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FOOD SECURITY AND SUSTAINABLE DEVELOPMENT DIVISION

SUMMARY REPORT OF THE PRESENTATION OF THE POPULATION, ENVIRONMENT, DEVELOPMENT, AND AGRICULTURE (PEDA) MODEL

4-6 NOVEMBER 1998
ADDIS ABABA, ETHIOPIA

By:

S.M.K. DONKOR

Addis Ababa, Ethiopia
30 December 1998

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1. BACKGROUND AND JUSTIFICATION OF THE PEDA MODEL.

Africa has been beset with very rapid population growth, poor agricultural performance and increasing environmental degradation. These three elements Population, Agriculture and the Environment, interact in vital ways for sustainable development. This interaction occurs mostly negatively in the African Region and therefore necessitates the holistic designing of development efforts to reflect the population-agriculture-environment nexus.

A consensus exists among African governments that an approach to economic development with emphasis on food security, social and economic development and environmental security is the key to poverty reduction in the region. It calls for an urgent reversal of the current trends requiring:

(i) Sustainable increases in agricultural productivity;

(ii) Harmonising population growth with the level of food production;

(iii) Better stewardship of the environment;

(iv) Better and equitable use of water;

(v) Utilization of Science and Technology in the promotion of Food Security and Sustainable Development.

The ECA, utilizing its power of Advocacy, aims to attain this reversal and thus bring about three key transitions: transition from low to high productivity in agriculture; transition from high to low population growth rates; and transition from poor to better stewardship of the environment.

1.1 Issues to be analysed:

The development of the PEDA (Population-Environment-Development-Agriculture Model is based on the premise that it is necessary to go beyond the traditional sectoral approach to national development if the transitions discussed above are to be achieved in Africa. The inter-sectoral nexus - closely interconnected issues in the real world- needs to be considered based on the recognition of the scientifically well founded mutual interdependencies and synergistic relationships between population, environment and agriculture

