9	83,7
85.	N-production	dev.ing	FEP_{12}	tons	4,4	8,3+	12,9	16,9	21,2	25,7	3o,2
86.		world			33,o	42,8+	6o,7	73,8	87,1	1oo,6	113,9
87.		dev.ed	FEP_{21}	million	18,5	21,3+	25,3	28,7	32,o	35,3	38,6
88.	P_2O_5 production	dev.ing	FEP_{22}	tons	2,2	3,1+	7,1	9,7	12,3	15,1	17,9
89.		world			2o,7	24,4+	32,4	38,4	44,3	5o,4	56,5
9o.		dev.ed	FEP_{31}	million	17,4	19,4+	28,o	34,3	39,7	44,3	48,2
91.	K_2O production	dev.ing	FEP_{32}	tons	o,4	o,6+	o,8	1,o	1,2	1,3	1,5
92.		world			17,8	2o,o+	28,8	35,3	4o,9	45,6	49,7
93.	Net export of N	dev.ed	$FENTR_{11}$	million	3,9	4,6+	6,4	9,6	14,1	2o,4	29,6
94.	Net import of N	dev.ing	$FENTR_{12}$	tons	3,8	4,6+	6,4	9,6	14,1	2o,4	29,6

+Calculated values.

Scenario C.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
95.	P_2O_5 net export	dev.ed	$FENTR_{21}$	million tons	1,o	1,9+	1,o	1,6	2,6	4,4	7,3
96.	P_2O_5 net import	dev.ing	$FENTR_{22}$		o,8	1,9+	1,o	1,6	2,6	4,4	7,3
97.	K_2O net export	dev.ed	$FENTR_{31}$	million	1,5	2,3+	3,7	5,5	7,6	1o,4	13,9
98.	K_2O net import	dev.ing	$FENTR_{32}$	tons	1,3	2,3+	3,7	5,5	7,6	1o,4	13,9
99.	N gross export	dev.ed	$FEBTR_{11}$	million	6,3	6,1+	8,6	12,4	17,5	24,4	34,1
1oo.	N gross import	dev.ing	$FEBTR_{12}$	tons	4,3	5,4+	7,4	1o,8	15,3	21,4	3o,3
1o1.	P_2O_5 gross exp.	dev.ed	$FEBTR_{21}$	million	2,6	2,7+	2,5	3,6	5,o	7,1	1o,1
1o2.	P_2O_5 gross imp.	dev.ing	$FEBTR_{22}$	tons	1,1	2,3+	1,7	2,5	3,7	5,8	9,o
1o3.	K_2O gross exp.	dev.ed	$FEBTR_{31}$	million	9,4	13,7+	22,o	32,7	45,2	61,9	82,7
1o4.	K_2O gross imp.	dev.ing	$FEBTR_{32}$	tons	1,3	2,3+	3,7	5,5	7,7	1o,4	14,o
1o5.	N-stocks	dev.ed		million	.	o,4+	23,6	44,3	57,2	51,5	1o,5
1o6.		dev.ing		tons	-	-	-	-	-	-	-
1o7.	P_2O_5 stocks	dev.ed		million	.	o,2+	5,6	1o,9	13,8	9,7	-8,5
1o8.		dev.ing		tons	-	-	-	-	-	-	-
1o9.	K_2O stocks	dev.ed		million	.	-2,2+	o	8,6	17,2	18,4	3,4
11o.		dev.ing		tons	-	-	-	-	-	-	-

+Calculated values.

