From response to resilience: the role of system dynamics approaches in analyzing and developing value chains from urban and peri-urban agriculture

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ABSTRACT
Urban agriculture has become an important research theme in recent years. Over the past decade, a number of different, diverse value chains have been established in cities in the urban areas of developed and developing countries alike, with increasing convergence in their motivations related to food security and livelihoods development, particularly for poor and disadvantaged segments of society. At the same time, an important research gap is in bridging top-down planning approaches with a movement that is largely bottom-up, organic, and fluid in its origins. In particular, for urban agriculture to be sustainable as a livelihoods and resilience strategy will require decision-support tools that allow planners and participants alike to jointly develop strategies and assess potential leverage points within urban food value chains. In this paper, we argue that system dynamics (SD) models combined with participatory approaches have important roles in bridging this gap. We will first review elements of urban agriculture and some of the policy challenges faced in this growing phenomenon. We then motivate the use of SD models in the context of urban agriculture and note their potential utility in overlaying quantitative models of urban food value chains alongside their land-use characteristics, highlighting the dynamic feedbacks between intensive processes within changing urban food systems and extensive processes associated with land-use and planning. We will then provide a conceptual framework for blending value chain analysis and land use planning in the context of urban agriculture under a system dynamics rubric. We conclude by stressing the role of community group model building as a crucial component in both developing and refining such SD models, and ensuring opportunities for stakeholder participation and joint learning in the process.

Introduction

Urban agriculture has recently become an important research theme in both developed and developing countries even though it has existed long before it became a target of contemporary research. In modern history, urban agriculture began in various forms, most of which responded to the same issue – a lack of food. Typical examples of urban agriculture in the 19th century and the beginning of the 20th century include urban allotment gardens for poor urban workers during the Industrial Revolution, urban gardens in American cities during Great Depression, and urban agriculture campaigns during the two world wars (Viljoen, Bohn, and Howe 2005). These examples highlight that urban agriculture primarily developed and thrived the most in times when food insecurity was a serious societal issue, whether caused by economic or political reasons.

Over the second half of the 20th century, the fundamental purpose of urban agriculture as a source of food subsided with the increased availability of industrially produced agricultural products. Urban agriculture evolved in the form of allotment gardening and community gardens that were motivated by social and leisure pursuits. However, in the decades following the publishing of Rachel Carson's *Silent Spring* (1962) in which the author vividly disclosed the negative environmental impacts of industrial food production, there has been a gradual shift in the nature of urban agriculture. In this context, urban agriculture evolved as a means of localizing food production and shortening the food supply chain (Viljoen, Bohn, and Howe 2005), while remaining a leisure activity for some, combining safe food production with social and health benefits.

In the urban areas of developing countries, a number of different, diverse value chains have been established, including *inter alia* "safe vegetables" in Hanoi, Vietnam (Moustier et al. 2005); potatoes in Khartoum (Fadul 2010); and numerous urban-based horticulture markets in Tunis (Toumi and Vidal 2010), Yangon (O'Shea and Soe 2010), and Quito (Dueñas 2010). These markets have been driven increasingly by issues of food security, particularly for poor and disadvantaged segments of society (Ellis and Sumberg 1998; Mougeot 2005). According to a 2005 report of the U.N. Food and Agriculture Organization (FAO) (cited in Brown 2009 – pp 158-160), about 700 million urban residents worldwide received food from urban and peri-urban farms. For example, about 650 hectares of land around Dar es Salam, the capital of Tanzania, supplies fresh vegetables to city residents, while some 4,000 farmers intensively farm small plots of land in urban and peri-urban areas. Other examples include Hanoi, Viet Nam where 80 percent of its vegetable supply comes from farms in and immediately adjacent to the city; Kolkata, India where about 18,000 tons of fish per year are produced from managed wastewater fish farm near the city; and the approximately 8,000 microgardens that have been established in Caracas, Venezuela through a government sponsored project assisted by FAO (Brown, 2009).

One of the successful (if not the most successful) examples of urban agriculture in a developing country is the case of Havana, Cuba. The first steps in the implementation of urban agriculture in Cuba started in the late 1980's when scientific institutions together with the Ministry of Defense initiated governmental programs to reduce Cuba's dependence on oil and food imports (Koont 2009). The fall of the Soviet Union triggered the development of urban agriculture in Cuba, as the loss of the USSR market led to a 60 percent decline in food availability in Havana between 1991 and 1995 (Novo and Murphy 2000). What makes Cuba an outstanding example of urban agriculture is in its organization. Since the very beginning, urban agriculture was supported by formal authorities. New technologies and scientific research to support agricultural production were developed and the results disseminated to those practicing urban agriculture. New public policies were also promulgated to accelerate the development of urban agriculture, best characterized by the motto: "We must decentralize only up to a point where control is not lost, and centralize only up to a point where initiative is not killed." (Koont 2009, p.66). Such an approach facilitated a unique symbiosis of grass-root movements combined with a system of formal centralized leadership and the strong support of scientists and researchers (Koont 2009). Moreover, it promoted organic agricultural production since industrial chemical fertilizers and pesticides were unavailable (Koont 2009).

In light of the financial crisis of the past decade, the importance of urban agriculture as a source of food is rising. In countries facing serious austerity measures, such as Greece, where unemployment rates have increased to over 27% (Skordili 2013a,b), urban agriculture has become a natural response as a means for food security and employment, just as it did in the 19th and 20th century. Recent initiatives in urban Greece include the "potato movement" [1] (Morgan 2013), urban beekeeping [2] and vegetable gardening.[3] For instance, Pothukuchi and Kaufman (2000) analysed a survey conducted among 22 planning agencies in the United States, in which she tried to provide an overview of planner attitudes towards food systems and their integration in planning practices. While the surveyed planners seemed to understand the importance of food systems in urban environments, they claimed only very limited scope, knowledge, or expertise of their involvement in such issues. These attitudes have been shifting over the past 15 years (Lovell 2010; Morgan 2013; 2014), though the mainstreaming of a policy consensus to facilitate and support urban agriculture remains lacking.