1.2 Methodology:

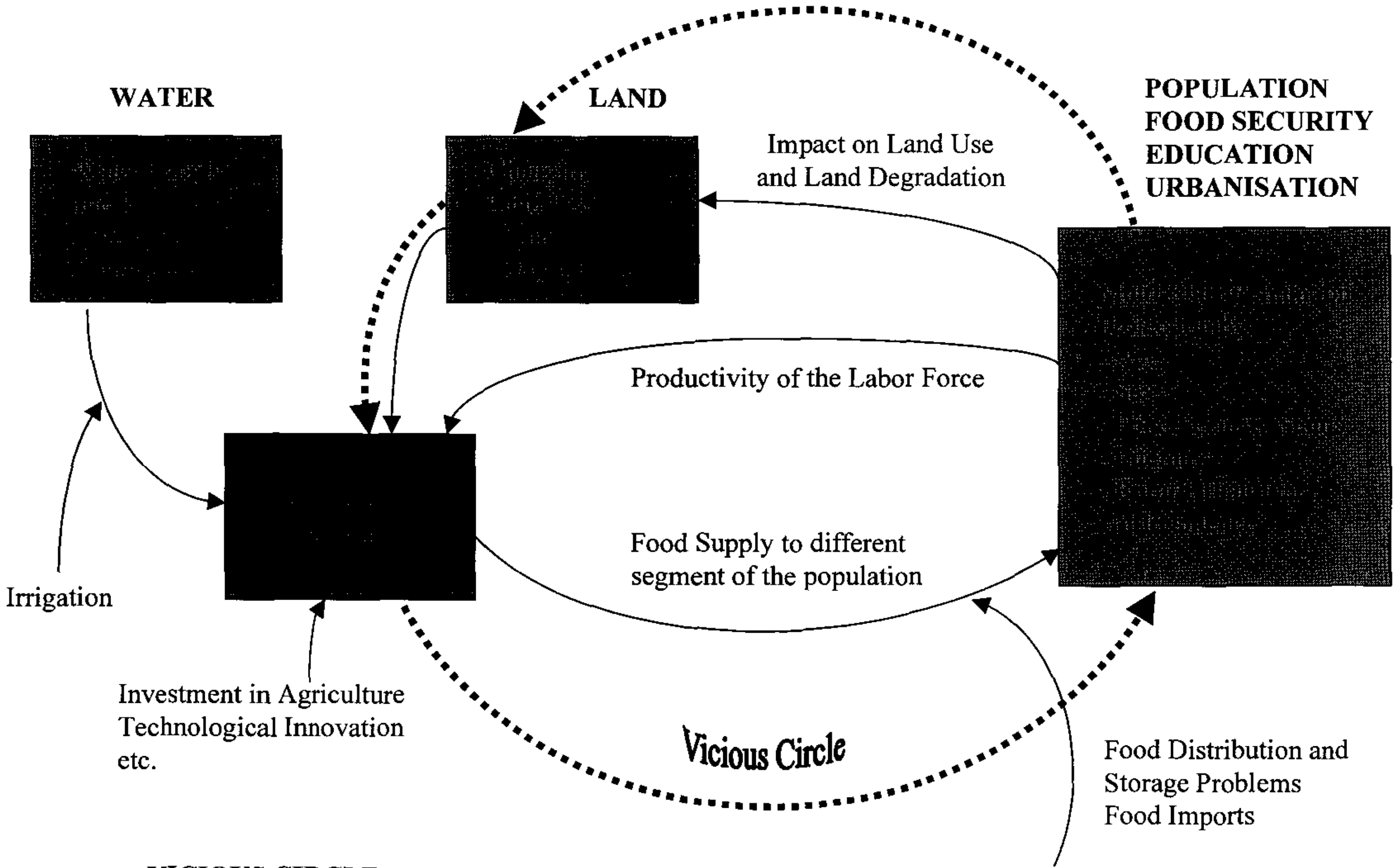
The ECA has given priority to awareness creation about the interdependencies in the medium to long term and intends to make it the cornerstone of its advocacy function. The PEDA model is a simple quantitative tool (computer simulation model) which is being developed to create awareness of the interdependencies at the level of national planners and policy makers. Based on the PDE Model developed by IIASA, with an application to Mauritius, it will allow the direct demonstration of the longer-term implications of certain alternative policies in terms of human development, land and water and their impact on the food security status of the concerned population. A simple schematic diagram of the model is given in chart 1 attached and essentially consists of three sectors:

- a human development sector (covering demographic factors, food security status, education and urbanization)
- a land sector as a proxy for agriculture
- a water sector as a proxy for the environment

When operational, the model will be used to demonstrate various policy options and strategies and their effectiveness in breaking the vicious circle. The VC as shown in the chart of the PEDA model. The vicious circle starts with high population growth of the rural food insecure, which leads to the cultivation of increasingly more marginal lands. This results in decreasing agricultural productivity both per unit of land and per capita. The decrease per unit of land means more land and thus more labour is needed per unit of food and the need for labour leads to the beginning of the circle where high fertility is desired which leads to high population growth rates. The PEDA model will also allow for sensitivity analysis of the various factors which underlie such options and strategies.

THE PEDA MODEL

Linking Population, Food Security and the Environment



...... VICIOUS CIRCLE:

High population growth of the rural food insecure population will contribute to degrade the marginal lands. This decreases agricultural production which in turn still increases the number of food insecure persons.

2 AGENDA AND TIMETABLE OF THE MEETING.

DAY 1 –4TH November , 1998

Location: Committee Room , UNCC.

8:30-9:30 Registration

9:30-10:00 Introductory Remarks by Chief, FSSDD.

10:00-11:00 Conceptual Basis of the PEDA model by Prof. W Lutz.

11:00-1130 Coffee/Tea Break.

11:30-13:00 Conceptual Basis of the PEDA model continued plus Discussion.

13:00-15:00 Lunch Break.

15:00-17:00 Model Demonstration and Discussion.

DAY 2 –5th November, 1998

Location: Training Room , UNCC.