Scenario D. Intensive growth rate of population and economy, a faster increase of grain yields in developed countries, increase in world market prices of fertilizers, improvement of productive capacities

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
1.	Number of	dev.ed	POP_1	million	1052	1097	1145	1192	1237	1282	1327
2.	population	dev.ing	POP_2	inhabit-	2558	2869	3231	3637	4095	4611	5192
3.		world		ants	3610	3967	4376	4829	5332	5893	6519
4.	Gross national	dev.ed	GNP_1	milliard	2316	3252	4150	5297	6761	8628	11012
5.	product	dev.ing	GNP_2	$	471	634	848	1135	1519	2033	2721
6.		world			2987	3886	4998	6432	8280	10661	13733
7.	Personal per	dev.ed	$PCINC_1$	$ per head	1411	1749	2139	2622	3224	3971	4896
8.	capita income	dev.ing	$PCINC_2$		129	155	184	219	260	309	367
9.	Per capita ce-	dev.ed	$PCFD_{11}$	kg per	162,5	156,4	148,1	119,5	90,5	65,0	44,7
10.	reals consumpt.	dev.ing	$PCFD_{12}$	head	125,9	133,6	139,1	145,9	151,9	157,2	161,8
11.	Per capita	dev.ed	$PCFD_{21}$	kg per	69,8	79,1	92,9	104,8	116,9	129,1	141,3
12.	meat consumpt.	dev.ing	$PCFD_{22}$	head	13,6	13,9	18,5	20,8	23,0	25,3	27,6
13.	Per capita	dev.ed	$PCFD_{31}$	kg per	324,5	332,8	361,1	380,3	399,9	419,6	439,4
14.	milk consumpt.	dev.ing	$PCFD_{32}$	head	26,2	29,9	36,3	42,1	48,9	56,7	65,8
15.	Per capita	dev.ed	$PCFD_{41}$	kg per	12,4	13,4	15,6	17,0	18,5	19,9	21,4
16.	egg consumpt.	dev.ing	$PCFD_{42}$	head	2,1	2,4	3,2	3,5	3,8	4,1	4,5

Scenario D.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
17.	Per capita con-	dev.ed	$PCGD_1$	kg per	565,3	582,4	657,5	668,8	680,3	696,0	717,6
18.	sumpt.of food	dev.ing	$PCGD_2$	head	241,0	249,0	278,5	301,9	325,3	349,1	373,6
19.	and feed grain	world			335,5	341,1	377,7	392,4	407,7	424,6	443,6
20.	Total consumpt.	dev.ed	TGD_1	million	595	639	753	797	842	892	952
21.	of food and	dev.ing	TGD_2	tons	616	714	900	1098	1332	1610	1940
22.	feed grain	world			1211	1353	1653	1895	2174	2502	2892
23.	World market price of grain	world	GPR	$ per ton	71	167	130	130	130	130	130
24.	Cultivated	dev.ed	L_1	million	680	695	695	695	695	695	695
25.	area	dev.ing	L_2	ha	795	811	854	911	988	1091	1228
26.		world			1475	1506	1549	1606	1683	1786	1923
27.	Proportion of	dev.ed	A_1	between	0,43	0,44	0,46	0,46	0,46	0,46	0,46
28.	grain land	dev.ing	A_2	0 and 1	0,52	0,54	0,53	0,53	0,53	0,53	0,53
29.	Grain yield	dev.ed	Y_1	tons per	2,13	2,25	3,48	4,06	4,57	5,06	5,54
30.		dev.ing	Y_2	ha	1,44	1,53	1,73	1,91	2,07	2,22	2,36
31.	Grain	dev.ed	GP_1	million	610	675	1113	1303	1468	1625	1780
32.	production	dev.ing	GP_2	tons	603	682	782	916	1078	1280	1541
33.		world			1213	1357	1895	2219	2546	2905	3321

