

Socio Economic Effects of Food Insecurity in Kenya and Possible Reduction of Undernourishment through a Different Crop Diversification.

Santiago Movilla Blanco, System Dynamics Group, Department of Geography, University of Bergen, Norway

1. Abstract:

Many studies have revealed that crop production in Kenya needs to increase at higher rate than the yield trends in order to meet the projected food demand from a rising population.

Since national production, especially maize, is not keeping pace with the growth in national demand, imports and changes in crop diversification are trying to fill the food needs gap.

The outcome of this paper is to provide a general perspective of the crop mix in Kenya and its influence on the different aspects of Food Security as well as on the economy and society.

To do so, the analysis has been performed using a System Dynamics model that includes the most basic sectors involved in Food Security in Kenya. The resulting model can simulate and evaluate different decisions under different scenarios. Such scenarios can help to identify adequate interventions to maximize reduction in food insecurity and undernourishment while observing the repercussions in economic growth, education and health.

2. Introduction:

Reducing food insecurity and malnutrition is a major challenge for many developing countries. Kenya is one of the African countries where still millions of people are undernourished. [\[1\]](#)

The causes of food insecurity are very diverse and interconnected, but poverty and food shortage are the main drivers, not only in Kenya but in the rest of the world. [\[2\]](#)

One way of reducing food insecurity is through improving the agriculture sector. Actually agriculture is the mainstay of the Kenya's economy: The sector still keeps the main share of Gross Domestic Product (GDP) and is the largest employer in the economy, accounting for 60 per cent of

the total employment. Over 80% of the population, especially living in rural areas, derives their livelihoods mainly from agricultural related activities [3]

Since part of the agro production is also the mean sustenance for most of the population related to agriculture, the choice of crops plays a very important role in their nutrition.

But nourishment needs are not the only criterion to set the crop mix. The incomes from farming also play an essential role in the decision. In this sense the crop mix could be based on market prices and yields, although in many cases the traditional farming practices and the resistance to change make farmers to maintain the same crops regardless prices and productivity [4].

A third component involved in the crop mix is related to the environment: A rich biodiversity not only provides a more sustainable way of agriculture by meeting higher soil fertilities without the aid of external inputs [5]. It is a matter of fact that biodiversity also provides a better maneuvering capacity against future climate change and moving prices.

Then the problem turns around how to combine the different criteria to provide an optimal crop mix.

In this sense, the analysis needs to address the nutritional basket in Kenya, which has some particular characteristics differing from other baskets, and it also needs to cope with the extent at which a suitable nutritional diversity is compatible with economic profitability, without forgetting ecological biodiversity.

These decisions will be also based on the extent at which calories collected from crops represent the nutrition of people related to farming, and on the extent at which the revenues represent part of the nutrition covered by food that people can buy, or acquire by other means.

“Selecting the right mix of foods to promote good growth and development is a complex matter because it involves translating nutrient needs to a diet consisting of a mix of foods, some of which are self-acquired and some of which could be provided through food assistance programs. [6]”

Additionally, even if farmers have a very clear idea about what to plant, there are many barriers impeding farmers to achieve their goals. The availability of seeds and the capacity to obtain and grow them are among the main problems, without forgetting poverty is the main restriction to undertake any development.

The objective of this study is therefore to provide a general perspective of the crop mix in Kenya and its influence on the different aspects of food security as well as on the economy and society.

The model allows estimating the possible effects of crop diversification in reducing undernourishment in Kenya on a mid-term horizon and under different scenarios. It also evaluates the effects of nutrition in economy and society, providing a general perspective of Food Security in the country.

3. Crop Mix in Kenya:

The agricultural sector in Kenya has a special status and significance in the country. Agriculture is directly contributing 24% of the GDP annually, valued at Ksh 342 billion (US\$ 4.6 billion) and another 27% indirectly of GDP (valued at Ksh 385 billion equivalent to US\$ 5.1 million). The sector accounts for 65% of country's total exports and supports 18% of formal employment and more than 60% of informal employment in the country (Vision 2030; October 2007). Therefore, the sector is not only the driver of Kenya's economy, but is also the means of livelihood for the majority of the Kenyan people. [7]

Kenya has a rich variety of soils and agro climatic zones that allow for the cultivation of different crops. The country can be divided into 7 broad regions ranging different scales from humid to arid. The next map gives a perspective of the different regions in Kenya.

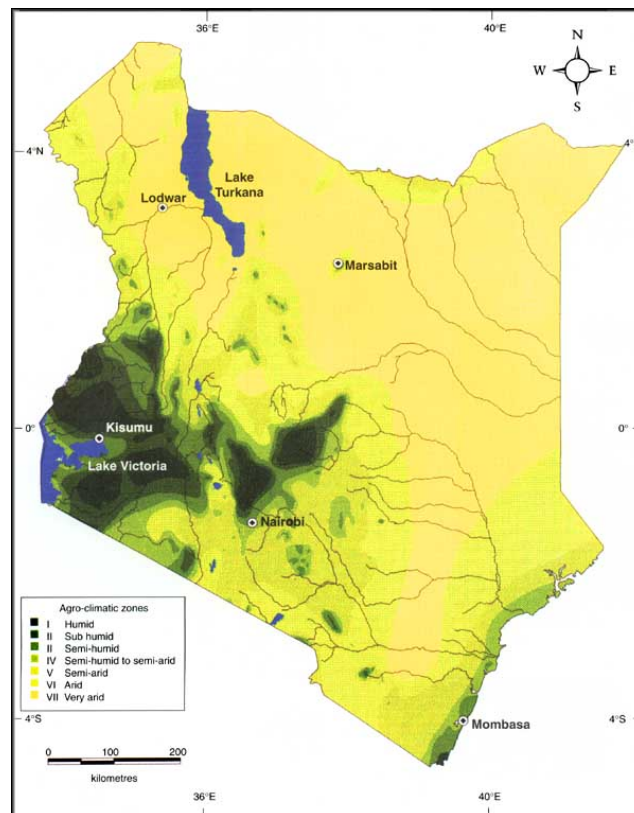


Figure 1. Agro-climatic zones Kenya

In this sense the climate is the most important factor influencing soil formation. Climate affects the soil types directly through its weathering effects and indirectly as a result of its influence upon vegetation. [8]

As a result, humid regions receive more annual rainfall and in consequence these lands are more fertile than the arid or semi-arid regions.

