DOCTORAL PROGRAM IN AGRI-FOOD AND BIOSYSTEMS SCIENCE AND ENGINEERING

DOCTORAL THESIS

Urban Agriculture as an Innovative Lever for Sustainable Development, Resilient Cities, and Inclusive Governance

Submitted by **Ouiam Fatiha Boukharta** to obtain the degree of
Doctor from the University of Valladolid

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REPORT ON THE PUBLICATIONS INCLUDED IN THIS DOCTORAL THESIS

This doctoral thesis is a compilation of previously published work, comprising seven articles published in scientific journals indexed in the Web of Science (WOS) - Journal Citation Reports (JCR) database. Three of these journals are in the first quartile (Q1), while two are in the second quartile (Q2) and one in the third quartile (Q3). Ms. Ouiam Fatiha Boukharta is first author of five of the publications, second author of one and third author of one. The full references of the articles that make up the body of this doctoral thesis are as follows:

Articles included in the compendium of the doctoral thesis:

1. O.F. Boukharta, F. Pena-Fabri, L. Chico-Santamarta, L.M. Navas-Gracia, L. Sauvée. "Governance structures and stakeholder's involvement in Urban Agricultural projects: an analysis of four case studies in France". International Food and Agribusiness Management Review, 2024, 27(1), 76–93, https://doi.org/10.22434/IFAMR2023.0072 ; Q2 SJR (Business and International Management), Q3 JCR (Science Edition – Agricultural Economics & Policy, 43.6 percentile). $JIF_{2023} = 1.5$.

2. O.F. Boukharta, L. Sauvée, L. Chico-Santamarta, F. Pena-Fabri, L.M. Navas-Gracia. "Reality vs. Expectations in the Implementation of Urban Agricultural Projects—A Polycentric Governance Analysis". Urban Science, 2024, 8(4), 260, https://doi.org/10.3390/urbansci8040260 ; Q1 SJR (Urban Studies), Q2 JCR (Urban Studies, 61e percentile). $JIF_{2023} = 2.1$.

3. O.F. Boukharta, L. Sauvée, F. Pena-Fabri, L. Chico-Santamarta, L.M. Navas-Gracia. "Disentangling metropolis-city relationships in the governance of sustainability transitions: An in-depth exploration of the case of Rouen, France". Cities, 2025, 163, 106019, https://doi.org/10.1016/j.cities.2025.106019 ; Q1 JCR (Urban Studies, 93.5 percentile), Q1 SJR (Urban Studies). $JIF_{2023} = 6.0$.

4. O.F. Boukharta, L. Chico Santamarta, A. Correa Guimaraes, L.M. Navas Gracia. "Assessing Citizens' Perceptions of Urban Agriculture and Its Contribution to Food Security—Worldwide Analysis and Specific Case Studies in Spain". Urban Science, 2025, 9(5), 150, https://doi.org/10.3390/urbansci9050150 ; Q1 SJR (Urban Studies), Q2 JCR (Urban Studies, ~60th percentile). $JIF_{2024} \approx 2.1$.

Articles published related to the thesis but not included in the compendium of this doctoral thesis:

1. O.F. Boukharta, I.Y. Huang, L. Vickers, L.M. Navas-Gracia, L. Chico-Santamarta. "Benefits of Non-Commercial Urban Agricultural Practices—A Systematic Literature Review". Agronomy, 2024, 14(2), 234, https://doi.org/10.3390/agronomy14020234 ; Q1 JCR (Science Edition – Plant Sciences, 65/238). $JIF_{2023} = 3.3$.

2. L. Sauvée, F. Fabri, M. Demba, O.F. Boukharta. "Requalification territoriale soutenable par l'agriculture urbaine. Études de cas au Havre et à Rouen". Cahiers Costech, 2024, 7, https://costech.utc.fr/CahiersCostech/spip.php?article197.

3. F.J. Diez, <u>O.F. Boukharta</u>, L.M. Navas-Gracia, L. Chico-Santamarta, A. Martínez-Rodríguez, A. Correa-Guimaraes. "Daily Estimation of Global Solar Irradiation and Temperatures Using Artificial Neural Networks through the Virtual Weather Station Concept in Castilla and León, Spain." Sensors, 2022, 22(20), 7772, https://doi.org/10.3390/s22207772 ; Q1 JCR (Instruments & Instrumentation, Electrochemistry, Chemistry Analytical), JIF$_{2022}$ = 4.2; Q1 SJR (Analytical Chemistry, Atomic and Molecular Physics and Optics, Instrumentation).

"Education is the passport to the future, for tomorrow belongs to those who prepare for it today."

- Malcolm X

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ABSTRACT

Confronted with demographic pressure, urbanization, food insecurity and territorial imbalances, cities are increasingly rethinking their development models to make them more sustainable, inclusive and resilient. Urban agriculture is emerging as a multifunctional approach that promises ecological transition, social cohesion and innovative governance. Its implementation is however raising questions about long-term impacts, governance arrangements and institutional anchoring. This thesis deploys an interdisciplinary framework that combines various research articles evaluating urban agriculture, the analysis of its polycentric governance, along with in-depth empirical case studies in France and Spain, with the aim of assessing how different actors - local authorities, metropolitan institutions, citizens, etc. - interact to promote sustainable urban development. The methodology consisted of a mixed methodological framework, combining qualitative and quantitative approaches, through questionnaires, interviews, fieldwork and statistical data to analyse the dynamics of urban agriculture and its impact on residents and the city. Numerous results were highlighted, where the systematic literature review identified the key roles of non-commercial urban agriculture in supporting inclusion, ecosystem services and collective empowerment, while pointing out its limitations. Case studies of urban agriculture projects in France demonstrate that an appropriate polycentric arrangement enables local involvement and joint construction, while also reflecting the underlying tensions between metropolitan governance and citizen initiatives. Regarding the urban agriculture cases evaluated in Spain, they highlight strong citizen involvement with limited institutional integration in terms of financial issues and support, thus illustrating the imperatives of territorial contextualization of governance models, thereby ensuring complementarity between the local and international cases evaluated. Finally, the worldwide survey revealed that while urban agriculture is widely perceived as part of sustainable development and food resilience, active engagement is low, reflecting weak institutional support for urban agriculture despite the perceived benefits. Overall, the results confirm that urban agriculture is a strategic political and territorial lever, whose contribution to sustainable urban transitions depends on appropriate governance, technical and financial support and greater institutional recognition.

Keywords: Urban transitions, Local food production, Food Security, Urban Agricultural Projects, Polycentric Governance, Qualitative analysis, Quantitative Analysis.

RESUMEN

Frente a la creciente presión demográfica, la urbanización, la inseguridad alimentaria y los desequilibrios territoriales, las ciudades se replantean cada vez más sus modelos de desarrollo para hacerlos más sostenibles, inclusivos y resilientes. La agricultura urbana se perfila como un enfoque multifuncional que garantiza el desarrollo sostenible, la cohesión social y una gobernanza innovadora. Su aplicación suscita preguntas sobre su impacto a largo plazo, sus mecanismos de gobernanza y su anclaje institucional. La presente tesis doctoral despliega un marco interdisciplinar que combina diversos artículos de investigación que evalúan la agricultura urbana, el análisis de su gobernanza policéntrica, junto con estudios de caso empíricos en profundidad en Francia y España, con el objetivo de evaluar cómo interactúan los diferentes actores -autoridades locales, instituciones metropolitanas, ciudadanos, etc.- para promover el desarrollo urbano sostenible. La metodología consistía en un marco metodológico mixto, que combinaba perspectivas cualitativas y cuantitativas, a través de cuestionarios, entrevistas, trabajo de campo y datos estadísticos para analizar la dinámica de la agricultura urbana y su impacto en los residentes y la ciudad. Se destacaron numerosos resultados, en los que la revisión sistemática de la literatura identificó las funciones clave de la agricultura urbana no comercial en el apoyo a la inclusión, los servicios ecosistémicos y el empoderamiento colectivo, señalando al mismo tiempo sus limitaciones. Los estudios de casos de proyectos de agricultura urbana en Francia demuestran que una organización policéntrica adecuada permite la participación local y la construcción conjunta, al tiempo que refleja las tensiones subyacentes entre la gobernanza metropolitana y las iniciativas ciudadanas. Respecto a los casos de agricultura urbana evaluados en España, destacan una fuerte implicación ciudadana con una integración institucional limitada en términos de cuestiones financieras y de apoyo, ilustrando de esta forma los imperativos de la contextualización territorial de los modelos de gobernanza, asegurando así la complementariedad entre los casos locales e internacionales evaluados. Por último, la encuesta mundial reveló que, si bien la agricultura urbana es ampliamente percibida como parte del desarrollo sostenible y la resiliencia alimentaria, el compromiso activo es bajo, lo que refleja un apoyo institucional insuficiente a la agricultura urbana a pesar de los beneficios percibidos. En general, los resultados confirman que la agricultura urbana es una estratégica política y un instrumento territorial, que contribuye a las transiciones urbanas sostenibles mediante una gobernanza adecuada, apoyo técnico y financiero y un mayor reconocimiento institucional.

Palabras clave: Transiciones urbanas, Producción local de alimentos, Seguridad alimentaria, Proyectos urbanos, Gobernanza policéntrica, Análisis cualitativo, Análisis cuantitativo.

RÉSUMÉ

Confrontées à la pression démographique, à l'urbanisation, à l'insécurité alimentaire et aux déséquilibres territoriaux, les villes repensent de plus en plus leurs modèles de développement pour les rendre plus durables, inclusifs et résilients. L'agriculture urbaine s'impose comme une approche multifonctionnelle prometteuse de transition écologique, de cohésion sociale et de gouvernance innovante. Sa mise en œuvre soulève cependant des questions sur les impacts à long terme, les modalités de gouvernance et l'ancrage institutionnel. Cette thèse déploie un cadre interdisciplinaire qui combine divers articles de recherche évaluant l'agriculture urbaine, l'analyse de sa gouvernance polycentrique, ainsi que des études de cas empiriques approfondies en France et en Espagne, afin d'évaluer comment les différents acteurs - autorités locales, institutions métropolitaines, citoyens, etc. - interagissent pour promouvoir un développement urbain durable. La méthodologie repose sur un cadre méthodologique mixte, combinant des approches qualitatives et quantitatives, à travers des questionnaires, des entretiens, du travail de terrain et des données statistiques pour analyser la dynamique de l'agriculture urbaine et son impact sur la ville et ses habitants. De nombreux résultats ont été mis en évidence, où l'examen systématique de la littérature a identifié les rôles clés de l'agriculture urbaine non commerciale dans le soutien à l'inclusion, aux services écosystémiques et à l'autonomisation collective, tout en soulignant ses limites. Les projets d'agriculture urbaine en France démontrent qu'un aménagement polycentrique adéquat permet l'implication locale et la construction conjointe, tout en reflétant les tensions sous-jacentes entre la gouvernance métropolitaine et les initiatives citoyennes. Concernant les cas d'agriculture urbaine évalués en Espagne, ils mettent en évidence une forte implication des citoyens avec une intégration institutionnelle limitée en termes de questions financières et de soutien, illustrant la nécessité d'une contextualisation territoriale des modèles de gouvernance, assurant ainsi la complémentarité entre les cas locaux et internationaux évalués. En outre, l'enquête mondiale a révélé que si l'agriculture urbaine est largement perçue comme faisant partie du développement durable et de la résilience alimentaire, l'engagement actif est faible, ce qui reflète le faible soutien institutionnel à l'agriculture urbaine en dépit des avantages perçus. Dans l'ensemble, les résultats confirment que l'agriculture urbaine est un levier politique et territorial stratégique, dont la contribution aux transitions urbaines durables dépend d'une gouvernance appropriée, d'un soutien technique et financier et d'une plus grande reconnaissance institutionnelle.

Mots clés : Transitions urbaines, Production alimentaire locale, Sécurité alimentaire, Projets d'agriculture urbaine, Gouvernance polycentrique, Analyse qualitative, Analyse quantitative.

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1. INTRODUCTION

1.1. The challenges of urban growth and the potential contribution of urban agriculture

Ensuring sustainable urban food systems is of extreme importance, given that urban areas are currently characterized by rapid population growth, aggressive food marketing, and unhealthy diets [1], and where by 2030, the United Nations Human Settlements Program has estimated that 60% of the population will live in urban areas [2]. The first and foremost human need after air and water is food, and currently, agricultural production is at risk due to population growth and the scarcity of water resources worldwide [3]. However, one of the key future challenges facing our society is to meet the demand for consumable products to feed these 9 billion people expected by 2050, while limiting the environmental impact of food production [4].

Food is fundamental to human well-being and development, and sustainability is achieved when people always have access to the food they need for a normal, healthy life [5]. As a result, today's world is a combination of tradition, modernity, and agriculture [6], and where urban agriculture is currently able to occur wherever humans can cultivate grains, even in the smallest part of the soil [7], thereby providing interactions and adaptation to an urban ecosystem [8].

Urban agriculture is a system of growing, processing, distributing, or selling food or food products through the intensive cultivation of plants or livestock in urban areas, and which can take a variety of forms and occupy a variety of locations [9], and which, according to the FAO in 2019, is considered as a way to remedy food insecurity in cities [10]. Indeed, several farming practices are currently being implemented, with the aim of guaranteeing the three aspects of sustainable development (social, environmental and economic) along with its different goals, therefore providing ecosystem services to residents and the city [11].

1.2. Urban agriculture – forms evaluated and benefits

Forms of urban agriculture evaluated in this thesis

Many forms of urban agriculture are currently being practiced [9]. The focus in this thesis is about a mixed-model urban agriculture, including the non-commercial practices along with some private aspects in some cases, focusing particularly on urban farms, community gardens, school gardens, allotments and other private urban agricultural initiatives, which are: Community Gardens, Allotments, School Gardens and Urban Farms. Community gardens are defined as open spaces which are managed and operated by members of the local community in which food or flowers are grown, and whose total area is maintained collectively, ranging from small neighbourhood gardens to larger ones [9,12]. Allotments, have been defined as plots of land designated by local authorities for the purpose of growing vegetables for home consumption and when land is acquired through a personal-use lease [13]. Nevertheless, when allotments meet the criteria of growing food or flowers in a communal manner, they can also be considered as community gardens [14]. Another form of non-commercial urban agriculture is school garden, which feature vacant land on school sites

designed for a range of food education-related agricultural activities involving student participation, which are useful for improving children's nutritional outcomes and knowledge [15], making them more willing to try unfamiliar varieties of fruits and vegetables [16]. The final form of urban agriculture that is evaluated in this study is urban farms, which are considered the main source of income for many urban households [17]. According to the FAO, by 2022, urban and peri urban farmers will increasingly strive to produce high demand crops efficiently, making the best use of available resources and inputs, whether by planting in the ground or in containers [10].

Benefits of UA

Urban Agriculture is considered as an important component of practices aimed at food sovereignty and the protection of urban ecosystems [18]. Indeed, several studies demonstrate the importance of Urban Agriculture in providing a variety of social, economic and environmental services within urban territories [19,20]:

- Economic aspects towards the implementation of urban agriculture revitalize local economies by creating new jobs and attracting investment [21,22], offers direct access to a wider range of nutritionally rich foods at a lower cost than the market price [21,23] and transform abandoned spaces to resilient cities [24,25].
- Environmental benefits are related to reduce food and nutritional insecurity in relation to food sovereignty, accessibility and quality [26,27], support better food security and public health [28,29] and air purification and biodiversity conservation [30,31].
- Social aspects are related to recreational and leisure spaces for relaxation [32,33], improve mental health and wellbeing, promoting stress management and encouraging social cohesion [34,35] and sustaining spaces for the exchange of knowledge and the creation of community bonds [36,37].

1.3. Urban Agricultural cases evaluated:

This doctoral thesis focused on the evaluation of different urban agricultural practices, in Spain and France.

1.3.1. In Spain:

In Spain, two initiatives were evaluated, in the cities of Valladolid and Segovia. The motivation to work on these two initiatives was linked to their prior knowledge, in particular with regard to the number of activities they carry out and their importance within the cities, where all the inhabitants are very supportive of this type of projects and where their neighbours lead them to develop similar approaches. In fact, the results obtained from this study have ensured the ongoing publication of an article:

- "Alimenta Conciencia" In Segovia: Segovia is an active city in terms of health and equity, education, and participation. To achieve a sustainable and healthy food system, Segovia's sustainable food strategy has the objectives of coordinating between the different administrations and promoting better administrative coordination. The main objectives of this initiative are to better know what is produced and consumed and how they affect the local economy and depopulation, as well as promoting a more sustainable, local, healthy, and seasonal diet. With the aim of combating food insecurity and promoting awareness, this innovative initiative was launched in 2019. However, due to the far-reaching effects of the Covid- 19 pandemic, the expected timeframe for completion of the project has been postponed from 2022 to the end of 2023. This delay was imposed due to major unexpected challenges posed by the pandemic, such as limited access to resources, restricted supply chains and the necessity to adjust project activities to ensure the safety of the participants.
- "Estrategia Alimentaria de Valladolid": The city of Valladolid has developed a process of reflection on the local agri-food system. This process of research and reflection has led to a participatory process for drafting a Food Strategy for the city, which will then be translated into an action plan. At the same time, the strategy has begun its implementation phase, which is currently underway. This project was launched by the City Council of Valladolid, the Foundation Entretantos and the University of Valladolid, which has been joined in 2019 by MercaOlid and the VallaEcolid associations. The principal objective of the project is to promote a space for collective transformation of the food system, work with other sectors for a more prolonged use of processed foods, as well as broadening the sales channels, opening a niche in collective catering and even the possibility of developing new allergen-free products and innovation. This would generate very positive learning, relationships and synergies for the local food system.

1.3.2. In France:

This was done through a 7-months Doctoral Exchange at the Polytechnic Institute Unilasalle in France, and was based on the analysis of 4 case studies in that country (two in each of the cities of Rouen and Paris), which served as a basis for investigations into the theme of governance structures. The results made it possible to compare the cases in pairs (social and economic), and then to draw conclusions regarding the alignment between governance mechanisms, including decision-making, cost/benefit sharing, as well as the distribution of the value created, together with the benefits this brings to the population.

- "Le Champ des Possibles" (The field of possibilities, in English): is a non-profit association that aims to help people eat better by educating them about food diversity, consumption and food processing at all stages, while integrating cooking into their

activities. "Le Champ des Possibles" is spread over two sites which were previously industrial areas. This project has been implemented thanks to a call for projects from the Region and the Rouen Normandy metropolis, which involved transforming an old horse-racing track in Rouen's Parc into an urban space. The association emphasizes the educational and social aspects, around which the economic model is built, by selling seedlings and never vegetables.

- "Le Jardin de l'Astéroïde" (Astéroïde Garden, in English): is an urban garden with the main aim of renting out individual plots to neighbouring residents so that they can grow their own fruit and vegetables. Before the garden was set up, there was a wild, abandoned area where cars used to park. After four years of administrative procedures with the town hall of Rouen, everything was ready to install these shared gardens in 2016. Moreover, within "Le Jardin de l'Astéroïde", the use and consumption of the harvested produce is solely for personal use or exchange between members, and any type of sale is not authorized. Additionally, until now, the garden's funding has been limited to the annual dues paid by members and other volunteers, leading to the project's continuity.

- "La Caverne" Urban Farm: private urban farm located in Paris, dedicated to the transformation of unused underground car parks into re-qualified spaces, where focuses on the production of three varieties of mushroom. Indeed, in 2017, it was launched thanks to its acceptance of the Paris-culteurs call for projects, which aims to introduce agriculture into the city. Since its acceptance, "La Caverne" has not stopped producing until today. Moreover, it is currently gradually expanding and has now opened its doors in 7 sites in France, including the cities of Lyon, Bordeaux and Paris, with the help of the French State's subsidies.

- "Veni Verdi": is an association that was set up in 2010 in the 20th arrondissement of Paris by the Metropolis of Paris, with the main objective of establishing gardens on the roofs of schools or in the open ground, to raise awareness among young people, where they first started with opening their first school urban garden in 2011, and are now working with 9 sites, all located in Paris. Every year, the association must respond to calls for projects in order to obtain subventions and funding, to ensure the continuity of the project. The main objective of "Veni Verdi" is to provide sustainable food, while building up a territorial network to ensure a circular economy and short supply chains, as well as selling vegetables, fruit and flowers to local stores near their sites. Preparing the younger and current generations for environmental challenges, while working on the region's food resilience, is the main aim of this association.

1.4. Objectives of the Doctoral Thesis
1.4.1.   General objective

In a context marked by increasing urbanization, food crises and environmental challenges, this Doctoral Research aims to explore the strategic role of urban agriculture as a lever for sustainability, city resilience and other impacts, all related to the sustainable development goals (SDG) [38]. Indeed, this is achieved through the evaluation of the contribution to food security and improved nutrition (SDG 2), the creation of sustainable and resilient cities (SDG 11) and the promotion of responsible production systems (SDG 12) [39,40]. Moreover, urban agriculture is emerging as an innovative solution for rethinking our territories and consumption patterns, while contributing to the ecological transition by reducing the environmental impact of food production and strengthen social inclusion and equitable access to food resources (SDG 10) [39], along with contributing to the preservation of soil and biodiversity in urban areas (SDG 15) [41].

1.4.2.   Specific objectives

In order to respond to our problematics and are as follows.

- Analyse the current literature on urban agriculture on an international scale to understand its mechanisms, benefits and impacts, and thus through a systematic review of the literature that generated information related to our problem in different countries around the world.
- Assess and evaluate urban agriculture projects, their governance structures and stakeholder involvement, through an in-depth analysis of various cases in France (2 in Paris and 2 in Rouen), through semi-structured interviews, field work and statistical analysis.
- Examine the relationships between the various local entities involved in the governance of sustainable transitions in several selected cases in France and Spain. This objective aims to assess, through interviews with project leaders, local authorities, etc., what is implemented and how it is managed.
- Comparison between expectations and reality in the implementation of urban agriculture projects, through an analysis of polycentric governance between local authorities and actual urban practices implemented in the field, and thus in the Rouen metropolitan area.
- Investigate and assess how urban agriculture can be implemented to ensure greater food security and achieve sustainable development goals, through a worldwide survey and real-life cases evaluated in each of Spain and France.

1.5. Justification of the thematic unity of the articles

This doctoral thesis addresses the strategic role of urban agriculture for the sustainability and resilience of cities. Different urban agriculture initiatives have been compared with the aim of examining whether such projects serve urban policy objectives with greater emphasis on food systems, environmental planning and social integration issues. By considering the urban governance interactions between different project initiators, technical and institutional issues, the thesis seeks to affirm the ways in which urban agriculture can be a lever for more integrated and reflexive urban governance while addressing the real needs of local authorities and urban residents.

Article 1 (not included in the compendium) is a scientific research literature review that was carried out on an international scale to identify the main theoretical and empirical issues related to urban agriculture. This revealed a lack of in-depth comparisons between countries all around the world with different political and socio-economic contexts. Indeed, this study aims to assess the presence or absence of urban agriculture practices, their forms, the benefits they bring to the population and the city, their relationship with public authorities and their impact on urban sustainability. In addition, this literature review has identified the limitations and obstacles faced by these urban practices, while presenting recommendations for future studies.

➔ **Article title:** "*Benefits of Non-Commercial Urban Agricultural Practices—A Systematic Literature Review.*". Agronomy, 2024, 14(2), 234, https://doi.org/10.3390/agronomy14020234; Q1 JCR (Science Edition – Plant Sciences, 65/238). JIF2023 = 3.3.

Article 2 (included in the compendium) is a research paper focusing on the creation and the benefits derived from the implementation of urban agriculture projects. The comparison is based on four case studies in France, featuring different vocations - social vs. economic - and which serves as the basis for further investigations. The results show that the structure of the governance mechanisms in all four cases is well defined and respected, which in turn enables them to better express their needs and make good progress with their projects. Further limitations have also been concluded such as not getting enough economic support from local authorities, and which should be more considered in order to have successful and long-term projects.

➔ **Article title:** "*Governance structures and stakeholder's involvement in Urban Agricultural projects: an analysis of four case studies in France*". International Food and Agribusiness Management Review, 2024, 27(1), 76–93, https://doi.org/10.22434/IFAMR2023.0072 ; Q2 SJR (Business and International Management), Q3 JCR (Science Edition – Agricultural Economics & Policy, 43.6 percentile). JIF2023 = 1.5.

Article 3 (included in the compendium) is a research paper that evaluates the relationships between different entities at different levels of governance, in order to assess what they intend to achieve and what is actually implemented. The methodology consisted on conducting interviews with representatives from local authorities, along with field work and data analysis. The results revealed that there is complementarity between the entities, such as the organization of regular meetings with project promoters, the monitoring of urban agriculture projects, the desire to ensure the sustainability of urban projects, and so on. However, many differences were highlighted, such as the selection of urban agriculture projects, where the metropolis is less strict than the city in terms of plot size and soil analysis requirements, along with other criteria.

→ **Article title:** *"Disentangling metropolis-city relationships in the governance of sustainability transitions: An in-depth exploration of the case of Rouen, France"*. Cities, 2025, 163, 106019, https://doi.org/10.1016/j.cities.2025.106019 ; Q1 JCR (Urban Studies, 93.5 percentile), Q1 SJR (Urban Studies). JIF$_{2023}$ = 6.0.

Article 4 (included in the compendium) investigates a multi-level governance framework to assess how local authorities implement their prescriptions at different levels of decision-making and objectives, and whether these conditions and aspects are actually implemented by urban agriculture initiatives. This was carried out in 2023 and 2024, in order to track their progress and evolution. The results revealed a positive alignment with polycentric governance between different entities in terms of socio-economic integration, climate improvement and nutritional diversity, all of which were achieved by the cases evaluated. Moreover, local authorities are seeking to achieve urban food self-sufficiency, which highlights a limitation and challenge of this study, given that urban areas are compromised by population density, limited space capacity, lack of space and lack of resources.

→ **Article title:** *"Reality vs. Expectations in the Implementation of Urban Agricultural Projects—A Polycentric Governance Analysis"*. Urban Science, 2024, 8(4), 260, https://doi.org/10.3390/urbansci8040260 ; Q1 SJR (Urban Studies), Q2 JCR (Urban Studies, 61e percentile). JIF2023 = 2.1.

Article 5 (included in the compendium) aims to assess how urban agriculture can be implemented in cities to ensure greater food security. A global quantitative survey was carried out to provide an overview of public perceptions, along with an analysis of two case studies in Spain to provide deeper knowledge on how urban agriculture is practiced and experienced at the local level. The survey results helped to understand people's perceptions of urban agriculture, its effects and its contribution to food security and self-sufficiency. In addition, the cases evaluated provided lessons and insights into the implementation of similar urban

projects in Spain and other countries, all aligned with the three dimensions of sustainable development.

➔ *Article title:* *"Assessing Citizens' Perceptions of Urban Agriculture and Its Contribution to Food Security—Worldwide Analysis and Specific Case Studies in Spain".* Urban Science, 2025, 9(5), 150, https://doi.org/10.3390/urbansci9050150 ; Q1 SJR (Urban Studies), Q2 JCR (Urban Studies, ~60th percentile). $JIF_{2024} \approx 2.1$.

Article 6 (not included in the compendium) investigates how urban agriculture projects are involved in the requalification of abandoned industrial areas, through the evaluation of four case studies in France, along with examining the success of these projects. A mixed methodological approach was used, including qualitative and quantitative frameworks. The results highlight the vital importance of good governance, through the creation of partnerships between public stakeholders, residents, associations and project owners, to ensure the sustainability and longevity of these projects. Furthermore, this research also shows that urban agriculture is perceived as a strategic tool for the sustainable requalification of territories, enabling ecological, social and economic progress in cities.

➔ *Article title :* *"Requalification territoriale soutenable par l'agriculture urbaine. Études de cas au Havre et à Rouen".* Cahiers Costech, 2024, 7, https://costech.utc.fr/CahiersCostech/spip.php?article197.

Article 7 (not included in the compendium) presents a new method based on an artificial neural network for the daily estimation of the main meteorological parameters - solar radiation and temperature - from geographical data, in the absence of physical weather stations. The concept of the virtual weather station, present an extremely useful tool for regions poorly equipped with measurement sites, as well as for urban agriculture. The results show that this approach makes it possible to better forecast irrigation requirements, facilitate precise crop management and help develop more sustainable urban agriculture, by providing localized and accessible information to support agronomic planning and the transition to sustainable food systems in peri-urban and urban areas.

➔ *Article title:* *"Daily Estimation of Global Solar Irradiation and Temperatures Using Artificial Neural Networks through the Virtual Weather Station Concept in Castilla and León, Spain."* Sensors, 2022, 22(20), 7772, https://doi.org/10.3390/s22207772 ; Q1 JCR (Instruments & Instrumentation, Electrochemistry, Chemistry Analytical), $JIF_{2022} = 4.2$; Q1 SJR (Analytical Chemistry, Atomic and Molecular Physics and Optics, Instrumentation).

1.6. Methodology followed in this doctoral thesis

This doctoral research is based on a mixed methodological framework, involving qualitative methods and quantitative approaches, to analyse the dynamics of urban agriculture in a perspective of ecological transition and territorial requalification. The combination of these approaches has enabled us to obtain a precise and in-depth understanding of the real situation, with a comprehensive analysis covering both qualitative and quantitative aspects [42]. In order to provide a better understanding of the methodology used in this doctoral thesis to address each of our objectives, Table 1 shows the link between the methodology linked to the objectives of this thesis:

Table 1: Table illustrating the links between the methodology used and the objectives of the doctoral thesis

Objectives	Methodology used
1- Benchmark analysis of the benefits, impacts and limitations of urban agriculture.	Systematic literature review; NVivo Software for data and qualitative analysis; Cross-tabulation of frequencies.
2- Situate urban agriculture projects in each of our target areas.	State of the art of the projects in the region; A very precise choice based on the location, objectives and level of involvement.
3- Prepare interview guides.	Based on our objectives, the stakeholders' positions, and our problematics; Engaged in the informed consent form.
4- Evaluate urban agriculture projects, their implementation, governance structures and stakeholder involvement.	Identify key stakeholders; Mixed-methods: interviews and field work; Translation, transcription and codification; Qualitative and quantitative analysis for a complete and precise results
5- Compare urban agricultural projects and their outcomes.	Analysis of multiple case studies; Preparation of an Analysis Grid for an accurate and complete comparison; Cases evaluated in Spain and France
6- Expectations vs Reality	Multi-level governance perspective Interviews with actors from different institutional levels (local authorities, project leaders, citizens)
7- Worldwide survey	Prepared by experts using the Google form for its convenience and efficiency; Theory of Planned Behavior and COMB Model for in-depth analysis

From Table 1, we can clearly notice that the combination of these approaches enabled to obtain a precise and in-depth understanding of the actual situation, featuring a comprehensive qualitative and quantitative analysis [43]. Indeed, regarding the systematic literature review (article 1), it was carried out using NVivo software, one of the most renowned tools for qualitative analysis, which enabled us to structure and cross-reference a large volume of scientific data with a view to creating a rich and synoptic body of knowledge on the subject [44]. This first step enabled us to easily identify the main theoretical and methodological orientations sought& in the field, as well as the gaps in the literature.

The empirical study was based on a series of in-depth case studies carried out in five cities: Le Havre, Rouen and Paris in France (articles 2 to 4 and 6), and Valladolid and Segovia in Spain (article 5), with a total of 8 urban real-life urban agricultural cases evaluates in this doctoral thesis. It should be emphasized that the cases were chosen with particular precision and concern, as they addressed and covered the aspects that best corresponded to our research objectives. In fact, a wider selection of cases was first established before the final choice of our cases was made. Regarding the survey, it was distributed in an online manner and at the national and international level, through our networks, via e-mail, colleagues, projects, etc., and its establishment was performed through the Google Form platform, for its efficiency, simplicity and feasibility.