Scenario D.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	13o	196	27o	349	423
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	13o	196	27o	349	423
36.		dev.ed	GST_1	million	139	89	884	22o4	3794	5541	7389
37.	Grain stocks	dev.ing	GST_2	tons	3o	38	22	22	22	22	22
38.		world			169	127	9o6	2226	3816	5563	7411
39.	N-consumption	dev.ed	$FEDH_{11}$	kg per	34,1	44,5⁺	67,2	82,6	96,1	1o9,o	121,7
4o.	for one	dev.ing	$FEDH_{12}$	ha	1o,8	15,4⁺	21,6	27,2	32,6	37,9	43,o
41.	hectare	world			21,6	28,8⁺	42,o	51,2	58,8	65,6	71,4
42.	P_2O_5 consump-	dev.ed	$FEDH_{21}$	kg per	24,5	28,1⁺	38,9	45,3	5o,9	56,2	61,3
43.	tion for	dev.ing	$FEDH_{22}$	ha	4,5	6,o⁺	9,o	11,3	13,5	15,7	17,7
44.	one hectare	world			13,4	16,3⁺	22,5	26,o	29,o	31,5	33,5
45.	K_2O consump-	dev.ed	$FEDH_{31}$	kg per	22,1	27,7⁺	38,6	46,1	52,6	58,8	64,8
46.	tion for	dev.ing	$FEDH_{32}$	ha	2,1	3,5⁺	4,9	6,3	7,5	8,6	9,6
47.	one hectare	world			11,3	14,7⁺	2o,o	23,5	26,1	28,2	29,6

⁺Calculated values.

Scenario D.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
48.	NPK consump-	dev.ed	-	kg per	8o,7	1oo,3+	144,7	174,o	199,6	224,o	247,8
49.	tion for	dev.ing	-	ha	17,2	24,9+	35,5	44,8	53,6	62,2	7o,3
5o.	one hectare	world			46,3	59,8+	84,5	1oo,7	113,9	125,3	134,5
51.	N-consumption	dev.ed	$TFED_{11}$	million	23,2	3o,9+	46,7	57,4	66,8	73,8	84,6
52.	total	dev.ing	$TFED_{12}$	tons	8,6	12,5+	18,4	24,8	32,2	41,3	52,7
53.		world			31,8	43,4+	65,1	82,2	99,o	117,1	137,3
54.	P_2O_5 consump-	dev.ed	$TFED_{21}$	million	16,6	19,6+	27,1	31,5	35,4	39,1	42,6
55.	tion	dev.ing	$TFED_{22}$	tons	3,2	4,9+	7,7	1o,3	13,4	17,1	21,8
56.	total	world			19,8	24,5+	34,8	41,8	48,8	56,2	64,2
57.	K_2O consump-	dev.ed	$TFED_{31}$	million	15,o	19,3+	26,8	32,o	36,5	4o,9	45,1
58.	tion	dev.ing	$TFED_{32}$	tons	1,7	2,8+	4,2	5,7	7,4	9,4	11,8
59.	total	world			16,7	22,1+	31,o	37,7	43,9	5o,3	56,9
6o.	World market price of N	world	$FEPR_1$	$ per ton	1o9	434	271	299	33o	364	4o2
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	1o1	433	217	239	264	292	322
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	13o	143	158	175	193

+Calculated values.

Scenario D.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
63.	Annually formed	dev.ed	$FINVF_1$	milliard	.	5,5+	7,1	9,o	11,5	14,7	18,7
64.	investm. funds	dev.ing	$FINVF_2$	$	.	2,2+	3,o	4,o	5,3	7,1	9,5
65.	in fertilizer ind.	world			.	7,7+	1o,1	13,o	16,8	21,8	28,2
66.	N-productive	dev.ed	FEC_{11}	million	43,9	56,4	7o,4	79,3	88,4	97,6	1o7,2
67.	capacity	dev.ing	FEC_{12}	tons	1o,o	18,7	24,3	28,3	38,2	35,8	39,4
68.		world			53,9	75,1	94,7	1o7,6	12o,6	133,4	146,6
69.	P_2O_5 productive	dev.ed	FEC_{21}	million	3o,3	37,9	4o,4	42,4	44,3	46,3	48,2
7o.	capacity	dev.ing	FEC_{22}	tons	3,1	6,7	13,4	16,5	19,7	23,2	26,7
71.		world			33,4	44,6	53,8	58,9	64,o	69,5	74,9
72.	K_2O productive	dev.ed	FEC_{31}	million	21,o	3o,2	42,8	54,4	66,7	79,8	93,8
73.	capacity	dev.ing	FEC_{32}	tons	o,4	o,6	o,9	1,1	1,3	1,6	1,8
74.		world			21,4	3o,8	43,7	55,5	68,o	81,4	95,6
75.	Residue of in-vestment funds	dev.ed	$FINVR_1$	milliard	.	-5,8+	-2,2	9,7	3o,7	63,9	112,9
76.	in fertilizer	dev.ing	$FINVR_2$	$	.	-2,4+	-1,1	5,3	16,9	35,7	64,3
77.	industry	world			.	-8,2+	-3,3	15,o	47,6	99,6	177,2
78.	N-capacity	dev.ed	$FECU_{11}$	between	.	o,73+	o,78	o,83	o,88	o,93	o,98
79.	utilizations	dev.ing	$FECU_{12}$	o and 1	.	o,58+	o,66	o,73	o,81	o,88	o,96