9:00-11:00 Model Demonstration (cont'd). (Prof Lutz & Dr Scherbov as Resource Persons).

11:00-11:30 Coffee/Tea Break.

11:30-13:00 Model Demonstration (cont'd).

13:00-15:00 Lunch Break.

15:00-17:00 Feedback by Participants and Evaluation .

Day 3 –6th November, 1998

Location: Committee Room ,UNCC.

9:30-11:00 Discussion on Partnerships and Dissemination of Model.
(Chairman: Dr. S.M.K. Donkor, PEDA Focal Point)
11:00-11:30 Coffee/Tea Break.

11:30-13:00 Discussion on Partnerships and Dissemination of Model (Continued).

13:00-15:00 Lunch Break.

15:00-17:00 Any other matters and Closing Remarks by Dr. S.M.K Donkor, PEDA Focal Point, FSSDD.

3. SUMMARY OF FEED BACK COMMENTS FOR MODEL IMPROVEMENT.

The summary presented below is based on the feedback obtained from the evaluation questionnaire administered to participants at the end of Day 2 and the minutes of the Discussion on Partnerships and Dissemination Modalities which was chaired by the PEDA Focal Point, Dr S.M.K. Donkor.

In introducing the session, the chair briefly clarified the ECA's general view on the dissemination of the PEDA-model. According to the current planning the ECA will organize training sessions for the members of the SRDC who subsequently will accompany the application of the PEDA-model in their member states. Participants were invited to comment on this proposition.

First of all some participants shared their concerns that, at the current stage, the PEDA model is not yet ready for dissemination. Among other things they suggested the inclusion of the technological inputs, GNP per capita, investments, rural-urban migration and 'white noise' as potential variables to be considered or aspects to be modeled. Further, they requested the finalization of a comprehensive manual with clear guidelines on the data requirements and data input. In his response, the chair remarked that the PEDA model is not in its final stage of development and that the comments of the participants during the seminar as well as their written remarks will be gathered by the secretariat and communicated to the consultants in order to improve and finalize the model.

Since the PEDA-model is an open model, further customizations to country specific situations and needs can still be made afterwards.

In response to some question of members of the SRDC the chair clarified that, although the schedule is not yet fixed, the PEDA-model should be finalized within 3 months and that the training of the members of the SRDC could probably start from the 2nd quarter of next year.

Apart from using PEDA as an advocacy tool in sensitizing policy makers (and NGO members) awareness on the interrelationships of the nexus issues, participants also stressed the usefulness of the model as an instructive tool in graduate and post-graduate curricula of universities and research related institutes. It is precisely in these institutions that future policy makers are formed. Students and researchers could further play an important role in the further development and fine-tuning of the model. With this respect one participant suggested the ECA should raise the funds for a Ph.D.-scholarship on the subject.

The participants stressed once again the importance of the capacity building in the member states in order to take fully advantage of the PEDA model. One of the main potential sources of difficulties identified by many of the participants is the data collection and data preparation. With this respect, it was suggested that the subregional research institutes (such as RIPS, IDEP, IFORD, CERPOD and others including universities) might play an important supporting role. They are often the best informed on the type and availability of data that are required by the model. Some of the present representatives (including these of the CERPOD and the IOM) committed themselves to give such support. The member states themselves should also be prepared to make data assessments.

In their reaction, some members of the ECA headquarter remarked that, although the model has great potential, it should go through a substantive testing phase (in collaboration with the subregional research centers) and that, at this present moment, the ECA itself is too dependent on external expertise to further develop, improve and implement the model. As such the remark made earlier on capacity building is also applicable to the ECA itself. Further, it was said that the model also needs a French interface and that the dissemination through the Internet should be considered.

In his closing remarks the chair promised that the ECA will make every effort to include most of the participants remarks in the finalized version of the PEDA model and its dissemination and invited the participants to communicate written comments to the secretariat of the ECA.