The semi-structured interviews were conducted with various stakeholders (project developers, associations, local institutions, citizens, etc.), along with content analyses of planning documents and field work, in order to understand the emergence and divergence patterns, logics of action and governance configurations for each urban context. In order to have a clear perception of the content of these interviews, Table 2 presents the main questions that have been asked to the stakeholders in France.

Table 2: Example of questions asked during interviews. Source: Boukharta et al., 2023

	QUESTIONS INTERVIEWED
General information	Can you tell us a bit about yourself?
	What motivated you to work on this project?
Related to the project	In your opinion, what are the objectives of this project?
	What kind of activities are you organising for this project?
Challenges and obstacles	What challenges did you face when working on this project?
	Could you find solutions to solve them?
Urban agriculture	What is urban agriculture and why is it important?
	What urban farming practices do you use?
Environmental aspects	How do you think urban agriculture could contribute to ensuring biodiversity conservation?
	How does urban agriculture contribute to a healthy, sustainable environment?

Social and nutritional aspects	Could urban agriculture help to improve soil regeneration? If so, how?
	Are you maintaining relations with other stakeholders (experts, farmers, municipalities, consumers, etc.)?
	Can you explain how urban agriculture could contribute to food security?
Economic aspect	Does this project aim to ensure the development of an economic level?
	How are products distributed or sold?
Governance structure (project managers)	How do you measure the results of the project and use them to adjust your governance structure and improve the performance of the project?
	Do you benefit from financial or non-financial support? From whom?
	How are costs and investment managed within the project?

Table 2 provides a clearer explanation of the types of questions asked during the interviews. In addition, further questions relating to the project's governance structure, budget management, etc. were only asked of project leaders and coordinators. As far as the Spanish cases are concerned, Table 3 shows the questions which were put to the interviewees and which fully address our problematic. In addition, an international survey was used to broaden the scope of the study by incorporating perceptions, needs and practices from different regions (article 5), the main questions of which are also presented in Table 3.

Table 3: Main questions employed in the worldwide survey and throughout the interviews realized in Spain. Source: Boukharta et al., 2025

Variable name	Question used in Survey	Question used in Interview
Behavior (intention)	Would you support Urban Agriculture in your city?	If you had to give advice to other initiatives like yours, what kind of advice would you give to the actors involved in these initiatives?
Behavior (Actual)	Have you ever been involved in some Urban Agriculture initiatives?	What was your motivation for working on this project/initiative?
Attitudes towards UA	What do we mean by urban agriculture and food security?	What are the activities you are implementing in your UAP?
Subjective Norm	To what extent are the themes of UA and FS linked?	What should be the objectives of these urban agriculture projects to meet the needs of the inhabitants and their communities?
Project	Do you think your city needs the implementation of such initiatives?	What do you think makes this initiative successful?
Capability	Would you be interested in participating in such projects?	How do you try to promote your idea in your city? What method was the most effective?
Other motivation?	Would you like to tell us more about your thoughts/ideas on this subject?	What was your motivation for working on this project?

Table 3 provides a very clear explanation of the different variables highlighted in each of the questions used in the global survey and in the interview conducted with stakeholders in the Spanish urban agriculture cases. In addition, specific efforts to predict local climatic

conditions using advanced models provide valuable support for the technical management of urban agriculture (article 7).

Regarding data collection and processing, it should be noted that the interviews were conducted and recorded vocally (with the interviewees' permission) and transcribed into French (for cases of urban agriculture in France) or Spanish (for cases of urban agriculture in Spain), then professionally translated into English for a clear and in-depth analysis. The data obtained in this research article were processed using NVIVO software, as it is now widely recognized for its efficiency in processing data related to qualitative and mixed-methods research, as well as for coding and carrying out cross tabulations that allow for the best possible analysis of the results [44,45]. As many authors suggest, this software not only makes it possible to unravel the complexity of real-life situations, but also, through iterative approaches, to generate and develop a theory based on a comparative qualitative analysis of a selected set of case studies [46]. Other statistical tools were used to ensure proper evaluation of the questionnaires and interviews: the theory of planned behaviour [47] and the COMB model [48], as well as the theory of social practices for the interviews [49]. Indeed, this technique offers a very precise approach to understanding the behaviour of individuals in the face of the research problematics, thus evaluating the results through the responses collected, as well as the engagement of participants in specific practices.

The strategies and methodologies used in this doctoral thesis have ensured a strong coherence and complementarity between its different objectives, through the realization of several research articles, while using different approaches and different analyses, thus ensuring a complementarity between them and a more precise and concrete analysis, which underlines this unique work and contribution, thus enabling it to be a very valid and strong source for future studies and research on urban agriculture and its involvement within cities. Furthermore, it should be noted that all our issues and findings are in line with the Sustainable Development Goals and aim to contribute to more resilient, self-reliant and sustainable cities by enhancing the capacity of urban systems to integrate urban agriculture as an ecological driver of societal transformation.

1.7. Graphical methods for this doctoral thesis

The preceding sections have explained in detail the objectives, the methodology, with all its aspects of data collection and analysis, the content and execution of the interviews and questionnaires, along with the statistical tools used, in order to make the understanding of this doctoral thesis clearer and more explicit. Moreover, Figure 1 illustrates the methodology used with the aid of a constructive graph.
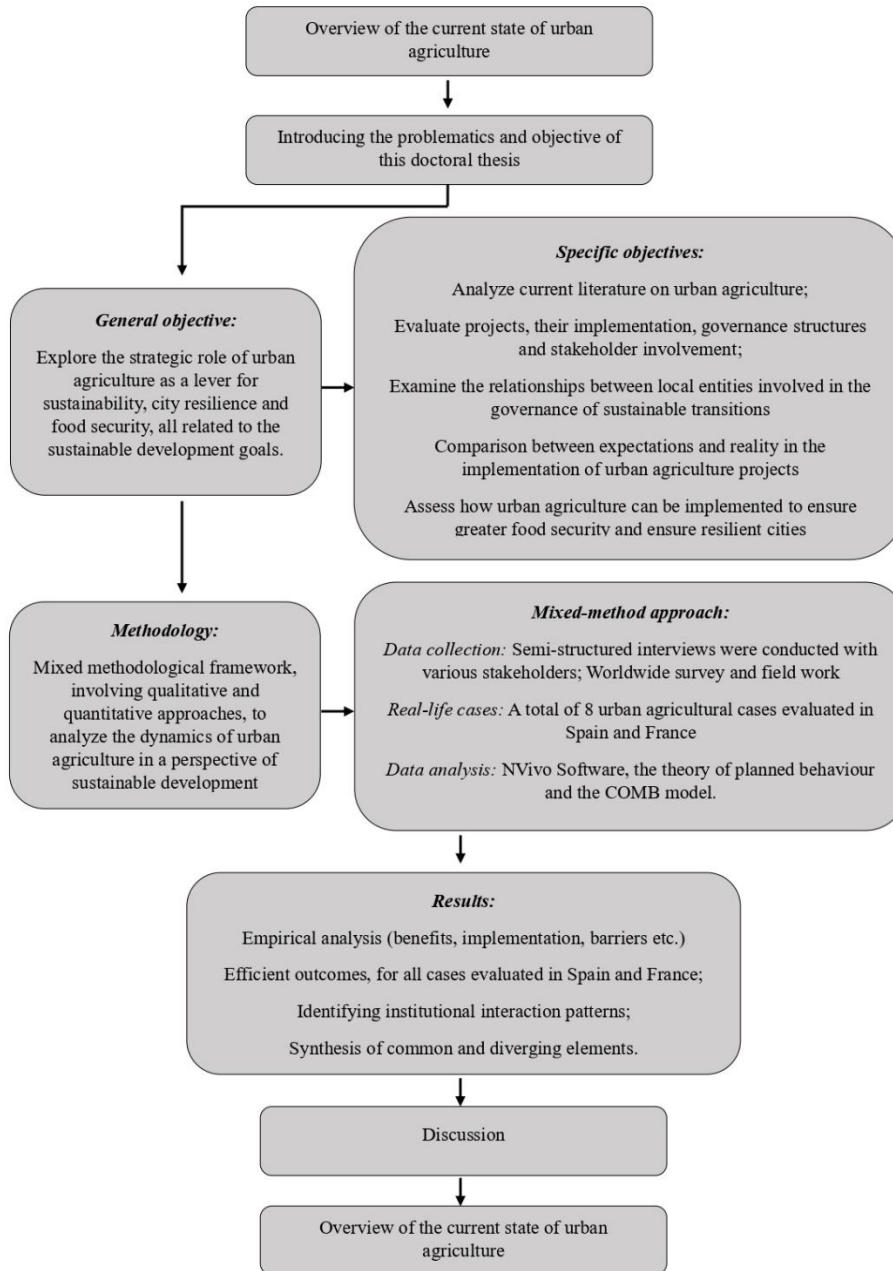
Figure 1: Graphic methods that shows the logic and process followed in this doctoral thesis.

From Figure 1, we can clearly see that it describes the methodological approach adopted in this thesis, highlights the reasoning process applied, from the definition of the objective to the analysis of empirical evidence, going through the choice of case studies, the tools deployed and the theoretical frameworks. This representation attempts to clarify the entire research process, making understanding more effective and efficient at all stages.

2. COMPENDIUM OF PUBLICATIONS

Article 1:

<u>*Title and reference:*</u> "Benefits of Non-Commercial Urban Agricultural Practices—A Systematic Literature Review". Agronomy, 2024, 14(2), 234, https://doi.org/10.3390/agronomy14020234 ; Q1 JCR (Science Edition – Plant Sciences, 65/238). JIF2023 = 3.3.

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Agronomy 2024, Volume 14, Issue 2, 234
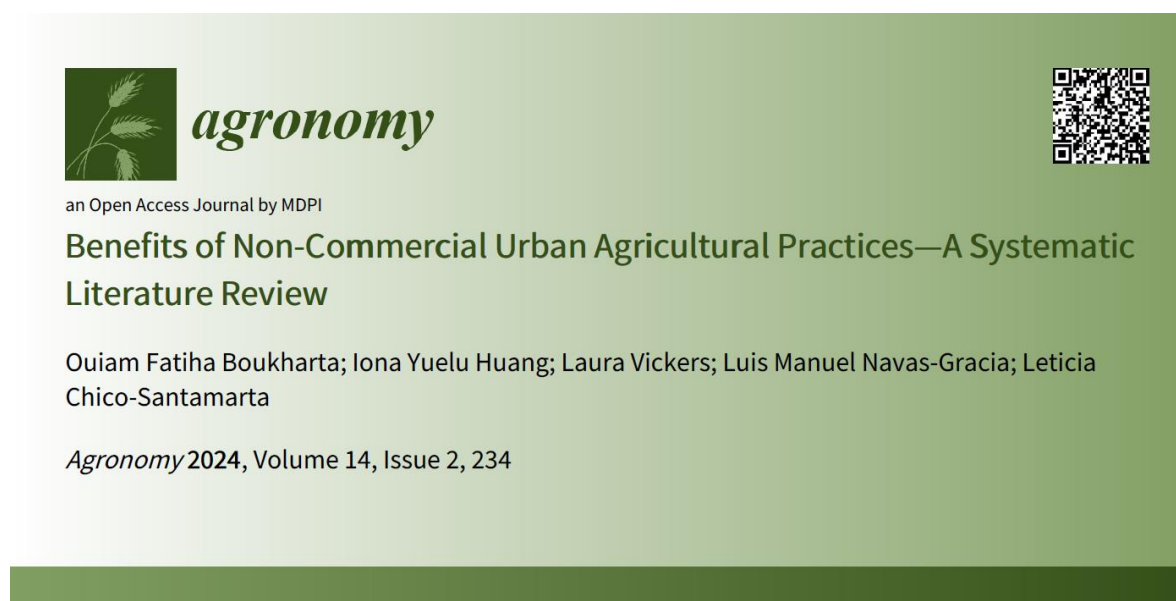
NB: This article is not included in the compendium. However, its contribution to this thesis is substantial, as it enabled the achievement of significant results, supported the formulation of numerous conclusions, and served as a foundation for the subsequent articles.

Benefits of Non-Commercial Urban Agricultural Practices—A Systematic Literature Review

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Abstract: Urban agriculture refers to any type of activity located within or around a city designed to provide ecosystem services. Given the rapid population growth and urbanization, urban agriculture is seen as a potential alternative route to a more sustainable urban food system. This review answers the main question: What are the benefits of non-commercial of Urban Agriculture (NCUA) forms and its contribution towards food production? using a systematic literature review approach. The methodology involved capturing 1355 recent articles from qualified search engines, using key terms according to the defined question, then screened for relevance and the defined scope of this review, resulting in a final selection of 40 articles for analysis. The results show that implementing NCUA practices has multifaced social, economic, and environmental benefits, such as improving people's health, reducing expenditure on food and creating sustainable cities, highlighting the need to recognize the multifaceted role of NCUA in promoting a more sustainable lifestyle and strengthening local communities and engagement. Moreover, awareness of urban agriculture differs between developed and developing countries, as does the recognition and valorization of its benefits. Further research is needed to examine the enabling factors and barriers to NCUA adoption in different urban context, the resource implications, and the long-term sustainability of these practices.

Keywords: non-commercial urban agriculture; benefits; community gardens; school gardens; allotments; urban farms

1. Introduction

Ensuring sustainable urban food systems is of extreme importance, given that urban areas are currently characterized by rapid population growth, aggressive food marketing, and unhealthy diets [1]. Indeed, these areas and their inhabitants face numerous challenges linked to the expansion of urbanization, including socio-economic, ecological, and environmental issues, which have a negative impact on the environment and unsustainable urban development and a huge impact on health [2]. According to the World Health Organization (2020), we are now in an era of concern for mental health and well-being, in which the presence of green spaces has been shown to reduce the mental health burden associated with depression [3], affecting more than 264 million people. In addition, cities increasingly need food supplies, but growth of cities is reducing urban and peri-urban green spaces and removing food production. Sustainable food production should therefore be located close to the centers of consumption [4].

To address these challenges, urban agriculture (UA) is seen as a potential solution that can provide green space and bring food production [5]. Indeed, UA is defined as any type

of activity located within or at the periphery of a city and aimed at providing products and ecosystem services to the residents, such as physical and mental health benefits, mitigation of social and economic problems, and community resilience [6].

Many forms of UA are currently being practiced [6]. In this systematic review, the focus is on NCUA, focusing particularly on urban farms, community gardens, school gardens, and allotments. Community gardens (CG) have been defined as 'open spaces which are managed and operated by members of the local community in which food or flowers are grown, and whose total area is maintained collectively, ranging from small neighborhood gardens to larger ones of up to 1000 m^2' [6,7]. This is a popular strategy for strengthening social cohesion and improving health [1]. As far as allotments (A) are concerned, they have been defined as 'plots of land designated by local authorities for the purpose of growing vegetables for home consumption' [8]. A occurs when land is acquired through a personal-use lease [8]. Nevertheless, when A meet the criteria of growing food or flowers in a communal manner, they can also be considered as CG [9]. Another form of NCUA are school gardens (SG), which feature vacant land on school sites designed for a range of food education-related agricultural activities involving student participation [10], which are useful for improving children's nutritional outcomes and knowledge [11], making them more willing to try unfamiliar varieties of fruits and vegetables [12]. In addition, SG provide an opportunity to meet and interact with other students in a natural environment, developing social skills, communication, and cooperation [13]. The final form of UA that is evaluated in this study is urban farms (UF), which are considered the main source of income for many urban households [14]. According to the FAO, by 2022, urban and peri-urban farmers will increasingly strive to produce high-demand crops efficiently, making the best use of available resources and inputs, whether by planting in the ground or in containers [4]. Moreover, they can provide shelter for birds and beneficial insects, helping to preserve urban biodiversity [15].

The benefits of implementing NCUA practices within the cities have long been demonstrated in the literature, which can be categorized into economic, environmental, and social benefits. The literature considers NCUA to have a number of potential social benefits, including strengthening social capital, increasing social cohesion and community resilience, and improving public health [16]. Moreover, the positive social effects of being in nature have been shown to increase feelings of generosity, friendship, and empathy [17,18]. Indeed, it reduces personal feelings of anxiety and improves mental health and well-being [19–21]. In terms of economic benefits, a number of studies have shown that the implementation of urban agricultural practices (UAP) helps to reduce the global food supply and demand situation, as it can be seen as a source of income while providing direct access to a wider range of nutritionally rich products [22]. In other words, UA can generate an additional source of income, improving the economic situation of many households [14]. The final aspect is that of the environmental, where the outcomes of UA are generally highly valued and recognized by scientists for their great potential to improve the quality of urban life and the environment [23]. In fact, the creation of UA spaces in cities helps to retain stormwater, purify the air, and conserve biodiversity [24], thus helping to mitigate the pollutants responsible for global warming [25]. Moreover, as food is grown and produced locally, it reduces transport costs and ensures environmental protection [26].

In view of continuing population growth, shrinking urban spaces, and increasing food insufficiency, it is worth discussing and examining the NCUA and its current relevance. Although the categories of benefits of NCUA have been presented in existing literature, there is a lack of understanding of the variations in the types of benefits derived from different forms of NCUA and how these benefits may vary in different contexts. To this end, the following main research question (RQ) was defined:

What are the benefits of non-commercial forms of Urban Agriculture and its contribution towards food production?

To facilitate the understanding and structure of this review, this main question is complemented by the following sub-research questions:

- RQ1: Which countries have conducted this type of research? And what are the similarities and differences across countries/continents?
- RQ2: What forms of NCUA food production have been practiced?
- RQ3: What are the similarities and differences reported across different forms of UA?
- RQ4: What are the challenges and limitations of implementing UAP faced by the authors of the selected articles in this review?

The main objective of this systematic review is therefore to synthesize the evidence on the benefits of NCUA practices, since much of the existing research is case-specific and lacks a comprehensive systematic analysis of the benefits in different contexts and at different scales, such as the lack of awareness of these projects, the benefits they bring to the population and the city, and the feasibility of integrating UAP [27,28]. To this end, and through this review, we aim to summarize the findings and relevance of the available literature, using a systematic mapping, in order to provide an overview of NCUA practices to ensure a healthy and accessible food supply while improving urban environmental performance for current and future generations.

Section 2 describes the methodology used for this review and presents the main inclusion and exclusion criteria that enabled the final selection of the articles analyzed and coded to answer and address our RQs. Section 3 presents the results and conclusions of this analysis, highlighting the different categories of NCUA benefits, the differences between and across countries, along with the difficulties and limitations reported in the selected articles with regard to NCUA implementation. Section 4 places these results in a clearer perspective, exploring some of the main implications of the NCUA, taking up the results at a global level and filling in the gaps found in the literature. The final section is the conclusion, in which an overview of the current situation is presented, together with some recommendations that should be followed for better implementation of the future NCUA.

2. Materials and Methods

The methodology used in this review follows the systematic literature review process recommended by James et al. (2016). This involved searching for and capturing relevant articles on the topic under review, using key terms derived from the main RQ, and then screening them according to their relevance to the specific topic of this study, and other criteria that will be described further in the following sub-sections. The methodology aimed at ensuring a rigorous, comprehensive, and objective literature collection and filtering processes, in order to reduce reviewer selection and publication bias and guarantee transparency of evidence inclusion decisions [29].

2.1. Search Strategy

The databases consulted included the Web of Science and Scopus search engines. The search terms used were developed on the basis of the key elements of a systematic literature review: population, intervention, and outcomes, where population refers to the object of our study, in this case *urban agriculture*, intervention refers to the description of the action addressed and the studies, namely *food production* in this review, and outcomes represent the results we wish to find, which are *benefits*. In addition, Boolean operators such as "AND" and "OR" were used for the combinations of our keywords for this search, enabling the following string to be formed:

((((urban AND (agricul* OR farm*)) OR "community garden*" OR "school garden*" OR allotment*) AND benef*) AND (food OR fruit* OR veg*)).

Details of the components and relevant key terms are presented in Table 1.

In terms of components, it shows the different ways in which a keyword can be searched for. For example, in the case of urban agriculture, agriculture can be written in different ways, such as agriculture, agricultural, etc., which is then searched for under agricul*; similarly, benefits, which can be written in different ways, such as benefit, benefits, beneficial, etc., to avoid missing information, is searched for under benef*. This is the best way to be sure of obtaining all the relevant information needed to address our problem.

Table 1. Search terms used in Scopus and Web of Science.

	Components	Key Terms
Population	urban agricul*—urban farm* school garden—school gardens community garden—community gardens	urban AND (agricul* OR farm*) "school garden*" "community garden*" allotment*
Intervention	food production	food OR fruit* OR Veg*
Outcomes	benefit—benefits—beneficial— benefic—etc.	benef*

2.2. Inclusion and Exclusion Criteria

The inclusion criteria for this review were articles and early accepted articles published in English between 2016 and 17 January 2023 to ensure that the review included the most recent literature on the subject, given that the growing interest in UAP and their implementation in cities has improved since 2016, and increased significantly from 2020. No country limitation was used, as the aim was to carry out a global review. The specific inclusion and exclusion criteria presented in Table 2 were applied manually for screening at title and abstract and at full text. If the criteria could not be applied at title and abstract screening due to incomplete information, they were included for full text screening.

Table 2. Inclusion and exclusion criteria.

Criterion	Eligibility	Exclusion
Document type	Articles and early accepted articles	Conference papers, book chapters, reviews, editorials, conference reviews,
	Open and non-open access	full text articles not accessible
Language	English	Others
Timeline	From January 2016 until 17 January 2023	Before 2016
Relevance	Non-commercial urban agriculture	Commercial urban agriculture
Type of articles	Empirical paper with primary findings about the benefits of NCUA	Review papers, commentaries, or primary studies with no benefits reported

2.3. Data Extraction and Analysis

The search and selection process identified 1754 articles from the Web of Science and Scopus search engines. After deleting 399 duplicates, the total number of articles selected was 1355. After applying the inclusion criteria by selecting articles and early accepted articles in open and non-open access, all in English between 2016 and 17 January 2023, as well as the exclusion criteria, excluding conference papers, book chapters, etc., directly from Web of Science and Scopus via the selection filters provided on their web pages, and then checking the resulting data and eliminating articles that do not meet our selection criteria, 45 articles were deemed eligible for results mapping. When coding and analyzing each article, 5 articles were excluded: 2 for including commercial UAP, 2 for not including any NCUA content, and 1 for not including any NCUA benefits, which resulted in a final selection of 40 articles for analysis. The diagram illustrated in the PRISMA Figure 1 demonstrates in detail the process and results of screening stage by stage.
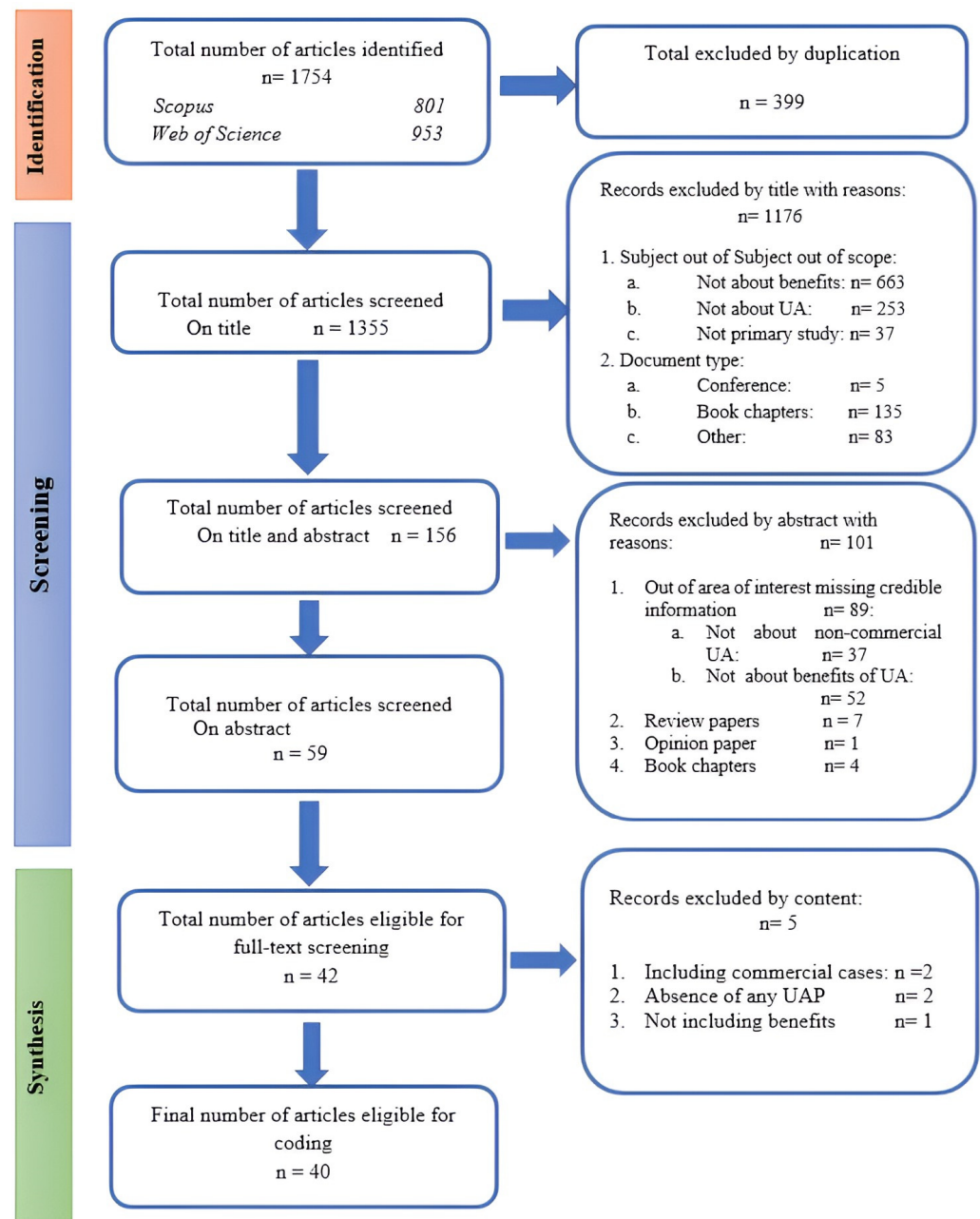
Figure 1. The PRISMA 2020 flow diagram of the systematic literature review process (adapted from Page et al., 2020 [30]).

A qualitative synthesis approach was adopted to map the results of the included articles. For this purpose, the software used in the present review is NVivo, one of the most used qualitative data management programs. NVivo has features such as character-based coding, rich text capabilities, and multimedia functions that are crucial for qualitative data management [31]. In addition, it enables researchers to process large amounts of data with greater transparency and provides opportunity for double-checking the reliability of coding by members of the research team [32].

3. Results

The following sections present the results obtained from this review, which clearly answer our main RQ and the sub-questions. It should be noted that across the articles obtained, there is a steady increase in the number of articles published per year, with

accelerated progression from 2020 to 2023, showing that the concept of UA has become more popular in recent years, and that interest in its application is growing.

3.1. Study Sites Location

From the included papers, Figure 2 shows the number of articles from different countries using a map to facilitate data analysis and processing the country distribution of the selected studies using a bar chart indicating the number of articles published by each country:
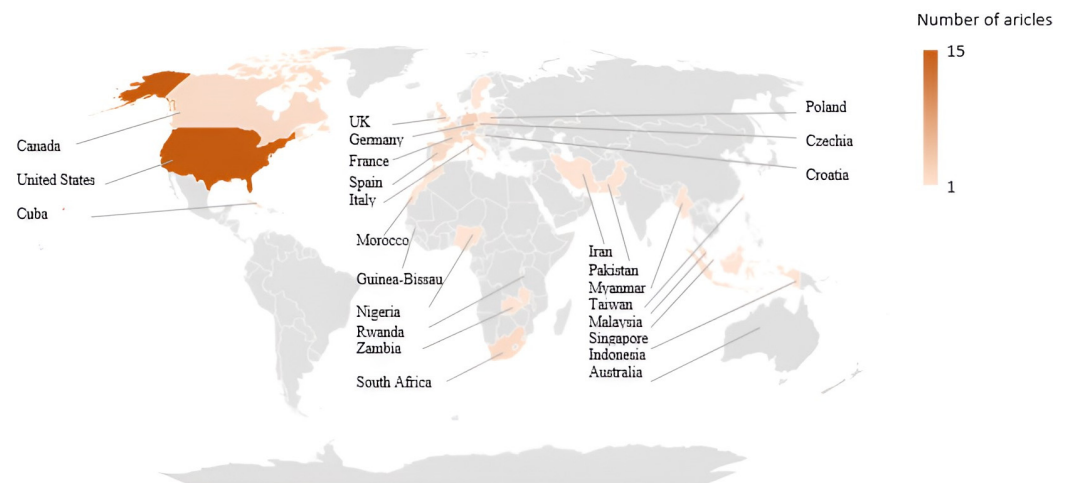
Figure 2. Location of the study sites identified from the 40 articles analyzed in this systematic literature review, represented on a world map featuring a heatmap showing the number of articles published per country (where the darker the color, the more articles exist).

Figure 2 shows that there was a very wide distribution of NCUA related studies throughout this research, in which it can be seen that around 30 countries were analyzed. Figure 2 also presents a heatmap showing the frequency of articles published by country, where the darker the color, the more articles were published. It can be seen that USA and Canada have the highest number of published articles in this overview. Figure 2 is complemented by Figure 3, which illustrates in greater detail the countries where the most UAP have been analyzed:
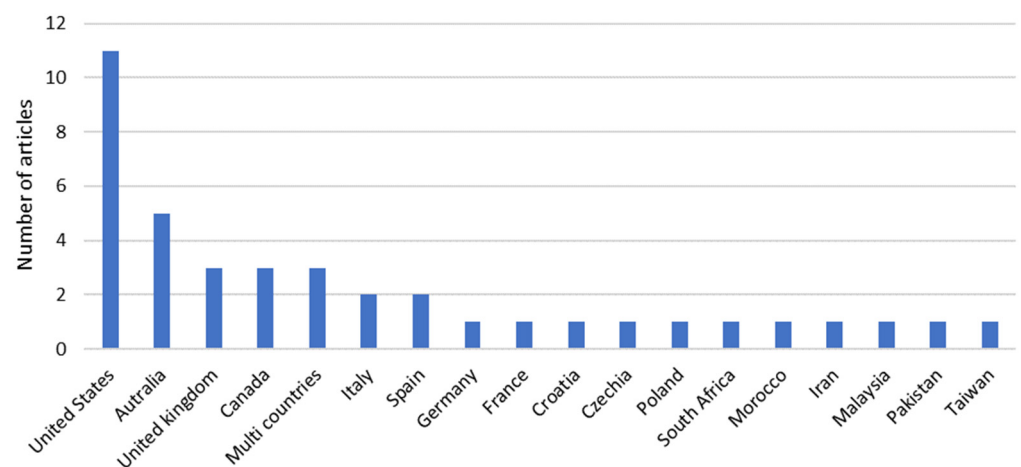
Figure 3. Cross-country distribution of articles analyzed in this review.

According to Figure 3, the largest number of articles are found in USA, Australia, Canada, UK, and EU countries. In addition, other African and Asian countries are also

implementing UA, such as Morocco and Malaysia, demonstrating that NCUA is now a global concept that is increasingly widespread around the world (particularly in more developed countries), given the benefits it provides.

3.2. NCUA across Continents

In North America, food insecurity affected around 14.3 million people in 2018 [33]. Consequently, NCUA has become very popular in New York City, which has at least 500 urban spaces [34]. The aim is to improve access to fresh produce for city dwellers, especially the food-insecure, and has been attributed to tackling poverty and food shortages in times of war and economic depression [35].

