System Dynamics Updates of FAO Methodological Guide to Understand the Food Supply and Distribution Systems (FSDS) in developing and transition countries

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1 ABSTRACT

What should be the policy to meet urban food needs in developing countries and those in transition? Is the main question of the Food and Agriculture Organization of the United Nations (FAO), posed into the "FAO's methodological and operational guide to study and understand Food Supply and Distribution Systems (FSDS) to cities in developing countries and countries in transition" (Aragrande and Argenti, 2001), in order face the current overwhelming increase of urban population and the increasing urbanization pressures on food systems. The System Dynamics Italian Chapter has been assigned to lead the FAO's methodological update for FSDS using complex system methodologies. We argue that clarifying the several problems and structure behind FSDS in urban environments is vital to assess policies that aim at meeting urban food needs. Thus, the aim of this work is to improve FSDS understanding by addressing the limitations of the current "FAO's methodological and operational guide to study FSDS" or what is called in this paper "FAO's Framework for FSDS Analysis" (FFFA) through a Systems Thinking (ST) and System Dynamics (SD) approach, and to propose an alternative, systemic, view of the various aspects involved. In order to do this, in previous works we have developed an epistemic ground to understand FSDS and compare the performance of different methodologies to analyse and manage food systems properties and, identified and categorized the main FFFA variables, re-conceptualized – by simplifying it – its overall structure and characterized and analysed its dynamics. A framework setting aimed at better understanding FFFA's structure and its dynamics is presented and described. In the light of the results, recommendations based on FAO's competence are made.

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2 INTRODUCTION

During the past 50 years, several international organizations using different methodological approaches have predicted the increase of world's population and, therefore, food demand for the next decades. The increase of urban population in developing countries' cities is particularly alarming for FAO. For this reason, the international organization has launched the Meeting Urban Food Needs initiative to find the latest and best complex systems methodologies for food systems analysis and management, with the purpose of updating its methodology.

An integrated assessment of changing technical, economical, social and environmental conditions affecting both, the urban and the rural areas, is calling not just for the use of new tools, capable of evaluating how dynamic elements interact among themselves, but also for a new understanding capable of revealing a systemic structure coherent with real world FSDS and urban issues.

The System Dynamics Italian Chapter (SYDIC) has been assigned to lead the FAO's FSDS methodological update. Therefore, as part of these updates, SYDIC has developed an epistemic ground to understand FSDS and compare the performance of different methodologies to analyse and manage food systems properties (Armendariz et al., 2015a) and has categorized the main FSDS variables and conceptualized its general structure according to FAO (Armendariz et al., 2015b). These are important inputs for this paper.

This paper addresses part of the SD updates to the document from the Food and Agriculture Organization of the United Nations (FAO) "Studying Food Supply and Distribution Systems to Cities in Developing Countries and Countries in Transition - Methodological and Operational Guide (Revised Version)" (Aragrande and Argenti, 2001) or what is called in this paper "FAO's Framework for FSDS Analysis" (FFFA).

FFFA highlights the need for effective, coordinated and sustainable interventions into developing and in-transition countries to meet urban food needs and places as main question "*what should be the policy to meet urban food needs those countries?*"

The objective of the work is to improve the understanding of FSDS general structure presented in (Armendariz et al., 2015b) and re-conceptualizing – by simplifying in a new systemic framework setting– its general structure and characterizing and analysing its dynamics. Among the main dynamics identified is the traditional logic to build policies, which decreases the efficiency of the system when called to meet urban food needs.

Such exercise was done by the FFFA study and complementary publications from the *Food into the cities* under a System Thinking (ST) and System Dynamics (SD) perspective which made possible the identification of the limitations of FAO's approach, among them, its unclear problem, solutions and policies statements which allowed for a dynamic hypothesis formulation on the problem of the FSDS structure and a problem and goal clarification after the analysis.

Recommendations based on FAO's competence have been also made in the light of the insights deriving from the proposed dynamic analysis.

2.1 STATE OF THE ART

A State of the Art on the use of complex system methodologies to the analysis and management of food systems (Armendariz et. al. 2015a) showed that: 1) Food Supply and Distribution Systems present complex systems properties and, in fact, complex systems methodologies have been progressively used to understand and manage them, 2) the formal consideration of food systems as complex systems opens the possibility of broadening the use of complex system methodologies to analyse, understand, simulate and manage specific aspects of food systems or deal with them as a whole by integrating the use of different methodologies. In that work, a qualitative comparison between Agent Based Modelling (ABM), Social Network Analysis (SNA) and SD methodologies performance to assess FSDS was carried out (Table 1).

Table 1 - Assessment on Complex System Methodologies performance in the analysis of FSDS (Source: Armendariz et al., 2015a).

