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PEDA ADVOCACY BOOKLET -POPULATION, ENVIRONMENT AND FOOD SECURITY: THE NEXUS

For discussion at the Second Advisory Board Meeting on Population, Environment and Agriculture

PEDA ADVOCACY BOOKLET

- Population, Environment and Food Security: the Nexus -

ECA/FSSDD

October 2000

I. INTRODUCTION

During the past three decades, there has been a discerned shift of focus from dealing with sectoral issues to considerations of linkages. This paradigm shift is best exemplified by the discussions which have dominated major United Nations Conferences since the 1960s on Population, Environment and Food Security.

At the United Nations Conference on Human Environment held in Stockholm in 1972, discussions were mainly on the environment. By the time of the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil in 1992, the links between rapid population growth, environmental degradation and poverty were generally acknowledged. The conference dubbed the Earth Summit also popularised the concept of Sustainable Development which raised the issue of intergenerational equity with respect to the use of natural resources. The issue of sustainability and the need to adopt a holistic approach to developmental problems were also underlined in the UN global Conferences in Copenhagen, Beijing and Rome where social and gender and food issues were discussed respectively.

It is within this general context of the new global development paradigm that the nexus between population, environment and agriculture has been advocated for by the Economic Commission for Africa (ECA). The concept was first promoted by the World Bank in a publication entitled "*Reversing the Spiral: The Population, Agriculture and Environment Nexus in Sub-Saharan Africa*". The authors of the book, Cleaver and Schriber asserted that "their findings confirm the hypothesis of strong synergies and causality chains linking rapid population growth, degradation of the environment resource base and poor agricultural production".

Although this synergistic relationship can be established at the grassroots level, operationalising the concept in modern economies which are sectorally managed is a daunting challenge. But there are advantages to be derived from operationalising the concept. The adoption of a holistic approach to addressing problems in the different sectors will result in better co-ordination of efforts and ensure cost-effective programmes. It has increasingly been demonstrated in the field that applying single solutions to multifaceted problems cannot achieve the desired results.

In order to understand the complex interrelationships that exist among the NEXUS issues – rapid population growth, environmental degradation and food security and how changes in one nexus component affect the others, a population-based computer simulation model known as PEDA (Population, Environment, Development and Agriculture) has been developed by the United Nations Economic Commission for Africa (UNECA).

This advocacy booklet is intended to give short descriptions on PEDA and to advocate for the use of the model in adopting a holistic approach to national development and food security by policy makers and development planners at

different levels in the African continent. This idea is also supported by providing in the annex some examples of policy questions that can be answered using the model.

II. PEDA MODEL

1. What Is PEDA?

PEDA is an interactive computer simulation model demonstrating the medium to long-term impacts of alternative national policies on food security. The model is intended to be used in understanding within a holistic framework, the interrelationships between population change (P), environment (E), socio-economic development (D) and agriculture (A). It is an advocacy tool giving answers to a wide range of policy questions regarding the nexus interactions and demonstrating the impact of different policy options in relation to the goal of ensuring food security and by implication poverty alleviation and sustainable development in the ECA region.

2. The Interlinked Modules

The PEDA model consists of four interlinked modules pertaining to land, water, economy and human development. The last module which is the most complex combines demographic factors, food security status, education and place of residence in a multi state population projection and it is central to the model. Three important individual characteristics of the population are used in the model namely:

- Place of residence i.e., whether rural or urban
- Literacy status
- Food security status

These sub-groups are further sub-divided into 8 categories as:

i. Urban / Literate / Food Secure
ii. Urban / Literate / Food Insecure
iii. Urban / Illiterate / Food Secure
iv. Urban / Illiterate / Food Insecure
v. Rural / Literate / Food Secure
vi. Rural / Literate / Food Insecure
vii. Rural / Illiterate / Food Secure
viii. Rural / Illiterate / Food Insecure

The land module considers potential soil fertility, actual land use over time and land degradation. The water module on the other hand, considers theoretical water supply due to the topography and climatic conditions, man made water systems and the availability of water for agricultural and residential use.

A combination of land, water and production of labour force with capital investments in agriculture and technological innovation is expected to indicate an

