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Sub-regional Expert Group Training
Workshop on PEDA

Kigali, Rwanda
11-15 December 2000

Report

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A. ATTENDANCE AND ORGANIZATION OF WORK

1. The sub-regional expert group training workshop on PEDA was held on 11-15 December 2000 in Kigali, Rwanda, as the first of a series of Sub regional workshop to build the capacity of ECA's member State in the use of the PEDA Model for the analysis of the nexus issues at national level. The training aimed to give the participants a clear view of the structure, the underlying assumptions and the data requirements of the model as well as the initialisation process to enable them to use PEDA as advocacy tool at national and sub-regional levels.

2. The workshop was organised by the ECA's Food Security and Sustainable Development (FSSDD) in collaboration with the Eastern Africa Sub-regional Development Centre of the Commission (EA/SRDC).

3. The workshop was attended by 18 delegates from Rwanda, Madagascar, and Tanzania as well as by representatives from FAO and UNDP local Offices. The list of participant is in Annex 2.

B. AGENDA

4 The meeting adopted the following agenda:

(1) Introductory remarks
(2) Presentation of participants
(3) Adoption of draft agenda and draft programme of work
(4) Presentation and discussion of country case studies
(5) Country expectations from Models dealing with the nexus
(6) Background and objectives of the PEDA model (including a comparison with other models)
(7) General introduction of the model (powerpoint presentation)
(8) Demonstration of the PEDA software
(9) The use of PEDA as an advocacy tool (presentation of draft advocacy booklets)
(10) Hands on sessions
(11) Discussion arising from the hands on sessions
(12) Discussion of the User's Manual
(13) Presentation of the future plans with PEDA and potential collaboration with research institutions
(14) In depth discussion of the different segments in the model (incl. the treatment of HIV/AIDS, and water, agricultural production and food distribution)
(15) Demonstration of the software structure (excel spreadsheets, the Access databases)
(16) Demonstration and discussion of more advanced model features (manipulating model parameters beyond user's interface, extracting and generating other than the standard output)
(17) Hands on session
(18) Discussion of the data requirements
(19) Discussions on the initialization of PEDA
(20) Hands on session
(21) Discussion on the Technical Manual
(22) General discussions/Evaluation Form
(23) Closing

C. ACCOUNT OF PROCEEDINGS

5 The Workshop was organized into three main sessions: 1) presentation and discussion of country case studies, 2) Introduction to the PEDA Model; 3) Training of the participant on the use of the PEDA Model (hands on session).

1. Introductory remarks

6 In his opening statement, Mr. Baye Diouf, Director of the EA/SRDC, first expressed his sincere appreciation to Mr .Maurice Bucagu, Director of the "*Office National de la Population*" (ONAPO) who has accepted to preside over the opening of the workshop. He also thanked the government of Rwanda for the support provided during the preparation of the workshop. He then welcomed the delegates to the workshop. He emphasized the need for participants to know how to use the Model because it is an advocacy tool to analyze and manage the nexus issues in region.. He also noted that the PEDA has been developed to support the major shift in development planning being advocated by ECA; that is the shift from sectoral to holistic planning approach. He said the holistic approach would help to better understand and manage the linkages that exist between rapid population growth, food insecurity and environmental degradation.

7 In his address, Mr. Maurice Bucagu, Director of ONAPO, on behalf of the Minister of Finance and Planning, welcomed the participants and wished them a pleasant stay in Kigali. He expressed his sincere thanks to ECA/FSSDD for organizing the first workshop on PEL`A Model in Kigali, Rwanda. He said that the government of Rwanda had embarked on the formulation of new development policy to fight against poverty and promote the economic recovery of the country. He noted that the PEDA Model had come at the right time as new policies and strategies were being put in place. The Model could play a very important role in helping the design of these policies especially in the case of Rwanda where the population pressure constitutes a serious development challenge. He than wished the participants a very successful workshop and declared the meeting officially opened.

2. Presentation of National Case Studies

2.1 Tanzania

8. Mr. Timothy Banda, consultant from Tanzania presented the study entitled "Report on Food Security, Environment and Population in the context of Policy orientation for Sustainable Development: Case study of Tanzania" document number ECA/EA-SRDC/2000/6(ii)/NCS (4).

9. The consultant presented the major features of the economy before touching on the relationship between population, agriculture, development and the environment, the emerging issues with regard to the country and the Government response to these issues.

10. Emerging issues as identified in the paper include the following:

(i) Population growth is undermining economic growth and food security in the country;

(ii) Urbanization, worsening poverty and pollution of natural resource in the urban centres;

(iii) Lack of inputs force farmers to increase food production by area expansion, which leads to deforestation and general environmental degradation. Forest cover removal is estimated at 500,000 ha per annum;

(iv) Institutional and technical constraints make it difficult to view the nexus issues in holistic manner. Additionally, lack of understanding of the linkages has weakened inter-sectoral coordination because there is no single organization that looks at all the three issues.

11. Government response included the formulation of policy documents for environment, forest, land, agriculture and livestock. However, these documents are taken as ends rather than means. These have therefore not been translated into working tools. Moreover, efforts to eradicate poverty, particularly in the rural areas, are severely undermined by high population growth. and the lack of population policy means that there is a weak link with the other issues.

12. The participants discussed issues such as the lack of cross sectoral planning process which remains common in many countries. In addition, issues of input supply and demand for farmers are mutually affected by abrupt introduction of policies into the system, like implementation of economic reform policies. Issues of poverty should be linked to rural development as well as to nutritional intake. The need for methodologies of programme analysis or modeling to understand inter-linkages of nexus issues of population, environment and agriculture. Other issues raised included institutional arrangements dealing with nexus issues in an integrated manner. Issues related to the implications of rapid population growth on economic development and environment came up for discussion.

13. The response to some of the issues was that in many countries policy documents existed, but the difficulty was in executing the policies, partly as a result of lack of coordinating system and Programme implementation being dependent upon availability of budgetary resources. Finally, it was pointed out that information gaps worsen the issues.

2.2 Ethiopia

14. Mr. Dejene Aredo, consultant, presented the study entitled "Report on Food Security, Environment and Population in the Context of policy framework for Sustainable Development: Case Study of Ethiopia" document number ECA/EA-SRDC/2000/6(ii)/NCS(1).

15. The paper (1) highlights a theoretical and empirical literature on the nexus issues between population, environment, development and agriculture with a view to critically examining the assumption of vicious circle of poverty adopted by PEDA; (2) presents an overview of the situation of food, agriculture, environment and population in Ethiopia, and outline the relevant sectoral policies currently operational in the country.

16. In the summary presentation it was pointed out that Ethiopia is the second largest country in Sub-Saharan Africa and it is among the poorest in the world. Repeated drought, famine and chronic food insecurity are among the features of the country. Different regimes have designed various sectoral policies to address prevailing development issues. One interesting feature of

these policies is that they are designed in isolation from each other and their implementation is left to compartmentalized departments of the federal and regional government. Consequently, policy-makers, experts and researchers do not appreciate the interdependence and interaction between population, environment and development. Reasons may be due to limited data, lack of innovative models reflecting its concrete conditions including a macro-economic model. The PEDA model confronts the policy-makers with another challenge.

17. In the discussion that followed, it was pointed out that PEDA is not a pessimistic model as was being argued in the paper. It only showed the extent of the vicious cycle into which countries would be absorbed if proper policies were not taken. It indeed shows that if correct policies in the area of education, technology, fertility, etc. were taken this vicious cycle could be broken.

18. The Best Practice cases that were cited, such as the Machakos is also supported by the PEDA in that if only right policies were taken the favourable results would emerge. In actual situations, the vicious cycle has been broken whenever correct policies have been taken.

2.3 Madagascar

19. The Madagascar's case study (document number ECA/EA-SRDC/2000/6(ii)/NCS(2)) was presented by Havoson Nirina Rakotoarivelo. He gave an overview of the general characteristics of the economy and later presented some of the policies that are being taken to address the poverty and vicious cycle facing the country.

20. It was reported that Madagascar has considerable agricultural potential. Mechanization is not practised much because of the hilly nature of the arable land. There is extensive land degradation which has accelerated soil erosion.

21. As a result of the seriousness of the poverty issue, a strategy to reduce poverty was initiated with the participation of the entire active population. The main aspects of the strategy include:

- (i) Improvement in economic performance by (a) setting up a favourable framework for direct external investment into sectors with potential for growth (tourism, manufacturing, industry, etc., and (b) undertaking supplementary measures to ensure increased environmentally sustainable agricultural production on both a small and a big scale and an increase in agro-businesses;
- (ii) Development of basic essential amenities (education, health and clean water) and widening of economic and social security to cater for the most vulnerable sectors of the population;
- (iii) Establishment of an institutional framework for economic development and poverty reduction and enhancement of capacity for good governance;
- (iv) Setting up autonomous provinces and,
- (v) Improvement in the management of public affairs.

22. During discussions it was pointed out the need to develop a strong population policy and work out coordinated policies so that problems of individual sectoral un-coordinated policies which are common in most African countries do not arise.

2.4 Rwanda

23. Mr. Kalisa Mbanda, one of the consultants for the Rwanda study presented the study entitled "Report on Food Security, Environment and Population in the Context of Policy Orientation for Sustainable Development: Case Study of Rwanda" document number ECA/EA-SRDC/2000/6(ii)/NCS(3).

24. The paper presents the characteristics of Rwanda by giving the population, environment and food security; their interactions and relation to development. Later, food security and policies in agriculture and environment were discussed.

25. Rwanda has a density of 308 persons/km2. Although the total surface area is 26,338 km2, the arable surface area is only 13,850 km2 so that the physiological density reaches 586 persons per km2, making it the most densely populated country in Africa. Rwanda, like most African countries is predominantly agricultural with the average size of land holding per family as 0.75 hectares. There is extensive land degradation which has accelerated soil erosion.

26. In the early 1950s there was significant food production compared to the low population. The result was that food security was achieved. However, after 1985, as a result of population increase, less available arable land, drought, war, economic and social crises, food production began to fall and food security became a problem.

27. During discussion, the usual problem of policies being undertaken on sectoral lines with very little inter-linkages was noted. It was pointed out that with high population growth, limited urbanization and huge densities restricted to arable areas, there was the urgent need to attend to these inter-linkages.

3. <u>General Introduction and Presentation of the PEDA Model</u>

3.1 Background and objectives of the PEDA Model and Country Expectations

28. In introducing this agenda item , the Secretariat reminded the participants that the two main working documents for the workshop are the Draft Users Manual and the Draft Technical Manual which are in Annex 2 and 3 respectively.

29. The Secretriat then discussed the existence of negative inter-linkages between population, environment and agricultural development. While population was growing faster than GDP, food production per capita was declining. Food production was declining because of the reduction in the use of inputs and other technology. The use of fertilizer, other inputs and machinery in Africa was the lowest in the world.

30. Populations concentrated in the rural areas increasing the density in those areas. Where the rural populations were the poorest, environmental degradation tended to be high. Land

became scarce with the recourse to using marginal lands. This led to decreasing productivity and production. As a result there is the perceived need for more children to increase the labour force and produce more. This led to a vicious cycle of population growth, environmental degradation, reduced food production and increased food insecurity. There is a need to break this cycle.

31. In the 1970s, it was thought that high population growth was the problem and so population policies were devised. The educational sector was also looked at with the program of universal enrolment of children. These policies to a large extent failed because they considered the particular sectors alone without investigating their inter-linkages.

32. In the 1990s, attention was focused on sustainable development. The ECA was restructured to deal with issues holistically. The division of Food Security and Sustainable Development was created to study the nexus issues and advocate a holistic approach to them. The PEDA model is now being used as an advocacy tool for the nexus. The Secretariat also indicated that there are several models that look at the inter-linkages between Population, Environment and Agricultural Development but the PEDA model is more focused and ideal for advocacy purposes.

33. PEDA utilizes the present situation of the vicious cycle nature of African economies and estimates the proportion of food insecure population in a country. An assumption that was used in developing the model is the existence of an illiterate rural poor who degenerate the environment. It is an advocacy tool for policy makers, civil society and NGOs. It asks policy makers to take account of the negative synergy between population, environment and agriculture. It can be used as a population projection tool. PEDA can also be used to demonstrate the virtuous cycle dynamics where population growth can lead to an increase in food security provided other supporting positive policies are undertaken.

34. The consensus of the discussion on Country Expectations from the Models dealing with the nexus issue was that from all the studies, there was a negative synergy between population, environment and agriculture which is leading to food insecurity in those countries. Following these difficulties, therefore, Structural Adjustment Programmes were being undertaken which tendered to be sectoral in nature. The challenge is how to make these policies recognize the inter-linked nature of the problem and solve them holistically.

3.2 Presentation of PEDA Advocacy Tool for Cameroon

35. The Secretariat presented a paper on PEDA as an advocacy tool for Cameroon. PEDA in the paper is used as a multisectoral approach to help policy makers take the nexus issue more seriously. It was pointed out that although Cameroon has the lowest population growth rate and lowest fertility rate in the region, increasing agricultural production is taking place through land expansion. Why this is a problem is that although Cameroon has substantial arable land, the population is concentrated in this arable land area. The low use of inputs causes the land expansion leading to land degradation.

36. The vicious cycle is now operating in Cameroon and although policies are being put together to address this, they are in most part not implemented apart from the fact that some are sectoral in nature.

37. Before the initialization of PEDA for Cameroon, a national study was undertaken and the results used for alternative scenarios. The objective of the exercise is to show the magnitudes of the scenario results if the status quo remained so that leaders can see the gravity of food insecurity and other negative consequences.

3.3 Power Point Introductory Presentation of PEDA

38. In introducing the PEDA model, the Secretariat indicated that PEDA is an interactive computer simulation model which now takes HIV/AIDS on board. The three main components are: (i) population projection; (ii) estimation of food availability and, (iii) food distribution estimates.

39. The theoretical basis of the model is the vicious cycle of illiterate rural poor degrading the environment. This vicious cycle can be broken through better food production, increasing literacy rate, reduction in population growth and reduction in the spread of HIV/AIDS. The model has evolved since 1998 and is now in the final process of completion. One of the aims of the workshop is to help improve the model.

40. There are multi-state projections using 8 population subgroups by literacy (literate or illiterate), residence (rural or urban) and food security status (food secure or food insecure). The user can make assumptions about fertility, mortality, education and internal migration as well as other factors determining food production and the inequality in food distribution.

41. A lively discussion on the model took place about what food security means and the possible avenues of getting there. There were several questions about the model for which participants were asked to wait for the detailed presentations which were to follow.

4. <u>Hands on Session with PEDA</u>

42. The Secretariat introduced the model and made a demonstration on how to construct scenarios, make simulations and view results. The model on CD was then installed on all the computers by the participants with the help of the three instructors from the Secretariat. The first part of the morning was devoted to this exercise.

43. An exercise was given to the participants to try the software and discuss the results. Two main questions were given. The participants with the faster machines were put into group 1 while those with the slower machines were in group 2.

44. Group 1 participants were asked to estimate and discuss the impact of efforts to increase only female education in rural areas to the levels prevalent in cities or to increase both male and female education in rural areas to the levels prevalent in cities on the total fertility rate, the land stock, agricultural production and food security status of the population.

45. Group 2 was asked to estimate and discuss the impact of efforts to increase the technological inputs in agriculture (machinery use, fertilizer use, irrigation) by 2% a year on the land stock, agricultural production and food security status of the population.

46. Discussions mainly focused on the difficulties with the manipulation of the simple examples during the hands-on-session. There was keen interest in arriving at results of those exercises. Discussions also arose from the presentation of the user's Manual.

5. In-depth discussion of Segments of the Model

47. Following a detailed presentation of different segments of the model including HIV/AIDS, land and water by the three instructors from the Secretariat, there was an in-depth and exhaustive discussion with several questions from participants.

5.1 HIV/AIDS

48. On HIV/AIDS, the questions mainly concentrated on how to integrate effects of HIV/AIDS directly on production. It was emphasized that Africa has surplus labour in that there was significant un-employment and under-employment even in the rural areas. Therefore, the mortality arising from the disease might not affect agricultural production as is envisaged in the model. It was clarified that since the disease is represented as a general mortality rate, it will affect agricultural output the same way as mortality is represented in the model. Also there is not enough data on the disease to specifically enter the mortality rates for each of the eight sub-groups separately which could be more meaningful. As more data become available, the model can be made richer.

5.2 Land

49. On the treatment of land it was pointed out that the degradation factor D(t) function should come on page 15, after the paragraph on D(t) , before the explanation of the various components of the equation.

5.3 Agricultural Production

50. It was felt that an income variable, such as GDP could be part of the production function. The reason is that apart from the inputs, there are government expenditures that should be undertaken to enable improvement of agricultural production. Examples are infrastructural expenditures, such as roads, telecommunication, hospitals and clinics, credit, extension, etc which can be increased when the GDP increases. Although other inputs such as fertilizer, mechanization, technology and irrigation will increase when income increases, with the privatization going on in most countries, it is expected that most of these activities will be undertaken by the private sector. Thus GDP takes care of the enabling environment that the nation has to undertake to improve agriculture.

51. The elasticities of the production function come from estimations using data from developing countries. Since there is access to data from African countries, it will be better if such estimations are done for African countries to come up with realistic elasticities for Africa. Then later each African country can customize by estimating its own elasticities.

52. A suggestion was made as to the enrichment of the production function by including factors, such as type of technology and rate of adoption, improvement of seeds, institutions and external shocks such as drought, wars and oil prices.

53. It was also thought that the use of agricultural output as a composite product was not satisfactory. It was argued, for instance, that animal husbandry is not treated in the model. It was pointed out that to some extent it was difficult to disaggregate agricultural output into various sub-sectors. Livestock particularly is not a problem since land and water are used by livestock and these variables have been treated in the model. Furthermore, when we consider agriculture, it includes livestock and fisheries.

54. It was further argued that the rural illiterate poor are not the only degraders. Some include loggers and miners. It was argued that since we are concerned with agricultural production in PEDA and since it is a fact that the largest degradation sector is agriculture, that assumption is not too unrealistic.

5.4 Food Distribution

55. Agricultural outputs include cash crop output which is exported to earn foreign exchange. Part of this foreign exchange can be used to import food. Even in this era of structural adjustment when governments no longer import anything, food imports will be a function of GDP and on its profitability. There will not be a one-to-one correspondence between agricultural output that was exported and food that will be imported. In terms of food security, when food is imported most of it is available to the urban rich and so the more agricultural output that is exported the likely food insecure that the rural poor will be. Food imports should be a function of income.

6. Demonstration of More Advanced model Features

56. The instructors demonstrated more advanced features of the model by going into the Access and Excel features. These features are situated behind the user interface of the model. They demonstrated how one can add and delete scenarios and change some of the more advanced model parameters. These are changes one can make outside the interface mode. Hands-on-exercises continued for the rest of the afternoon. Although this was an advanced form, participants were getting familiar with them in addition to the normal manipulation of scenario variables and carrying out simulations.

7. Discussion of the data requirements and on the initialization of PEDA

57. In introducing this agenda item, the Secretariat indicated that PEDA is a very multidisciplinary model that needs a well-groomed inter-disciplinary country experts to work on initialization that requires:

(i) Preparation of Demographic baseline data;
(ii) Estimation of the agricultural production function elasticities;
(iii) Estimation of the Water saturation curve;
(iv) Estimation of the land degradation and recovery parameters;

(v) Estimation of the food distribution function;
(vi) Inclusion of new variables.

58. The data are then stored in the 'init.mdb' file and can be improved with time. Important segments of the Baseline Data include the following:

(i) Distribution of the population by sex and single years of age for each of the eight subgroups;
(ii) Food distribution functions for rural and urban areas;
(iii) Age-specific fertility and mortality schedules.

59. There is a common shell and data should be added to the shell by the users. The extension and adjustment of data was also demonstrated and it was further indicated that for demographic requirements, there are utilities for graduating population data which are in 5 years or more into single year basis.

60. Hands-on-session took the rest of the morning in which participants were assisted in the exercise of adding new data to the shell.

8. Evaluation of the Workshop

61. At the last session of the workshop, the participants were required to make an evaluation of the workshop using a questionnaire that covered aspects of the administrative arrangements and documentation for the workshop along with discussions during the workshop and suggestions for the improvement of future workshops. The participants also commented on the benefits they had derived from the meetings.

62. The participants were of the view that more practical sessions will be needed than were allocated in the workshop. They also indicated that there should be a written documentation describing a step-by-step handling of the PEDA software in terms of its practical use. Participants admitted that the model is a very useful tool to advocate for the holistic approach in the development of policies but that the next important assignment was how to initialize the model for the remaining countries. The evaluation report is attached as Annex 1.

9. Closing of the Workshop

63. In his closing statement, the Secretariat thanked all the delegates for their active participation in the training. He expressed the hope that each participant will carry the acquired knowledge on PEDA to the respective countries. He assured the delegates that FSSDD and the Kigali SRDC are ready to provide them the necessary technical assistance to support any initiative on the building of the national capacity and in the initialisation of the Model. He then declared the Workshop closed.

Annex 1

Evaluation Report of the Training Workshop on PEDA

1. Background

1. The Training Workshop on the PEDA model for Eastern Africa was organized jointly by ECA/FSSDD and EA-SRDC in Kigali, Rwanda, from 11 to 15 December 2000. At the end of the workshop, an evaluation form was distributed to the participants. The form deals with some aspects related to the organization of the workshop, opinion on the model itself, and suggestions with regard to future workshops, the advocacy role of ECA in connection with the model and the follow-up activities of the workshop *(see attached form)*.

2. The information contained here was drawn solely from the evaluation forms filled out and submitted by the participants and does not contain any part of the discussions that were held during the workshop.

3. The purpose of this exercise is to help ECA, specifically FSSDD, draw lessons from the organizational aspects of the workshop (it was the first in its kind as a training workshop aimed at disseminating the model at sub-regional levels and using as resource persons the staff of FSSDD), and better design the future activities of the model.

2. Evaluation

2.1 Response rate

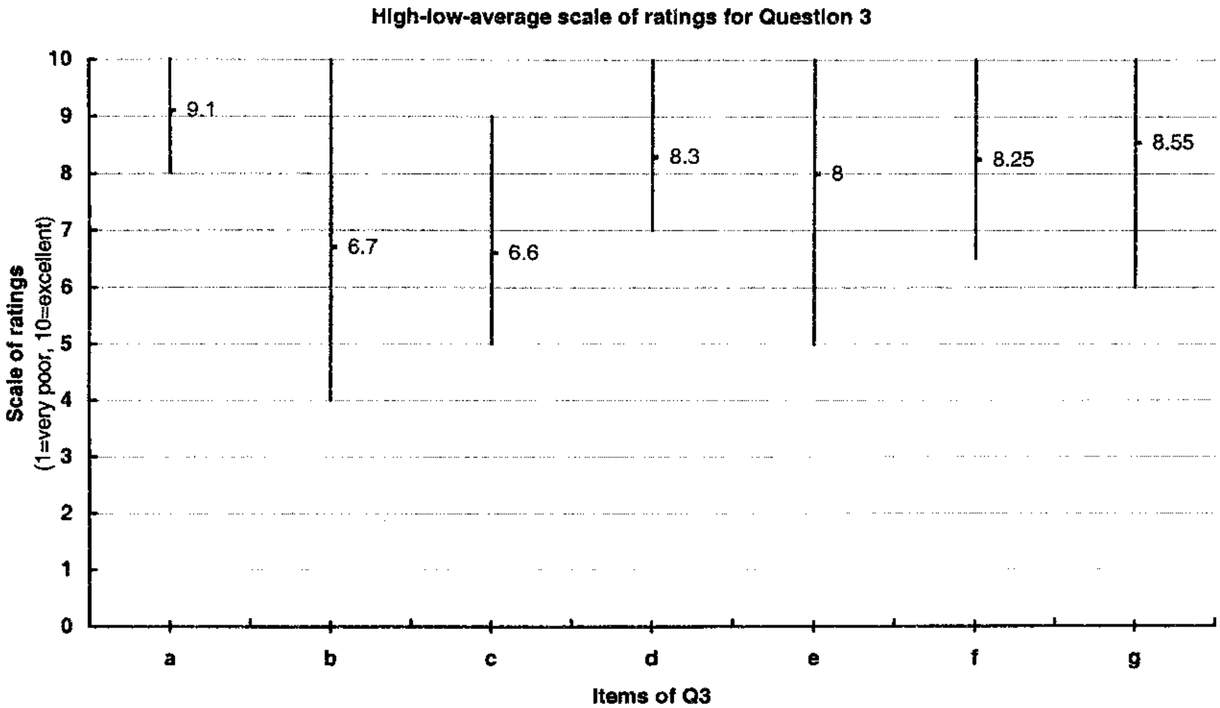
4. Out of 18 participants, 10 persons submitted their answers (56%). The others couldn't reply because most of them were not present at the last session during which the form was distributed. They had to leave early due to the pressing flight schedule or other assignments in their offices.

2.2 Organizational aspects of the workshop

5. The evaluation of the participants of the organizational aspects of the workshop was positive. None of them had participated in the previous workshops that took place in 1998 and 1999, and therefore learned the model for the first time during this workshop. Only 50 percent of repliers said that they received the invitation early enough to prepare themselves for the workshop. In terms of the duration of the workshop, most of participants (70%) had a feeling that the workshop was adequately organized while the remaining said that the workshop was too short to get familiar with the essential features of the model.

6. The participants also expressed their positive appreciation vis-à-vis the facilities (aver. point 9.1) and the training materials provided (aver. point 8.6), the preparation of the workshop and the organization of the sessions (aver. point 8.3), the content and presentation of the

theoretical sessions (aver. point 8.0), and the content and guidance provided by resource persons during practical session (aver. point 8.3).



a: the facilities of the conference environment
b: the professional mix of participants
c: the technical level of participants
d: the preparation of the workshop and the organization of the sessions
e: the content and presentation of the theoretical sessions
f: the content and guidance from resource persons during practical sessions
g: the relevance of the documents received

7. In this regard, it is important to pay attention to the comments made by some participants. The comments can be summarized as follows:

- More practical sessions are needed.
- The documentation should also include a chapter describing a step-by-step handling of the PEDA software in terms of its practical use.

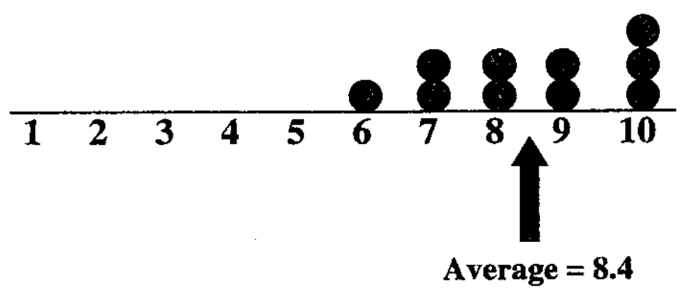
8. This feeling of participants about the time allocated to practical sessions was so common that their expectations in relation to the assumed outcome of the meeting seem to be not fully met. The ratings in this connection range from 10 to 5 with an average point of 7.5. Some of participants added that another workshop for the same people would be necessary to enable them to be conversant with the operational aspects and the initialization of the model.

2.3 Opinion on the PEDA model

9. Participants admitted that the model is a very useful tool to advocate for the holistic approach in the development policy making. However, some of them also expressed their

concern about the limitations of the model as it stands now. They suggested that the model should be further improved to capture more aspects of the real life in connection with the environment and the agricultural production. For example, seed and density may need to be included in the model. To increase the operational impacts and effectiveness of the model at the national level, it was also suggested that customization of the model would require not only efforts to collect more empirical data but also efforts to include other critical variables in a country-specific situation.

Opinion of the PEDA model (1=Very poor, 10=Excellent)



2..4 Suggestions relating to future workshops, the advocacy role and follow-up activities of ECA

- Disseminate PEDA to a broader public using all kinds of means, e.g. internet, CD-ROM etc. so that anyone interested in the model could easily get access to it.
- Initialize the model for new countries (e.g. Rwanda) or even for existing countries in close collaboration with national team of experts
- National capacity building for the efficient use of PEDA. Such sub-regional training workshop may be useful in this regard. But national experts of various disciplines who may participate in the future initialization process for their respective countries could not be fully involved. It may be useful to organize such workshop at the country level involving a good mix of expertise and more policy makers.
- ECA should keep on finetuning the model.
- The French version of the model along with documentation in French should be prepared.

3. Conclusion

10. The overall evaluation of the PEDA model and the workshop was fairly positive. All participants were very much interested in operationalizing the model for their countries in a more sophisticated manner so as to reflect better the specific settings (social, economic, demographic, environmental etc.) of the individual countries. In spite of the positive feedback, there is need for ECA to rethink in-depth on the way forward to have the PEDA model serve better African countries.

Annex 2

United Nations
•Economic Commission for Africa

Population Environment Development Agriculture MODEL

Users Manual

Developed for ECA by W.Lutz and S.Scherbov
v1.0, December 2000

Draft, 27 November, 2000

Table of Contents

1. Installation Instructions

The Population, Environment, Development, Agriculture (PEDA) software is under licence of the United Nations Economic Commission for Africa (ECA). The model may be used for demonstrations but not copied or redistributed without the consent of the ECA.