People have repeatedly either discovered or returned to urban agriculture in response to economic or political crises. Without any formal support, urban agriculture in both developing and developed countries has mostly been a bottom-up process, typically initiated by individuals or non-governmental organizations rather than by governments or facilitated by planners; the case of Havana is notable exception. In other words, food and urban planning policies should include urban agriculture in order to use it as a preventive tool that will enhance the city's resilience when facing up to future crises. The question is thus how to support and mainstream urban agriculture as a strategy that could be used not only as a reaction in times of crises but also as a livelihoods strategy that can enhance the resilience and sustainability of urban areas and populations. In this paper, we provide insights into a framework that can help to better analyze the urban agriculture system and provide policy guidance that bridges the gap between planners and practitioners.

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[1] http://inhabitat.com/greece-potato-movement-directly-connects-farmers-consumers-during-the-debt-crisis/

[2] http://www.cafebabel.co.uk/society/article/urban-farming-cultivating-utopia-in-greece.html

[3] http://www.theecologist.org/campaigning/food_and_gardening/1193541/greeks_reclaim_the_land_to_ease_the_pain_of_economic_austerity.html

Urban agriculture – role, definition and scale

In order to successfully integrate urban agriculture into food system planning, it is important to first define its role within the system. Urban agriculture should not try to replace rural agriculture, as certain products are virtually impossible to be produced in urban settings, such as cereals (Lovell 2010). Also, some types of agricultural production might not be appropriate in certain locations because of the climate, which might require environmentally inappropriate solutions such as heated greenhouses or extensive irrigation (Born and Purcell 2006). Urban agriculture should thus complement rural agriculture (Mougeot 2000) and focus on products that are location appropriate and avoid products that can be produced more sustainably elsewhere.

It is also important to clarify the meaning of 'urban' in this context. If we rely on the definition of urban as "within the built environment" (De Zeeuw , van Veenhuizen, and Dubbeling 2010, p.1), it will constitute only a very small part of the food system and will eliminate the areas around the city that are neither urban nor rural. To avoid such simplification, FAO has introduced the term urban and peri-urban agriculture (UPA) that broadens the scope of urban-related agricultural activities by including areas on the urban periphery. For the purpose of analyzing the role of UPA in food system planning, we propose to use the definition of peri-urban areas as those areas where agricultural production (or a part) is linked directly to the city. The percentage of agricultural production from these areas that is supplied to a given city then identifies the level of involvement in UPA. We further propose not to draw a line between urban and peri-urban agriculture and assess them separately but to include them together in a common assessment and analysis of an urban food system.

Scale in food systems is an enormously important and sensitive issue. Many researchers and stakeholders involved in urban agriculture accept the presumption that localizing food production is positive as a fact (Born and Purcell 2006). However, empirical research has shown that this is not always the case, with each location requiring individual assessment in order to avoid the blind application of food-localizing strategies that may not have positive impacts (Purcell and Brown 2005). Negative effects can arise if food localization is promoted without assessing the whole value chain (Born and Purcell 2006), as well as issues of land use, environment consequences, and social acceptance. Another food system related issue that planners face is the informal character of UPA. Most UPA activities are initiated as a bottom-up process, while urban planners with a more top-down approach might find it difficult to find common ground with other stakeholders in the process.

As Lovell (2010) indicates, food system and urban agriculture are multifunctional and multi-faceted issues that involve a number of diverse stakeholders and their successful implementation requires broad knowledge and expertise. The development of efficient policies that address the resilience of the urban food system will require decision-support tools that allow planners and participants alike to jointly develop strategies and assess potential leverage points within urban food value chains, identify appropriate areas to promote urban agriculture, and which can appropriately target stakeholders such as the poor and disadvantaged (Dubbeling, Hoekstra, and van Veenhuizen 2010). Moreover, such strategies should take into account both short- and long-run impacts, as well as feedbacks that exist between various social, cultural, environmental, and financial phenomena.

This suggests a role for developing a research paradigm that accounts for the broader system associated with urban agriculture as part of the planning process. Such a process should necessarily integrate participatory tools (to account for the bottom-up nature of UPA) with a systems modeling process that is flexible yet robust enough to analyze fit-for-purpose policy strategies within the UPA milieu. In the following sections, we outline the role of qualitative and quantitative system dynamics in providing a laboratory that conceptualizes and jointly validates a process of jointly learning and policy planning that can enhance the resilience and sustainability of UPA over time.

System dynamics for urban agriculture planning: a conceptual framework

Urban agriculture takes place in a variety of diverse value chains depending on its context. Within an urban agricultural setting are a number of important contextual drivers that influence and feedback within the urban agriculture value chain and present an important overlay to the analysis. We can classify them into formal and tangible, and socio-economic. The formal and tangible drivers include broader issues such as environmental impacts (i.e. waste management), tangible issues such as land availability, or formal planning matters such as land use zoning which can significantly influence the implementation of urban agriculture by either allowing or prohibiting certain practices. On the other hand, there are a number of socio-economic drivers that arise at the community-level social networks at the community level that are just as important. These include factors such as people's willingness to participate in urban agriculture, either actively as producers and consumers, or passively by approving the practice of urban agriculture in their neighborhood, and the dynamics of both types of adoption over time. Both categories of drivers are influenced by external macroeconomic conditions which influence the processes in the UPA environment but which cannot be modified at such a level.