In Australia, rapid population growth and ageing in capital cities are increasing pressure on social, environmental, and public health systems, where one in four Australians experience chronic episodes of loneliness [10]. Australian local authorities are therefore coordinating their efforts to improve the urban canopy within the cities, which would offer significant opportunities to improve well-being [36].

The NCUA situation in Europe differs from country to country: Germany is a typical European country where NCUA is about much more than just food production, and where there is an appreciation of the benefits NCUA brings to citizens, through active participation in European Union projects [37]. In the UK, therapeutic and prescriptive gardening is gaining increasing support to help people overcome or live with mental health problems [9,38]. In Spain, CG have only emerged recently and are developing rapidly. In Croatia, urbanization, environmental issues, the future development of tourism, and social issues (mental health, unhealthy diet, and poverty) are behind the development of UA [39].

In North Africa, Morocco has an agricultural strategy adopted in 2008, known as the Plan Maroc Vert (Green Morocco Plan, in English), and whose second pillar supports small- and medium-sized farmers so as to encourage the implementation of NCUA within the cities [40]. Finally, in South Africa, several studies have been conducted to assess the role of NCUA in contributing towards poverty alleviation and food security [41].

3.3. Forms of NCUA Identified

Many forms of NCUA can be implemented in a city, including community gardens (CG), allotments (A), school gardens (SG), and urban farms (UF) [3]. In this section, the aim is to map the different forms of NCUA studied in different countries on the basis of the articles selected, processed and analyzed in this review. To this end, Figure 4 presents the result of the cross-tabulation analysis of the forms of NCUA identified in the studies carried out in the selected countries.

Figure 4 shows that the most widespread form of NCUA found from the selected articles is CG, with 29 articles out of 40, followed by UF and then A and SG (this analysis considered that the same study can deal with several forms of NCUA at the same time). Other forms of NCUA reportedly used are rooftop gardens, backyard gardens, etc., but these were not part of the selection criteria of this review. These results show that there is a diversity in the implementation of different forms of NCUA within countries, differing from a country to another, as explained in Section 3.4.

3.4. Forms of NCUA by Countries

CG is an abundant form of UA. Figure 4 shows that of the 11 articles analyzed in the USA, 10 address CG cases, while in Australia and Spain, CG cases are found in all the articles analyzed from these two countries. For the other countries, only 3 of the 18 categories selected do not contain that form of NCUA in their analysis.

Regarding UF, it is the second frequently used NCUA form in this review, which is most widely used in multi-countries (studies that evaluated more than one country), followed by Italy and USA. Finally, UF, A, and SG forms were the least used in the selected articles for this review.

Reviewed articles	A	CG	SG	UF	Other	Total
USA	0	10	2	2	1	11
Australia	1	5	0	0	0	5
Spain	0	2	0	0	0	2
Canada	1	2	1	0	1	3
Czech	0	1	0	0	0	1
Multi countries	1	1	0	3	0	3
Taiwan	1	0	1	0	1	1
Germany	0	1	0	0	0	1
Italy	0	1	0	2	0	2
Croatia	0	1	0	0	0	1
Morocco	0	1	0	0	0	1
UK	2	1	0	1	0	3
Iran	0	0	0	1	0	1
South Africa	0	1	0	0	0	1
France	0	1	0	0	0	1
Malaysia	0	0	0	1	0	1
Poland	1	0	0	0	0	1
Pakistan	0	1	0	0	0	1
Total	7	29	4	10	3	40

Figure 4. Cross-tabulation of NCUA forms implemented across the countries evaluated in the selected articles of this review. A: allotments; CG: community gardens; SG: school gardens; UF: urban farms. Colors: red: no articles mentioning the form of NCUA practices; yellow: low; dark yellow: medium; light green: high; dark green: very high (Source: the authors).

3.5. Methodology Employed and Its Link to NCUA Forms

Understanding the methodology employed to analyze the different NCUA forms is one of the main objectives of this review. The following subsections will present different results extracted from the analysis carried out via coding in NVivo 14 Software:

3.5.1. Methodologies Used for the Realization of the Article

Identifying the different research methods used in each of our 40 articles provides a better understanding of the type of research methods employed to analyze the benefits of NCUA, as shown in Figure 5:

Figure 5 shows that the most commonly used research methods approach adopted is the survey to collect data for analysis. Surveys were used in 15 articles out of 40 (37%), followed by interviews and observation with 7.5% each, and finally the experimental method with 5%.

The use of the mixed method is the most interesting. Indeed, it indicates that the most frequent approach in the articles was to use a mixture of research methods. The percentage breakdown of the mixed method is presented in more detail in Figure 6.

In these 17 articles out of 40, surveys have the highest percentage of use, followed by interviews, and finally observation and experimentation (Figure 6). The results show that the joint use of surveys and interviews to analyze NCUA forms is favored for analysis, and can be supplemented by observation and/or experimentation, making understanding and evaluation more precise.
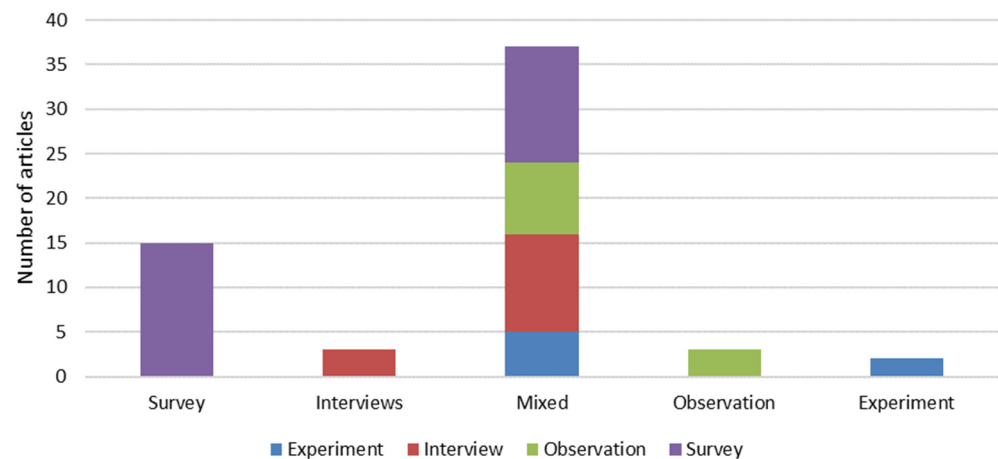
Figure 5. Number of articles that employed exclusively each research methodology in the selected articles, except for the mixed category which is where articles employed more than one research method.
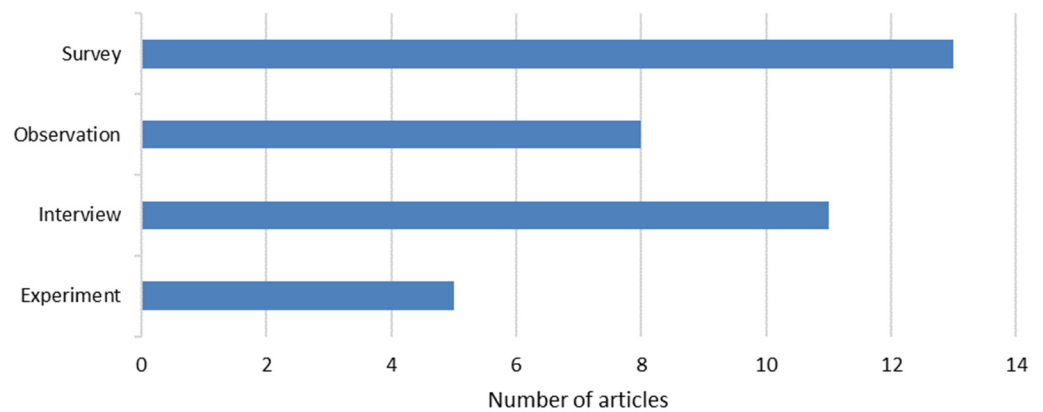
Figure 6. Frequency of use of each search method in articles using the mixed search method.

3.5.2. The Methodology Used for Each NCUA Form

One of the main purposes of this systematic review is to analyze the relationship between the different forms of NCUA and the research methodology used. To this end, Figure 7 details the methodology used for each UA form.
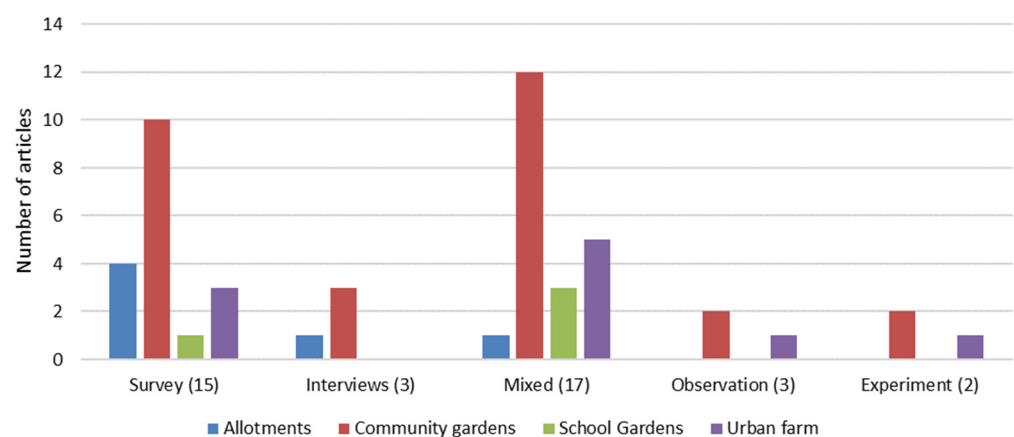
Figure 7. Number of articles that used each research methodology, related to the form of non-commercial Urban Agriculture Practice evaluated.

Figure 7 shows that several research methods are used to analyze the implementation of NCUA in cities and the resulting benefits, i.e., through interviews, surveys, experiments,

observations, or even a mix of these methods employing at least two of them, making the analysis more precise and comprehensive. Experimental methodology is the least used in the articles selected, and was used in only 2 articles out of 40. For interviews and observation, four and three articles, respectively, used only these methods to obtain results. Once again, the methodology most used in our 40 articles is the mixed method, which is employed for the majority of UA forms, where CG is the most analyzed with this approach, followed by UF, SG, and A.

These results show us the diversity of existing research methodologies employed for analyzing the use of UA and the benefits they bring, and shows preference for some research strategies over others.

3.6. Benefits of the Implementation of NCUA Practices

Identifying the benefits that NCUA practices bring is the main objective of this review article. Indeed, in-depth coding of the selected articles has resulted in the cross-tabulated table shown in Figure 8, which was obtained from NVivo 14 Software, and where the green color refers to the highest number of studies and the red color to the lowest number.

Categories of benefits	Sub-categories	CG	UF	SG	A	Mixed	Total
Economic		12	3	0	0	5	20
Environmental		6	4	0	0	6	16
Social	Social cohesion (including community and networking and other aspects)	24	6	1	0	6	37
	Community and networking	17	4	1	0	2	24
	Society economic growth	5	4	1	3	0	13
	Human (mental health, health and nutrition, skills and education)	21	5	1	2	5	34
Total		24	6	1	3	6	40

Figure 8. Cross tabulation showing the frequency of benefit against the types of UA: CG: Community Gardens; UF: Urban Farms; SG: School Garden. Colors: red: no articles mentioning the benefits of UA; dark orange: the lowest; light orange: low; dark yellow: medium; yellow: medium to high; light green: high; dark green: very high (Source: the authors).

Categories of Benefits Identified in This SR

The findings from the analysis of this systematic review shows that the benefits of NCUA can be divided into three categories: economic, environmental, and social:

- Economic benefits: the implementation of NCUA practices helps to promote community resilience and stimulate economic development [42]. The analysis of this aspect identified two sub-categories, namely cost reduction and income generation: cost reduction is related to people saving money on their groceries [43], by reducing the prices and making them accessible to low-income households [44]; income generation relates specifically to the fact that these gardens offer the opportunity to develop an agricultural system that matches their values and is adapted to their needs, and which can be translated into revenue [45,46].
- Environmental benefits: implementing NCUA practices has been shown to promote greening and environmental enhancement [10,47], support city adaptation to climate change, and reduce human damage and health problems [4]. NCUA helps to improve carbon sequestration and limit extreme weather events, thereby improving the quality of urban life and the environment [23].
- Social benefits: the main benefit of implementing UAP would be to improve well-being in terms of mental and physical health [9,38]. The most obvious would be to increase access to fresh and healthy products. In addition, NCUA can play an important role in

the social integration of less privileged people at risk of social exclusion, contributing to a more sustainable society [13,21].

Figure 8 presents a cross-tabulation of the results obtained, demonstrating the outcomes of implementing these practices linked to its various forms of NCUA:

As shown in Figure 8, there were four sub-categories under social benefits in the 40 articles selected and analyzed in this systematic review. All the articles that analyzed the CG form of NCUA reported social benefits of UA, focusing on the human aspects, including health benefits, nutrition, and trusting relationships with others. Furthermore, all three studies of allotments (A) reported the social benefits, especially for the socio-economic and human subcategories. Economic benefits were reported in 20 of the 40 articles, with results showing that setting up UA areas could save money and generate income for individuals, and where, once again, the CG form of NCUA had the highest frequency of reported economic benefits (Figure 8). Finally, environmental benefits were the least reported, found in 16 articles out of 40, although all 6 studies using a mixed form of NCUA reported environmental benefits.

3.7. Benefits vs. Countries

The main objective of this literature review is to identify the different benefits of involving NCUA spaces within cities, which has been reported in the previous section. In addition, this section shows whether there is any variability in the reported benefits of NCUA across the countries identified in the selected articles. Figure 9 presents a cross tabulation of the benefits of NCUA in relation to the countries studied, in order to better identify the potential/targeted benefits of NCUA use in each country:

| | Economic | Environmental | Social | | | | | | Total |
			Community and networking	Society economic growth	Health and Nutrition	Mental health	Skills and Education	No significant social benefits	
USA	6	5	7	1	10	1	1	0	11
Australia	0	2	4	0	5	3	0	0	5
Spain	2	0	2	1	1	0	1	0	2
Canada	2	2	2	2	3	0	1	0	3
Czech	0	0	1	0	1	1	0	0	1
Multi countries	2	2	2	2	3	1	1	0	3
Taiwan	1	1	1	0	0	0	0	0	1
Germany	1	0	0	0	0	0	1	0	1
Italy	1	2	1	1	1	0	0	0	2
Croatia	0	0	1	0	0	1	1	0	1
Morocco	0	1	1	1	1	0	0	0	1
UK	1	0	0	0	3	3	0	0	3
Iran	0	0	1	1	1	0	0	0	1
South Africa	1	0	0	1	0	0	0	0	1
France	1	0	0	0	0	0	0	1	1
Malaysia	1	1	1	0	1	0	1	0	1
Poland	0	0	0	1	1	0	0	0	1
Pakistan	1	0	0	0	1	0	0	0	1
Total	20	16	24	11	31	10	7	1	40

Figure 9. Cross tabulation showing the frequency of evocation of the benefits of involvement and integration of urban practices across the countries covered through the analysis of the articles selected for this review. Colors: red: no articles mentioning the benefits of NCUA per country; yellow: low; dark yellow: medium; light green: high; dark green: very high (Source: the authors).

From Figure 9, the USA is by far the country that cited the most benefits compared with other countries, especially for health and nutrition. Second place goes to Australia, which also has the greatest number of reports on the social aspect, followed by community networking. In third place come Canada, Spain, Italy, and the multi-countries (studies that evaluated more than a country), all of which mention the benefits of NCUA in their articles, focusing almost equally on all three aspects.

Figure 9 also shows that the social aspect is most often mentioned in the 40 selected articles, with health and benefits being the most cited in the 19 countries analyzed (31 out of 40 articles), followed by community and networking, and mental health. Economic benefits were the second most common focus (20 of the 40 articles), and were most frequently mentioned in studies carried out in the USA, Canada, and multi-countries. Economic benefits were not the focus of studies in countries such as Australia, Morocco, and Iran. Lastly, the environmental aspect was the least mentioned, being mentioned in less than half the articles, particularly in the USA, Australia, Canada, and multi-countries.

The final analysis involved mapping each article according to the benefits reported, as shown in Figure 10, providing an overview of the results founded by each article with regard to economic, social, and environment aspects, and which have been explained above.

Category of benefits		References	Cited
Economic		Ambrose et al. 2023 - Camps-Calvet 2016 - Delshad 2022 - Górna 2021 - Hammelman 2019 - Hsiao 2021 - Kirby et al. 2021 - Krikser et al. 2019 - Lucertini et al. 2021 - Mejia et al. 2020 - Palau-Salvador Et al. 2019 - Porter 2018 - Santo et al. 2021 - Schoen et al. 2020 - Sonti and Svendsen 2018 - Swanepoel et al. 2021 - Tharrey and Moisa 2020 - Thiesen et al 2022 - Yusoff et al. 2017 - Zulfiqar 2021	20
Environmental		Bailey and Kingsley 2021 - Delshad 2022 - Furness and Gallaher 2018 - Górna 2021 - Guitart et al. 2015 - Hammelman 2019 - Hsiao 2021 - Kirby et al. 2021 - Lucertini et al. 2021 - Mansur et al. 2022 - Romagny et al. 2021 - Santo et al. 2021 - Sanyé-Mengual et al. 2020 - Sonti and Svendsen 2018 - Thiesen et al 2022 - Yusoff et al. 2017	16
Social	Community and networking	Alemu and Grebitus 2020 - Camps-Calvet 2016 - Delshad 2022 - Diekmann et al. 2020 - Dubová et al. 2020 - Egerer 2019 - Furness and Gallaher 2018 - Guitart et al. 2015 - Hsiao 2021 - Kingsley 2021 - Kirby et al. 2021 - Mansur et al. 2022 - Menconi 2020 - Moffatt 2016 - Moghayedi et al. 2022 - Palau-Salvador Et al. 2019 - Pollard Et Al. 2018 - Porter 2018 - Poštek 2021 - Romagny et al. 2021 - Sanyé-Mengual et al. 2020 - Shafieisabet and Mirvahedi 2022 - Sonti and Svendsen 2018 - Yusoff et al. 2017	24
	Society economic growth	Delshad 2022 - Dobson et al. 2021 - Górna 2021 - Janus et al. 2022 - Kell et al. 2018 - Lucertini et al. 2021 - Mansur et al. 2022 - Moffatt 2016 - Moghayedi et al. 2022 - Palau-Salvador Et al. 2019 - Romagny et al. 2021 - Shafieisabet and Mirvahedi 2022 - Swanepoel et al. 2021 -	13
	Human	Alemu and Grebitus 2020 - Ambrose et al. 2023 - Bailey and Kingsley 2021 - Delshad 2022 - Diekmann et al. 2020 - Dubová et al. 2020 - Dobson et al. 2021 - Egerer 2019 - Furness and Gallaher 2018 - Górna 2021 - Guitart et al. 2015 - Hammelman 2019 - Janus et al. 2022 - Kell et al. 2018 - Kingsley 2021 - Kirby et al. 2021 - Krikser et al. 2019 - Mansur et al. 2022 - Mejia et al. 2020 - Menconi 2020 - Moffatt 2016 - Moghayedi et al. 2022 - Palau-Salvador Et al. 2019 - Pollard Et Al. 2018 - Porter 2018 - Poštek 2021 - Romagny et al. 2021 - Santo et al. 2021 - Sanyé-Mengual et al. 2020 - Schoen et al. 2020 - Shafieisabet and Mirvahedi 2022 - Sonti and Svendsen 2018 - Thiesen et al 2022 - Yusoff et al. 2017 - Zulfiqar 2021	34
	No significant social benefits	Tharrey and Moisa 2020	1

Figure 10. Matrix coding query that summarizes all information obtained in this systematic review and which showed individual authors against the different benefits. Binary system where 1 shows the presence of the benefit and 0 reflects its absence (Source: the authors) [1–4,6,8–10,13,14,17,23,25, 27,28,34–57].

Figures 9 and 10 show that only one article mentions that there are no significant social benefits. This study was carried out in France, where the authors describe that "that

the practice of gardening for one year in a CG may not be sufficient to change health and sustainability behaviors", giving a culturally dependent aspect to consider in the analysis.

3.8. Reported Challenges and Limitations from the Studies against NCUA Implementation

The analysis of the articles selected for this review has enabled the identification of a number of challenges and limitations in the implementation of UAP, which may differ from one situation to another, and which have been commented on by the authors:

3.8.1. Challenges

Despite the many positive effects of UA, its implementation faces a number of challenges. The field is still under-researched and requires collaboration between agricultural specialists, developers, and local authorities [39]. Pollution could be one of the major problems for the safe production of urban food systems. For example, urban soils may be contaminated or of poor quality, so local production and consumption need to be monitored; access to water may also reduce their implementation [4,48]. Another challenge is to ensure that UAP values are reflected in urban planning and decision-making, including civic engagement and willingness [49,50]. NCUA is now gaining ground around the world, but its true value is not understood beyond its ability to help reduce food insecurity [45]. Moreover, NCUA offers an opportunity for creating jobs, which should be of major importance, reducing poverty and enabling households to have access to food [41].

3.8.2. Limitations

Regarding the limitations identified from the selected articles in this systematic literature review, most articles reveal that gardens face political obstacles due to zoning laws, unreliable access to water, and lack of funding and access to land, where discrepancies between theory and reality of operations are striking with regard to NCUA economics [43,51]. In addition, many authors have also mentioned a lack of awareness of how to carry out a project (technical knowledge, engaging the community, etc.), ref. [4,27], as well as a lack of empirical evidence to support claims of environmental benefits on how general gardening and horticultural activities can potentially shape the environment of urban areas [28].

4. Discussion

With more than half of the world's population currently living in cities and an urban population estimated to reach 60% by 2030 [3], achieving more sustainable, livable, and resilient cities is one of the greatest challenges for urban policy and planning in the 21st century [58]. This systematic literature review analyzed the benefits that different forms of NCUA bring to the population, and to the city itself, in different countries. The results show that NCUAs have multiple functions, which contribute to a variety of outcomes associated with urban food systems, in the different cases and countries analyzed [59], and which can be categorized into social, environmental, and economic aspects, explained more in depth in the following sections.

4.1. Social Benefits

The implementation of NCUA yielded in four categories of social benefits from gardening: mental health and wellbeing, society economic growth and employment opportunities, nutrition, and social cohesion: First, mental health and wellbeing, where it was found that living in green environments was associated with reduced instances of depression and helped reduce personal feelings of anxiety [60], with an 8–12% reduction in mortality risk [9,35,61]. Secondly, the society economic growth and employment opportunities, where a number of professionals, technicians, and farmers are hired to manage the UAP by offering help and advice to users [62], making these NCUA areas a "refuge sector" for unemployed workers, retired people, or failed entrepreneurs [46,52]. In the third place comes the nutrition aspect, where gardens expand access to healthy nutritional fruits and vegetables in economically significant quantities, and where fruit and vegetable consump-

tion has improved [53,63], increasing food security and providing livelihoods for urban dwellers [64]. Finally, the social inclusion is the aspect most cited by the authors of the articles selected for this systematic review. Indeed, the implementation of NCUA offers spaces for socialization and, consequently, multiple opportunities to increased 'social cohesion and integration' [19], which can be defined as links between individuals that cultivate norms of reciprocity and civic engagement [65], helping people to break out of isolation and anxiety [54].

4.2. Environmental Benefits

The analysis of the 40 selected articles shows that the implementation of NCUA makes an essential contribution to the sustainable development goal of creating sustainable cities and communities [55], where environmental sustainability remains a potential priority [56]. They could help improve the green infrastructure that contributes to creating and maintaining habitats for a wide range of plants and animals by providing shelter and nesting sites, offering water and food resources, and integrating into surrounding ecosystems. [56]. A number of potential biodiversity enhancements in CG have been identified, such as plants that attract and feed pollinators [15]. In addition, one of the main environmental benefits cited for different forms of NCUA in different countries is improved air quality, increased air humidity, and lower air temperatures during the summer months, which can significantly mitigate the urban heat [23]. Furthermore, the implementation of NCUA forms enables community development as a means of rebuilding declining cities and neighborhoods and reducing food miles and the resulting carbon emissions [66].

4.3. Economical Benefits

In terms of economic benefits, this review finds that the implementation of urban areas has improved the economic situation of many households, as gardens inherently amplify the aesthetic appeal of neighborhoods, and as a result, are likely to increase property values in the immediate vicinity, particularly in deprived neighborhoods [14]. Indeed, results suggest that gardeners harvest nutritionally and economically significant quantities of food [63], and also enable the integration of aspects of Circular Economy [67]. Moreover, at an individual level, growing one's own produce also has a tangible economic benefit, as it reduces the amount spent on groceries, although the exact savings have not been studied extensively [68].

From the analysis presented above, it is clear that using this systematic literature review processing approach has helped to address our main problematic, namely the identification of the outcomes and benefits that the implementation of NCUA brings to the city and the population, which may vary from case to case and person to person, but nevertheless offer many of the services we are looking for today.

The findings of this review are aligned with the results found by Nikolić et al. (2022), who highlight the potential of UA in providing alternative food sources for growing urban populations, focusing on UA's multifunctionality and its perceived benefits in improving cities and combating food insecurity, taking into account the various economic and social impacts of UA, along with its environmental potential for mitigating the effects of climate change and creating sustainable cities [69]. Furthermore, in 2023, Boukharta et al. also stated the importance for policy makers and urban planners to consider the potential benefits of UA and to prioritize stakeholder engagement in the development and implementation of NCUA [70].

The explanation of the significance of the results and actions taken can be reinforced by a qualitative assessment with benchmarks focusing on aspects such as resource use, community involvement, the impact and benefits of NCUA, and their measurement against established standards to assess the performance and impact of the UA initiative.

5. Conclusions

UA has multiple functions, contributing to a variety of outcomes associated with localized urban food systems, including food access, food and agriculture education, community building, and civic engagement [57,70]. The analysis of the articles selected for this review has enabled us to identify a number of benefits that the NCUA forms provide, such as improving the health and well-being of the population, increasing the social inclusion and society economic growth, helping customers to obtain a variety of fruit and vegetables at lower prices, purifying the air, etc., and which can be categorized into three aspects, namely social, economic, and environmental. Furthermore, the results obtained clearly show that there is a difference in the implementation of UAP and the assessment of its benefits between countries, with UA being more common and encouraged in developed countries and less known and used in developing countries, suggesting the need to explain and share the concept further within communities, which has also been mentioned by Boukharta et al. (2023), by organizing workshops for residents along with other activities that can help strengthen ties between residents and provide them with the opportunity to learn more about UA and its services [70].

The authors of the selected articles for this review highlighted numerous challenges and limitations, such as pollution, water scarcity, and lack of interest on the part of the authorities. However, it must be emphasized that the fundamental limitation to the realization of such UAP is a poor or incomplete understanding of the concept of UA, as it is thought to be linked only to food security issues, but its other functions are ignored and insufficiently known, hence the need to insert a specified and explained outline of the UA concept. In addition, there is a lack of skills to engage the community in UA initiatives, which should be mentioned as a limitation, but also as an area where interventions from public authorities are required. Future research should seek to quantify the extent of the ecological benefits of UA, and to identify where and how local authorities should provide reliable and affordable access to land and water, so that all residents can participate and enjoy the benefits that the NCUA provide. Moreover, they should also highlight strategies of how best to include NCUA into the municipality's long-term land-use planning, as mentioned in 2022 by Nikolić et al., emphasizing UA multifunctionality and perceived benefits for city improvement [69].

The development of NCUA could be supported by local policymakers or land-use managers, when planning and making decisions about the use of public spaces in cities, by making municipal land available free of charge, providing water at a lower price, helping to provide seeds, etc. This is in line with the work carried out by Bednarska-Olejniczak et al. in 2019, which points to the role that policymakers could perform in adjusting existing laws, plans, and strategies to integrate the principles of sustainable development through the revision of regulations on urban development and environmental protection, in partnership with NGOs and SDGs that can facilitate community engagement in the development of sustainable smart cities, driving the transition to sustainable and smart urban and rural landscapes [71]. Finally, it is also necessary to consider other aspects and criteria for NCUA success, such as sustainability strategy and return on investment, as NCUA can play an important role in promoting a circular economy in contributing to various aspects of sustainability, minimizing waste, optimizing resource use, promoting local and sustainable practices, and supporting resilience and community engagement.

This systematic literature review demonstrates the gaps in knowledge about NCUA at a worldwide level, along with its benefits. The methodology used showed that the main assumption of the approach employed in this review is that we were able to obtain relevant studies and that there is a body of literature that enabled us to address our problems. Furthermore, this approach provided us with studies of sufficient quality, validity, and representativeness. However, the process of searching for multiple eligibility and exclusion criteria can present a limitation, due to the time required for the search and the availability of numerous databases. In addition, this study was confined to studies conducted in English; future studies could evaluate more published languages to have a wider range of

results and openness around the world. The present study is one of the first to illustrate the perceived benefits of NCUA to both the population and the city itself, improving cities and making them more sustainable and resilient. However, we suggest that further research should be carried out in the future to further explore and understand this discipline which is currently of great importance to current and upcoming generations, using more critical appraisal of study design and contextual information which may produce more nuances into the variances of findings.

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List of Abbreviations

A	allotments
CG	community gardens
NCUA	non-commercial urban agriculture
RQ	research question
SG	school gardens
UA	urban agriculture
UAP	urban agricultural practices
UF	urban farms

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Governance structures and stakeholder's involvement in Urban Agricultural projects: an analysis of four case studies in France

RESEARCH ARTICLE

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Abstract

Nowadays, there is great pressure in cities on the demand and supply of food as well as environmental needs, and where Urban Agriculture emerges in various forms to confront this situation. Indeed, Urban Agriculture is a form of agriculture, highlighting its multiple functions in ensuring food security, maintaining urban ecosystem services, and improve the quality of life. Moreover, the use and transformation of abandoned areas is proving to be an appropriate way of creating new green spaces. This research article focuses on analysing the alignment between governance mechanisms, the distribution of the value created, together with the benefits derived. The comparison is based on four case studies in France, two in Paris ("La Caverne" and "Veni-Verdi") and two in Rouen ("Le Champ des Possibles" and "Le Jardin de l'Astéroïde") with different vocations (social vs economic), and which will serve as a basis for investigations into the theme of Food Governance Structures. This research work consisted of carrying out interviews with the stakeholders involved in Urban Agricultural Projects, as well as on-site visits for analysis and evaluation. An empirical analysis through the NVivo Software is used, which allowed the qualitative analysis of the data. The results show that there are similarities between the different initiatives, such as having a well-structured administrative office headed by a president, treasurer and employees. At the same time, there are a few differences in terms of the type of structure, key priorities and management structure. Indeed, three of the four initiatives evaluated aim to reach out to local residents and to understand the benefits of having agricultural spaces in our cities and to recreate this link with nature, unlike the economic initiative, which focuses more on business and commerce and less on social and educational inclusion.

Keywords: government mechanism, interviews, stakeholders, Urban Agriculture, Urban Agricultural benefits
JEL codes: C83, C93, I18, I38

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1. Introduction

By 2030, the United Nations Human Settlements Program has estimated that 60% of the population will live in urban areas (UN-Habitat, 2011). Ensuring a secure and accessible food supply for this ever-growing urbanization is therefore one of the most urgent and complex challenges facing the world, and where Urban Agriculture - cultivation, processing and distribution of food products by growing plants in and around cities (Poggi *et al.*, 2021) - is the way to remedy food insecurity in cities (FAO, 2019). Furthermore, Urban Agriculture is also increasingly seen as an essential component of food security, and is regarded by researchers as a highly promising pillar of food supply (Mougeot, 2005; Paganini and Lemke, 2020), which ensures a reconnection to nature (Clement, 2010).

