Deploying Urban Agricultural System for an Innovative and Sustainable Urban Renewal

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Abstract: This article claims to present the interest of a systemic method mobilisation in order to study the urban agricultural system and to characterise its sustainability. This logical reasoning is based on the principle that urban agriculture can be a lever for sustainable city, and that this effect requires a frame for planning urban agriculture projects. Hence, it presents the development prospects of a decision support system, based on an urban agricultural system, allowing prospective studies for urban agriculture deployment.

1 INTRODUCTION

At international scale, the concept of sustainable city took a huge turn in 1994, as representatives of many European cities signed the Aalborg Charter. These representatives took a major responsibility for the ecological crisis. They also identified urban agglomerations as relevant spaces for a more virtuous strategy in terms of environment and climate. This strategy needs to be built on social justice, sustainable economies and viable environment. Since the definition of these principles, one of the main innovative and recent propositions is the development of urban agriculture, as a lever for sustainable city (Deelstra & Girardet, 2000; Lovell, 2010), or even a genuine project serving food security (Smit et al., 1997; White, 2010). These current propositions regarding urban agriculture for the benefit of sustainable cities are the main subject of this article.

As defined by the Food and Alimentation Organization of the United Nations, Urban and Peri-Urban Agriculture (AUP) refers to farming practices in and around cities that use resources - land, water, energy, labor - that can also be used for other uses to meet the needs of the urban population. And according to the Committee on World Food Security (2014), “Agriculture and food systems encompass the entire range of activities involved in the production, processing, marketing, retail, consumption, and disposal of goods that originate from agriculture, including food and non-food products, livestock, pastoralism, fisheries including aquaculture, and forestry; and the inputs needed and the outputs generated at each of these steps. Food systems also involve a wide range of stakeholders, people and institutions, as well as the socio-political, economic, technological and natural environment in which these activities take place”.

In the case of European cities, which constitute the privileged space for this research, urban agriculture is not primarily intended to supply food products. It acts above all as a vector of sustainability for territories and populations (Mendes et al., 2008; Ferreira et al., 2018), and can in theory be associated with numerous environmental, social and economic benefits.

These advantages could consolidate and include in the urban space a real policy of sustainable development. However, agricultural plots remain very rare in cities, especially in towns where projects rarely go beyond the experimental stage. As S. Hagan humorously points out, it seems that “freeing up or

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reclassifying land for urban agriculture requires more than a desire to hold hands and plant vegetables" (Viljoen et al., 2005). Therefore, a gap between the theorical benefits of urban agriculture and its practical application is emphasized. In this context, it now seems essential to identify the obstacles explaining this paradoxical situation, and to determine the innovations required to remove the current barriers. Indeed, it has been known for a long time that urban planners, besieged by various demands, often work with few resources in an environment leaving them little time to innovate (Van Veenhuizen, 2001). A global exploration of this issue would prove to be extremely useful to gain a better understanding of the urban agricultural system and to characterize the potentials it truly offers for the sustainability of territories. This exploration must be based on specific objectives in terms of territorial prospective and support for public decision-making.

The purpose of the research project presented here is to deploy an urban agricultural system for an innovative and sustainable urban renewal. Therefore, the discussions will address methodologies deployed around urban agriculture, through dynamic systems, but also thanks to the spatial representation of these systems. The expected results will then be presented according to different objectives of characterization of the potential for sustainability in the urban agricultural system, through the creation of a decision support system.

2 METHODOLOGY: A TRIPARTITE OBJECTIVE

2.1 Highlighting the Borders of Urban Agriculture

The first step of this research project is to study what urban agriculture is, to answer the simple question "*what?*". Urban agriculture is distinguished by different objectives: urban planning, economic development, recreation, health, food security, environment, social interactions, education. It also stands out in several forms: farms, specialized farms, vertical farms, urban farms, collective henhouses, allotment gardens, family gardens, shared gardens, community gardens, educational gardens, community vegetable gardens, back to work gardens, etc. Urban agriculture is multifunctional and polymorphic (Ferris et al., 2001; Holland, 2004; E. Duchemin et al., 2008; Lovell, 2010). This leads to understanding urban agriculture differently than through a single definition. Assembling the typologies of E. Duchemin (2013) and V. Magali (2017) from ADEME (the French public Environment Agency and Control of Energy) and field observations, afford the creation of a new typology. This typology does not present a unique definition of urban agriculture space by space, but rather characterizes it according to 7 criteria: the actors and project leaders, the economic system, the places, the purposes, the production supports, the distribution systems, and the production. As a result, the different shapes observed in European cities each represent urban agriculture, but according to different criteria.