Since the model is still undergoing sensitivity analysis, the software may still contain bugs and minor inconsistencies.

The model is now in a shell containing nine countries. Namely, Botswana (July 2000), Burkina Faso (June 99), Cameroon (December 99), Ethiopia (July 2000), Madagascar (June 1999), Mali (December 99), Nigeria (July 2000),Uganda (December 99), and Zambia (August 99). In future, more countries will be added to the database in the shell.

PEDA runs under Windows 95/98/NT with Office97 (preferably Office 97, Service Release 2) installed. Microsoft Office 97 Service Release 2 (SR-2) is a free update to Office 97. It contains a series of fixes for each program in Office 97. Details on update can be found at the following address:
http://officeupdate.microsoft.com/downloadDetails/sr2off97detail.htm

PRESENTLY, THE SOFTWARE MAY NOT FUNCTION PROPERLY WITH FRENCH VERSIONS OF OFFICE AND OFFICE 2000 INGGENERAL.

The speed of the application will depend on the speed of the computer.

To install the software, follow the steps below:

1. Make sure the PEDA CD-ROM is in the drive
2. Open the folder referring to the PEDA Shell
3. Double click on the 'setup.exe' icon. During the setup some system files are updated and you may need to restart your computer and restart the setup procedure before completing the installation.
4. In the setup screen, change the default directory to 'c:\Program files\PEDA Shell

Any inquiries about the model or its implementation, and comments about the software can be communicated to the Food Security and Sustainable Development Division (FSSDD) of the ECA:

ECA-FSSDD
P.O. Box 3001
Addis Ababa
Ethiopia
fax +251 1 51 44 16
e-mail: peda.uneca@un.org
http://www.un.org/Depts/eca/divis/fssd/

Additional information on the software can be downloaded from http://www.un.org/Depts/eca/divis/fssd/popin/ (click on 'software' in the options bar on the left and look for PEDA)

2. Input and Output Variables

PEDA is an interactive computer simulation model (developed for a windows environment), demonstrating the medium to long-term impacts of alternative national policies on the food security status of the population. Through the manipulation of scenario variables, the model enables the user to project the proportion of the population that will be food secure and food insecure for a chosen point in time. As food security is a factor of developments in the field of population, agriculture, the environment and socio-economic development, the model demonstrates the relationships between these fields as well. It also includes the results of the first experiments to introduce an HIV/AIDS component and to illustrate its impact on the other variables in the model. As such the PEDA model is able to give answers to a wide range of policy questions regarding the nexus interactions.

This section briefly presents in tabular form the input and output variables of the model. For more details, please refer to the **Technical Manual.**

2.1 Input Variables

The general input variables are summarized in Table 2.1.

Table 2-1 : Parameter and variable definitions of the general model settings

Parameter or variable name	Description
Initial year	The starting year of the projections. This is the year to which the baseline data apply. This value cannot be changed by the user as it is part of the initialization process. It is only presented as a reference.
End of Projection period	The end of the projection period. All simulations will be run in single year steps up to that year and all results will be stored up to the end of the specified period. Although there is no direct limit set to the value of this parameter, projection periods of longer than 50 years will slow down calculations and may become very unreliable (see the Technical Manual for more information).

Production of Kcal per capita in the initial year	Refers to the average daily per capita amount of food produced in the starting year. All the agricultural production variables are treated as indexes to increase or decrease upon this initial volume of production.
Assumed min kcal per capita to be consumed in order to be food secure	In the PEDA model, calorie (energy) requirements are used as a proxy for food requirements. *"The minimum energy requirement is the amount of energy that is required on average in a population to satisfy the basic physiological needs and the needs for light activities of adults and the normal energy needs of children and adolescents (including the extra needs for the growth). Two main factors determine the estimation of the energy requirement of a population: the distribution by age and sex; and the body weight."*[1] The value of this variable may thus vary under different national conditions, or the user can set the value to define different thresholds to evaluate its effect on the model interactions.
Land degradation impact factor	This variable reflects the assumed negative impact of population growth on the natural resource stock. See the Technical Manual for more detailed information on the definition of this parameter.
Proportion of the cohort moving from rural to urban areas	This variable enables the user to set net rural-urban migration rates. A value of 0.2 means that of every cohort born in rural areas, 20% will move permanently to urban areas over their lifetime. These movements are distributed over the different ages according to standard age-specific migration schedules (see the Technical Manual for more a more precise definition).

The sub-population variables include fertility (Total Fertility Rate), Mortality (Life Expectancy at Birth), Education (Literacy Rates), and HIV/AIDS Morbidity Rates.

Other input variables include those shown in Table 2.2 (endogenous/exogenous):

Table 2-2: Other Input Variables

Variable name	Description
Size of the rural labour force	Endogenously determined variable
Literacy of the labour force	Endogenously determined variable
Land	Endogenously determined variable
Fertilizer use	The amount and productivity of fertilizer used in agriculture. The user needs to set a value that expresses a relative improvement/worsening with respect to the conditions in the starting year.

[1] This definition is taken from the African Nutrition Database Initiative (ANDI) web site, at http://www.africanutrition.net/

Machinery use	The amount and productivity of machinery used in agriculture. The user needs to set a value that expresses a relative improvement/worsening with respect to the conditions in the starting year.
Technical education	In addition to literacy, the user can give value to specific technical capacity of the rural labour force for agricultural purposes. As with Fertilizer an machinery use, one needs to give a value that expresses a relative improvement/worsening of the conditions in a particular year as compared to the starting year.
Water related variables	
Climate	to be completed
Réservoirs	to be completed
Irrigation	to be completed
Loss in transport and storage	Individuals will not consume all the food that is produced. Some of the food will be lost during the treatment of the food, the transport or storage. This variable enables the user to take these effects into account.
Urban bias factor	This variable enables the user to allocate food disproportionally between urban and rural areas (see the Technical Manual for more information).
Food imports and exports	This variable allows the user to take food imports and exports into account. As all other variables influencing the availability of food it is treated as an index that has value 1 for the starting year of the projections.

2.2 Output Variables

Output variables include standard ones shown in Table 2.2.

Table 2-3: standard output variables in PEDA

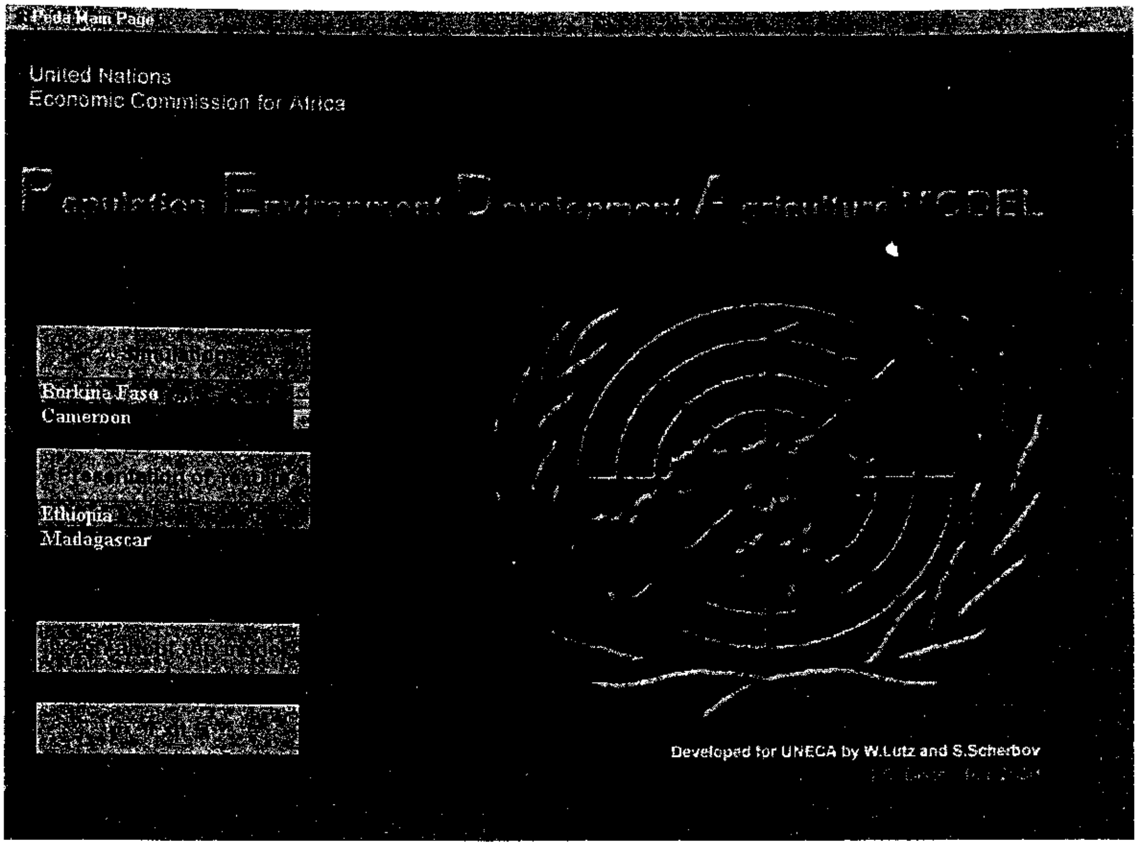
Variable	Variable description
Available food	This is the sum of the total amount of food produced in the country in a particular year minus the loss of food in the harvest, transport and storage, +/- food imports and exports. This indicator is only available for the country as a whole.
Births	Total number of births
Current land	The combination of the quantity and quality of land for each year of the projection period. Index value summing up the effects of land degradation and regeneration. This indicator is only available for the country as a whole.
Deaths	Total number of deaths
Life expectancy (e_0)	When requested for each of the eight sub-groups separately and sex specific, this is the graduated value of the assumptions of the user. At the country level, however, it is also influenced by the relative weights of the subgroups in the population (provided that different life expectancies have been set for the different subgroups).
Literate Life	See the Technical Manual for more information).

Expectancy (LLE)	
Fertilizer	Is an input variable.
Food import/exports	Is an input variable
Food production	This is the sum of the total amount of food produced in the country in a particular year. This indicator is similar to food availability, but it does not account for loss in the harvest, transport and storage or food imports or exports. This indicator is only available for the country as a whole.
HIV/AIDS morbidity rates	Is an input variable
Irrigation	Is an input variable
Loss in transport/storage	Is an input variable
Machinery	Is an input variable
Proportion food insecure	In addition to the population size that can be generated by urban/rural place of residence, literacy status and food security status; the model has an extra output variable that portrays the proportion food insecure in the country for any year of the projection period. This indicator is only available for the country as a whole.
Total population	Population size. It can be generated for each of the eight subpopulations separately and for both sexes separately. There is also a possibility to extract age specific information from the databases. See the Technical Manual for more information).
Technical education	Is an input variable
TFR	When requested for each of the eight sub-groups separately, this is the graduated value of the assumptions of the user. At the country level, however, it is also influenced by the relative weights of the subgroups in the population (provided that different fertility rates have been set for the different subgroups)
Urban bias factor	Is an input variable
Water	See the Technical Manual for more information

3. How to use the PEDA Software

3.1 General Instructions

The PEDA software runs under Windows, is based on Excel spreadsheets and uses the Access database. PEDA will run on any machine with Windows, but the power of the machine will influence the speed of calculation. When you start the PEDA application, you will see the following welcome screen.

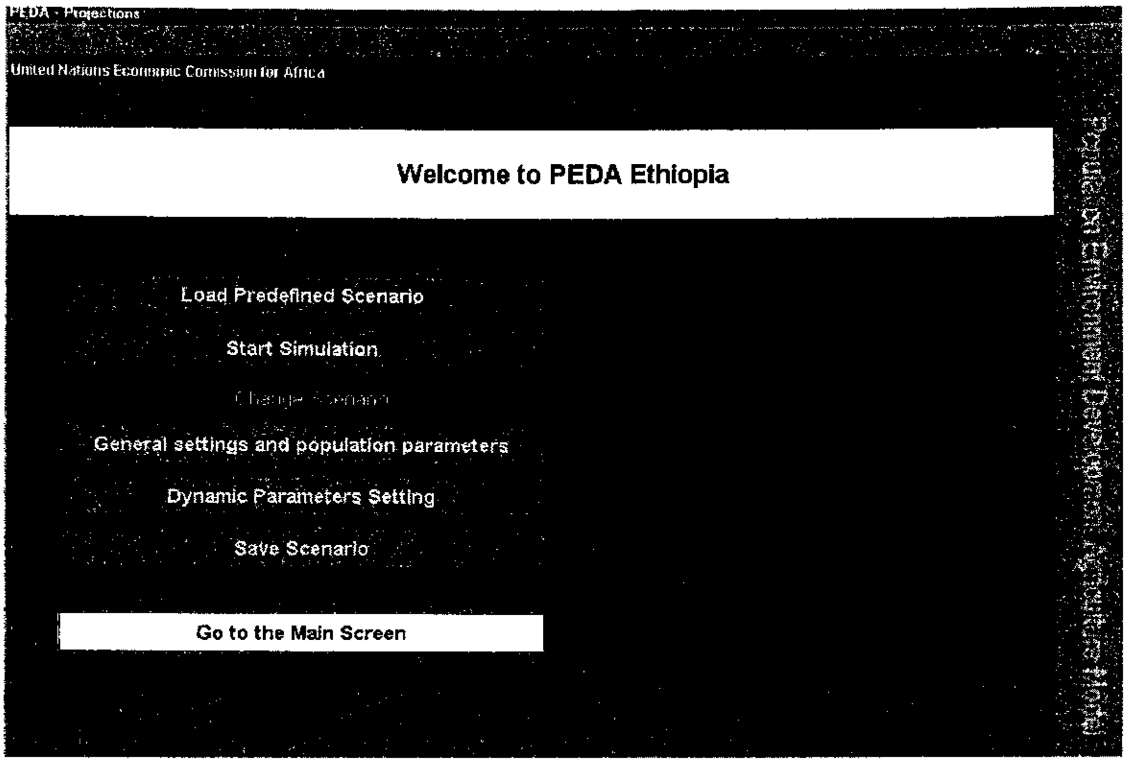


On this screen you can choose among four options:

- "Learn about the model" will give you more information about the structure of PEDA. The most complete description is given in the Technical Manual (Chapter 2).
- "Simulation" will first ask you to choose among one of the countries that has been initialized for PEDA and will then bring you to the country specific simulation screen.
- "Presentation of results" will directly bring you to the results of previously calculated and stored scenarios for the countries indicated.
- "Exit" will end the application.

3.2 Using scenario settings and simulations

If you click on Simulation, e.g. for Ethiopia, you will see the below given country specific screen *Welcome to PEDA Ethiopia.* PEDA can only be run for countries that have been initialized. This means that data on the starting conditions and on certain country-specific settings have already been entered. Initializing the model for a new country is not a trivial task and requires substantive analysis and knowledge about the country as well as sufficient knowledge of Excel. More information about the initialization process is given in the Technical Manual (Chapter 5). Here we only discuss the scenario variables and parameters that can be set on this user surface.



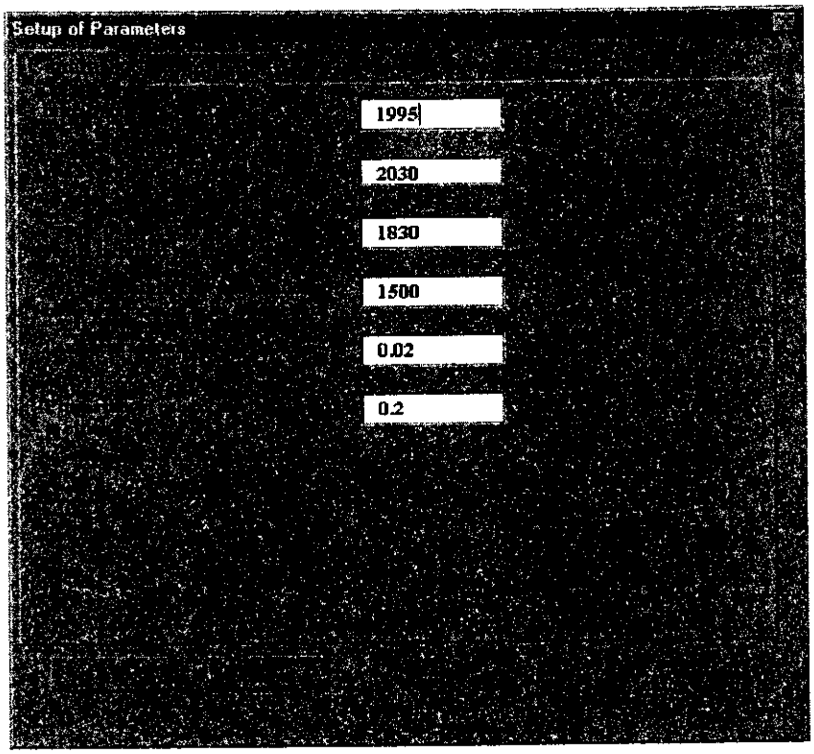
The button on the top allows you to load an already predefined scenario. This is a useful option if you already have a certain baseline scenario that shall be compared to other scenarios in which only a few variables will be changed. Other buttons let you save the current scenario settings for later reference, let you start the simulation (once you are satisfied with all parameter settings for one specific scenario), and let you go back to the main screen.

The next three buttons enable you to change the current scenario settings. The setting of scenarios can be done in two different modes, the General settings and population parameters button allows you to change parameters that are kept constant over the projection period or can be set to change in a piecewise linear fashion over time (like fertility and mortality). For other variables under the Dynamic parameters setting button you can freely define any time path over

the simulation period. In order to set those parameters or see what the predefined values of the parameters are, click the appropriate box.

3.2.1 General model settings and population parameters

If you click on the General settings and population parameters button you get the following screen.



If you choose the folder "General" tab, you will be able to set some of the basic model specifications that cannot be changed over time or across sub-populations.

Among these general parameters you can first specify the initial year of your calculations. This is typically the year for which the specific country application has been initialized, i.e. in most cases the last year for which empirical information is available (but you can also choose other dates if you have specific reasons to do so such as simulating "alternative histories"). Next you can determine the end of the projection period. All simulations will be run in single year steps up to that year and all results will be stored up to the end of the specified period. PEDA will run scenarios for end points up to the year 2050.

On this general parameter screen you can also enter the calorie production per capita per day in the initial year (in kcal) and the assumed minimum consumption in kcal per capita in order to be considered food secure. This minimum requirement can be chosen according to the definition of malnutrition and food security that you prefer. It will enter the calculations for

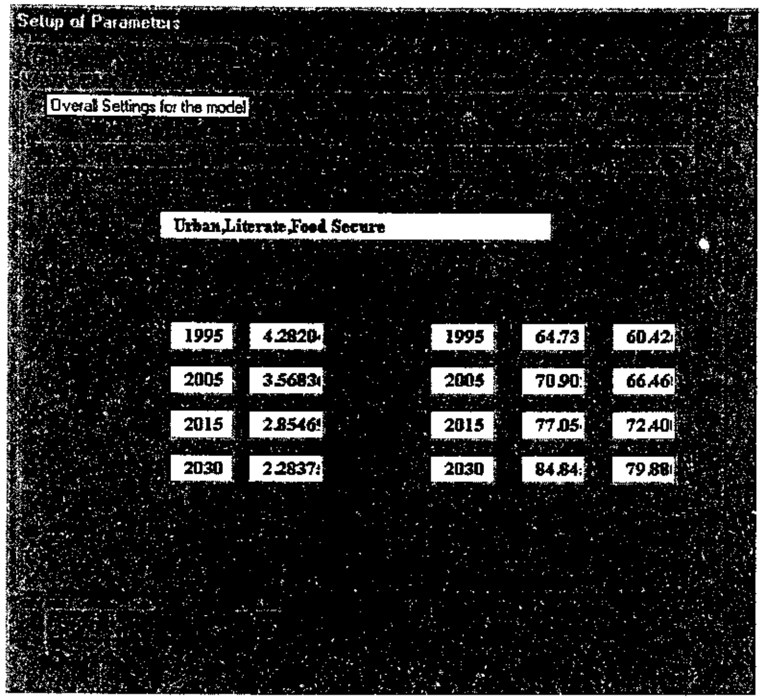
determining the proportion of the population that will be considered food insecure. This specification will have significant impacts on the results: if the minimum requirement is specified to be rather high then this will result in a greater proportion of the population considered food insecure and vice versa.

On this screen you can also set the "land degradation impact factor" which lets you define the assumed impact of an increase in the food insecure rural illiterate population on the land variable. This factor will enter a non-linear land degradation function (see Technical Manual), which also considers population density and the state of the land resource. The state of current land (which combines quantity and quality aspects) will then enter the food production function. This assumed effect of an increase in the food insecure rural illiterate population is one of the two feed back loops in the model that go from the population to food production. The other one operates through the size and skill level of the population.

Since this model distinguishes between urban and rural areas, migration between the two areas also needs to be considered. This is done by making assumptions on the net movements from rural to urban areas, which is specified here in terms of the proportion of a cohort moving to cities. A value of 0.2 thus means that of every cohort (group of people born in the same year) 20% will move permanently to urban areas over their lifetime. In the actual calculations these movements are distributed over the different ages according to standard age-specific migration schedules.

If you go to the tab "sub-populations" you can set parameters separately for each of the eight sub-populations listed. By cross-classifying food security status, literacy status and rural/urban place of residence eight states are being defined and PEDA performs population projections by age (single year) and sex for each of the groups also considering movements between the groups in every year. By simply clicking on the field with the name of the sub-population, e.g. the rural/ illiterate/food secure as seen on the screen below, you get a form for defining trends in fertility and mortality of that specific sub-population and educational transition rates for women and men.

For setting future trends fertility, as described by the Total Fertility Rate (TFR), i.e. the mean number of children per woman, and mortality, as described by life expectancy at birth follow a similar scheme. The user has to first enter the values for the starting year of the simulation



(which is a question of getting empirical data or appropriate estimates). Then scenario assumptions for fertility and female and male life expectancy for three points in the future can be entered. If two subsequently specified values are different, the model will automatically calculate a gradual linear change between the two points in time. Hence the specified fertility and mortality scenarios will be piecewise linear.

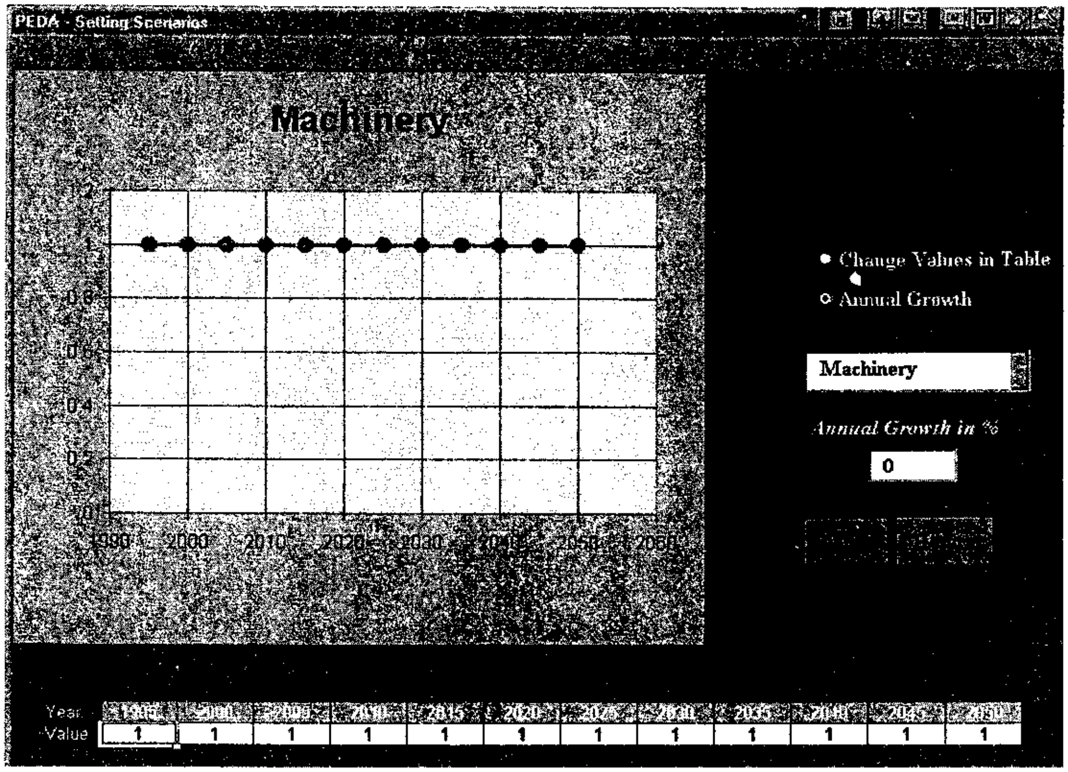
The user has to keep in mind that the resulting trend in the fertility and mortality of the total population does not only follow from the paths specified in this manner but will also be influenced by the changing weights of the various sub-populations. If you assume for instance constant fertility at 4.0 for the illiterate and at 2.0 for the literate population, and over time the female population of reproductive age will become more literate, the aggregate fertility level of the total population will show a declining trend. In this sense the aggregate fertility and mortality levels are already a result of the scenario calculation and cannot be specified as a specific scenario assumption.

Under "Education" you can specify the proportion of women and men in each birth cohort that will move over their lifetime from the illiterate to the literate state. The age pattern of this transition to the literate state can be specified during the initialization process. For sub-groups that are already educated you will see a screen without educational transition because in PEDA there is no movement back to the illiterate state.

3.2.2 Dynamic parameter settings

If on the country specific screen ("Welcome to PEDA Ethiopia") you choose the button with Dynamic Parameters Setting you will see the following screen on which you can choose from the right hand list (which you get by clicking on the little arrow next to the currently listed variable) which scenario variable you want to set. The exact interpretation of these variables and the functional form in which they enter the model are given in the Technical Manual (Chapter 3). Fertilizer, machinery and technical education will directly enter the food production function with certain elasticities. Food Import/Export and the Urban Bias Factor relate to the distribution of food to the population. Water is essentially a climate variable referring to rainfall and soil moisture. The initial value of water is set during initialization to correspond with the country's climate conditions. The impact of water on food production is modeled in a highly non-linear way with additional water having a strong effect under dry conditions, then coming to saturation where more water brings little change in output and finally moving to flood conditions where more water is destructive. Decreasing or strongly increasing the water variable in certain periods can simulate draughts or floods. The irrigation variable measures the efforts in irrigation but its effect will also depend on the availability of water. AIDS morbidity finally gives an estimate of the proportion of the young adult population that is already symptomatic with AIDS. This specified level will influence the shape of the age-specific mortality curves applied. Its setting should be consistent with the time paths assumed for life expectancy. The Technical Manual gives information of how to do this (Chapter 5).

Except for AIDS morbidity and water, these variables are all treated in index form, which means that their level in the starting year is set to be 1.0 and their levels in all the subsequent years are seen as relative to this starting year. This setting allows you to use the model even if you do not have empirical information about the exact quantitative level of each factor since you only have to specify the relative change as compared to the starting year.



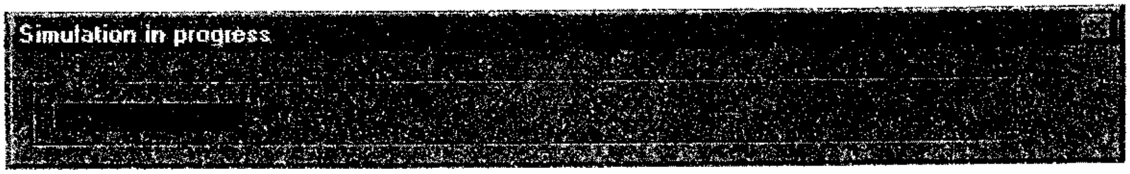
You can change the factors over time either by setting the values numerically in the table below the chart (click on "Change Values in the Table" in upper right corner) or by applying a constant rate of annual growth (click on "Annual Growth").

For practical reasons the options for setting values numerically are limited here to every fifth year with intermediate years being interpolated for the simulations.

It is also possible to combine the automatic application of a growth rate with specific numerically entered deviations from the exponential path in certain periods. For this you must first apply a constant growth rate (do not forget to apply it by clicking the ok button), then switch to the manual setting option and change the values in the table as desired. The graph will always give you a representation of all annual values resulting from that procedure.

3.2.3 Simulation

After you have set all the scenario parameters that you want for a specific simulation run, you click the Return button and go back to the country main screen. There you can either save the scenario that you have just defined or load another already defined scenario. Then you can click the "Start Simulation" button. This will bring you to the following screen.