To tackle this challenge, the creation of Urban Agricultural spaces as part of the redevelopment of industrial areas is a process that has been designed to create new green and public spaces that will enhance the development of new positive social and cultural projects (Childers and Diaz, 2000). Therefore, the objective of this research article will be to analyse the alignment between governance structures, stakeholder involvement and the benefits of Urban Agricultural Projects, through the evaluation of decision-making, the cost and benefit that such projects require, as well as the distribution of the value created, together with the benefits this brings. In this study, four cases are evaluated, two in Paris ("La Caverne", which is a private urban farm located in an unused underground space for mushroom production, and "Veni Verdi" which is an association whose goal is to establish gardens on school roofs or in the open ground) and two others in Rouen ("Le Champ des Possibles", designed to help people eat better by educating them about food diversity, consumption and processing at both practical and theoretical levels, and "Le Jardin de l'Astéroïde", whose aim is to rent individual plots to local residents so that they can grow their own fruit and vegetables).

This research paper is structured as follows: First, an analytical framework is established to facilitate understanding of the various concepts that will be used in the remainder of the paper. Then comes the methodology, which consists of fieldwork and visits to various urban initiatives, accompanied by interviews with a number of stakeholders, which leads on to the results section. Finally, the discussion section will be based on a critical evaluation of the results, contrasting with other researchers work, followed by a series of conclusions.

2. Analytical Framework

Understanding this document requires prior knowledge of a number of key concepts and fundamentals, since understanding them is essential to correctly analysing and evaluating the results obtained. The following sections present the key concepts on which this article focuses.

2.1 Organizational specificities of Urban Agricultural Projects (UAP)

Diversity and heterogeneity of stakeholders

In 1984, Freeman defined stakeholders as those who can influence or be affected by a specific decision. They can also be defined as representatives of institutions capable of influencing decisions taken at municipal level (Foltýnová *et al.*, 2020). Indeed, most of the fieldwork is carried out by involving stakeholders, as they play the crucial role of local pioneers and experimenters. It should also be noted that the integration of different types of stakeholder can be an asset in obtaining the necessary resources, but it can also make collaboration more complex (Prové *et al.*, 2015).

According to Freeman (2010), there are two types of stakeholder: primary and secondary. Primary stakeholders are those who have a direct involvement with the organisation concerned, such as customers, shareholders, employees, suppliers and regulators. Secondary stakeholders refer to those who are not involved in transactions

with the organisation but who can affect it or are affected by it, such as academic institutions, NGOs, neighbours, advocacy groups and social activists. In this article, both primary and secondary stakeholders are analysed. In fact, the application of critical analysis methods of internal heterogeneity within stakeholder categories lends to the development of greater inclusivity by acknowledging important differences, with a view to deepening our understanding of societal uncertainties and the heterogeneity of stakeholder perspectives (Lelea *et al.*, 2015). Moreover, relationships between stakeholders are often dynamic and mutually dependent, and their degree of significance is based on a wide range of degrees of legitimacy and power (Hall *et al.*, 2014; Mitchell *et al.*, 1997).

Outcomes of Urban Agricultural Practices (UAP)
Benefits of UAP

Urban Agriculture is considered as an important component of practices aimed at food sovereignty and the protection of urban ecosystems (Opitz el al., 2016). Indeed, several studies demonstrate the importance of Urban Agriculture in providing a variety of social, economic and environmental services within urban territories (Chalmin-Pui *et al.*, 2021; Scott *et al.*, 2020).

From Table 1 we can suggest that the implementation of UAP within territories would ensure many benefits. For example, the requalification of abandoned areas such as urban and industrial spaces is a process that can make the cities more resilient (Gros-Balthazard, 2018), leading to the creation of new green and public spaces, and the development of new economic and cultural projects and activities (Childers *et al.*, 2000).

Challenges of UAP

Despite the many potential benefits of ecosystem services provided by urban areas, Urban Agricultural Gardens (UAG) are known to be heterogeneous and difficult to characterise from one garden to another (Orsini *et al.*, 2020), making it difficult to establish a coherent picture of the demographic characteristics of the distribution of urban gardens (Ambrose *et al.*, 2023). Moreover, further research is needed to empirically assess the environmental impacts of urban soils prior to UAG implementation, as it can be contaminated or of poor quality, air pollution, water contamination, etc. (Guitart *et al.*, 2015).

Table 1. Benefits of the implementation of UAP from the literature.

Environmental and nutritious aspect	Social aspect	Economical aspect
Reduce food and nutritional insecurity in relation to food sovereignty, accessibility and quality (Golden, 2013; Ribeiro *et al.*, 2015)	Recreational and leisure spaces for relaxation (Bottiglione, 2014; Companion, 2016)	Revitalize local economies by creating new jobs and attracting investment (King and Shackleton, 2020; Okvat and Zautra, 2011)
Support better food security and public health (Egerer *et al.*, 2022; Flies *et al.*, 2017; Ribeiro *et al.*, 2015)	Improve mental health and well-being, promoting stress management and encouraging social cohesion (Clatworthy *et al.*, 2013; Maheshwari 2017; Soga *et al.*, 2017).	Offers direct access to a wider range of nutritionally rich foods at a lower cost than the market price (Grebitus *et al.*, 2020; Okvat and Zautra, 2011).
Air purification and biodiversity conservation (Czembrowski *et al.*, 2019; Delshad, 2022).	Sustaining spaces for the exchange of knowledge and the creation of community bonds (Hallberg, 2018; Uhlmann *et al.*, 2018)	Transform abandoned spaces to resilient cities (Gros-Balthazard, 2018; Satterthwaite *et al.*, 2010)

Source: The authors and review of literature.

Besides the cost of implementation (Lemeilleur and Sermage, 2020), the sustainability of the governance mode and achieving optimal alignment between governance mechanisms and stakeholder benefits/costs is proving to be a real challenge (Romagny *et al*., 2023), which can result in a poor governance structure (Mintz and McManus, 2014). Therefore, to overcome this challenge, successful UAG implementation needs to be coupled with "political and/or administrative support" (Fox-Kämper *et al*., 2018), for which an understanding of local and political conditions, and the barriers they generate, is also necessary for policy development and reform (Mougeot, 2001).

2.2 The issue of governance of UAP

Governance can be seen as the system of strategic processes and inputs, as well as appropriate institutions, regulations, and interactions, that enable effective policymaking (OECD, 2015), managerial implication in a multilevel approach. Indeed, local and national governments play a role in promoting Urban Agriculture, as well as facilitating multi-stakeholder processes that support the multifunctionality of Urban Agriculture activities (Halloran and Magid ,2013).

This issue of governance for UAP requires consideration of the multiplicity of benefits and outcomes (Nicholas *et al*., 2023) which must be aligned with the main governance mechanisms set up at local as well as territorial level. Following this alignment concept, Prové *et al*. (2015) suggest for instance that "the complexity of the UA advocacy movement, involving different (state, market, civil society) actors operating at different governance levels and advancing different (sustainability) goals, makes novel demands on urban policy-making and planning processes". They argue that "in light of this complexity and uncertainty, scholars have pointed out the need to identify governance arrangements and tools that can orchestrate the new creative multi-actor, multilevel, multi-purpose and multi-sector trajectories" (Prové *et al*., 2015).

Moreover, assessing UAP requires an analysis of the governance of Urban Agriculture and its stakeholders to better understand the appropriate governance processes. For this, it is necessary to consider three levels of complexity that have an impact on governance processes: the wider urban context, the external characteristics and the internal characteristics of governance. By external characteristics of governance, are meant partnerships and public policies, while the characteristics of internal governance are the initiative's objectives, scale, timetable, stakeholders, power and capacity to act (Prové *et al*., 2015).

2.3 Analytical framework

Understanding the governance of a project or initiative requires a deep understanding of the various components that make it up, as well as the roles, objectives, and missions of the players at different levels of the system and its environment, analysed through the concept of alignment as developed below. Table 2 explains the various elements with which it is necessary to cope in order to better understand the analysis.

Regarding the stakeholders, who were defined in 2020 by Foltýnová as representatives of institutions that can influence decisions taken at municipal level, represent a crucial element, with the role of responding to requests and providing assistance where needed (table 2). As far as balanced value is concerned, this is very important, as it encompasses many variables, including motivation, benefits, costs, and so on (Table 2). In addition, the governance mechanism serves to ensure proper supervision, control and management of the project, as well as a post-political environment, focused on the development of consensual policies and the narrowing of political opportunities (Swyngedouw, 2015), as shown in Table 2.

Consequently, the present research paper analyses, for each case study, the results for the three dimensions of environment, economy and human/social aspects, in order to better understand the distribution of the value created and the resulting benefits, together with the proper understanding of the alignment between governance mechanisms and stakeholder involvement. Correspondingly, four components of governance

Table 2. The various components and their role in project governance.

Component	Variable
Stakeholders	Respond to requests/assistance
	Investors
Users	Person interaction with a product or service
Governance mechanism	Supervision
	Incentives
	Control mechanisms
Value balance	Motivation
	Rewards
	Benefits
	Costs

Source: The authors.

structures are detailed, including type of structure (ownership), financial support, cost management, stakeholders/administrative office. Therefore, our analytical framework helps identify the structural invariant of governance structures based upon the rationale of governance value analysis developed by management scientists, where the global value of the set of relationships within a collective form of organization must be maximized by the institutional matrix, i.e. governance forms and governance mechanisms, which are implemented by players in place.

3. Methodology

In this research article, the methodology employed follows Yin's (2003) researcher's model, which consists of analysing the case studies in an exploratory and descriptive manner. This methodology makes it possible to investigate, clarify ambiguities, uncover unexpected results and information-rich material in order to gain an in-depth understanding of the underlying research (Rice and Ezzy, 1999). Moreover, interviews have been done with many stakeholders (project leaders, managers, communications managers, farmers, volunteers, etc.) of each Urban Agricultural project, as well as visits onsite to make a better investigation and analysis.

3.1. Data collection

Study area

To carry out this work, 4 case studies were selected, two with a social vocation ("Le Champ des Possibles" and "Le Jardin de l'Astéroïde") and two with an economic vocation ("La Caverne": urban farm and "Veni Verdi"). These cases have been carefully and precisely chosen, since they deal with and apply the aspects that correspond most closely to our research. In fact, a vaguer selection of cases was first drawn up before the final choice of our cases was made.

Table 3 gives a description of the main characteristics of each of the sites evaluated, specifying the number of square meters in each site, as well as the number of people interviewed. More detailed information on the content of the interviews will be given in the following sections, while more information on the description of each site will be evaluated and developed in the results section, since this information was obtained from the interviewees 'own words'.

Interviews and data analysis

In-depth interviews were carried out with each of the four selected initiatives in order to gain a better understanding of the structure and objectives of each project, which would enable an inter- and intra-analysis

Table 3. Main characteristics of the evaluated study sites.

Initiative	Location	Area (m²)	Type of UAP	Number of interviewees
"La Caverne": Urban Farm	Paris, France	10 000	Underground Urban Farm	2
"Veni Verdi"	Paris, France	15 000	Open-ground and Rooftops Gardens	3
"Le Champ des Possibles"	Rouen, France	20 250	Urban Garden: permaculture	9
"Le Jardin de l'Astéroïde"	Rouen, – France	4500	Allotments	6

Source: The authors.

Table 4. Example of questions asked during interviews.

	Questions interviewed
General information	Can you tell us a bit about yourself?
	What motivated you to work on this project?
Related to the project	In your opinion, what are the objectives of this project?
	What kind of activities are you organising for this project?
Challenges and obstacles	What challenges did you face when working on this project?
	Could you find solutions to solve them?
Urban Agriculture	What Urban Agriculture is and why is it important?
	What urban farming practices do you use?
Environmental aspects	How do you think Urban Agriculture could contribute to ensuring biodiversity conservation?
	How does Urban Agriculture contribute to a healthy, sustainable environment?
	Could Urban Agriculture help to improve soil regeneration? If so, how?
Social and nutritional aspects	Are you maintaining relations with other stakeholders (experts, farmers, municipalities, consumers, etc.)?
	Can you explain how Urban Agriculture could contribute to food security?
Economic aspect	Does this project aim to ensure the development of an economic level?
	How are products distributed or sold?
Governance structure (project managers)	How do you measure the results of the project and use them to adjust your governance structure and improve the performance of the project?
	Do you benefit from financial or non-financial support? From whom?
	How are costs and investment managed within the project?

Source: The authors.

of the organisation of each of the projects, whether they had a social or economic vocation. Table 4 provides a clearer explanation of the various types of open-ended questions we have asked, and which have been answered in an orientation to our needs. Furthermore, it should be noted that other questions relating to the project governance structure and budget management etc. were only asked to project managers and coordinators. Overall, the interviews lasted around an hour with each of the participants, and the questions were very clear and precise, which allowed in obtaining the desired results.

The interviews were conducted and recorded vocally (with the interviewees' permission) and transcribed in French, followed by a professional translation into English for subsequent analysis. The data obtained in this research article was processed using NVIVO software, as it is now widely recognized for its effectiveness in processing data related to qualitative and mixed-methods research (NVivo, 2019; Zamawe, 2015). As many authors suggest, this software not only makes it possible to unravel the complexity of real-life situations, but also, through iterative approaches, to generate and develop a theory based on a comparative qualitative analysis of a selected set of case studies (Dalkin *et al*., 2021).

Field analysis

In order to obtain more concrete and relevant results, it was essential to carry out field research. Travelling to the field several times enabled us to get in touch with the participants so that we could carry out the interviews, since no other method was available as we did not have all their contacts, so travelling made it easier to obtain confirmation of participation in the project. In addition, the fieldwork served as a basis for analysing the current situation and its evolution over time, given that each of the sites had been visited at least thrice, and above all, the managers, volunteers and partners showed us around the sites and explained what existed and what they were planning to do. Visits are therefore an invaluable way of getting to know people and learning more.

4. Results

The following sections present in greater detail the results obtained, with the ultimate aim of answering our research question about analysing the alignment between governance mechanisms, along with the distribution of the value created, together with the benefits it brings:

4.1 Case studies evaluated

This research study evaluated four case studies in France, two each in Paris and Rouen. The following sections will first give a presentation of each of the cases, taking into consideration their objectives and history of implementation. Indeed, the four cases analysed are: "La Caverne" and "Veni-Verdi" located in Paris (Figure 1), and "Le Champ des Possibles" and "Le Jardin de L'Astéroïde" located in Rouen. The following maps represented in Figure 2 were created using QGIS Software, where the location of each of
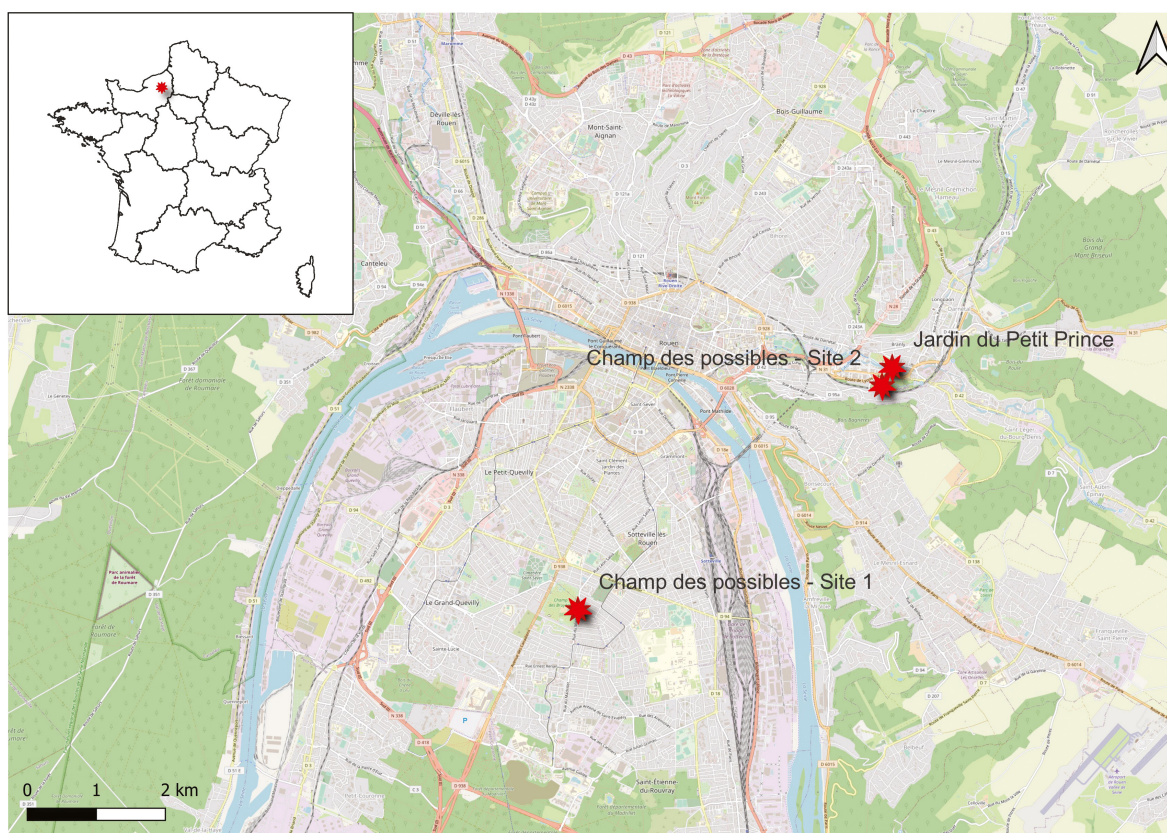
Figure 1. Location of the initiatives evaluated in Paris. Made using QGIS Software.
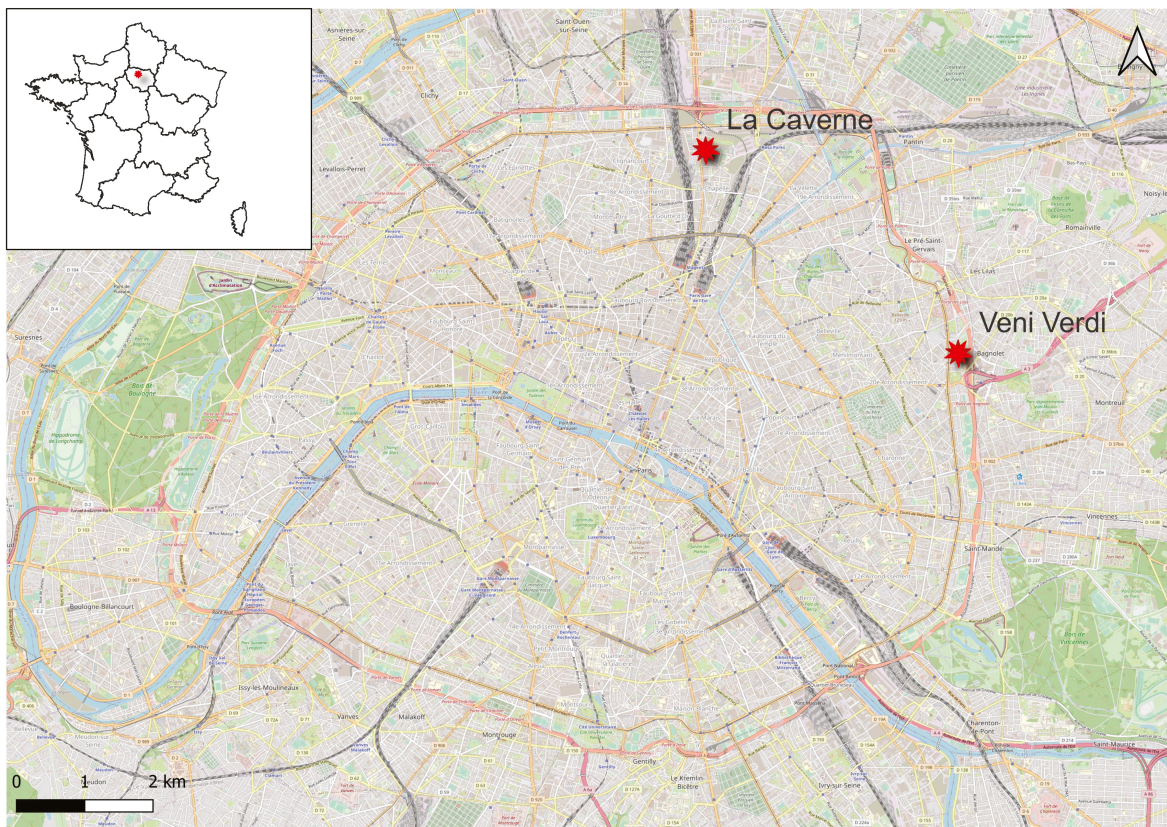
Figure 2. Location of the initiatives evaluated in Rouen Made using QGIS Software.

the two cities is clearly indicated in the map of France in the corner of the map, as well as the initiatives evaluated in each of the cities.

From Figures 1 and 2 we can clearly see that, in the case of Paris, the two cases evaluated are in the heart of the city, but are nonetheless moving towards the periphery, while maintaining good accessibility for citizens. This can be explained by the presence of more greenery and the possibility of setting up urban farms, as well as by the distance from pollution and population density, which facilitates installation and procedures. The same applies to Rouen, where initiatives are moving more towards the outskirts of the city while remaining in the centre. Plus, one of the "Le Champ des Possibles" sites (Figure 2, Site 1) is right in the centre of the city.

Cases in Paris

"La Caverne" Urban Farm:

"La Caverne" is a private urban farm located in Paris (Figure 1), dedicated to the transformation of unused underground car parks into re-qualified spaces. "La Caverne" focuses on the production of three varieties of mushroom. Indeed, in 2017, it was launched thanks to its acceptance of the Paris-culteurs call for projects, which aims to introduce agriculture into the city. Since its acceptance, "La Caverne"has not stopped producing until today. Moreover, "La Caverne" is currently gradually expanding and has now opened its doors in 7 sites in France, including the cities of Lyon, Bordeaux and Paris, with the help of the French State's subsidies.

"Veni Verdi" Association:

"Veni Verdi" association was set up in 2010 in the 20th arrondissement of Paris by the Metropolis of Paris (Figure 1), with the main objective of establishing gardens on the roofs of schools or in the open ground, to raise awareness among young people, where they first started with opening their first school urban garden in 2011, and are now working with 9 sites, all located in Paris. Every year, the association must respond to calls for projects in order to obtain subventions and funding, to ensure the continuity of the project. The main objective of "Veni Verdi" is to provide sustainable food, while building up a territorial network to ensure a circular economy and short supply chains, as well as selling vegetables, fruit and flowers to local stores near their sites. Preparing the younger and current generations for environmental challenges, while working on the region's food resilience, is the main aim of this association.

Cases in Rouen

"Le Champ des Possibles" (The field of possibilities, in English)

"Le Champ des Possibles" is a non-profit association that aims to help people eat better by educating them about food diversity, consumption and food processing at all stages, while integrating cooking into their activities. "Le Champ des Possibles" is spread over two sites: Park of Bruyères and Repainville, both located in Rouen (Figure 2) and which were previously industrial areas. Indeed, this project has been implemented thanks to a call for projects from the Region and the Rouen Normandy metropolis, which involved transforming an old horse-racing track in Rouen's Parc into an urban space. The association emphasizes the educational and social aspects, around which the economic model is built, by selling seedlings and never vegetables.

"Le Jardin de l'Astéroïde" (Astéroïde Garden, in English)

"Le Jardin de l'Astéroïde" is an urban garden based in Rouen (Figure 2), with the main aim of renting out individual plots to neighbouring residents so that they can grow their own fruit and vegetables. Before the garden was set up, there was a wild, abandoned area where cars used to park. After four years of administrative procedures with the town hall of Rouen, everything was ready to install these shared gardens in 2016. Moreover, within "Le Jardin de l'Astéroïde", the use and consumption of the harvested produce is solely for personal use or exchange between members, and any type of sale is not authorized. Additionally, until now, the garden's funding has been limited to the annual dues paid by members and other volunteers, leading to the project's continuity.

4.2 Activities realized and urban practices employed

When conducting the interviews, a number of questions were asked about the activities carried out within each of the projects, as well as the urban practices they employ. Table 5 provides a clearer and more detailed illustration of these two aspects.

Regarding the activities carried out, it is clear that the 4 initiatives share a number of common activities. In fact, what all the initiatives have in common is that they are all open to the public for visits, but in different ways: Visits to "La Caverne" are strictly limited to professionals, and require an entrance fee. On the other hand, for "Le Jardin de l'Astéroïde" and "Le Champ des Possibles", they organize open days and events for the general public so that people can come and discover their urban farm for free, and even perhaps join their project as volunteers, since this is one of their main objectives (considering that "Veni Verdi" also organizes paid professional courses). With regard to the "Le Jardin de l'Astéroïde", the interviews conducted show that so far, they have not yet organized any visits with other actors, but that they are always open to the general public so that they can come and get to know the association, discover the garden and feel the freshness of the countryside.

Table 5. Activities and urban practices employed within Urban Agricultural cases analysed.

Project	Activities realized				Urban practices employed				
	Worksite	Pedagogy	Workshops	Visits	Individual plots	Collective garden	Biological agriculture	Roof	Apiary
"La Caverne"				x*			x		
"Veni Verdi"	x	x*	x	x		x		x	
"Le Champ des Possibles"	x	x	x	x		x			
"Le Jardin de l'Astéroïde"	x		x	x	x	x			x

x*, charges included. Source: The authors.

Secondly, it is clear that "Veni Verdi", "Le Champ des Possibles" and "Le Jardin de l'Astéroïde" are organizing workshops and worksites, which includes activities related to cooking learning and the use of vegetables correctly, since its objective is more related to producing savings, as well as learning how to plant a seed and how to properly cultivate it to be able to grow a good final crop.

Table 5 also shows the urban practices applied in each of the four selected cases, where we can see that there are both similarities and differences. "Veni Verdi", "Le Champ des Possibles" and "Jardin de l'Astéroïde" share a common practice: collective gardens. What's more, each of the initiatives employs an additional practice that differs from the others: for example, the "Jardin de l'Astéroïde" also has individual plots and beekeeping, while "Veni Verdi" installs its crops on rooftops. At the same time, "La Caverne" uses a completely different practice: organic soilless cultivation. This diversity in the use of urban practices within cities shows the different possibilities for urban involvement that these projects can bring.

4.3 Economic, social and environmental aspects

When conducting the in-depth interviews, interviewees were asked a number of questions about the social, economic and environmental impacts of their involvement in these projects and the resulting contributions. To facilitate the understanding of the impacts in the three dimensions of sustainability and make it easier, Figure 3 gives a clearer picture of these three key aspects, drawn from the results of interviews with the respondents questioned, and where the arrows refer to the link between each aspect to the other.

The interviews we conducted with the stakeholders we interviewed enabled us to identify three key aspects, which form the basis for the implementation of each of the initiatives (Figure 3). Moreover, these aspects may be directly or indirectly linked. Regarding the environmental aspect: "Le Champ des Possibles", "Le Jardin de l'Astéroïde" and "Veni Verdi" agree that the use of natural, relatively inexpensive fertilizers for food production helps to improve soil quality and hence its regeneration while providing better air purification. However, "La Caverne" does not work with soil since they are using biological agriculture. Another important aspect is the social aspect, which involves creating links between different participants, which will help to ensure good social inclusion as well as reconnecting urban areas with rural areas. The same applies to the economic aspect, which involves making savings on supermarket purchases, thereby improving the consumer's quality of life and well-being. Indeed, all the interviewees agree that their implementation within those initiatives allowed them to improve their quality of life and living conditions.

4.4. Impact of Urban Agriculture on the community

All of the interviewees acknowledge that their participation in these initiatives has enabled them to improve their quality of life and living conditions, as one of the "Veni Verdi" interviewees said: "It's really nice to be
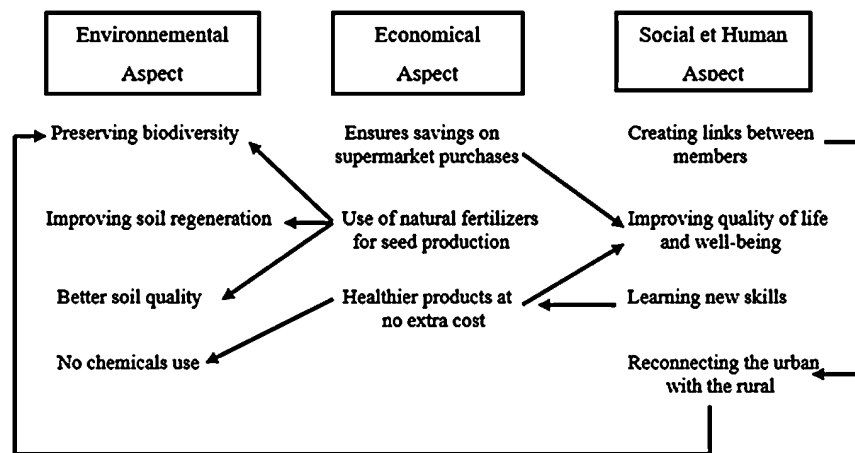
Figure 3. Economic, social and environmental aspects identified from the interviews.

here and I'm very happy to contribute to this team". In addition, the socio-economic profiles of the gardeners suggest that their implementation in the UAG plays an important role in social integration. In fact, they feel closer to their neighbours, more relaxed and improve their mental health, as one member put it: "It's a time to relaxation, physically and mentally". In addition to the social benefits, all the participants agree that the implementation of these UAP has enabled them to make certain savings, since it allows them to produce fresh, healthy food at a much lower price, as one of the members interviewed said: "my quality of life has improved a lot, and I can have access to fresh fruit and vegetables at a lower price".

4.5 Governance structure and mechanisms

One of the main lines of this research study is to analyse the alignment between governance structures, stakeholder involvement and the costs/benefits balance of Urban Agricultural Projects. The purpose of Table 6 is to gain a better understanding of the type of structure of each company, the identification of costs versus benefits, and the involvement of stakeholders in these aspects, which will enable us to better frame and respond to our problem, consisting of analysing the alignment between governance mechanisms, the distribution of the value created, and the resulting benefits. All the information contained in this table was obtained through the interviews we conducted.

Table 6 shows that various governance aspects were evaluated during the interview. Firstly, the type of governance structure is not the same for our selected case studies, where "La Caverne" is a 100% economic enterprise, while le "Le Jardin de l'Astéroïde" is 100% social, and "Veni Verdi" and "Le Champ des Possibles" are in-between entities, i.e. they carry out their pedagogical and learning activities, while having a developed economic side.

On the financial side, "La Caverne" is entirely supported and financed by the State and claims that these subsidies are "sufficient", while "Veni Verdi" and "Le Champ des Possibles" claim to receive quite a few subsidies, notably from the city of Rouen/Paris, the town hall or volunteers, and that they have to respond to calls for projects to ensure the continuity of their project. "Le Jardin de l'Astéroïde", on the other hand, says it does not need any subsidies, and that it relies solely on donations from members (it has received help from the city to set up an apiary and create some basic elements).

In terms of cost management, we can see that there is a lot in common between the different entities, where they all have a treasurer who deals with cost management, as well as the town council in some cases ("Le Champ des Possibles" and "Le Jardin de l'Astéroïde"), for carrying out tasks such as installing fences, poles, and so on.

Table 6. Presentation of the governance structure of the various entities, results obtained through interviews.