4. CONCLUSIONS AND RECOMMENDATIONS.

Some of the major conclusions that can be drawn from the proceedings of the Meeting are:

1. The PEDA model is a very relevant and needed tool for the holistic analysis and integration of the Nexus Issues (Population Growth, Environmental Degradation and Agricultural Stagnation) in Development Planning efforts in Africa.
2. The Meeting provided very useful feedback for the further development of the Model. some of the comments were either Country or Discipline specific. With the intention to customize the model for individual countries it is hoped that some of these concerns will be addressed.
3. much concern was expressed about the capacity to generate adequate and reliable local data to make the analyses from the Model useful. It is hoped that adoption of the model will stimulate fresh efforts at local/national level to improve data collection institutions and structures.
4. building Capacity at all levels starting from ECA Headquarters to National/Local levels is a major prerequisite for the successful dissemination of the PEDA Model.
5. National Universities and related Research Institutions should form the vanguard for future refinement of the PEDA model and should be involved as soon as possible.

LIST OF INVITED PARTICIPANTS.

A. UNFPA

1. Professeur Pierre Klissou, University of Benin, Benin..
2. Mr Dakuyo Louis Marie, Burkina Fasso.
3. Dr Manuel dos Santos Pinheiro, Cape Verde.
4. Mr Sunkur Jumoondar, Mauritius.
5. Mr Ousmane Ndoye, Senegal.
6. Mr Hamidou Raby Wane, CERPOD, Mali.

B SRDCs

7. Mr S. Jugessur, N. Africa.
8. Mr Toma Makannah, W. Africa.
9. Mr. Ela Ela Amos, C. Africa.
10 Mr. Kampion Banda, E. Africa.
11 Mr Robert Okello, S. Africa.

C Affiliates.

12. USAID-J. Wolgin.
13. World Bank-J. Baah-Dwomoh.
14. WRI – Arthur Getz.
15. Peter G. Veit – Invited from World Resources Institute .
16 Mariano Bernado – International Organisation for migration.
17 Igor Mantsurov – International Organisation for Migration.

D. ECA

18. Executive Secretary.
19 Dep. Executive Secretary.
20. All Division Chiefs & Staff

ANNEX 1.

Population

Environment

Development

Agriculture

A Computer Model for Demonstrating and Projecting

PEDA Interactions in the Member Countries of the UNECA

First Draft of a Users Manual

1. What is PEDA?

PEDA is a user-friendly computer model for the analysis of Population-Environment-Development-Agriculture (PEDA) interactions. It can be used for (a) interdisciplinary scientific analysis and projection and (b) for science-policy communication in the field of planning for sustainable human development at the national level.

(a) Interdisciplinary Scientific Analysis and Projection lies at the heart of PEDA. In dealing with cross-cutting issues, such as the effects of education on fertility and population structure and in turn on agricultural productivity and food security, the model necessarily needs to refer to the state of scientific analysis in a number of different disciplines, ranging from demography to economics, agricultural sciences, land use analysis and even water engineering. By putting information down in quantitative terms and specifying the specific quantitative inter-dependencies such a computer model can also help to contribute to overcome traditional disciplinary boundaries that have been characterized by specific research paradigms and approaches. Models like PEDA can contribute to improved communication between the disciplines by inviting scientists from the different disciplines to add to the model the specific structure and data they consider appropriate without loosing the interaction with the other segments of the model. Specific empirical case studies (at the national or sub-national level) seem to be the right strategy to advance this goal and they are also the most useful under a policy perspective when the model is used to produce alternative projections under alternative policy-relevant scenarios.