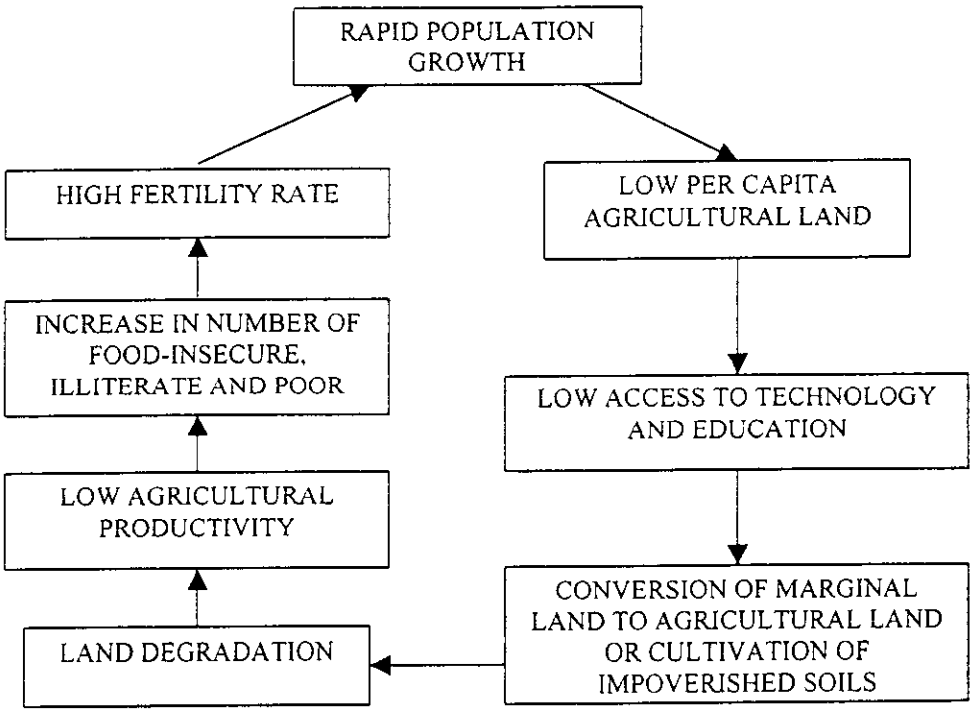
estimate of the proportion of the population that is food secure for each of the eight sub-groups of the population.

3. The Vicious Circle

The model assumes that a vicious circle exists. In most of Sub-Saharan Africa, population growth has been higher in the rural areas compared to the urban. As a result of lack of access to high technology and education, the food-insecure and illiterate population needs to utilise more and more lands in order to continue to produce enough for their sustenance. Alternatively, they may need to continue to cultivate impoverished soils, the end result of which is a degraded landscape and lowering agricultural productivity.

Correspondingly, low agricultural productivity produces a large army of economically poor and food insecure persons who tend to increase their family sizes through high fertility parity as the only viable option for them to increase labour and also to provide security for themselves during old age. In the process, the number of food insecure or the poor in the population further increases in this cycle (Fig. 1).

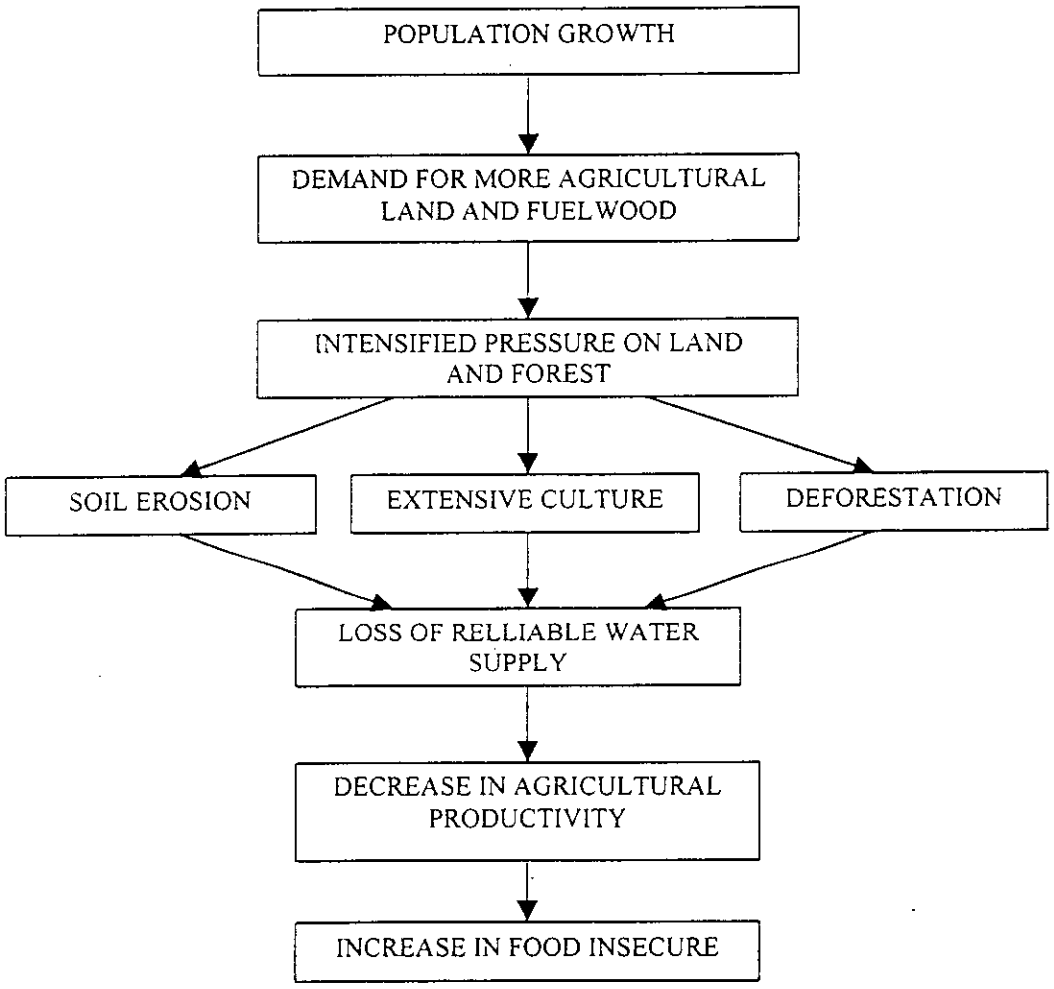
Fig. 1: The Vicious Circle



In order to understand the vicious circle, it is better to illustrate how each module interrelates with each other, for example, the interrelationships between population (P), environment (E) and agriculture (A).