Governance structure		Paris		Rouen	
		"La Caverne"	"Veni Verdi"	"Le Champ des Possibles"	"Le Jardin de l'Astéroïde"
Type of structure	Enterprise	x			
	Profit-making association		x	x	
	Non-profit-making association				x
Financial support	State	x*	x		
	Metropolis			x*	
	Town hall/City		x*	x	x
	Private		x		
	Membership/volunteers			x	x*
Cost management	Deputy Treasurer/Finance Director	x	x	x	x
	Town hall/City			x	x
Stakeholders/ administrative office	President and Director	x	x	x	x
	Management office	x	x	x	x
	Salaried employees	x	x	x	x
	Interns	x	x	x	
	Trainees		x	x	x
	Members with plot				x
	Members without plot				x

* Financial entity. Source: The authors.

Concerning the administrative office, the four entities have a well-structured office composed of a president, manager and employees. In addition, interns also have a place in each of "La Caverne", "Veni Verdi" and "Le Champ des Possible", unlike "Le Jardin de l'Astéroïde", which does not employ interns, but does have other participating stakeholders and trainees (Table 6).

5. Discussion

Urban Agriculture has become a key research area seen its relevance to current challenges and future considerations. The changing living conditions, including drought, climate change and increasing urbanisation, require a closer look at the role of Urban Agriculture (Türker and Akten., 2022).

On the basis of the results of the study presented above, we note that the four initiatives evaluated have points of convergence and points of divergence. "Veni Verdi", "Le Champ des Possibles" and "Le Jardin de l'Astéroïde" have as their main objective and motivation to reach out to local residents and particularly young public, since they believe that "children are our future generation", as an employee of "Veni Verdi" expressed it, which will allow to understand the benefits of involving UAG's projects in the sense of recreating this link with nature and thus creating value (Figure 3). However, "La Caverne" has more of an economic objective, namely the production and sale of locally-grown mushrooms.

Regarding the social community participation and involvement, as far as activities are concerned, "Veni Verdi" and "Le Champ des Possibles" organize free open days for the general public, while "La Caverne" organises paying visits reserved exclusively for professionals, allowing the company to generate an added value. In contrast, "Le Jardin de l'Astéroïde" does not organise any activities, but "intends to do so in the future" (Table 5), according to one of the office members. Indeed, in this sense, we can find the work of

Yusoff *et al*., in 2017, which has shown through its research and field practices in Malaysia that community participation in Urban Agriculture activities can help to strengthen links between residents and help them to learn more about and live with this subject, given its vital importance in our daily lives; and to ensure a better food future for all.

On the economic side, as shown in Table 5 and described before, "La Caverne" only organizes visits for professionals, not for the public, although the visit is subject to a fee. Moreover, it does not organize other activities for the public, on the pretext that it is a business and that its objective is commerce and not social and educational inclusion. In line with this aspect of the economic side of sustainability and the creation of new job opportunities, the work carried out in Germany by Krikser *et al*. (2019) shows also that these urban and peri urban practices also aim to increase economic competitiveness by making use of new business opportunities through direct marketing, innovation and interaction with customers, thereby contributing to greater economic recovery and reducing dependence on public support. In parallel, "Veni Verdi" organizes paid professional events and sells all its products directly to consumers or through grocery stores, which plays an important role in their economy. Same for "Le Champ des Possibles" that sells only seedlings, and never vegetables, either through their on-site open house, or through local events or partners. In a similar vein, the Organization of Markets and Producers of Urban Agriculture (OMPAU), which includes as distribution networks to individuals either directly at the place of production by picking or selling baskets, or through restaurants, markets, grocery stores (both luxury and solidarity) (Saint-Ges, 2021). Finally, " Le Jardin de l'Astéroïde", for its part, departs from all these perspectives and declares that the creation of this garden is mainly linked to the desire to create a place of natural and cultural value for the public, while giving them the opportunity to grow, harvest and use their own fruit and vegetables. This is in line with the work carried out in the Centre-Val de Loire Region in France, where members claim that allotment gardens provide them with vegetables, fruit and flowers, and are motivated by the need for "quality food", which is "healthier", chemical-free and, above all, more economical (Robert and Yengué, 2017).

Regarding to the alignment of governance structure, Table 6 clearly shows that the four cases analysed have a well-defined main governance structure, composed of a president, directors and employees, who are responsible for the proper management of the business. The difference is clearly visible in the way tasks are carried out, which, after the intervention of the project manager at "La Caverne", emphasizes that "everyone has their task", and that employees therefore have well-defined tasks which they must respect. At "Le Champ des Possibles" and "Veni Verdi", it is the same thing, except that the people interviewed emphasize that they always help each other to accomplish their goals. At the "Le Jardin de l'Astéroïde", everyone works on their own plot and harvests what they have sown, and social relationships are created between residents through organized workcamps or during work on the collective plot. Generally speaking, the players maintain good relations with each other, with of course, as all the interviewees from each company pointed out, a few misunderstandings that may arise. This can be complemented with the work carried out by Hammelman (2019) who points out that a number of social norms and social assumptions are deeply rooted in local governance and reproduced in our food systems in a way that limits progress towards social equity.

The four cases analysed show that the structure of the governance mechanisms is well defined and respected, enabling them to identify their needs, in terms of administration, task performance and project progress, which in turn enables them to better express their needs to the State, the metropolis, the cities of Rouen/Paris, private funding and through the calls for projects in which they participate to ensure the continuity of their project, enabling them to obtain subsidies and make good progress on their projects. And where their objectives fit perfectly with the implementation of UAP within cities, given the many benefits that accrue, environmentally, beneficially, socially and in terms of a sustainable supply of nutrients. The study carried out by Halloran and Magid (2013) in Dar es Salaam and Copenhagen also highlights the role of a good governance structure in promoting Urban Agricultural activities. In fact, as reported previously, both local and national authorities are supporting the involvement of the community at local level in the provision and conservation of space for Urban Agriculture, as well as access to such land to provide many benefits such as providing fresh food and vegetables

6. Conclusion

Over the past two decades, Urban Agriculture in cities has attracted growing interest due to its potential benefits in terms of socio-cultural development, public health, the environment, and the economy (Santo *et al.*, 2016). In addition, there is a growing awareness of the significant contribution that the connection with nature brings to our mental health and well-being (Capaldi *et al.*, 2015; Uhlmann *et al.*, 2018), and which have been recognized through many initiatives such as Milan's Urban Food Pact, which promotes local food production as a way of addressing the issue of Urban Agricultural (MUFP, 2015). Due to the high diversity of stakeholders involved, and potentially impacted, by these Urban Agriculture Projects, and also of the complexity of urban milieu, the question of how the governance of these projects, at the multiple levels of their organisation, is designed, is paramount to their success. Thus, this research article evaluated the alignment between governance mechanisms of implementing Urban Agricultural Projects, and the distribution of the value created, together with the benefits and costs this will bring.

The case studies evaluated were carried out in two cities with different locations, Paris being densely populated and facing pollution problems, while Rouen is a metropolis whose main objectives are to support the environment and agriculture within cities, in a context of industrial transition. In this sense, it is interesting to note that both cities are currently aiming to make their cities green and sustainable for current and future generations. This means that the various players in charge are encouraging these projects and are increasingly setting up subsidies to facilitate the involvement of these projects within the cities.

From the analysis carried out in this research work, it can be seen that the main objective of the four cases studied is to ensure the production of crops within the city by setting up urban spaces: "La Caverne" ensures local production and the sale of mushrooms in an underground garage, "Le Champ des Possibles" grows different fruit and vegetables for local consumption by participants and members, "Le Jardin de l'Astéroïde" rents out plots of land to local residents, enabling them to grow their own fruit and vegetables, which improves their diet and saves them money, and "Veni Verdi" grows fruit and vegetables in the city's schools and colleges and sells them to local grocers.

The results show that the structure of the governance mechanisms in all four cases is defined and respected in a rational way, enabling them to identify their needs, both in administrative terms and in terms of task implementation and project progress, which in turn enables them to better express their needs to the State, the metropolis, the cities of Rouen and Paris as well as private funding, and thus to obtain subsidies and make good progress with their projects. And where their objectives fit perfectly with the implementation of Urban Agricultural Projects within cities, given the many benefits that accrue, environmentally, beneficially, socially and in terms of a sustainable supply of nutrients.

Following these results, we suggest approaching the topic of urban projects' governance through the definition of a comprehensive typology of their diversity. As a first output of this research, the main delineation principle which could help this categorization of projects is to be found in a holistic (i.e. taking into account the diversity of players) approach of all the benefits and all the costs of such projects, in order to avoid mal adaptations and major misalignments.

The results of this research show that there are limitations, such as not getting economic support from those in charge by drawing up several open calls for tenders for large production projects and start-ups, as well as providing them with more subventions and support. In addition, it is difficult to get people to attend and take part in workshops and other activities, and above all to help share information about the benefits and advantages that Urban Agriculture brings to the lives of present and future generations.

Finally, the various benefits and contributions of Urban Agriculture to our quality of life, health, physical and moral well-being show the importance of involving and integrating urbans spaces into our daily lives. To

this end, various projects relating to Urban Agriculture are being planned in all its different forms, whether on rooftops, gardens, balconies, urban gardens, etc. These projects should be carried out with the help of experts in the field, while taking into consideration the various indicators that may or may not allow the implementation and optimal governance of such projects, to ensure greater productivity and better results, which will be beneficial for the population and for the city itself.

Acknowledgements

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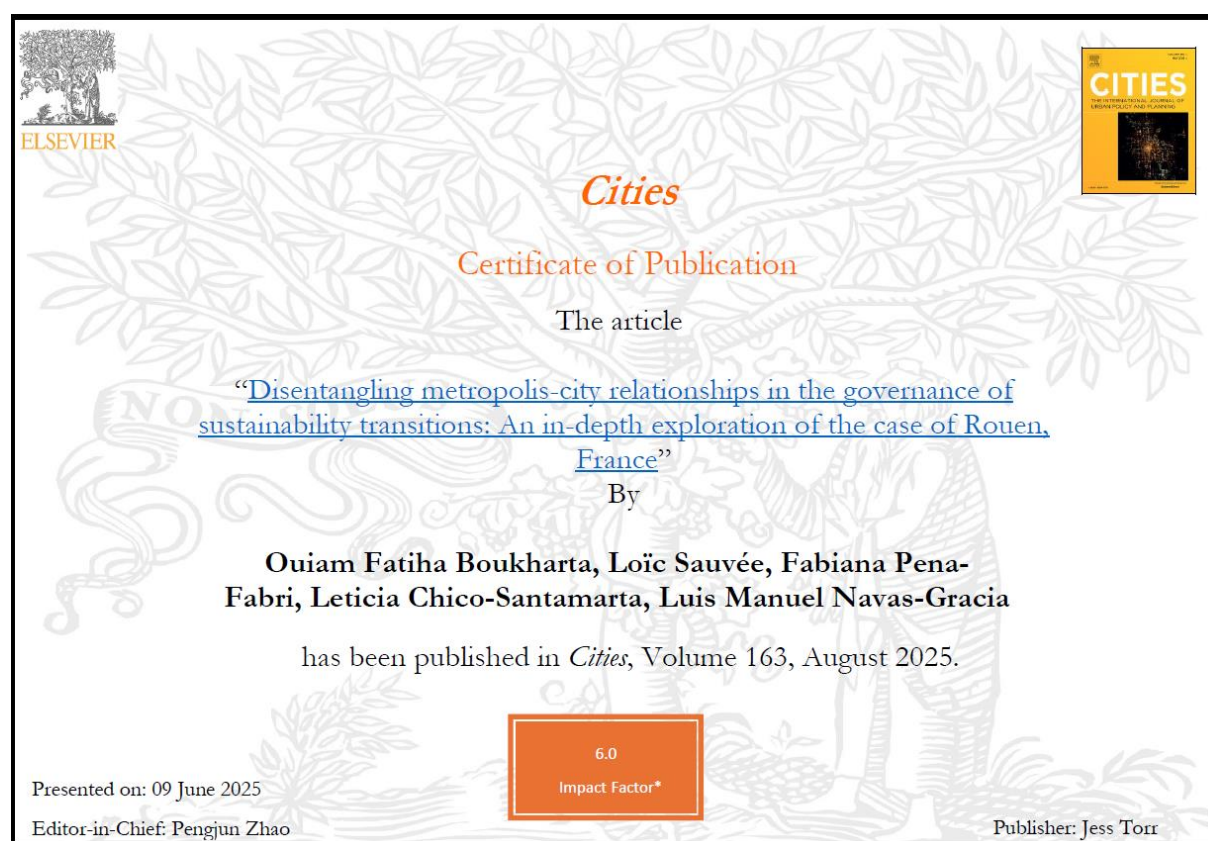
Disentangling metropolis-city relationships in the governance of sustainability transitions: An in-depth exploration of the case of Rouen, France

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A B S T R A C T

Urban agriculture, defined as a system of growing, processing and distributing food in cities, is currently emerging as a sustainable solution for ensuring food autonomy and resilience, particularly with rapid population growth and urbanization. This article aims to explore a multi-level governance system, through the hypothesis that two levels of governance (Metropolis and City of Rouen - France) effectively complement each other in the domain of urban agriculture, using institutional consultation mechanisms, such as coordination committees and regular meetings with project leaders, while monitoring urban agricultural projects, coordinating initiatives, specifying responsibilities and resolving disagreements. A total of 19 semi-structured interviews were conducted, to gain a better understanding of their actual achievements and future goals. The results show that many similarities exist relating to social aspects and education, consumption of fresh products and the desire to ensure the long-term viability of urban projects. However, many differences were highlighted, such as the selection of urban agricultural projects, where the metropolis is less strict than the city in terms of plot size and soil analysis requirements. This paper is recommended as a basis for future research to maximize the implementation these projects, toward more sustainable cities, and eventually in other institutional contexts.

1. Introduction

Nowadays, one of the main future challenges facing our society is to meet the demand for consumable products for the 9 billion people expected by 2050, while limiting the impact of food production on the environment (Randahl & Belcheva, 2017). The local food system has therefore been widely examined in various frameworks for its importance in defining principles for ensuring the sustainability and protection of the food system through its internal balance and coherence with the external environment (Atkočiūnienè et al., 2022). These modes of cooperation and related practices continue to grow and evolve over time, leading to the collaborative and collective construction of a vision of the type of farming systems that should be sustained, through the participation and contribution of stakeholders (Boukharta et al., 2023).

Furthermore, urbanization trends and the diffusion of political power and responsibility lead to the inescapable conclusion that cities around the world have an ever-increasing role in sustained economic growth and sustainable development, and that will be increasingly expected more of the municipal authorities that they take the initiative and assume their responsibilities for local development (Gilbert et al., 2013). From this perspective, challenges related to land use and municipal regulations, as well as concerns about community food security, make urban agriculture (UA) a key element of urban planning and a major issue that needs to be addressed (Meenar et al., 2017).

UA is a system of growing, processing, distributing, and/or selling food or food products through the intensive cultivation of plants or livestock in urban areas, and which can take a variety of forms and occupy a variety of locations (Menconi et al., 2020). Within the cities, several urban farming practices are being implemented, with the aim of guaranteeing the three aspects of sustainable development -social, environmental and economic- and providing ecosystem services to residents and the city (Boukharta et al., 2024; Menconi et al., 2020).

Numerous municipalities recognize UA as an integral part of planning and zoning practices and are developing policies to facilitate it. However, the process of its integrating into planning and land-use practices remains inconsistent, with insufficient reporting of its social, economic and environmental impacts (Meenar et al., 2017). Therefore, mapping out the role of local authorities in sustainable urban development, as well as the framework for cooperation to carry out the goals and programs of the Habitat Agenda, will be central to the discussions and negotiations in this investigation (Gilbert et al., 2013).

This research article aims to identify the various interests and ambitions of two institutional levels, the metropolis and the city, and to assess whether they are aligned and complementary, starting from an initial hypothesis that there is a coherent and synergistic relationship between both entities, in which their respective policies and objectives converge and mutually support each other in the pursuit of common outcomes. Indeed, exploring jointly these two entities is of major conceptual and theoretical interest, as this multi-level governance assessment can fill important gaps in the existing literature on urban sustainability and resource management (Mougeot, 2005a, 2005b).

In order to address this issue, a mixed-methods approach was adopted, including semi-structured interviews, observations and field work, where 19 interviews were conducted with representatives from the Rouen metropolitan region and the city of Rouen, located in the Normandy region of France. This area of investigation is largely known for its potential for agricultural production, partially unexplored in other studies, and from which this study will lead to an in-depth assessment at different scales and across multiple dimensions.

This article follows the following sequence: First, an overview of a specific contextual framework including information on UA and its benefits, along with an explanation of governance for sustainability transitions, which is necessary to understand our hypothesis, that is also defined and presented in this section. Second, the methodology used is more explored and detailed in order to make understanding more efficient and understandable. Third, the results section would present the outcomes obtained from this analysis concerning the authorities' perception of the implementation of urban agricultural projects (UAP) in cities, the norms and standards they apply, through a qualitative analysis that has been carried out through NVivo Software, allowing us to answer our hypothesis and draw interpretations, discussions and conclusions.

2. Conceptual framework and hypothesis

For a better understanding, many concepts are explained in the following sub-sections, along with the hypothesis of this research is presented, where it highlights how our analysis had been conducted, and following which problematic and concern to solve.

2.1. Concepts and literature review

2.1.1. Urban agriculture (UA)

UA is as any type of activity located within or at the periphery of a city and aimed at providing products and ecosystem services to the residents, such as having access to fresh fruits and vegetables, physical and mental health benefits, mitigation of social and economic problems, and community resilience (Menconi et al., 2020). This definition can be shortened into the processing and distribution of food products by growing plants in and around cities (Poggi et al., 2021), which corresponds clearly to the purpose of this study. Moreover, UA is increasingly seen as an essential component of food security and is regarded by researchers as a highly promising pillar of food autonomy (Mougeot, 2005a, 2005b; Paganini & Lemke, 2020), hence the need to address this evolving issue in this research paper. Many forms of UA are currently being practiced as a part of green infrastructures, including community gardens, allotments, school gardens etc. (Menconi et al., 2020), where community gardens can be defined as a collectively gardened open

garden area, managed and operated by members of the local community, dedicated to the cultivation of food and/or flowers (Genter et al., 2015: Menconi et al., 2020); Allotments are defined as plots of land assigned by local authorities for the cultivation of fruit, vegetables and herbs destined for personal use and consumption (Tharrey et al., 2020); and finally, as the name implies, school gardens are areas of land within schools dedicated to a series of agricultural activities linked to food education and involving the participation of pupils, enabling them to acquire nutritional knowledge (Hsiao, 2021). This investigation focuses on community and allotment gardens, as these are the most frequently UAP used in the assessed region, and generate greatest output and results.

The benefits of implementing UAP within the cities can be categorized into three aspects: economic, environmental, and social benefits (Boukharta et al., 2024). The social benefits include increasing "social cohesion and integration", along with reducing feelings of anxiety and improving mental health and wellbeing, and by making these areas a "refuge sector" for unemployed workers, retired people, and/or failed entrepreneurs (Palau-Salvador et al., 2019; Shafieisabet & Mirvahedi, 2022). The economic aspect is more considered as being a source of income while providing direct access to fresh products, which would allow to improve the economic situation of many households along with making savings, as it reduces the amount spent on groceries (Bonuedi et al., 2022). The final aspect is environmental, where it has been proven to promote greening and environmental enhancement, while supporting adaptation to climate change (Pollard et al., 2018), since they help limit extreme weather events, thus improving the quality of urban life and the urban environment (Sanyé-Mengual et al., 2016).

2.1.2. Governance for sustainability transitions

Effective governance in UAP requires consideration of the multi-level dynamics of decision-making (Wolfram, 2019). Indeed, governing these transitions requires an integrated approach that involves diverse actors at different levels, which implies institutional innovations and adaptive governance practices that can respond to the complexities and uncertainties associated with these processes (Avelino & Wittmayer, 2016).

Many forms of governance exist to ensure the sustainability of the UA section, principally collaborative and polycentric governance. Polycentric governance consists of mutual adjustments and involves multiple actors, interacting internally and across scales with the aim of sharing governance, encouraging innovation and policy diffusion, and supporting flexibility through the rapid reconfiguration of policy networks to achieve specific goals (Morrison, 2017). Regarding the collaborative governance, it refers to a collaborative arrangement in which one or more public bodies directly engage non-state stakeholders in a collective decision-making process that is formal, consensual and deliberative, and which aims to develop or implement public policies or manage public programs or assets (Ansell & Gash, 2008).

Effective governance of sustainability transitions in UA involves coordinating local initiatives with regional and national policies to maximize synergies and avoid conflicts of interest (Frantzeskaki et al., 2018), while emphasizing the importance of citizen engagement and participatory approaches to ensure that sustainability initiatives are rooted in the needs and aspirations of local communities (Avelino & Wittmayer, 2016).

Moreover, the growth of the food industry has nowadays increased food availability and product delivery times, while reinforcing the concentration of production, processing and marketing capital. At the same time, the awareness and risk perception of many consumers has increased (Atkočiūnienè et al., 2022), where the supply of agricultural inputs and the production, packaging, processing, transport and distribution of food account for 19–29 % of global greenhouse gas emissions; and they exert significant pressure on natural resources (Vermeulen et al., 2012). It is therefore essential to reform food systems in the direction of greater sustainability to ensure the transition to a low-carbon,

resource-efficient society (Dedeurwaerdere et al., 2017).

2.1.3. Urban planning tools managing UA

To address this current situation, a number of specific urban planning tools exist to ensure that UA is recognized and supported as a valuable component of urban life, including land-use planning, or It involves conducting land-use studies that enable planners to understand the types of agricultural activities that take place in urban areas. Environmental capacity and sensitivity assessments, to determine land suitability and productivity, as well as its response to agricultural activities. Land inventories, to identify land available for UA and facilitate access to it for urban farmers. Of all the above, among the most important practical tools is the involvement of resource mapping and Geographical Information Systems to analyze an area's potential for UA, thus facilitating planning and decision-making.

2.2. Hypothesis

The hypothesis drawn in this research paper is that the two levels of governance (Rouen Metropolis and City of Rouen) are effectively complementing each other in the domain of UA through institutional consultation mechanisms, such as coordination committees and regular meetings with project leaders and associations, while monitoring their UAP, coordinating initiatives, specifying responsibilities and resolving disagreements. Moreover, this multi-level analysis enables the exchange of information and the adaptation of strategies according to local and national needs, ensuring greater operational synergy and efficiency, enabling the development of well-informed UAP that are consistent with what is required and what is produced.

3. Material and methods

This investigation was conducted in France, in the metropolis of Rouen, located in the north of France. In terms of methodology, several interviews were conducted with local and regional authorities, to understand the current situation of UA in the city and the metropolis, with the aim of understanding what they intend to achieve and their principal objectives for future urban development.

3.1. Study area: Metropolis and city of Rouen

This investigation explores two administrative scales, exploring both metropolitan and municipal perspectives in the Normandy region of France toward the involvement of UA, while integrating strategies that address social and environmental challenges at different administrative scales (Mougeot, 2005a, 2005b). Furthermore, effective coordination between these levels can therefore facilitate the creation of urban planning policies that support UA, thereby contributing to the sustainability of cities by providing green spaces and improving access to improving access to fresh, locally produced food (Sarker et al., 2019), while also making a significant contribution to the resilience of cities by enabling better resource management and a more effective response to food crises (De Zeeuw et al., 2011).

The Rouen Normandie metropolitan region was chosen because it is characterized by the size of its vast area dedicated to agricultural activities (Fabri et al., 2024) and ongoing urban support from local authorities (Birks et al., 2022). In addition, the actions of the metropolis and the city of Rouen around UA projects are increasingly developed, where higher expectations in terms of agricultural renewal are met, due to land pressure and the significantly low level of food self-sufficiency (around 10.6 %) (Métropole de Rouen Normandie, 2019). All these aspects underline the need for an in-depth assessment of the feasibility of implementing this approach at its various levels of governance, the structural factors influencing its application and the weaknesses encountered.

3.2. Location of the study area

The Rouen Normandy Metropolis, centered on the city of Rouen and located in France's Normandy Region, presents an interesting case of inter-municipal grouping (500,000 inhabitants and 71 municipalities; MRN Métropole Rouen Normandie Site, 2015). This industrial and port area is in social and ecological transition, with a green belt of 25,600 ha of woodland (Birks et al., 2022). Since 2020, the Rouen Normandy Metropolis has been announcing its ambition to make this zone "the epicenter of the socio-ecological transition" (RNM Rouen Normandy Metropolis, 2020).

Starting in 2020, the Metropolis of Rouen Normandie has announced its ambition to make this region "the epicenter of the socio-ecological transition" and the "capital of the Next World" (RNM, 2020; Birks et al., 2022), and to rely on a concerted approach to action, across subjects, with the idea of leading the ecological transition in a port and industrial city, and therefore, represents an essential contribution to the sustainable development goal of creating sustainable cities and communities (Sonti & Svendsen, 2018).

3.3. Data collection

To respond to our problematics and hypothesis, a mixed-methods approach was adopted involving semi-structured interviews, observation, field investigation, and discourse analysis of public documents, providing an in-depth assessment at different scales and across multiple perspectives, including detailed, qualitative information on respondent perceptions (Thurman, 2018). Indeed, this qualitative analysis has a significant heuristic valueespecially for the researches related to the governance aspects (Huberman & Miles, 2002; Mohajan, 2018; McNulty et al., 2013), as it provides an in-depth understanding of the social, environmental and institutional dynamics of UAP, thereby revealing aspects that are essential to the long-term development and sustainability of these initiatives. The interview guide was prepared by our research team and approved by professionals with expertise in the discipline. It included open-ended questions on the interests and motivations of participants from both local and regional entities on the subject, perceived benefits related to the city and region, lived experiences and their own conceptions on the subject, available resources and future plans, obstacles encountered throughout their activities, and their relationships with UA project managers, with other organizations and among the neighborhoods. Some of the main questions are presented in Table 1.

Table 1
Some of the questions included in the interview guide prepared and carried out with our interviewees (Source: the authors).

Interviewee	Questions
Actors from the Metropolis/ City of Rouen	Can you tell us a bit about yourself and your position within the metropolis/city of Rouen?
	Can you give me an overview of current city/ metropolitan policy regarding field projects and their integration into urban planning?
	How has this policy evolved over time? What have been the main changes or initiatives in this area? (timeline)
	What are the main objectives of the city/metropolis in terms of field projects and their impact on the local community?
	When you choose a plot of land or an UA project, what criteria do you base your decision on?
	And when you were working on these projects, did you encounter any obstacles?
	How do you keep in touch with other actors (project managers, residents, companies, etc.)?
	What do you think the creation of these urban agricultural spaces within cities brings to people's daily lives?

The questions have been prepared following a consecutive of questions to gain a better understanding and evaluation of each of both entities, since it is necessary to evaluate each of the different aspects, for a thorough and well-designed structure (Table 1).

Table 1 illustrates the main questions addressed to our interviewees, where it can be seen that there is a continuum of questions to obtain a better understanding and assessment of each of the two entities, since it is necessary to assess different aspects, for a thorough and well-designed structure, and which enabled us to gather a lot of information and data helping to reach our objectives and solve the problematics, more fully outlined in the results section.

Some of the questions interviewed are related to self-presentation and position within the entity, as this information is necessary for the proper continuity of the questionnaire and a better understanding of the governance structure and policy of the city/metropolis. Additionally, other questions related to the entity's main objectives are asked, as it is necessary to assess the UAP's current challenges and future planning, along with their ongoing contact with other stakeholders and institutions to assess the interaction of the multi-level governance system and mutual results.

3.4. Stakeholders interviewed

This research is based on the evaluation of two entities - the Metropolis of Rouen and the City of Rouen - The mentioned metropolis and its central city were selected as being broadly representative of French Regions where green spaces and environmental protection are more important, and where various projects related to UA are being planned. Numerous interviews were conducted at different levels. Data were collected using purposive and well-structured sampling: $n = 19$ semi-structured interviews conducted from January to April 2024 with key informants ($n = 6$ directors, $n = 8$ managers and $n = 5$ UA program leaders) from both entities, of whom $n = 11$ representatives of the Rouen metropolis and n = 8 representatives of the city of Rouen. Interviews were exclusively conducted with representatives, as decisions are taken in their hands and they are the ones who define the various conditions for the implementation of UAP. So, for each local entity and department, the number of directors, managers and project leaders is countable, resulting in a total of 19 interviews, a fairly large number of interviews that allowed us to reach data collection saturation, where all our answers were obtained, with even a few repetitions.

The characteristics of the UA program participants are presented in Fig. 1, where, for each of the joint respondents, their role is explained in more detail to provide a better understanding of their position:

It's worth noting that in this research article, interviews were conducted with actors holding important positions within the city and metropolis of Rouen (Fig. 1). Indeed, interviewing them was necessary to better understand the current situation of UA and to respond to our problematic and objectives.

The interviews were done in different manners, including face to face, online and telephonic meeting, in order to respond to the availability of the interviewee and his preferences. All interviews were voice-recorded, with the permission of the interviewees, while preserving the anonymity of each, and coding was carried out on a blind basis. Qualitative data was collected through the semi-interviews that were conducted in French, transcribed using Descript software and translated into English, and coded using NVIVO Software, one of today's leading qualitative data processing software packages (NVivo, 2019).

4. Results

The results section will present in detail all the substantial results obtained from the interviews conducted. Indeed, numerous aspects were analyzed, with the aim of responding to our main problematic which consists of assessing and analyzing the relationships between the metropolis and the city of Rouen in the governance of sustainability transitions, exploring their similarities and differences and determining the links between them.

1. The results of this study are structured around seven key points, each chosen to assess and analyze the relationships between the metropolis and the city of Rouen and their governance of transitions toward sustainability, exploring their similarities and differences and determining the links between them:

2. *Chronology of UA Initiatives:* tracing the evolution of initiatives, examining how these historical relationships influence current governance dynamics.

3. *Policies of the City and Metropolis of Rouen:* comparing local and metropolitan policies, analyzing their similarities and differences to understand how they complement or contradict each other.

4. *Objectives targeted by UA:* this section analyses strategic convergences or divergences and tests the hypothesis that aligned objectives facilitate cooperation.

5. *Criteria for Site Selection:* revealing their respective priorities and enabling us to understand how decisions are made and coordinated.

6. *Support, Monitoring and Continuity:* This point examines institutional and community support at each level of governance, assessing its role in the continuity and success of UAP.
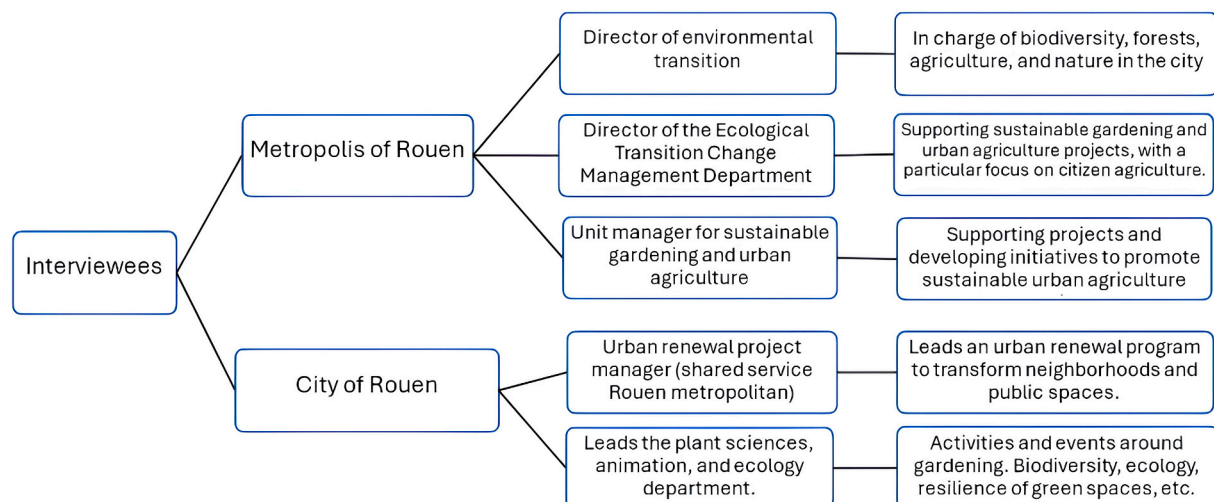

Fig. 1. Actors interviewed from the metropolis and city of Rouen, their position, and the main functions they perform.