(b) Science – Policy Communication: Similar to science being broken down into different disciplines, government policies tend to be compartmentalized according to the competencies of different ministries. This works well for some areas where the issues are limited in scope and require specialized treatment but it does not work so well for cross-cutting problems. Issues such as food security have to do with population, the skills of the labor force, agricultural production technologies and environmental issues such as soil quality and water availability. These diverse aspects do not fall into the responsibility of any one ministry in any country of the world. For this reason new ways need to be found to have inter-ministerial connections reflect the fact that in the real world things are also interconnected. An inter-sectoral model such as PEDA can help to demonstrate the usefulness and even necessity of for several ministries to work together on these issues. Furthermore, specific quantitative figures showing the outcomes of alternative policy choices over the coming decades are an efficient means of communication between scientists and policy makers. When using such models scientists do not only provide policy makers with vague opinions or unproven recommendations, but they can clearly and quantitatively demonstrate what alternative outcomes are to be expected, given of course that the specific assumptions of the model are accepted. But if the assumptions seem inappropriate, they can be changed and the new results can be compared to the old ones. (There will be much more discussion of the benefits but also the dangers of such models if they are being interpreted in an inappropriate way).

2. Focussing on the Vicious Cycle Model of poverty, illiteracy, high fertility, land degradation and food insecurity.

Unlike other quantitative models in the field of population and development PEDA focuses explicitly and one chain of causation that has recently received much attention in the international literature, especially in the field of interactions between population, food security and environmental factors. It is based on work by Partha DasGupta of Cambridge University and others and has been summarized recently in a UNESCO study

= Here give a short summary of the main reasoning as described in the above literature =

PEDA quantitatively operationalizes this model of a vicious circle and possible ways to break out of it in a way that is easy to follow and can be comprehended even if the underlying economic and demographic reasoning is not studied in depth. Before going into a description and demonstration of the model itself it is however useful to say a few words about the basic approach chosen, namely that of population based analysis which is quite different from the usual economic approaches.

3. The Basic Model Approach: Population Based Analysis

The population based approach takes the human beings and their characteristics (such as age, sex, education, health food security status

etc) both as the agents of social, economic, cultural and environmental change and as those at the risk of suffering from repercussions of these changes but also benefiting from positive implications. I this sense the human population comes in at both ends, it is seen both as a driving force of these changes and in terms of the outcomes and consequences of these changes. Economics, if it comes into the picture, e.g. through the importance of markets in distributing goods, plays only an intermediate role and is not seen as an end in itself as you frequently find it in the development economics literature.

This population based approach is not assuming that population growth or other demographic changes are necessarily the most important factors in shaping our future, rather the phenomena are studied mostly with respect to different characteristics that can be directly attached and measure with individual members of the population. Characteristics such as age, sex, literacy, place of residence and even nutritional status can be assessed at the individual level and sum of these individual characteristics make up the distribution in the total population. This is different from other frequently used indicators such as the GNP per capita that cannot be measured as an individual characteristic and is also not really indicative of the average amount of money that an individual has in his pocket due to various conceptual and measurement problems. Although many of the powerful quantitative economic tools cannot be applied due to this choice of approach, other very powerful but less well known tools of demographic analysis and projection can be applied. The tools of multi-state population analysis allow for the projection of the population by several characteristics (such as age, sex, education and place of residence) at the same time. Hence this tool does nothing, but group all individuals of a given population into different sub-groups which then are projected into the future while people over time can also move from one sub-group to another (e.g. from rural to urban or illiterate to literate for each sex and age group).

Obviously, this population-based approach is only applicable to aspects involving human beings. When we talk about soil quality or water availability other adequate characteristics of those phenomena need to be defined and measured in the appropriate physical units (such as cubic meters of water available, possibly broken down by different water quality groups). As we will see below the PEDA model remains to a large part in the domain of different population based characteristics but also includes the environmental aspects of land, water and agricultural production of protein on the natural science side of the model in order to have a fully closed loop of the vicious cycle model.

4. Basic Structure of PEDA

4.1. General Design and Justification

4.1.1 Calibrating the Vicious Cycle Model

The basic structure of PEDA is given in Figure 1. To the right of the chart are the four main aspects population, food security, education and urbanisation that will all be dealt with in terms of multi-state population projections. For the starting year one must have the distribution of the population by age (in 100 single-year age groups, sex (female/male), food security status (food secure/food insecure as defined below), literacy (literate/illiterate according to UNESCO definition) and urban/rural place of residence (according to national definition of what is a town). If not all the information is readily available, one must estimate some of the distributions as will be discussed below.