In its simple form, increasing population would lead to a corresponding demand for agricultural land and for fuelwood, the main source of energy for rural people. This process puts an intensified pressure on land and forest resources, which, in turn, sets in motion rapid soil erosion and deforestation. This contributes to a loss of reliable water supply for agricultural activities. The end result is decreasing agricultural productivity and increasing number of food insecure persons in the total population (Fig. 2).

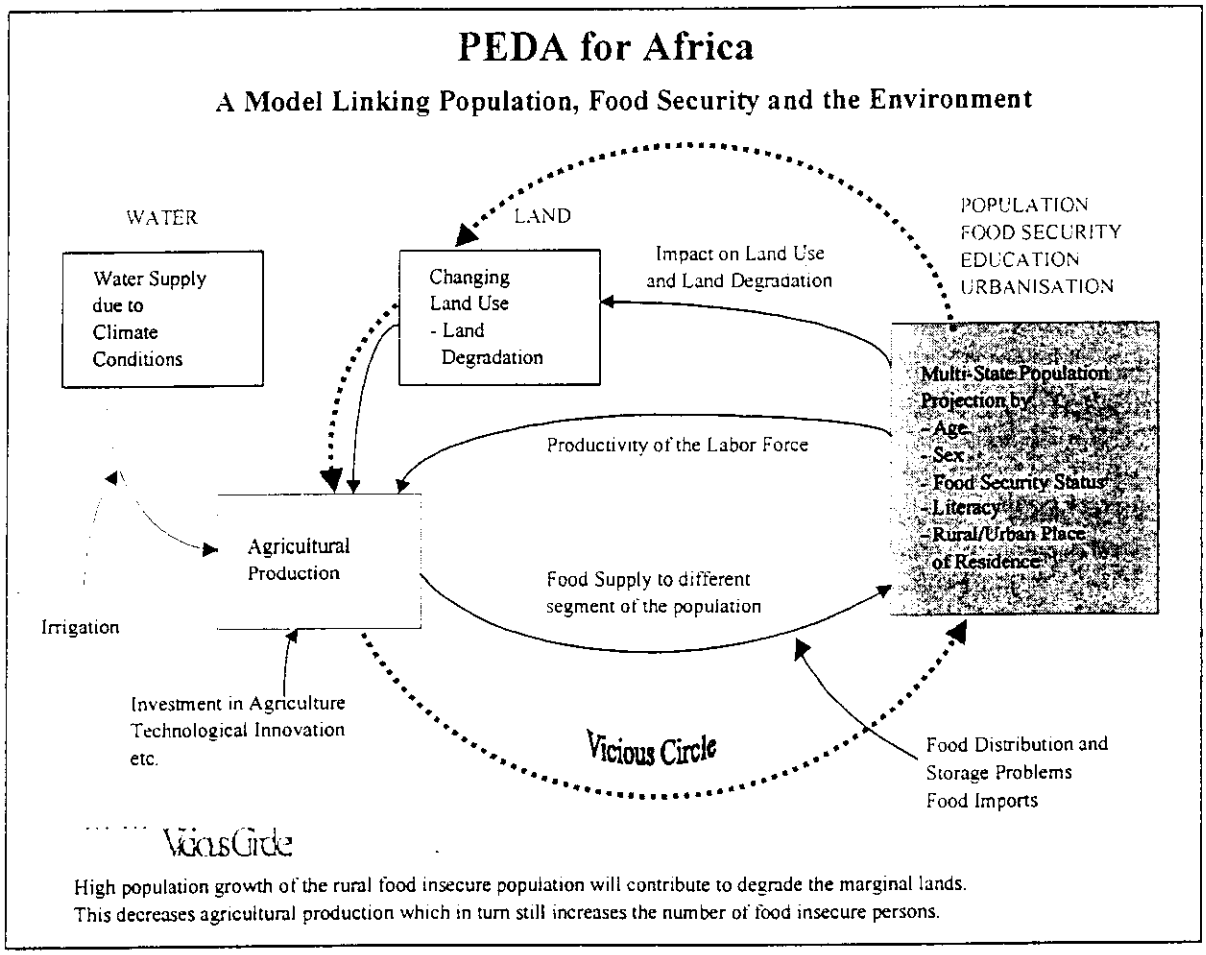
Fig. 2: Interrelationships between Population, Agriculture and Environment



Again, the interrelationships between human development, agricultural production, food security and poverty can also be summarised. The impact of the population growth on agricultural production and food security depends on the size and quality of labour force supply as determined by the level of education and the type of technology available to them. This will in turn determine the poverty status and general standards of living of the population. Fertility rates are bound to be high to ensure security in old age while the reverse is true in situations of higher quality of life.