All of these types of contextual factors can be potentially modeled in a systems-type model, whether through systems dynamics (SD) models, agent-based, or network models that can interact and feedback with an SD model of the urban agriculture value chain. Ulli-Beer, Anderson, and Richardson (2007) developed an adoption model of urban recycling using system dynamics, for instance, while Berger (2001) applied a multi-agent spatial model to model the diffusion of innovation and water uses at household level in Chile. All of these types of models could be integrated as an overlay within a model of an urban agriculture value system. As our proposed level of analysis is at the level of the system, our focus will be on SD models, given their flexibility in integrating a host of social, technical, and environmental phenomena, and the means to bring in participatory processes as a means of model design and validation.

An SD model is a dynamic model that maps out the flows, processes, and relationships between actors that exist within a complex system (Sterman 2000). An important focus of an SD model is an understanding of the evolution of the system and its behavioral feedbacks over time. Unlike many types of economic models (e.g. partial or general equilibrium models), SD models are simulation approaches that provide a laboratory in which various policy scenarios can be conducted to compare the evolution of simulated dynamic paths of change (Rich and Hamza 2013). Furthermore, through the use of a graphical modeling interface, such models can transcend disciplinary boundaries, and have been used from technical fields such as engineering and ecology to soft systems analysis in the social sciences and humanities.

All SD models are a combination of a few key building blocks: stocks, flows, convertors, and feedbacks. Stocks represent a collection of something (goods, services, etc.) at any given period of time. Flows represent the entry and/or exit of goods or services into (inflows) or out (outflows) of a stock, respectively. Convertors mediate the magnitude of inflows or outflows within the system. In every SD model, there is a process of feedback, defined as the means by which changes in one part of the system affect other parts of it and, consequently, impacts the original shocked component over time (McGarvey and Hannon 2004). In SD models, we can predict different types of individual behaviors based on their patterns of feedback, with our simulations aimed at unpacking the system-wide effects associated with the combination of many interacting types of feedback (Rich and Hamza 2013).

In urban settings, the use of SD models is not new – one of the pioneering works in system dynamics was *Urban Dynamics* by Jay Forrester (1969) that modeled the patterns of growth and decay in urban environments, and the means by which public policies could influence the evolution of these patterns.

We illustrate a conceptual framework for using SD in urban agriculture planning in figure 1. On the right hand side of this figure, we highlight the influence of the mutual feedbacks that arise between the value chain and dynamics of adoption, for instance, which in turn are influenced by social network structures that define social norms (see Feola and Binder 2010; Ulli-Beer et al. 2010). Changes to the chain or external macroeconomic pressures (positive or negative) can in turn feedback and change the nature of social networks that can subsequently influence the pattern of future adoption and investment in the value chain. In an austerity context, which as noted in the introduction is an emerging driver of urban agriculture, linking changes in economic conditions to value chain development could be useful in understanding the areas in which urban agriculture could emerge, as well as its implications on land use and planning. On the left side of the figure, we show the environmental and land drivers of value chain development that represent the formal external part of the system. Changes in regulations, land availability, or environmental technology can influence the supply side of urban agriculture value chain development. This in turn can create positive feedback into the development of more urban agriculture-friendly policies, although these can be mediated and influenced by local and economic pressures.

An important aspect of the conceptual framework in figure 1 is the role that space plays in the analysis. Environmental, availability of land, land use, and socio-economic considerations all have important spatial dimensions that need to be taken into account in modeling. In particular, an urban agriculture value chain will co-evolve with different contextual drivers that are grounded in space. For example, social norms and networks can vary within and across different locations, implying that the “where” of urban agriculture value chain will matter. Likewise, land use patterns and zoning in a particular setting will influence and be influenced by urban agriculture value chains, and will further feedback to other environmental considerations as well. Urban agriculture can be conducted on a large variety of plots – idle land, brownfields, allotment gardens, back yards, etc. As the tenure or functional usage of these pieces of land may change in time, urban agriculture is sometimes only a temporary use of a given plot. However, even though the exact locations may change, urban agriculture remains a permanent phenomenon (Veenhuizen & Danso 2007). This suggests a need for integrated, spatially sensitive modeling platforms.

How space is to be integrated in our model depends on the form of spatial behavior. Neuwirth, Peck, and Simonovic (2015) focus on coupling feedbacks between processes and spatial structures by linking SD models with GIS models. In their analysis, stocks are made spatial, with rules defined that link changes from the SD model to the spatial structure (visualized via GIS) and vice-versa. This type of approach is particularly amenable to the environmental and land use considerations noted in figure 1. BenDor and Kaza (2012) provide an example of network-defined space, where interactions can arise between an SD model and the network structure. They provide an example of the evolution of disease on a weighted network, where changes in disease occurrence can change the number of links between network nodes (e.g., from quarantine, blocking roads, etc.), which will subsequently alter the spatial course of disease (see Rich, Winter-Nelson, and Brozovic 2005 for a similar example along a landscape). In a value chain setting, promoting urban agriculture could influence social network structures in different points of space (socio-economic, demographic, cultural), which in turn could reinforce or mitigate adoption practices or intervention uptake, thus influencing (positively or negatively) the sustainability of the value chain over time. Taken together, integrating both types of space within our value chain model could give planners much more information that can be used to understand the potential ramifications of different planning or policy practices.

Participatory processes and group model building

Given the multi-faceted character complexity of the system, we propose the use of participatory processes as a crucial step to collect necessary data and construct SD models in order to conduct a thorough value chain analysis of urban food systems. Through a participatory process of group model building (GMB), SD models can be jointly conceptualized and developed with stakeholders (Vennix 1996). SD modelers can then process this model into an SD framework capable of examining various scenarios of policy implementation (Hovmand 2014).