+Calculated values.

Scenario D.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
80.	P_2O_5 capacity	dev.ed	$FECU_{21}$	between	.	0,65+	0,70	0,75	0,80	0,85	0,90
81.	utilizations	dev.ing	$FECU_{22}$	0 and 1	.	0,43+	0,50	0,57	0,64	0,71	0,78
82.	K_2O capacity	dev.ed	$FECU_{31}$	between	.	0,76+	0,76	0,76	0,76	0,76	0,76
83.	utilizations	dev.ing	$FECU_{32}$	0 and 1	.	0,97+	0,97	0,97	0,97	0,97	0,97
84.		dev.ed	FEP_{11}	million	28,6	40,0+	54,9	65,9	77,8	90,8	105,0
85.	N-production	dev.ing	FEP_{12}	tons	4,4	10,7+	16,0	20,8	26,1	31,7	37,8
86.		world			33,0	50,7+	70,9	86,7	103,9	122,5	142,8
87.		dev.ed	FEP_{21}	million	18,5	25,0+	29,6	33,3	37,1	41,1	45,4
88.	P_2O_5 production	dev.ing	FEP_{22}	tons	2,2	3,1+	7,2	10,0	13,5	17,5	22,3
89.		world			20,7	28,1+	36,8	43,3	50,6	58,6	67,7
90.		dev.ed	FEP_{31}	million	17,4	22,3+	32,5	41,4	50,7	60,6	71,3
91.	K_2O production	dev.ing	FEP_{32}	tons	0,4	0,6+	0,8	1,1	1,3	1,5	1,7
92.		world			17,8	22,9+	33,3	42,5	52,0	62,1	73,0
93.	Net export of N	dev.ed	$FENTR_{11}$	million	3,9	2,4+	3,2	5,0	7,5	11,2	16,8
94.	Net import of N	dev.ing	$FENTR_{12}$	tons	3,8	2,4	3,2	5,0	7,5	11,2	16,8

+Calculated values.

Scenario D.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
95.	P_2O_5 net export	dev.ed	$FENTR_{21}$	million	1,0	1,9+	0,8	0,7	0,5	0,3	0,4
96.	P_2O_5 net import	dev.ing	$FENTR_{22}$	tons	0,8	1,9+	0,8	0,7	0,5	0,3	0,4
97.	K_2O net export	dev.ed	$FENTR_{31}$	million	1,5	2,3+	3,4	4,7	6,2	8,0	10,2
98.	K_2O net import	dev.ing	$FENTR_{32}$	tons	1,3	2,3+	3,4	4,7	6,2	8,0	10,2
99.	N gross export	dev.ed	$FEBTR_{11}$	million	6,3	3,9+	5,4	7,9	11,1	15,4	21,6
100.	N gross import	dev.ing	$FEBTR_{12}$	tons	4,3	3,4+	4,5	6,6	9,2	13,0	18,6
101.	P_2O_5 gross exp.	dev.ed	$FEBTR_{21}$	million	2,6	2,7+	2,4	2,9	3,3	3,8	4,4
102.	P_2O_5 gross imp.	dev.ing	$FEBTR_{22}$	tons	1,1	2,5+	1,6	1,7	1,6	1,6	1,9
103.	K_2O gross exp.	dev.ed	$FEBTR_{31}$	million	9,4	13,7+	20,2	28,0	36,9	47,6	60,7
104.	K_2O gross imp.	dev.ing	$FEBTR_{32}$	tons	1,3	2,3+	3,5	4,8	6,2	8,0	10,3
105.	N-stocks	dev.ed		million	.	4,7+	27,7	31,4	30,1	27,1	21,2
106.		dev.ing		tons	-	-	-	-	-	-	-
107.	P_2O_5 stocks	dev.ed		million	.	2,4+	8,6	7,7	5,6	4,9	6,3
108.		dev.ing		tons	-	-	-	-	-	-	-
109.	K_2O stocks	dev.ed		million	.	-1,1+	-3,1	-0,9	12,5	40,2	83,9
110.		dev.ing		tons	-	-	-	-	-	-	-