Complex Systems features	Agent Based Modeling	Social Network Analysis	System Dynamics
Entirety	Medium	Low	High
Emergence	High	Low	Medium
Interrelations	Medium	Medium	High
Non-linearity	High	Low	High
Feedbacks	Medium	Low	High
Self-organization	High	Low	High
Adaptation	High	Low	Medium
Counter-intuitive nature	High	Medium	High
Time perspective	High	Low	High
Hierarchical organization	Medium	Low	High
General Assessment of the methodology	- Focus on emergent processes and adaptation - Bottom-up analysis - Attention to independence and heterogeneity of agents - Sensitive to initial conditions - Too difficult to analyse several combinations of attributes of agents	- Focus on relational data - Descriptive approach - No consideration of attributes of nodes in a complex system	- Focus on behaviour of a complex system over time - Top-down analysis - Descriptive and normative analysis - Possibility of exclusion of important factors affecting the system (subjective bias in the choice of the appropriate model parts) - SD models cannot address spontaneous changes by agents in the system that might constitute an emergent behaviour.

The results of the comparison showed that System Dynamics (SD) stands out as a methodology capable of addressing FSDS in relation to their complex systems properties. SD allows describing the system's structure and its behaviour over time, to identify high leverage points for intervention on the system, to test (by applying them in a virtual environment) possible policies and to forecast the outcomes of such decision on the system through simulation (Sterman, 2001). In the other hand, SD presents limitations in addressing emergent behaviour, in the assessment of individual dynamics of agents or actors, and in carrying out a proper and detailed spatial-geographic assessment, generally also very important to analyse specific aspects of FSDS.

2.2 FAO'S FRAMEWORK FOR FSDS ANALYSIS (FFFA)

2.2.1 FFFA Description

FFFA consists in a fundamental study for the characterization of food supply and distribution systems based on the observation developing countries and countries in transition, especially from Latin America, Africa, Near East and Asia. FAO defines Food Supply and Distribution Systems as "*complex combination of activities (production, handling, storage, transport, process, package, wholesale, retail, etc.) operated by dynamic agents, enabling cities to meet their food requirements*" (Argenti & Aragrande, 2001). The subsystems are represented in Figure 1.

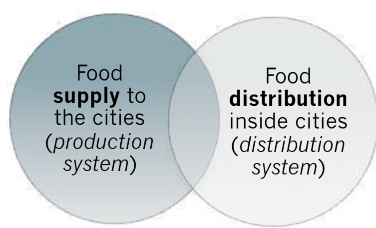


Figure 1 - FSDS sub-systems. (Armendariz et al. 2015b)

"Food supply to cities" or the food production system includes all the activities that generally take place outside the urban area: production (including urban agriculture), storage, marketing, processing and transport of food to the urban area (generally to a wholesale market). Some of the main constraints faced by actors in this subsystem are:

1. The scarcity of suitable lands, safe water and pesticides, or the latter's inadequate use, which can contaminate food crops;
2. Difficult evacuation of food crops - mostly by smaller producers - to markets, due to inadequate or non existing rural roads;
3. Inadequate handling, packaging and transport modalities;
4. Lack of cold storage facilities;
5. Unofficial taxation levied by authorities.

"Urban food distribution" or the food distribution system consists of the activities required to distribute food within urban areas. They range from wholesale markets, to intra-urban transportation and formal-informal retailing. Some of the main constraints faced by actors in this subsystem are:

1. The capacity of existing wholesale markets in efficiently handling growing food quantities. In many countries, they were constructed in areas that now are densely populated.
2. Growing urban traffic congestion, being exacerbated by increasing lorries and vehicles for food transport;
3. Inadequate retail markets, many of which are often congested and unhealthy places;
4. Limited entrepreneurial mentality of food shops;
5. Higher food contamination risks caused by informal food sector activities.

FAO's policy advises: in order understand the policy logic proposed by FAO, policies contained in the FFFA were classified (Armendariz et al, 2015b). Municipalities' local authorities are presented as the most significant actors. FFFA provides the following considerations to improve FSDS (p. 93-101):

- Description of supply and distribution agents needs (producers, wholesalers, retailers, market administrators and consumers);
- Limitations, instruments and needed collaboration efforts of municipalities and local authorities to solve difficulties faced by the FSDS agents;
- Role of the urban planners supporting the urban and peri-urban supply describing their intervention scale and actions.

2.3 FFFA limitations

From the study on FFFA and complementary material on the FAO's *Food into the cities* collection selected readings, the following shortcomings were found:

Analytical issues:

1) As there is no direct reference to "a problem" to be addressed with urgency, policies proposed are belonging to a different nature of issues, intervention scales and stakeholders responsibility.
2) There is no method suggested to assess any kind of test and/or prioritization between policies intended for the improvement of FSDS, which in the guide is understood as the solution to meet the goal, not to solve the problem.
3) In later publications belonging to the Food into Cities collection, after the FFFA publication in 1999 and its revisited version in 2001, there is a clearer focus on urban development issues and the state of resources such as land, water, infrastructure, and capital. As a prioritization of issues and a systemic analysis are absent, reaching the goal does not seem feasible.