Putting together all the scenarios that have been described into one complex model (Fig. 3), one would have to understand the components of population in the model to include the age and sex structure, the status of food security, literacy level as well as its rural-urban composition by place of residence. These describe the quality of the human population. In this respect, population impacts on land such that depending on the size, growth and distribution of the population, the end result may be either positive or negative which in turn affects the level of agricultural production.

Fig. 3: The PEDA Model - Linking Population. Food Security and the Environment



Population also determines the size and quality of the labour force, which has important implications for agricultural production. Conversely, the level of agricultural production to a greater extent will determine the level of food security and hence the capacity of the population to take care of itself in respect of education which is one of the main vehicles for achieving sustainable development.

The model underscores the fact that in most African countries, agriculture depends mainly on water supply as may be determined by the prevailing climatic conditions, which may or may not be favourable all the time. However, provision is made for irrigation to supplement the water supply to enhance agricultural productivity.

Furthermore, investments could be made in agriculture through sustained research and technological innovation, which could further boost agricultural production. To forestall the perennial problem of post-harvest food loses that have plagued Africa for decades, effective distribution mechanisms, processing and improved storage practices as well as supplementary food imports in the worst circumstances in turn, could increase the amount of food supply to the population.

4. Breaking the Vicious Cycle

Among the options which may be adopted to break out the vicious cycles are:

- Building the needed infrastructure
- Intensification of agriculture
- Marketing and Pricing
- Enhancing human capacity
- Reducing rate of population growth

Building the needed infrastructure. Poor storage and communication network such as roads, railways and waterways have led to much post-harvest losses. Thus the construction of efficient communication lines linking the main agricultural production centres with the rest of the country, would improve distribution and reduce losses.

In addition, introduction of appropriate storage facilities and rural electrification could also reduce losses and promote food processing. This would improve food security and reduce poverty in the rural areas.

Intensification of agriculture would prevent further expansion of farmlands into marginal areas which leads to land degradation. It is possible to use the same piece of land and produce higher yields through intensification i.e., use of manure, chemical fertilizers, shorter yielding plant varieties and irrigation.

Markets and pricing. The food market has been separated from other commodity markets during the era of Structural Adjustment Programmes in Africa. Thus, as food prices get depressed during bumper harvest, the prices of other commodities keep increasing. This renders farmers incapable of competing in the

other markets and hence their inability to adopt best practices. This is a major channel through which the vicious cycle is perpetuated.

Development of the human capital. This involves strengthening the educational sector and providing requisite skills for the labour market. In this respect, efforts should be intensified not only to attain universal education for the entire population but most importantly to bridge the yawning gap that often exists between males and females in education. This has the added incentive of reducing people's preference for larger family sizes and hence a reduction in population growth.

Reduction in the rate of population growth. Educational campaigns that are aimed at increasing the use of family planning methods among the population should be intensified. This should be done alongside improvements in education especially female education as a way of reducing fertility, and hence rapid population growth.

III. CONCLUSION

After pursuing sectoral development over the past several decades, there is now a growing consensus on the need to adopt a holistic approach to development. As it has been demonstrated in this publication, issues of population, environment and food security are interrelated. They cannot therefore be addressed fully by any sector Ministry. But while the new development paradigm makes sense, operationalising the Nexus concept poses difficulties. In an attempt to address these, the Economic Commission for Africa has developed the PEDA (Population, Environment, Development and Agriculture) computer model.

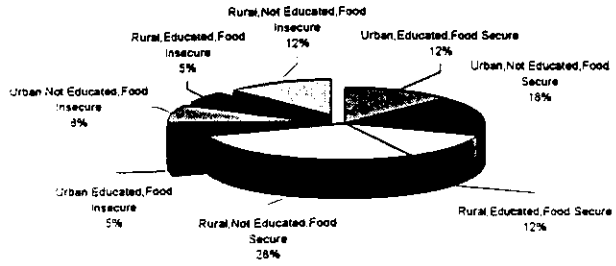
PEDA makes it possible to deal with cross-cutting issues and also to determine possible outcomes of policy options. PEDA can be used in countries with the required data such as Burkina Faso and Mauritius.

Annex: Some examples of policy questions that could be answered using PEDA

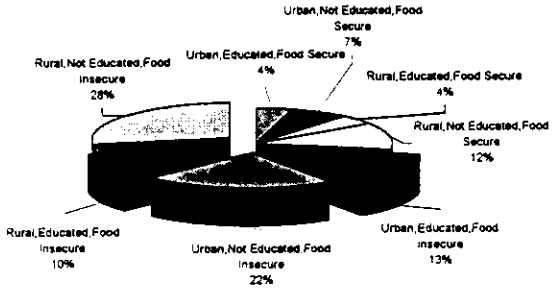
PEDA carries great potential as an advocacy tool through its ability to illustrate how evolutions in different sectors such as population agriculture and the environment influence and reinforce each other. Hereunder, a number of interesting policy questions are summarised as well as the kind of answers[1] PEDA is able to give to such policy questions.

The outputs presented are produced with the Zambia prototype of PEDA. Although the data apply to a specific country, they do not pretend to be accurate in any way. In most cases, the results of the projections are compared to a constant rates scenario, that is a scenario wherein it is assumed that all variables will remain at the levels of the starting period throughout the projection period. An enumeration of the different scenario variables and their values in the constant rates scenario in the PEDA prototype for Zambia are given in the annex. The two pie charts below illustrate the evolution of the total population by residential, literacy and food security status under the constant rates scenario.