7. *Benefits of UA Obstacles Encountered:* this point measures the impact of projects on both levels, along with the challenges they are facing.
8. Summary of the main findings of this investigation: where a diagram is presented to provide a more concrete, global visualization of the outcomes, including similarities and differences between the two entities, along with a more precise explanation of the multi-level perspective that exists between them.

Each point contributes to an in-depth understanding of the governance relationships between the metropolis and the city of Rouen in promoting transitions toward sustainability and UAP.

4.1. Timeline and history of UA

With the aim of understanding the evolution of the actions carried out in each of the Rouen metropolitan area and the city of Rouen. Our interviewees answered the question: "Is it possible to give me a chronology of the actions carried out by the city/metropolis in relation to this?", which enabled to identify the main milestones in the involvement of urban spaces within cities. This comparison of historic and contemporary UA initiatives between the city and the metropolis would also allow to deepen the analysis of their multi-level governance.

4.1.1. Metropolis of Rouen

Findings from interviews with stakeholders in the metropolis indicate that there has been a chronology of actions and milestones that have made UA an important element today, as shown in Fig. 2.

Historically, the Rouen metropolitan area has had allotments and allotment gardens, which are clearly not very well identified by an older population. Shared gardens were quite marginal. Until about ten years ago, there were hardly any. The second most significant milestone was in 2013, when the city launched the Gardeners' Club, with the aim of encouraging gardening, supporting initiatives to make gardens more resilient and ensuring the preservation of ecosystems. The third stage was in 2021, at the end of the COVID pandemic. This was the launch of the "metropole nourricière" call for projects, which stemmed from a

genuine political desire to develop shared garden projects. So, in concrete terms, our interviewee points out that "in concrete terms, before 2021, there was no scheme at the metropolitan level that really supported the creation of shared gardens". Finally, in 2023, Agri Paris Seine was created as an associative structure bringing together seven cities, namely the metropolis of Rouen, the city of Paris, Greater Paris, etc., which aims to "reduce the impact of food production on the environment, along with improving collective catering between towns and residents", as stated by an intervener from the metropolis (Fig. 2).

4.1.2. City of Rouen

The following Fig. 3 shows that there is also a chronology within the city of Rouen concerning the actions carried out around UA and its implementation within cities, as well as the implication of these ideas over time:

The first point mentioned by our interviewee was that about ten years ago, the city decided to encourage the maintenance and development of market gardening. Several stakeholders intervened, namely in the *Repainville district* in Rouen. In 2011, as part of the Agenda 21 proposals, the green space department initiated a shared garden project in Rouen's *Lombardie district,* which one of the interviewees described it as "originally being a striking wall", and which the city proposed to transform into a shared garden. And so, it was between 2011 and 2014, that the garden took off in terms of activity and convinced the elected officials that it was a very effective device in terms of social links. According to one of our speakers reacting directly in this area, the year 2014 was a key period, when "the municipal council adopted the charter aimed at developing a network of shared gardens in the city". More recently, there has also been a demand for the creation of collective orchards, to introduce the whip-tree aspect into these schemes. Finally, in 2020, residents of Rouen were able to make an online request for sidewalk clearing, via the Green Thread scheme, which consists of clearing sidewalks to free up strips of land for local residents (Fig. 3).
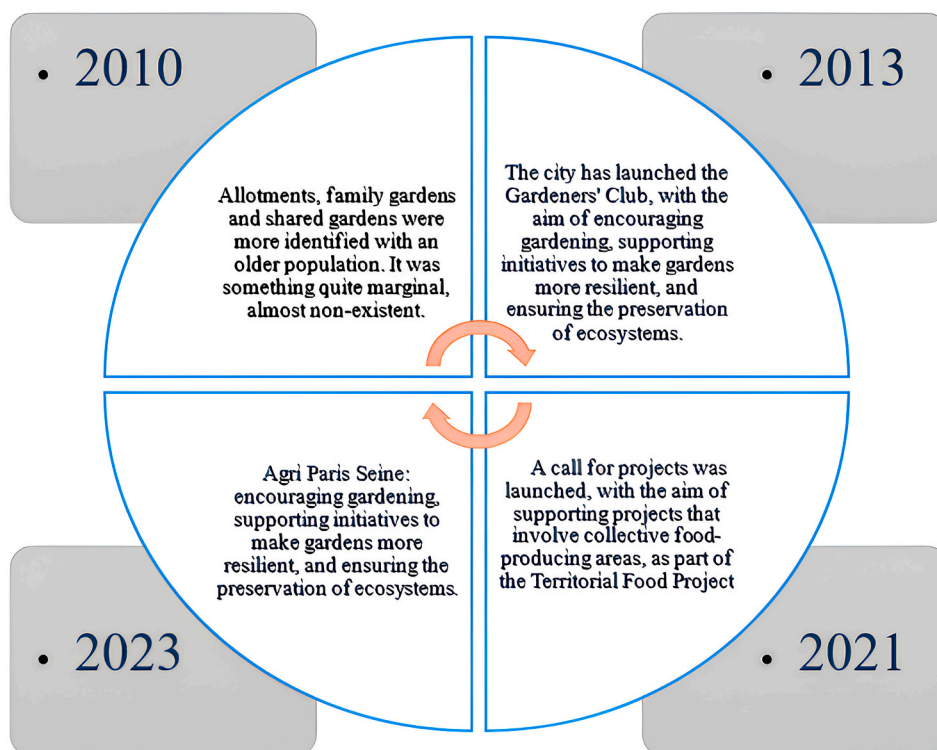

Fig. 2. Chronology of Rouen's metropolitan main actions carried out toward UA (Source: the authors, from the interviews conducted).
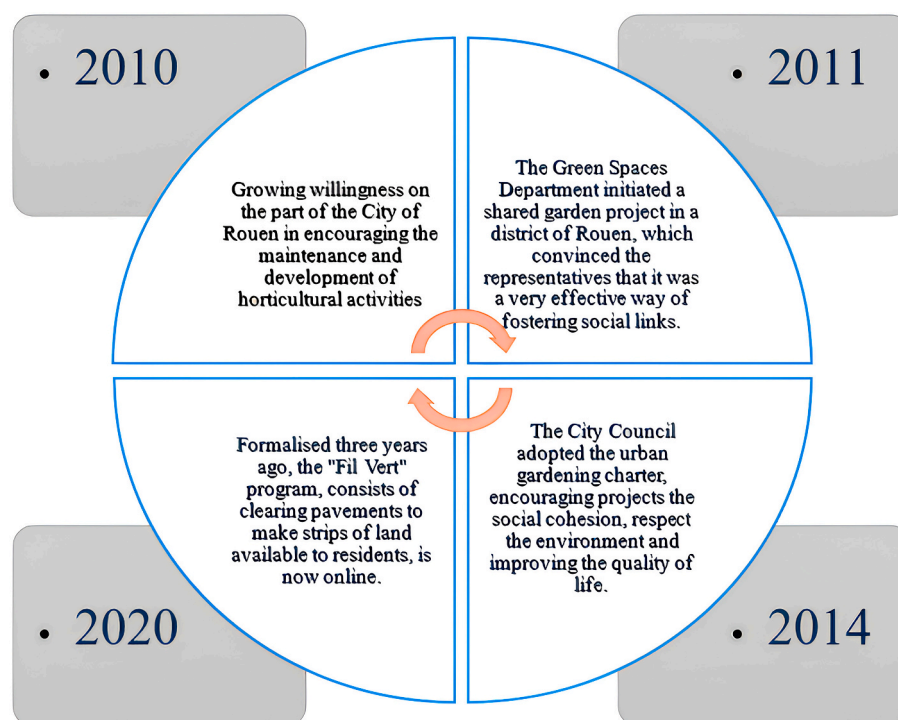
Fig. 3. Chronology of the city of Rouen's main actions carried out toward UA (Source: the authors, from the interviews conducted).

4.2. City and metropolitan Rouen policies in relation to the involvement of UAP

Table 2 shows that the Rouen metropolitan area and the city of Rouen have different approaches toward the implementation of urban agricultural practices in cities.

In the Rouen metropolis, the interviews conducted confirm that they have involved agriculture policy for around ten years. According to the interviews, representatives from both entities agree that "UA does not necessarily serve an economic purpose, but is rather one of those complex projects that have to do with food, acculturation and education in an urban environment". For this reason, local authorities deal with all agricultural initiatives and sectors that have economic autonomy based on agricultural production. Moreover, the most encouraged UAP are those that have a strong link with the local population, and which aim in particular to restore an urban link with seasonality, food quality, knowledge of products and their applications (Table 2).

Regarding the city of Rouen, the interviews conducted confirm that the development of public spaces and the living environment is planned through an urban renewal program under an agreement signed with the National Agency for Urban Renewal (ANRU) in the *Hauts-de-Rouen* and *Gramont neighborhoods*, where Nine districts of the city are involved. In addition, our interviewees from the city stated that "UA in Rouen is a

relatively limited compared with the rest of the metropolis, because we don't really have any farmland. So, we're getting involved in UA by trying to develop short supply chain initiatives". The real responsibility for UA lies with the metropolis. But the city of Rouen is also involved, seeing urban gardening as part of this (Table 2).

4.3. Objectives that the metropolis of Rouen and the city of Rouen wish to realize regarding the implementation of UA within the cities

One of the main questions that have been asked to our interviewees from the city of Rouen and the Metropolis of Rouen are their main objectives and perspectives they are willing to achieve while implementing UAP. Indeed, this aspect is fundamental for a better understanding and analysis of the current situation of UA, which will give a clearer picture and identify if the two authorities share the same desired outcomes or not. The following Fig. 4 is presenting the key elements that have been identified by our interviewees from the two authorities.

From Fig. 4, and according to the interviews conducted with the Rouen metropolitan authorities, the first aspect mentioned by the director of the metropolitan authority's environmental transition is the issue of zero net artificialization, which is enshrined in law, where he stated that it means, "destroying less and less space, systematically, in order to seek to re-naturalize it, something that is and should be seen as a constant concern". In addition, the unit manager in charge of supporting sustainable gardening and UA within the metropolis emphasized that "contributing to food self-production on the territory, would enable access to self-production and greater food for quality, seasonal and organic, something that today constitutes a real lever for eating well and consuming well while being less dependent on imports". In addition, she added that bringing plants back into the city, in whatever form, also contributes to making cities more breathable, through demineralization, particularly in highly urbanized areas. Finally, the director of the Ecological Transition department mentioned the need to re-localize production, which also ties in with our region's food self-sufficiency (Fig. 4). She pointed out that currently, less than 5 % of our region's surface area is dedicated to agriculture and emphasized that "this is far from enough to guarantee the food self-sufficiency of our 500,000

Table 2
City and metropolitan Rouen policies toward implementing UAP.

Metropolis of Rouen	City of Rouen
The metropolis has been involved in agricultural policy for around ten years.	There is an urban renewal program under an agreement signed with the National Agency for Urban Renewal Relatively small theme compared with the rest of the metropolis.
UA is more concerned education in the urban environment and not solely an economic purpose.	
The main searched objective is to restore an urban link to seasonality and quality food	The city of Rouen is also involved in urban agricultural practices, seeing urban gardening as part of this.

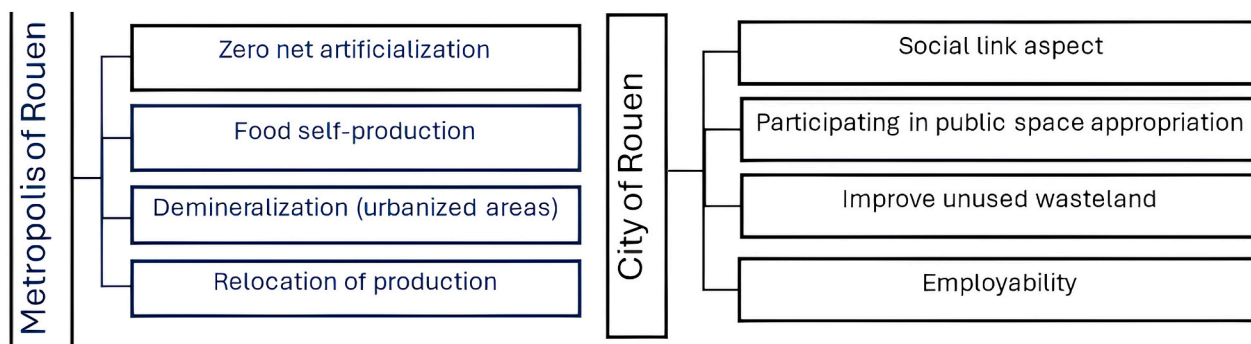**Source:** the authors, from the interviews conducted.

Fig. 4. Objectives that each of the city/metropolis of Rouen are tending to realize toward UA (**Source:** the authors, from the interviews conducted).

inhabitants".

4.4. Selection of criteria for UAP plots

The following Fig. 5 is clearly s that the criteria used to select UAP are not very "strict", since their main objectives are to create sustainable, green cities, and to encourage people to learn how to feed themselves and re-connect with nature.

From the interviews carried out and from Fig. 5, it can be noticed the Rouen Metropolis emphasizes that one of the main criteria on which they base themselves is the number of shared gardens supported per edition, since the idea is to be able to say that the project has enabled the emergence of so many square meters of cultivated surface area in such and such a period. In addition, there's the number of events held per year, as well as the number of visitors and the number of days the gardens are open to the public. Indeed, for these criteria, the higher the number, the more the project in question is encouraged. Another important point cited was the "autonomy with regard to food", as well as "indicators linked to community living", since this type of place brings sociability, along with additional income. Finally, it was mentioned that, if necessary, soil analyses can be carried out, while opting for the protection of drinking water catchments (Fig. 5).

As far as the city of Rouen is concerned, the first criterion cited by the head of the plant sciences, animation and ecology department is to "check with the urban planning department that there are no real estate projects on the land in question, to make sure that the land is not just available for a few months, but rather for years". He also added that "in general, agronomic analyses can be carried out if necessary, but projects

are never made on land on which there is a history of suspicions of possible pollution". On the other hand, he adds that there may be a need to import compost, and possibly change the topsoil layer on the surface, giving the example of the Lubrizol incident in Rouen, which was handled by ADREAL, and which required a major procedure to treat the land. On this point, pollution analyses can be carried out on some target gardens, but in the case of shared gardens, there is often no doubt as to the quality of the soil. All that's needed is agronomic analysis to determine the level of organic matter, water retention capacity, etc. (Fig. 5).

4.5. Project support, follow-up, and continuity

Regarding the maintenance of relations and contacts with the various stakeholders, both representatives from the two entities report that they are "in regular contact, particularly with project developers".

4.5.1. Metropolis of Rouen

Our interviewee from the Rouen metropolis mentioned that there are three main stages in project implementation:

Preparatory phase: one of the staff will meet people in the field and ask them to explain the project they want to carry out, along with technical recommendations, mobilisation, etc. to help them prepare their proposal. The aim is to assist them in completing their application, while giving them advice on how best to organize it.

Individual support: Depending on the type of project, the target audience, the location, etc., the metropolis entrusts the support for each project to a service provider. In this way, the metropolis designs the
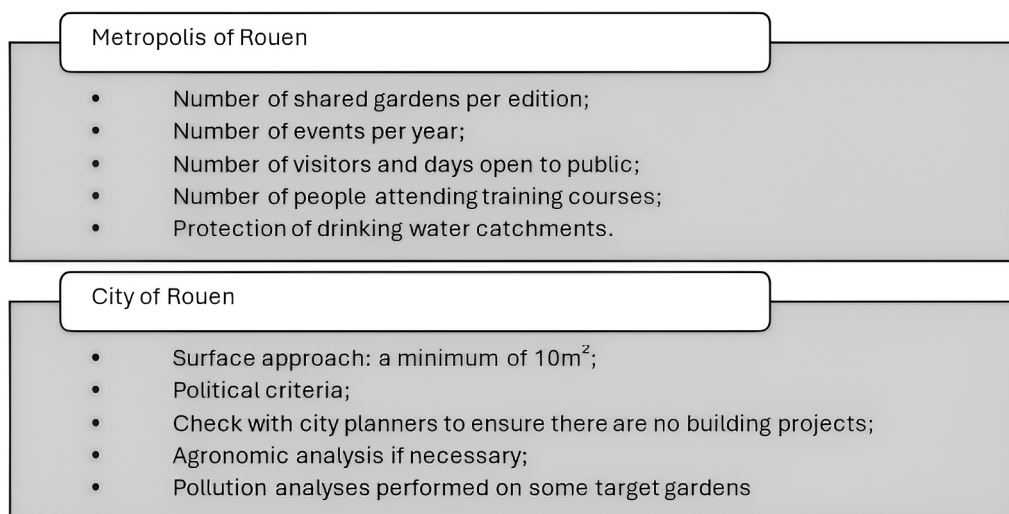

Fig. 5. Criteria used by each of the city/metropolis of Rouen toward implementing Urban Agricultural Practices (**Source:** the authors, from the interviews conducted).

support and allocates a couple of sessions, rising to seven sessions a year, depending on each individual case.

Feedback and analysis (if necessary): The service providers act as a link between the projects and the metropolis during the first year, providing feedback and analysis where necessary. At the end of this period, the city will contact the project leaders again for a review, which may or may not take the form of a face to face meeting, as there are many projects.

4.5.2. City of Rouen

This is partly the same with the metropolis of Rouen, which explains that there are three main stages: Consultation, formalization, and handover of the land to the association:

Consultation: which consists of a few meetings to explain what a shared garden is, to explain the method that the city wants to adopt and then to work on defining the project.

Formalization: where an official event is held with the elected representatives, to make it official in the neighborhood that the city supports the project, and that all the inhabitants of the neighborhood, who were not aware of the project, can ask all the questions they might have. In this stage, formalizing the partnership that will be established between the City of Rouen and the association.

Handover of the land to the association: often takes place after the work that has been carried out by the city, when there's an official inauguration to sign the agreement, and above all for the association, to sign the urban gardening charter, but in a very official way.

4.6. Benefits and obstacles of including UAP

The conducted interviews enabled to identify many of the benefits and obstacles that UAP bring to the population and to the city itself. Table 3 summarizes the main points raised by our interlocutors:

From the interview's responses summarized in Table 3, most of our interviewees mentioned that one of the main benefices of implementing UAP is "recreate contact with nature, to enable reconnection with the seasons, climate, biodiversity, pests, diseases, etc. … along with the capability to plant, to experience the seed growing, to reconnect with the earth and nature, and to food production". This contact with nature can be complementary to the food aspect, since gardening gives the consumer a real sense of satisfaction in eating what has been produced in a healthy, diversified way. Moreover, the social aspect was widely cited, as these places are places of sociability and exchange, social lines in the city, and represent a vector of human contact, a vector of learning too, between members and through training courses, since these aspects have an important impact on physical, moral health and well-being. These aspects, mentioned above, allow the achievement the resilience

Table 3
Benefits of integrating UA practices into the city and its impact on people's daily lives.

	Benefices	Limitations
Metropolis of Rouen	Autonomy in relation to self-supply	Reconstitute a suitable growing base Creation of a network of associations
City of Rouen	Conservation of green spaces Bringing nature back to the city Learning ground and place	Setting up the association
Both entities	Healthy and varied consumption of products Places for socializing and sharing Reconnecting with nature Reconnecting with food and cooking Resilience of urban communities	Human resources Ensuring the long-term viability of projects Food Autonomy

Source: the authors, from the interviews conducted.

of community agri-food systems in urban areas, since the establishment of the UAP, as it provides access to different sources of food, protects the environment and green spaces, helps homeowners to make savings, etc. (Table 3).

Regarding the obstacles and limitations, as far as the city of Rouen is concerned, the interviews conducted confirm that they didn't experience any real difficulties or obstacles when it came to implementing UAP. However, the human resources issue had been mentioned, i.e., sometimes it's necessary to rely on relays in the departments and services, which are more their domain. Our speaker pointed out that "there are three stages in bringing a project to fruition: the land, the project and the creation of the association". Land, a project and a supporting structure. The project is supported directly by the city, which sets out all the rules to be respected, so there's no copying and pasting. The project must be defined by each group of residents. And then the last stage, which is perhaps the most complicated, is for an association to be set up. But emphasizes that, so far, they've never had any obstacles on this point, and that this stage may just take a little longer on certain projects.

The Metropolis of Rouen, on the other hand, has several obstacles to overcome. Firstly, it has to deal with "poor-quality or very disadvantaged land", where in this case the metropolis is obliged to reconstitute a suitable growing base (Table 3). Then, there's the creation of a network of associations able to carry out this type of project, knowing the inhabitants and capable of doing so, but emphasizing that this doesn't really cause any major problems, as there are also people from outside who come and this creates many opportunities for conviviality, mutual aid and socialization, and this is the example where, at some point, the inhabitants need to take charge of this type of project.

Finally, the critical voices concern the main obstacles that were mentioned by all our speakers about the issue of ensuring the long-term viability of UAP and enabling a sufficient food autonomy of the region. In other words, the local authorities are willing to help creating urban spaces, but the main constraint they are trying to avoid is failing to ensure the sustainability of these projects (Table 3), since the goal is "to keep these projects for years" and that "these forms of UA could help to ensure healthy consumption and access to fresh food, but could not fully feed the city", as mentioned by an interviewee from the metropolis of Rouen.

4.7. Summary of the main findings of this investigation

The results presented below can be illustrated in the diagram below in Fig. 6, which shows a simplified overview and summary of the main points:

From the diagram featured in Fig. 6, it is clear that there are several points of convergence and divergence between the two entities. The start-up period for the implementation of these UAP seems to be more recent in the city than in the metropolis. Moreover, both entities focus on the three aspects of sustainability, but at different scales, in which the metropolis is more focused on education and social aspects, and the city additionally includes the economic aspect as an important component that makes a difference in the daily lives of the inhabitants. Fig. 6 also demonstrates that a number of common points are mentioned by the metropolis and the city, which relate more to their interest in implementing such projects and the support they would give to the realization of UAP. The long-term sustainability of the projects is a main common objective, aiming to implement these projects as long as possible, wishing to ensure a self-sufficient food production within the city and the metropolis. Another important aspect to consider in this diagram is the multi-level governance perspective, where the in-depth interview results show that there is a coherent synergistic relationship between the two entities, in which they are both aligned on the same main objective, and where a proper contact and structure between them enables a better implementation of the UAP and the achievement of effective and efficient actions.
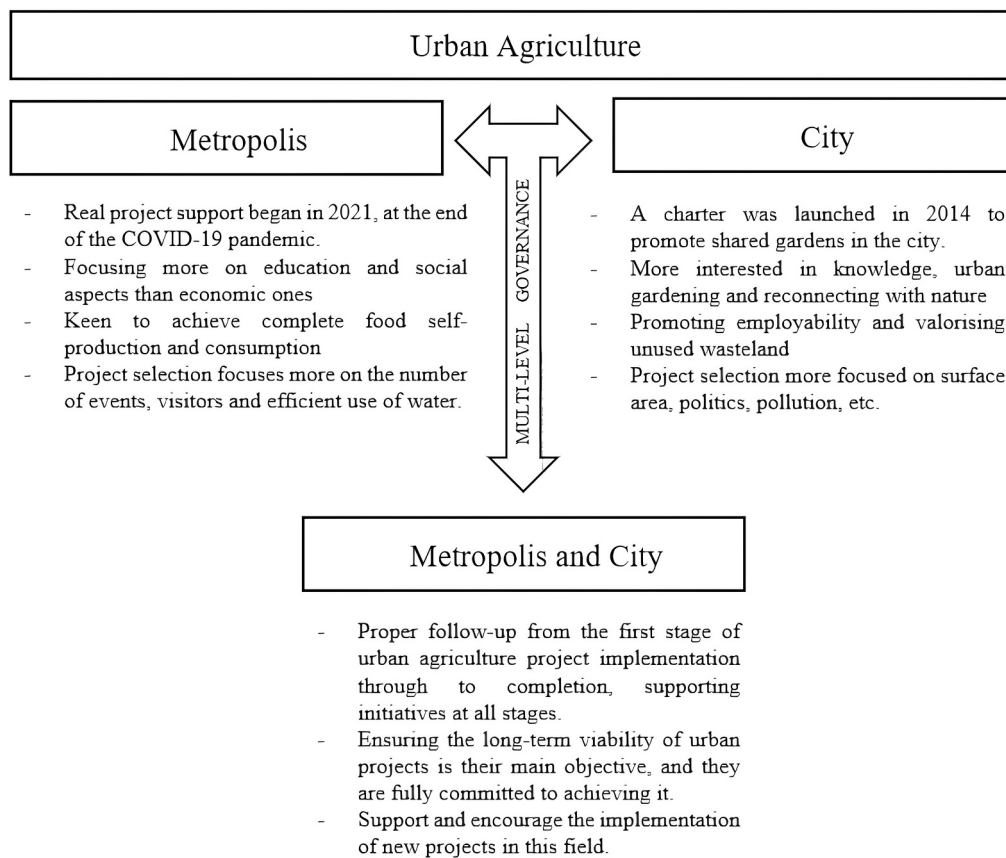
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                              Urban Agriculture

        Metropolis              <=>              City

-  Real project support began in 2021, at the end    -  A charter was launched in 2014 to
   of the COVID-19 pandemic.                             promote shared gardens in the city.
-  Focusing more on education and social             -  More interested in knowledge, urban
   aspects than economic ones                           gardening and reconnecting with nature
-  Keen to achieve complete food self-              -  Promoting employability and valorising
   production and consumption                           unused wasteland
-  Project selection focuses more on the number      -  Project selection more focused on surface
   of events, visitors and efficient use of water.      area, politics, pollution, etc.

         (MULTI-LEVEL GOVERNANCE)

                        Metropolis and City

        -  Proper follow-up from the first stage of
           urban agriculture project implementation
           through      to      completion,    supporting
           initiatives at all stages.
        -  Ensuring the long-term viability of urban
           projects is their main objective, and they
           are fully committed to achieving it.
        -  Support and encourage the implementation
           of new projects in this field.
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Fig. 6. Summary of the main findings of this investigation in relation to the metropolis and the city of Rouen.

5. Discussion

UA has become a topical issue due to its numerous benefits for both residents and the city itself (Dubbeling et al., 2019). This research investigation took as its starting point the hypothesis that the two levels of governance - the Metropolis of Rouen and the City of Rouen - have an effective complementarity in the field of UA, ensuring greater synergy and operational efficiency, enabling the development of well-informed UAP that are consistent with what is required and what is produced. Furthermore, this starting hypothesis also assumes that these two entities have common objectives, aligning with the three aspects of sustainable development (economic, environmental and social), while helping young associations and residents to develop their projects. To analyze these hypotheses, semi-structured interviews were conducted with stakeholders from each of the two entities, asking precise and straightforward questions in order to obtain as many answers as possible to our problematic questions.

The findings of this investigation have been grouped into seven main points, which were presented in the results section and will be further discussed in the following points. It is important to emphasize that, while this research draws on studies conducted in various regions to provide a broader context for UA, the references provided do not constitute direct evidence of the effects of UA in Rouen. However, they are intended to place local findings within a broader discourse on UA, highlighting trends and challenges observed elsewhere. The present research is essentially based on local, empirical data drawn from interviews with key Rouen stakeholders from the local authorities, and the analysis focuses on their perceptions and experiences. This distinction is essential, as it ensures that the conclusions drawn are based on the specific local context, rather than generalized from other regions.

Regarding the chronology of the actions carried out, the interviews conducted with the stakeholders of each of the city of Rouen and the

metropolis confirm that the integration of UA within cities is a recent term, which began around ten years ago, and which is in line with the work carried out by Yan et al., 2022, which highlights that despite the importance of UA, its implementation and the attention it attracts is growing considerably over the years. Furthermore, this comparative historical analysis has shown that there is a well-structured governance dynamic that supports UAP, helping their implementation and achievement of goals, with support potentially coming from both entities and other initiatives through a multi-level system of governance. Indeed, this finding has been confirmed by most stakeholders interviewed in this investigation, along with Sano et al. who highlight the need and necessity for a well-designed government structure contributing to the smooth running of projects, through a study that has been conducted in the Republic of Guinea (Sano & Kassim, 2021). Another aspect that has been mentioned by all our interviewees is that the metropolis has very clear stages linked to calls for projects, support for projects including collective food-producing and above all relations with other French regions in terms of sustainable development and the preservation of ecosystems. This aspect has also been mentioned by Urban Policy Platform, 2023, which conforms that metropolises are multidimensional and address complex situations, which simultaneously include social, economic, community, sustainability or digital aspects, among other issues. On the city side, local entities are more encouraging projects including the social cohesion, respecting the environment and improving the quality of life. These findings are well aligned with the work carried out by Qian et al. confirming that cities with good smart infrastructure including UA spaces demonstrate greater resilience in the event of a crisis, as they have a more efficient flow of information and are less reliant on physical space (Qian et al., 2024).

The second aspect concerns policies of each of the entities in relation to the involvement of UAP, where in the metropolis of Rouen and the city of Rouen agree that UA is more concerned on education, protection

of the environment and not solely for an economic purpose. In fact, this was confirmed by the systematic review carried out by Boukharta et al. in 2024, where the analysis revealed that social and environmental results take precedence over economic ones. However, the city's stakeholders mentioned a limitation in this sense, relating to the fact that the land is relatively small compared to metropolitan land, making it more complicated to carry out these practices. In this sense, Sanyé-Mengual et al. show that there is an absence of UA in Barcelona's current sustainability policies and suggests that the perception of UA must be as an activity with a social vocation rather than one of food and economic production, so as not to slow down the process of creating UA policies and institutionalizing them through sustainability planning, something that results in there being a lack of confidence in the benefits of local production in terms of sustainability (Sanyé-Mengual et al., 2016).

The third aspect concerns the objectives that each of the metropolis of Rouen and the city of Rouen are willing to realize. In this point, the interviewees responses have shown that there are many objectives, including the improvement of unused wastelands and demineralization, as pointed out by many studies as Gawryszewska et al. (2019) in Manchester (England) and Elbardisy et al. (2021), in Galliera–Bologna (Italy). However, many common points have been mentioned in this aspect, where the social link aspect has been mentioned by all our interviewees. This is in line with work carried out in Australia by Kingsley et al. who mention that several social benefits are associated with UA, including well-being and improved health, and Kirby et al. who drew this same conclusion from an analysis carried out in numerous European cities (Kingsley et al., 2019; Kirby et al., 2021). The second most mentioned aspect is food self-production and the consumption of fresh food and vegetables, which was also mentioned in 2023 by Boukharta et al. who indicate that this production is healthier and more nutritious and that when people produce their own products, they learn better and eat better.