Practical implications:

1) FAO as international organization has no coercive competence for intervention in the countries of study. Nevertheless, it explicitly offers to urban planners and local authorities (the only two main roles or stakeholders identified at municipal level) technical assistance for a proper understanding on the FSDS and the application of an interdisciplinary, multi-sectoral and participatory approach to find sustainable solutions (FAO, 2001, p.5)
2) FAO's goal might differ from the goals of food production and distribution agents.

In reference to the report *"A briefing guide for Mayors, City Executives and Urban Planners in Developing Countries and Countries in Transition"* none of the economic, social and Health and Environmental goals are related to the main one "Meeting urban food needs". Particularly, none of these is explicitly related to a main problem, which makes clear the risk of not selecting significant policies to meet the goal because the problem is unaddressed.

In FFFA we also observed a description of events that are part of the FSDS dynamics but a strict causality and categorization of dynamics is absent. It is assumed that external factors are stable in the short run or their change can be anticipated. According to FFFA system boundaries and changes are affected by:

- "External factors" which are tendencies and regulatory framework (laws) part of the market interaction rules of the sociopolitical arena and stocks of infrastructure and land (urbanization, food needs, institutional constraints and services)
- "Internal factors": these are food production and consumption items and variables that affect them (consumer habits, supply chains, market strategies, distribution infrastructures, etc.).

What FFFA divides is the perception of what would be internal factors and external factors of FSDS processes, which are part of the system structure or a result of it. Such categorization as FFFA sets it does not allow for a dynamic analysis, i.e., the categorization of stocks, flows and main variables and a system boundary definition is required for a dynamic assessment. The following picture shows the main items characterizing a FSDS according FFFA (Figure 2) characterized for a clear linear perspective. The supply sources are shown as three levels of territorial boundaries – rural, urban and peri-urban. The processes involved before meeting the food demand, which are part of the supply and distribution systems.