Figure 2 provides a framework for conducting GMB in an urban agriculture value chain context, highlighting the significant iteration, repetition, and feedback between stakeholders along the supply chain in the design of the final model. The number of these cycles may vary as conditions in every city are specific and require individual assessment. Such a process takes significant time to organize and convince enough stakeholders to participate in model building. It also requires consistent and recurrent participation for feedback and iteration as reflected in figure 2. However, the building of the model is not the only outcome of the GMB process, as the process itself promotes awareness and motivation of people to take part in decision-making processes concerning their community, thus providing a platform for the joint-ownership of results (Hovmand 2014).

Two main approaches to GMB have evolved over the past few decades. One is mainly focused on distributing tasks (e.g., problem definition, model conceptualization, model formulation, model validation, and policy identification) to various scripts to conduct GMB where the time allocated for each script is predetermined. These are known as structured group model building sessions (Andersen and Richardson 1997). The other approach is more focused on open discussion for each task until consensus is reached among stakeholders (Vennix 1996). While both approaches to GMB have their advantages and disadvantages, the main aim of both approaches is to reach consensus among involved stakeholders. This is particularly important to avoid policy resistance among stakeholders because some policies may favor some groups more than others. By involving all stakeholders in the model building process, most of the underlying causes of a problem, policy leverage points, and possible factors that could cause policy resistance will be better addressed.

Vennix (1996) provided different examples of the applicability of GMB in a management context through the use of Nominal Group Techniques (NGT) and a Delphi based approach to build qualitative models of the Dutch fleet and the health system, respectively. In a similar vein, Vennix (1996) also provided a formal quantitative system dynamics model for a housing association in the Netherlands that was built through multiple GMB sessions. In the context of using GMB in agriculture, McRoberts et al. (2013) developed a quantitative SD model through multiple GMB sessions to assess rural dairy cooperatives in South-Central Mexico. GMB sessions were held at different stages (problem definition, model conceptualization, validation, and policy assessment) of the model building process to increase stakeholder confidence in the model.

Olabisi (2010) applied GMB to understand the gaps between micro- and macro-level perspectives towards reforestation initiatives in the Philippines. GMB sessions revealed significant gaps in the perceptions of both researchers (reforestation planners) and community actors. In this context, GMB sessions were crucial in linking both local community insights on local issues and researcher perspectives on macro issues in the design of more sustainable reforestation policies (Olabisi 2010). While Olabisi (2010) retrieved insights from a qualitative model, Jones et al. (2002) used a participatory approach to develop and parameterize a quantitative SD model of resource sustainability in a model of the sawmill industry in the northern forests of the northeastern United States. Other examples of GMB can be found in Beall and Zeoli (2008) in wildlife systems and Pahl-Wostl and Hare (2004) in water management.

The GMB approach is particularly important because powerful models and databases alone are not enough to make or sustain policy changes. Rather, the process of model building and demonstrating how the model fits with the surrounding policy environment is crucial for the applicability of a model to contribute to changes in the policy making process (King and Kraemer 1993). GMB provides a platform to elicit knowledge and information from a group of stakeholders rather than individual players. A model that is developed from a group discussion is much more powerful than one from a model based on individual actor contributions (Vennix et al. 1992). This is particularly important in the context of UPA, as conflicts in land use among stakeholders can become a constraining factor in scaling out activities. Involving all stakeholders in the model building process (i.e. decision making) is thus of significant importance to establish a reliable policy environment that supports long-term, sustainable UPA development. While GIS information is increasingly ubiquitous in planning settings, the data required to map, parameterize, and simulate the interface of value chains with socio-economic drivers is often lacking. However, the fact that urban agriculture has been primarily a bottom-up process of development suggests that participatory approaches that leverage the experiences of participants can potentially bridge the gap between formal and informal stakeholders.

GMB shows promise as a means to link quantitative models with participatory processes that help to both validate the model structure and the results that arise from it. In the context of UPA, the participatory development of system dynamics models through GMB sessions could provide significant insights into decision-making processes at the local level and the level of planners, thus linking bottom-up and top-down perspectives. Through GMB sessions, urban planners and other stakeholders can share and incorporate insights and information about opportunities and costs of UPA within a community and larger urban areas, thus contributing to better planning decisions.

System dynamics models and urban value chains

As noted earlier SD models have an important role in bridging the gap between bottom up processes of urban agriculture initiatives and top-down systems of urban planning. In addition, they can provide a powerful tool for policy makers to assess outcomes of different intervention scenarios and thus provide important information in decision-making processes.

Rich et al. (2011) have argued that SD models can play an important role in developing quantitative models of value chains that provide greater guidance on the potential impacts of policies in value chains as compared to conventional qualitative value chain analysis (cf. Kaplinsky and Morris 2000; GIZ 2008). While conventional value chain analysis methods provide insights on the structure of the value chain and provide an important diagnostic tool, they are limited in their ability to prioritize or quantify the impact of possible policy interventions. As value chains are complex and dynamic, SD models provide an ideal laboratory to quantitatively model the processes and relationships inherent within the value chain that are informed by qualitative value chain analysis (Rich et al. 2011).

We highlight this in figure 3, which illustrates a generic, simplified agricultural value chain model abstracted from a combination of different models previously developed by the authors and other SD practitioners (Rich 2007; Hamza et al. 2014a,b; Sterman 2000). This model is not meant to be an operational one, but illustrative of a generic system of SD building blocks that could be modified and adapted to a particular urban food system. In this figure, modeled in the SD software iThink (see http://www.iseesystems.com), stocks are represented by rectangular shapes that denote the amount of goods being grown or held in inventory at any period of time. The thick arrow shapes represent flows. In the model, we have for instance inflows denoting planting at the farm level (at the left hand size of the figure) and outflows denoting sales and trade to downstream actors in the value chain (wholesalers, processors, retailers). Various convertors that define technical parameters such as costs, sales drivers, and price relationships are expressed as circular shapes that can themselves create other convertor relationships and/or affect inflows and outflows.