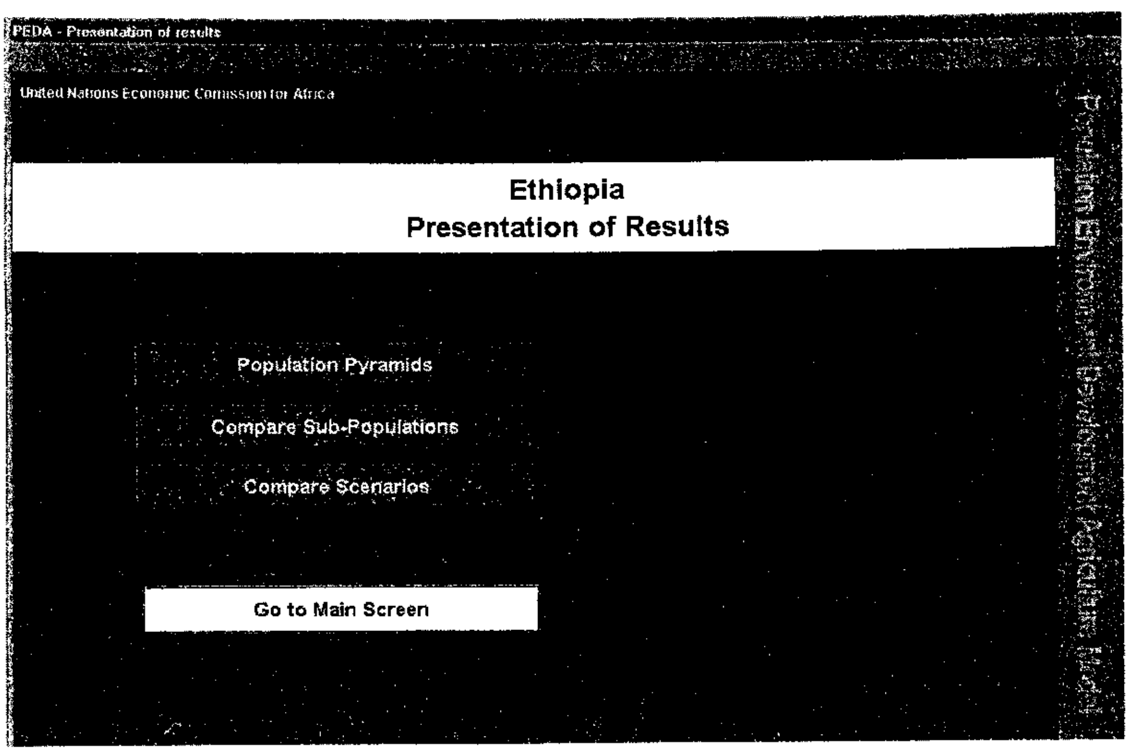
In order to know which scenario you are using, every scenario must be given a name (e.g. "baseline"). In the box below the name you may specify some more detailed information about what you have assumed in the scenario in case you want to have it for future reference. It is not necessary, however, to make notes on individual assumptions because in the case of any doubts the software lets you easily check all specific values assumed for each scenario. This same form will come up whenever you save scenarios or load already existing scenarios.

The "Continue" button will start actual simulation of the model according to the scenario assumptions currently loaded and then bring you back to the country main screen from which you can either specify additional scenarios or exit to the initial screen (the very first one with the PEDA logo). From there you may enter the presentation of results mode by clicking on the "Presentation of results" button

3.3 Presentation of results

For the graphical presentation of results you can choose among three different kinds of graphs:

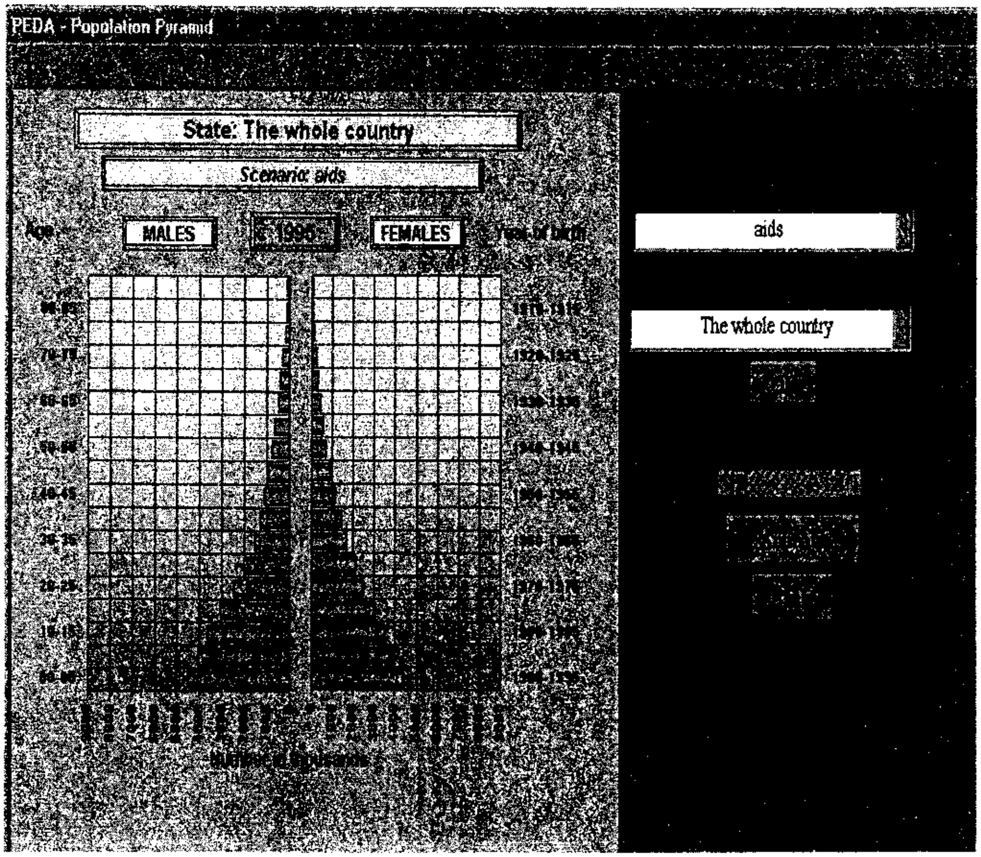
a) Simple or animated Population Pyramids (by age and sex)
b) Compare Sub-Populations for any given scenario.
c) Compare Scenarios for any given sub-population or the whole country.



On the graphs, the numerical values corresponding to any point of the line charts will be displayed by moving the mouse to that point.

Since all the results are stored in a database, any table with an appropriate selection of numerical data can be printed on either paper or in a file for further processing.

3.3.1 Population pyramids

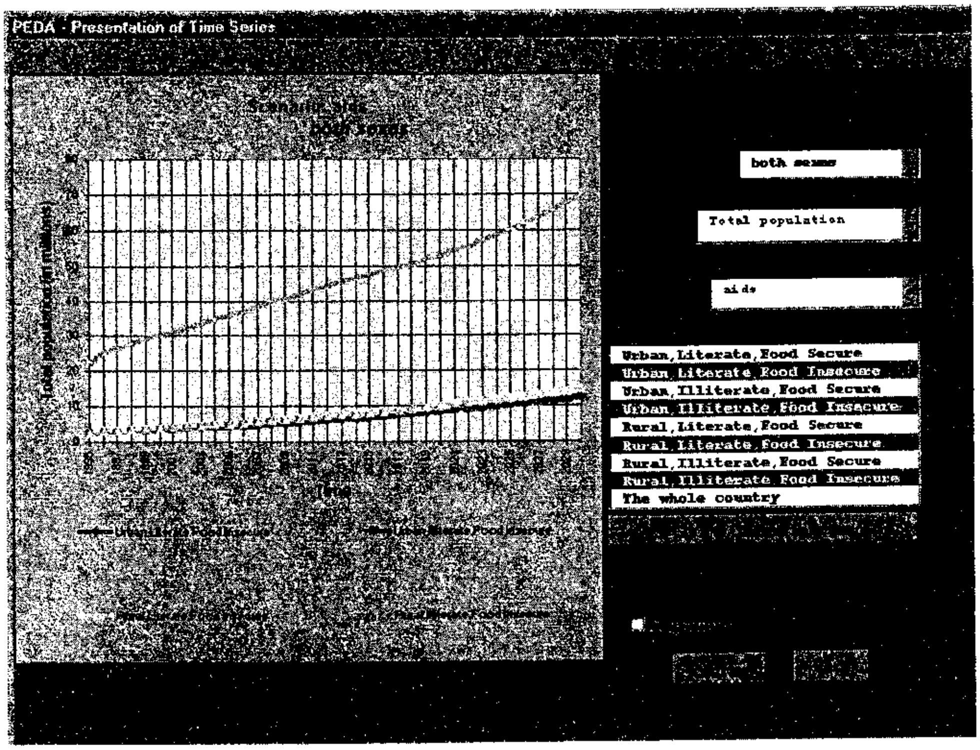


If you click the "Population Pyramids" button, you will see the following screen:

For any scenario or sub-population (here called state due to multi-state population terminology) that you choose, you see the usual age pyramid with men on the left and women on the right sorted by age. For the purpose of display, the single-year age groups of the model have been aggregated into 5-year age groups. By moving the time bar (click on the center piece and move left or right while holding it), you can choose an age pyramid for any simulation year (in a single or 5-year steps). Alternatively, you can choose an animation, which will show the gradual evolution of the age structure over time if you click on "Animate". These animations can give you a better feeling of the dynamics of the system than only looking at static information. The year stated on top of the pyramid always tells you at what year you are looking. Similarly, the name of the scenario and of the sub-population under consideration are indicated.

3.3.2 Compare sub-populations

If you click on the "Compare Sub-Populations" button on the Presentation of Results screen, you get the following picture which compares the trends over time for different sub-populations under one given scenario.



On the right hand side of this presentation screen, you have different options. First, you can choose to plot men or women or both sexes and secondly, you can choose the demographic indicator to be plotted, which is total population in our example. Next, you must select the scenario for which you want to compare the sub-populations.

In the box below, you can click on any of eight sub-populations (called state here) that shall be shown in the graph. You can also choose any number and any combination of sub-populations. Moreover, by clicking on the button "Aggregate" below you can calculate the sum of the chosen sub-populations to be also presented on the graph. To verify your choice you must hit the Click to Confirm Selection button.

As indicated before, you can read the exact numerical value of each point of the graph by moving there with the mouse.

3.3.3 Compare scenarios

If you click the third presentation option "Compare Scenarios", you will see a similar screen, which compares different scenarios for any selected output indicator and any specific sub-population or the whole country. To do this again, you can chose the sex, the indicator to be

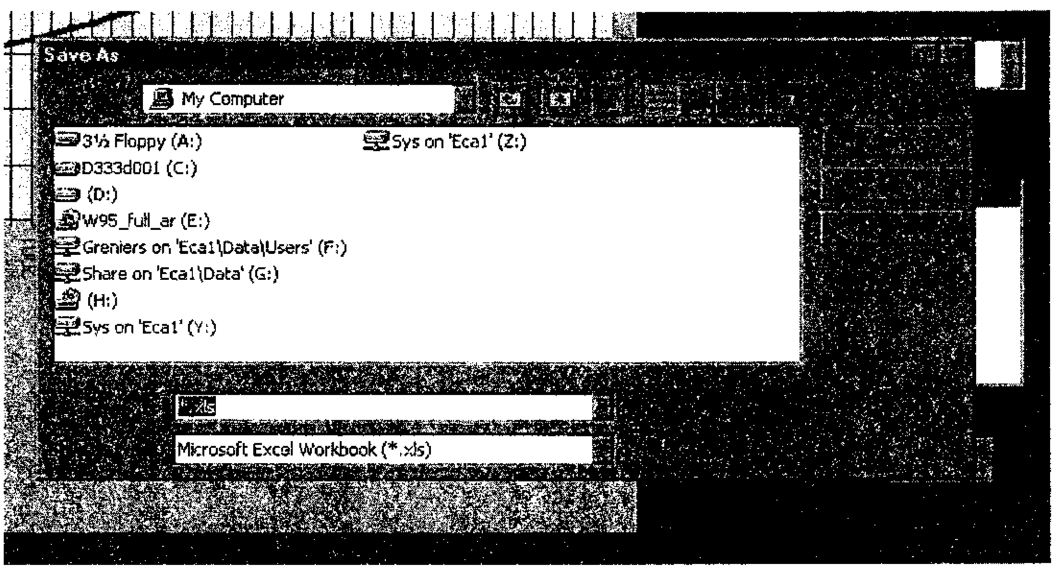
plotted and the state (i.e. the sub-population) to be studied. You will then see line charts over time for all the scenarios that you have defined.

3.4 Additional Useful Features

One very useful option is that under the selection of indicators you can also view some of the most important scenario assumptions that underlie the different scenarios that you examine. Hence, if you do not remember what you assumed in terms of e.g. the machinery production factor in the different scenarios, you can select this indicator on the list and then the graph will display the assumed trends of this parameter for all scenarios. After this, you select again the resulting population size and can compare the assumptions to the results.

On the top line of each of these screens, you find additional options. You can either zoom in, i.e. enlarge the graph, or zoom out, i.e. reduce the graph by clicking on the corresponding boxes on the menu bar.

An important option is the save table button. If you click it, you will get an insert as shown on the following screen print:



On this insert, you can specify the file name under which the table should be stored. These tables can then be formatted and transformed in any way that Excel allows.

Finally, if you want a print out, you can click on the "Print" options and can specify the printer where the graph shall be printed.

Annex 3

United Nations
Economic Commission for Africa

Population Environment Development Agriculture MODEL

Technical Manual

Developed for ECA by W.Lutz and S.Scherbov
v1.0, December 2000

Draft (October 20, 2000)

Table of Contents

1. The PEDA model: an advocacy tool modeling the interrelationships between population, development, the environment and agriculture

1.1 Background

The last two decades, Africa experienced a severe crisis manifested among others in the constant decline of its economic growth rate. Since 1994, the economic situation of the continent has improved steadily, but this resumption is still below the necessary level to have a significant impact on poverty. Although the proportion leaving in extreme poverty in Africa may have declined with a few percentage points in the last couple of years[2], high population growth rates mean that the absolute number of poor still increases dramatically on a daily basis. Additionally, Africa's economic performance seems to be highly dependent on the international economic environment and weather conditions; two exogenously determined factors that do not embody any guarantee for future growth (ECA, 1999).

Two basic pressures account for the continued deterioration in the quality of life in Africa. First, the population growth rate exceeds that of economic growth and food production in most African countries. Additionally, the rapid deterioration of the environment on the continent prevents the desired increase in agricultural productivity. Today, over three-fourths of sub-Saharan African countries produce less food per capita than they did in the 1980s. Daily calorie availability is well below the recommended minimum and as high as 30-40 per cent of the population is undernourished. Malnutrition affects even more people. Food insecurity, rapid population growth and environmental degradation constitute a very important challenge for public policy in Africa today.

Table 1-1: Africa's economic performance vs. population growth, 1965-98

Indicator	Years					
	1965-73	1974-79	1980-85	1986-89	1990-94	1995-1998
Population growth rate	2.6	2.7	2.8	2.7	2.5	2.4
Growth rate of GDP (average)	5.7	3.5	1.8	2.5	1.9	
Growth rate of per capita GDP (average)	3	0.7	-1.1	-0.5	-1.1	
Growth rate of agricultural output (average)	2.7	3	1.5	2.7	2.1	

*Source: ECA Secretariat **** be more specific about the source *****

Inspired by the notion of sustainable development as reflected in the series of United Nations conferences during the 1990s, there is increasing understanding of the necessity to go beyond the traditional sectoral approach to national development to one that captures the interaction between sectors and interdependencies between policy objectives. It has been demonstrated that, at least in the medium to long run, a country's economic performance and the food security of its citizens are closely related to its demographic and educational trends as well as to the health of the natural environment. Since these issues are closely interconnected in the real world, they should also be viewed together in national politics and development planning. Not considering this inter-sectoral nexus could have serious repercussions in the future.

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[2] Currently, around 46 per cent of Africans are living on less than $1 a day (IMF,OECD, UN and IBRD, 2000)

The scientific understanding of mutual interdependencies is, however, not yet sufficiently reflected in the political institutions of individual countries. There is tremendous inertia in such systems, partly due to the traditional training of experts that is often characterized by compartmentalization of disciplines, and partly to the fact that the impact of developments in one sector is often invisible in another sector in the short term.

Hence, convincing policy makers and country experts of the negative synergy arising from the interconnections of population growth, environmental deterioration and declining agricultural production is a major objective of the Food Security and Sustainable Development Division (FSSDD) of the ECA. With that goal in mind, the FSSDD engaged itself to develop a computer simulation model that will be used to illustrate the interactions between population changes (P), the environment (E), socio-economic development (D) and agriculture (A).

The first prototype of the model was formally presented to a group of experts including invited scientists from member States and affiliate international organizations in November 1998 at the ECA in Addis Ababa. Provisional data for three countries (Burkina Faso, Madagascar and Zambia) have been prepared to test the assumptions and structure of the model and the evaluation and revision of the model since then has eventually led to v1.0 that is presented herewith. From here onwards, PEDA can be used and customized by researchers, universities and policy makers for policy-making and analysis for specific countries. The ECA will, nevertheless, continue to support the model and any effort for its further application.

1.2 PEDA, in brief

PEDA is an interactive computer simulation model (developed for a windows environment), demonstrating the medium to long-term impacts of alternative national policies on the food security status of the population. Through the manipulation of scenario variables, the model enables the user to project the proportion of the population that will be food secure and food insecure for a chosen point in time. As food security is a factor of developments in the field of population, agriculture, the environment and socio-economic development, the model demonstrates the relationships between these fields as well. v1.0 includes the results of the first experiments to introduce an HIV/AIDS component and to illustrate its impact on the other variables in the model. As such the PEDA model is able to give answers to a wide range of policy questions regarding the nexus interactions.

Box 1-1: policy questions

[illegible]

1.3 Two approaches in modeling the nexus interactions

In the field of population-environment models we can distinguish between two kinds of approaches: 1) comprehensive models that try to assess the full range of population-environment interactions for a specific region, and 2) models that limit the focus to specific chains of causation and therefore tend to be more focused and theory-driven. Both approaches can contribute to the better understanding of this complex field of studies. Both have their strengths and weaknesses. The more comprehensive (holistic) approach, which tries to evaluate all relevant factors, can help us to better understand the relative contribution of specific factors to the full picture. The series of PDE (Population-Development-Environment) case studies conducted by IIASA in different parts of the world are a good example of such comprehensive studies, which try to incorporate all relevant factors. Recent applications on Namibia and Botswana, which originally planned to focus primarily on population growth and water scarcity, had to be modified because the HIV/AIDS pandemic turned out to be of paramount importance for the future. Since around one-third of the population of these two countries is estimated to be HIV positive, IIASA has decided to dedicate a big share of the effort to HIV modeling. The PEDA model presented in this paper follows the other, substantively more focused, strategy. It attempts to quantify one specific causal path, which actually is an assumed loop, or circle that follows a clearly defined theoretical model. It is restricted to portraying factors that are relevant to that specific mechanism, leaving out many others. This approach is more in line with the tradition of economic modeling that tends to make *ceteris paribus* assumptions on all factors that are not directly relevant to the hypothesis studied, even though such factors may be very significant for the future of a country under a more comprehensive approach. For planning purposes and science-policy interactions, both the more comprehensive and the focused approaches have their virtues and shortcomings. In an ideal world a comprehensive super-model may incorporate several focused models, but this is difficult to achieve and may, indeed, suffer from some of the well-known shortages of mammoth models.

Having dwelt on difference, it is also worth nothing that both approaches, i.e., the IIASA-PDE approach and PEDA, have important features in common, namely and emphasis on (a) interdisciplinary scientific analysis and projection, and (b) science-policy communication.

Interdisciplinary scientific analysis and projection lies at the heart of both approaches. In dealing with cross-cutting issues such as the effects of education on fertility and population structure and in turn on agriculture 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. Such models 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 losing 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.

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 well for crosscutting problems. Issues such as

food security have to do with population, the skills of the labour force, agriculture 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 support interministerial connections to 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 the necessity 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 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.

1.4 An advocacy tool

As a model with a focus on a specific chain of interactions, the mission attributed to PEDA at its conception was one of advocacy; illustrating the negative development spiral resulting from high population growth environmental degradation and decreasing per capita agricultural production. It is to demonstrate the magnitude of existing interactions and suggest alternative policy strategies to break this vicious cycle in Africa. With this v1.0 of PEDA, the ECA has reached the point where it can be effectively used as such.

Since its conception and after several rounds of evaluation and review, the different components of the model have grown and have been refined steadily to support ambitions that may exceed its advocacy function. However, the degree to which PEDA can be actually used as a prediction tool to concretely support policies of a given country is not yet clear. For that purpose more sensitivity analysis is needed and more, better and country specific data need to be collected and fed into the model. This is an effort for which the ECA invites research institutes and universities to collaborate in an effort to improve the value of the PEDA model for concrete policy support.

1.5 Two user levels

The model can be used at two different levels. Initializing the model for a new country would ideally be the job of a team of experts with specializations in demography, agriculture and natural resources modeling and with sufficient computer skills. However, once the model has been initialized for a specific country, persons with basic computer and demographic skills can easily make projections themselves and test the effect of alternative policy scenarios on the food security status of the population.

This manual is designed for use by both users. Those initialising the model for a new country or change some of its assumptions will find the necessary information and guidelines in the procedures to follow. Others, only interested in carrying out projections for already initialised countries will find information on the model assumptions, its possibilities and limitations, the manipulation of the scenario variables and the interpretation of the outputs.

The rest of this manual is divided into a substantive account of the model, a more technical section with a description of the structure and content of the databases and excel spreadsheets underlying the user interface and a chapter that gives some methodological support in initializing the PEDA model for a new country

2. A Substantive description of the PEDA model

2.1 Theoretical foundations and the structure of PEDA

A theoretical construction, often labeled the "vicious circle model," has recently become a very influential paradigm in the discussion around population, poverty, food security and sustainable development. It essentially assumes that high fertility, poverty, low education and status of women are bound up in a web of interactions with environmental degradation and declining food production in such a way that stress from one of the sources can trap certain rural societies, especially those living in marginal areas, into a vicious circle of increasingly destructive responses. One possible illustration of this assumed mechanism is the parable of the firewood (Nerlove 1991): In many countries the collection of firewood takes a lot of time, and more children can help to collect more firewood. But this leads to less firewood near the villages, increasing degradation of the natural resource and the desire for more children to go still further, also depriving the children of educational opportunities. Dasgupta (1993) presents this argument in a more generalized form. The condition of poverty and illiteracy of the households concerned prevents substitution of alternative fuel sources or alternative livelihoods. A gender dimension is being added through the fact that the low status of women and girls also devalues the increasing amount of time and effort that they must devote to daily fuel wood gathering (Agarwal 1994; Sen 1994). The education of girls is blocked because girls are kept at home to help their mothers. The result is faster population growth, further degradation of the renewable resource base, increasing food insecurity, stagnating education levels, and yet a further erosion of women's status.

From a theoretical point of view this vicious circle model is a useful contribution toward a more general framework in causally linking fertility, poverty, low female status and environmental degradation. It is also attractive because it explicitly addresses equity concerns. Its multi-dimensional structure helps to view different possible interventions in, e.g., reproductive health, education, environmental conservation and agricultural efficiency in a unifying context rather than in isolation from each other. Each of the interventions may, under certain conditions contribute to breaking the vicious circle, but a comprehensive strategy viewing all these aspects together and recognizing their interdependencies is likely to be more successful (O'Neill *et al.* 2000).

In terms of its empirical relevance, the vicious circle assumption is more controversial. Because the economic reasoning of this model largely operates at the household level, empirical studies on the issue have been mostly confined to that level and reached mixed results. At the macro level of different population segments this model could potentially be very relevant, especially in the African context, although some of the assumptions of the stricter version of this model are empirically unconfirmed and controversial. Especially the assumption that environmental degradation may actually lead to increases in fertility is difficult to be defended at a time when fertility rates are rapidly falling all over Africa with simultaneously degrading environmental resources. This does not necessarily imply that the assumed effects are entirely

absent, but it seems to imply that if they operate, they are overlaid by the powerful and dominating process of demographic transition. Hence, it may be reasonable to alternatively assume that food insecurity is associated with a slower decline in fertility, although under certain conditions and in the short run famines may well induce declining fertility. Whatever the position on this issue, the PEDA model as outlined below is general enough to represent alternative assumptions through alternative parameter choices and scenarios.

Figure 0-1: the structure of the PEDA model

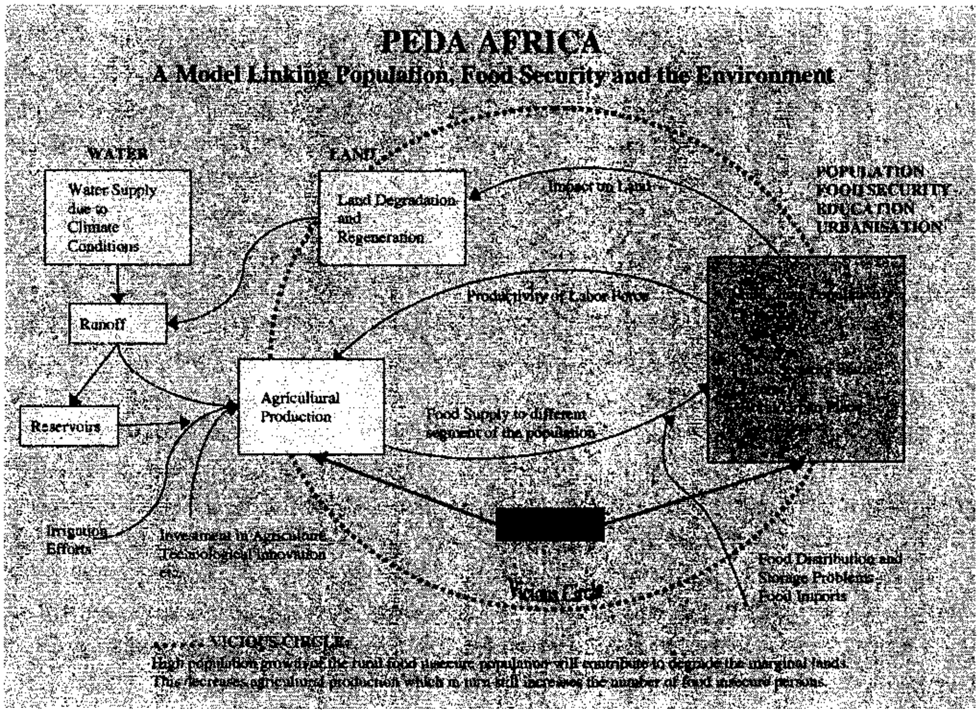


Figure 0-1 gives the basic structure of PEDA. Although the PEDA model is flexible with regard to the underlying theoretical assumptions, by default it is set to be compliant with the main principles of the vicious circle at the macro-level described earlier; i.e. that the growth of the (illiterate and food insecure) population in rural areas contributes to the degradation of land, and thus lowering agricultural production and further increasing the number of food insecure. If not broken, this vicious circle would lead to ever increasing land degradation and increases in the food-insecure population. The model, however, does not assume increasing fertility as an automatic response to food insecurity. Rather, the food secure and food insecure fractions of the population are assumed to have different fertility levels (subject to exogenously-defined trends) and hence the aggregate fertility level only responds to changes in the food insecurity through the changing weights of the groups in the calculation of the overall fertility. The vicious circle can be broken through several possible interventions in the field of food production, food distribution, education, environmental protection and population dynamics.

Food production and availability in PEDA is influenced by a set of endogenous and exogenous variables. An important resource for agricultural production is land. In the model it is treated in index form combining the quantity and quality of land that is to be determined by the user.

Although the user can omit this effect, by default the model assumes a negative impact of population growth on natural resources. More specifically, it is assumed that it is particularly the rural illiterate food insecure segment of the population that will deplete natural resources in their quest for survival. Agricultural production is further influenced by the size and qualification level of the labour force, the availability of water, and efforts in irrigation, fertilizer and machinery use. The contribution of water in the agricultural outputs is dependent on climatic conditions but also on the status of the land degradation and efforts in irrigation and building of reservoirs.

The size and literacy of the labor force are taken from the population module. Land, which here is in index form combining quantity and quality changes, is exogenously set but is also determined by land degradation due to population pressure and subject to a set rate of natural recovery. On the water side rainfall can be assumed exogenously, but the degree of runoff is influenced by land degradation. The effects of irrigation efforts are also subject to the availability of enough water. Finally, the total food production of one year will be distributed through a non-linear food distribution function and thus determine the proportion of the population food insecure in the following year. Recently an HIV/AIDS component has been added to PEDA which influences both the population segment and agricultural production.

Such a quantitative model can help policy makers and other users to (a) view these interconnected aspects, and (b) think in terms of alternative outcomes of alternative policy scenarios. In the following sections, the different modules or segments of the model will be described extensively.