+Calculated values.

Scenario E. Intensive growth rate of population and economy, a faster increase in grain yields in developed countries, decrease in the efficiency of fertilizer utilization

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
1.	Number of	dev.ed	POP_1	million	1052	1097	1145	1192	1237	1282	1327
2.	population	dev.ing	POP_2	inhabit-	2558	2869	3231	3637	4095	4611	5192
3.		world		ants	3610	3967	4376	4829	5332	5893	6519
4.	Gross national	dev.ed	GNP_1	milliard	2516	3252	4150	5297	6761	8628	11012
5.	product	dev.ing	GNP_2	$	471	634	848	1135	1519	2033	2721
6.		world			2987	3886	4998	6432	8280	10661	13733
7.	Personal per	dev.ed	$PCINC_1$	$ per head	1411	1749	2139	2622	3224	3971	4896
8.	capita income	dev.ing	$PCINC_2$		129	155	184	219	260	309	367
9.	Per capita ce-	dev.ed	$PCFD_{11}$	kg per	162,5	156,4	148,1	119,5	90,5	65,0	44,7
10.	reals consumpt.	dev.ing	$PCFD_{12}$	head	125,9	133,6	139,1	145,9	151,9	157,2	161,8
11.	Per capita	dev.ed	$PCFD_{21}$	kg per	69,8	79,1	92,9	104,8	116,9	129,1	141,3
12.	meat consumpt.	dev.ing	$PVFD_{22}$	head	13,6	13,9	18,5	20,8	23,0	25,3	27,6
13.	Per capita	dev.ed	$PCFD_{31}$	kg per	324,5	332,8	361,1	380,3	399,9	419,6	439,4
14.	milk consumpt.	dev.ing	$PCFD_{32}$	head	26,2	29,9	36,3	42,1	48,9	56,7	65,8
15.	Per capita	dev.ed	$PCFD_{41}$	kg per	12,4	13,4	15,6	17,0	18,5	19,9	21,4
16.	egg consumpt.	dev.ing	$PCFD_{42}$	head	2,1	2,4	3,2	3,5	3,8	4,1	4,5