Many criteria exist for selecting one UAP or another, depending on the entity and the objectives sought. Our analysis has shown that the Rouen metropolitan authority and the city of Rouen have many objectives in common. However, the selection criteria differ between them. The Rouen metropolitan authority confirms that it encourages the implementation of these projects and that it tries to make the criteria less strict in order to encourage people and associations to become more involved. In other words, if there aren't too many, they'll select them all. If there are too many, they'll select on the basis of, for example, the number of events that will be organized, the number of people involved and who will take part, with the emphasis on protecting drinking water catchments. In fact, many studies are in line with this aspect, since, according to the 2006 study by Mubvami et al. in Philippines, local authorities are now seeking to ensure a consensus-building process to address food production issues and develop a vision for the city's development. On the other hand, the city of Rouen has more limitations than the metropolis, since it has to verify with urban planners and architects that the area proposed for the UAP has no construction projects, to ensure that the project will last for many years (or always). Indeed, there is the political issue that the city must confirm with local by-laws and policies, in order to follow the rules and do things properly, along with a soil analysis that may be necessary before accepting a UAP, especially if the space was industrial, or a pollution analysis since these projects are located in cities. Secondly, some of the interviewees mentioned that the area must be a minimum of 10m^2, otherwise it will not be accepted for an UAP. The above criteria were also addressed by Fricano & Davis, 2020, through a study conducted in Southern United States, highlighting the need to involve urban planners in the regulation and monitoring of UA areas, as they contribute to the implementation of UA policies and programs and advise local decision-makers.

The city of Rouen and the Rouen metropolitan area both maintain regular contact with stakeholders and project developers but differ in their implementation processes. The metropolis of Rouen emphasizes a structured approach with a preparatory phase where representatives

engage with the community, individualized support from service providers tailored to each project's specifics, and ongoing feedback and analysis, culminating in a review after the first year. In contrast, the city of Rouen follows a three-stage process: initial consultation meetings to define the project, a formalization event with elected representatives to declare city support and engage the community, and a formal handover of the land to the association with an official signing ceremony. Both approaches ensure stakeholder involvement but vary in their methods of project support and formalization. This is affirmed and cited by Masuda et al., 2022, underlining that effective collaboration between the various stakeholders is essential to achieving the goals of sustainable development and, consequently, good progress in urban practice and more resilient cities, through an analysis made in several cities in Japan.

Last but not least, interviews with stakeholders from the Metropolis of Rouen and the City of Rouen highlighted numerous benefits and obstacles associated with UAP. Key benefits include reconnecting with nature, which helps residents appreciate the seasons, climate, and biodiversity while experiencing the satisfaction of growing and consuming their own food, aligning with recent studies such as those by Russo et al. (2017) and Specht et al. (2014). These projects also enhance social interactions and community engagement, significantly impacting physical and mental well-being, as supported in Soga et al., 2017 However, it is important to recognize that the involvement of UAP can also present limitations. Indeed, results have shown that the implementation and effectiveness of such projects can vary considerably depending on local conditions, including available suitable land, soil quality, etc., along with the availability of economic resources, notably financial support from local authorities and the continued follow-up. In addition, it should be noted that effective government management is essential to ensure the sustainability of these initiatives, and where this is a key factor, the human aspect and commitment represent a major challenge today. Indeed, similar findings were mentioned in Orsini et al., 2013 who highlighted that the implementation of UAP faces challenges such as low-quality land requiring rehabilitation and the creation of a network of competent associations. Finally, although urban agriculture has its advantages and many positive aspects, it cannot today guarantee long-term viability and food sufficiency, which can be a limitation and a challenge to achieve at the same time, and similar conclusions have been made by many scientists, such as Edmondson et al. (2020) and Opitz et al. (2016), who have stressed the importance of ensuring the long-term viability of projects and helping to ensure food self-sufficiency.

6. Conclusion

UA is increasingly recognized for its multiple benefits around the world (Calvet-Mir & March, 2019). Indeed, this is an increasingly relevant topic in the science and planning of urban food systems aimed at ensuring household self-sufficiency and food sufficiency, protecting the environment, creating social links, reconnecting people with nature, etc. (Boukharta et al., 2024; Diekmann et al., 2020; Smith et al., 2013). The study hypothesized that the Metropolis of Rouen and the City of Rouen complement each other effectively in promoting UA, while ensuring synergy and operational efficiency in their governance. The findings of this analysis confirmed that the two entities share common objectives aligned on the economic, environmental and social aspects of sustainable development, and that they work together to support young associations and residents in the development of their projects.

The interviews revealed that while both levels of governance maintain regular stakeholder engagement, they differ in their implementation processes and project selection criteria. However, this diversified but structured approach ensures that UAP are fully supported and formalized and adapted to their needs and specific requirements. The city of Rouen focuses on smaller-scale projects that strengthen social cohesion, respect the environment and improve quality of life. However, it can face challenges such as the need for human resources and pollution. On the other hand, the Rouen Metropolitan Area supports larger

and more diversified initiatives, but has to deal with issues such as the quality of land and the creation of a network of competent associations. Moreover, both organizations stressed the importance of ensuring the long-term viability of UAP, which requires ongoing support and collaboration to overcome obstacles and maximize the benefits of UA. However, regardless of the actual significance of UA, various potentially transferable results on governance could be achieved, underlining its essential role in promoting sustainable and resilient urban communities.

It should be underlined that this study presents some limitations. First, the Rouen metropolis contains about 9 main cities and the results specific to Rouen, although it is the main city and seat of the metropolis, may not be directly applicable to others with different contexts, and therefore, future research could focus on the evaluation and study of another city, which would allow a comparison of the evolution of UAP across several cities in the metropolis. Second, although the aim has been to focus on local authorities, it would be very interesting to have a full understanding from residents and associations of the impact of UAP in their lives. These limitations should be taken into consideration and may guide future research to improve the understanding and implementation of UAP.

Many recommendations can be drawn from this analysis, both for the metropolis and the city of Rouen. Indeed, they should be in closer contact with urban planners and architects, to define the area where the urban practice will be carried out and to ensure that it will not be used in any future type of construction or building. Furthermore, they should provide ongoing support for the initiatives, striving to meet their needs and support their ambitions for future achievements. Finally, both entities should launch an ongoing call for projects around this type of initiative, to raise awareness among citizens of the role it plays for them and for future generations.

This research study provides a highly relevant response to a current and future challenge, focusing on the complementarity between the levels of governance of the Metropole of Rouen and the City of Rouen in the promotion of UA. This investigation is one of the first evaluations in this specific field, highlighting the issues of sustainability, community support and urban green development associated with UA. Given the growing importance of these UAP in guaranteeing food self-autonomy and sufficiency, improving quality of life, strengthening the resilience of urban communities and recreating the contact with nature, this subject deserves particular and ongoing attention from decision-makers, researchers and local stakeholders. Overall, this study is recommended as a basis for future research aimed at maximizing the implementation of the UAP, in order to maximize the benefits of UAP while overcoming the identified barriers, for a more sustainable future and resilient cities.

CRediT authorship contribution statement

Ouiam Fatiha Boukharta: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Loïc Sauvée:** Writing – review & editing, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Fabiana Pena-Fabri:** Writing – review & editing, Visualization, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Leticia Chico-Santamarta:** Writing – review & editing, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Luis Manuel Navas-Gracia:** Writing – review & editing, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no competing interests.

Data availability

Data will be made available on request.

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Article

Reality vs. Expectations in the Implementation of Urban Agricultural Projects—A Polycentric Governance Analysis

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Abstract: Population growth and urbanization are threatening food security. Urban agriculture is therefore a solution for urban food production and distribution. This paper investigates a multi-level governance framework to evaluate how local authorities implement their prescriptions at different levels of decision-making and objectives for urban agricultural projects and their role in building urban resilience. A qualitative assessment based on interviews and fieldwork over two periods in 2023 and 2024 was conducted with stakeholders from different entities in the Normandy Region of France, including the metropolis, the city, and two projects' presidents. The findings revealed a positive alignment on polycentric governance between different entities in terms of socio-economic integration, climate improvement, and nutritional diversity, all of which were achieved by the cases evaluated. Additionally, local authorities are seeking to achieve urban food self-sufficiency in order to reduce the scale of food imports, thus highlighting a limitation and challenging aspect of this study, given that urban areas are compromised by population density, limited space capacity, and the impermanence of projects. This investigation clearly shows that using this combined systematic approach of interviews and fieldwork provides an in-depth understanding of authorities' needs and assesses the existence of polycentric governance compliance across multiple units.

Keywords: urban agriculture; food security; city resilience; multi-level analysis; polycentric governance; qualitative research; case studies; France

1. Introduction

The first and foremost human need after air and water is food, and currently, agricultural production is at risk due to population growth and the scarcity of water resources worldwide [1]. Indeed, food is fundamental to human well-being and development, and sustainability is achieved when people have access at all times to the food they need for a normal, healthy life [2]. Food security is thus determined by food stability, availability, and access, and is linked to livelihood security [3]. The main drivers of current food insecurity are global weather variability, urbanization, and population growth, along with various other factors responsible for changing food consumption patterns [4].

As a result, today's world is a combination of tradition, modernity, and agriculture [5], and where urban agriculture (UA) is currently able to occur wherever humans can cultivate grains, even in the smallest part of the soil [6,7], thereby providing interactions and adaptation to an urban ecosystem [8]. As a matter of fact, besides producing food from these urban spaces, green and sustainable cities enable cleaner air, water, and streets, empowering their environmental, social, and economic outcomes [9,10]. For those reasons, UA is a way to support sustainable development goals, where it includes environmental

protection, ensuring health and nutrition, decreasing poverty, along with societal economic development [11], and where the purpose of this article is to examine these aspects through real cases of UA, considering the polycentric governance (PG) dimension, which is crucial for the proper development of these organizations.

PG is an approach in which a variety of stakeholders come together to formulate regulations adapted to local contexts. With this approach, stakeholders can freely participate in different decision-making, policy formulation, and rule enforcement spheres according to their needs and concerns [12]. To do so, both metaphorical pillars and institutional design parameters are used to show how they can be mutually combined to achieve desired goals and manage spillovers. Within the context of UA, PG is seen as the interaction between multiple stakeholders (farmers, local authorities, non-profit organizations, etc.) within various institutional settings and rules aimed at ensuring that, under different conditions, everyone benefiting from a given commons pays their fair share and decides on that commons.

In other words, when thinking about polycentricity, it should be considered how autonomous actors can, nevertheless, interact formally and informally with each other through cooperation to ensure polycentric order or equilibrium within the system [13]. Such interconnection is highly pertinent in the UA context, as decision-making mechanisms are closely linked at different levels of the urban community, encompassing local projects, district councils, and city administrative structures [14]. This interconnection requires a polycentric approach to effectively coordinate and support the various urban activities and their benefits throughout the city and its inhabitants, in line with aspects of sustainable development, to which the present investigation is contributing.

This paper is structured according to the following chronology: Section 2 describes the various concepts used in this investigation and their application for a better understanding, while Section 3 presents the methodology employed, along with the main inclusion and exclusion criteria allowed to better trace our interviews with the different actors at the various institutional and regulatory levels. Section 4 presents the results of this analysis, highlighting PG and its effects on the involvement and realization of these urban practices, presenting the various similarities, diversities, and obstacles present, as well as evaluating two real-life cases for a more comprehensive assessment. Finally, Section 5 places these results in a clearer perspective, enabling conclusions to be drawn in Section 6, in which an overview of the current situation is presented, along with some recommendations that should be followed for better implementation of the practices.

2. Conceptual Framework and Application

2.1. Urban Agriculture (UA)

UA is defined as any type of agro-industrial activity located in or around the city, intended to provide products and ecosystem services to residents [15], including social, environmental, and economic impacts [6,16]. The benefits include physical and mental health improvement, alleviation of social and economic problems, and community resilience [15]. The primary aim of UA is to build healthier, more sustainable, and resilient communities, and not necessarily to produce large quantities of food [17]. Currently, UA represents a small but important percentage of the food distribution system in cities, since few urban agricultural projects (UAP) aim to replace traditional food distribution, in the expectation of leading to food self-sufficiency for individuals or cities [18].

It is therefore important to recognize that UA is not the only solution to address food insecurity and improve accessibility to food, but rather a transfer of responsibility for policy-makers to expect and institutionalize urban farms to serve as subsistence or primary food environment production sites managed by and for low-income communities operating without external support [19], making it imperative that these projects should be well led and managed by local decision-makers and authorities [20].

Expanding UA in densely populated environments requires complex coordination between different stakeholders, such as local authorities, developers, residents, and private actors [21]. Moreover, UAP encounter significant challenges in terms of governance,

particularly due to the polycentric structure of the decision-making process [22]. In this sense, it is also necessary to underline the importance of collaborative and participatory governance mechanisms, which, in the absence of effective coordination, struggle to ensure strategic coherence between the multiple stakeholders [23].

2.2. Polycentric Governance (PG)

PG can be defined as a self-organizing governance system composed of mutual adjustment and multiple governing actors, decision-making centers, and political issues, along with the relationships between them to better synthesize the concept [24,25]. Indeed, polycentric systems have been conceived as consisting of numerous centers of authority interacting internally and across scales for a shared governance purpose, where they facilitate equal representation of different governance actors, encourage policy innovation and diffusion, and support flexibility through the rapid reconfiguration of policy networks in order to achieve specific goals [12,24], which is clearly explained through Figure 1. PG is therefore a vehicle for specialization, distribution of work between the central, regional, and local levels; subsidiarity; and adaptation of interventions to local–regional circumstances and community preferences, improving effectiveness in the context and scale of the specific challenge [26], which is the focus of this research in order to evaluate this departmental distribution of work between the various local and regional entities.
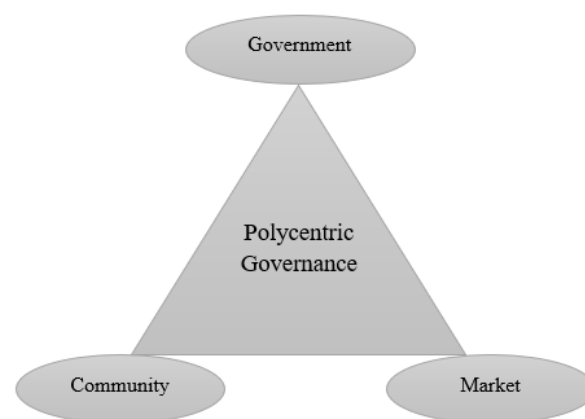
Figure 1. PG on the central Government-Market-Community axis.

PG can be decomposed into different elements, particularly governance actors, decision-making venues, policy issues, etc. [27]. Governance actors include individuals who influence decision-making processes and who have an interest in one or more policy issues or who are affected by decisions taken, with the aim of addressing coordination and conflict for multiple purposes [28] (Figure 1). Actors can include government agencies and civil servants, user groups, scientists and consultants, individuals from the general public, etc. In relation to the decision-making venue, this is a space of collective action with the power to design and adopt public policies and implement them, and where actors engage with each other, which enables actions to be initiated to make a joint decision [29]. In terms of the political issue, these are the topical policy areas or issues they address, and where issues can be both general and specific and vary in terms of importance and complexity. Considering these types of relationships, polycentric systems present multiple links through various actors who affect other places through their political decisions in the form of institutional rules and political decisions [26].

Regarding the PG model, according to Frimpong Boamah (2024) and the purpose of this paper, it enables a more integrative and adaptive management of urban resources [12], thus empowering diverse stakeholders to participate in the policy-making process that is crucial for UA and the socio-political dynamics that influence social patterns of urban food distribution and access. These interconnections within polycentric systems are therefore essential to fostering resilience and equity in sustainable food systems.

2.3. Scope of This Research Article

The aim of this study is to critically evaluate the alignment between metropolitan and urban policy frameworks and the practical implementation of UA initiatives. Indeed, it investigates the implementation and involvement of various UAP in France, more specifically in the metropolis of Rouen and its central city, applying a PG framework and an experimental field approach and focusing on their contribution to building urban resilience. It also considers the way in which these initiatives align with sustainable development goals and the transition to green cities, along with the impact of governance structures on their integration, coordination, and effectiveness within the framework of urban policies. These elements will be reinforced by the presentation of concrete UAP and their evolution over time between 2023 and 2024.

Such an analysis seeks to identify how multiple decision-making centers, such as local authorities, project leaders, and local community groups, can operate independently while simultaneously interacting together at different scales (local, regional, and global). These centers of authority work together to achieve shared governance, i.e., the collaborative management of decision-making and resources through cooperative action and mutual accountability, rather than relying on a single governing body.

3. Materials and Methods

The methodology followed in this paper consists of conducting semi-structured interviews with different actors, along with fieldwork analysis. Indeed, applying this approach makes it possible to control and monitor changes over time and to gain an overall understanding of the process [30].

3.1. Methods and Data Collection

Data were collected through semi-structured interviews, a qualitative method widely used to explore participants' perceptions and experiences at a deeper level, using an interview guide prepared by our research team, providing a clear, structured framework while allowing the order of questions to be adjusted so that the interviewer feels comfortable and flexible as the interview progresses [31], all selected using a purposive sampling approach [32,33]. In fact, this methodology enables an in-depth analysis to be provided at different scales and from several angles, including detailed qualitative information on interviewees' perspectives [34]. Moreover, systematic thematic analysis was used to pinpoint and interpret significant patterns in qualitative field interview data [35], enabling new and emerging concepts to be identified and developed, with rigorous double coding and in-depth analysis.

The interviews were conducted with 28 stakeholders, where *n* = 15 from the metropolis, *n* = 10 from the city, and *n* = 3 for project leaders. A multimodal approach was therefore used, consisting of face-to-face interviews and, in the case of non-compliance, telephone calls and/or online meetings, in order to adapt to participants' schedules and availability [36]. Such an approach ensured broad coverage of perspectives while respecting logistical constraints and stakeholder preferences [37]. Each interview was recorded with the participants' informed consent, in accordance with the principles of research ethics [38]. All interviews were transcribed in their entirety to guarantee the most accurate data analysis and processing possible. Fieldwork experimentation has also been performed in order to evaluate in a concrete way the UAP and to examine the evolution over time [39].

The experiment consisted of two phases, covering periods from 2023 to 2024, in which each phase tested the progress made over time and/or the performance/success of the projects, providing a more comprehensive perspective on project dynamics, encompassing more than concrete progress, challenges and strengths, and even the sustainability of initiatives [31].

3.2. Actors Involved

The aim of in-depth interviews is to include a variety of perspectives and expertise, thus fostering a comprehensive assessment of institutional aspirations and actual expe-

riences in the field [40]. This analysis covered several assessment dimensions, including the metropolis, the city, and real-life UA practices, all selected using a purposive sampling approach and a PG analysis to ensure relevance and diversity of perspectives, resulting in a multi-level governance (MLG) assessment [32,33], as illustrated in Figure 2.
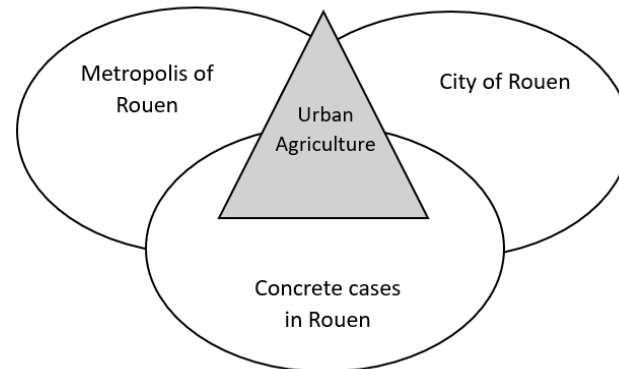

Figure 2. MLG analysis of UAP.

The MLG strategy provides generated, rich, narrative qualitative data, which are necessary for nuanced insight into systemic relations and social interaction, and where the outcomes are a very useful empirical basis for strategic recommendations and reinforcement of future urban planning [41]. Moreover, this methodology of MLG combined with a PG analysis is important in drawing attention to disparities and similarities between public policy and existing operational practices, which can enhance the ability to chart an effective pathway to plan urban transformation for sustainability [42,43].

Interviewees and Their Positions

Several actors occupying different positions were involved in this investigation in order to guarantee a PG approach and an MLG analysis of the context studied, as shown in Figure 3:

Figure 3. Key actors, their roles, primary functions, and presidents of urban practices in the metropolis and City of Rouen.

A total of 28 semi-structured interviews were conducted with local authority representatives, UAP managers, community leaders, and experts in urban planning and sustainable development (Figure 3). These interviews provide a better assessment of the coverage of the three entities towards the same objectives or whether there is divergence or non-complementarity. This analysis consist of evaluating the MLG perspective approach together with the PG framework in order to make it possible to understand the current situation of UAP through the expectations and real-life cases of UAP while anticipating and monitoring future evolution and changes.

3.3. Study Area

This investigation has been carried out in the Region of Normandy (Rouen metropolis and Rouen city), located in northern part of France.

3.3.1. Normandy Region

The French region of Normandy is widely known for its potential for agricultural production [44], partly unexplored in other studies, and for the ongoing urban support of local authorities from the different PG levels, including the metropolis, the city, associations, etc. The following Table 1 shows the main economic variables of this region, including population, agricultural area, gross domestic product (GDP), agricultural value added, etc.

Table 1. Key economic variables of the Normandy Region of France.

Economic Variable	Value	Reference
Population	3.3 million inhabitants	[44]
Area	29,906 Km^2	[45]
Agricultural area	22,000 Km^2	[46]
GDP	EUR 95 billion in 2018	[44]

Table 1 clearly shows that Normandy's agriculture covers 70% of its territory, making it a major component of the region's economic system. It is also, through its practices and diversity, an activity that shapes the Normandy landscape [46]. The local economy in Normandy is very strong, particularly in the agricultural and agri-food sectors, but still relatively modest compared with the rest of France, especially the Ile-de-France region [44]. However, to better assess UA practices in this area, it is necessary to apply a PG analysis across multiple actors and at different scales, assessing what is requested by local authorities and what is actually performed and applied in real UAP cases in the city.

3.3.2. Metropolis of Rouen (MR)

The MR Normandy is an intercommunal group of 71 communes that includes the CR [47] and covers most public transport (especially in Rouen) as well as managing waste, etc. The metropolis is a pivot point in the sustainable development of the region, where optimization is oriented towards quality of life [48], promoting innovative ideas like urban farms and community gardens that increase biodiversity along with recreational and educational opportunities for citizens [23].

3.3.3. City of Rouen (CR)

The CR is situated on the banks of the Seine River in France and is the historic capital of the Normandy Region [49]. The city is famous for its extensive cultural and historical heritage, featuring a number of emblematic monuments. Regarding UA, the CR is engaged in promoting initiatives to integrate green spaces and UAP, where community and allotment gardens are established to promote local and sustainable food production while strengthening social links and promoting environmental awareness [23].

3.4. Urban Agricultural Cases Evaluated

«Le champ des possibles» (CP)

A non-profit association located in two sites, one within the CR, the other in Sotteville city in the MR, and which is engaged in the development of UA and the ecological rehabilitation of derelict spaces in urban areas. Its main objective is to transform urban wastelands into areas dedicated to biodiversity and local agriculture and to ensure access to healthy food [23]. Moreover, awareness-raising, animation, and training activities around food, fostering a collective and participatory approach on the part of local residents, make this association a key reference for all other UAPs in the region. Such actions help to reconnect inhabitants with nature and encourage ecological practices in an urban framework [50]. To maximize the impact of its actions, the association collaborates with public institutions, schools, etc., and is supported by CR and the MR with the aim of enriching urban spaces with food production while strengthening social cohesion [51].

«Le jardin de l'Astéroïde» (JA)

Allotments which operates on a non-profit associative model and whose main objective is to promote agroecological practices in an urban environment while enabling residents to grow their own fruit and vegetables and participate in garden activities [26]. Prior to its creation, this site was used as an unauthorized parking lot. Its transformation into an allotment not only improved the value of the area but also contributed to environmental protection and the enhancement of biodiversity [52]. The garden is made up of small plots of 20 square meters and two large plots of 40 m^2, where each member has their own plot and is obliged to maintain and cultivate it properly while not being allowed to use chemicals or make any kind of sale [26]. The project is supported by the CR and works with other local associations to strengthen UA initiatives. This partnership makes it possible to create quality green spaces that meet the challenges of urban reappropriation while integrating an educational and green community dimension [53].

4. Results

Interviews and fieldwork enabled us to gather all the information needed to answer our problem, which is to study the interest of an MLG framework to assess the actual implementation of local authorities' mandates at different levels of decision-making devices, along with an assessment of the objectives of UA schemes and their role in strengthening urban resilience.

4.1. Stakeholders' Objectives

The interviews revealed a number of strategic objectives that encourage the development and promotion of urban areas. Figure 4 illustrates the main objectives that the metropolis, the city, and the two UA cases aim to achieve while ensuring compliance with the PG approach, emphasizing empowerment and decentralized decision-making.

From Figure 4 above, the MR asserted that the creation of these spaces is aligned with the French law on zero net artificialization. The effort hopes to reduce the future environmental impact and foster the re-naturalization of regions affected by urbanization at a rate of 66%. Furthermore, it is worth mentioning that this approach represents a concern in today's progress of the MR, signaling commitment to locally ecological sustainability, raising urban air quality and life conditions, and fostering food self-sufficiency/autonomy, which has been mentioned by all metropolitan respondents.

Regarding the CR, employability was highly mentioned by the stakeholders interviewed, with a rate of 66%, as it enables individuals to be inserted and/or reintegrated into the job market, thus emphasizing the human aspect and the social link. Furthermore, guaranteeing the social link remains a central objective that was mentioned by all our interviewees (rate of 100%), underlining the desire to integrate the notions of neighborhood and intergenerational interactions (Figure 4). Interveners from the CR also emphasize at 100% that one of their main objectives is to improve certain plots of previously unused fallow

land by giving them a cultivated character, thus promoting environmental sustainability and food self-sufficiency.

Figure 4. Main objectives that each of the metropolis, city, and UA cases in Rouen are aiming to achieve. The symbol * refers to the citation's intensity, where: * least cited; **: moderately cited, and ***: highly cited.

Last but not least, the presidents from the two real-life cases of UA evaluated stressed at a rate of 100% the importance of converting vacant lots into shared gardens to prevent them being used as parking lots or for other purposes by residents. This initiative aims to optimize the use of urban spaces while promoting the learning of the skills needed to maintain and cultivate the plots, thus guaranteeing participants' food self-sufficiency. In addition, they have expressed a desire to maximize the greening of the city while integrating a greater proportion of vegetation into the urban landscape. More broadly, this is a part of an integrated, beneficial approach that provides soil conservation and human wellness while building social bonds between neighbors to increase the connection and positive environment within the cities (Figure 4). However, only 33% of participants mentioned the need to have maintenance and cultivation skills developed beforehand, as for them, these skills are acquired over time.

4.2. Effect of UA on Residents

Interviews with different actors were performed to examine the effect of UA on local inhabitants. Figure 5 summarizes the main aspects cited by our interviewees, highlighting the effects of these urban spaces on residents.

Figure 5 highlights the impact of the insertion of UA practices on local residents and shows that there is considerable diversification between the entities examined, revealing both similarities and differences, all related to the three aspects of sustainability, categorized into social, economic, and environmental. Firstly, the social aspect is highlighted by all three entities with a rate of 100%, emphasizing its central role in facilitating interactions and exchanges between participants. In addition, this aspect contributes to improving the health of residents, fostering their social integration, personal development, and a reconnection with nature, which today tends to fade away in urban environments.

The second aspect is the food dimension, mentioned with a rate of 80%, where participants emphasize that gardening brings tangible satisfaction through the production and consumption of healthy, diversified food. Not only does this practice reinforce reconnection

with daily eating and food self-sufficiency, which also acts as an economic lever, helping to reduce expenses while maintaining a high-quality diet.
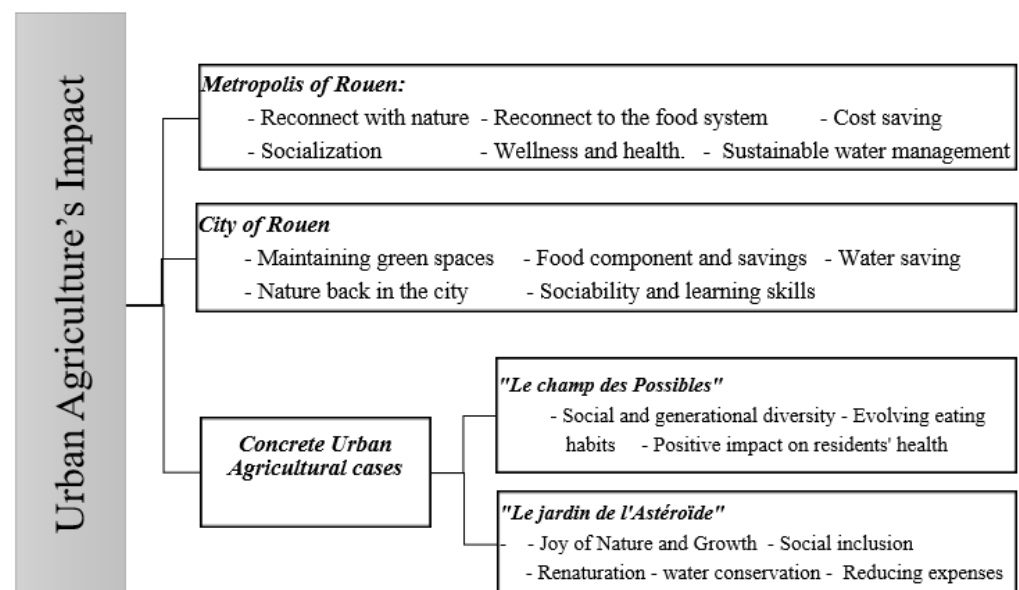

Figure 5. Impact of UA on local residents, according to the metropolis, city, and UA cases in Rouen.

Furthermore, from Figure 5, the third most frequently mentioned item relates to the preservation of biodiversity and water resources by promoting renaturation and protection of the environment, and thus, with a rate of 60%. Indeed, with the expansion of green spaces in urban areas, it is ensured that protected natural habitats are largely designed because of the additional space, and these areas act, therefore, as formidable water filters, increasing infiltration and enabling the replenishment of water tables.

4.3. Baseline Criteria (Indicators)

The creation or development of an urban area is subject to a number of requirements and indicators, prompting local authorities to choose one project over another. The local authorities evaluated share a number of common criteria, including soil analysis prior to implementation, the pursuit of food self-sufficiency, and the efficient use and preservation of water resources. In addition, other indicators have been mentioned and guaranteed by the UAP, as shown in Figure 6 below and explained below.

With regard to the common indicators mentioned by the three entities, our interviews reveal that local authorities (MR and CR) require soil analyses to be carried out beforehand, in order to guarantee two aspects. Firstly, to ensure that the land is suitable for the production of good quality fruit and vegetable crops, and secondly, to identify any missing nutrients so that they can be adequately compensated in the right way. The CP president explained that, to ensure the smooth running of the project, 40 cm of soil had to be removed and new soil had to be added, which is a measure imposed even though it had not originally been requested.

The second aspect concerns food autonomy (Figure 6), in which a key condition is that members have access to healthy, fair, and sufficient food. This aspect is indeed fundamental and must be achieved, whether partially or completely, as emphasized by the presidents of the UAP evaluated. The third common element involves sustainable use, protection, and management of water resources. In fact, the protection of catchment areas for drinking water is a crucial requirement long regulated and compelling local governments to make drastic arrangements to keep water resources healthy. These regulations are essential to meet the growing demands of urbanization and environmental constraints.
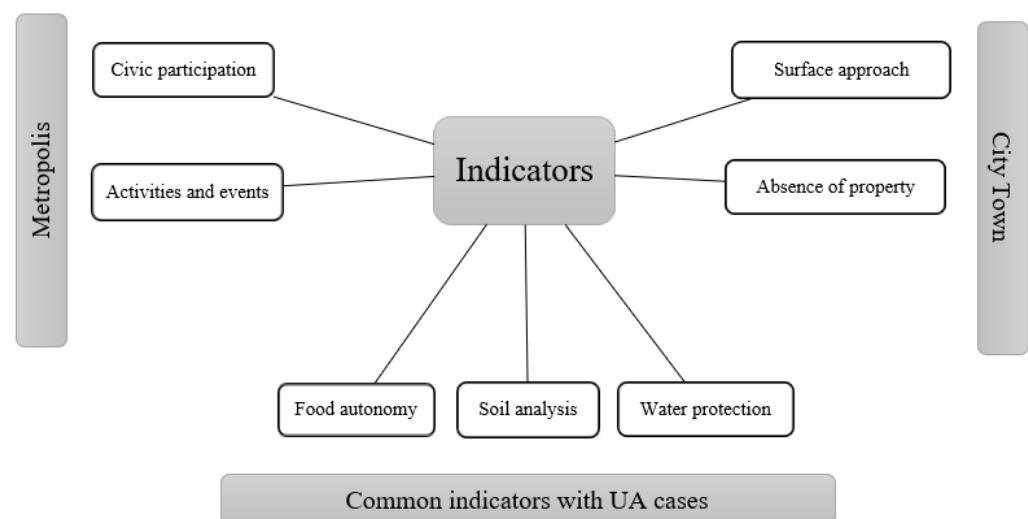
Figure 6. Criteria by entity that were mentioned by participants to ensure UAP.