Zambia 1996



Zambia 2050, constant rates



Whereas the proportion of food insecure people in Zambia is to be situated around 30% in 1996, this percentage would dramatically increase under the constant rates scenario. It is expected that the proportion food insecure would reach 73% by 2050 if fertility and mortality rates, educational enrollment rates and all other factors influencing the availability of food would remain at their 1996 levels.

Q & A 1:

Q : What will be the effect of the Total Fertility Rate if the educational enrollment rates for girls would be brought to 75%

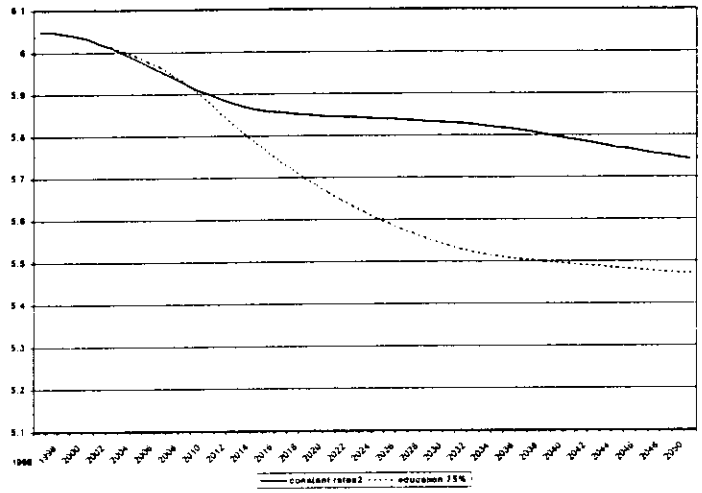
A : This questions refers to one of the well known relationships in demography, i.e. that between the educational level and fertility of women. As the fertility rates of educated women are generally lower than that of non-educated women, the TFR for Zambia will decrease with 0.5 points by 2050 if the literacy rate of the women would be brought from 33% (rural areas) and 44% (urban areas) to 75%.

[1] The answers as they are given here do, however, no full justice to the flexibility of the model in terms of its presentation potential and output possibilities. If we, for example, talk about the food security situation in a country, we cannot only consider the aggregated food security situation on a national level (as is done in most of the answers stated below) but we can further breakdown the food security in the country by sex, urban/rural place of residence, literacy status and age group. On the other hand, the PEDA model is not designed for, and does not pretend to be a planning tool that will provide us with the evolution of exact number of food insecure people in a country under the conditions stated in the different scenarios. Agricultural production and availability of food are subject to unpredictable market evolutions and climatic conditions, and therefore it is difficult to make accurate medium to long-term projections of the availability of food for consumption. Moreover, the data as they are used now, consist of too much estimation to be used as the concrete example of country where upon we can rely. In order to allow for such an exercise more accurate data collection is needed to feed into the model. What is important in the outputs and answers given by PEDA are the direction and magnitude of the relationships between the variables considered and these are perfectly illustrated by the model, without the pretension of precision.

Details on the projections

The question can be answered through changing the settings for the educational transition rates and projecting the TFR for the whole country. Setting the educational transition rates to 75% means that from year two in the projection, 75% of the boys and girls that reach the age of six will attend school and will thus be considered as literate.

This exercise singles out the effect of education on the TFR for a country. Under the educational scenario, it is expected the TFR will decline from 6.05 in 1996 to 5.5 in 2050 whereas it would only decrease to 5.75 under the constant rates scenario. Note that even under the constant rates scenario, fertility rates are expected to decline. This has several reasons. First of all, this is due to the fact that the current enrollment rates in Zambia are higher than in the past and this has an ongoing effect on the fertility rate in the projections. Secondly, it is assumed that food insecure people have lower fertility rates than food secure people and under the constant scenario it is precisely the first category that increases proportionally. Also note that changes in educational enrollment rates will only make a visible difference after 15 years. This represents the time-lap between the improvements in the educational system and the age that women having benefited from it reach reproductive age.
This example gives us a confirmation of the relationship between the general development of a country (here measured through the literacy of the population) and its consequences in terms of population growth.



Q & A 2:

Q: What will be the impact on the food security situation by 2050 if the educational enrollment rates would be brought up to 75% for both sexes?

