Food Security in Development Countries:

A systemic perspective

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Abstract: Food security is a worldwide problem that has called the attention to Governments and the scientific community. It particularly affects developing countries. The scientific community has had increasing concerns for strategic understanding and implementation of food security policies in developing countries, especially since the food crisis in the 70s. The process of decision-making is becoming increasingly complex due to the interaction of multiple dimensions related to food security. This research explores the food security process from a national approach for developing countries through the study of its three main components: availability of food, access, and the stability of food security.

It is based on a systemic perspective through the use of systems dynamics as means of understanding the complexity of this phenomenon as well as the (interrelation) linkage and interdependency of its factors. The study empower the planners of local regions in the decision making process, to foresee future threats, to alleviate partly the scarcity of food and to handle the mismanagement of food resources.

Keywords: Food security, models, food policy, system dynamics, systems thinking, methodology.

1. Introduction

Since the World Food Conference in 1974, due to food crises and major famines in the world, the term Food Security (FS) was introduced, evolved, developed and diversified by the academic community and politics. Around two hundred definitions of the term have been deployed (Smith et al., 1992) considering the problem of FS from original view points. The diversity of these visions indicates that intervention in the existing system is not a simple matter.

The high complexity in a country's FS is due to several factors, including the lack of tools or methodologies capable of assessing the effects of long-term policies in the system, actors failures in playing proper roles in the system thus acting under different influences and pressure, the lack of a holistic system model to facilitate intervention and understanding of the system (Saeed, 1994), the high causality between different contexts in a country such as the socio-economic, political and environmental development, performance of the food economy and practices related to the health sector.

Policy makers tend to make decisions supported by models from which potential effects, trends and behavioral policies emerge. The purpose of this article is to study food security from a national level viewpoint through modeling within system dynamics, and the analysis of its key components such as food availability, access to food resources and stability of food security in a country with the aim to supporting plans, programs and food security strategies. Would evaluation of public policies in the sector, and its long-term effects, facilitate the understanding of this phenomenon from a systemic formulation? What lessons can be drawn from existing approaches for future methodological developments? How serious would the behavior of the system be if there exists an identification and effective coordination of actors performing their roles over it?

In response to these questions, our proposal is to identify a methodology capable of providing understanding and an integrative view of the system that serves as a lever on decision making by assessing the impact of policies in the food sector.

The system dynamics modeling and simulation are tools that provide identification of causal relationships and critical variables yet allowing the analysis of various scenarios of intervention in favour of an effective decision-making.