In figure 3, farmers plant, grow, and harvest products, which are sold to wholesalers. Wholesalers store goods in inventory prior to sale to either other distributors or processors (depending on the good). These are then sold to retailers who themselves keep product in inventory prior to final sale to consumers. Inventory relationships play a critical role in SD models of value chains by mediating price relationships. Higher than desired inventories put pressure on prices to fall, while low inventories create incentives to bid up prices (Sterman 2000; Whelan and Msefer 1996). Price relationships further have a feedback effect on production incentives for farmers in both the short- and long-term. In the short-run, higher prices relative to variable costs lead to positive profits which in turn provide direct incentives for increasing production through increasing capacity utilization, and vice versa. At the same time, in the long-run, higher price expectations relative to both fixed and variable costs of investments lead to higher expected profits of new investments which in turn provide incentives to invest in building up capacity or investing in new technology (with some time lag) to adjust the capacity gap, and vice versa; this is represented by a capacity stock-and-flow diagram in figure 3. In general, the process of developing UPA and the magnitude of price movement effects on investing in (or abandoning capacity) capacity stock are highly dependent on macroeconomic conditions. This is represented by an exogenous parameter denoted as “producer income.” Higher levels of producer income reduce incentives to build capacity for UPA, and vice versa. Note that this model is generic and does not directly model the flow of finance or information that is a critical part of value chain dynamics (see Hamza et al. 2014a for an example). Other feedback effects will also arise as we will discuss shortly.

An important innovation in modeling value chain dynamics using SD is the ability to examine the impact of various intervention options. In figure 4, we highlight potential entry points for investments within the generic value chain diagram of figure 1. At the farm level, we could consider technical investments in different crop mixes (new crops e.g.), technologies, or the extensification or intensification of land area. We could also examine new types of institutional arrangements that shorten the value chain (e.g. direct farm sales to consumers) or provide strong linkages to buyers via contracts. Further downstream, we could simulate the effects of introducing new value-added products or providing improved information via extension or market information services. In each case, we can assess the net returns to such investments financially; the addition of other types of social or environmental criteria is also possible as well. Some examples of how such models have been used in *ex-ante* impact analysis in a value chain-type setting include Hamza et al. (2014a,b) and Naziri, Rich, and Bennett (2015) in the context of livestock in Southern Africa; Rich and Roland-Holst (2013) on livestock disease in Cambodia; Hamza, Rich, and Wheat (2014) for salmon; Teimoury et al. (2013) on trade policy for fruit and vegetable products; Higgins et al. (2007) for sugar; Mowat, Collins, and Spencer (1996) for persimmons; and Ross and Westgren (2006) for pigs.

Moving forward – operationalizing the framework

Following the methodology suggested, the process of food system planning will require municipalities as clients to employ a body of experts. These experts could include researchers or a private company with a relevant capacity and expertise in GMB and SD modeling to conduct and facilitate the process previously discussed. These experts would then facilitate a series of GMB and SD modeling sessions, involving all relevant stakeholders from the UPA system, private section, and local government. The planning department of the particular municipality would also be involved in this process. However, it would only represent the municipality (client) in the GMB process and would interact as a co-participant like other stakeholders. Such a horizontal arrangement would prevent the possibility of a top-down planning approach whereby planners advocate or decide for the system in the absence of consultation.

Figure 5 shows the structure of this participatory process that would be used for data collection and developing mental models of the particular food system. Experts would use these data and mental models for creating *inter alia* the types of SD models as described earlier and shown in figures 1, 3, and 4. This process is meant to be a learning process whereby planners and UPA stakeholders work together to conceptualize and identify problems, constraints, and opportunities within the UPA system and jointly develop models that assess future scenarios together. Furthermore, it is crucial that an independent third party without an agenda in the process is in charge of facilitating the process of model building to ensure that the full potential of the approach can be realized.

Conclusions

Urban and peri-urban agriculture has significant potential in providing food and livelihoods security to participants, offering a means to respond to crises and a path for resilience against future shocks. While its organic, bottom-up development has promulgated a new dynamism among participants, its sustainability and mainstreaming over the medium- and long-term requires planning perspectives that take into account the needs and constraints of all stakeholders in the food system to develop win-win solutions. Participatory systems modeling provides a potential solution to address the means to improve and sustain UPA decision-making that takes into account the various actors and layers within the urban food system. Mainstreaming participatory systems modeling will require the development of new skill sets within planning and policy agencies to institutionalize this process, with further research needed to test and document the impact of such approaches on sustaining the development of urban agriculture value chains.