For those regions where agriculture is possible, the distribution of some of the main crops can be seen in the following map:

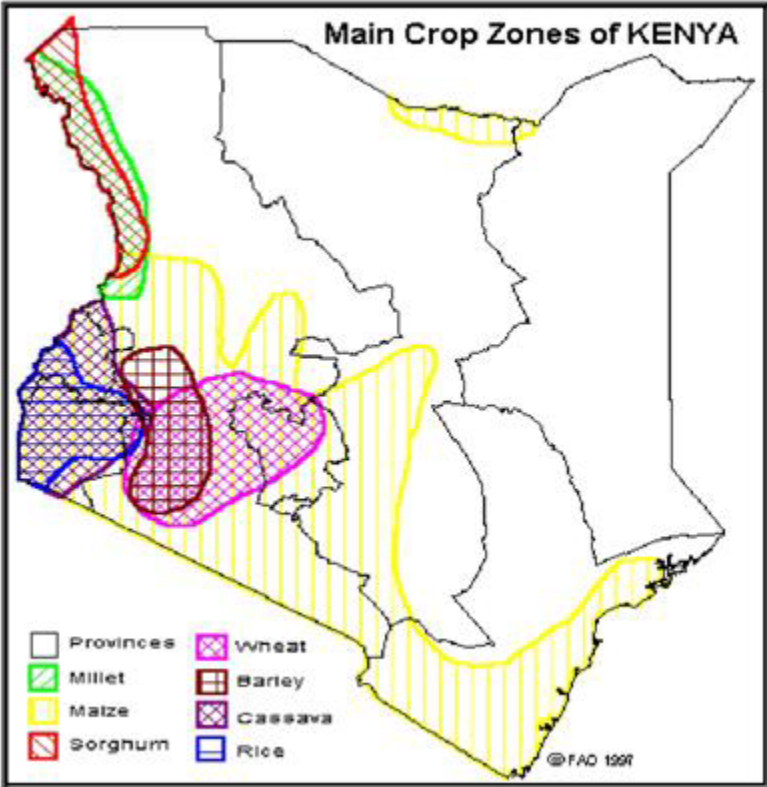


Figure 2. Main crop zones Kenya

The staple food crops in Kenya are (sorted by thousand tons of production in 2009): Maize (2439), Sweet potatoes (931), Plantains (843), Cassava (820), Beans (465), Wheat (219), Sorghum (99), Millet (54), Barley (42) and Rice (28), being maize far the most produced and consumed crop.

4. Nutrition in Kenya:

The staple foods involved in the diet of the Kenyans are mainly obtained from the local chief crops:

According to FAO Stat (2009), the average person in Kenya consumes 2155 kilocalories of food per day. Of this, 1183 kilocalories (55%) are in the form of the main staples: maize, wheat, beans, potatoes, plantains, and rice. Over the last 40 years, caloric intake per person appears to have been roughly constant over time in Kenya, dipping in the early 1990s but rising gradually since then.^[7]

The following table indicates the importance of the different food crops in the diet of Kenyan population.

Table 1. Importance of staple foods in diet of Kenya

Commodity	Quantity consumed (kg/person/year)	Daily caloric intake (kcal/person/day)	Share of caloric intake (percent)
Maize	88	768	65%
Wheat	26	196	17%
Plantains	23	56	5%
Potatoes	31	60	5%
Beans	11	103	9%
Total	180	1183	100%

Source: FAO, 2009a

Maize is clearly the main staple food in Kenya, accounting for 65% of total staple food caloric intake and 36% of total food caloric intake (FAO Stat, 2009, Table 1).

Actually in Kenya, food security has generally been taken as synonymous with maize security by policy makers and other segments of society. This is because maize is not only the main staple food but also the most common crop grown by rural poor households for food (Nyoro et al., 1999).

The average person consumes 88 kgs of maize products per year. Wheat is the second most important staple nationally, accounting for 17% of staple food consumption in Kenya. However, recent urban consumption surveys indicate that wheat products have overtaken maize in terms of expenditures in urban areas, and the share of rice in urban food consumption is also rising (Muyanga et al, 2005).

Because national maize production is not keeping pace with the growth in national demand, imported wheat and rice are increasingly filling the residual food needs gap. For this reason, the share of wheat and rice in staple food expenditures are rising, leading to more diversified basket of staples over time.

Beans are the third most important staple food nationally, accounting for 9% of staple food calories and 5% of total food calories in the national diet.

Individually, plantains, potatoes, and rice constitute less than 5% of staple food calories and 3% or less of total food calories. These crops provide a consumption “shock-absorber” to annual variations in production of the main staple, which is maize.

Vegetables, fruits and meat are also part of the diet of the Kenyans, but the list of staple foods could not be completed without paying special attention to the milk: Kenya milk consumption levels are among the highest in the developing world with an average consumption of more than a quarter liter per person per day. Most of the milk bought is raw milk supplied by the informal dairy sector.