2. Literature Review on Food Security

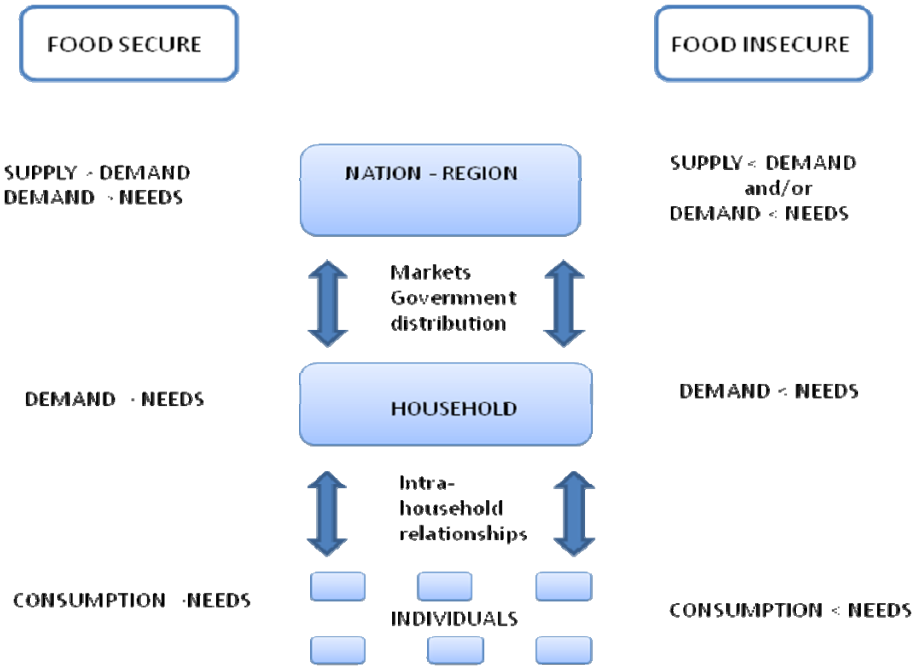
2.1 Contextualizing

During the debates that preceded the World Food Summit held in Rome in 1996, it was established that "*There is food security when all people at all times have sufficient physical and economic access to safe and nutritious food to meet their dietary needs including food preferences, in order to live a healthy and active life*". When an invidual or population lacks, or is potentially vulnerable due to the absence of, one or more factors outlined above, then it suffers from, or is at risk of, food insecurity.

It is considered that over 854 million people in the world are affected by food insecurity from which -According to assessments made by the Food and Agriculture Organization of the United Nations (FAO) in the years 2001/2003- 820 million are in developing countries, 25 million in countries in transition and 9 million in industrialized countries (FAO, 2006). A common strategy among different nations of the world to reduce or eliminate all manifestations of hunger and tackle food insecurity is currently under implementation as the World Food Summit and the Millennium Development Goals have proposed, i.e., to achieve the halving in the proportion of people in the world who suffer from hunger. The time horizon raised for the achievement of this goal is the year 2015, focusing on developing countries to generate food plans, national and regional programs, and public policies aimed at improving the FS.

These initiatives should basically pursue three objectives: ensure adequate food production, ensuring maximum stability in the flow of food and guaranty access to available food of those in need. Figure 1 shows the related factors of FS expressed in terms of supply, demand and stability related to nutritional needs.

Figure 1. Levels of Food Security.



Source: (Thomson, A. and Metz, M., 1999)

2.2 Approaches to Food Security

The evolution of FS approaches has basically followed three phases. The first took place as a dominant theoretical explanatory framework for food crises, since the time of Malthus (the late eighteenth century) until the year 80, what Sen. (1981:57) called the FAD approach, Food Availability Decline. This approach conceived famine as shortages of food supplies per capita, motivated by natural factors; e.g., drought, floods and other calamities that undermine crops; or demographic factors, i.e., vegetative growth that goes beyond the supply (Hewitt de Alcantara, 1993).

The second approach claimed that hunger and famine does not necessarily evolve from lack of food supplies in the market, but lack of resources in sectors to produce or purchase them. These criticisms over the FAD ended up in the alternative model of "Entitlement" proposed by the economist Amartya Sen, in his decisive 1981 book, Poverty and Famines, as an explanation of famine. "Entitlements" to food are the capabilities or resources of an individual or family to legally access, produce and purchase or accept donations from the State or the community (Perez A, 1996). This approach focuses on the family rather than

the country, but shortly after introducing the term individual, focuses not only on the availability but on the access to food, as determined by vulnerable socio-economic degrees (Sahn, 1989; Swift, 1989; Frakenberger and Goldstein, 1990).

From an individual perspective, it is said that a person enjoys food security when his/her consumption is always greater than his needs, defined as physiological needs. Following this logic, many current definitions of food security focus on the individual. However, there is a complex link between the individual, household, community, nation and the international economy.

To construct public policies, food security can be approached from various perspectives, from the micro-nutrition (single), family level, as a means to ensure a regular supply of food as well as from national, to the regional or local level. To create an environment that permits access to supporting systems for each individual in order to ensuring food security from both micro and macro perspectives, represents a great challenge and an important goal of food policy.

2.3 Models on food security.

During the last half century, a number of individuals and institutions have used models with the aim of projecting and predicting global food security, focusing on the future demand for food, supply and variables related to the food system at different levels. For a detailed description of developed models and assessment on the implementation of these projections see MacCalla and Revoredo (2001).

The methodology used to develop the projections and predictions on food relies on correlated models. Such methodology is controlled purely by data and do not give insights into the causal relationships in the system. This definition implies that what really matters in these models is their aggregate behavior, which is independent from the particular characteristics of their internal structure. Econometric models —widely spread in the macroeconomic modeling area— belong to this category. Their main objective is to forecast at short or medium term, and their validity depends mainly on the similarity of behavior generated by the model within historical data; their modelers focus on enhancing the ability of the model to reproduce the real behavior of the system in the past rather than the representation of the actual structure of the system. Due to their interest on the behavior of the input-output and low interest given to the internal structure of the model, these types of models are not designed to be transparent and are often tagged as "black boxes". See some of the models developed around the FS and their different approaches to implementation in Table 1.