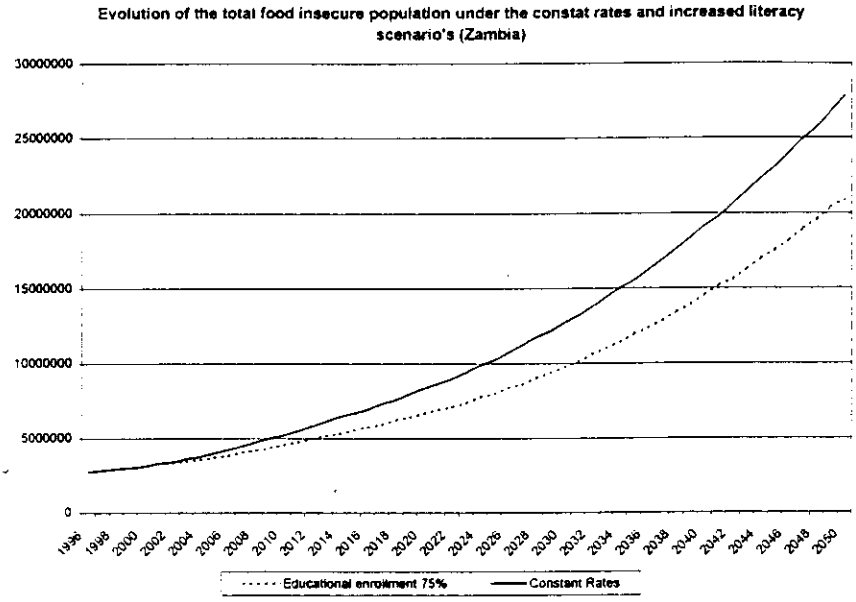
A: Literate farmers tend to be more productive then non-literate farmers, literate women usually have less children, and literate people do not deplete natural resources to the same extent as illiterate people. In the long run, increasing literacy means increasing agricultural production and decreasing the number of mouths to feed. Increased literacy thus has a positive impact on the food security situation in the country. However, efforts in raising the literacy rate of the country alone will not be enough to combat food insecurity: even a steep increase in the literacy rate as suggested in the question will not lead to a decreasing number of food insecure people. It is estimated (under the condition that all other factors remain constant) that the total number of food insecure will be 7.5 times higher in 2050 than in 1996.

Details on the projections
In this case one would set the educational transition rates to 75% and project the total population by food security status.

Under the constant rates scenario the total food insecure population will be multiplied by a factor 10. If urban and rural educational enrollment rates would be brought up to 75% (from approximately 30%

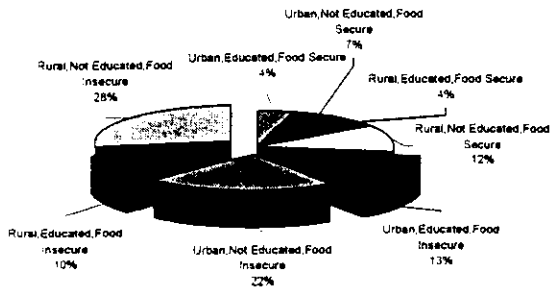
for rural areas and 45% for urban areas), the total amount of food insecure people would increase to a level that is equal to a multiplication by a factor 7.5 .

As mentioned before, the amount of food insecure people will drastically increase given the assumptions in the constant rates scenario. Also serious efforts in the educational sector alone will not solve the problem of food insecurity in the country.

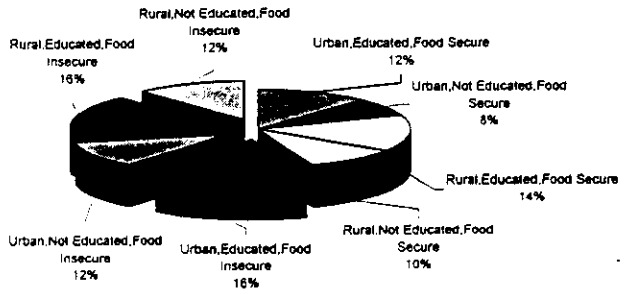


Below are two pie charts giving the population distribution by residential, literacy and food security status for the constant rates scenario and the education scenario.

Zambia 2050, constant rates



Zambia 2050, education (75%)



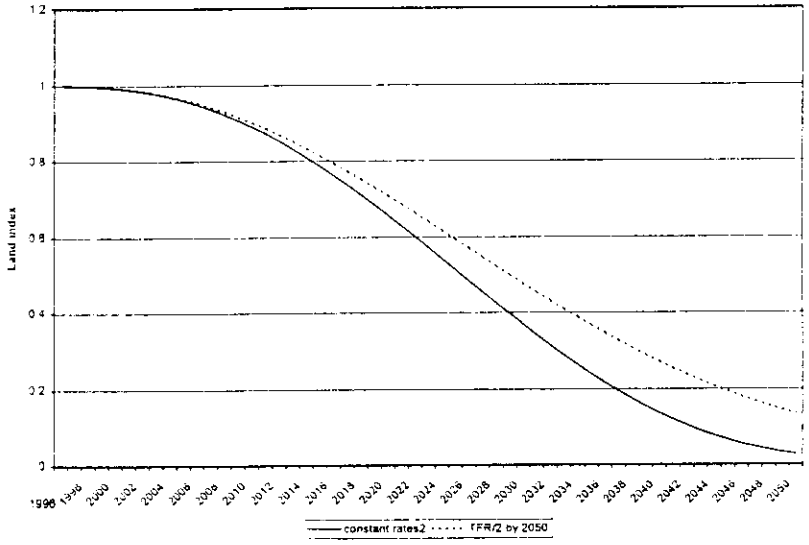
Q & A 3 :

Q : How does a reduction in fertility rates to half their present levels by 2050 influences the food production and food security situation in a country ?