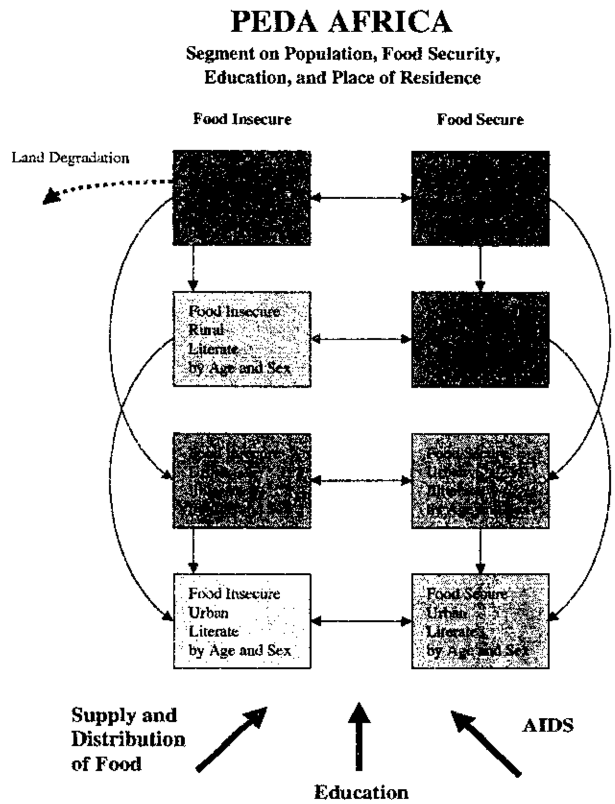
2.2 The population segment

PEDA is different from most macroeconomic models in that it uses a population-based approach. The population-based approach views human beings with their specific characteristics (such as age, sex, education, health, food security status, place of residence, etc.) as agents of social, economic, cultural and environmental change. But the population is also at risk of suffering from repercussions of these changes and of benefiting from positive implications. In this sense, human beings are seen as a driving force of these changes and the first to be affected by 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 economic indicators are not seen as an end in itself or the primary object of modeling. In this, the population-based approach chosen here differs from much of the development-economics literature.

The population-based approach does not assume that population growth or other demographic changes are necessarily the most important factors in shaping our future. Instead, the phenomena that we want to model are studied in terms of different characteristics that can be directly attached and (at least theoretically) measured with individual members of the population. Characteristics such as age, sex, literacy, place of residence and even characteristics makes up the distribution in the total population. In using these individual characteristics, PEDA distinguishes itself from models that rely on other frequently used economic indicators such as the GNP per capita which. Although the GNP it is indicative of the average amount of money that an individual has in his/her pocket, it cannot be directly measured at the individual level. It results from aggregated indicators of national accounting with various conceptual and measurement

problems. Although many of the powerful quantitative economic tools (such as general equilibrium models) 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. Multi-state projection groups all individuals of a given population into different sub-populations which are then simultaneously projected into the future, while at each time interval, people can also move from one sub-population to another (e.g., from rural to urban or illiterate to literate for each sex and age group).

Figure 0-2: the population segment



As shown in Figure 2, in PEDA the population of a country under consideration is broken down into eight sub-groups according to urban/rural place of residence, educational and food security status. Place of residence and food security status are core elements of the vicious circle reasoning as mentioned earlier. Education, or more precisely literacy status, has been introduced into the model as one of the assumed key sources of population heterogeneity, which I s related to both agricultural production and land degradation. Significant educational fertility differentials give the explicit consideration of education in the model a strong rationale, but education has many other important effects. There is abundant literature on the significance of literacy in population-development-environment interactions (see, e.g., Lutz 1994). The potential

of explicitly including education as a demographic dimension in multi-state population projection models has recently been evaluated (see Lutz *et al.* 1999) and is strongly recommended in the case of educational fertility, productivity or other relevant differentials.

Each of these eight sub-groups further subdivides the population by age (in single-year age groups) and sex, i.e., every one of the eight groups has its own age pyramid. During each one-year simulation step, a person will move up the age pyramid by one year within the same sub-group, or move to another sub-group while aging by one year (or die or leave the country). It is also possible for some people to move twice within one time step, e.g. from rural/food insecure/illiterate to urban/food secure/illiterate. The movements between groups that are possible are shown by arrows in Figure 2. For education and rural/urban migration, the model is hierarchical, i.e., people can only move in 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 the relevant year and the food distribution function.

This PEDA population module is in itself a useful piece of software (written in Excel) for multi-state population projections. As part of the initialization process, the user can set for each of the eight states, age and sex-specific fertility, mortality and educational transition rates. As scenario variables, dynamic future paths can be defined for fertility and mortality. The model automatically adjusts age-specific fertility and mortality patterns according to the levels of total fertility and life expectancy chosen for each year. The methods of multi-state population projections are well described in the literature (e.g. Nathan Keyfitz, Multidimensionality in Population Analysis, in: "Sociological Methodology 1980", Karl F. Schuessler, ed. San Francisco 1979). The specific details of this application in PEDA are described in the mathematical appendix. Here is suffices to say that the multi-state population projection model is a generalisation of the one-dimensional cohort-component model of population projections in which cohorts (i.e. groups of men and women born in the same year) are moving up the age pyramid while being exposed to age-specific mortality rates and women experience age-specific fertility rates with the children born in each year being moved to the bottom of the age pyramid. In the multi-state case the age-specific vectors become matrices referring to membership in different sub-population (states). In the multi-state case the model must also consider age-specific transition rates from one sub-population to another.

Education and rural-urban migration are defined in terms of the proportion of male and female cohorts that will become literate and move from rural to urban areas. While education is concentrated in childhood rural-urban migration tends to follow a typical patter with highest migration intensities in young adulthood. For this a standard internal migration schedule has been applied (A. Rogers and L. Castro: Model Migration Schedules, RR-81-30. International Institute for Applied Systems Analysis 1981). In the current version of the PEDA model, both education and internal migration are treated statically. That is, the user can set a specific transition rate and that remains constant throughout the projection period. For education the models allows for a sex and age specific educational transition rates.

Generally, before specific scenarios can be calibrated for a chosen country application, this country first needs to be initialized in terms of setting all empirical data for the starting conditions. This initialization is a significant task to be done outside the normal software, which requires more demographic skills than the use of the initialized model.

most recent version of PEDA also explicitly deals with this issue. The user can exogenously define assumed future paths in HIV prevalence/AIDS morbidity and the correspondingly assumed impacts on the course of life expectancy for each of the population groups. This procedure considers the fact that the age pattern of mortality is very different for countries with high HIV prevalence. In addition to this direct impact of AIDS on the population segment through mortality, AIDS morbidity is also assumed to impact directly on agricultural production as is outlined in section 0.

2.3 Land

Land is a key environmental resource for agricultural production in a given climate zone. It can be positively and negatively influenced by human activity.

Like many of the variables that affect agricultural production, land is treated as an index variable set to 1.0 in the starting year. This value must be seen as describing both the quantity and quality of land. Since the dynamics described below apply to both interpretations, it is not necessary to distinguish between the two aspects at this stage. In many applications one will have to deal with combinations of both aspects (e.g., erosion affecting both the quantity of the total arable land and the quality of that land). In a more general way one can label the land variable the natural resource stock.

The change in the stock of natural resources $R(t)$ is the result of a combination of indigenous growth or regeneration $g(R(t))$ and a reduction through population induced environmental degradation $(D(t))$:

$$R(t) = g(R(t)) - D(t)$$

Whereby R(t) for the initial year is equal to 1 and indigenous growth or regeneration is defined as:

$$g(R(t)) = a(\overline{R} - R(t))$$

Herein parameter a reflects the speed at which the resources recover[3]. However, it is assumed that the pace of resource recovery diminishes as the saturation level ($\overline{R}$) is approached. The saturation level stands for the stationary solution of R if the resources are not degraded. The saturation level has to be chosen in accordance with the specific conditions in the country of application and remains constant over the whole projection period.

The degradation (D(t)) of the resource stock depends on the stock of available resources and on the increase in the rural illiterate food insecure population as well as on changes in the total population density.

[3] If we consider the area under cultivation, the term $a(\overline{R} - R(t))$ stands for new cultivated land, where the cultivation is performed with constant intensity independent of any economic or social forces. Bilsborrow notes that the increase in demand due to population growth "can be met by an increase in the land under agricultural use or an increase in the intensity of use of existing land or an increase in both (...) The greater the land resources available and potentially arable, the more likely is extensification instead of intensification." (Bilsborrow, R.E., 1992)

As mentioned earlier, the model allows the user to assume that it is especially the rural illiterate food insecure segment of the population that depletes natural resources in their quest for survival. The growth of this subgroup thus leads to the degradation of resources. As this is often used as an assumption in natural resources modeling, this impact diminishes as the stock of resources decreases. In mathematical form this is given by:

$$P_I(t)\frac{R(t)}{R(t)+\eta}$$

Whereby $P_I(t)$ stands for the relative change in the number rural illiterate food insecure population. η is a constant factor that has default value of 1, but can be adjusted by an advanced user of the model if there is good reason to assume a different pattern of diminishing impact..

The scale of environmental degradation is also a function of the change in the population density. Mathematically, this is expressed as:

$$\frac{P(t)}{\overline{\overline{R}}}$$

Whereby P (t) stands for the relative change in the total population from one year to the next. The denominator reflects the upper limit of the natural resource stock and has a constant value that is country specific and reflects the relative status of the resource stock in the year for with the initial data are prepared.

The complete mathematical expression for environmental degradation is thus:

$$D(t)=\gamma\frac{P(t)}{\overline{\overline{R}}}P_I(t)\frac{R(t)}{R(t)+\eta}$$

The only parameter not yet described in this function is γ. This parameter is called the land degradation impact factor in PEDA and influences the intensity of the effects described above. The value of γ can be adjusted by the user in a scenario variable. This expression of land degradation implies that if resources are completely degraded (i.e. R(t)=0), than the value of D(t) will be zero as there is nothing to be depleted. Similarly, if the stock of rural illiterate food insecure population is zero, environmental degradation will be zero as well.

In each year the adjusted index value of current land enters the agricultural production function with the elasticity described below.

2.4 Water

Water is a key resource for life and human development. Fresh water is a renewable resource that is unevenly spread over the planet. The development of civilization is closely associated with the management of water, be it in the distribution of scarce water or the management of regular floods. To human life water is directly necessary for drinking and more indirectly for producing food. Water is also an important factor of personal hygiene and health and a necessary input to many industrial processes in modern society. For its key role in food security and sustainable human development, water deserves particular attention in models dealing with the nexus issues such as PEDA.

In the PEDA model, water is treated in a separate module that has an eventual multiplier effect on agricultural outputs. In its current form, the water module contains two externally defined scenario variables (water and irrigation) that can be changed dynamically and two user defined parameters: the reservoir capacity effect (RCE) and a parameter specifying the impact of land degradation on water availability (subsequently labeled as the water impact factor, WIF). The latter two parameters should ideally be defined during the process of initialization although different values can still be assumed by an advanced user as part of the scenario settings. The water segment in PEDA also relies on the input from other variables in the model such as the quantity and quality of land and calculates a number of intermediate variables. This input is completely endogenously determined and cannot be manipulated by the user.

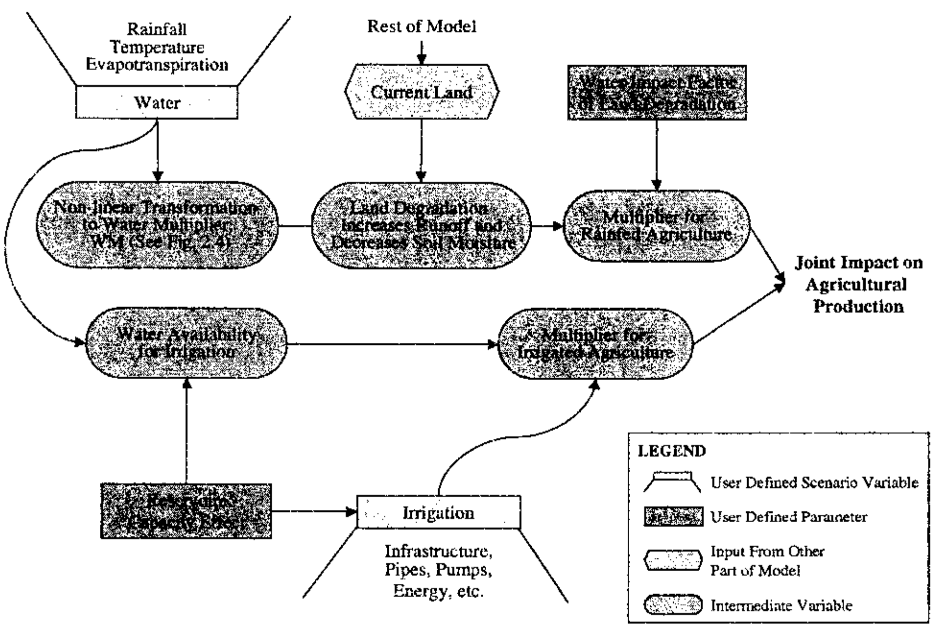


Figure 0-3: the water module

The water module essentially has two parts, one referring to rain fed agriculture and the other to irrigated agriculture. The scenario variable water, W(t), is relevant for both segments and covers the general climatic conditions in year t particularly with respect to rainfall and evapotranspiration. It therefore can be used to simulate both short term or cyclical droughts and longer term climate change. Unlike most of the other scenario variables, water will not be set to 1.0 in the starting year, but its initial value will be defined in terms of its position on the nonlinear curve (Fig. 2-4) as will be described below. This definition of the initial value depends on the specific climate conditions of the country in the initial year and is to be part of the initialization procedure.

For calculating the impact of the scenario variable water on rain fed agriculture a nonlinear transformation into a water multiplier is introduced because an increase of one unit

water unit does not always have an equal impact on agricultural production. The assumed relationship that is derived from the hydrological and agricultural literature is presented in stylized form in Figure 2-4. The specific shape of this non-linear relationship greatly depends on local conditions and the kind of crops and/or life stock under consideration. For in-depth applications of PEDA the definition of this curve requires serious attention. For the current version of PEDA a hypothetical curve has been assumed. Its general features are that in case of serious drought nothing can grow, but after this point small increases in water availability can produce great returns. With further increases in water availability the curve flattens to eventually reaching a saturation level, starting from which more water will adversely affect agricultural outputs. Beyond this point, flooding starts to be harmful to production and may ultimately destroy all production.

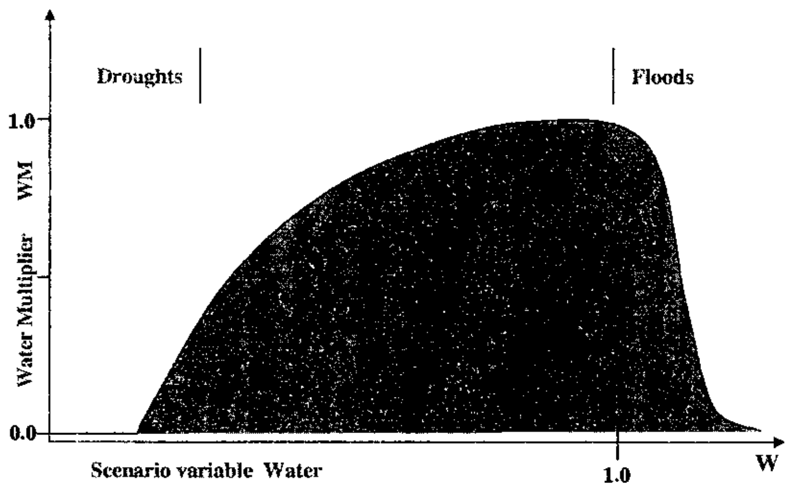
The assumed non-linear relationship of water on agricultural output, however, only holds if other relevant determinants of soil moisture remain constant over time. Unfortunately land degradation and land erosion tend to increase the runoff of rain water and therefore decrease the moisture that will be stored in the soil thus negatively affecting agricultural productivity. Since land degradation is explicitly modeled in other parts of PEDA, the impact of land degradation can be directly taken into account. To do this in quantitative terms, another user defined input parameter has been introduced, i.e. the water impact factor of land degradation or short WIF. WIF is defined in the form of an elasticity applied to current land (defined as R(t) in the previous section) This results in an effective water multiplier (EWM) for rain fed agriculture:

$$EWM = WM(t) * R(t)^{WIF}$$

Values bigger than 1.0 for WIF, increase the effect of the status of the land or resources in the calculation of the effective water multiplier; values smaller than 1.0 decrease it's elasticity.

Figure 2-4

Nonlinear relationship between water multiplier for rain fed agricultural production and user-defined scneario variable water



For irrigated agriculture the dynamics in which water and irrigation efforts jointly impact on agricultural output are even more complex. The functional relationships defined here are already a great simplification but should still be able to capture the most important dynamics. The formula given below creates an intermediate variable, effective irrigation (EIR). For this we have to distinguish between the situations where water is already at or above the saturation level of 1.0 (see Fig. 2-4) or when it is still below that. In the first case, irrigation efforts do not make any difference and in the second case the result depends on irrigation efforts, on the reservoir capacity effect (RCE) and on the general availability of water for irrigation.

In the formula W(t) stands for the value of the scenario variable water at time t and Ir(t) for the value of the irrigation variable. Frt is the elasticity of fertilizer in the production function that is being applied to irrigation as well because of the lack of better data on the effect of irrigation on agricultural production.

$$EIR(t) = \begin{cases} 1; if\ W(t) \geq 1 \\ \left[RCE * \frac{IR(t)}{IR(0)} * \frac{W(t)}{W(0)} \right]^{Frt} ; if\ W(t) < 1 \end{cases}$$

This second line of the above given formula may not seem quite straightforward and requires some explanation since it is an approximation of several more complex mechanisms. The main reasoning is that even for high irrigation efforts there needs to be water available in

order to have any effect and that even high reservoir capacity does not help if it does not rain for a long time. Ideally, this would require the calculation of cumulative water storage effects over time. A simple approximation is obtained through the multiplication with a ratio of current water over initial water in case that current water availability is still below saturation level. This also implies that if there are no extra irrigation efforts but simply more water, it also generates positive returns in terms of agricultural outputs. This can be interpreted as an additional direct effect of water on production that is weighted by improvements in irrigation and reservoir capacity.

Both effective irrigation (EIR(t)) and the effective water multiplier (EWM(t)) are then added onto the agricultural production function as additional multipliers. It is worth noting that in this setup, the two water related variables and current land enter the agricultural production twice but in two different forms and after transformations as outlined above. The water variable enters both through rain fed and irrigated agriculture as discussed. Land degradation as captured by current land enters as a regular production factor with a given elasticity (as described in the next section) and through the impact of land degradation on increasing runoff and therefore decreasing soil moisture. Depending on the other settings of the model and the specific parameters choice this indirect effect of land degradation through declining soil moisture may even be more relevant than the direct effect through the production function.

2.5 Agricultural production segment

The total agricultural production in one year, measured in total calories produced (in index form), is calculated in PEDA through a Cobb-Douglas type agricultural production function. 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. In stead, they largely focus on physical and financial inputs. The chosen production function is a notable exception. Based on pooled data sets of time series in most countries in the world, Hayami and Ruttan (1971) estimated a large number of Cobb-Douglas type production functions with different combinations of input factors for different groups of countries. The equation that seemed most appropriate for PEDA Africa is the Principal Components Regression for developing countries including educational variables.

The total production is a result of the inputs in terms of the human labor force by educational level, land and technological investments in fertilizer use mechanization, etc. In PEDA, some of these inputs are endogenously determined by the other segments in the model and others are treated in terms of externally defined scenarios because these factors are not assumed to depend directly on other variables of the PEDA model (Table 0-1).

As indicated in Figure 1 (the population module), the population by age and sex in the eight defined categories affects total agricultural production in two different ways. First, the population projections produce an estimate of the size of the rural labour force. Their productivity is affected by the proportion literates within that category (endogenously determined) in addition to their technical training (externally defined scenario variable). The values for all these variables directly enter the agricultural production function as discussed below.

The other chain of causation is a reflection of the vicious cycle reasoning: the factor land is degraded as a function of the relative change in the rural illiterate food insecure segment of the population and of the population density in general as has been discussed above. Other main factors influencing the agricultural output of a country such as mechanization and fertilizer use need to be specified in externally defined scenario variables. If, however, a user wants to make for example the rate of technological investments in agriculture dependent on population growth in either a positive or negative way, it is not difficult to define corresponding scenarios and study the alternative results. As mentioned before, water is treated in a separate module with a multiplier effect on the total agricultural output.

Table 0-1: the elasticities and the specific variable definitions in agricultural production function as taken from Hayami and Ruttan (1971, p. 145, Q 19):

Variable	Description	Elasticity
Labour force, LF(t)	Total rural adult population aged 15-60, calculated from combining the appropriate age groups in all four rural sub-groups	0.534
Total agricultural land, R(t)	As endogenously determined by the land segment	0.088
Fertilizer use, FERT(t)	Exogenous scenario variable	0.162
Tractors, MECH(t)	Exogenous scenario variable, in the PEDA model considered to cover mechanization in general	0.072
Literacy of the labour force, LITLF(t)	Specified as the proportion literate of the total rural population aged 10-45 , (both male and female). The value is determined endogenously by combining both the food-secure and the food-insecure rural literate sub-populations	0.276
Technical education , TE(t)	In addition to literacy, this variable represents the technical education of the labour force. In the current version this variable is still treated as an exogenous scenario variable. In a later stage it may be related to the educational efforts parameter	0.158

All these inputs to agricultural production are considered on a relative scale, i.e., their values are set to 1.0 in the starting year and change over time as a result of effects emanating from the other segments in the model or as defined in the scenario settings for the exogenous variables. If, for example, we assumed an increase in fertilizer use of 20 percent by 2003, this would mean that the value of that variable is set to gradually increase to 1.2 by that year.

In sum, total agricultural production in terms of total calories produced is calculated in the following multiplicative manner, in which the last two factors are water multipliers which have already elasticities applied as discussed above:

$$\Pr odIndex = LF(t)^{0.534} * R(t)^{0.088} * FERT(t)^{0.162} * MECH(t)^{0.072} *$$
$$LITLF(t)^{0.276} * TE(t)^{0.158} * EIR(t) * EWM(t)$$

Although the variables of the agricultural production function and their elasticities are by default distributed with the model and applicable to all countries, a thorough initialization of the model for a particular country should include estimating new elasticities for the given variables in the agricultural production function or even consider the inclusion of other variables.

2.6 Food distribution segment

Not all food that is produced in a country will be consumed by its citizens. A fraction will be lost during the harvest, transportation and storage of the food and a part of it may be intended for export. On the other hand, imports may complement the food that is produced locally. All these factors can be accounted for through external scenario variables. Their values can be changed over time and alternative starting values may be assumed.

After the correction of the stock of produced food in a country for the loss in the harvest, transport, storage, imports and exports, the estimated amount of available food is distributed over the population in two steps. First an 'urban bias factor' (external scenario variable) determines which proportion of the available food is consumed by the rural and urban population respectively. As with the other scenario variables this is done on a relative scale, with 1.0 reflecting the starting conditions. If for instance a value of 1.2 is chosen this means that of the total production urban areas now get 20% more. Within urban and rural areas, however, not everybody will receive an equal amount of food. In practice, the distribution of food is unequal because some persons 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 theoretically sufficient to provide the necessary minimum diet for everybody. As the access to food is usually more unequal in urban than in rural areas, PEDA works with two food distribution functions, one for rural and one for urban areas.

There is abundant theoretical and empirical evidence indicating that the inequality in the food distribution is at least as important as the total production of food in explaining food insecurity. Especially the work of Amartya Sen (1994) demonstrated that some of the worst famines occurred under conditions in which theoretically there would have been enough food for everybody, if the distribution had been appropriate. For this reason it is evident that a model focusing on food security without paying attention to the distributional aspects would be incomplete, 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 African countries of today, and that theoretical distributions are hardly appropriate because conditions tend to vary significantly from one country to another. PEDA opts for another solution to approximate the inequality in the access to food through household income distribution functions that exist for a number of African countries on the basis of household expenditure surveys[4]. Hence, PEDA relies on the assumption that the inequality in the access to food follows a similar distribution than the inequality in the access to income in respectively urban and rural areas.

In each one-year step of the projections, food is allocated to rural and urban areas following the urban bias factor and within each of these areas the food distribution function determines the new sizes of the food secure and insecure sup-populations. Figure 4 gives an example of such a food distribution function. It is a Lorenz Curve with the cumulated proportion of the population on one axis and the cumulated calories available for distribution on the other. The available food is then distributed from right to left along the curve. If the Lorenz curve coincides with a 45°-diagonal, the slope of the curve is equal to 1.0 and everyone in the economy

[4] World Bank African Development Indicators 1998/99. Section 15

will have access to the mean available calories; i.e. it describes a situation of perfect equality. The convexity of the curve therefore measures the prevailing inequality.

The given curve in Figure 0-4 indicates that in this case, the first (most privileged) 10 per cent of the population use 30 per cent of the available food. Going further down the curve, about 23 per cent of the population consumes half of the food, and half of the population uses 75 percent of the food. The borderline between the food-secure and the food-insecure population is then established by applying an externally defined minimum calorie requirement per person. The iteration is carried out in steps of 1 percent of the population. At the point where the food allocation of the current percentile falls below the minimum food requirement specified, the borderline for the population considered to be food insecure is established. In this example, the least privileged 34 per cent of the population has access to only 15 per cent of the food. As this fraction of the remaining food is considered to be insufficient to fulfill the necessary minimum daily food intake (on the basis of a threshold level set by the user in a scenario variable, not shown in the illustration), 34 per cent of the population is considered food insecure. Over time the proportions food insecure may change as a consequence of changes in the population size, food availability, or, possible changes in the assumed food distribution function. In the current version of the PEDA model, however, the food distribution function is assumed to remain constant over the whole projection period. Defining the food distribution functions for rural and urban areas is part of process of initializing the model for a new country.

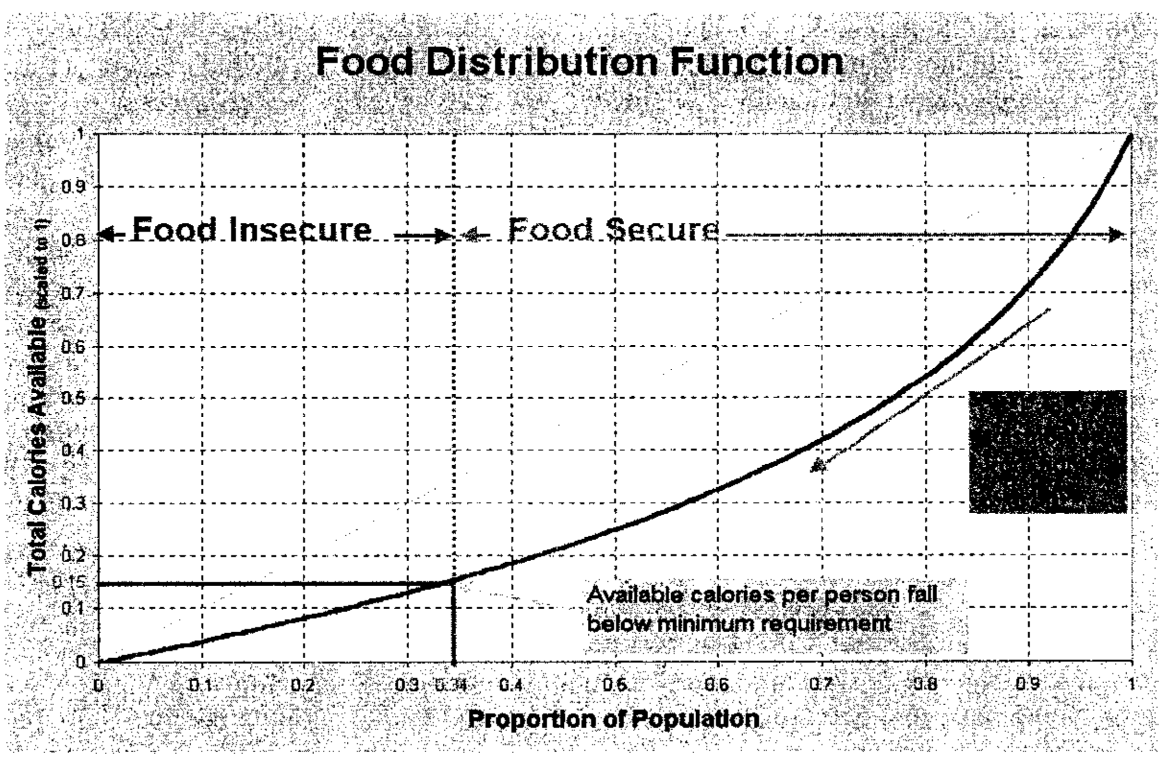


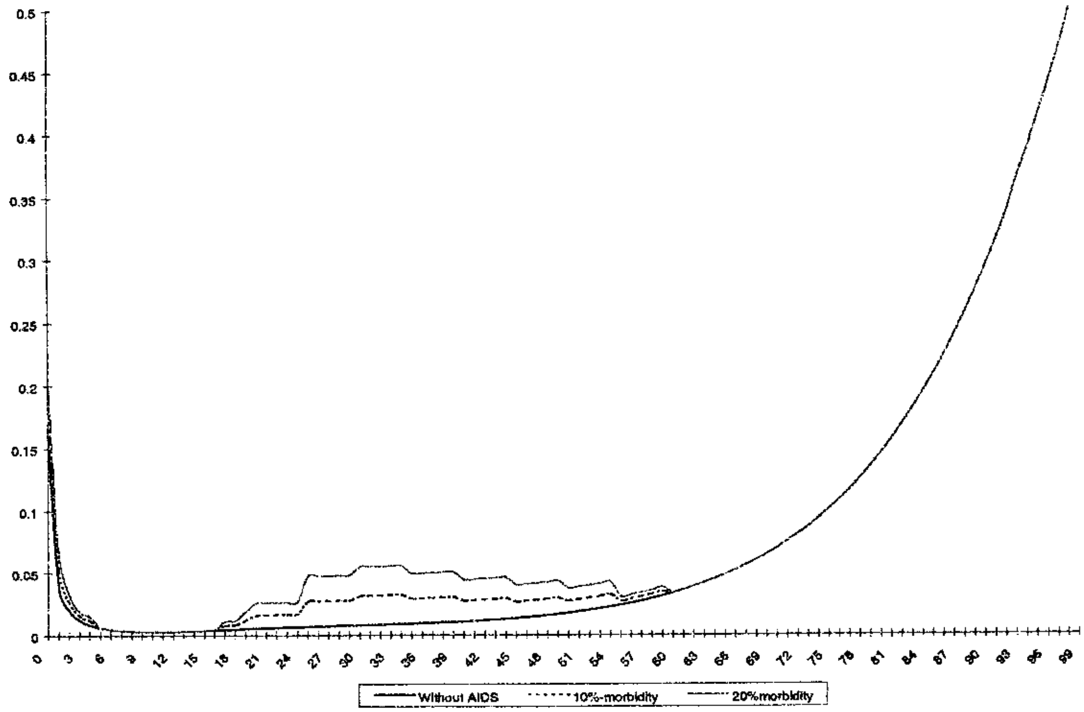
Figure 0-4: the food distribution function

2.7 HIV/AIDS in PEDA

As a model demonstrating the interaction between population, education, environment and food security, PEDA has not been designed to explicitly cover the possible sustainable development and food security consequences of HIV/AIDS. However, since the pandemic has become such a challenge for many African countries and it is not meaningful to talk about the future development in these countries without explicitly considering HIV/AIDS, this section will discuss the way in which PEDA incorporates HIV/AIDS and how it can fully account for its consequences. As there is still relatively little empirical knowledge on the trends of the pandemic and especially not on its effect on the different sectors on the economy, the model is necessarily experimental in its conception and treatment of HIV/AIDS.