The model will now start to run in single years of time. In the first year the people that have been classified according to these criteria will have two effects as indicated by the two solid arrows leaving the population box on the right. The most important impact will be the contribution of the agricultural labor force to agricultural production. How many people exactly are assumed to belong to be the agricultural labor force can be determined by the modeler, as a default it is assumed that all men and women living in rural areas and aged 15-60 (?) constitute the agricultural labor force. This group is comprised of illiterate and literate persons as well as of food secure and food insecure ones. However, an important feature of this model is that it can assume different agricultural productivities for these different subgroups as will be discussed for the agricultural production function below.

4.1.2. Land and Water

The second solid arrow only depends on the number of persons that are part of the rural, illiterate and food insecure category and affects the degradation of the land. A negative impact of the size of this group of persons on the quality of the land is an important part of the vicious cycle model as described above. In this version of PEDA this impact is operationalized in the following manner: the amount of high quality agricultural land will also enter the agricultural production function and it is assumed that the higher the size of this group of illiterate food insecure rural persons is the larger will be the annual impact of this group on reducing the available high quality agricultural land through degradation. As in most parts of PEDA the specific parameters of the intensity of this degradation can be varied by the users in terms of alternative scenarios to be calculated.

The other environmental aspect taken into account in PEDA is the availability and use of water. In this version we do not have a detailed water module that could be constructed if appropriate data are available and a more detailed model is assumed to make a difference on the model results in other sectors of PEDA. Here water is seen as a factor in agricultural production that can work both ways, water scarcity can reduce agricultural production whereas increased use of water for irrigation (if this water is available and its use does not negatively affect other areas of agricultural production) can increase agricultural output. Both the extent of irrigation as well as total water availability are here treated as scenarios variables that can theoretically be changed for every year based on assumed climatic conditions and efforts in increasing irrigation.

4.1.3. Agricultural Production

The total agricultural production in one year, measured in total calories produced, will then be a result of the inputs in terms of human labor force by different educational levels, water, land and technological inputs such as fertilizers, mechanization etc. Those additional inputs will also be treated in terms of externally defined scenarios because these factors are not assumed to depend directly on other variables of the PEDA model. (If a user, however, wants to make e.g. the rate of new agricultural investment dependent on population growth in either a positive or negative way, it is not difficult to do so and study the alternative results). The specific agricultural production function used here has been derived from an internationally highly renowned book in the field ("Agricultural Development: An International Perspective"" by Y.Hayami and V. Ruttan) and will be specified in the definition section below. This production function will then result in a certain total calorie production by the end of the year.

Unfortunately, in reality, not all the production will be consumed by individuals to satisfy their food needs. Some proteins will be lost during the treatment of the food, others will be lost during transport and some will be lost due to inadequate storage. Of the food that will actually reach people for consumption a certain fraction will go to urban areas and another part to rural areas. All these factors can be assumed in PEDA as scenario variables specific for a country and can be changed over time or alternative starting values can be assumed.

4.1.4 Food Distribution

But even when the total amount of food reaching the population would be theoretically sufficient to provide the necessary minimum diet for everybody, in practice the distribution of food is unequal because some persons do have more purchasing power than others or have privileged access to food by other means. This will result in the fact that some people remain food insecure even when the average total amount of food reaching the population is above the minimum.

There is abundant empirical evidence backed up by theoretical considerations clearly showing that the distribution of food is as least as important as the total production of food in explaining food insecurity. Especially the path breaking work of Amartiya Sen (who recently was awarded the 1998 Nobel Price in Economics for his work on hunger and entitlements) demonstrated that some of the worst famines occurred under conditions in which theoretically there would have been enough food for everybody if the distribution would have been appropriate. For this reason it is evident that a model focusing on food security without paying attention to the distributional aspects would be in complete if not misleading. The main problem with considering such distributions, however, lies in the fact that hardly any empirical data exist on distributive mechanisms in the countries of Africa today and that theoretical distributions are hardly appropriate because conditions tend to vary significantly from one country to another. As a solution to this problem in PEDA we chose to approximate the food distribution function through an income distribution function which does exist for a number of African countries based on household income surveys.