Table 1. Some models on FS and its approaches

MODEL	EMPHASIS
Diakosavvas and Green (1998) *Assessing the impact on food security of alternative compensatory financing schemes. A simulation approach with an application to India*.	Studies the impact on consumption of food and the different variations of CCFF)
Coxhead (2000) *Consequences of a food security strategy for economic welfare, income distribution and land degradation the Philippine case.*	Approaches the study of food policies from environmental and economic welfare perspectives
Mohanty and Peterson (2005) *Food security and government interventions a study of indian grain markets*	Analysis on supply and demand of food and the demographic changes
Rosegrant et, al. (2005) *The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT-WATER).*	Global availability of food. Applied demand of water.
Holden et, al. (2005) *Policy Analysis for Sustainable Land Management and Food Security in Ethiopia. A Bioeconomic Model with Market Imperfections***.**	Bio-economy model explores the relationship between ecology and economy and its impact.
USDA (2006) *Food security assessment*	Food consumption, access and food gaps.
Ianchovichina et, al. (2001). *Resource use and technological progress in agriculture: a dynamic general*	Effects on economy, population growth and environmental

equilibrium analysis.	resources on food security.
FAO, (1995*) World Food Model (WFM).*	Demand and Availability of food and Development of software for forecasting supply -vs- demand and sales network from 150 countries
PODIUM (Policy dialogue model) by IWMI	Availability of food and supply of water
Falcon et, al. (2004). *Using climate models to improve Indonesian Food Security*	Relationship between climatic change, supply and availability of food.

3. Why System Dynamics?

System dynamics is a problem-oriented multidisciplinary approach that allows to identify, to understand, and to utilize the relationship between behavior and structure in complex dynamic systems. The underlying concept of the System Dynamics implies that the understanding of complex system's behavior -such as the national food insecurity- can only be achieved through the coverage of the entire system rather than isolated individual parts. However, it is important to note that the approach is not entirely holistic, as it is necessary to use some elements from reductionism in order to describe the behaviour of the various components of the system (Colin 1997).

Generally, the models developed around food security used correlations to explain relationships, but the introduction of systemic methodology is preferred in the formulation of models due to the following: because it is a methodology that helps to understand why things are happening now, its great interest is on the causation of variables, furthermore, its main purpose is the evaluation of policies and their long term influence. Such models can be designed to allow the user analyze and manipulate its internal structure as well as to study the relationship between the structure and the behavior of the model. These models are often tagged as "white boxes" due to their transparency.

The use of the System Dynamic tool, for better understanding the phenomenon of FS, finds its main application on those environments in which human complex decisions —often guided by the logic— are involved and where attempts to stabilize the systems end up oftenly in a real destabilization of it (Sterman, 2000).

The simulation of dynamic systems models are more explicit when taking into consideration the assumptions on how they interact with each other. It does allow to identify the critical variables that affect the phenomenon, how they face induced changes and their behaviour over time, encouraging the development of more probable scenarios.

Different models have been developed worldwide in order to understand the interaction of various factors and how to carry out the optimization of demographic, economic, industrial and agricultural systems among others. Among the pioneering works are The Limits of Growth Dynamics, Dynamics of Growth in a Finite World, Mankind at the Turning Point and Catastrophe of New Society (Deutsch, 1984), all designed through the use of different software tools. What behavior is the best scenario for the future?, It depends on the policies chosen by men (Forrester, 1971).

As they are more transparent and appropriate for policy evaluation, descriptive -causal models tend to make more useful contributions to the study of the phenomenon of FS. See some of the models developed using the System Dynamics around the FS and their different approaches to implementation In Table 2.

Table 2. Some Systems Dynamic models on FS.

MODEL	EMPHASIS
Bach et al. (1992). *Food self-sufficiency in Vietnam: a search for a viable solution.*	Studies various possible solutions to self-sufficiency on food (supply) in Vietnam.
Bala (1999). *Computer Modelling of Energy, Food and Environment: The case of Bangladesh.*	An integrative Vision of energy, food and environment applied to Bangladesh.