The most obvious impact of HIV/AIDS on the nexus is through excess mortality and thus indirectly through a reduction of the labour force. As the age pattern of AIDS mortality differs from the one observed in a population without AIDS, it was opted to include that effect via a user specified scenario variable. In that scenario variable the user needs to specify AIDS related morbidity rates and these are translated into an age specific mortality rates, which are added to the age specific mortality pattern of each of the eight different subgroups in the population. The additional age specific mortality pattern due to AIDS has been estimated on the basis of a rather complex simulation model for Botswana (see Warren Sanderson, Modeling AIDS in Botswana, forthcoming IIASA Report 2001). This age-pattern of AIDS mortality as a typical shape with very high rates on the young to medium adult ages and in early childhood due to vertical transmission. The specified age specific excess mortality due to AIDS is then scaled up or down depending on the morbidity level set by the user in the HIV/AIDS scenario variable and superimposed to the mortality from other causes. If a user wants to specify age specific excess mortality on the basis of country specific data, this has to be implemented during the process of initialization. Figure 0-5 gives an illustration of the age specific mortality rates (m_x) for one of the subgroups in an imaginary population without AIDS and with a 10 and 20% morbidity level. The figure clearly illustrates the above mentioned fact that AIDS related mortality is concentrated in the early childhood and young adulthood.

Figure 0-5: age specific mortality rates (m_x) in a population without and with HIV/AIDS



The user should also be aware that one cannot account for the demographic impact through manipulation of this scenario variable alone. A consistent scenario should include setting lower life expectancies than one would have assumed excluding AIDS and the development of life expectancy over time will have to be set in such a way that it reflects the recent and anticipated future trend of HIV prevalence and the resulting AIDS mortality.

See

Table 0-2: reductions in life expectancy under different HIV/AIDS morbidity levels (as specified in the top row) for some guidelines in setting similar scenarios.

Table 0-2: reductions in life expectancy under different HIV/AIDS morbidity levels (as specified in the top row)

HIV/AIDS Adult morbidity	0.0	0.1	0.3	0.5
Life Expectancy	40	31.0	21.4	16.8
	45	34.5	23.5	18.3
	50	38.8	25.5	19.6
	55	41.3	27.3	20.9
	60	44.6	29.0	22.0

When interpreting this table one has to be aware of the fact that the AIDS morbidity rate of the adult population aged 15-49 for a given population tends to be much lower than the frequently cited HIV prevalence rate based on Sentinel Surveys. Due to the fact that the incubation period (HIV positive without symptoms) tends to be 5-10 years in Africa whereas the symptomatic period before death is much shorter (may be 1-3 years) the morbidity level tends to be less than a third of the HIV prevalence level. Due to this delay, in the early phases of the disease there may be cases where AIDS morbidity is still very

low while HIV prevalence is growing rapidly. This dynamism of the disease can be captured in PEDA through dynamic assumptions of life expectancy.

In the current version of PEDA, the scenario variable wherein the user specifies the AIDS morbidity rates is applicable to the population as a whole. As of now, different morbidity rates cannot be applied to the eight sub groups separately. However, the user can make different assumptions regarding the expected reduction in life expectancy and thus indirectly account for a potential different impact of HIV/AIDS in rural and urban areas, among literates and illiterates etc.

HIV/AIDS not only induces increased mortality with its impact on the population structure; it also seriously affects agricultural production through different mechanisms. Most of these effects are not endogenized in PEDA and need to be dealt with in the form of consistent user-defined scenarios. Similar to many other possible future developments, such as droughts, climate change, wars, heavy new investments in technical education or in irrigation, etc., the user of PEDA has to choose the various model parameters and scenario variables in such a way that they describe consistent "stories" or scenarios of possible future trends.

If AIDS is assumed to be a major issue in a country, then AIDS mortality and morbidity should be assumed to reduce the educational enrollment and technical education due to AIDS orphanhood, fewer qualified teachers (they may die) and AIDS-induced economic difficulties. These likely negative consequences of AIDS on the incomes of affected households may also reduce investments in fertilizer, irrigation and mechanical inputs in agriculture. The only edogenized feed back from the AIDS morbidity rates, as set by the user, on agricultural production is the reduction in the productivity of the labour force. Again, very limited empirical evidence on the issue exists, therefore an experimental solution had to be chosen. By default the model assumes a linear decline in the productivity of the labour force at a rate of the morbidity level. But in simple words, people who are sick , i.e. symptomatic, with HIV/AIDS are substracted from the labor force. The rationale is that the capacity of sick people to work is greatly reduced and that some healthy people will have to look after their sick relatives instead of working and thus reduce their productivity in agriculture.

Taken together these different effects may have a drastic impact on agricultural outputs and the development of a country, but at the moment, hardly any systematic empirical evidence exists on these issues. Hence, the assumptions need to be highly speculative at this point. If more empirical information on these effects becomes available in the future, then PEDA could be expanded into a model that quite comprehensively captures the impacts of AIDS on human development and food security.

3. An overview of the user defined scenario variables and output variables

As mentioned earlier in this manual, working with PEDA can happen at two different levels. The initialization of PEDA for a new country requires significant effort by -ideally- an interdisciplinary group of experts. Some methodological support for initializing the PEDA model for a new country is given in chapter ***** of this manual. Most users of PEDA will, however, work with already initialized countries and possibly pre-defined scenarios. For them there is no need to go into the second level of PEDA and modify parameters or other settings directly in the Excel spreadsheets. They can focus on a number of model parameters and scenario variables that can be set and adjusted in an easily accessible user interface. This allows the user to specify a very large number of alternative scenarios without having to go to the second level of PEDA. An overview and description of these parameters and variables is given below with a reference to the page where these variables are treated substantively. In a later section, the standard output variables are summarized.

3.1 Model parameters and scenario variables

3.1.1 General model settings

These include some of the basic model specifications that are set at the beginning of each simulation. They are considered constants that cannot be changed over time or across sub-populations. In other words, these parameters apply to the whole country and throughout the projection period. Figure 0-1 presents a screenshot of the window wherein these parameters can be changed. In Table 0-1, a brief description of each of these parameters is given.

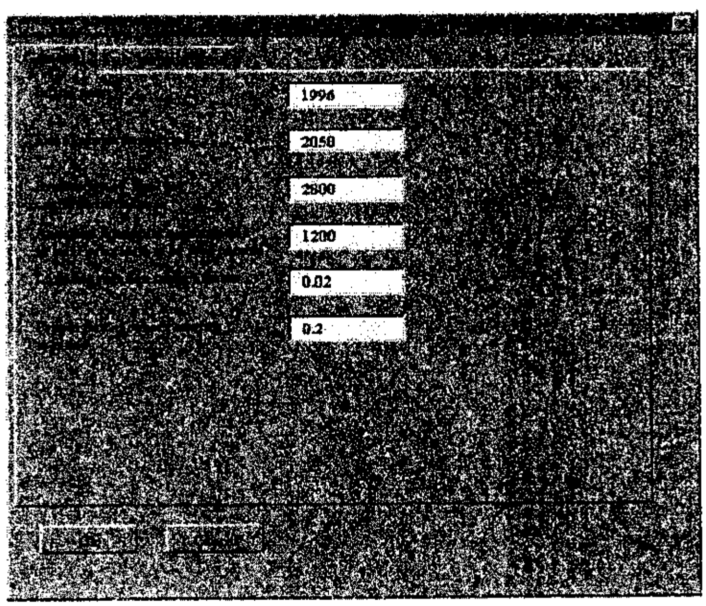


Figure 0-1: the general model settings window

Table 0-1 : Parameter and variable definitions of the general model settings

Parameter or variable name	Description
Initial year	The starting year of the projections. This is the year to which the baseline data apply. This value cannot be changed by the user as it is part of the initialization process. It is only presented as a reference.
End of Projection period	The end of the projection period. All simulations will be run in single year steps up to that year and all results will be stored up to the end of the specified period. Although there is no direct limit set to the value of this parameter, projection periods of longer than 50 years will slow down calculations and are subject to increasing uncertainty.
Production of Kcal per capita in the initial year	Refers to the average daily per capita amount of food produced in the starting year. All the agricultural production variables are treated as indexes to increase or decrease upon this initial volume of production.
Assumed min kcal per capita to be consumed in order to be food secure	In the PEDA model, calorie (energy) requirements are used as a proxy for food requirements. "*The minimum energy requirement is the amount of energy that is required on average in a population to satisfy the basic physiological needs and the needs for light activities of adults and the normal energy needs of children and adolescents (including the extra needs for the growth). Two main factors determine the estimation of the energy requirement of a population: the distribution by age and sex; and the body weight.*"[5] The value of this variable may thus vary under different national conditions, or the user can set the value to define different thresholds to evaluate its effect on the model interactions.
Land degradation impact factor	This variable reflects the assumed negative impact of population growth on the natural resource stock. See p. 46 for more detailed information on the definition of this parameter.
Proportion of the cohort moving from rural to urban areas	This variable enables the user to set net rural-urban migration rates. A value of 0.2 means that of every cohort born in rural areas, 20% will move permanently to urban areas over their lifetime. These movements are distributed over the different ages according to standard age-specific migration schedules (see p. *** for more a more precise definition).

3.1.2 Sub-population parameters

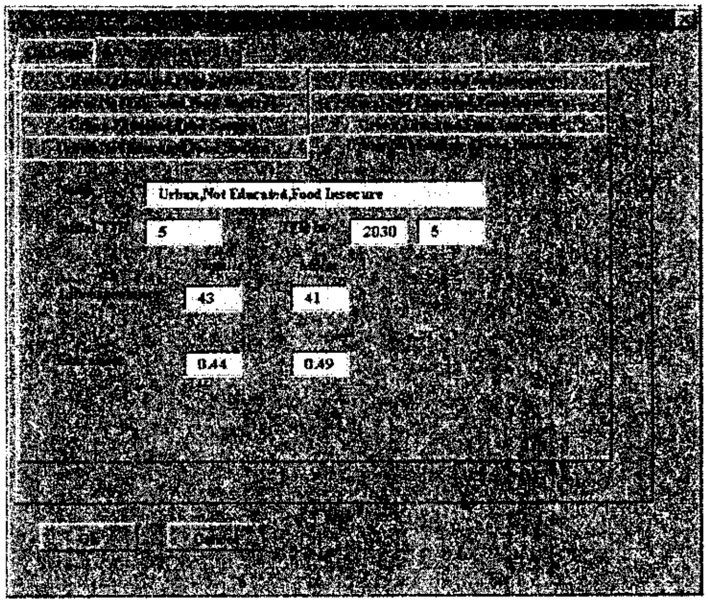
These variables allow the user to make assumptions with respect to the future path of fertility (through the Total Fertility Rate, TFR), mortality (through life expectancy, e_0) and literacy (through educational transition rates). All these variables are directly related to the population projections segment in the model and can be specified for the eight different subgroups independently. All these variables are summary measures that, after adjustment, will influence age specific transition rates as defined during the process of initialization. Both fertility and mortality are treated dynamically. Educational transition rates are assumed to remain constant over the whole projection period.

The Total Fertility Rate (TFR) is the mean number of children a woman would get throughout her reproductive life (if she survived to age 50 and were exposed to the age-specific fertility rates observed or assumed for a given year). TFR is treated dynamically in the model, i.e it can be assumed to change over time. The pattern of age-specific fertility rates is adjusted

[5] This definition is taken from the African Nutrition Database Initiative (ANDI) web site, at http://www.africanutrition.net/

accordingly. In addition to the TFR for the starting year, the user can set two intermediate levels and one final assumed level of fertility to be reached at the end of the projection period. If the assumed values are different, the model will calculate a gradual change from the first to the second value that is linear over time. The TFR set for the starting year should reflect the situation in the year for which the data were initialized.

Figure 0-2: the sub-population parameter settings window



Life expectancy at birth (e_0) can be set for men and women separately for each of the eight sub-groups. Life expectancy is treated dynamically in an analogues was as fertility. Note that, although the user may keep the TFR and e_0 constant for experimental reasons, their aggregated values in the total population may change due to changing weights of the different subgroups over time (this of course is only valid if different assumptions regarding fertility and mortality are made for the subgroups in the population).

In addition to fertility and mortality, the user can make assumptions regarding the educational transition rates. The enrollment rate (these are usually the one that is used) can be set for men and women separately and is treated as a constant variable over time. The number entered in the model is the proportion of girls and boys in each birth cohort that will move over their lifetime from the illiterate to the literate state. In the present form of the model, these transitions are concentrated around age 10 although more advanced users may specify a particular age pattern for the transition from the illiterate to literate status. Such an age specific pattern for the transition from illiterate to literate status (as opposed to an assumed total proportion to become literate)) will influence the other variables in the model only to a very limited degree.

As mentioned before, educational transition rates assumed by the user, remain constant over the whole projection period but a user may assume higher transition rates than those reflecting the conditions in the initial year and these will then be applied from the first year in the projections and thus adding a dynamic aspect to the treatment of education. In any case the future educational composition of the population of the next few decades is mostly a function of past changes in educational enrollment reflected in the educational distribution by age in the starting

year. Since education is concentrated in young age, it will take quite some time to have changes in enrollment reflected in the working age population. For the sub-groups that are already educated no educational transition rates can be set, because PEDA doesn't consider movements back from literate to illiterate.

3.1.3 HIV/AIDS

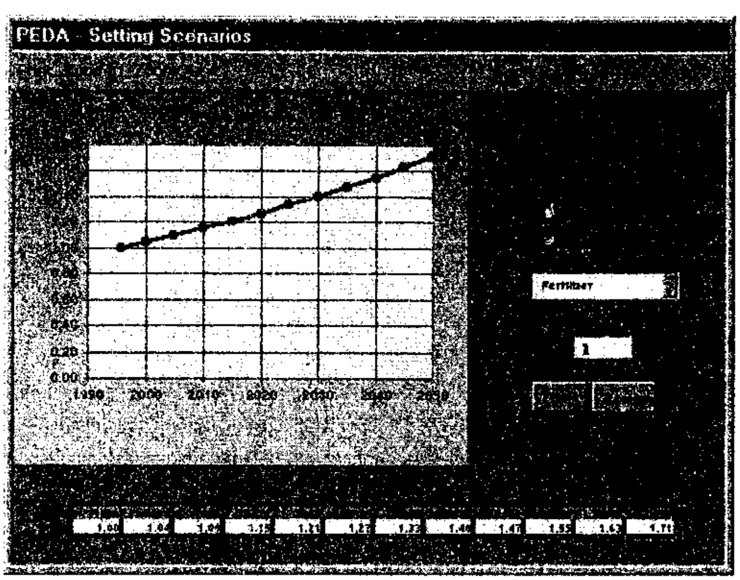
HIV/AIDS morbidity rates can be set in a user specified scenario variable that adds an age specific mortality pattern to the mortality schedules for each of the eight subgroups. Just as mortality, HIV/AIDS is treated dynamically but unlike life expectancy, this special age-specific mortality pattern can be specified only for the population as a whole. Variations in the impact of HIV/AIDS on the different sub-populations can only be accounted for through setting different life expectancy trends in these sub-populations.

In the HIV/AIDS scenario variable, the user is expected to set an HIV/AIDS related morbidity pattern over time that is defined in terms of proportions of the whole young adult population, aged 15-49 (similar to the most frequently used HIV prevalence data). A value of 0.15 for this variable means that 15 per cent of the young adult population is assumed to be sick to an AIDS related complaint. In any population this proportion tends to be lower than the HIV prevalence rate because the period of morbidity tends to be short than the incubation period.

3.1.4 Parameters for food supply

The factors associated with food supply are all treated in index form, which means that their level in the starting year is set to be 1.0 and their levels in all the subsequent years are seen as relative to this starting year. The setting allows using the model even if one does not have empirical information about the exact quantitative level of each factor since one only has to specify the relative change as compared to the starting year. The variables considered in PEDA with respect to the food supply are summarised in the tables below. The first set of variables will enter the agricultural production function (i); the second set corrects the available amount of food for distribution to the population (ii).

Figure 0-3: the parameters for food supply settings window



Some of the variables that influence the agricultural production in a country are endogenously determined by the model and are not elaborated upon here. See section 0 for a more complete definition of the agricultural production function and its components. The scenario variables related to the availability of water are -strictly speaking- not part of the agricultural production function, but are part of the PEDA-water segment with an eventual multiplier effect on agricultural outputs.

Table 0-2: variables of the agricultural production function

Variable name	Description
Size of the rural labour force	Endogenously determined variable
Literacy of the labour force	Endogenously determined variable
Land	Endogenously determined variable
Fertilizer use	The amount and productivity of fertilizer used in agriculture. The user needs to set a value that expresses a relative improvement/worsening with respect to the conditions in the starting year.
Machinery use	The amount and productivity of machinery used in agriculture. The user needs to set a value that expresses a relative improvement/worsening with respect to the conditions in the starting year.
Technical education	In addition to literacy, the user can give value to specific technical capacity of the rural labour force for agricultural purposes. As with Fertilizer and machinery use, one needs to give a value that expresses a relative improvement/worsening of the conditions in a particular year as compared to the starting year.
Water	This covers the change in weather/climate conditions. Its initial value depends on the climate conditions of the country at the time of initialisation. Assuming period in which water is lower than 1 the initial case, means simulating droughts, if it is higher it means better rainfall, if it is very high it means flooding.
Irrigation	This covers the efforts made in irrigation as compared to the starting years, including such things as pipelines, pumps, energy etc. (Reservoir capacity is set with another parameters at a lower level, i.e. directly in Excel)

Table 0-3: other variables influencing the availability of food

Variable name	Description
Loss in transport and storage	Individuals will not consume all the food that is produced. Some of the food will be lost during the treatment of the food, the transport or storage. This variable enables the user to take these effects into account.
Urban bias factor	This variable enables the user to allocate food disproportionally between urban and rural areas. A value of 1.0 means distribution according to population size, 1.2 means 20% more to the urban areas.
Food imports and exports	This variable allows the user to take food imports and exports into account. As all other variables influencing the availability of food it is treated as an index that has value 1 for the starting year of the projections.

*3.2 Output varia*bles

3.2.1 Multiple interfaces to access the output of the projections

PEDA has large numbers of output parameters and variables that can be accessed in different formats and for different subgroups in the population. For each one-year step in the simulation every

age and sex specific number for each of the eight different subgroups is stored in a database and can be accessed by any user in a relatively easy manner. The latter is also true for most of the parameters that result from or affect land (degradation), water availability and agricultural production. A description of these databases is given in the following chapter. In addition, the PEDA model contains a number of integrated and standardized output modules including (dynamic) population pyramids, and graphs showing trends for a number of variables over time. The user can specify to compare sub-populations given for a particular scenario and indicator or he/she can compare scenario's for a given indicator. Please refer to the **PEDA User's Manual** for more information on these output modules.

3.2.2 List of indicators

Hereunder, we have listed the output variables available to the user with their explanation wherever they are not self-explanatory. If no specification is given, the indicators can be generated for the eight different subpopulations separately. Otherwise it is specified that the indicator is only available at the country level. The standard output modules in the PEDA model allow the user to request the values for the scenario variables as well. This option was included for the user to be able to verify his/her assumptions for a given scenario while being in the output module. In the table below these variables labeled as input variable.

Table 0-4: standard output variables in PEDA

Variable	Variable description
Available food	This is the sum of the total amount of food produced in the country in a particular year minus the loss of food in the harvest, transport and storage, +/- food imports and exports. This indicator is only available for the country as a whole.
Births	Total number of births
Current land	The combination of the quantity and quality of land for each year of the projection period. Index value summing up the effects of land degradation and regeneration. This indicator is only available for the country as a whole.
Deaths	Total number of deaths
Life expectancy (e_0)	When requested for each of the eight sub-groups separately and sex specific, this is the graduated value of the assumptions of the user. At the country level, however, it is also influenced by the relative weights of the subgroups in the population (provided that different life expectancies have been set for the different subgroups).
Literate Life Expectancy (LLE)	Number of years a person is expected to live in a literate status from the age of 15 onwards. See section 0 for a more detailed description.
Fertilizer	Is an input variable.
Food import/exports	Is an input variable
Food production	This is the sum of the total amount of food produced in the country in a particular year. This indicator is similar to food availability, but it does not account for loss in the harvest, transport and storage or food imports or exports. This indicator is only available for the country as a whole.
HIV/AIDS morbidity rates	Is an input variable
Irrigation	Is an input variable
Loss in transport/storage	Is an input variable
Machinery	Is an input variable
Proportion food insecure	In addition to the population size that can be generated by urban/rural place of residence, literacy status and food security status; the model has an extra output variable that portrays the proportion food insecure in the country for any year of the projection period. This indicator is only available for the

	country as a whole.
Total population	Population size. It can be generated for each of the eight subpopulations separately and for both sexes separately. There is also a possibility to extract age specific information from the databases (see ****).
Technical education	Is an input variable
TFR	When requested for each of the eight sub-groups separately, this is the graduated value of the assumptions of the user. At the country level, however, it is also influenced by the relative weights of the subgroups in the population (provided that different fertility rates have been set for the different subgroups)
Urban bias factor	Is an input variable
Water	*** use EWM in stead ? ***

3.2.3 Literate Life Expectancy (LLE)

As it is a less well known indicator, Literate Life Expectancy deserves particular attention in this manual. LLE stands for *the average number of yeas a man or a woman lives in the literate state; i. e. is able to read and write under the prevailing mortality and literacy conditions.* Literate Life Expectancy (LLE) has recently been proposed as an indicator of social development and quality of life. LLE is perfectly fit for the structure of PEDA which gives projections of the population by age, literacy status and mortality levels (depending among others on the food security status) and it may even have a number of advantages over another widely spread development related indicator, namely the Human Development Index (HDI).

A single indicator that comprehensively describes a population's quality of life and can be used for comparative purposes can be very useful if it has a clear interpretation. In the past, GNP per capita has almost exclusively been used for this purpose, although it remains a highly problematic indicator for comprehensively measuring quality of life and development. UNDP (1990 through 1999) offered a more comprehensive alternative by introducing the Human Development Index (HDI). This index combines indicators of life expectancy, educational attainment and income in one figure on a scale between 0 and 1. HDI served an important purpose in giving more attention to the social aspects of development but also has some conspicuous shortcomings (which has been discussed in the literature)

The fact that measures of income (through whatever concept of national accounting) are not reflected in LLE can be seen as a benefit in terms of purity rather than a deficiency. Finding the right level of mortality and of literacy is a largely empirical issue once an operational definition of literacy is applied. In practice there are of course all kinds of difficult measurement problems. But any figure for material wealth does not have only the measurement problem. It is to a much higher degree dependent on the accounting framework applied, whether only the formal economy is considered, whether the depletion of natural capital, whether real purchasing power, or distributional aspects are considered. It may be wiser not to mix these two very different kinds of indicators (one based on individual characteristics, the other on an abstract entity called the economy); let GNP per capita describe economic development in the formal economic sectors and take literate life expectancy to describe social development.

Finally,Literate Life Expectancy as a summary indicator of social development is based on two underlying sets of indicators, age-specific mortality rates and age-specific proportions literate. There are convincing arguments for taking individual survival probabilities and empowerment

through basic education as two of the most important and least ambiguous aspects of human quality of life. Below is an attempt to highlight some of the underlying reasoning which in this brevity will certainly be incomplete.

Personal survival to a mature age and the survival of immediate family and close friends is about the most universal human aspiration that one can think of. It is one of the few values likely to be shared by a Buddhist monk, a Wall Street broker, and a street child in Sao Paulo. Individual survival is the necessary prerequisite for enjoying any kind of quality of life. In more economic terms, increases in life expectancy at the level of society also increase the expectation of returns from investments ranging from education to housing, consumer durables, production sites, etc. This expectation is a basic prerequisite for any kind of development.

But increasing life expectancy not only facilitates development, its level also reflects social advancement and quality of life in a very comprehensive and sensitive manner. Life expectancy responds positively to most of the things that we consider important ingredients of quality of life (good diet, efficient health care, good housing, benign technologies, good social and economic infrastructure, healthy working conditions, education, intellectual stimulation, etc.) and negatively to things we want to avoid (armed conflict, malnutrition, poverty, hazardous work, stress, depression, etc.). One might even go so far as to say that happiness tends to reduce adult mortality, while unhappiness increases the risks; a lot of psychosomatic evidence points in that direction. Given all the problems involved in directly measuring health (not to speak of happiness), longevity is still the best proxy of health and possibly even telling of emotional conditions. On a societal level the mortality crisis in Eastern Europe, for instance, clearly reflects a social, economic, environmental and psychological crisis.

Basic education as an indicator of empowerment also has an individual and a societal component. On the individual level, reading and writing skills are basic prerequisites for almost every kind of professional advancement and improvement of living conditions. It is also important for securing one's basic entitlements. Not being able to read and write in most societies means being excluded from progress, and carries the danger of being further dis-empowered. Especially for the empowerment of women in society and in her family, basic education is the key variable.

On the level of society it makes a big difference whether educational budgets are spent towards achieving universal primary education or for the higher education of small elites, while large proportions of the population remain illiterate. Historical analysis shows that countries that worked towards universal basic education do significantly better in several aspects ranging from population stabilization to economic development and social equity. More generally, human capital--of which education is the most essential ingredient--seems to be by far the most important factor of economic development in the long run. A view to the historical developments of European countries over the last century shows that some initially very backward countries without any significant natural resources or financial capital (such as Finland) made it to the very top simply by pushing for education and achieving near to universal literacy as early as the beginning of the century, by-passing other central and southern European countries that originally had much more sophisticated cultures and significantly more physical and financial capital. In short, literacy not only shows the current level of social development, it also characterizes a country's potential for future development.

The calculation of LLE requires empirical data on age-specific mortality rates and age-specific proportions literate, which are both readily available from PEDA. The calculation of LLE follows the regular life table method that is used to calculate the mortality-based life expectancy, adding only that the number of person-years at each age is weighted with the age-specific proportion literate. Literate Life Expectancy is always somewhat lower than regular life expectancy because early childhood is always an illiterate state. Since data on literacy of children varies for different PEDA applications, here literacy starts only at age 15. The data given on LLE do still refer to life expectancy at birth, considering child mortality, but do not count the years some children may be literate before age 15.