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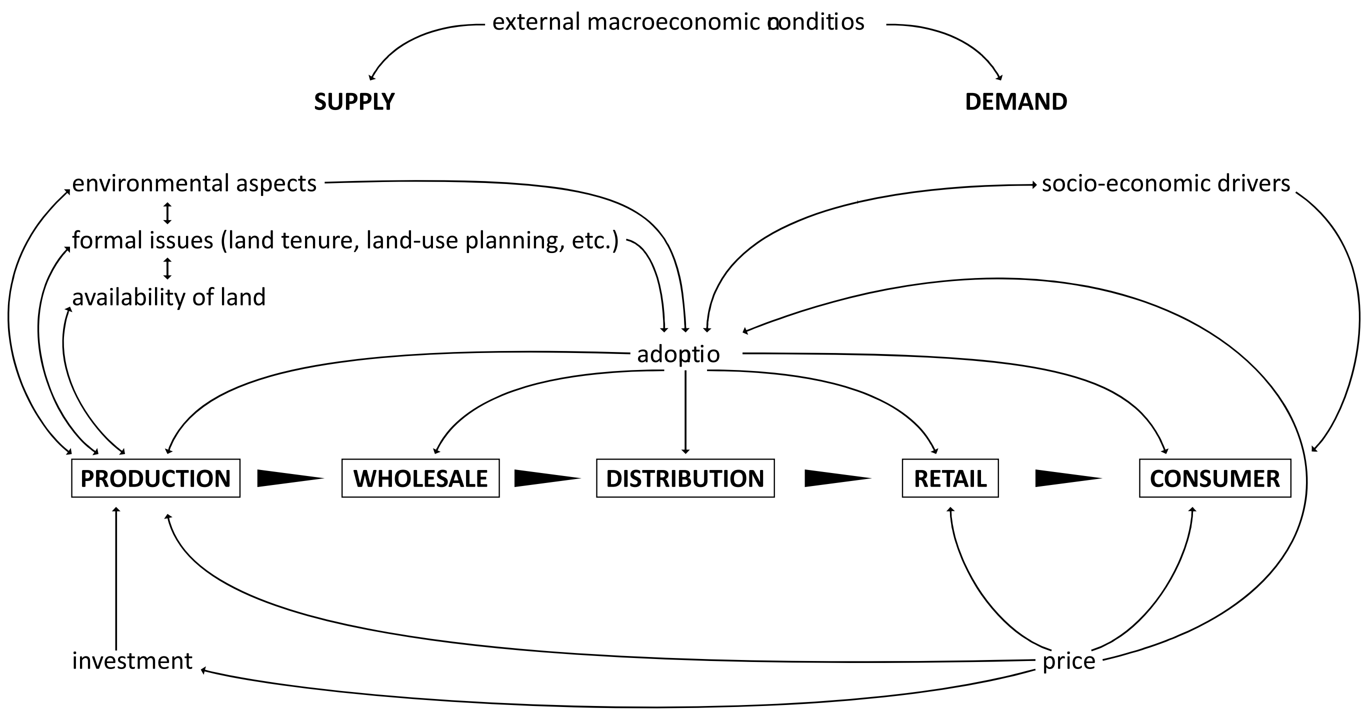
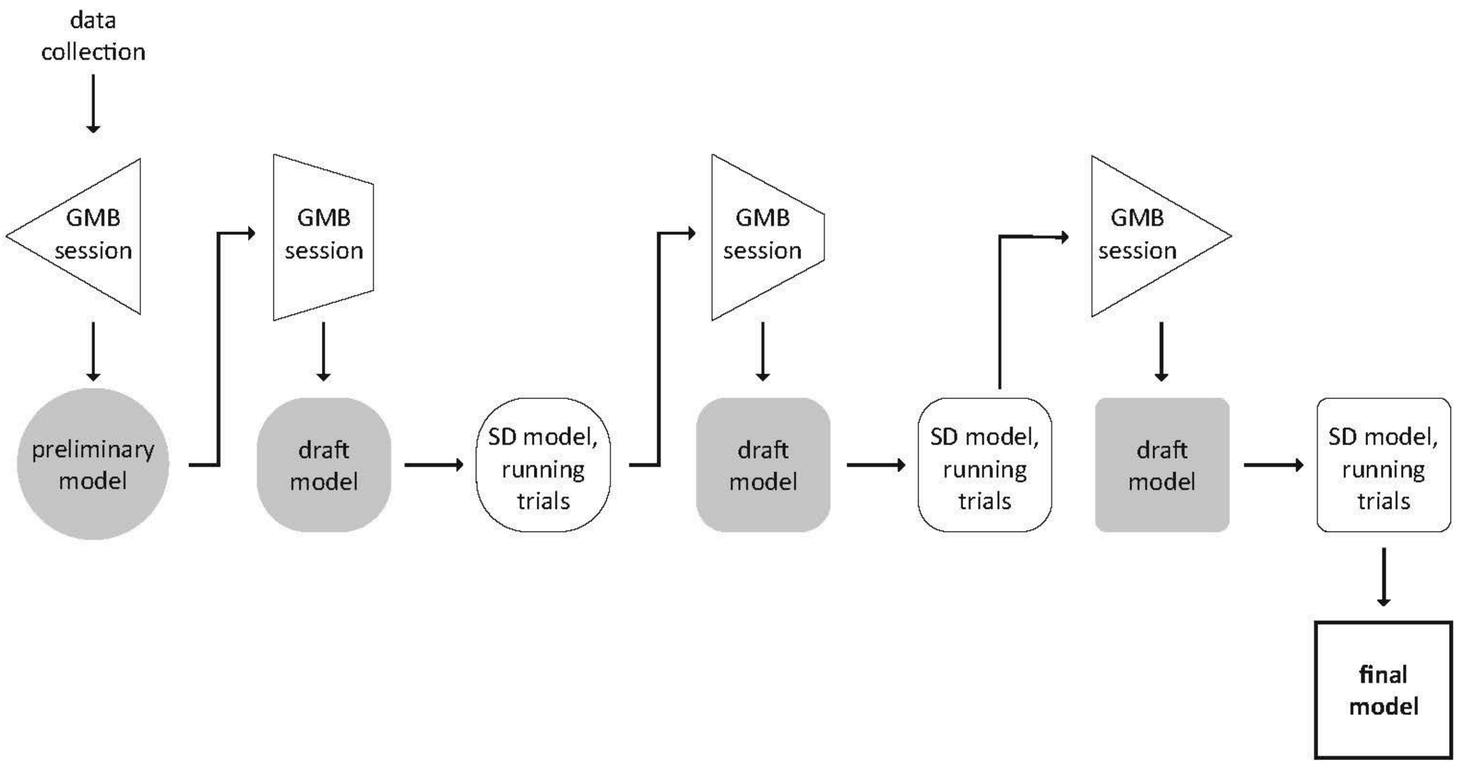
Figure 1
A conceptual framework of the contextual drivers of urban agriculture