However, this typology is not sufficient in itself, and does not make it possible to represent urban agriculture in a satisfactory manner. This analytical approach shows limits because it only allows to study each urban agriculture project individually, while a systemic approach would allow to study urban agriculture as a whole. The systemic approach offers a global study of all the elements entering into the ecosystem of urban agriculture and makes it possible to take an interest in the exchanges caused by urban agriculture projects. In order to understand the urban agricultural system, several elements must be taken into account, such as the actors (farmers, associations, local authorities, etc.), economic systems (market, non-market, both), places (wastelands, fields, green spaces, etc.), objectives (productive, social, recreational, etc.), upstream services (provision of land, equipment, support, etc.) and downstream (places of processing, distribution systems). Other agricultural systems (rural, peri-urban, export) also come into play. Therefore, exploring a dynamic system is a worthwhile path to represent the set of elements taking action in an urban agricultural system.

A system is a set of units in mutual interrelationships (Van Bertalanffy, 1948), organized according to a goal (de Rosnay, 1995). Its study, through a systemic approach, makes it possible to go beyond an analytical approach. The analytical approach is based on the principles of obviousness, reductionism, causalism and exhaustiveness. Without opposing these principles, systemic approach rather complements the analytical approach by basing itself on relevance, globalism, teleology, and aggregativity (Lemoigne, 1994). According to J. de Rosnay (1995), a systemic approach connects the elements of a system by focusing on their interactions and effects. It is based on a global perception. Each element is no longer studied individually, but rather by considering the completeness in which it is placed, and simultaneously. This approach can be linked to

Aristotle's principle, stating that the whole is more than the sum of its parts.

These principles can be applied to the study of urban agriculture. Indeed, as mentioned previously, the study of urban agriculture through the construction of a typology, observing urban agriculture, project by project, does not allow us to completely understand urban agriculture. This analytical approach has limits: urban agriculture can only be observed fixed in the moment and compared to the typology created. But by referring to the presentation of a dynamic system, it answers the question *How?*. The field of possibilities expands, to leave room for a systemic approach observing agriculture in its entirety, studying all the elements composing it at the same time. This approach allows urban agriculture projects to be put into context. Beyond studying urban agriculture projects individually, it makes it possible to do so simultaneously. It allows to study the interactions between the elements entering into the ecosystem component of agriculture projects. Coupled with actors, economic systems, distribution sites, these projects form an entirety: the urban agricultural system.

This urban agricultural system has already been approached by various authors. Artmann and Sartison (2018) feel the need to approach agriculture as an ecosystem, in order to be entirely able to develop urban agriculture to its full potential. Their approach anticipates both opportunities and threats from urban agriculture in a multidimensional way. Likewise, although the literature has extensively studied urban agriculture projects, Abu Hatab et al. (2019) see a flaw in the way this topic is studied. Indeed, the interactions between the different aspects of what they call urban food systems are hardly analysed. Based on this inventory, they choose to observe the urban food system as an entirety, and to include external factors, such as socioeconomic, demographic, natural resource, and environmental. They conclude that taking these factors into account as a whole would make it possible to avoid isolated consultations, factor by factor, actor by actor. They underline the need for research on the interactions components of an urban food system can have between them, highlighting the dynamics of this system which can include feedback loops. Not studying urban agriculture as a system would make researchers and governance actors miss some of these causes and effects.

The idea of observing urban agriculture as a system is therefore not new, nor the idea of feedback loops. Thus, urban agriculture can be studied through a systemic approach, and in a dynamic way. This is indeed what Rich et al. (2018) propose using a dynamic system for the deployment of urban agriculture. They are developing a representation of the urban farming system in Christchurch, New Zealand, using the VENSIM modelling tool. Indeed, VENSIM is an interactive environment simulation software, allowing the analysis and optimization of model simulation.

Modelling an urban agricultural system may be a first lever for its deployment. However, outlining the sustainability of an urban agricultural system would be a significant addition.

2.2 Characterizing the Potential for Sustainability

From the 1980s, different currents emerged and questioned the relationship between city and nature. The emergence of models of sustainability called into question the place of nature in cities, or rather its absence. More than spaces for relaxation, real spaces rethinking the ecology of the city would be introduced, calling into question the entire living environment in cities. Several principles are proposed (European Conference on Sustainable Cities and Towns, 1994), such as building a social justice, sustainable economies and a viable environment. To do so, objectives are set: cities should become multifunctional, turn to sustainable spatial planning and sustainable urban mobility, fight against pollution at its source, and rely on its citizens by involving them in these processes.

However, the notion of sustainability is difficult to measure. Its definition is not consensual, which complicates its adaptation in the form of indicators (Hély & Antoni, 2019). The concept of urban agriculture is no exception to this ongoing scientific problem. Tool for food security, service of nature in the city and the sustainable management of fluxes, actor of solidarity and social cohesion, tool of citizen involvement and support for democracy, favourable instrument for a virtuous economy, benefits in terms of public health, appreciation of unused or neglected spaces… These various functions results are mostly difficult to quantify. Indeed, it would be a question of concretely translating a concept whose repercussions seem mainly qualitative.