In PEDA, time series of LLE for the country and scenario under consideration are a standard output feature in the presentation of results segment. Together with the total proportion food insecure LLE may be used as a major criterion to see whether one calculated development path should be considered preferable to another one. In fact this additional indicator is a very necessary complement to the proportion food insecure, which taken alone may be very misleading. There can be scenarios in which the food insecure population declines due to very high mortality (e.g. through epidemics). This clearly is not a desirable scenario, although this would not be apparent if one only looks at the food insecure population or even the proportion food insecure. LLE in this case would clearly reveal the dramatic deterioration in quality of life.

Box 0-1: a methodological note on the calculation of life expectancy

Necessary input data: Age specific mortality rates (m_x)
Age specific proportions literate (PL_x)

Method: In a regular life table, the L_x column (total number of person-years lived in age group x) is multiplied by PL_x to generate the LL_x column (literate person-years lived). Like in a regular life table, literate life expectancy (Le^0_x) is then obtained by dividing the cumulative literate person-years (LT_x) by the l_x column.
Example: LLE of rural men in Egypt, 1986.

	Regular Life Table				Literate Life Table			
Age	m_x	l_x	L_x	e^0_x	PL_x	LL_x	LT_x	Le^0_x
<1	1.041	100.000	93340	58.60	0.00	0	2382889	23.8
4	.081	90.105	353413	64.00	0.00	0	2382889	26.4
5-9	.017	87.232	434130	62.06	0.42	183203	2382889	27.3
10-14	.010	86.494	431434	57.57	0.84	364130	2199686	25.4
15-19	.012	86.062	429077	52.84	0.68	290485	1835556	21.3
20-24	.017	85.548	426000	48.15	0.78	333558	1545071	18.1
25-29	.021	84.824	421991	43.54	0.48	202978	1211513	14.3
30-34	.027	83.938	416986	38.97	0.48	200570	1008535	12.0
35-39	.032	82.812	410905	34.46	0.38	156966	807964	9.8
40-44	.035	81.498	404094	29.98	0.38	154364	650999	8.0
45-49	.069	80.084	393900	25.46	0.30	118170	496635	6.2
50-54	.121	77.368	375934	21.26	0.30	112780	378465	4.9
55-59	.240	72.824	344335	17.43	0.25	85051	265684	3.6
60-64	.252	64.580	304529	14.32	0.25	75219	180633	2.8
65-69	.572	56.925	250441	10.89	0.20	50088	105415	1.9
70-74	.682	42.681	183565	8.66	0.20	36713	55327	1.3
75+	1.625	30.247	186136	6.15	0.10	18614	18614	0.6

4. Structure of the software and underlying data bases and spreadsheets

4.1 Introduction

The PEDA model is developed for a windows environment and written in Visual Basic. Both the input and outputs are stored in Microsoft Access databases and the calculations are carried out in Microsoft Excel. When running the PEDA software, the user is not immediately aware of the manipulations of databases and data in spreadsheets. The interface or shell acts as a buffer between the commands (e.g. read a previously defined scenario X for country Z) and the operations that are carried out in the background (e.g. open the database with scenario X for country Z, load the information into Excel and display the values of the scenario variables in the user interface). This, however implies that the professional version of Microsoft Office has to be installed on the computer where one wants to run the PEDA model (***see installation procedure and system requirements for more details***).

The first prototypes of the software consisted of a package wherein the mathematical model, country data and scenario assumptions were integrated. Although this had been a viable option for testing the main model assumptions, the design turned out to be inflexible when applying the model to multiple countries or use different sets of baseline data for one country as each of them would result in a different application. The original approach also complicated the task of implementing adjustments in the mathematical model to the different applications as they had to be carried out as many times as there were applications. To cope with the potential inconveniencies as the applications of PEDA to different countries expand, the mathematical model has been separated from a number of databases containing the country data and scenario assumptions. In v1.0 of the PEDA model, there is only one version of the software containing the main user interface and the mathematical definition of the model. From within that interface, the user can choose between already initialized countries to carry out projections or to see the results of already carried out simulations.

The following sections of this technical manual contain a presentation and description of the databases and spreadsheets whereupon the PEDA model relies. It is not so much dealing with the user interface, but it is explaining what happens behind that interface. Hence, what follows will be much more of interest to those that want to go further than carrying out projections with already existing data or make use of non standardized output features. This may be the case during the process of initializing the model for a new country or when, for example, the elasticities of some of the assumed effects want to be changed, or what may be most commonly the case, when a user wants to generate output that is not by default provided by the software. In these explanations we assume that the model has been installed on the computer. For installation instructions and guidelines to use PEDA to carry out simulations, we refer the reader to the **PEDA User's Manual**.

4.2 The structure of the application and databases

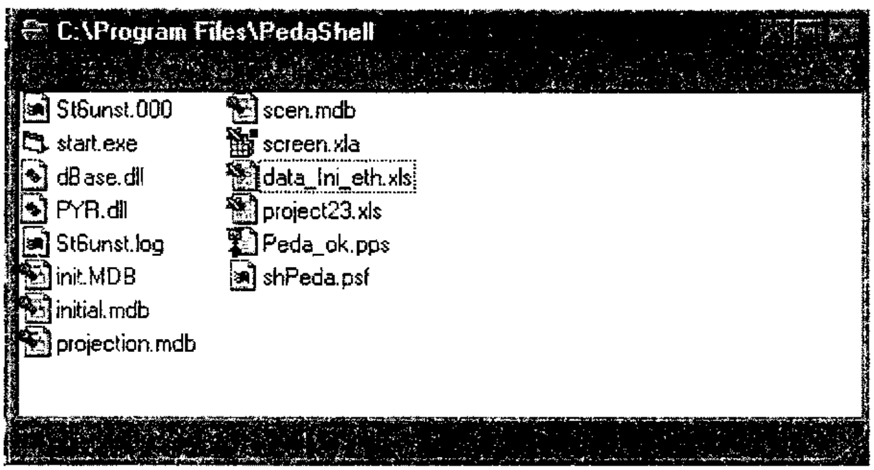
There are basically three distinct operations a user may want to carry out with PEDA. The first and most sizable task is to initialise the model for a new country. Further, the user may probably want to carry out simulations and eventually see the results of these projections. The PEDA application is built around these three distinct logical steps and this is also reflected in the

structure of the databases underlying the user interface. The management of these databases is usually carried out in the background: for each particular task or command, the PEDA application opens the relevant database, selects the appropriate information from within that database, loads it into Microsoft Excel which takes over to carry out calculations if required, or, displays the requested information in the user interface. If the command includes performing calculations, the results are later again stored in the appropriate database. The structure of the Excel spreadsheets wherein the calculations are carried out will be discussed in section ****. First we'll describe the database files and how they are used in PEDA. Users wanting to manipulate any of the information stored in these databases without passing through the PEDA user interface, should be sufficiently familiar with Microsoft Access and the PEDA model as a whole to do so.

4.2.1 Four databases

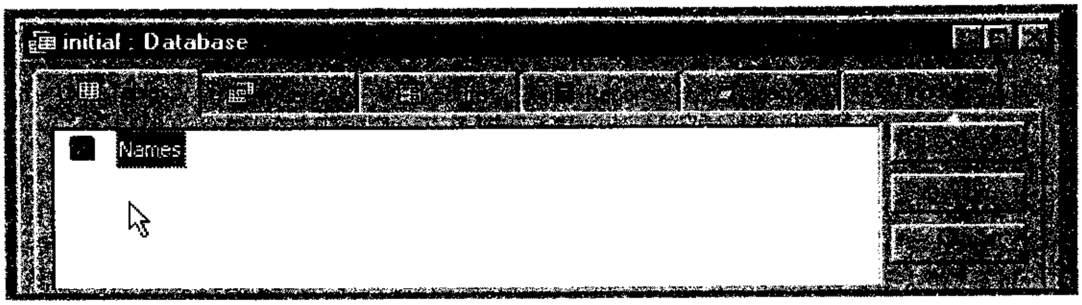
Each installed version of the PEDA model relies on four database files (Microsoft Access files in this case). These files can be found in the PEDA programme folder (Figure 0-1) on the hard drive. By default the PEDA program folder is located in 'c:\Program Files\'.

Figure 0-1: screen shot of the PEDA program folder (draft)



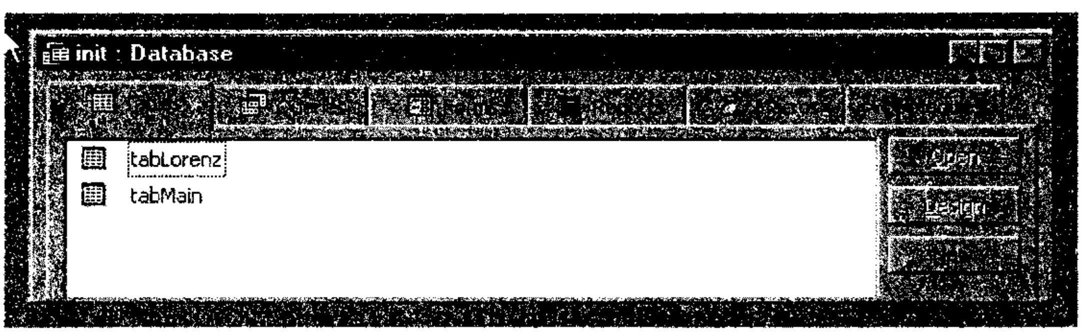
The files 'initial.mdb' and 'init.mdb' contain information on the status of the initialization of the PEDA model for a particular country and the baseline data for already initialized countries. Although the initialization of the model will be dealth with in detail in chapter ***, some comments on the content of these databases may be useful at this stage. The database 'initial.mbd' contains only one table 'Names' and keeps track of the countries which are already initialized and which not, together with fields presenting standard UN and World Bank codes for the countries in question. This table should not be manipulated manually.

Figure 0-2: the 'Initial.mbd' databa



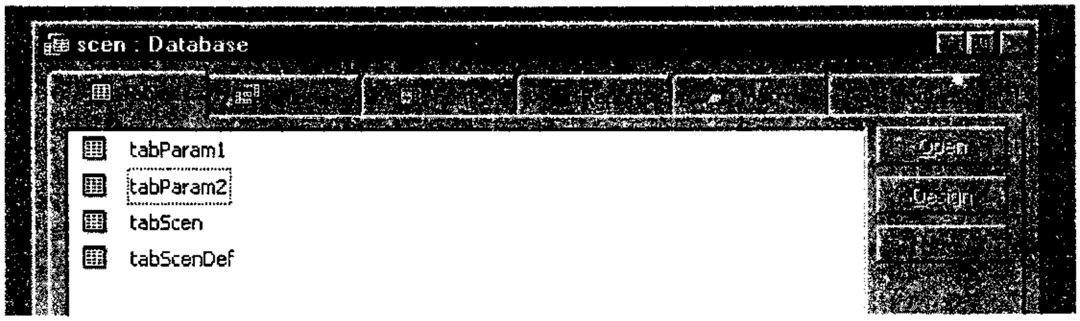
The 'init.mdb' file (Figure 0-3) contains the baseline data for all the initialized countries. These baseline data are made up of the year to which the data apply (i.e. the starting year in the projections); the population by age and sex; age and sex specific mortality schedules; age specific fertility rates and age and sex specific transition rates from the illiterate to the literate status. All this information is defined for each of the eight different subgroups in the population separately. These demographic baseline characteristics are stored in the table 'tabMain'. The other table in the 'init.mdb' database 'tabLorenz' contains the food distribution function for the rural areas and the urban areas separately. Note that this is the only information that is not changeable for a particular initialized country. All the other information (e.g. the elasticities of the agricultural production function, the curve defining the relationship between water availability and agricultural production, etc.) is stored as part of the scenario definitions. This has the advantage that the user can for example make different assumptions regarding the elasticities of the agricultural production function, store these as different scenarios for the same country and compare the results directly. On the other hand, all the information in the 'init.mdb' database cannot be changed once the country has been initialized. Therefore different assumptions regarding the food distribution function for example will eventually lead different to two different initializations for one country.

Figure 0-3: the 'init.mbd' database



With the exception of the process of initialization, the content of the 'init.mdb' and 'initial.mdb' databases does not change. The information in these databases is used by the application whenever a user selects a country to define new scenarios and carry out projections.
The scenario database ('scen.mdb') contains al the user defined scenarios for all initialized countries. This database consists of four tables (Figure 0-4) and most of the information stored here has been specified by the user in the PEDA application interface. This database gradually expands as the user specifies more scenario's. The PEDA software will be distributed with at least one (baseline) scenario for each of the initialized countries.

Figure 0-4: the scenario database ('scen.mdb')



In the scenario database, the table 'tabScenDef' keeps track of all the scenarios that have been defined for the initialized countries with their description. For each scenario and each country, the table 'tabParam1' stores the scenario assumptions regarding fertility, mortality and education. A screenshot of the content of that table is shown in Figure 0-5. The second column identifies the country and the third column the scenario name. In the third column the name of the indicator is given and the fourth column further specifies that indicator. Usually whether it is applicable to females or to males. From the fifth column onwards the values of the different variables are given for each of the eight subgroups in the population. These values are only applicable to this particular scenario and were originally read from the values that the user entered in the PEDA application interface.

Figure 0-5: the tabParam1 table in the scenario database

Nr	Country	scen	ind0	ind1	st1	st2	st3	st4
1	BWA	baseline	Popr	f				
2	BWA	baseline	Popr	m				
3	BWA	baseline	C-T	tfr	5	5	6	5
4	BWA	baseline	C-T	k	0.534164172	0.534164172	0.534164172	0.534164172
5	BWA	baseline	C-T	a0	12.68725739	12.68725739	12.68725739	12.68725739
6	BWA	baseline	C-T	m	0.244025585	0.244025585	0.244025585	0.244025585
7	BWA	baseline	e0	f	50	42	49	43
8	BWA	baseline	e0	m	48	40	47	41
9	BWA	baseline						
10	BWA	baseline						
11	BWA	baseline						
12	BWA	baseline						
13	BWA	baseline	Education	f	0.18	0.17	0.33	0.33
14	BWA	baseline	Education	m	0.25	0.25	0.33	0.33
15	BWA	baseline						
16	BWA	baseline	Year_e0_0	f+m	1991	1991	1991	1991
17	BWA	baseline	Year_e0_1	f+m	2021	2021	2021	2021
18	BWA	baseline	Year_e0_2	f+m	2041	2041	2041	2041
19	BWA	baseline	Year_e0_3	f+m	2051	2051	2051	2051
20	BWA	baseline	e0_0	f	70	59	49	57
21	BWA	baseline	e0_1	f	71	60	50	58
22	BWA	baseline	e0_2	f	72	61	51	59
23	BWA	baseline	e0_3	f	73	62	52	60
24	BWA	baseline	e0_0	m	68	57	47	55
25	BWA	baseline	e0_1	m	69	58	48	56
26	BWA	baseline	e0_2	m	70	59	49	57
27	BWA	baseline	e0_3	m	71	60	50	58
28	BWA	baseline	Year_TFR_0	f	1991	1991	1991	1991
29	BWA	baseline	Year_TFR_1	f	2021	2021	2021	2021
30	BWA	baseline	Year_TFR_2	f	2041	2041	2041	2041
31	BWA	baseline	Year_TFR_3	f	2051	2051	2051	2051
32	BWA	baseline	TFR_0	f	5	5	6	5
33	BWA	baseline	TFR_1	f	4.5	4.5	5.5	4.5
34	BWA	baseline	TFR_2	f	4	4	5	4
35	BWA	baseline	TFR_3	f	3.5	3.5	4.5	3.5

The table 'tabParam2' contains another set of important parameters. Unlike those in the 'tabParam1' they are not applicable to each of the eight subgroups separately, but to the country as a whole. These indicators are summarized in Figure 0-2 and are mostly self explanatory. Most of these indicators can be set as scenario variables, however some of them do not appear in the user interface and if they want to be change they need to be changed in the Excel spreadsheets (cfr. infra). It is better not to change the value of any of the indicators in the databases.

Figure 0-6: the 'tabParam2' table in the scenario database

Country	scen	IndFull	IndShort	Value
BWA	baseline	Initial year	Initial_year	1991
BWA	baseline	Proportion of females born	prF	0.487805
BWA	baseline	Projection year	Projection_year	2090
BWA	baseline	Minimal consumption of Ckal	minKcal	1900
BWA	baseline	Initial production of Kcal	initialKcal	2200
BWA	baseline	Auxilary	AX1	0
BWA	baseline	Auxilary	AX2	0
BWA	baseline	Auxilary	AX3	0
BWA	baseline	Labor	Labor	0.534
BWA	baseline	Land	Land	0.088
BWA	baseline	Fertilizer	Fertilizer	0.162
BWA	baseline	Machinery	Machinery	0.072
BWA	baseline	General education	GE+PAR	0.276
BWA	baseline	Technical education	TE_PAR	0.158
BWA	baseline	Auxilary	AX4	0
BWA	baseline	Auxilary	AX5	0
BWA	baseline	Auxilary	AX6	0
BWA	baseline	Auxilary	AX7	0
BWA	baseline	Gross migration rate	GMR	0.2
BWA	baseline	Land recoverey	a	0.02
BWA	baseline	Land degradation param.	g	0.02
BWA	baseline		n	1.00
BWA	baseline	Natural resources upper limit	R	1.50
BWA	baseline	Water Impact Factor	WI	1
BWA	baseline	Reservoir Capacity Effect	RCE	1

Among the indicators or variables that are do not appear in the PEDA user interface are the proportion of the females born (the fraction of each birth cohort that is female), the elasticities of the agricultural production function, and a number of parameters of the land and water modules. See the respective sections on land and water for a detailed description of these parameters (see 2.3). For each scenario there are a number of auxiliary indicators. This is space reserved in the database in case future revisions of the model require the inclusion of new variables.

The table 'tabScen' (Figure 0-7) contains the values applying to the scenario variables of the agricultural production, the availability of food in general and the HIV/AIDS morbidity rates. Just as the variables or parameters in the 'tabParam2', these variables are defined at the level of the country (thus not for each of the eight subgroups in the population separately), but unlike the parameters in the 'tabParam2' table, these are dynamic parameters. Different values can be assumed for different years throughout the projection period.

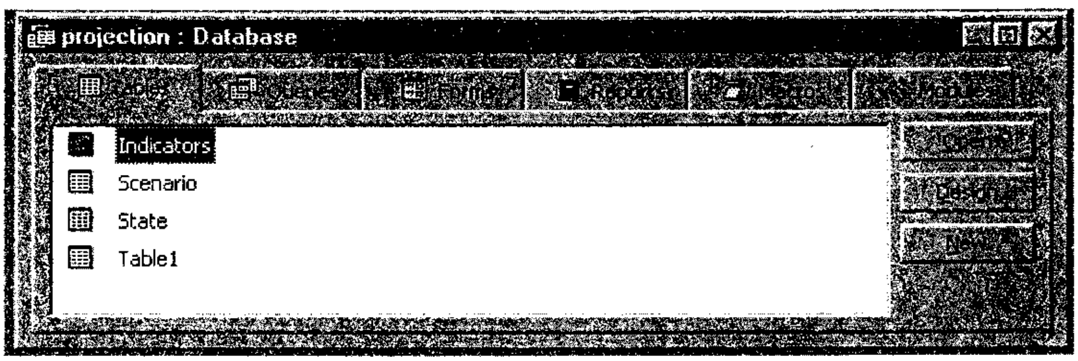
Figure 0-7: the 'tabScen' table in the scenario database

Country	Scen	Ind	y1	y2	y3	y4	y5	y6	y7	y8	y9	y10	y11
BWA	baseline	year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
BWA	baseline	LT	0	0	0	0	0	0	0	0	0	0	0
BWA	baseline	FIE	1	1.01	1.0201	1.030301	1.040604	1.05101	1.06152	1.072135	1.082857	1.093685	1.104622
BWA	baseline	UB	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BWA	baseline	HIV	[illegible]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
BWA	baseline	F	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BWA	baseline	M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BWA	baseline	TE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BWA	baseline	W	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
BWA	baseline	IR	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70

The values for the variables stored in this table are the loss of food in the harvest, transport and storage (LT); food imports and exports (FIE); the urban bias factor (UB); the HIV/AIDS morbidity rate (HIV); fertilizer use in agriculture (F), machinery use in agriculture

(M); the technical education of the labour force (TE), climate (W); and irrigation (IR). With the exception of HIV/AIDS morbidity rates, climate and irrigation, these variables are treated as indexes having value 1 for the starting year. Other factors that affect the availability of food but are endogenously determined by the model (e.g. the size and literacy of the labour force) cannot be found in this table as their values are not the result of scenario assumptions.
The projection database ('projection.mdb', Figure 0-8) stores all projection results. It consists of four tables. In the projection database, the 'indicators' table only contains a list of the indicators that are part of the standardized output modules in PEDA with their abbreviations. In that table, those indicators marked with a '*' are only available at the level of the country as a whole. The 'scenario' table keeps track of all scenarios for which simulations have been carried out and their description. It is different from the 'tabScenDef' in the scenario database in the sense that scenario will only appear here once the simulation for that particular scenario and country have been carried out and stored in the projection database. The table 'State' only contains a description of the eight different subgroups in the population and their abbreviation.

Figure 0-8: the projection database



'Table1' (Figure 0-9) is by far the most bulky table in this database and contains all the projection results for all scenarios and all countries. For each year in the projection period of each scenario and each country, there are currently about 116 records keeping track of the values of all possible output variables and if appropriate, for each of the eight subgroups in the population and 5 year age intervals. Although projections in PEDA are carried out by single years of age, the results are only stored by 5-year age intervals.

This will be the database table that users will most commonly refer to. It is particularly useful in the case the user wants to present the results of projection in another format than the ones predefined in the PEDA application. This may for example be the case when one age-specific time series. It is fairly easy to extract that information for this table using standard database query techniques.

Figure 0-9 gives a fragment of the 'Table1' in the scenario database. From the rows labeled 54 to 63 it gives the population (both sexes) in each of the eight different states for the age groups 55 to 100 for the year 2010 for a scenario called 'mali1'. The next line gives the expected number of births for the year 2010 under the scenario assumptions specified in 'mali1', etc.

Figure 0-9: Table1 in the scenario database

54	MLI	popr	mali1	2010	t	55	27817.0982437	13781.5942472	17436.562693	9342.921
55	MLI	popr	mali1	2010	t	60	27760.5322739	14096.8885179	17628.5909993	9562.676
56	MLI	popr	mali1	2010	t	65	28035.1302679	14531.8890149	17497.9042811	9544.92
57	MLI	popr	mali1	2010	t	70	24299.5809714	12747.9729850	17684.0617680	9657.069
58	MLI	popr	mali1	2010	t	75	15889.2780047	8304.36880038	10481.0253395	5724.847
59	MLI	popr	mali1	2010	t	80	7478.00181620	3684.55768437	4484.34037474	2464.883
60	MLI	popr	mali1	2010	t	85	2147.33766319	1122.02207493	1562.80762561	870.5954
61	MLI	popr	mali1	2010	t	90	372.750926558	199.437249908	345.851846294	196.9281
62	MLI	popr	mali1	2010	t	95	0	0	0	
63	MLI	popr	mali1	2010	t	100	0	0	0	
64	MLI	birth	mali1	2010	f	tot	58730.2088709	38524.7128537	106341.726988	51174.61
65	MLI	ptotr	mali1	2010	f	tot	673945.504926	353222.224531	1279704.10363	719841.0
66	MLI	ptotr	mali1	2010	m	tot	696116.126649	358806.250634	1378477.06229	730503.7
67	MLI	ptotr	mali1	2010	t	tot	1370061.63157	712028.475165	2658181.16591	1450344
68	MLI	tfr	mali1	2010	f	tot	4.2	5	6	

4.2.2 The integration of the databases in the PEDA application

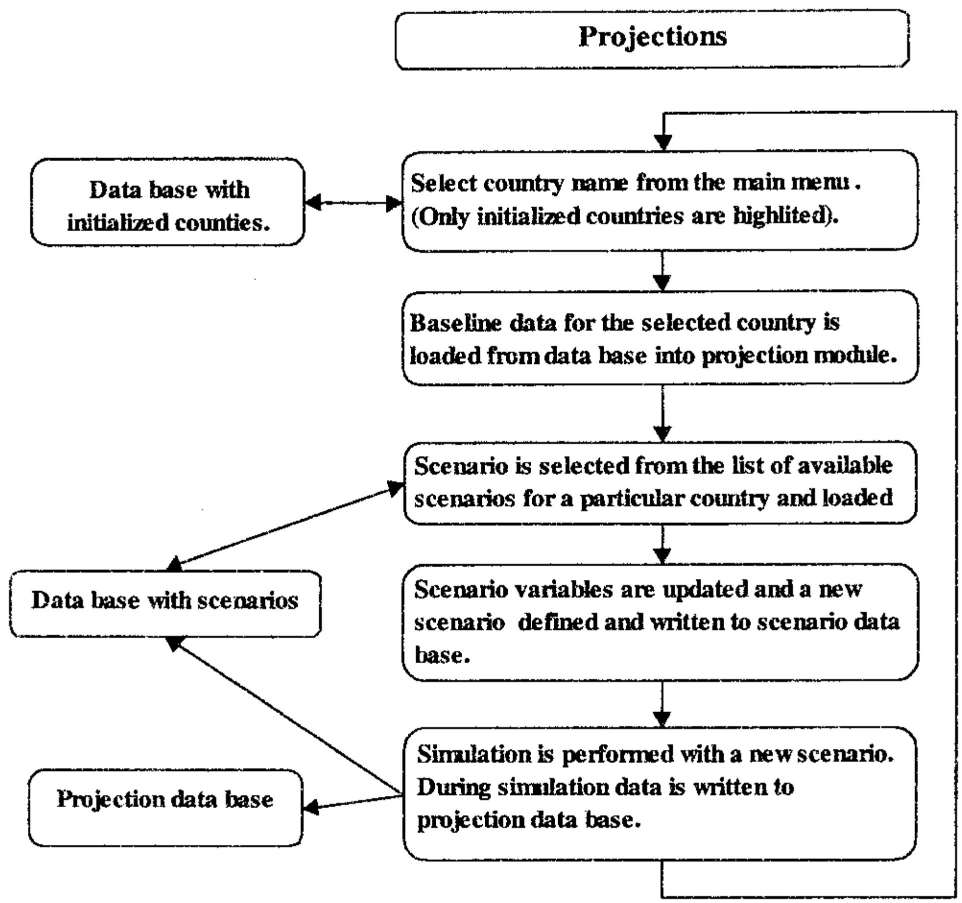
In making projections

To carry out projections, the user first has to select a country from the main menu of the PEDA application. Only if the country has already been initialized it appears in the list. Once a country is selected, the corresponding data and model parameters are loaded from the database into the model or spreadsheet. After the baseline data have been loaded, the user selects a scenario for this particular country. At least one scenario exists for each initialized country. By default this is called the baseline scenario.

Once a scenario is selected and loaded into the model the user may begin working with the model. From here onwards the user may want to change some of the parameters of the scenario that has been loaded, or he may want to carry out projections with the loaded scenario In any case a scenario that has been changed needs to be saved before simulations can be carried out. Once simulations are performed the results are stored in the projection database. It is not required that each scenario that is stored in a scenario data base has the output parameters stored in the projection data base. Scenarios may be made in advance and stored in a scenario data base which also takes much less space than storing the full set of resulting data in the projection data base. But if desired the results can be replicated later by applying a given stored scenario to the baseline data.

The operations involved in carrying out projections are given in Figure 0-10. It may seem as if many operations are involved, but most of it is carried out behind the user interface and can be done in a few mouse clicks.