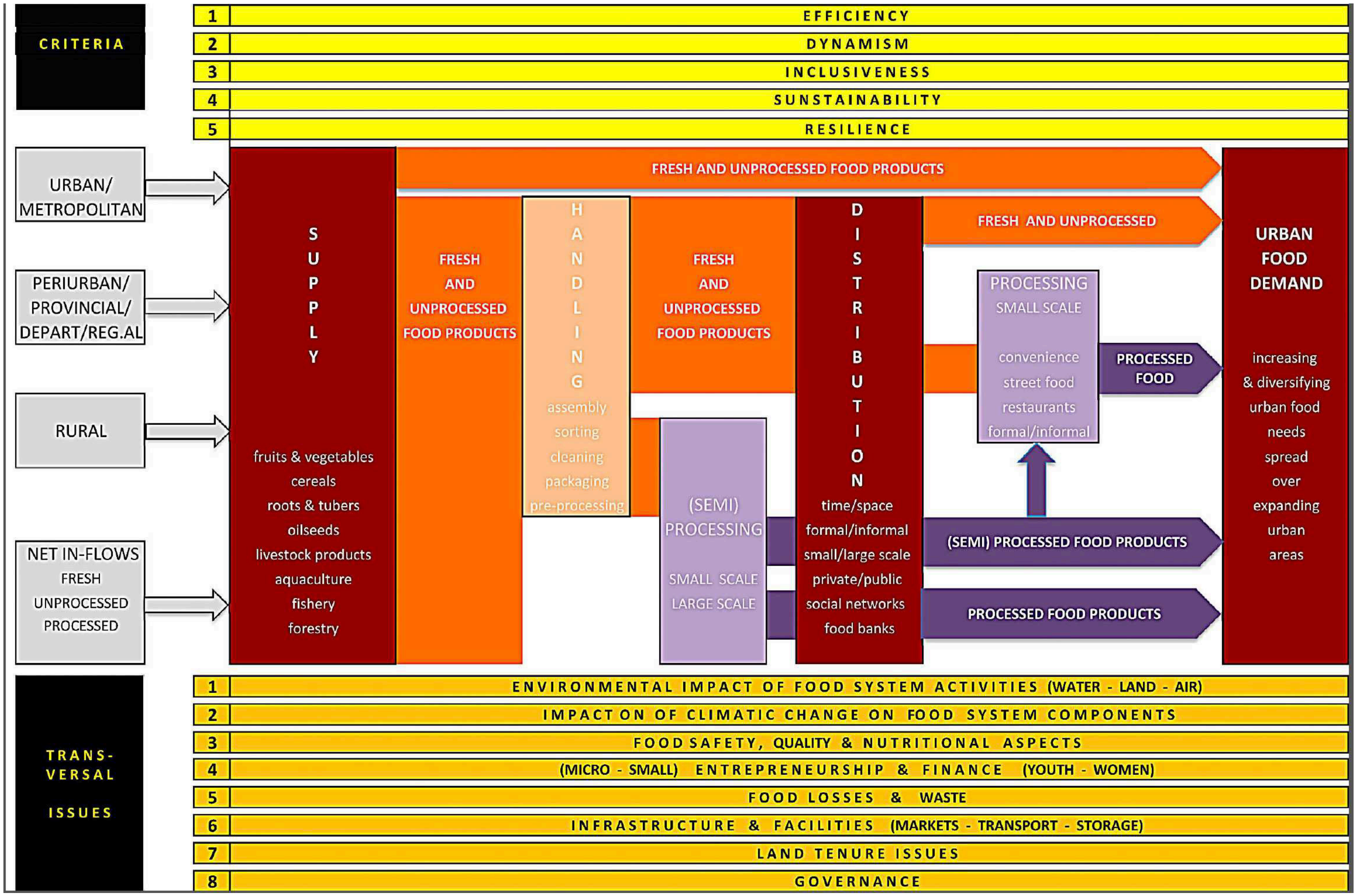


Figure 2 - Food Supply and Distribution Systems flows representation based on: Studying Food Supply and Distribution Systems to cities in developing countries and countries in transition: Methodological and operational guide, revisited version (Argenti and Aragrande, 200

3 SYSTEM DYNAMICS UPDATES TO FFFA

The System Dynamics updates to FFFA, developed using System Thinking (ST) and System Dynamics (SD) approaches, by SYDIC have consisted on:

1) The development of an epistemic ground to understand FSDS assessing their characteristics and properties as complex systems, in order to evaluate the feasibility of using complex system methodologies to analyse them
2) The analysis of the FFFA and other documents from the *Food into the Cities* collection using ST and SD. Which includes the generation of system archetypes analyses, to qualitative characterization of FSDS by two group model building sessions with FAO experts, the creation of a framework setting to analyse the main FSDS dynamics (presented in this work) and a first simple quantitative model to analyse the population growth and urban dynamics impact on food supply and distribution system efficiency to eliminate the gap among food demand and food availability in a city (still on progress).

In the next section we will deep on how the previous work has allowed us to propose the FFFA statements clarification on the: A. Problem, B. Goal and C. Feasible and effective solutions, which assessment might require the combination of other methodologies and disciplines as we explain later in this work.

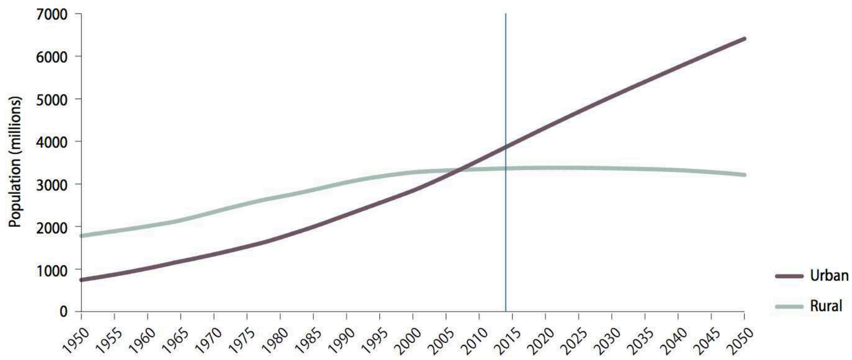
3.1 PROBLEM ELICITATION FROM FAO'S LITERATURE

FFFA does not make a direct reference to a single main problem, which has important implications for FAO to address policy recommendations. Yet from FAO's literature one issue is elicited as the most relevant: the urban population growth. As support to this, the publication *Food supply and distribution to Cities: Urban Dynamics and Food Security*" (FAO, 2000, p.1) states:

> " *The increasing urbanization of transition and developing countries represents the need to organize food production, processing and marketing facilities so as to satisfy an urban demand characterized by growing poverty levels*."

In addition, FFFA (p. xiii) presents as main question: *How that growing population can adequately feed, in particular, the low-income households?*

a)



b)

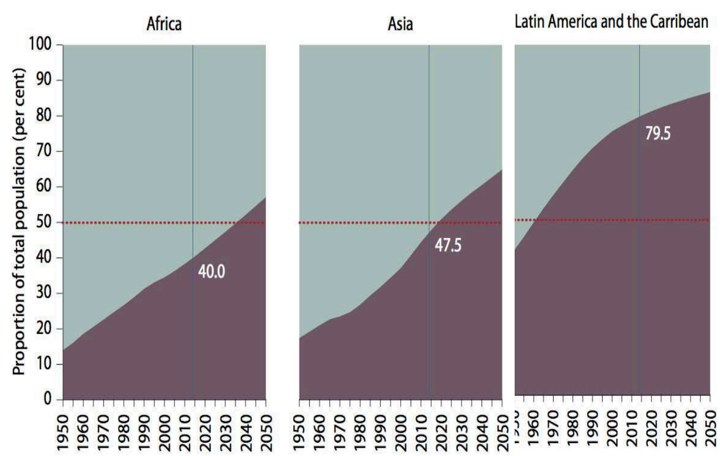


Figure 3 **- Urban and Rural population of the world 1950-2050. Figure a) Worl population b) Proportion urban-rural in Africa, Asia & Latin America.UN (2014).**

Based on the work related SD updates by SYDIC using ST and SD approaches, the following clarifications on the goal, problem and possible solutions are understood from FAO:

A. Goal: "Meeting the urban food needs"

FAO's *Food into the cities* collection seems to be addressing this goal, which is sometimes confused with a problem statement in the literature. Chapter 5 in the same document contains an explanation of a "gap" covering need to reach the goal and how this indicator drives policies in FSDS.