In fact, households spent an average 18% of their income on dairy products, second only to their expenditure on cereals such as maize (27%).^[8]

5. Factors Involved in Food Security:

In Kenya the achievement of national food security is a key objective of the agricultural sector. Actually the country's food and nutrition insecurity is often attributed to the performance of the agricultural sector.

In the recent years the country has been facing severe food insecurity problems. These are depicted by a high proportion of the population having no access to food in the right amounts and quality. [3]

Current food insecurity problems can be attributed to several factors:

- Climatic factors, including the frequent droughts in most parts of the country.
- High costs of domestic food production due to high costs of inputs especially fertilizer.
- Displacement of a large number of farmers, especially those in the high potential agricultural areas.
- High global food prices associated to low purchasing power for large proportion of the population due to high level of poverty.

As a result, more than 10 million (almost a third of the population) are chronically food insecure (Republic of Kenya 2011; FAO 2011; Republic of Kenya 2008).

The next figure displays the percentage of population with food energy deficiency in some of the African countries. The bars compare results from Household Survey and FAO.

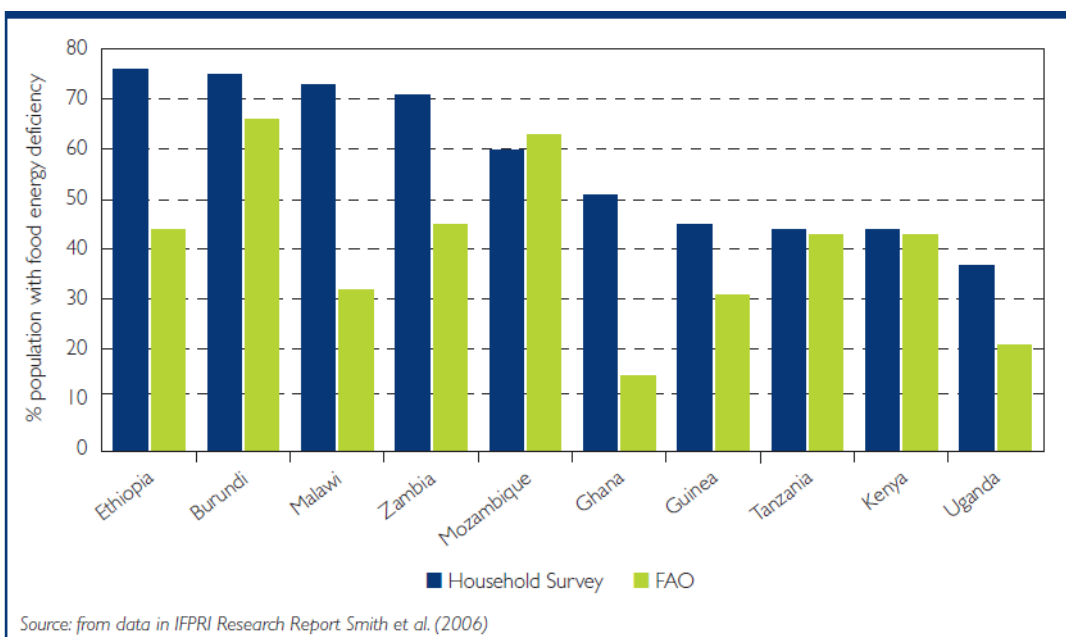


Figure 3. Percentage of population with food energy deficiency Kenya

Kenya’s 2011 National Food and Nutrition Security Policy (NFNSP) indicates that in the past 30 years, per capita food availability has in fact declined by more than 10% (Republic of Kenya 2011). Moreover, Kenya’s food security and nutrition needs are further complicated by an unstable economic environment, a recent rise in food and fuel prices, adverse weather conditions, insufficient budgetary allocations and weak sector coordination. [10]

In order to measure numerically the dimensions of food insecurity and undernutrition, FAO provides with the indicators displayed in the following table: [11]

FOOD SECURITY INDICATORS	DIMENSION	
Average dietary energy supply adequacy Average value of food production Share of dietary energy supply derived from cereals, roots and tubers Average protein supply Average supply of protein of animal origin	AVAILABILITY	STATIC and DYNAMIC DETERMINANTS
Percentage of paved roads over total roads Road density Rail lines density	PHYSICAL ACCESS	
Domestic food price index	ECONOMIC ACCESS	
Access to improved water sources Access to improved sanitation facilities	UTILIZATION	
Cereal import dependency ratio Percentage of arable land equipped for irrigation Value of food imports over total merchandise exports	VULNERABILITY	
Political stability and absence of violence/terrorism Domestic food price volatility Per capita food production variability Per capita food supply variability	SHOCKS	

Table 2. Indicators involved in Food Security

The table summarizes the main determinants of Food Security, not only for Kenya but for any region in the world.

These determinants combined result into different outcomes such ‘Prevalence of undernourishment’ or ‘Share of food expenditure of the poor’ that give a perspective of the problems of food insecurity in a country.

6. Policy Making for Changes in Farming Practices:

There are many policy responses to alleviate food crisis and to improve Food Security in a country. These can be divided into 3 categories [3]: Supply related policies, Price related policies and Income related policies.

Some of the policies for improving Supply are enumerated in the next list:

- Subsidies on farm inputs, especially fertilizers.

- Rural credit for farming.
- Improvement in rural infrastructure.
- Development rural agricultural markets.
- Improvement of the management of natural resources, especially water.
- Providing farmers with planting materials and quality seeds.
- Encouraging diversification of crops planted.
- Encouraging the citizens to diversify their eating habits to other foods and avoid over-reliance on maize.

The present paper mainly deals with the last 2 policies, analyzing the outcomes under a different crop diversification and different eating habits, looking also at the influence of these changes in other sectors of economy and society. A future continuation of the present research will take over the consequences also in the environment.