Armanda, Guinée and Tukker (2019) point out there is no overall measure making it possible to assess the environmental impact of urban agriculture. To achieve such a measurement tool, they believe it would be necessary to take into account the entire chain of the production system of urban agriculture.

This may be how the urban agricultural system could offer a comprehensive study of its sustainability. In consequence, the indicator to measure the sustainability of an urban agriculture project does not exist. However, it would be interesting to look at the various sustainability indicators already existing, and to analyse how to combine these indicators to identify all aspects of urban agriculture. The question to be asked would not be "*is this project sustainable?*" but rather "*are the technical, economic and social characteristics of the urban agricultural system sustainable?*" by responding through the analysis of the various specific functions it includes.

Azunre et al. (2019) highlight the lack of literature on measuring the sustainability of urban agriculture. Thus, they mobilize three indexes. First, the Green City Index includes 30 indicators. Second, the Global City Indicators covers aspects of urban life on economic and social aspects. Third, the Global Compact Cities Circles of Sustainability includes 28 indicators grouped into four categories: politics, culture, economics and ecology. Based on these three indexes, the authors analyse the sustainability of urban agriculture projects according to different criteria: fulltime employment, income generation and gross domestic product, savings and expenditure, tax revenue, educational functions, civic engagement, safety and security, gender equality and social equity, health benefits, recreation, technology and innovation promotion, management of emissions, water management, waste management, energy efficiency, and finally organic farming in percentage of total agricultural area.

Gómez-Villarino and Ruiz-Garcia (2021) propose a model making possible to study the urban agricultural system according to different stages: first, the spaces virgin of urban agriculture are observed. Their development is then monitored, regarding sustainable objectives, and corrective measures are proposed. Finally, the results obtained make it possible to present the faults in the urban agricultural system, but also to highlight the benefits.

In consequence, beyond the need to represent urban agriculture projects as a whole embodied by a system, it seems necessary to introduce, into this dynamic model, the possibility of answering the question "*is this urban agricultural system sustainable?*", through a multi-criteria approach.

2.3 Mapping and Assembling: An Additional Step

Modelling an urban agricultural system is vital to its understanding and representation. However, the essential object of planning is a simple question: *where?* Spatializing the model of the urban agricultural system seems necessary to fully support the urban development of agriculture in cities. Thus, the literature presents spatialized modelling methods for the planning of urban agriculture. La Rosa et al. (2014) present, for example, a method of sustainable planning of urban agriculture, using a GIS-based modelling tool. The interest of this tool is to detect non-urbanized areas, and to point out those having the potential to evolve into new forms of urban agriculture.

This GIS-based modelling principle can be imported to a dynamic system tool such as VENSIM. So comes the idea of assembling a dynamic system to cartography. The objective is to create a single tool, allowing to bring together both the interest of tools for representing dynamic systemic models, and the interest of GIS tools. The creation of such assembling makes it possible to simplify the use of multiple tools by reducing their number, and by automatically introducing spatialized data into the dynamic systemic model studied.

This method of introducing spatial data into the VENSIM tool has already been used for various research. This is the case of Neuwirth (2017) who uses a software called SimSyn to link VENSIM to databases, and in this case to rasterized data. This is also the methodology employed by Wingo et al. (2017) who developed Open Modelling Environment, an Open Source System Dynamic allowing to represent spatially explicit relationships, based on a stock-flow model. This approach makes it easy to include spatialized data in a dynamic model, while simplifying visualization.

These methodologies for introducing spatial data into a dynamic systemic model could be a response to the problem of representing an urban agricultural system.

To summarize, urban agriculture, although often observed in the literature, is much less observed in a systemic way. Furthermore, urban agriculture is seen as one of the levers for the development of sustainable cities. But to apply these principles in practice, planning must be able to quantify the sustainability of urban agriculture projects. Thus, a need to measure the sustainability of the urban agricultural system of territories is felt and can be reflected by a GIS mobilization and the creation of a forward-looking modelling. These tree axes of research can support the answers of tree simple yet essential questions: *What? Where? How?* This methodology is illustrated in figure 1.