B. Problem: Increasing urbanization.

After the SD updates conceptualizing the system (Armendariz et al, 2015b) it was found that any other problem mentioned in FAO's literature FSDS is derived from this main one. Four basic consequences are highlighted:

2. Land competition: between housing, industry, and infrastructure and agricultural production within and around cities; it also includes the competition among land use for biomass production destined to food, feed or renewable energy;
3. Increasing quantities of food required to feed cities and its distribution within the expanding urban areas;
4. Consumption habits and food purchasing behaviors modifications
5. Low-income households food accessibility problems due to the likelihood to reside far from food markets and the lack of basic infrastructure -roads, electricity and water -.

C. Solution proposed: Ambiguous considered as none.

When the main problem elicited from the literature study using ST and SD is the increasing urbanization, the major part of policies proposed in FFFA address instead the functioning of FSDS. In Armendariz et al. (2015b) a detailed analysis of those policies is presented as an input to assess FAO's possibility to reach the goal under its current framework of analysis considering also the "key" stakeholders, according to FAO the municipalities' local authorities, competences.

3.2 DYNAMIC HYPOTHESIS

According to the SYDIC's clarifications on problem, goal and solutions, we have elicited the following hypothesis due its relevance at an analytical and practical level while studying FSDS:

- Conceiving the urban population growth as the main problem in effectively feeding cities (thus given the raise in food demand) is partially correct, hence we argue that it is wrong: it is the way most cities are conceived, structured and reproduced what contributes to the system unsuccessfulness meeting urban food needs.

Considering the following has also supported our hypothesis creation:

1) An example of application system archetypes (Braun, 2002) to FSDS analysis (Armendariz et al, 2015a) and presented in Figure 4. B1 and B2 indicate the main balancing loop of a general "*Drifting goal"* archetype. R3 indicates the effect of a reinforcing loop within a "*Shifting the burden"* archetype and R4 indicates a possible "*Fixes that fails*" archetype associated with reductionist focus of food policies. A supplemental R4 can be drawn, from policies that tend to increase production and industrial processing without take into account benchmarks of social metabolism (Giampietro et al., 2014) and sustainability of natural resources.

2) The extended conceptualization of FSDS based on FFFA variables, the characterization of its dynamics and its validation in two experts meeting at FAO's headquarters (Armendariz et al., 2015b).

Forrester's philosophy states that in order to understand and possibly, solve a problem you should not make a model of the specific system your problem belongs to, but a model of the family of systems to which yours belong. In the next section, the framework setting created out of the simplification of the extended FSDS conceptualization mentioned in point 2 is presented. This diagram has been useful to sustain the SD updates for FFFA and clarify the hypothesis.

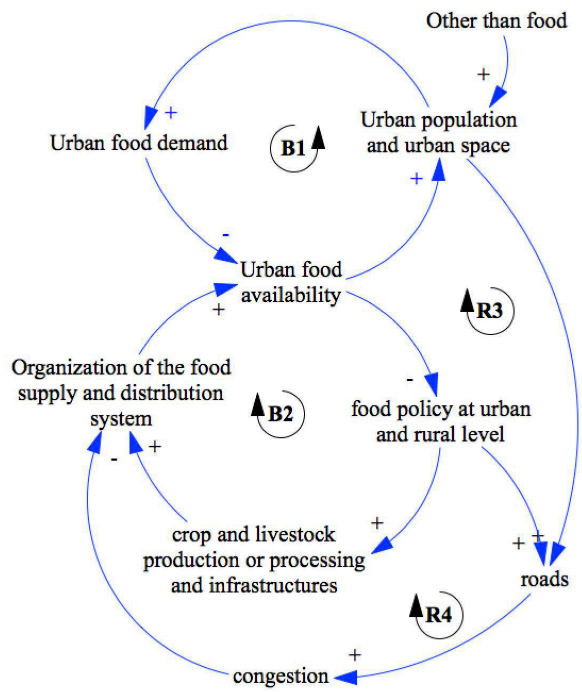


Figure 4 - System archetypes applied to food supply and distribution system (Armendariz et al. 2015a).

3.3 ANALYSIS

After the identification of the main dynamics and stocks from the food production and food distribution subsystems from FFFA and their conceptualization into a single general system (Armendariz et al., 2015b), we have selected the main modules that allow us to conceptualize in a simple way the environment and complexity of FSDS.

The diagram in Figure 5 is an example of the general framework setting to describe a complex issue in a simple and simplified way without loosing its validity. A preliminary version of this framework setting proposed by the authors to capture the structure where FSDS are embedded and its dynamics. The general framework will be described below by focusing on the identified loops.