Gohara (2001). *A System Dynamics Model for Estimation of Future World Food Production Capacity.*	Analysis on supply and demand of food worldwide.
Meadows (1976). *Food and Population: Policies for the United States.*	Analysis on supply and demand of food as well as demographic changes.
Meadows, (1977). *The World Food Problem: Growth Models and Nongrowth Solution.*	Analysis of the global food problem as seen from both, growth models as well as non-growth models approach.
Quinn (2002). *Nation State Food Security: A Simulation of Food Production, Population Consumption, and Sustainable Development.*	Model simulation that links food production, the requirements of the population consumption and sustainable development.
Saeed, et al. (1983). *Rice Crop Production Policies and Food Supply in Bangladesh.*	Policy analysis applied to rice and food supply
Georgiadis et al. (2004). *A system dynamics modeling framework for the strategic supply chain management of food chains.*	Analysis on management of food supply chain.
Saeed (2000). *Defining Developmental Problems for System Dynamics Modeling: An Experiential Learning Approach*	Application of a model to constructing a reference mode addressing the food security problem in Asia

4. Approach to the Model

An added model has been proposed to study the performance of the system structure and how it would assess the implications of proposed policies in a time-horizon of 20 years. This proposal is based—as stated in the initial part of the article—on the study of the interaction between the three major components covered by national food security such as: food availability, access to food and stability among the media production and the means to acquire them.

Three basic levels in the system related to the stock of food products, land intended for food and nonfood have been identified. On this assertion a proposed hypothesis is now designed: If the representation of food is understood as the mixture of food products, it would be easy to predict that the system will not change in the future and, if it changes, it would not affect the dynamics of the system. Prices of food commodities as well as prices of nonfood determine the flow between the type of land use and food production.

The relationship between food production and livelihoods are given by the labor productivity due to adequate access to food propitiated by the income for feeding and non feeding production, as well as the income distribution and commodity prices needed to sustain an active and healthy life. Price of nonfood, demand of nonfood, non agriculture production and income distribution have been defined as exogenous variables because they are not subject to this research.

The population dynamics related to access to food, and the necessary basic quantities of food, define the flow of sales of the food produced.

Perhaps the best way to define food security from a national perspective is the satisfactory balance between the demand and supply of food at reasonable prices. According to the above definition, and representations in Figure 2, changes in food security can be identified over time in accordance with price increases. These increases will first affect the poorest as they spend a greater portion of their income on food. The absence of imbalance, between demand and supply of food, does not mean that all households in a country enjoy food security, but if lacking, it is because they are not entitled to food, i.e., what economists call effective demand, for the poorest have no opportunity to fully express their preferences and real needs for food in the market.