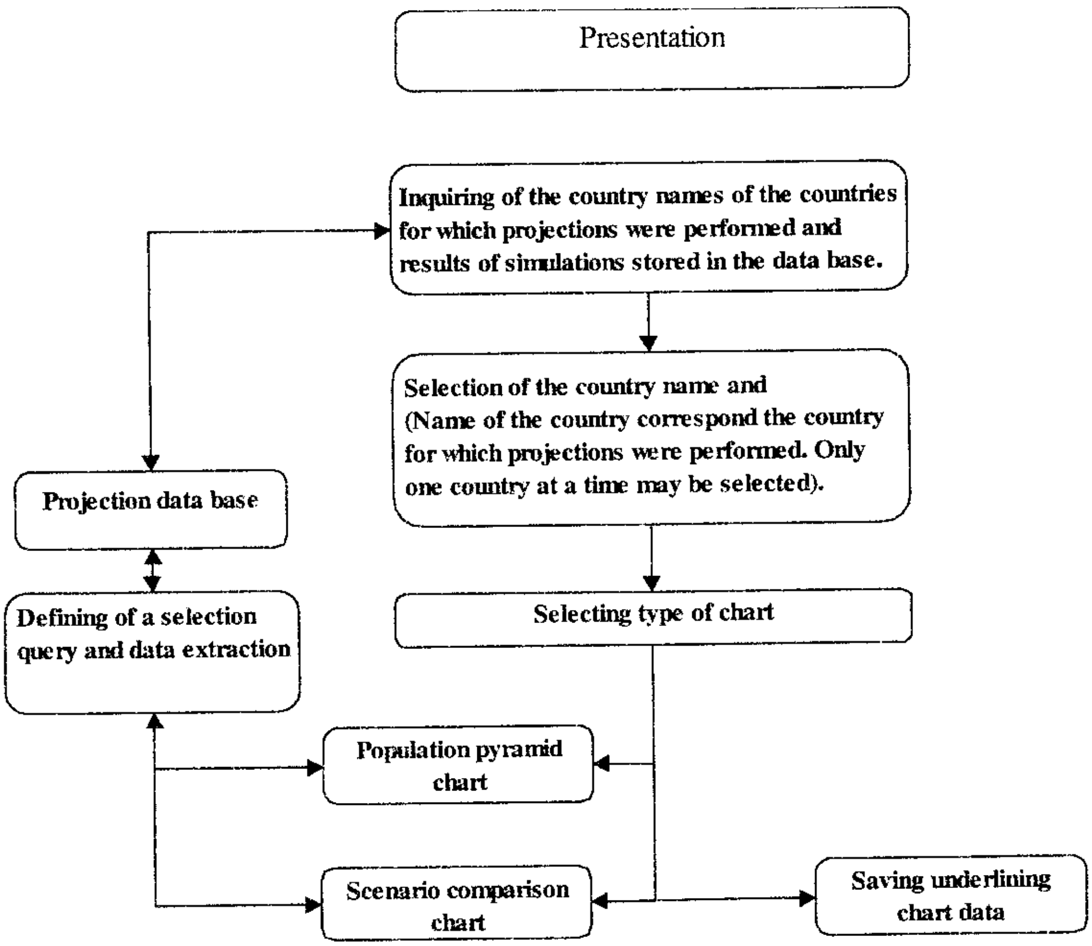
Figure 0-10: schematic overview of the steps involved in carrying out projections



After the simulation has been performed the user may want to repeat the whole process for another country or another scenario.

In presenting the results

There are three ways in which the user can obtain the data from the projections. Of course, this can only be done for countries that have already been initialized and for scenarios for which the projections have been carried out. The first option for the user is to make use of the standard output features of the PEDA application. The latter contain population pyramids and time series. The tables for these charts can be saved from within the PEDA application into Excel format to be reworked later. The third option is to extract data for the Access databases using queries. As mentioned earlier, this will be most useful to chart characteristics for different age groups.



In managing the information

In order to be able to maintain a well-structured and up to date data base, it will be necessary to delete data for particular scenarios and/or countries from the projection data base from time to time. Similarly data can also be deleted from the scenario database. Since all databases are MS Access databases these procedures could be easily performed directly from MS Access. After the deletion of scenarios or projection results the databases could compacted in order to reclaim the space that corresponds to deleted data. This can be also achieved by standard Access tools.

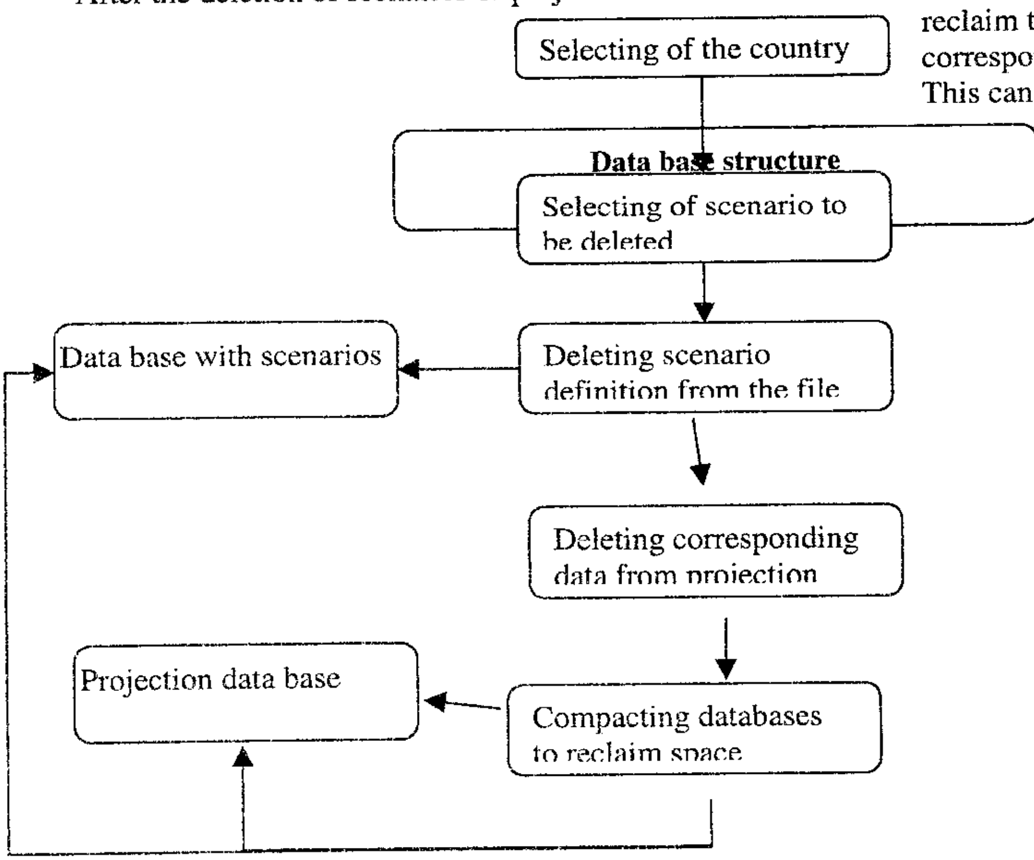


Diagram 3: The Data Base Segment

4.3 The Excel spreadsheets

The projections and calculations are always carried out in Excel spreadsheets. Just as is the case for the operations with the different databases, this is usually not directly visible to the user of the model but happens behind the user interface. In most cases, a user will not need to go into these spreadsheets to manipulate information or define scenarios. However, a good knowledge of these spreadsheets may enable the user to change some of the more advanced parameter settings if required. In the following paragraphs, the content of the different Excel spreadsheets will be discussed with indications where the user can intervene and adjust parameter settings. Again, the user should be sufficiently familiar with the PEDA model and Excel to do so.

When carrying out projections for a particular country, first the initial data for that particular country are loaded into the Excel spreadsheets as well as the variable and parameter settings of the baseline scenario. Only then, it makes sense for the user to view and adjust some of the information in the Excel spreadsheets. To do so, first click on the 'Simulation' button in the main PEDA application window after having selected a country. Once the Simulation/Parameter settings window is open, press the <ctrl> <shift> and <R> keys simultaneously. This action resets the main workbook and allows the user to go directly to the PEDA projections workbook for viewing and editing. If settings want to be changed for another scenario than the baseline scenario, this scenario needs to be loaded first (through clicking on the 'Read predefined scenario').

The workbook consists of 17 spreadsheets. The simulation window in the PEDA application is one of them and is active after pressing the <ctrl> <shift> and <R> keys simultaneously. This worksheet is called 'Main'. By clicking on the tabs at the bottom of the screen, the user can switch from one worksheet to the other (see Figure 0-11).

Figure 0-11: the different worksheets in the PEDA projections workbook

Hereunder a description is given of each of the 17 worksheets with indications where information may be changed. Whenever information has been changed in any of these worksheets, the user MUST return to the 'Main' worksheet (the one selected in Figure 0-11) and click on the 'save scenario' button to save the changes made under a different scenario name. In the tables describing the worksheets, those ranges than MAY NOT be changed by the user in any case are labeled with a ' ! '; those ranges that contain information that can ONLY be changed in the worksheets and not through the PEDA user interface are labeled with ' * '; ranges that contain information that can both be changed through the user interface and in the spreadsheets are not labeled. To avoid problems it is preferable to change the information through the user interface wherever possible. Wherever ranges with are not mentioned in the description that follows, they should not be touched in any case.

Some of the worksheets where changes are allowed are protected. To unprotect a worksheet, choose the 'Protection -> Unprotect sheet ...' command from the 'Tools' menu.

4.3.1 The 'Params' worksheet

This worksheet contains some major scenario parameters, including fertility and mortality assumptions, the food distribution function and the water saturation function.

Table 0-1: the content of the 'Params' worksheet

Range	Description	
B1:D1	The message displayed in the Simulation/Parameter settings window in the PEDA application interface	
D5:M12		[illegible]
D17:M39	Scenario settings for educational transition rates and the dynamic settings for fertility and mortality for each of the eight subgroups	
A48:CX52	The definition of the food distribution curve for rural and urban areas separately	*
AO23:AR30	The definition of the water saturation function for the calculation EWM	*
Y7:AA16	Definition of the names of the subpopulations	
AH7:AI16	Description of the dynamic scenario variables and their abbreviations	
AO4:AW17	Information used in the definition of the graphs	!

4.3.2 The 'Params1' worksheet

This worksheet contains some important model and scenario parameters, including the elasticity of the production function, parameters for the land and water modules and HIV/AIDS related mortality schedules

Table 0-2: the content of the 'Params1' worksheet

Range	Description	
E4:G4	The initial year of the projections. This is the year to which the baseline data apply and is defined as part of initializing the model for a new country.	!
E5:G5	The proportion of females born. This parameter refers to the sex ratio at birth. As it can change a little between countries a value can be specified here. This is the only place where this parameter can be adjusted.	*
E6:G8 & E22:G22	Parameter values for some of the general model settings, including the assumptions regarding rural-urban migration, the amount of daily per capita calories produced in the initial year, the minimum per daily per capita food requirements, etc. All of these values can be changed through the user interface.	
E9:G12 & E18:G21	Ranges not used in the current version of the PEDA model. This is space foreseen would future version of PEDA require the inclusion of new variables.	!
E23:G26	Parameters of the land module. Of these only the land degradation impact factor can be changed through the user interface. (g stands for gamma, n for eta and R for Rbar, See section 0) for their full description).	*
E27:G28	Two parameters of the water module. See section 0 for their full description).	*
L3:W105	Definition of the age specific additional mortality rates (m_x) depending on the HIV/AIDS morbidity rates	*

4.3.3 The 'SetScen' worksheet

This worksheet contains the definition of the user interface for the setting the dynamic scenario variables. It should not be changed.

4.3.4 The 'NDScen' worksheet

In this worksheet the values for the dynamic scenario variables are stored. It is recommended to change these values through the user interface. However, as the user interface only allows

assumptions to be made by five year periods or a gradual annual increase or decrease, the user can define in this worksheets scenario assumptions with a precision of one year.

Table 0-3: the content of the 'NDScen' worksheet

Range	Description	
D6:DE15	Definition of the values of the dynamic scenario variables	*
All other ranges	All other ranges on this worksheet are used for calculating purposes and should not be touched	!

4.3.5 The 'DistribF' worksheet

In this spreadsheet, most calculations are carried out concerning the food production and the calculation of the food secure and food insecure fraction of the population.

Table 0-4 : the content of the 'DistribF' worksheet

Range	Description	
F2:C9	Elasticities of the food production function. They cannot be changed here. (see section 0)	!
A11:DC26	Range wherein the food production is calculated for the whole projection period. Different assumptions can be made in this range regarding the variables that affect food production (e.g. the endogenous feed back of HGIV/AIDS morbidity on the labour force input into the agricultural production function). Only users that are very well acquainted with PEDA should engage in making changes in this range.	*
A33: DD152	Range used for calculation the population per sub group for each year in the projection period. No changes should be made.	!

4.3.6 The 'St1' through 'St8' and 'Total' spreadsheets

These spreadsheets are used for the calculation of the population by age and sex for each of the eight different subgroups in the population. In the 'Total' spreadsheet, the same is done for the country as a whole. No changes are allowed in these spreadsheets.

4.3.7 The 'IPop' spreadsheet

This worksheet contains the initial or baseline data for each country. These data are automatically read from the 'init.mdb' database that is updated with data for each country during the process of initialization. The information in these spreadsheets can nevertheless be changed here.

Table 0-5: the content of the 'Ipop' worksheet

Range	Description	
E8:L98	The total population by single years of age and subgroup, females	*
E130:L222	The total population by single years of age and subgroup, males	*
E254: L357	Age specific mortality rates by subgroup, females	*
E378: L481	Age specific mortality rates by subgroup, males	*
E502:L525	Age specific transition rates from illiterate to literate status, females	*
E527:L550	Age specific transition rates from illiterate to literate status, males	*
E556:L596	Age specific fertility rates	*
A5:C596	Auxiliary range used for performing calculations. No changes are allowed	!

4.3.8 The 'Main' worksheet

This is the worksheet that has to be activated if one wants to return to the PEDA application user interface. If any changes have been made in any of the worksheets; these can be saved ONLY by clicking on the save scenario button in this worksheet. Do not try to save the changes through the File/Save command as you would do in any other software package.

4.3.9 The 'Results' worksheet

This worksheet regroups the outputs of the projections before they are stored into the projections database. This worksheet is of little use to the user as it only contains temporary results of the projections for one year at the time (the values of the output variables for the last year of the projection period in the scenario under consideration). No changes are allowed in this worksheet.

5. Methodological support for the initialization of PEDA for new countries

5.1 Introduction

Since PEDA is a multisectoral model, the initialization of PEDA for a new country should ideally be done by a team of experts from various disciplines. An in depth initialization of the model for a particular country includes among others the preparation of the demographic baseline data, the estimation of the agricultural production function elasticities (if necessary, it may even entail the definition of a new agricultural production function), the estimation of the water saturation curve, the estimation of the land degradation and recovery parameters, the estimation of the food distribution curves, and even the inclusion of new variables that prove to be important in the population, environment, development and agriculture interactions for that particular country. However, there is a more minimalistic approach to the initialization of PEDA that is satisfactory if the PEDA model is to be used for advocacy purposes only. This approach entails the preparation of the demographic baseline data and the estimation of the food distribution curve. For all the other relationships, the model will then rely on the theoretical distributions as described in the previous sections of this manual. Here, you will find some guidelines in the preparation of these baseline data. These are only to be seen as possible steps to be followed as the data available for different country may come in different formats and may thus require different estimation techniques etc.

These baseline data contain all the necessary information to be fed into the 'init.mdb' database and are the technical minimum requirement to make PEDA operational for a new country. Although it is the minimum, it is not necessarily the end of the initialization process. Further improvements to the data and relationships can be gradually implemented as they become available. As mentioned before most of the other relationships and distributions are stored in databases as part of the scenarios and not as part of the initial data per se. If a country has already been initialized and a better empirical description of the water saturation function becomes available at a later stage, it can be easily added to PEDA to replace the current theoretical function and stored as part of the scenarios. The PEDA model thus allows for a gradual improvement of the data and the country applications.

The necessary baseline data include the distribution of the population by sex and single years of age for each of the eight subgroups in the population (states); the food distribution functions for urban and rural areas separately; fertility and mortality schedules for each of the eight states; and the age specific educational transition rates for the non literate states. Hereunder the different steps in the initialization process will be illustrated with data for Ethiopia. The preparation of the data is most likely to be done in Excel, and after all initial data are collected, they are fed into a small utility that comes with the PEDA model that automatically updates the databases.

5.2 The food distribution function

As we assume that all the citizens of a country do not have equal access to the available food in a country, a food distribution function has to be defined that reflects that inequality. This food distribution function is of crucial importance in the process of estimating the fraction of the population that is considered food secure and which proportion is food insecure. Adequate data

on such a food distribution functions do, however, not exist. The solution applied in PEDA is to use household expenditure curves that exist for a number of African countries. The model thus relies on the assumption that the inequality in the expenditure curve is equal to the inequality in the access to food. This relationship does not seem to be immediately obvious, but as we now that savings are relatively low in Africa, the step to assume that income equals expenditure is only a small one. What we are left with is the assumption that the inequality in the access to income is similar to the inequality in the access to food. The knowledge that income inequality is usually different in rural and urban areas is extended into PEDA through the use of two food distribution curves; one for rural areas and one for urban areas.

In our example of Ethiopia, no data are available on expenditures or income. Therefore, we used household expenditure data for Uganda as a proxy. These data are available from the World Bank[6]. The data give household expenditures in national currency from the poorest quintile to the richest. These figures include the value of own produce consumed. As we are thinking in terms of income or food distribution in PEDA, we will consider these figures to represent income from now on.

Table 0-1: preparation of the food distribution function

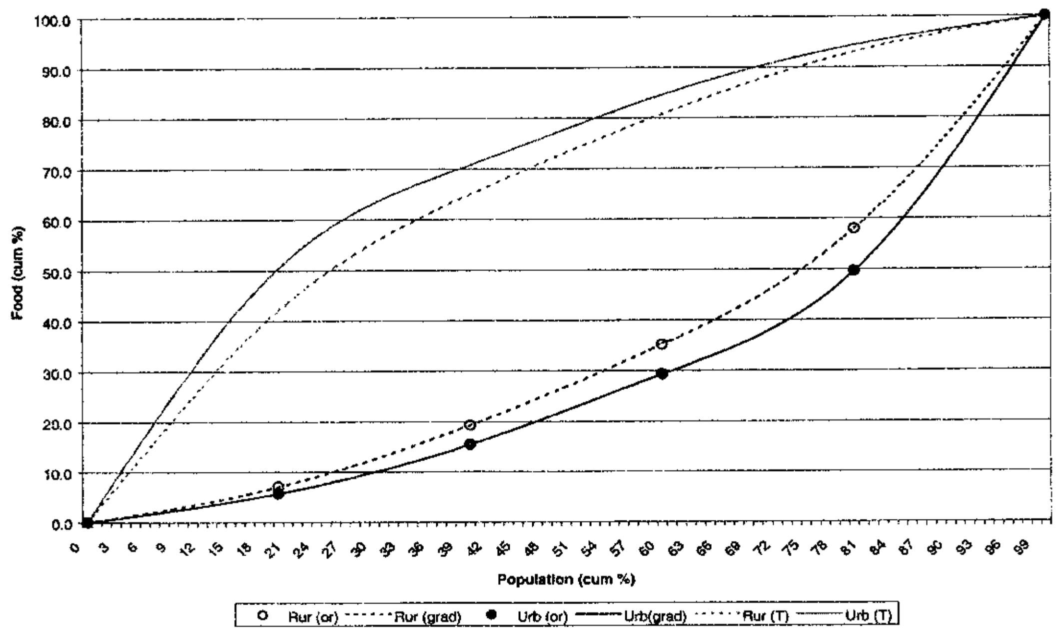
	Rural			Urban		
Pop quintile	Mean income	% of the total income	cum income	Mean income	% of the total income	cum income
			0.0			0
1	4	7.0	7.0	7	5.7	5.7
2	7	12.3	19.3	12	9.8	15.4
3	9	15.8	35.1	17	13.8	29.3
4	13	22.8	57.9	25	20.3	49.6
5	24	42.1	100.0	62	50.4	100.0
	57			123		

As we do not need national currency as a measurement unit but simply the relative share of each quintile in the total income, we first need to transform the actual income into fractions of the total income that is obtained by a particular quintile of the population. These fractions are then cumulated to obtain the total income available to the total population (in rural and urban areas separately). Read from the bottom to the top, it means that for the rural population 100 per cent of the income/food is available to 100 per cent of the population, and 58 per cent of the income/food is available to 80 per cent of the population. In this case, the richest 20 per cent of the rural population has already consumed 42 per cent of the food, leaving the rest for the less privileged. Similarly, 65 per cent of the food is consumed by the most privileged 40 per cent of the population, leaving the remaining 35 per cent of the food for the 60 least privileged per cent of the population. PEDA determines the fraction and number food insecure people in a subgroup on the basis of these food distribution curves and the amount of available food in a particular country and year. If the remaining amount of food per capita is not sufficient to fulfill minimum food requirements, the remaining fraction of the population is considered to be food insecure. To determine this we need two additional peaces of information; i.e. the available amount of total

[6] African Development Indicators

per capita food available in a country and the assumed minimum requirement. The FAO usually collects and publishes these data[7].

Figure 0-1: original data points, the graduated & and transposed food distribution curves for rural and urban areas, Ethiopia



The data, as given in Table 0-1 are, however, not sufficient as the PEDA model works with a precision of 1 percentage points. Both curves thus need to be graduated before they are of any use to PEDA. The graduation of these and similar curves can be done, using a variety of techniques. In this example we used Spline[8]. The result of the graduation is shown in Figure 0-1. The cumulative proportion of the population is given on the abscis ordered from least to most privileged, the cumulative share of the food on the Y-axis. The circles stand for the original data points, the dotted and full lines for the graduated curves. Before these Lorenz curves can be entered in PEDA, they curves need to be transposed so that the most privileged section of the population is situated towards the origin of the x-axis. In Figure 0-1, the transposed curves as they have to be entered in the PEDA model are indicated with (Rur (T) & and Urb (T)). To come back to our example, in the case of Ethiopia, the daily average per capita food supply in 1995 is to be situated around 1830 calories. With an assumed threshold value of 1500 kcal per capita, a proportional distribution of the available food between urban and rural areas and the food distribution curves as defined above, this results in a proportion of 53 per cent of the rural population being food insecure and 63 per cent of the urban population.

5.3 The age and sex distribution of the population for each of the eight states

PEDA relies on multi state demographic techniques whereby eight different subgroups in the population are projected at the same time while transitions from one group to the other at each step in the projection period are possible. The eight different states are defined on the basis of

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[7] A good source for these and similar data is http://www.africanutrition.net

[8] A small Excel application for Spline has been developed by S. Scherbov that simplifies this task (see Annex ***).

three dichotomous characteristics: rural/urban place of residence, literacy status and food security status. The eight states are:

st1: Urban, literate, food secure
st2: Urban, literate, food insecure
st3: Urban, illiterate, food secure
st4: Urban, illiterate, food insecure
st5: Rural, literate, food secure
st6: Rural, literate, food insecure
st7: Rural, illiterate, food secure
st8: Rural, illiterate, food insecure

For each of the eight states, a population distribution by single years of age (0-100) and sex needs to be defined. This information is usually not readily available from any document. A census report or UN publications are probably the best source to find population distributions by age, sex and often also urban rural place of residence. Sometimes these distributions are even given by singly years of ages, sometimes only in five year age groups. Be aware that the population distribution by single years of age reported in census monographs often concern the observed population and not necessarily the best to work with. Population projections require the mid year population and observed populations distributions are often subject to many errors such as age misreporting. Therefore it is preferable to use the population distributions at the mid year following the year of the census and tables giving the population distribution in five-year age groups and graduate them later to obtain the population distribution by single years of age. These corrected population distributions are usually reported in census monographs. The starting table would thus look like the one in Figure 0-2.

Figure 0-2: the population distribution for Ethiopia (1995) by age, sex and rural-urban place of residence

Pop by age sex and place of residence, July 1995 (CSA, 1999:302)

	Urban		Rural		
age-group	Male	Female	Male	Female	
0-4	435,140	415,519	4,087,055	3,980,497	
5-9	466,269	485,985	3,615,734	3,459,602	
10-14	486,684	540,154	3,138,687	2,951,401	
15-19	453,512	512,854	2,633,003	2,506,687	
20-24	392,116	443,216	2,049,295	2,058,120	
25-29	329,663	370,252	1,653,812	1,722,678	
30-34	252,162	278,391	1,291,759	1,422,906	
35-39	204,111	217,067	1,072,736	1,183,876	
40-44	167,350	161,023	929,828	970,159	
45-49	133,362	125,469	789,829	789,509	
50-54	98,783	98,739	657,738	614,389	
55-59	75,796	78,924	544,319	484,922	
60-64	57,417	64,182	439,758	374,701	
65-69	42,298	48,992	340,619	278,014	
70-74	28,972	34,270	244,639	188,808	
75-79	17,449	20,013	151,804	107,080	
80+	21,541	29,025	195,380	133,110	
total	3,662,625	3,924,075	23,835,995	23,226,459	**54,649,154**

Age, sex and rural-urban specific literacy rates can usually be obtained from census reports as well. One thus has to apply the proportions literate to each of the subgroups in Figure 0-2 to obtain the population by sex, age, literacy status and rural-urban place of residence. This gives us the distribution of four subgroups by (five year) age (groups) and sex.

These four subgroups or states still have to be split up by food security status to obtain the eight states required in PEDA. On this issue no data are available at all. The only information we have (estimated ourselves under section ***) is the proportion of food insecure people in urban areas and rural areas separately. It is then up to the user whether to apply these proportions to both states of literacy, sex and age groups equally or not. As we do not have any empirical evidence of a potential unequal distribution of food insecurity over the population by sex, literacy status and age, earlier initializations of PEDA have only accounted for rural-urban differences in the food security status of the population. The proportions food secure and food insecure found under section 0 will thus be applied to both literate and illiterate states to obtain the eight states by sex and (five year) age (groups).

As PEDA carries out projections by single years of age and uses 100 age groups, these data need to be graduated. Again, Spline is an ideal technique to do so (see Annex ***).

5.4 Age and Sex specific mortality rates (m_x) for each of the eight states

In order to carry out the population projections, age and sex specific mortality rates need to be prepared for each of the eight states. As these are usually not available for each of the eight subgroups separately, they have to be estimated. The first step in such a procedure is to estimate life expectancies at birth (e_0) for each of the eight states by sex. Usually census reports give the value of e_0 for both sexes separately and by another characteristic such are rural urban place of residence or literacy status. In addition, census reports often present a table with differences in e_0 by a number of background characteristics that may also be of use in the process of estimation.

No standard techniques exist for such an estimation procedure. They are necessarily experimental in their nature.

In the case of Ethiopia e_0 is given for males and females by place of residence (CSA, 1999: 238). These are the four 'observed' and aggregated e_0's from which we will estimate the life expectancies for each of the eight states. Life expectancies for literates and illiterates in Ethiopia are only partly available from the census report (CSA, 1999: 242), and for food secure and food insecure they are not available at all. In estimating the life expectancy for food secure and food insecure, we for example assumed a deviation of two years from the national level e_0, These estimates are then to be turned into a multiplier effect of being in the category literate, illiterate, food secure and food insecure (see Figure 0-3). These multipliers are applied to the four observed values in the population to obtain the e_0 for the eight states by sex.

Observed					
				M	F
overall LE	50.7		Rural	48.8	51
			Urban	52.7	56
First guess			contribution of literacy		
literate	56		1.104536		
illiterate	49.7		0.980276		
			contribution of food security		
food secur	52.7		1.039448		
food insec	48.7		0.960552		
First guess of LE by sex and state					
				Fsecure	F insecure
male	rural	literate		56.0	51.8
		illiterate		49.7	46.0
	urban	literate		60.5	55.9
		illiterate		53.7	49.6
female	rural	literate		58.6	54.1
		illiterate		52.0	48.0
	urban	literate		64.3	59.4
		illiterate		57.1	52.7

Figure 0-3: illustration of the estimation of e_0 by state and sex

To obtain the e_0 for the rural, literate and food secure males; we thus multiplied the cells F8 by E12 by E15 in Figure 0-3. These are first estimates of the life expectancy at birth by sex for each of the eight states.

In the next step, the MATCH module of MORTPAK (UN, ******) can be used to generate age specific mortality rates based on the e_0 for each of the different subgroups. In the case of Ethiopia, we used the Coale-Demeney West model life table. As the PEDA works by single years of age, the output of Match needs to be graduated using UNABR; another module of MORTPAK. UNABR also gives Heligman Pollard parameters that can be used to extend these life tables to the age of 100 (PEDA works with 100 single year age groups). Another method of extending the life tables can be done through a linear transformation and regression. From here onwards, we could proceed to calculate the age specific m_x that are needed as part of the initial data. However, it is recommended to test the whether our estimates for the life expectancies for

each of the eight states by sex and the transformations carried out afterwards are still concordant with the aggregated values for e_0 as given in the census reports.

In the case of Ethiopia, we had four 'observed' values for e_0 (e_0 by sex and rural urban place of residence). Let's take for example the case of urban females. Their 'observed' e_0 was 56 and starting from this value, we estimated the values for the urban females by literacy and food security status. If we build life tables around the four nested subgroups of urban females (starting from q_x we obtained as an output of UNABR and the population by age, sex and state that was obtained following the procedures in section 0), we can estimate the number of age specific deaths in each subgroup. The population and age specific deaths can be summed up to obtain the aggregated population and age specific deaths for the urban females. These two columns can be used as the basis of a new life table to calculate the aggregated life expectancy for the urban females (Figure 0-4). If that value is close to the 'observed' value, the estimates are plausible. If the aggregated life expectancy is far from the 'observed' value, the estimation procedure as illustrated in Figure 0-3 needs to be repeated with different assumptions.