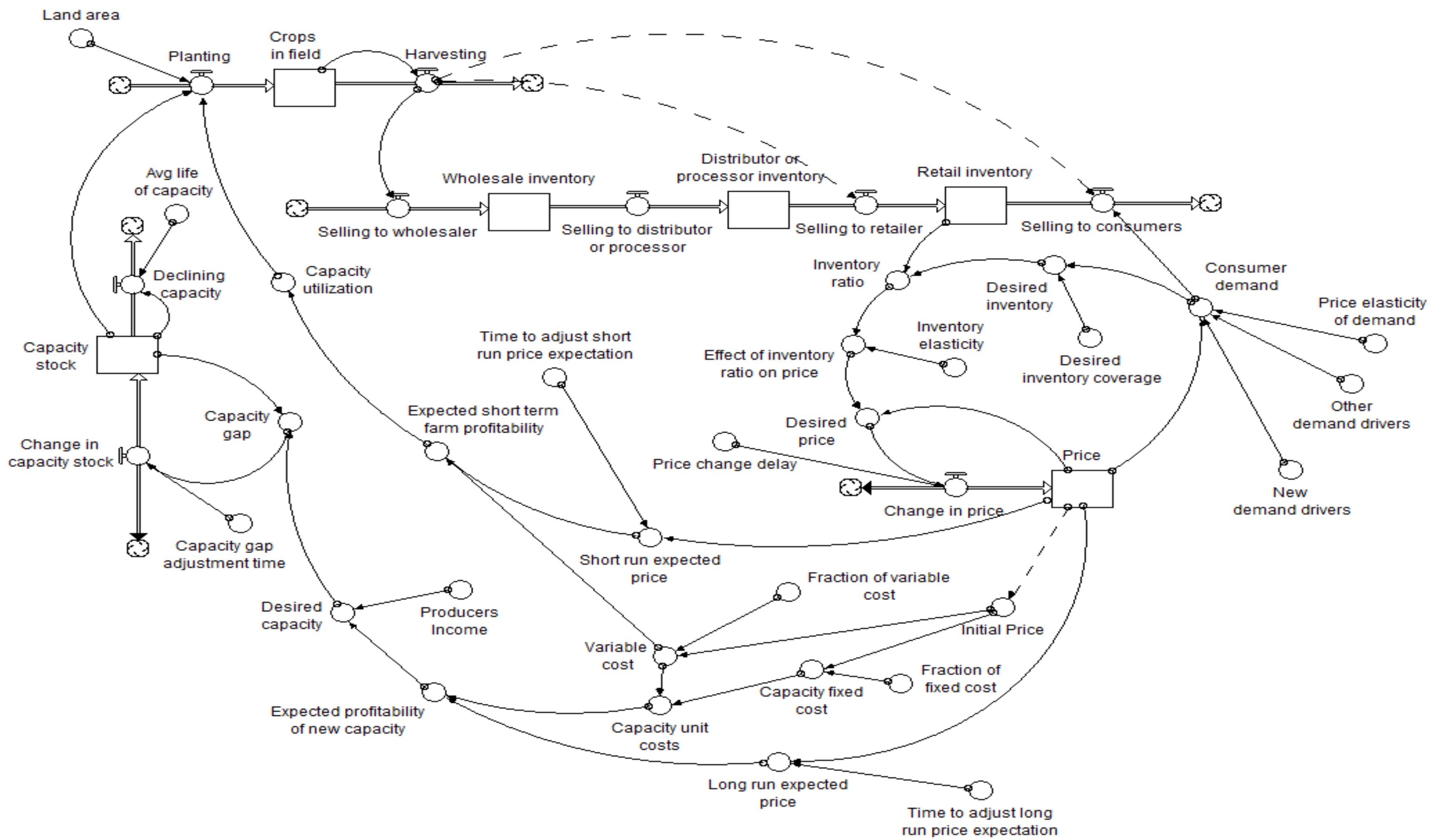
Source: Developed by the authors

Figure 2
A framework for implementing group model building and system dynamics modeling in urban agriculture value chains