This allocation of food to urban and rural populations and the food distribution within

These populations then determine the new sizes of the food secure and food insecure sub-populations in the following year.

4.1.1. Specific Variables and Functions Used in the Different Sectors of PEDA

4.1.2. Sub-groups of the multi-state population model

As shown by Figure 2 the population of a country under consideration is broken down into eight sub-groups according to urban/rural place of residence, education and food security status. Each of these sub-groups further subdivides the population by age and sex, i.e. every one of the eight groups has its own age pyramid. During each one year simulation step persons will move up the age-pyramid by one year within the some sub-group or move to another sub-group while also aging by one year. The movements between groups that are possible within each step are shown by arrows in Figure 2: For education and rural/urban migration the model is hierarchical, i.e. people can only move into one direction, from lower to higher education and from rural areas to urban areas. Movement between food security states can happen in both directions depending on the food conditions in any given year.

4.2.2.Fertility and Mortality

In addition to these movements between these sub-groups, each of the groups also experiences the vital events of births and deaths.

Different sets of age-specific fertility rates are applied to the female populations in each of the sub-groups. The data for the starting year are based on empirical information about differential fertility rates by education and urban/rural place of residence. Fertility differentials by food security status typically need to be assumed because of the absence of empirical information. For the future years fertility within each sub-group can either be held constant or be changed according to an assumed linear trend.

*** Insert screen print on setting fertility levels ***

The births generated through the application of those age-specific fertility rates will be put to the bottom of the age pyramids (after applying a sex ratio at birth) in the food security or residential state of the mother, i.e. it is assumed that children of an urban mother are also urban and children of a food insecure mother are also food insecure. Only with respect to education the children may end up in a different

sub-group than their mother because babies cannot yet be literate. In other words all children of educated mothers are put into the uneducated category for their initial years and can then only move to the educated groups according to the educational transition rates assumed in the specific scenario.

Age- and sex-specific mortality rates can also be set up independently for the different groups. This can have important implications for population dynamics since the food insecure groups can be expected to have much higher mortality rates than the food secure groups. Since almost no empirical information exists on these mortality differentials, unfortunately most of the differentials need to be based on assumptions. Sensitivity analysis can then demonstrate the implications of different assumptions.

All the specific formulas for this sector are given in Appendix 1.

4.2.3 Education and Rural/urban migration

As indicated above, here it is assumed that persons can only move from the illiterate state to the literate one, but if considered important secondary illiteracy can also be incorporated relatively easily. For simplicity it is also assumed that all education takes place in childhood, but again adult literacy campaigns can be incorporated if necessary. In the model the transition to literacy can be defined in terms of the total educational transition rate (see screenprint above) which defines the proportion of each cohort of girls or boys that will become literate.

In a similar fashion, the level of rural to urban migration can be defined through the total migration rate, giving the proportion of each rural cohort to move to urban areas. The only difference to education is that the migration is assumed to be less concentrated in a specific age-group but is spread over a broader age range according to typical age-specific migration patterns.

International migration has not yet been specified as a scenario variable in this prototype application. For simplicity countries are being considered as closed populations. But it is not difficult to explicitly include international migration to and from the specific sub-populations by age and sex. Theoretically, if considered appropriate the PEDA models of neighboring countries could also be linked through international migration and considered simultaneously.

4.2.4. Agricultural Production Function

AS indicated above, domestic agricultural production is a key component of PEDA because it largely determines the degree of food security in the country. Many agricultural production functions exist but most of them surprisingly do not consider the labor force and the skills of the labor force as a production factor but largely focus on physical and financial inputs. A notable exception is the above-mentioned book by Hayami and Ruttan. Based on pooled data sets of time series in most countries in the world they estimate large numbers of Cobb-Douglas type production functions with different combinations of input factors and for different groups of countries. The one equation that seemed most appropriate for the PEDA Africa model is the one giving a Principal Components Regression for developing countries including education variables.