Scenario E.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
17.	Per capita con-	dev.ed	$PCGD_1$	kg per	565,3	582,4	657,5	668,8	68o,3	696,o	717,6
18.	sumpt. of food	dev.ing	$PCGD_2$	head	241,o	249,o	278,5	3o1,9	325,3	349,1	373,6
19.	and feed grain	world			335,5	341,1	377,7	392,4	4o7,7	424,6	443,6
2o.	Total consumpt.	dev.ed	TGD_1	million	595	639	753	797	842	892	952
21.	of food and	dev.ing	TGD_2	tons	616	714	9oo	1o98	1332	161o	194o
22.	feed grain	world			1211	1353	1653	1895	2174	25o2	2892
23.	World market price of grain	world	GPR	$ per ton	71	167	13o	13o	13o	13o	13o
24.	Cultivated	dev.ed	L_1	million	68o	695	695	695	695	695	695
25.	area	dev.ing	L_2	ha	795	811	854	911	988	1o91	1226
26.		world			1475	15o6	1549	16o6	1683	1786	1925
27.	Proportion of	dev.ed	A_1	between	o,43	o,44	o,46	o,46	o,46	o,46	o,46
28.	grain land	dev.ing	A_2	o and 1	o,52	o,54	o,53	o,53	o,53	o,53	o,53
29.	Grain yield	dev.ed	Y_1	tons per	2,13	2,25	3,38	3,91	4,33	4,74	5,14
3o.		dev.ing	Y_2	ha	1,44	1,53	1,73	1,9o	2,o6	2,21	2,35
31.	Grain	dev.ed	GP_1	million	61o	675	1o8o	1253	1392	1524	1652
32.		dev.ing	GP_2	tons	6o3	682	781	914	1o72	127o	1523
33.		world			1213	1357	1861	2167	2464	2794	3175

Scenario E.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	13o	198	276	359	44o
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	13o	198	276	359	44o
36.	Grain stocks	dev.ed	GST_1	million	139	89	62o	1729	2976	4233	5434
37.		dev.ing	GST_2	tons	3o	38	22	22	22	22	22
38.		world			169	127	642	1751	2998	4255	5456
39.	N-consumption	dev.ed	$FEDH_{11}$	kg per	34,1	51,5+	87,o	1o4,5	118,6	131,9	144,8
4o.	for one	dev.ing	$FEDH_{12}$	ha	1o,8	15,4+	21,5	27,o	32,2	37,1	41,8
41.	hectare	world			21,6	32,1+	5o,9	6o,6	67,9	74,o	79,o
42.	P_2O_5 consump-	dev.ed	$FEDH_{21}$	kg per	24,5	31,1+	47,3	54,5	6o,2	65,5	7o,5
43.	tion for	dev.ing	$FEDH_{22}$	ha	4,3	6,o+	9,o	11,2	13,2	15,2	17,o
44.	one hectare	world			13,4	17,6+	26,1	3o,o	32,6	34,8	36,3
45.	K_2O consump-	dev.ed	$FEDH_{31}$	kg per	22,1	31,2+	48,5	57,1	64,o	7o,5	76,8
46.	tion for	dev.ing	$FEDH_{32}$	ha	2,1	3,5+	4,9	6,2	7,4	8,4	9,4
47.	one hectare	world			11,3	16,3+	24,5	28,3	3o,8	32,6	33,7

+Calculated values.

Scenario E.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
48.	NPK consump-	dev.ed	-	kg per	8o,7	113,8+	182,8	216,1	242,8	267,9	292,1
49.	tion for	dev.ing	-	ha	17,2	24,9+	35,4	44,4	52,8	6o,7	68,2
5o.	one hectare	world			46,3	66,o+	1o1,5	118,9	131,3	141,4	149,o
51.	N-consumption	dev.ed	$TFED_{11}$	million	23,2	35,8+	6o,5	72,7	82,5	91,7	1oo,7
52.	total	dev.ing	$TFED_{12}$	tons	8,6	12,5+	18,4	24,6	31,8	4o,4	51,3
53.		world			31,8	48,3+	78,9	97,3	114,3	132,1	152,o
54.	P_2O_5 consump-	dev.ed	$TFED_{21}$	million	16,6	21,6+	32,9	37,9	41,8	45,5	49,o
55.	tion total	dev.ing	$TFED_{22}$	tons	3,2	4,9+	7,6	1o,2	13,1	16,6	2o,9
56.		world			19,8	26,5+	4o,5	48,1	54,9	62,1	69,9
57.	K_2O consump-	dev.ed	$TFED_{31}$	million	15,o	21,7+	33,7	39,7	44,5	49,o	53,4
58.	tion total	dev.ing	$TFED_{32}$	tons	1,7	2,8+	4,2	5,7	7,3	9,2	11,5
59.		world			16,7	24,5+	37,9	45,4	51,8	58,2	64,9
6o.	World market price of N	world	$FEPR_1$	$ per ton	1o9	434	281	326	378	438	5o8
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	1o1	433	225	261	3o3	351	4o7
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	13o	143	158	175	193

+Calculated values.