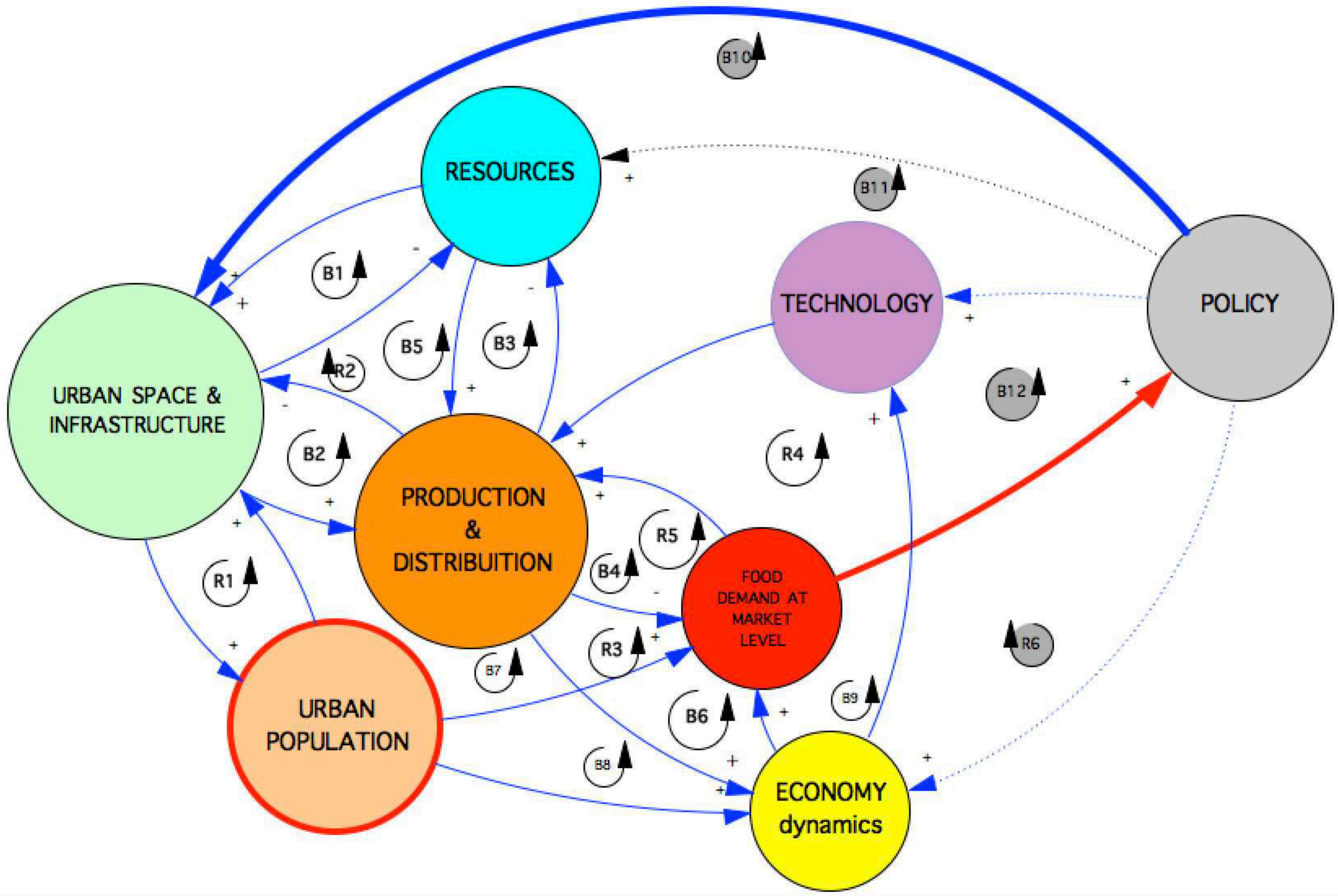


Figure 5 - Framework setting of FSDS suggested by Armendariz et al. (2015b).

Within the system, loop **R1** represent the relationship among urban population and urban space and the dynamics of the urban geographical boundary. It depends on population dynamics and job dynamics. It also summarizes the urban planning and the infrastructure building process, which mainly depends on local factors. Natural resources are reduced as the urban space and infrastructures increase, especially if we think in land use, land consumption, pollution or variation of available non-renewable natural stocks. In this sense, **B1** indicates the carrying capacity of the system and the limit to growth. The urban space for markets and food logistics are also part of urban planning, aimed to optimize the efficiency of the organization of the system, it consists of a balancing loop **(B2)** as urban space is limited its availability impacts the distribution and production processes, within this dynamic, land dedicated to urban food production means less land to roads

building. **B3** indicates the ecological footprint of the FSDS that has a similar dynamics than **B1.** There is an internal reinforcing loop **(R2),** which indicates the food and distribution process are only possible after the urban space use and this, after the resources use, which includes non-urban land and non-renewal resources. An external loop with these same modules **(B5)** indicates that production and distribution processes make also use of the resources by its part, competing with the infrastructure and urban dynamics resources use. Both of these dynamics are expressing the risk of overconsumption resource rate for the maintenance of, not just the food and distribution activities, but also the system itself.
Urban population, intended as human aggregation (geographically, social status, cohort, etc.) is one of the main drivers of the current food demand understood as the amount of food which the people is looking for in a certain market condition. It depends on different factors: population number, income level of people living in the area and food availability provided by supply and distribution chains. Population dynamics are undoubtedly one of the most important drivers of food demand. However, production and distribution management deficiencies contribute to decrease the food supply of cities, to increase the nutritional gap of the people and the food demand.