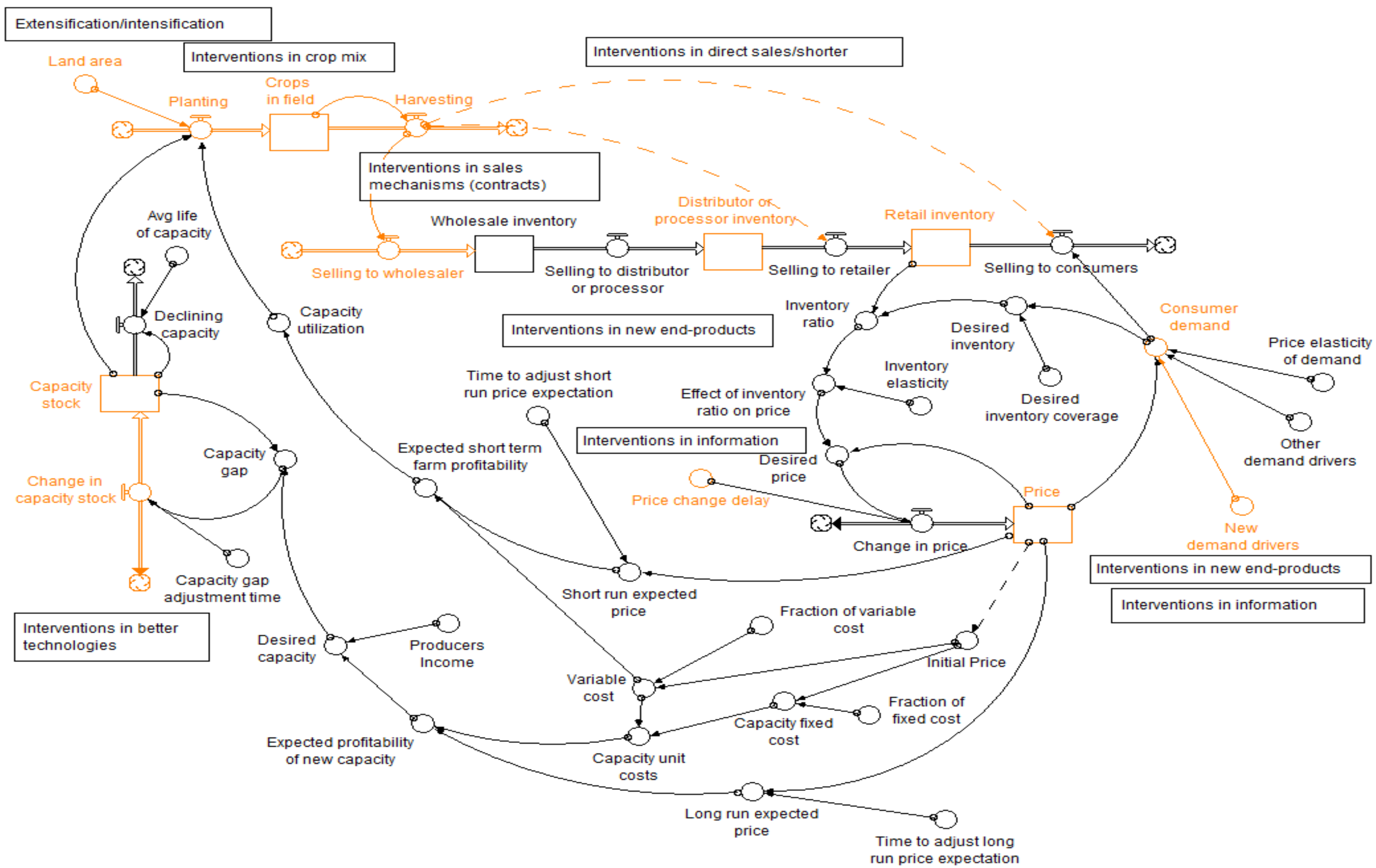
Source: Developed by the authors

Figure 3
A generic SD model of an agricultural value chain



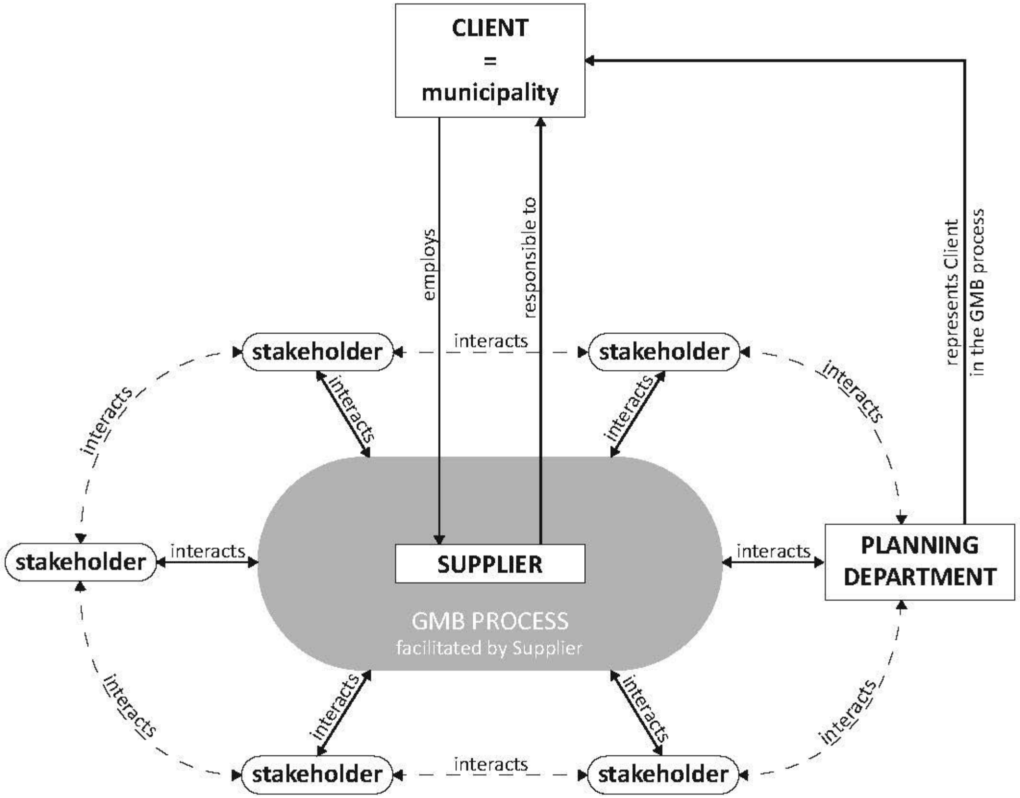
Source: Developed by the authors based on Hamza et al. (2014a) and Sterman (2000).

Figure 4
Possible intervention options in an agricultural value chain



Source: Developed by the authors based on Hamza et al. (2014a) and Sterman (2000).

Figure 5
Implementation process of mainstreaming a system dynamics approach of planning in urban agriculture



Source: Developed by the authors