Scenario A. The results of simultaneous solution

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
23.	World market price of grain	world	GPR	$ per ton	71	167	137	135	133	13o	122
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	1o5	148	182	2oo	193
35.	Net import of grain	dev.ing	GTR_2	million tons	11	43	1o5	148	182	2oo	193
36.		dev.ed	GST_1	million	139	89	184	416	667	961	1348
37.	Grain stocks	dev.ing	GST_2	tons	3o	38	2o	21	21	21	22
38.		world			169	127	2o4	437	688	982	137o
6o.	World market price of N	world	$FEPR_1$	$ per ton	1o9	434	253	249	262	284	314
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	1o1	433	211	193	192	2o2	217
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	91	96	1o2	1o8	113
93.	Net export of N	dev.ed	$FENTR_{11}$	million	3,9	3,5+	8,1	11,6	15,5	2o,2	26,3
94.	Net import of N	dev.ing	$FENTR_{12}$	tons	3,8	4,8+	7,9	11,3	15,3	2o,9	27,8
95.	P_2O_5 net export	dev.ed	$FENTR_{21}$	million	1,o	1,3+	2,1	3,o	4,1	5,4	7,1
96.	P_2O_5 net import	dev.ing	$FENTR_{22}$	tons	o,8	2,3+	1,7	2,3	3,4	4,9	6,9

+Calculated values.

Scenario A.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
97.	K_2O net export	dev.ed	$FENTR_{31}$	million	1,5	2,1+	4,o	5,5	7,2	9,2	11,6
98.	K_2O net import	dev.ing	$FENTR_{32}$	tons	1,3	3,o+	4,8	6,5	8,6	11,o	13,8
99.	N gross export	dev.ed	$FEBTR_{11}$	million	6,3	6,6+	11,9	16,o	2o,5	25,8	32,4
1oo.	N gross import	dev.ing	$FEBTR_{12}$	tons	4,3	5,6+	8,8	12,3	16,6	21,9	28,7
1o1.	P_2O_5 gross exp.	dev.ed	$FEBTR_{21}$	million	2,6	3,5+	4,8	6,1	7,6	9,3	11,3
1o2.	P_2O_5 gross imp.	dev.ing	$FEBTR_{22}$	tons	1,1	2,8+	2,3	3,3	4,6	6,3	8,5
1o3.	K_2O gross exp.	dev.ed	$FEBTR_{31}$	million	9,4	12,5+	23,8	32,7	42,9	54,9	69,2
1o4.	K_2O gross imp.	dev.ing	$FEBTR_{32}$	tons	1,3	3,1+	4,8	6,6	8,7	11,1	13,9

+Calculated values.

Scenario D. The results of simultaneous solution

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
23.	World market price of grain	world	GPR	$ per ton	71	167	98	92	88	88	88
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	147	229	315	4o3	47o
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	147	229	315	4o3	47o
36.		dev.ed	GST_1	million	139	89	777	166o	2611	3583	4359
37.	Grain stocks	dev.ing	GST_2	tons	3o	38	25	27	27	28	27
38.		world			169	127	8o2	1687	2638	3611	4386
6o.	World market price of N	world	$FEPR_1$	$ per ton	1o9	434	271	275	295	328	344
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	1o1	433	212	215	225	242	163
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	1o8	111	118	127	76
93.	Net export of N	dev.ed	$FENTR_{11}$	million	3,9	6,o+	3,2	4,o	5,6	8,2	11,3
94.	Net import of N	dev.ing	$FENTR_{12}$	tons	3,8	2,8+	3,4	4,4	6,6	1o,1	13,9
95.	P_2O_5 net export	dev.ed	$FENTR_{21}$	million	1,o	3,1+	1,5	1,1	o,9	o,9	2,2
96.	P_2O_5 net import	dev.ing	$FENTR_{22}$	tons	o,8	2,4+	1,2	o,8	o,8	1,1	1,o

+Calculated values.