Figure 0-4: testing the plausibility of the estimated life expectancies through aggregation and comparison with the original value

alpha:	0							
female urban								
Px	Dx	mx	qx	l_x	d_x	LL_x	T_x	e_x
74897	7914	0.105663	0.1003607	100000	10036	94982	5543211	55.4
76948	2040	0.026518	0.02617071	89964	2354	88787	5448229	60.6
81052	1135	0.014005	0.01390722	87610	1218	87000	5359442	61.2
87207	780	0.008942	0.00890259	86391	769	86007	5272442	61.0
95415	600	0.00629	0.00626978	85622	537	85354	5186435	60.6
104186	492	0.004718	0.0047067	85085	400	84885	5101082	60.0

In figure Figure 0-4, the columns Px and Dx are the sum of the respective columns of the nested life tables for urban females. From these two columns a life table can be built to obtain an aggregated e_0 for urban females. In our case the value is 55.4, which is very close to the value of 56.0 as reported in the census monographs. This means that our estimates are plausible and that we can use the m_x values of the nested life tables as an input to PEDA. If desirable, it is fairly easy to adjust the nested m_x values proportionally, to obtain an aggregated value that precisely equals the observed e_0 of 56. In Excel one can do this through creating new m_x columns for each of the nested life tables that are equal to the old m_x column times (1+ alpha). This is illustrated in Figure 0-5.

Figure 0-5: the " * (1+alpha)" transformation of the m_x column for urban illiterate food secure females

Illiterate, Food Secure				
pop	Mx	mx*(1+alpha)	Dx	e_x
24716	0.08967	0.087297	2158	57.5
25393	0.02096	0.020396	518	61.7
26747	0.01107	0.010777	288	62.0
28778	0.00712	0.006932	199	61.7
31487	0.00505	0.004916	155	61.1
34381	0.00382	0.003719	128	60.4

The new m_x column has to be used as the one to build the life table of each of the nested groups and to calculate the aggregated number of age specific deaths etc. With the 'Goal seek' function in Excel it is easy to scale the mortality schedules of the nested subgroups proportionally up or down with the objective of obtaining the aggregated e_0 of 56 for urban females in this case. The new m_x values will then be the adjusted mortality schedules that are to be used as the part of the baseline data for Ethiopia. The new values for e_o also need to be introduced as those reflecting the situation in the initial year.

The example given here is to be repeated four times as we had four observed values for e_0 with each four nested values that must be estimated and subsequently tested through aggregation. If only two observed values exist for e_o the procedure needs to be repeated twice but for eight nested subpopulations.

5.5 Age specific fertility rates (ASFR) for each of the eight states

The procedures to follow in estimating age specific fertility rates for each of the eight states is analogue to the ones used in estimating age specific mortality rates. Starting from the observed fertility rates we estimate those for the nested subgroups. From the estimated fertility rates we work backward to calculate the aggregated fertility rates and control whether they are consistent with the observed/reported values.

In the case of Ethiopia the census report gives observed and adjusted fertility estimates by rural urban place of residence. As fertility is often underreported (e.g. through not reporting children that died), adjusted TFR's are to be used preferably. To obtain fertility estimates for each of the eight states, we have to estimate again ****. This process is illustrated in Figure 0-6.

Figure 0-6: illustration of the estimation of TFR by state

TFR from census report (CSA, 1999: 229)			**Estimated multipliers for literacy and food security**			**First estimates of TFR by state**	
	obs	adj					
country	4.3	6.74	multipl for illiteracy	1.023256		urban literate Food Secure	4.08
			multipl for literacy	0.906977		Urban Literate Food Insecure	4.09
rural	4.6	7.19				Urban Illiterate Food Secure	4.50
urban	2.8	4.5		urban	rural	Urban illiterate Food Insecure	4.60
			multipl for food sec	1	0.930233	Rural Literate Food Secure	6.07
illiterate	4.4		multipl for food insec	1	1.069767	Rural Literate Food Insecure	6.98
literate	3.9	?				Rural Illiterate Food Secure	6.84
						Rural Illiterate Food Insecure	7.87

6. Annex: A mathematical description of the demographic model

Demographic model is the most complicated part of the whole model. Population is divided by 16 states such as place of residence (rural, urban), food security state (food insecure, food secure), literacy state (illiterate, literate), sex (male, female). The model is discrete with discretization step by age and time equal to one year (population is treated by single year of age). The following assumptions were used to develop the demographic model.

- Population from Rural Food Insecure Illiterate group may have transition to Rural Food Secure Illiterate group, Rural Food Insecure, Literate group and Urban Food Insecure Illiterate group.

- Population of Rural Food Secure Illiterate group may have transition to Rural Food Insecure Illiterate group, Rural Food Secure, Literate group and Urban Food Secure Illiterate group.

- Population of Rural Food Insecure Literate group may have transition to Rural Food Secure Literate group and Urban Food Insecure Literate group.

- Population of Rural Food Secure Literate group may have transition to Rural Food Insecure Literate group and Urban Food Secure Literate group.

- Population from Urban states may migrate to Rural states (however the rest states should be the same, in other words multiple transitions are not allowed within 1 year simulation step). There is no migration to Rural place of residence).

- Children born in any group are considered to be illiterate (all their rest state indicators are the same as for the group of their parents).

- Transfers of people from Food Insecure state to Secure state and vise versa were made with taking into account unequally in distribution of food among people.

- The external emigration and immigration flows were not taken into account.

The common structure of the demographic model is presented on Pic.1 and Pic.2 (without external emigration and immigration components). In order to give mathematical description of the model let us introduce the following notations.

x,t – discrete age and time varying relatively within intervals $[0,x_l]$ and $[t_0,t_l]$ with step equal to 1;

x_1, x_2 – initial and final fertility ages;

rg – region (place of residence): $rg=r,u;$ r – rural, u – urban;

fd – food security state ($fd = fis, fs$; fis – people are food insecure, fs – people are food secure);

l – litaracy state (l=ilt,lt; ilt – people are illiterate, lt – people are literate);

s – sex (s=m,f; m – male, f – female);

$P(rg, fd, l, s, x, t)$ – number of people of sex s at age x living at time t in the region rg and having food security state fd) and literacy state l;

$d(rg, fd, l, s, x, t)$ – mortality specific rate;

$mg_{il}(rg, fd, l, s, x, t)$ – literacy specific rate, characterizing intensity of transferring of people from Illiterate state to Literate one;

$mg_u(r, fd, l, s, x, t)$ – migration specific rate from Rural place of residence to Urban one;

$emg(rg, fd, l, s, x, t)$ – emigration specific rate;

$\Delta P(rg, fis, l, s, x, t)$ – change of number of people with Food Insecure state on time interval $(t.t{+}1)$;

$\Delta P_{img}(rg, fd, l, s, x, t)$ – number of immigrants on time interval $(t, t{+}1)$;

$b(rg, fd, l, x, t)$ – fertility specific rate;

$pr_s(rg, fd, l, x, t)$ – share of children of sex s born by women in corresponding group and at age x and time t.

In this notations the equations describing dynamic of demographic processes can be written in the form

$$
\begin{cases}
P(r,fis,ilt,s,x,t+1) = P(r,fis,ilt,s,x-1,t)\cdot[1-d(r,fis,ilt,s,x,t)-mg_{lt}(r,fis,ilt,s,x,t) \\
\qquad -mg_u(r,fis,ilt,s,x,t)-emg(r,fis,ilt,s,x,t)]+\Delta P(r,fis,ilt,s,x,t)+ \\
\qquad +\Delta P_{img}(r,fis,ilt,s,x,t) \\
P(r,fis,lt,s,x,t+1) = P(r,fis,lt,s,x-1,t)\cdot[1-d(r,fis,lt,s,x,t)-mg_u(r,fis,lt,s,x,t)- \\
\qquad -emg(r,fis,lt,s,x,t)]+\Delta P(r,fis,lt,s,x,t)+\Delta P_{img}(r,fis,lt,s,x,t) \\
P(r,fs,ilt,s,x,t+1) = P(r,fs,ilt,s,x-1,t)\cdot[1-d(r,fs,ilt,s,x,t)-mg_{lt}(r,fs,ilt,s,x,t)- \\
\qquad -mg_u(r,fs,ilt,s,x,t)-emg(r,fs,ilt,s,x,t)]-\Delta P(r,fis,ilt,s,x,t)+ \\
\qquad +\Delta P_{img}(r,fs,ilt,s,x,t) \\
P(r,fs,lt,s,x,t+1) = P(r,fs,lt,s,x-1,t)\cdot[1-d(r,fs,lt,s,x,t)-mg_u(r,fs,lt,s,x,t)- \\
\qquad -emg(r,fs,lt,s,x,t)]-\Delta P(r,fis,lt,s,x,t)+\Delta P_{img}(r,fs,lt,s,x,t) \\
P(u,fis,ilt,s,x,t+1) = P(u,fis,ilt,s,x-1,t)\cdot[1-d(u,fis,ilt,s,x,t)-mg_u(u,fis,ilt,s,x,t)- \\
\qquad -emg(u,fis,ilt,s,x,t)]+\Delta P(u,fis,ilt,s,x,t)+P(r,fis,ilt,s,x-1,t)\cdot \\
\qquad \cdot mg_u(r,fis,ilt,s,x,t)+\Delta P_{img}(u,fis,ilt,s,x,t) \\
P(u,fis,lt,s,x,t+1) = P(u,fis,lt,s,x-1,t)\cdot[1-d(u,fis,lt,s,x,t)-emg(u,fis,lt,s,x,t)]+ \\
\qquad +\Delta P(u,fis,lt,s,x,t)+P(r,fis,lt,s,x-1,t)\cdot mg_u(r,fis,lt,s,x,t)+ \\
\qquad +\Delta P_{img}(u,fis,lt,s,x,t) \\
P(u,fs,ilt,s,x,t+1) = P(u,fs,ilt,s,x-1,t)\cdot[1-d(u,fs,ilt,s,x,t)-mg_{lt}(u,fs,ilt,s,x,t)- \\
\qquad -\Delta P(u,fis,ilt,s,x,t)+P(r,fs,ilt,s,x-1,t)\cdot mg_u(r,fs,ilt,s,x,t)+ \\
\qquad +\Delta P_{img}(u,fs,ilt,s,x,t) \\
P(u,fs,lt,s,x,t+1) = P(u,fs,lt,s,x-1,t)\cdot[1-d(u,fs,lt,s,x,t)-emg(u,fs,lt,s,x,t)]- \\
\qquad -\Delta P(u,fis,lt,s,x,t)+P(r,fs,lt,s,x-1,t)\cdot mg_u(r,fs,lt,s,x,t)+ \\
\qquad +\Delta P_{img}(u,fs,lt,s,x,t) \\
\qquad s=m,f;\;\; x=1,2,...x_l;\;\; t=t_0,t_0+1,t_0+2,...,t_l
\end{cases}
$$

The equations for children born ($x=0$) can be written in the form:

$$
\begin{cases}
\begin{aligned}
P(r, fis, ilt, s, 0, t+1) = {} & [\sum_{x=x_1}^{x_2} P(r, fis, ilt, f, x-1, t) \cdot b(r, fis, ilt, x, t) \cdot pr_s(r, fis, ilt, x, t)] \cdot [1 - \\
& - d(r, fis, ilt, s, 0, t) - mg_u(r, fis, ilt, s, 0, t) - emg(r, fis, ilt, s, 0, t)] + \\
& + [\sum_{x=x_1}^{x_2} P(r, fis, lt, f, x-1, t) \cdot b(r, fis, lt, x, t) \cdot pr_s(r, fis, lt, x, t)] \cdot [1 - \\
& - d(r, fis, lt, s, 0, t) - mg_u(r, fis, lt, s, 0, t) - emg(r, fis, lt, s, 0, t)] + \\
& + \Delta P(r, fis, ilt, s, 0, t) + \Delta P_{img}(r, fis, ilt, s, 0, t) \\
P(r, fs, ilt, s, 0, t+1) = {} & [\sum_{x=x_1}^{x_2} P(r, fs, ilt, f, x-1, t) \cdot b(r, fs, ilt, x, t) \cdot pr_s(r, fs, ilt, x, t)] \cdot [1 - \\
& - d(r, fs, ilt, s, 0, t) - - mg_u(r, fs, ilt, s, 0, t) - emg(r, fs, ilt, s, 0, t)] + \\
& + [\sum_{x=x_1}^{x_2} P(r, fs, lt, f, x-1, t) \cdot b(r, fs, lt, x, t) \cdot pr_s(r, fs, lt, x, t)] \cdot [1 - \\
& - d(r, fs, lt, s, 0, t) - mg_u(r, fs, lt, s, 0, t) - emg(r, fs, lt, s, 0, t)] - \\
& - \Delta P(r, fis, ilt, s, 0, t) + \Delta P_{img}(r, fs, ilt, s, 0, t) \\
P(u, fis, ilt, s, 0, t+1) = {} & [\sum_{x=x_1}^{x_2} P(u, fis, ilt, f, x-1, t) \cdot b(u, fis, ilt, x, t) \cdot pr_s(u, fis, ilt, x, t)] \cdot [1 - \\
& - d(u, fis, ilt, s, 0, t) - emg(u, fis, ilt, s, 0, t)] + \\
& + [\sum_{x=x_1}^{x_2} P(u, fis, lt, f, x-1, t) \cdot b(u, fis, lt, x, t) \cdot pr_s(u, fis, lt, x, t)] \cdot [1 - \\
& - d(u, fis, lt, s, 0, t) - emg(u, fis, lt, s, 0, t)] + \\
& + [\sum_{x=x_1}^{x_2} P(r, fis, ilt, f, x-1, t) \cdot b(r, fis, ilt, x, t) \cdot pr_s(r, fis, ilt, x, t)] \cdot mg_u(r, fis, ilt, s, 0, t) + \\
& + [\sum_{x=x_1}^{x_2} P(r, fis, lt, f, x-1, t) \cdot b(r, fis, lt, x, t) \cdot pr_s(r, fis, lt, x, t)] \cdot mg_u(r, fis, lt, s, 0, t) + \\
& + \Delta P(u, fis, ilt, s, 0, t) + \Delta P_{img}(u, fis, ilt, s, 0, t) \\
P(u, fs, ilt, s, 0, t+1) = {} & [\sum_{x=x_1}^{x_2} P(u, fs, ilt, f, x-1, t) \cdot b(u, fs, ilt, x, t) \cdot pr_s(u, fs, ilt, x, t)] \cdot [1 - d(u, fs, ilt, s, 0, t) - \\
& - emg(u, fs, ilt, s, 0, t)] + [\sum_{x=x_1}^{x_2} P(u, fs, lt, f, x-1, t) \cdot b(u, fs, lt, x, t) \cdot pr_s(u, fs, lt, x, t)] \cdot [1 - \\
& - d(u, fs, lt, s, 0, t) - emg(u, fs, lt, s, 0, t)] + \\
& + [\sum_{x=x_1}^{x_2} P(r, fs, ilt, f, x-1, t) \cdot b(r, fs, ilt, x, t) \cdot pr_s(r, fs, ilt, x, t)] \cdot mg_u(r, fs, ilt, s, 0, t) + \\
& + [\sum_{x=x_1}^{x_2} P(r, fs, lt, f, x-1, t) \cdot b(r, fs, lt, x, t) \cdot pr_s(r, fs, lt, x, t)] \cdot mg_u(r, fs, lt, s, 0, t) - \\
& - \Delta P(u, fis, ilt, s, 0, t) + \Delta P_{img}(u, fs, ilt, s, 0, t) \\
& s = r, u; \quad x = 1, 2, \ldots x_l; \quad t = t_0, t_0 + 1, t_0 + 2, \ldots, t_l
\end{aligned}
\end{cases}
$$

The fertility and mortality specific rates $b(rg, fd, l, x, t)$ and $d(rg, fd, l, s, x, t)$ are derived from total fertility fertility rate and life expectation for each population group. The change of number of people with Food Insecure state $\Delta P(rg, fis, l, s, x, t)$ at time interval $(t.t+1)$ is calculated by the following algorithm using the model of food production and distribution.

According to this algorithm at the time moment t the total amount of food $F(t)$ is calculated (in kcal) by using Food Production Model and population data for this moment. Then amount of food produced and distributed between rural and urban regions is calculated using the following formulas

$$F(u,t) = a_F \cdot F(t) \cdot \frac{P(u,t)}{P(t)}, \qquad F(r,t) = F(t) - F(u,t), \quad P(t) = P(u,t) + P(r,t)$$

$$P(u,t) = \sum_{fd,l,s,x} P(u, fd, l, s, x, t) \quad P(r,t) = \sum_{fd,l,s,x} P(r, fd, l, s, x, t)$$

where $F(u,t)$, $F(r,t)$, $P(u,t)$, $P(r,t)$ are total amounts of food and population sizes for urban and rural regions, $P(t)$ – total size of population and a_F - coefficient larger than 1 but close to 1. Then by usage of $F(u,t)$, $F(r,t)$, $P(u,t)$, $P(r,t)$ and functions $G_u(p), G_r(p)\ (0 \le p \le 1)$ describing unequal distribution of food among people of urban and rural regions (these functions reflect unequal distribution of benefit among people) there are calculated shares of food secure people in urban and rural regions. Since formulas for urban and rural regions are identical we will describe the algorithm of calculating share of food secure people in urban region. The function $G_u(p)$ has the following meaning. Let P and $p=P/P(u,t)$ be the size and the share of urban population $P(u,t)$ respectively. Then value $G_u(p)$ is share of total amount of food $F(u,t)$ to be in disposal to the share of population size p. Thus the part of urban population P has amount of food $F(P)$ given by formula

$$F(P) = F(u,t) \cdot G_u(p) = F(u,t) \cdot G_u\left(P/P(u,t)\right)$$

Now it is necessary to concretize what kind of function $G_u(p)$ is used here. The matter is that there are two variants of function of such type. We use the type of this function to be obtained on statistical data in the following way. Let n_k people have amount of food f_k (nutrition level) ($k = \overline{1, N}$) and $f_1 \ge f_2 \ge ... \ge f_N$. Then empirical value of function $G(p)$ analogous to function $G_u(p)$ is calculated by the formula

$$G(p)=\begin{cases} 0 & if \quad p=0 \\ \sum_{i=1}^{k} f_i \Big/ \sum_{i=1}^{N} f_i & if \quad p_k \le p < p_{k+1},\ k=\overline{1,N-1}; \\ 1 & if \quad p=1 \end{cases} \qquad p_k=\frac{\sum_{i=1}^{k} n_i}{\sum_{i=1}^{N} n_i},\ k=\overline{1,N}$$

According to definition of function $G_u(p)$ it has the following properties

- $0 \le G_u(p) \le 1$, when $0 \le p \le 1$;
- $G_u(p)$ is monotonously increasing function when $0 \le p \le 1$;
- It's derivative $g_u(p)=\dfrac{dG_u(p)}{dp}$ is non-negative monotonically decreasing function when $0 \le p \le 1$.

Due to sense and properties of function $G_u(p)$ the value of derivative

$$F'(P)=\frac{dF(P)}{dP}=\frac{F(u,t)}{P(u,t)}\cdot g_u\big(P/P(u,t)\big),\quad g_u(p)=\frac{dG_u(p)}{dp}$$

is nutrition level (kcal per capita) and the part of population *P* has nutrition level greater or equal to $F'(P)$. Thus giving minimal admissible (crucial) nutrition level $F_{\min}$ the share *pr(u,fs,t)* of urban population size to be food secure can be obtained by solving the following non-linear equation

$$g_u(pr(u,fis,t))=F_{\min}\cdot\frac{P(u,t)}{F(u,t)}$$

Due to the properties of function $g_u(p)$ three situations may occur.

1. $g_u(0) < F_{\min}\cdot\dfrac{P(u,t)}{F(u,t)}$. In this case the equation has no solution and it means that *pr(u,fs,t)*=0 that is there are no food secure people.
2. $g_u(1) > F_{\min}\cdot\dfrac{P(u,t)}{F(u,t)}$. In this case the equation has no solution and it means that *pr(u,fs,t)*=1 that all people are food secure.
3. $g_u(0) \le F_{\min}\cdot\dfrac{P(u,t)}{F(u,t)} \le g_u(1)$. In this case the equation has unique solution *pr(u,fs,t)* and the number of people *Pr(u,fs,t)* to be food secure is equal to *pr(u,fs,t)*• *P(u,t)* that is *Pr(u,fs,t)=pr(u,fs,t)*• *P(u,t)*.

It is obviously that the number of people *Pr(u,fis,t)* to be food insecure is equal to

Pr(u,fis,t)=(1- pr(u,fs,t))• *P(u,t)*

Further change in the number of food insecure people • *P(u,fis,t)* in urban region is calculated according by the following formula

• • • • • • • • • • • • • •

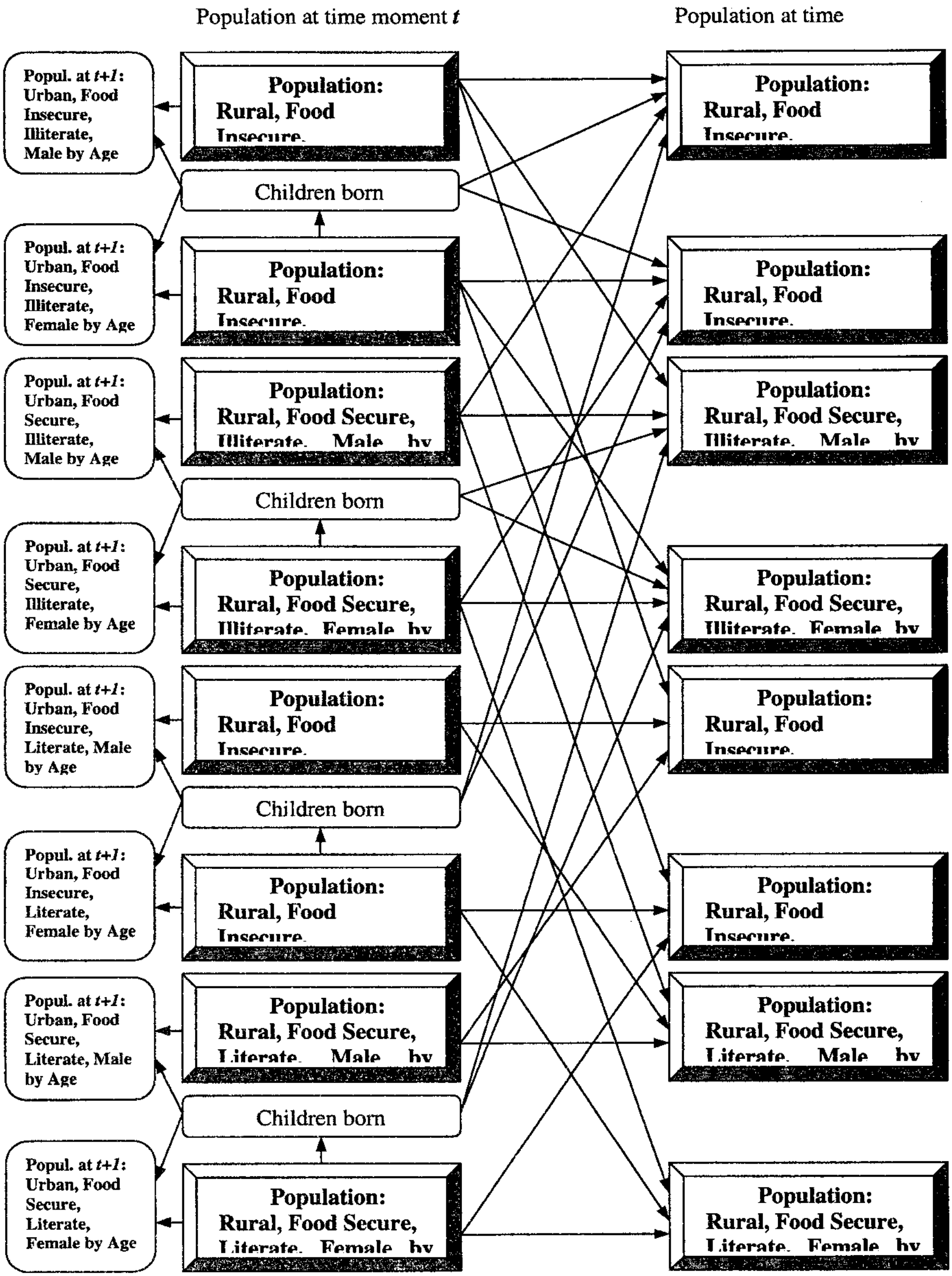
$$\Delta P(u, fis, t) = \Pr(u, fis, t) - P(u, fis, t), \quad P(u, fis, t) = \sum_{l,s,x} P(u, fis, l, s, x, t)$$

where *P(u,fis,t)* is food insecure population in urban region at time *t*. As soon as • *P(u,fis,t)* is known we can calculate the changes • *P(u,fis,l,s,x,t)* by the formula

• *P(u,fis,l,s,x,t)=• • P(u,fis,t)• (P(u,fis,l,x,t)/P(u,t)*
)

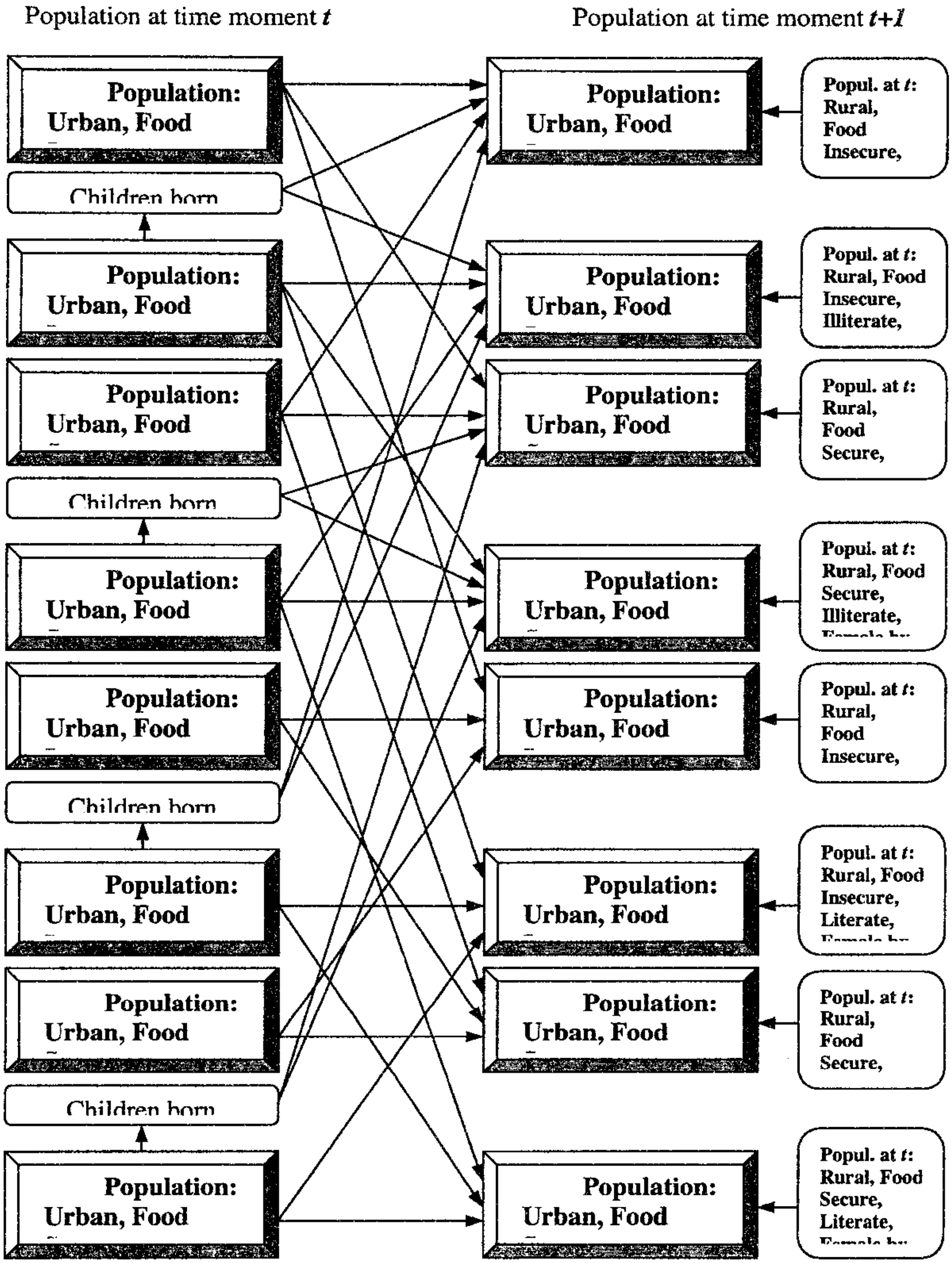
The values • *P(r,fis,l,s,x,t)* for the rural region are calculated using the same formulas as for the urban region (with substitution of symbol "*u*" by symbol "*r*").

Structure of Population Model (Rural Part)



moment $t+1$

Structure of Population Model (Urban Part)



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Compatibility

The model has originally been developed for and English version of Microsoft Office (SR-2). Although the software has been tested, and is running under Microsoft Office 2000, minor bugs may still occur in later versions of Office.

Annex 4

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