But before changes are introduced, any project has to take four matters into consideration [4]:

- The physical environment.

A project cannot introduce new crops or new varieties of crops that do not take differences in soils into account; otherwise the farmers will reject the changes.

- The technical feasibility of possible changes.

If a change in farming practices requires special inputs or equipment, the change is technically feasible only if the inputs or equipment can be made available to the farmers at the proper time.

- The economic return on new techniques.

The change must make farmers to earn more than it cost to them, even in a bad year when harvests are disappointing, otherwise they will reject the change.

- The social acceptability of the changes.

Food is grown to be eaten. If a farming household does not like the taste of a new variety of food crop, they are not going to grow it. The crop is not socially acceptable to them.

But when these constrains are overcome, changes in the crop mix are made under different priorities depending on the needs of the farmers and people involved in agriculture. In the case of Kenya it affects to a big share of the population in general.

In concordance with the physical environment as first limitation to implement new farming policies, the crop choice is mainly aimed to satisfy nutrition, meaning that, when it comes to

farmers, productivity and variety are assumed to be enough in order to satisfy the basic nourishment of their families.

In a second level the priority is to maximize profits through the choice of crops that return more revenues, and finally, in a third level farmers would be concern about an ecological way of farming:

Summarizing Crop Mix preferences by priority:

- 1st Nutritional needs (food demand (kcal per hectare), nutritional diversity)
- 2nd Incomes (yield (kg per hectare), price)
- 3rd Sustainability (environment, biodiversity, robustness against climate change)

The next picture depicts a synoptic diagram of the model that represents the first priority:

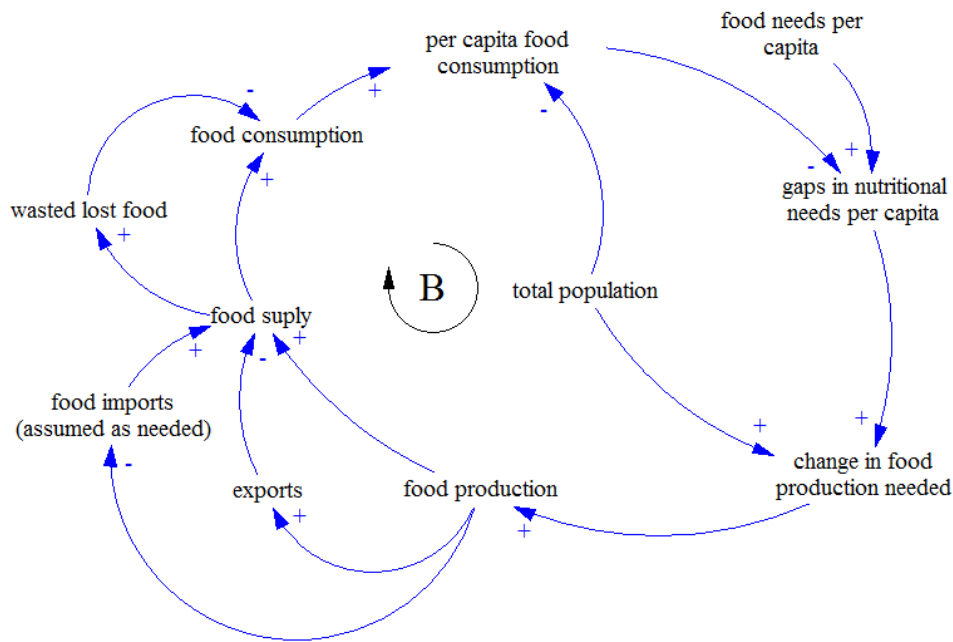


Figure 4. Causal Loop Diagram depicting the loop involved in nutritional needs.

1st Priority: When it comes to analyze crop yield, the units to take into account are kg per hectare. However, a very brief analysis of units tells that the aim of the first priority is optimize kcal per hectare, including a subscript that covers the different basic food branches.

On the other hand, if we consider prices, from yield we obtain incomes per hectare.

2nd Priority: For every 10% increase in yields in Africa, it has been estimated that this leads to a 7% reduction in poverty: growth in manufacturing and service sectors has no such equivalent effect. Also, countries will have to find novel ways to boost crop and livestock production if they are not to become more reliant on imports and food aid. [12]

3rd Priority: Sustainability also entails resilience, such that the food system, including its human and organizational components, is robust to transitory shocks and stresses. In the short to medium term non-renewable inputs will continue to be used, but to achieve sustainability the profits from their use should be invested in the development of renewable resources. [12]

The present paper deals with priorities 1 and 2 but leaves priority 3 for a possible future enlargement of the research.

7. Socio-Economic Impacts:

Isolating the effects of improved nutrition on labor productivity and on health, education, and other human-capital investments is proving to be very difficult. [13]

Also health, education, poverty level and other socio economic indicators have in turn a crucial influence on nutrition:

Kenya's high rates of undernutrition and poor micronutrient status are not only a result of a deficient agricultural system and high poverty rates, but also a consequence from lack of access to adequate water and sanitation and safe hygiene practices, as well as malaria and HIV/AIDS (Shrimpton and Saldanha 2011; KNBS & ICF Macro 2010). Insufficient "awareness and knowledge on nutritionally adequate diets and limited resource allocation and capacity to support the implementation of comprehensive nutrition programs" (Republic of Kenya 2008, 11) are additional factors.

Immediate causes of malnutrition include inappropriate dietary intake - primarily among young children - and a high disease burden. Most Kenyans still rely on diets composed primarily of staple foods that are not sufficiently diverse in micronutrients, compromising growth and development. Furthermore, the disease burden is high for children, which further contributes to and is worsened by undernutrition. Improving the micronutrient status of mothers can improve infant birth weight and growth after birth, and contribute to the reduction of stunting at two years of age, providing children with improved physical and cognitive capabilities as well as stronger immune systems.