Scenario D.

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
97.	K_2O net export	dev.ed	$FENTR_{31}$	million	1,5	o,9+	1,4	2,2	3,1	4,3	6,8
98.	K_2O net import	dev.ing	$FENTR_{32}$	tons	1,3	2,7+	3,2	4,2	5,6	7,3	6,6
99.	N gross export	dev.ed	$FEBTR_{11}$	million	6,3	9,o+	7,o	8,5	1o,8	14,o	17,8
1oo.	N gross import	dev.ing	$FEBTR_{12}$	tons	4,3	3,7+	4,7	6,o	8,4	12,o	15,8
1o1.	P_2O_5 gross exp.	dev.ed	$FEBTR_{21}$	million	2,6	5,o+	4,3	4,6	5,o	5,6	7,1
1o2.	P_2O_5 gross imp.	dev.ing	$FEBTR_{22}$	tons	1,1	3,o+	2,o	1,8	1,9	2,4	2,4
1o3.	K_2O gross exp.	dev.ed	$FEBTR_{31}$	million	9,4	5,1+	8,1	13,3	18,7	25,7	4o,5
1o4.	K_2O gross imp.	dev.ing	$FEBTR_{32}$	tons	1,3	2,7+	3,2	4,2	5,6	7,3	6,7

+Calculated values.

Scenario E The results of simultaneous solution

Ser. numb.	Variables	Country-group	Marking of vari-ables	Unit of measure	Factual values		Prognosticated values				
					1970	1975	1980	1985	1990	1995	2000
23.	World market price of grain	world	GPR	$ per ton	71	167	114	105	102	102	103
34.	Net export of grain	dev.ed	GTR_1	million tons	24	49	162	240	318	397	471
35.	Net import of grain	dev.ing	GTR_2	million tons	21	43	162	240	318	397	471
36.		dev.ed	GST_1	million	139	89	480	1136	1871	2624	3361
37.	Grain stocks	dev.ing	GST_2	tons	30	38	23	25	25	26	25
38.		world			169	127	503	1161	1896	2650	3386
60.	World market price of N	world	$FEPR_1$	$ per ton	109	434	399	351	357	386	432
61.	World market price of P_2O_5	world	$FEPR_2$	$ per ton	101	433	314	285	277	287	312
62.	World market price of K_2O	world	$FEPR_3$	$ per ton	66	154	133	128	134	143	155
93.	Net exp. of N[++]	dev.ed	$FENTR_{11}$	million	3,9	1,6[+]	-3,1	-1,4	0,6	3,4	7,5
94.	Net imp. of N[++]	dev.ing	$FENTR_{12}$	tons	3,8	2,6	0,8	1,2	3,3	6,9	12,5

[+] Calculated values.

[++] Minus values of export denote import and minus values of import denote export respectively.

Scenario E.

Ser. numb.	Variables	Country-group	Marking of variables	Unit of measure	Factual values		Prognosticated values				
					197o	1975	198o	1985	199o	1995	2ooo
95.	P_2O_5 net exp.++	dev.ed	$FENTR_{21}$	million	1,o	1,3+	-2,4	-3,5	-4,1	-4,5	-4,5
96.	P_2O_5 net imp.++	dev.ing	$FENTR_{22}$	tons	o,8	2,3	-o,8	-2,4	-3,2	-3,4	-3,o
97.	K_2O net exp.++	dev.ed	$FENTR_{31}$	million	1,5	-1,4+	-o,8	o,8	2,o	3,3	5,1
98.	K_2O net imp.++	dev.ing	$FENTR_{32}$	tons	1,3	2,5	2,6	3,8	5,3	7,3	9,7

+Calculated values.

++Minus values of export denote import and minus values of import denote export respectively.