The module Food demand at market level means amount of food demanded useful to calculate food availability. According to FFFA, food demand at market level calculation requires necessarily the consideration of people's income. This should not be confused with absolute food demand, which will be an indicator of food requirement per capita multiply by the total population which can be useful to calculate other indicators as food nutritional gap, food sufficiency. The relation among food demand at market level and the production and distribution system is described by the **(B4)** loop, it consists of a balancing feedback loop aimed to increase food supply and reduce food demand. In this sense more production and distribution reduces food demand because increases food availability, which in turn decreases demand. The balancing loop **(B4)** determines the food gap.

We found another external loop (**R5)** between urban space and infrastructure and food demand. Food demand pushes for the production processes and those in order to function require certain, urban space and infrastructure in order to meet the requirement. This reinforcing loop implies the burden of the food demand on the urban space, which requires more than short term thinking to provide a consistent solution; this will be further explained in the policies section.

Food demand at the market level is also limited or boosted by economy and job dynamics, which puts a pressure on production and distribution activities from where job and food market revenues are obtained **(R3).** An external balancing loop (**B6)** was found after capturing the effect of economy on the urban space and infrastructure, economy will boost the production and distribution process that will compete with other industries and households for space and infrastructure. The development of food production and distribution activities will rule economic dynamics as employment and therefore, income, for people working in those.

Indirect effects of food market in economic growth and technology improvement are shown with **R4**. The improvement of the efficiency of the supply chain depends on the organization and the technology levels applied to production and processing which can have an impact in the FSDS resource use and urban space due to technological advances in distribution or production processes **(B9).** In this case **B7** represents the food demand out of the population change, which determines the need for production and distribution processes and those the urban space and infrastructure change, which attracts population. Population allows for the economic dynamics, which increases their income to demand food in the market **(B8)** that follows the dynamic previously explained.

3.4 POLICIES

The red arrow in the system (Figure 5) is the main question of FFFA: "*how to meet the urban food needs in developing countries and those transition?"* Policies aimed to improve food security and food availability at market level, or to boost the willingness to buy the available food in the market, are directly stimulated by the variation in food demand at market level. The reduction of the food demand gaps is the most generic objective of the food policies, but the effectiveness of policies have to consider important leverage point in the system components. Following the FFFA perspective, future policies should target few main areas:

1) Urban space and logistic, aimed to optimize the organizational part of the system; it should aim to built an effective platform of food distribution able to support both the increasing population and the increasing supply chain without increase the food demand gap. Urban land and people density, low urban congestion, adequate food road maps and number and type of regular markets and informal markets are the key variables of this area that will reach the attention of policy makers (**B10**).
2) Technology level used in production and processing activities, in order to improve the efficiency of the supply chain, control pollution, reduce wastes, etc.; it consists of a balancing feedback loop aimed to increase food supply and reduce food demand (**B12**);
3) Economic and jobs dynamics are needed to be the engine of food access (**R6**). In addition, there is the hypothesis that the socio-economic aspects of urban population are highly related with undernourishment/obesity problems and with the type and quality of preferred foods by the consumers, in this case, a health assessment should be considered out of the economic development. All the considered loops are aimed to balance the forces that are driving the system behavior and to enhance system equilibrium, which will cause the reduction of public policies.
4) An important "side effect" of the food policy could be represented by the relationship with natural resources; land use, environmental sustainability and social metabolism variables are strongly related with supply chains, consumers' life and waste disposal and it should be taken into account when food policies are designed in rural and urban areas. In fact, a dangerous reinforcing loop, that links natural resources and growth of

human activities (both for supply chain and consumption) might drive an exponential decay of the system inputs (**R2**). For that reason food policy have to directly take into account the environmental impact of the entire chain and its future sustainability.

New indicators should be developed and FAO's *Food into the city* collection late publications shows urban planning as a central idea for policy. When policies of urban planning are formulated, blue arrow in the system diagram (figure 5), they have indirect or side effects in FSDS (B1, B2, R1, R2, B5).

3.5 FINDINGS

The identification of main stocks and dynamics of FFFA and its conceptualization and characterization in a general FSDS structure allowed the identification of the main dynamics where the *urbanization loop* and the pressures it represented in the system (land use, congestion, rural population attraction) appeared to support this paper's hypothesis which stated the main problem of FSDS intended to meet urban food needs is not just the Urban Population growth but the cities' structure driven by the urbanization paradigm and current increasing trend in developing and in-transition countries due to its great consequences related to the congestion, land change, resource waste and population attractor.