The model presented in this paper includes in a brief manner the most important socio economic aspects linked to Food Security. The model is inspired by the Threshold 21 (T21) Kenya model developed by the Millennium Institute [14], which is a simulation-based decision support tool to facilitate the design of effective policies for the most relevant national development issues such as broad-based economic growth, poverty reduction, climate change, etc.

The next figure depicts the main links between the model sectors:

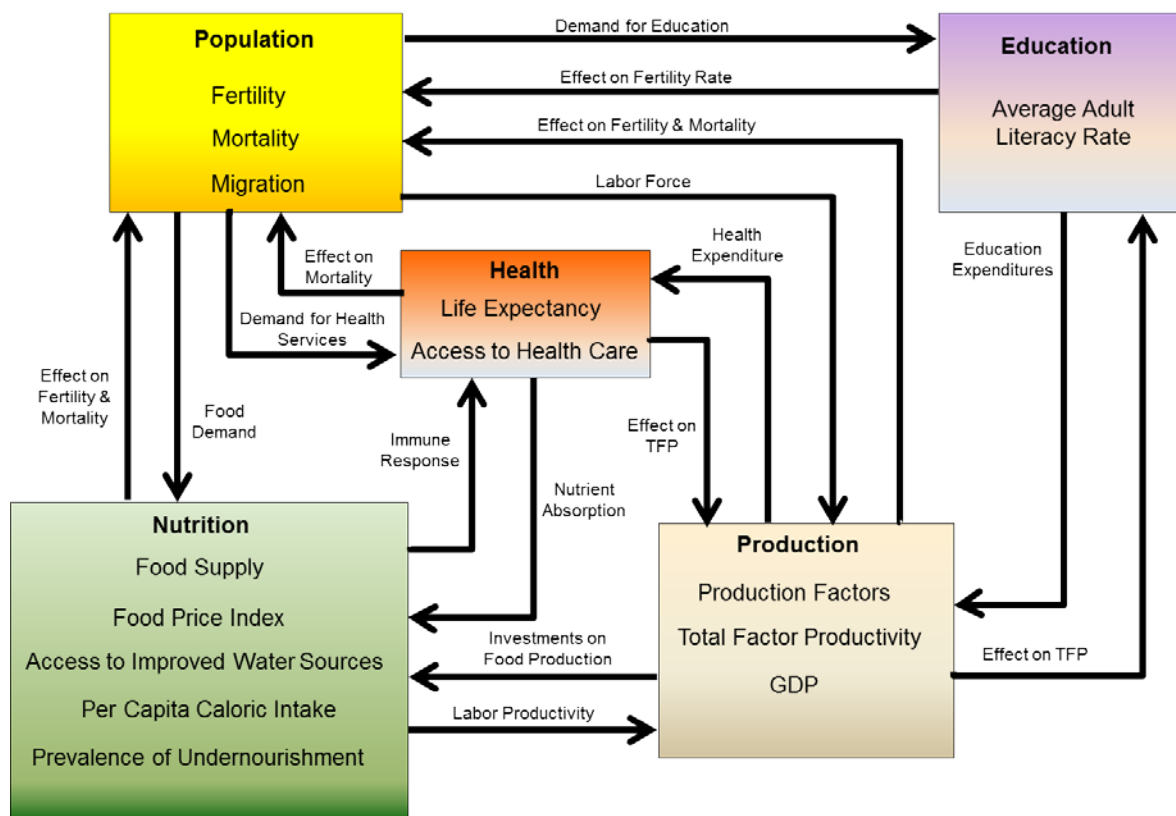


Figure 5. Main links between the different model sectors.

This structure is causative of the main feedback loops portrayed in the model.

In a more specific manner, the next causal loop diagram (CLD) shows the most relevant feedback loops that link prevalence of undernourishment, one of the key variables, with the rest of the socio-economic indicators:

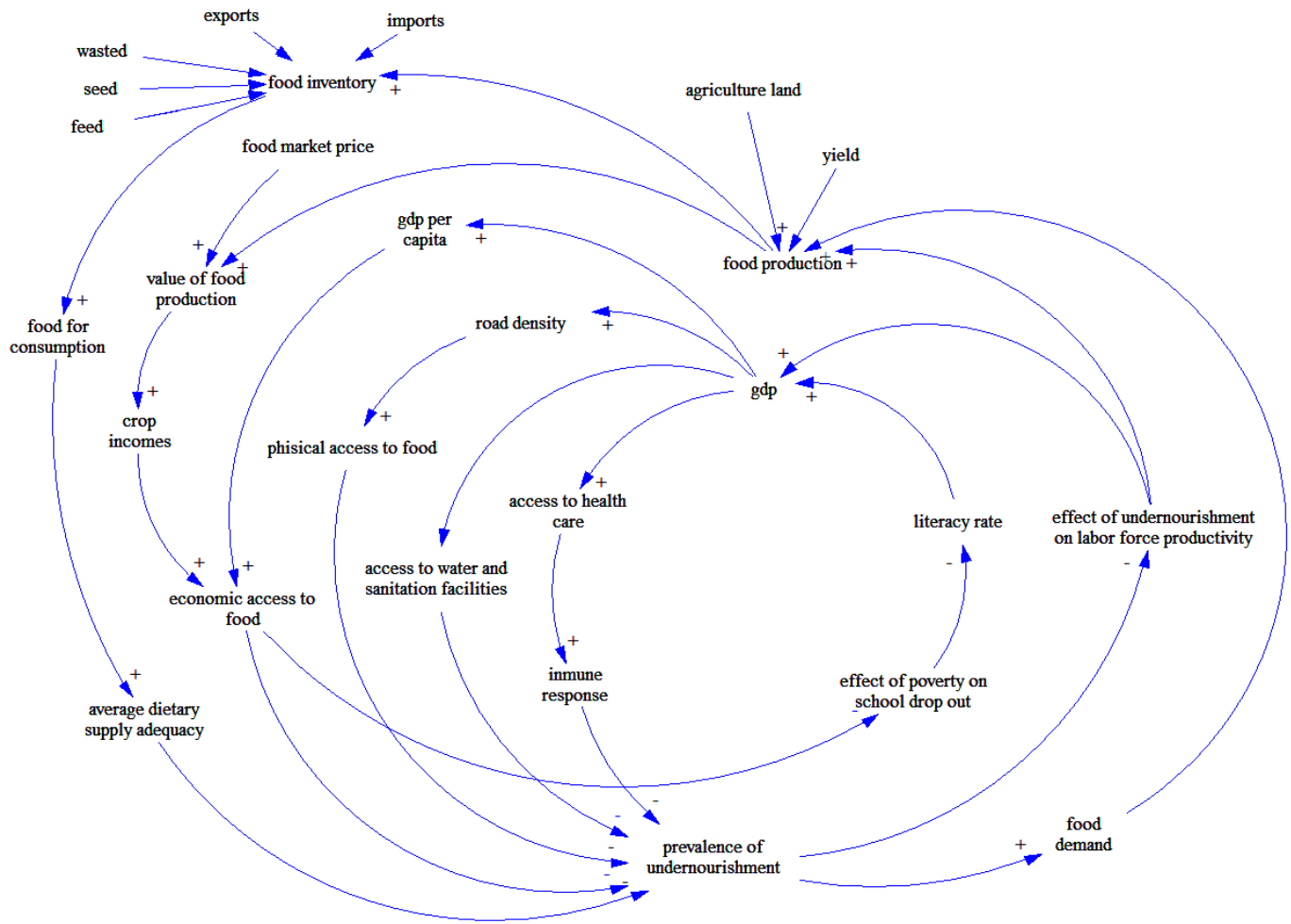


Figure 6. CLD with the main socio economic issues related to undernourishment.

The nutrition sector is dynamically linked two-way with the rest of the model: in one direction, the socio economic indicators decisively influence on the prevalence of undernourishment.

In the other direction, the nutrition level and daily calorie consumption has a critical influence in food demand and also in labor productivity.

As an example, the next picture gives a perspective of how daily calorie consumption can influence on agricultural labor productivity.

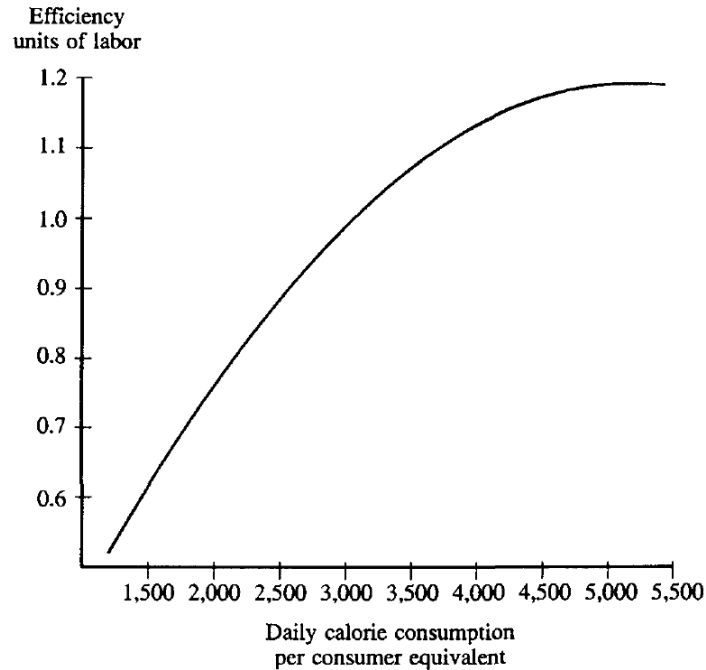


Figure 7. Estimated efficiency labor function for Sierra Leone farm households. [13]

Actually undernourishment reduces also the immune response of the population, resulting in a significant amount of hours lost at work [15]

8. Model Results:

As indicated before the model calculates the prevalence of undernourishment through the effect of different indicators.

The most relevant indicator is the Food Supply, which leads to Dietary Energy Supply (DES), a compound shaped by the supply of the most important staple foods: These are Cereals, Fruits, Pulses, Roots and Tubers, Sugar and Sweeteners, Vegetable Oils, Vegetables, Meat and Milk. The variables related to the staple foods include a subscript to differentiate the amounts for each of them.

The indicator Average Dietary Energy Supply Adequacy expresses the Dietary Energy Supply (DES) as a percentage of the Average Dietary Energy Requirement (ADER) in Kenya.

The average supply of calories for food consumption is normalized by the average dietary energy requirement estimated for its population, to provide an index of adequacy of the food supply in terms of calories.

Discrepancies between 'Average Dietary Energy Supply Adequacy' and 'Prevalence of Undernourishment' allow discerning whether undernourishment is mainly due to insufficiency of the food supply or to particularly bad distribution.

Actually the gap due to a bad distribution is calculated through the most relevant socio economic indicators that lead to the obtaining of the basic dimensions of Food Security: Access (physical and economic access), availability, utilization and vulnerability as the most important ones.