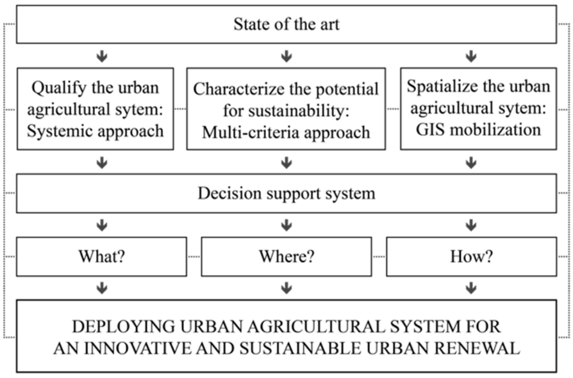

Figure 1: Graphic presentation of the methodology deployed.

3 A NECESSARY TOOL MOBILIZATION: DEVELOPING A DECISION SUPPORT SYSTEM

A need to support the development of urban agriculture is felt. Three needs have been identified. First, urban agriculture must be presented in its entirety, from the start of the chain upstream to downstream. For this, the systemic approach is considered the most relevant, in particular through the mobilization of a dynamic system modelling software such as VENSIM. Next, the reason why it is relevant to reflect on the establishment and operation of urban agriculture projects is its ability to respond to sustainability issues. Thus, the spatialized urban agricultural system must be able to produce a measurement of its sustainability thanks to relevant indicators. Finally, the development of urban agriculture cannot be done without taking spatial data into account. Knowing how to implement urban agriculture projects requires taking into account where they will be. The spatialization of the urban agricultural system can be achieved through an assembling that automates the inclusion of spatial data in the process of modelling this dynamic system. The systemic approach, the sustainability of urban agriculture as well as its spatialization are therefore the three pillars of the research project developed here.

The reflections presented lead to additional questions: what adequate tool should be mobilised in order to deploy the urban agricultural system for an innovative and sustainable urban renewal? Could the development of a decision support system to support actors involved in the development of urban agriculture be the answer? This decision support system, bringing together the systemic model, its spatialization and the measurement of sustainability, would accomplish three main missions.

Far from thinking of urban agriculture projects on a theoretical model, the decision support system would make it possible to observe a specific field of study. The first mission is to offer a tool making an inventory of the urban agricultural system already existing in the territory. Therefore, the functioning of the urban agricultural system at a precise moment could be studied, as well as its level of sustainability according to different indicators.

Once the existing urban agricultural system has been captured, the decision support system will have the second task of determining its development potential. It would make it possible to achieve a higher level of sustainability, according to various criteria, such as the distribution of places of urban agriculture, places of food distribution, or the assistance and supervision provided by governance, for example.

Finally, the decision support system will have the third mission of offering a simulation method supporting prospective studies. Thanks to the principle of the feedback loop of dynamic systems, it would observe how the urban agricultural system studied could develop according to external input elements. This would answer various questions such as "*How will the existing urban agricultural system develop if no planning is in place?*", "*How will the urban agricultural system evolve if such a development or framework is added?*". These different projections will allow actors involved in the development of urban agriculture to support their decisions.

4 CONCLUSIONS AND PROSPECTIVE

The main purpose of this article is to justify the need of a modelling and a systemic approach to serve sustainable cities and urban agriculture. It starts from the Aalborg Charter highlighting social justice, sustainable economies and viable environment, and the development of urban agriculture as a lever for sustainable cities and food security. Knowing that planning urban agriculture is not currently achieving its full potential, this article outlines tree simple but essential questions - *what? where? How?* - through tree strands: the qualification of the urban agricultural system, the characterization of its potential for sustainability, and its spatialization.

The qualification of the urban agricultural system expresses the need of representing urban agriculture beyond the individual study of projects, taking into account all the elements involved in urban agriculture: actors, economic systems, places, objectives, upstream and downstream services. To achieve this need, the relationships and interactions between these elements must be studied. The solution might be a systemic approach and the representation of urban agriculture through a dynamic system, allowing the study of urban agriculture as a whole, always in movement. In consequence, the urban agricultural system would need to be observed.

Furthermore, this article examined planning urban agriculture because of its potential capacity as a lever for sustainable cities. Therefore, measuring its sustainable impacts is essential. The literature brough up in this article highlights the plurality of indicators, and the difficulty of quantifying a mostly qualitative concept. The need of assembling measuring tools of sustainability to a spatialized dynamic model is felt.

Next, the necessity of planning urban agriculture and detecting places where it could entrench is formulated. Thus, a GIS-based tool must be mobilised. In order to simplify the study of urban agriculture, cartography and representation through a dynamic model should be assembled. In other word, a spatialization is required.

Answering these tree strands is seen as a lever for the deployment of urban agricultural system for an innovative and sustainable urban renewal. This purpose can be supported by the development of a decision support system, assembling a dynamic system, its spatialization and its sustainability. It would allow actors of urban agriculture to define the sustainability of a pre-existing system. But above and beyond that, it would also need a simulation method supporting prospective studies. The creation of this tool represents the main ambition of our future researches.

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