Figure 2. Causal loop diagram

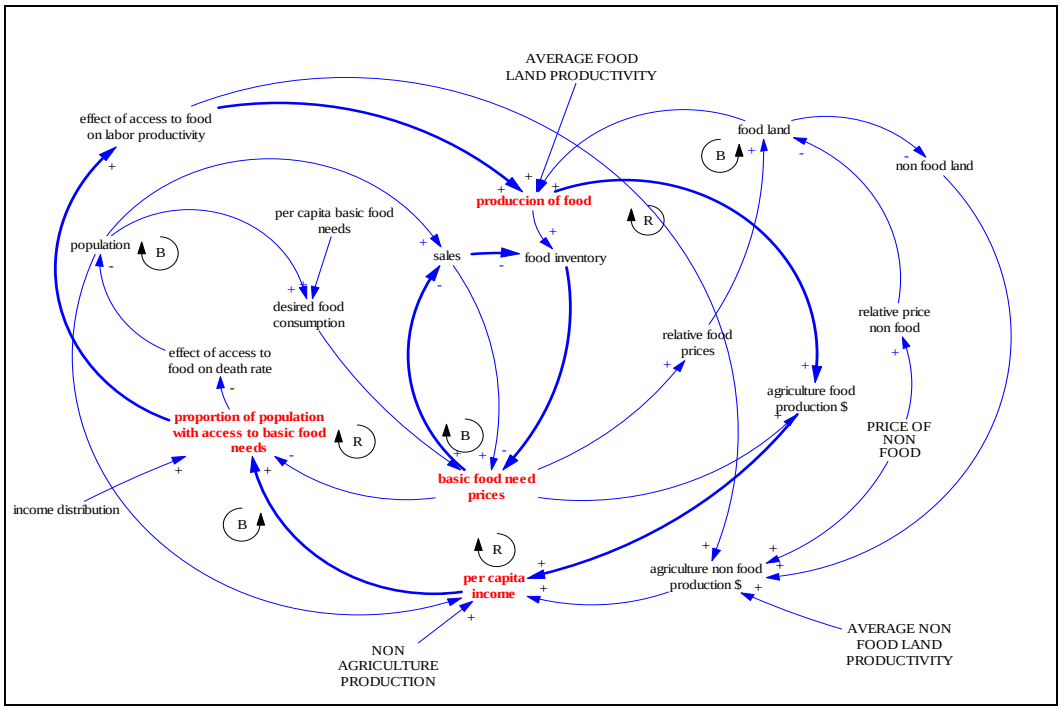
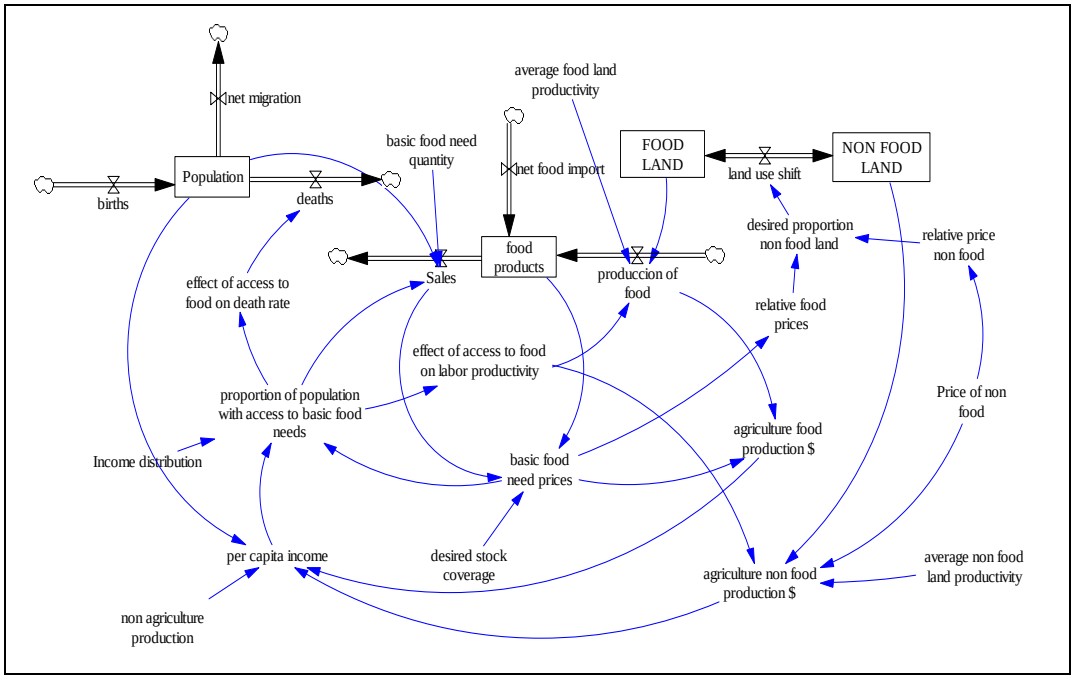


Figure 3. Flow and Levels Diagram



5. Final comments

This paper concerns the strategic understanding and the development of tools to guide the implementation of food security policies in developing countries. We consider the process of decision-making in the public sector, which has been increasingly complex due to the interaction of multiple dimensions, related to food security. Policy makers normally use models to support their decisions. This research explores the food security process from a national approach for developing countries through the study of its three main components: The availability of food, the access to food resources and the stability of food security. It bases its study on a systemic perspective through the use of Systems Dynamics as means of understanding the complexity of this phenomenon as well as the (interrelation) linkage and interdependency of its factors.

The study empower the planners of local regions in the decision making process, to foresee future treats, to alleviate partly the scarcity of food and handle the mismanagement of food resources. The model is under construction, with still a long way to have a useful model for policy analysis. The aim for a poster presentation is to get direct interaction with related scientific community.

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