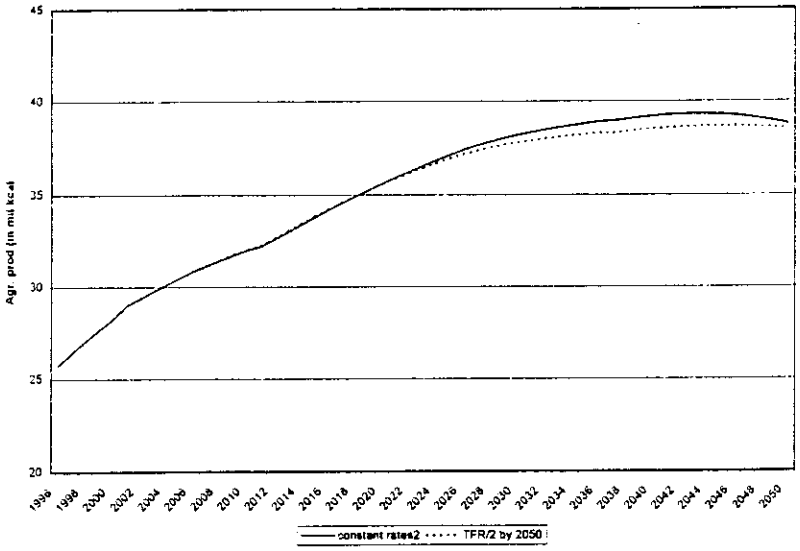
A : Contrary to what one would expect, a reduction in fertility rates does not negatively affect the food production in a country (through the reduction of the rural labor force). The total amount of food produced remains stable over the whole projection period, and this is because a reduction in the rural population has two opposing effects on agricultural production. On the one hand, it indeed reduces the rural labor force and thus one of the major contributors to agricultural production, but on the other, it also limits the negative effects on the environment of high population densities in rural areas. Hence, a reduction of fertility rates does not significantly affect the agricultural production in a country and consequently it significantly reduces the food insecurity because it simply reduces the number of mouths to feed. In other words, a decrease in the TFR of women will result in an increase in the per capita food production.
Nevertheless, a reduction in fertility rates to half their present levels by 2050 alone will not eliminate the food security problem in Zambia. If no other initiatives are taken in other sectors the total amount of food insecure people will still doubled by the end of the projection period.

Details on the projections

This question can be answered through the manipulation of the fertility rates as a scenario variable and the projection of the total population by food security status.



As a decrease in fertility rates affects the population growth and thus the population density in rural areas, it will also have a positive effect on the environment. Compared to the constant rates scenario, the total amount of land available for agricultural production will thus be higher (see graph). This will definitely affect the agricultural production. However, a reduction in fertility rates also means a reduction in the rural labour force and thus in a reduction of the total amount of food that is produced in a country. Both effects work in a different direction and tend to neutralise each other as is shown in the following graph. A decrease in fertility rates to half their current levels by 2050 thus not automatically leads to a decrease in the agricultural output of a country on the long term.

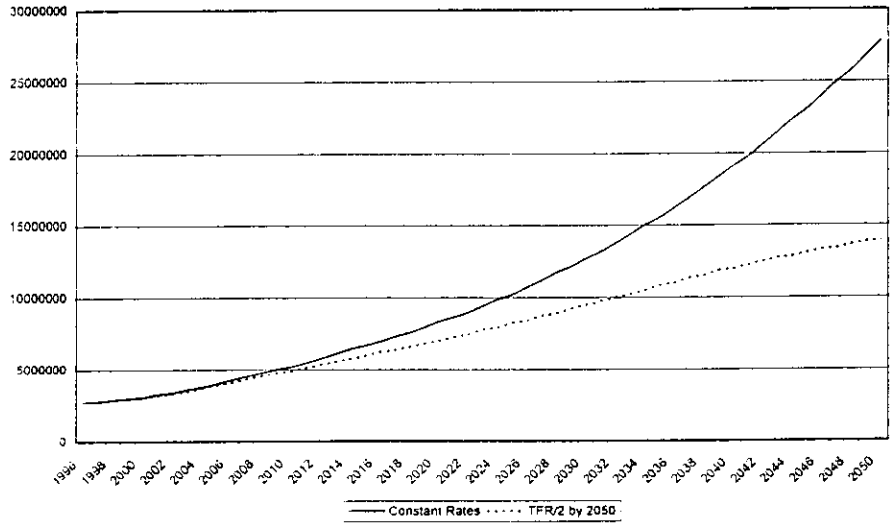


As a reduction in fertility rates does not influence agricultural production in a country, it will positively influence the per capita agricultural production. As such a reduction in fertility rates has a positive impact on the food security status of the population.

In the concrete example of Zambia, a reduction of the TFR to half their levels in 1996 by 2050 will result in a doubled total amount of food insecure people. This figure needs to be compared to the constant rates scenario for which it is estimated that the total amount of food insecure people will be ten times higher in 2050 then in 1996 (see graph below).

Nevertheless, a reduction in fertility rates to half their present levels by 2050 alone will not eliminate the food security problem in Zambia. If no other initiatives are taken in other sectors, the total amount of food insecure people will increase to almost 15 million.