It's important to note that for the projection of food supply, the simulation takes into account estimated trends in yield. The next picture is illustrative about future yield projections in some of the chief crops:

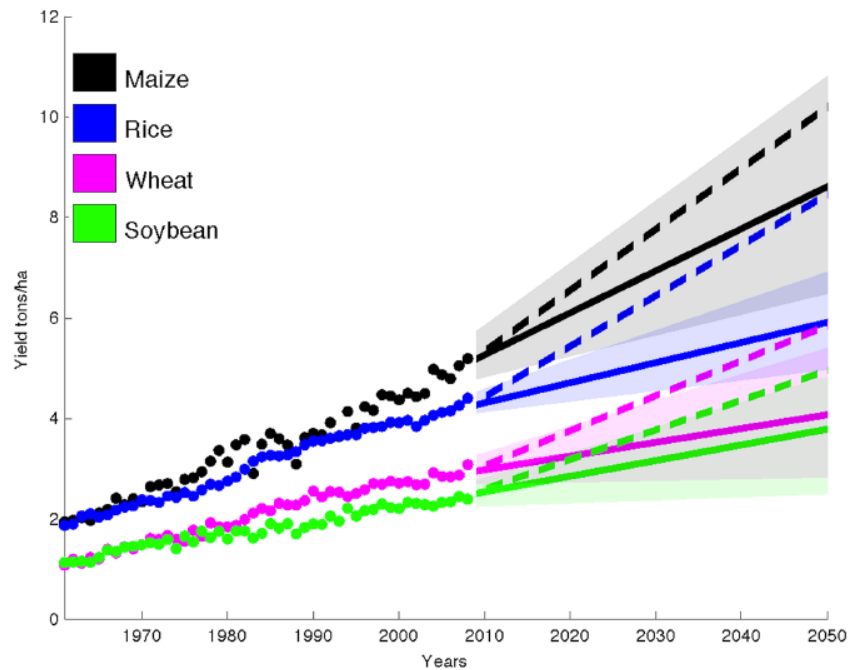


Figure 8. Estimated yield global projections [9].

The dots represent historical values while solid lines provide the projections for 2050. Shading shows the 90% confidence region and the dashed lines show the trend of 2.4% annual yield improvement required to double production by 2050 without bringing additional land under cultivation.

The model indicates that the most relevant and sensitive parameters in Kenya influencing food distribution are 'access to improved water resources', 'access to health services', 'road density', 'GDP per capita' and 'agriculture incomes'.

In a default scenario where yields follow the trends indicated in the literature and the population and economic growth as expected, it is observed a progressive increase of the percentage of undernourished people. This is basically because the increase in yield cannot cope with the population growth.

The next figure shows historical prevalence of undernourishment versus projected in the default scenario.

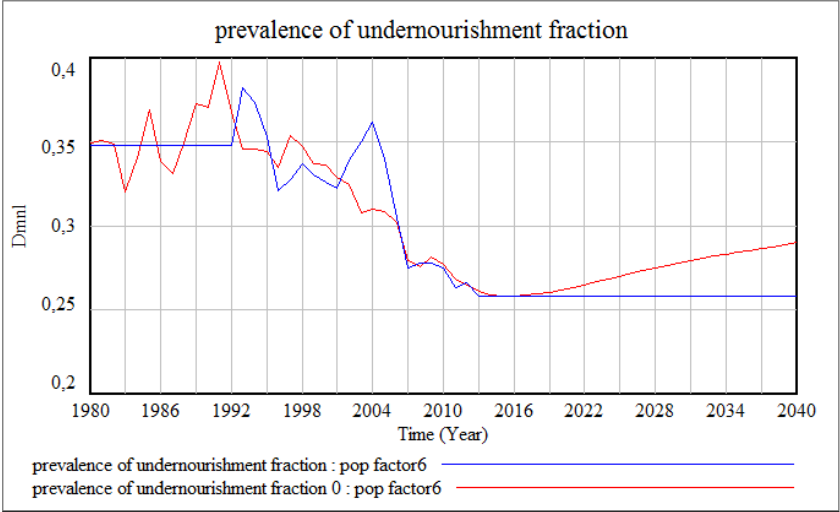


Figure 9. Prevalence of undernourishment in BAU scenario.

However, this scenario considers the total agriculture land as a constant, while possibly more land could be used for agriculture in the future. Moreover, imports are consider as constant at the level of 2009 (last data point), and since the projection of GDP per capita provides a significant increase during the next years, as indicated in figure 7, it's expected a parallel increase in food imports, reducing again the undernourishment level.

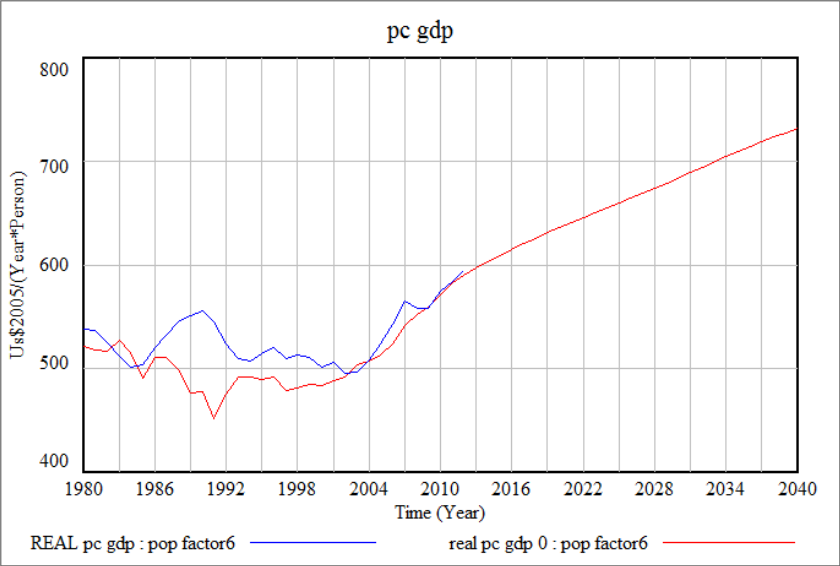


Figure 10. Historical GDP per capita versus GDP per capita in BAU scenario.