Specifically the elasticities form this equation and the specific variable definitions in PEDA are as follows:

.534 * Rural Labor Force (specified here as total rural adult population aged 15-60, calculated from combining the appropriate age groups in all four rural sub-groups

.088 * Total Agricultural Land (can be modified through land degradation or the clearing of new land as discussed below)

.162 * Fertilizer Use (will be treated as an exogenous scenario variable)

.072 * Tractors Available (will be treated as exogenous scenario variable called more broadly mechanization)

.276 * Literacy (specified here as the proportion literate of the total rural population aged 10-45, calculated by combining both the food secure and the food insecure rural literate sub-populations)

.158 * Technical Education (still treated here as exogenous scenario variable, may later be related to educational efforts parameter)

All these input variables to agricultural production are considered here an a relative scale, i.e. they are set to equal 1.0 in the starting year, and then change over time as it results from the other sectors of the model for the endogenous production factors or as defined in the scenario setting for the exogenous variables. (e.g. an assumed increase in fertilizer input of 20% by 2003 would mean that that variable is set to gradually increase to 1.2 by that year.

All of the exogenous scenario variables related to agricultural production can be set to vary over time in terms of any regular or irregular path that the user may want to assume. These changes of values over time can either be defined in terms of percentage changes over time or numerically or graphically by pulling up or down the line with the mouse (see screen print of scenario setting below).

Screen print of scenario setting

4.2.5 Land

The production factor land (as introduced in terms of total agricultural land in the equation above) is assumed to cover both the quantity and quality aspects of agricultural land in index form. It therefore only refers to the size of land and its average natural fertility because enhancements of land productivity through fertilizer use is treated separately as a scenario variable (as describe above) and the irrigation factor is also handled separately in the water section below.

But even the pure land factor without fertilizer and water consists of two components, one which is a feed-back affect covering land degradation in dependence from the size of the rural, illiterate and food insecure population (a key mechanism assumed by the vicious cycle model) the other one being a scenario variable describing possible exogenous changes in the area of totally available land through possible expansions of agricultural land or other assumed mechanisms. Also the degree impact of the rural illiterate food insecure population on land degradation can be defined by the user in form of a scalar parameter called land degradation impact factor (LDIF).

*** see screen print for ways to set this parameter ***

In formal terms the value of the variable "Land" which enters the production function
changes over time as a consequence of the exogenous scenario variable "New Land" and

the relative change in the size of the sub-group of rural, illiterate, food insecure men and women (POP(r,i,fi)) times the scale parameter:

Land (t) = Land (t-1) * New Land (t-1) * LDIF * POP (r,i,fi) t/ POP(r,i,fi)initial

An additional condition is introduced in which the last term of the equation can only be greater that one or equal to one. In other words, if the size of POP (r,i,fi) declines over time this does not improve the land, i.e. there is no inverse degradation. If one wants to consider a possible natural regeneration of the land this can easily be done by assuming higher values for 'New Land".

4.2.6. Water

4.2.7. Loss of food and import/export

Two user-defined factors are applied to the total agricultural output to calculate the total available food

- factor covering loss of food during the process of harvest, storage or transport
- possible increase of the total available food due imports or decreases through exports.

4.2.8. Allocation of food to urban and rural areas

Allocation proportional to the population sizes of the respective sums of urban and rural sub-groups and application of an urban bias factor (scalar parameter set by user) that tilts the food distribution in favor of the urban population.

4.2.9. Distribution of food within urban and rural areas

Application of food distribution function

Food Security

HOW TO USE PEDA?

A: Use of readily operationalized country applications through

- **predefined scenarios**
- **user defined scenarios**

B: Preparing new applications with new data

- **changing the data for a given country**
- **applying PEDA to a new country**

A: Steps in starting PEDA and using pre-defined scenarios