Evolution of the total food insecure population under the constant rates and TFR/2 scenario's (Zambia)



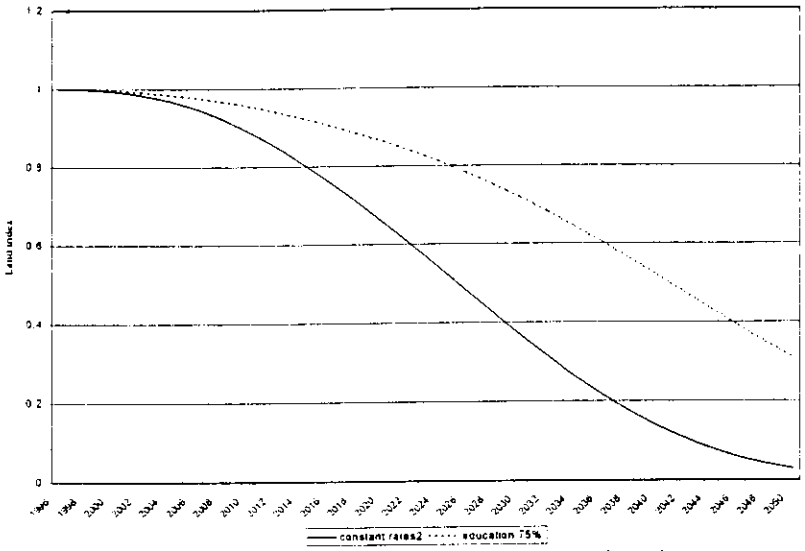
Q & A 4 :

Q: What is the impact of increased education on the environment and land degradation and food production?

A : An increase in educational enrollment rates has several reinforcing positive impacts on land use, agricultural production and food security. First of all, an increase in the literacy rates in a country will slow down population growth because fertility rates of literate women are generally lower than that of illiterate women. This has a positive impact on land degradation through decreased population densities in rural areas. Further higher literacy rates also have a direct and more important impact on land use because it is especially the rural illiterate and food insecure people that tend to deplete natural resources in their quest for survival. As such it can be estimated with PEDA that an increase of the educational enrollment rates by 30%-points will almost reduce the land degradation by half by the end of the projection period (2050). As a consequence of that and also because of an increase in the literacy of the rural labour force, the total amount of food produced will be more than doubled by 2050 as compared to a 40% increase under the constant rates scenario. Of course, the proportion of food insecure people will also be restricted importantly.

Details on the projections

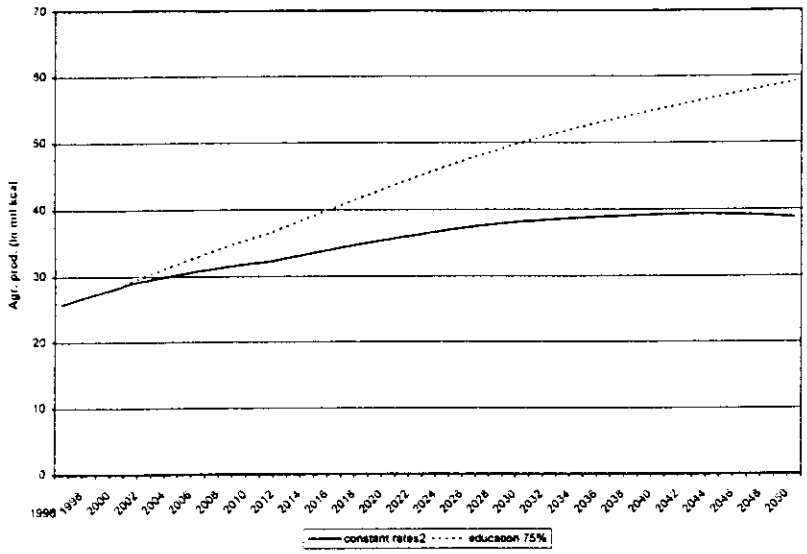
To answer this question we need to adjust the educational transition rates and project the land index variable and total amount of food produced. This exercise singles out the direct and indirect effects of higher literacy on land use and agricultural production.



Land is treated in the model as an index. For the starting year it is set to be 1 and under the constant rates scenario, this value drastically decreases to 0.03 by 2050[2]. An increase in the literacy rate of the population has a significant positive impact on land use since it would only lead to a reduction of the land available for agricultural production to 1/3 of its level in 1996.

As is shown in the graph, increased education also has a positive impact on food production. This is not only due to the positive impact of an increased literacy on the depletion of natural resources, but also because a literate labour force tends to be more productive than an illiterate labour force. It is

[2] This value is highly unlikely: under the constant rates scenario the number rural food insecure is approximately ten times higher than in 1996. In the documentation accompanying PEDA (the explanation on the land degradation factor), it is said that the amount of land available for agricultural production decreases with 2% as the rural food insecure population doubles. Under the constant rates scenario, this should result in a decrease of the total amount of land by 20%. Here the total amount of land available for agricultural production is 35 times smaller than in 1996 !



estimated that the food production in Zambia will more than double under the educational scenario whereas it would only increase with 40% under the constant rates scenario.

This example clearly illustrates intersectoral relationships; i.e. the effect of an improvement in the educational level of the population on the environment and agricultural production.

Notes: The policy questions and answers cited above were prepared in the old version of PEDA. They need to be improved after carrying out a sensitivity analysis of the new version of the model. New questions and answers will then be added.