After this, as a primary analytical step, a framework setting was developed, which explains in a more simplified way and at an abstract level the dynamics between land, population, distribution and production process, resources, technology and job dynamics. This systemic view provided us the insight that increasing the efficiency of the food production and distribution (production, assembling, handling, processing, packaging, transport, storage, wholesaling and retailing) could lead to increase the food supply to cities, reducing costs and waste, but, it does not imply automatically meeting the food requirement per capita. Socioeconomic conditions as: the prevalence of poverty –topic considered in the goal but absent of FAO's policies-, ecological conditions as the availability of resources and land or urban conditions as the urban space and infrastructure will get the system working in misbalance with its capacity. In this sense, we want to stress that as production and distribution processes will have to be improved, other big issues of the system we inhabit will be have to acknowledge. It is irrelevant to analyze FSDS without considering the important stocks that make them possible.

As summary, the next key points were elicited of the SD updates to FFFA:

1. The FSDS mechanics are embedded in the field of Urban Dynamics: population, infrastructures growth and urbanization highly impact the FSDS organizational capability to provide food.
2. Conceiving population growth as the main problem in effectively feeding cities (thus given the raise in food demand) is only partially correct, hence it is wrong. The way most cities are conceived structured and reproduced is what contributes to the system being unsuccessful on meeting urban food needs.
3. Supply and Distribution Systems are just a part of a wider system. Urban, rural and peri-urban dynamics cannot be longer treated in isolation if the aim is to meet population food needs for the next decades.

4 CONCLUSIONS & AGENDA

The System Dynamics updates to FFFA by SYDIC, developed using System Thinking (ST) and System Dynamics (SD) approaches, have consisted on:

1) The development of an epistemic ground to understand FSDS assessing their characteristics and properties as complex systems, in order to evaluate the feasibility of using complex system methodologies to analyse them.

2) The analysis of the FFFA and other documents from the *Food into the Cities* collection using ST and SD. Which includes the generation of system archetypes analyses, to qualitative characterization of FSDS by two group model building sessions with FAO experts, the creation of a framework setting to analyse the main FSDS dynamics (presented in this work) and a first simple quantitative model to analyse the population growth and urban dynamics impact on food supply and distribution system efficiency to eliminate the gap among food demand and food availability in a city (still on progress).

This work allowed us to propose a clarification on the FFFA statements about the Problem, Goal and Feasible and effective solutions. This clarification is useful to grasp FAO's problem understanding; clarify its competence as international organism in the possible solutions by identifying what actions could be useful for decision makers and are possible to execute by FAO.

The improvement of the FSDS is the solution proposed by FAO but its recommended policies are not free of conflict or contradiction with others. Interventions involve a stakeholder's variety with specific interests where an agreement is unlikely to happen. An advice for FAO from system thinking is to *look beyond the players, the rules*; given that solving specific needs of agents, as numerous policies proposed, might not be as significant as analysing interconnections among the system elements and identify the information and material flows that makes them operate in certain way (Meadows, 2008).

Opportunities of this research are in line with FAO's competence. As international organization it lacks of coercive capacity but has a potential role in disseminating useful information for better decision-making. Specifically, it could promote the FSDS dynamics understanding with its internal and external constrains for improving organization capacities and, finally, positively impact food security.

The ST and SD approaches applied to the FFFA resulted useful to explain the importance of overcoming the focus on the urban population growth as the main FSDS problem without being critical to way the cities are structured, which was the hypothesis managed in this paper. In the current work it is shown how urban population increase represents a pressure on the system to provide food, yet, the urban dynamics closely related to the urbanization and its consequences highly impact the natural resources (land, water, production and distribution assets on which FSDS depend) and is this urbanization paradigm what keeps pushing the increase of urban population. The ST and SD have allowed for a critical perspective also on the solutions proposed as any improvement on the food production or distribution processes might not imply automatically meeting urban food needs. An additional important finding is the consideration of the poverty condition, as a necessary issue to address to meet food needs.

The current paper findings present the limitation of being done under qualitative assessment. The goal for the next part of SD updates to FFFA, throughout quantitative modelling out of the ST/SD approaches, will focus on providing instruments to urban policy makers to:

- Estimate the urban food demand;
- Estimate the food supply to the cities;
- Dimension the infrastructures that maximize food availability, food quality and health safety of food chains;
- Dimension the interventions to reduce food gaps at market level acting on urban planning and land use planning and suitability;
- Reduce the environmental impact of food systems in order to increase sustainability.
- Discern between the most significant policies for their implementation and explore their priority according to the outcomes desired, through simulation.

Among the scientific community, multidisciplinary and co-disciplinary approach is encouraged to develop quantitative models and sub-models of the proposed framework on the basis of FFFA, background and expertise.

5 ACKOWLEDGEMENT

The authors would like to thank Olivio Argenti, Coordinator of the Project “Meeting urban food needs”, from the Food and Agriculture Organization, (United Nations, B619 – AGS, FAO - Rome – Italy) for providing valuable information and prior knowledge on the FAO’s FSDS framework of analysis, and for the help in the building of the revised SD framework.

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