Regarding alternative crop mixes the model indicates major differences in nutritional levels depending on the land share use for the different staple foods.

As an example, a possible interchange between the land used for cultivation of roots and tubers and the land used for cereals would provide a significantly higher caloric return per capita, resulting in a significant reduction in undernourishment as indicated in figure 8.

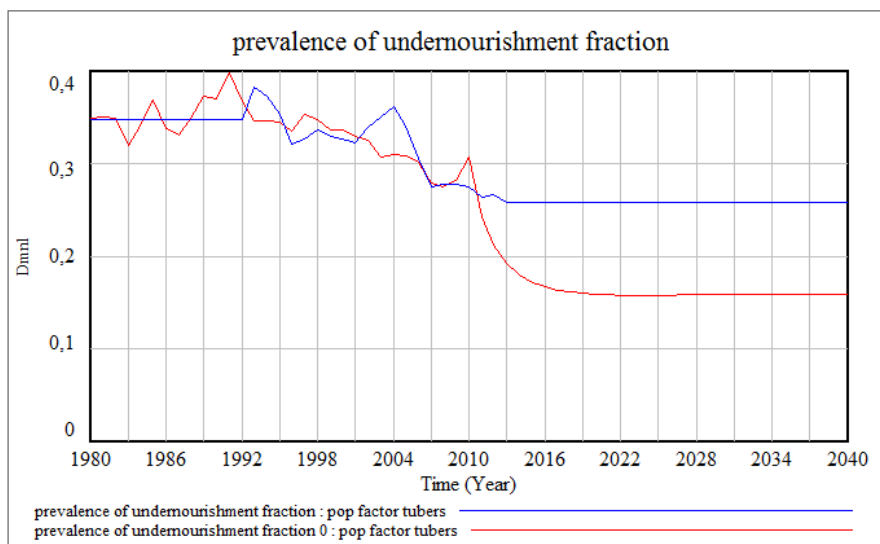


Figure 11. Crop mix interchanging Roots and tubers land with Cereal land.

However these changes in crop mixes would involve huge investments in infrastructure, inputs and resources that need to be taken into account since they would influence the economic growth in a decisive manner. Ongoing research will include the feasibility of such implementations, and provide with numeric results for the different sectors.

9. Conclusions:

There are many causes of a deficient agriculture system in Kenya that leads to food deficits and undernourishment. Poverty is a very important factor but also population growth, urbanization, land pressure, and a crop mix influenced by the needs of higher profitability.

Even assuming that the trends in yield for the future are achieved, it is unlikely that food production in Kenya will provide both, sufficient food supply and enough revenues for the farmers, especially in areas with low soil fertility like in the semi-arid regions.

Maize productivity growth is an essential goal to foster the development of the farming sector, to reduce import dependence and to improve food security. However, a gradual shift in the crop mix could also alleviate the problems of small farmers by moving to a more diversified crop mix that can maximize the value of output per unit of land.

In regions where the agro-climatic conditions are suitable, maize will continue to be the dominant crop. However, for small farmers in the rest of the regions agriculture should shift towards crops with higher returns per unit of land, and higher productivity growth.

While this transition is essential for poverty alleviation in millions of small farms in Kenya, especially in semi-arid areas, this outcome is not assured. Faster progress in reducing poverty rates will depend on larger investments in agricultural productivity growth. The government of Kenya has a crucially important role to play in this process.

References:

- [1] The State of Food Insecurity in the World. The multiple dimensions of food security. 2013
FAO.org
- [2] Food insecurity and malnutrition in Africa: Current trends, causes and consequences.
<http://www.consultancyafrica.com>
- [3] Food Security Report (Prepared by Kenya Agricultural Research Institute)
<http://www.foodsecurityportal.org>
- [4] CONSTRAINTS ON CHANGES IN FARMING PRACTICES <http://content.alterra.wur.nl>
- [5] Paul Maeder, Andreas Fliessbach, David Dubois, Lucie Gunst, Padruot Fried, Urs Niggli. May 2002. Soil Fertility and Biodiversity in Organic Farming
- [6] STAPE FOODS VALUE CHAIN ANALYSIS. COUNTRY REPORT – KENYA. January 2010. USAID
- [7] Improving the Nutritional Quality of WFP’s Food Basket –An Overview of Nutrition Issues, Commodity Options and Programming Choices. October 2008. United Nations World Food Program
- [8] Apollo Bwonya Orodho. Country Pasture/Forage Resource Profiles. FAO.org
- [9] Deepak K. Ray, Nathaniel D. Mueller, Paul C. West, Jonathan A. Foley. Yield Trends Are Insufficient to Double Global Crop Production by 2050. June, 2013
- [10] Kenya: Situation analysis for Transform Nutrition. 2011. <http://www.transformnutrition.org>
- [11] Food security indicators 2013. FAO.org
- [12] Foresight. Government Office for Science. The Future of Food and Farming: Challenges and choices for global sustainability.

[13] JOHN STRAUSS. The Impact of Improved Nutrition on Labor Productivity and Human-Resource Development: An Economic Perspective. ifpri.org

[14]. Andrea M Bassi, T21-Kenya core team, Dr. Prakash N K Deenapanray, Zhuohua Tan 2011. Strengthening Institutional Capacity for Integrated Climate Change Adaptation & Comprehensive National Development Planning in Kenya. Final Report.

[15] Ross A. Hammonda, Laurette Dubéb. A systems science perspective and transdisciplinary models for food and nutrition security. July 2012 PNAS.org