Besides the three core criteria covered by the three distinct entities being evaluated, additional indicators were identified as priorities, highlighting the MLG perspective, particularly for MR and CR (Figure 6). The metropolis emphasizes the need for citizen engagement in the learning of agricultural practices and agronomic processes but also participates in various activities related to green community life that contribute to strengthening social ties. Some of the key metrics also include the number of events organized annually, annual visitors, and frequency of public access to these initiatives. On the other hand, the CR is concentrating on compliance with certain regulatory constraints, in particular maintaining a minimum surface area of 10 m^2 for UA spaces and ensuring that no real estate projects are planned on the land, in order to guarantee its long-term use.

4.4. Institutional and Collaborative Partnerships

According to our investigation, relationships between local authorities (city and metropolis) and UA project leaders, as revealed through interviews, are structured around regular exchanges and well-defined collaborations:

MR: At the outset, coordination takes place mainly with the project leaders, while the involvement of local residents takes place on the ground via public consultations. In addition, a service provider accompanies each project individually, with annual reviews to assess progress, as mentioned by a metropolitan authority stakeholder, "At the outset, our contacts are the promoters, where there is often preparation for the application... Then, there's the part where we set up individual support ... And after that, we're back in touch with them for a review at the end of the first year".

CR: Regular feedback and consultations are organized to define and adapt projects according to needs. Partnerships with associations, such as support in signing the urban gardening charter, are formalized. A Rouen city official said, "Essentially there are three steps: first phase of consultation, second phase, of formalization and third phase we let the ground to the association.

In both cases, MR and CR representatives meet regularly with UAP presidents and members to monitor the impact of their project on the local population, as well as to follow up on signed agreements, thus promoting the accountability of those managing the initiative. By sharing responsibilities and providing a flexible framework, the unified action program can be successful and sustainable over the long term.

This institutional and collaborative management mode emphasizes the respected PG process, where various decisions are taken at all levels, thus promoting local autonomy and flexibility in management. However, it is necessary to integrate and respect the global rules imposed by the various local and regional authorities through an MLG perspective.

4.5. The UAP Evolution over Time

UAP were the subject of field visits in both 2023 and 2024, following the completion of the interviews carried out to follow up on their progress and evolution. At JA and CP, a mix of causes were responsible for noteworthy differences at both plots. In the case of JA, the CR financed the installation of fencing and supported the maintenance of various infrastructures, such as the management of wetlands and the repair of deteriorated parts of the garden. Lighting has also been improved with the installation of light poles. The most important transformation concerns the change in ownership of the project's presidency between now and 2023–2024, where the president (the founder of the project, itself) has ceded his position in favor of a loyal member who has been fully committed to the project from the outset.

A part of the park was also allocated for an agroforestry pilot project, named CP, to demonstrate that growing trees within a farm can reduce water consumption. Between the two visit periods, an information panel was installed at the entrance to raise public awareness of the project's objectives. Work is currently underway to extend the infrastructure and accommodate a wider public, while it is planned to double the number of activities, particularly workshops and events. The extension of the growing area is also part of a new operation in support of isolated pregnant women, funded by the MR. Besides the salaried employees already in the organization, the project's governing bodies have added a full-time coordinator, two full-time animators in 2023, and a master-trained gardener. Furthermore, new agreements have been signed to ensure the expansion and sustainability of these initiatives.

4.6. UAP's Alignment with the Authorities' Priorities

One of the main questions of this research study is to determine the relevance of UAP in the CR and its metropolis in meeting the needs and expectations of local authorities and to evaluate the effectiveness of the links and the interaction between the three entities. The interviewees' contributions provided answers to this question, revealing a wealth of information on each of these points, as shown in Figure 7.

According to the stakeholder responses presented in Figure 7, there is effective complementarity and coordination between the positive and negative responses in terms of meeting the needs identified. The MR emphasizes the importance of public health, as well as the organization of events and awareness-raising days to inform the public of the benefits of UA. It affirms that UAP fully meet these objectives and that the metropolis is generally satisfied with the results obtained while motivating local entrepreneurs to become actively involved, believing that there is always the opportunity to learn and do better. Urban project managers agree: "We are finally starting to address the underlying factors of a healthy society and most importantly food". Together with the CR, the local authorities confirm that the social and economic aspects are also satisfied, in that participants of all generations and nationalities are well integrated into the projects. Moreover, the local production of fruit and vegetables enables residents to make some savings, even if these remain modest.

However, as far as the unmet expectations of local authorities are concerned, it is noted that the capacity of UAP to feed the whole city remains limited. As the president of CP pointed out, "UA won't be able to feed the city". Nevertheless, it is already contributing to this objective, which is seen as a positive result. However, institutional stakeholders strongly suggest that UAP should aim to achieve exceptional initiatives, such as the introduction of innovative crops, in order to attract greater public interest and thus reinforce their impact (Figure 7).

These interactions occur in the context of PG, where the local government at different levels (metropolis and city council) and civil actors (project developers) coordinate to manage UAP. This governance model strongly encourages shared, decentralized management, in which each stakeholder can respond to specific local requirements while maintaining coordination of all practices. This form of multi-centric cooperation helps to increase the

flexibility and adaptability of urban systems to address local challenges such as public health and social integration, enhancing the resilience of urban systems.
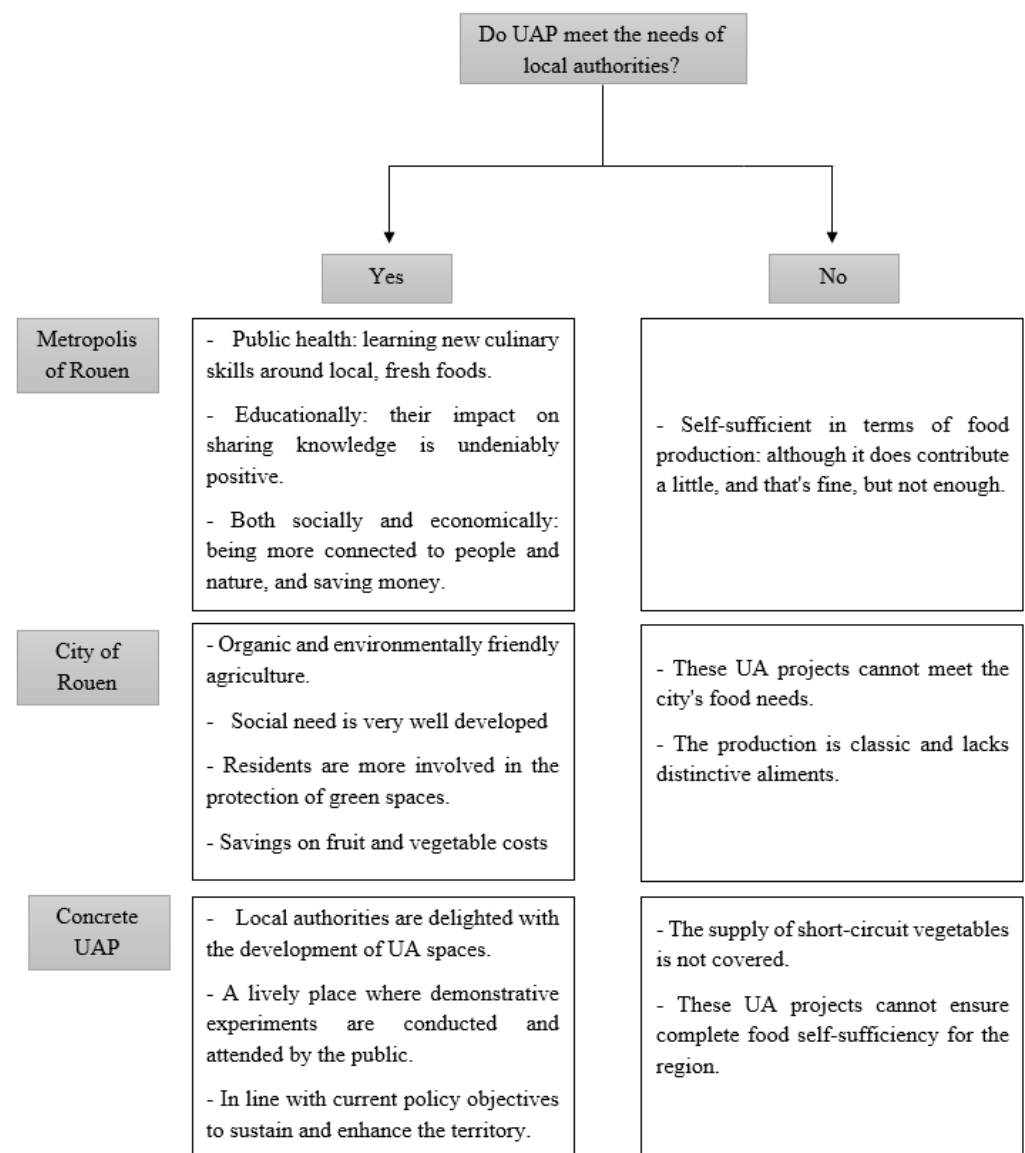

Figure 7. Evaluation of the effectiveness of the established links and the assessment of the extent of governmental interaction between the three entities.

4.7. Limitations and Potential Directions

This research revealed various limitations, focusing in particular on an aspect that is difficult to address in the short term: the city's food sufficiency and the long-term viability of UAP. Indeed, the findings from all three entities confirm that one of the main purposes of implementing such projects is to feed the city's inhabitants. However, this is a challenging objective given the region's high population and limited urban areas. As for long-term viability, local authorities have indicated that this is a major obstacle, as they are keen to contribute to the realization and implementation of the UAP but need to be sure that it will last for many years. On the presidents' side, these same limitations concern the urban areas available for the creation of such projects, since they complain that "it's difficult to find land on which to create an urban space given that today all the land is left for the construction of buildings".

Although the three entities recognize that significant improvements cannot be accomplished so quickly, they strongly believe that potential directions and future improvements can be achieved through the implementation of new forms of UA (vertical farming, rooftops, etc.) as well as through efficient water management and, in particular, through the implementation of future plans to integrate UA into city plans contributing to both sustainable food systems and city resilience.

5. Discussion

This research paper analyzes the interactions between different entities in a framework of MLG, focusing on the insertion of the urban sector within cities in order to analyze whether the expectations of local authorities are being realized by urban practitioners in the field. Conducted in the CR and its metropolitan area, this research is based on in-depth interviews with actors from each entity, including representatives of the MR, the CR, and presidents from two UAP, which yielded 28 interviews, a sufficient number to answer all our questions and solve our problematics. The methodological approach used in this article is well chosen to elicit the diversity of opinions on the various topics [30] and offers a valuable qualitative approach to the analysis of the various thematic and stakeholder contributions at different levels while also including quantitative results to make the analysis completer and more accurate.

Common features between the three entities were observed on the basis of the strategic objectives resulting from this investigation, where local entities emphasize that the creation of urban spaces ranges from the need to ensure healthy, cost-saving, and appropriate food to sharing new learning and connecting city dwellers to local environments, where this is perfectly achieved by the urban practices evaluated. These dimensions match those outlined by Menconi et al. [15] for the three pillars of sustainability: social, economic, and environmental, which are key objectives in the application of UAP. These urban projects aim not only to save money on a day-to-day basis but also to provide employment for retirees or job seekers. This finding has also been confirmed by [54,55], who reported significant potential savings after their involvement and employment in UAP.

The analysis also focuses on ensuring an integrated framework between the various entities to facilitate collective action among them. Indeed, the results obtained from the three entities underline the importance of an appropriate participatory approach through PG to facilitate fruitful partnerships and reconcile conflicting stakeholder interests by improving communication mechanisms and aligning objectives while ensuring combined efforts can have a greater influence on UA and make our cities more sustainable and healthier places to live. In the case of this research, this approach is positively affirmed by all stakeholders, since there is a reciprocity of satisfaction at different scales and levels. This perspective is also supported by Saint-Ges et al. [56], who assert that such an approach maximizes synergistic interactions between stakeholders while ensuring the resilient use of resources and infrastructure.

Apart from the common criteria mentioned above, in terms of food self-sufficiency, divergences remain, as the local authorities are keen to have independent and local cities and regions through the UAP, while urban practitioners do not and cannot meet the city's needs in terms of food supply due to the limited available area set aside for the UAP and the city's soil and pollution limitations. Moreover, our interlocutors at the MR and CR recognize these limitations but are nonetheless very satisfied with the current results that UAP is having on the residents and the city itself. However, local authorities still consider some indicators for the proper operation of the UAP, where the metropolis includes criteria relating to the number and integration of participants in projects, as well as the quantity of activities carried out per season and per year. The city, on the other hand, focuses more on setting standards for the surface area allocated to UA while imposing verification by urban planners to ensure the absence of future projects that could compromise the sustainability of UA initiatives. In this case, we need to consider the principle of subsidiarity, which means that responsibilities should be decentralized to the lowest level of governance that

can do the job and manage the task, something that was also mentioned by Marshall in 2008 [57] as a way of better understanding how responsibilities should be distributed between different levels of governance and that higher levels should not take on tasks that lower levels can manage.

The results reveal another important constraint related to the criteria imposed on UAP developers. These differences can be explained by the availability of land: at the metropolitan level, vacant spaces intended for the insertion of urban spaces are considerably more extensive than within the city. As a result, the latter must comply with strict surface area requirements and future planning regulations drawn up by urban planners and architects. These dynamics highlight the need to adapt the criteria for implementing UAP to the contextual specificities of each entity while considering space constraints and urban planning objectives. Nevertheless, UAP presidents and owners respect these requirements and would nevertheless appreciate greater flexibility.

6. Conclusions

UA is seen as a key lever for promoting sustainable and balanced nutrition in urban areas [20]. It also plays a role in social integration and well-being while generating economic and environmental benefits [26]. To achieve these objectives requires rigorous and sustainable management of PG in the implementation of these projects [20], and that is what this research article has investigated.

This investigation highlighted an essential aspect of the governance and institutional framework of UAP, particularly in the context of PG. Indeed, the results show that the MR and CR monitor the implementation of these projects and provide regular support to long-term project leaders. This support for collaborative working is underlined by the feedback from CD and JA project leaders, who express their satisfaction with working with local authorities, stating that they are "happy and satisfied to work with them". This underlines the strength of the organizational structure and the dynamic collaboration facilitated by the PG between local authorities and project leaders, providing an encouraging supportive environment for potential UAP owners to become more actively involved and committed to this field.

This research is one of the first to investigate the link between different entities in the UA field through a PG analysis and using an MLP approach, thus highlighting its original contribution. Indeed, this analysis assesses the results of three different entities separately, in order to reach a single comprehensive statement, which in this case is to analyze whether the expectations of local authorities are aligned with the reality of projects implemented in the CR, France. Future research might consider using this paper as a reference while following the same methodology of a combined approach between what is stated and mentioned by local authorities and what is actually implemented in different cities and countries, in order to have a complete picture of the actual situation and to determine in this case whether there is complementarity between the needs and main objectives of local authorities in implementing UAP and the real-life practices implemented. Furthermore, this document could be useful for planners, architects, and urban specialists to better understand, design, and shape the future dynamics of the UAP by promoting sustainable local food and resilient cities for the future, in line with the three aspects of sustainability, grouped into the economic, social, and environmental dimensions.

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Abbreviations

CR	City of Rouen
CP	«Le champ des possibles»
JA	«Le jardin de l'Astéroïde»
MLG	Multi-level governance
MR	Metropolis of Rouen
PG	Polycentric governance
UA	Urban agriculture
UAP	Urban agricultural projects

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Article

Assessing Citizens' Perceptions of Urban Agriculture and Its Contribution to Food Security—Worldwide Analysis and Specific Case Studies in Spain

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Abstract: There is growing worldwide concern about eating healthily and consuming local food. Consequently, urban agriculture has become a topical issue, especially in light of increasing demographics. The present article investigates and assesses how urban agriculture can be implemented to ensure greater food security and achieve sustainable development goals. The methodology consisted in distributing a worldwide survey, along with interviews with project managers of two urban agricultural practices in the cities of Valladolid and Segovia (Spain). The survey gathered 250 responses from nearly all continents, ensuring a diverse and global perspective and that most respondents were familiar with the concept of urban agriculture (80%) rather than food security (57.4%). The survey also revealed that 88.1% of respondents expressed their willingness to be engage in such projects. The interviews brought out a number of common points, such as ensuring that residents are properly aware about the value of integrating the food sector into cities and the benefits it provides, such as organizing activities and workshops, etc. However, promoting small organizations and start-ups linked to local production and consumption and integrating urban planning experts is crucial to ensure more resilient and sustainable cities. This research uniquely integrates quantitative survey data with in-depth qualitative case studies, linking global perceptions of urban agriculture and food security with local realities.

Keywords: urban agriculture; food security; sustainable development goals; survey; interviews; Spain

1. Introduction

Nowadays, it is extremely important to ensure sustainable urban food systems, given that urban areas are experiencing rapid population growth, intensive food commercialization and unhealthy nutritional patterns [1,2]. Indeed, the United Nations Human Settlements Programme estimates that 60% of the population will live in urban areas by 2030 [3,4], and where rapid urbanization and increasing industrial agricultural production exist, they have led to a growing disconnection between urban dwellers, their food sources and their connection with nature, distancing people from recent contact with each other [5,6]. Moreover, we live in a time of concern for people's mental health and well-being, as depression is now the leading cause of ill health and disability, with over 300 million people affected, according to the World Health Organization in 2017 [7,8]. However, there

is a growing realization that connection with nature contributes significantly to our mental health and well-being [9].

Considering this current situation, policymakers and scientific researchers, therefore, see urban agriculture (UA) as a promising pillar of food security (FS) and urban resilience [9,10]. UA has been defined by the FAO as "the cultivation of plants and the raising of animals for food and other uses in and around cities, along with related activities such as production and delivery of inputs, processing and marketing of products" [11,12]. Based on this definition, we clearly understand that UA is the cultivation, processing and distribution of food products by growing plants in and around cities serving to feed local inhabitants [13–15]. It is also characterized by the systematic and extensive occupation of unused land in urban areas, with the establishment of individual, community or collective gardens and allotments [11,16].

The success of UA has been widely recognized for its benefits, which are aligned with aspects of sustainable development [5]. The social aspect includes social inclusion and integration, along with raising awareness; the environmental aspect relates to environmental protection, biodiversity preservation and climate regulation; and the economic aspect is linked to cost savings and healthy produce at a lower price [17,18]. Moreover, the successful implementation of UA is strongly linked to its positive perception by the public for those who live within urban areas and for the wider community in general [19]. UA contributes to several Sustainable Development Goals (SDGs), notably FS and improved nutrition (SDG 2), the promotion of sustainable and resilient cities (SDG 11) and the preservation of terrestrial ecosystems (SDG 15) [20,21]. Additionally, it also promotes sustainable consumption and, to a greater extent, production patterns (SDG 12), and it can strengthen social inclusion and equitable access to food resources (SDG 10) [22,23].

This research aims to achieve two objectives which, combined, are perfectly complementary and lead us to a main and comprehensive result. Firstly, a quantitative survey to provide an overview of perceptions of the role of urban agriculture in food security; secondly, an analysis of two qualitative case studies has been conducted in Spain to deepen this understanding by exploring in a more concrete and real way how urban agriculture is practiced and experienced at a local level. By combining these two approaches, the research allows us to capture global trends in perceptions of urban agriculture while grounding them in the lived experiences of project leaders in two Spanish cities, thus linking general attitudes to specific urban governance and implementation dynamics. Moreover, despite the growing number of research studies on urban agriculture and food security, a comprehensive understanding integrating both large-scale perceptions and site-specific case studies remains limited, and this is precisely where the present research makes a significant contribution, by providing a more qualified and comprehensive perspective on the role of urban agriculture in achieving sustainable food security.

This research paper is structured as follows: Section 2 presents the methodology used to carry out this study, including the implementation and distribution of the survey, as well as the approach taken in the interviews. Section 3 presents the results obtained from the two research sections, outlining the findings with diagrams and tables to make them more comprehensible, leading on to the Section 4, which is based on an evaluation of the results, drawing contrasts with the work of other researchers, followed by a series of conclusions and findings, together with recommendations for future studies.

2. Materials and Methods

The purpose of this investigation is to gain a precise understanding of the population's perception of UA, while establishing direct contact with project leaders to gain a more detailed insight into how such initiatives operate, the obstacles they face and their main

challenges. To address our research problematics, a mixed-methods approach was adopted, involving different research methodologies, including a questionnaire survey and semi-structured interviews. The combination of these approaches enabled us to obtain a precise and in-depth understanding of the actual situation, featuring a comprehensive qualitative and quantitative analysis [24].

2.1. Theoretical Framework

This investigation has involved the integration of several theories that are essential for the proper performance of this research and for a complete and accurate assessment of our problematics. The survey comprised a series of questions that helped to better identify the population being evaluated, which allowed us to base our answers around this target population. Moreover, the development of the questions in relation to the adoption and influencing factors were underpinned by the Theory of Planned Behavior [25] and the COM-B model [26]. Regarding the interviews, the theory used was that of social practices [27]. It offered a very precise approach to understanding the behavior of individuals in the face of our problem, by examining the words of our participants. This theory allowed to better explore and evaluate the results through the responses collected, by assessing the participants' engagement in specific practices, their applications in their daily lives and how changes in materials, skills and meanings can influence their behavior. Analysis using Social Practice Theory shows how changes in practices can contribute to lasting changes in behavior and attitudes.

Besides the above-mentioned theories, a complementary analysis of the interview and survey data allowed us to provide an understanding of the psychological factors that influence individuals' behavior and attitudes in different contexts, as well as their decision-making in terms of actions, which will be further elaborated on and discussed in the following subsections [25,28].

2.2. Sampling Frame and Sampling Technique

The sample frame targeted individuals with direct or indirect involvement in UA, encompassing practitioners, researchers, policymakers and community members. Given the exploratory nature of the study, the selection process sought to capture a broad and diverse range of perspectives, ensuring the inclusion of both experienced and novice participants. This approach allows for a better understanding of the dynamics of the different contexts [29].

A random sampling method was used to maximize respondent diversity and avoid selection bias [30,31]. Although no strict stratification was applied, efforts were made to encourage responses from diverse demographic and professional groups to improve the robustness of the results. The survey was disseminated worldwide via our institutional and professional networks and our international research team, as well as our collaborators in several projects, enabling broad geographic and demographic coverage and diverse participation across all continents, offering a global visualization and perception of the worldwide perspective of urban agriculture and food security, not only at local and national levels, but also on an international scale. In addition, this approach involved voluntary participation while ensuring the representation of the various UA communities.

2.3. Data Collection and Administration

The survey was distributed between May and June 2022 in an online manner and at the national and international level, through our networks, via e-mail, colleagues and projects, etc., and its establishment was performed through the Google Form platform, for its efficiency, simplicity and feasibility. It should be emphasized that, given the purpose of this survey, no reliability analysis was applied, since such tests were not necessary and the

questions were essentially descriptive and aimed at capturing perceptions, experiences and practices, rather than measuring hidden concepts or performing parametric analyses. The interviews, on the other hand, were conducted during the same period, focusing on two urban agricultural initiatives located in Spain, namely "Alimenta Conciencia" in the city of Segovia" and "Estrategia Alimentaria de Valladolid".

The questionnaire was completed in full anonymity, with respondents' consent and acceptance of the general rules prior to the start of the survey, regarding the use of data in this investigation. The interviews with the project leaders of both initiatives were recorded with their consent vocally (in Spanish), transcribed and professionally translated into English for in-depth interpretation of the results. These transcriptions were subsequently coded using NVivo 14 Software, which enabled to better structure the results, and thus obtain all the information needed for interpretation.

2.4. Content of the Questionnaire and Interviews

Different variables were defined and targeted to better understand the content of these questionnaires and interviews. Indeed, this theory, employed by Ajzen in 1991 [25], provides an in-depth understanding of human behavior, since it identifies three interdependent and identifiable dimensions: ability, opportunity and motivation, which are considered essential for the behavior to occur [26]. Ability refers to the skills and knowledge required by the individual; opportunity encompasses the environment and external conditions that enable the individuals to better identify themselves, while motivation includes intrinsic and extrinsic motivations. Consequently, this analysis provides a comprehensive basis for analyzing the behavior of the individuals concerned. Table 1 provides a more detailed explanation of each of these variables and presents some of the questions that were asked, both in the questionnaires and in the interviews:

Table 1. Main questions employed in the survey and throughout the interview.

Variable Name	Question Used in Survey	Question Used in Interview
Behavior (intention)	Would you support UA in your city?	Does your project aim to achieve objectives that are useful to residents and the city?
Behavior (Actual)	Have you ever been involved in some UA initiatives?	What is the current situation of your project? How is it going?
Attitudes	What do we mean by UA and FS?	What are the activities you are implementing in your UAP?
Subjective Norm	To what extent are the themes of UA and FS linked?	What should be the objectives of these urban agriculture projects to meet the needs of the inhabitants and their communities?
Project	Do you think your city needs the implementation of such initiatives?	What do you think makes this initiative successful?
Capability	Would you be interested in participating in such projects?	How do you try to promote your idea in your city? What method was the most effective?
Other motivation?	Would you like to tell us more about your thoughts/ideas on this subject?	What was your motivation for working on this project?

Table 1 provides a very clear explanation of the different variables highlighted in this research, as well as presenting the questions that were asked to our interviewees and survey respondents. We can clearly see that this is a very good method of bringing the two approaches together, ensuring that they are both brought coherently into one overall framework.

Besides the above series of questions, other aspects were addressed, such as the definition of "urban agriculture," "food security" and other aspects related to their integration with the SDGs, all through their own understanding, via a series of proposed answers.

Indeed, on the basis of their answers, we can better frame the population being assessed, better understand how they assimilate this knowledge and, therefore, better draw appropriate conclusions for our investigation. Furthermore, based on these responses, it would be more accurate to assess the current state of knowledge regarding the integration of the food sector in cities through UA, and thus, in the case of negative responses or lack of interest on the part of stakeholders, to determine what needs to be enacted to address this situation.

3. Results

The results obtained from the questionnaires and interviews are presented and explained in the following subsections, illustrated with tables and figures to make their understanding and interpretation more effective and straightforward.

3.1. Results from the Survey

As previously mentioned in the methodology, the survey was distributed using a random sampling method to ensure a representative sample. This multi-faceted distribution approach allowed us to reach a wide range of potential respondents from different professional backgrounds and geographical locations, with a total of 250 respondents from all over the world. This diversity ensures the robustness and generalizability of our results, as it encompasses the perspectives of individuals from different cultural, social and economic backgrounds.

3.1.1. Characteristic of the Respondents

Identifying the characteristics of the respondents was the first step in designing the median profile studied in this study. Indeed, Figure 1 clearly and easily presents all the details required about our respondents.
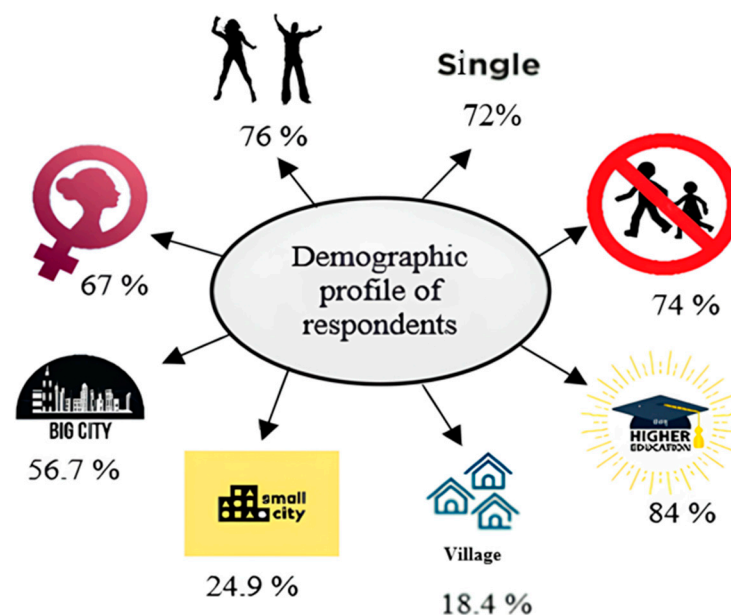

Figure 1. Characteristics of the survey respondents.

From Figure 1, it can be seen that the number of female respondents far exceeds the number of male respondents, with 67% female responses. Moreover, 72% of our respondents are single and in the 18–35 age range, and the majority have no children. In terms of place of residence, most of our respondents live in cities and only 18% live in villages. According to Figure 1, the demographic profile of the respondent appears to be

that of a young, single woman without children, with a higher level of education and who lives in the city.

3.1.2. Geographic Distribution of the Respondents

Regarding the residence of our respondents, it should be noted that the survey was conducted on a global scale, bringing together participants from a variety of geographical regions. Figure 2, therefore, presents the geographical distribution of respondents to illustrate the geographic diversity of the sample and to support the global character of the study, rather than to perform a specific comparative country analysis.
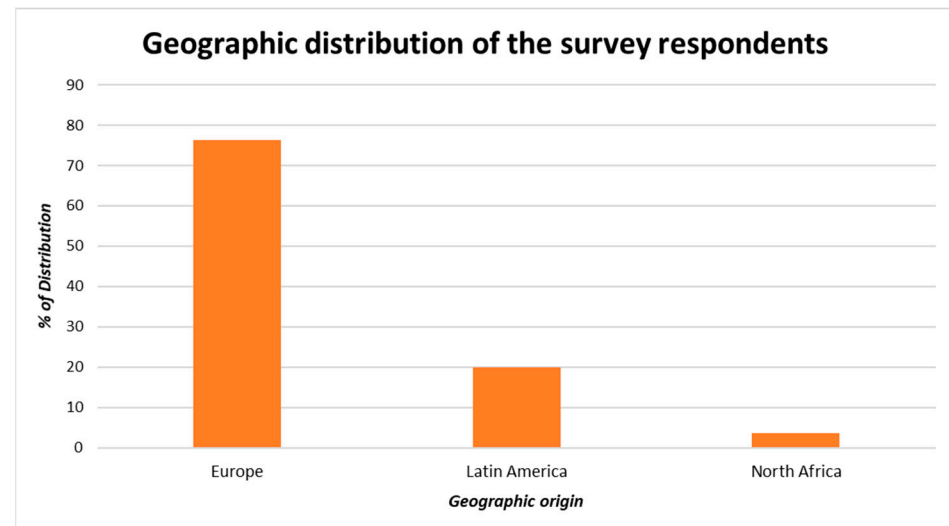
Figure 2. Percentage share of survey respondents' geographical distribution.

The results from Figure 2 show that 76.3% of responses came from European countries, including Spain, with the highest percentage of responses (20.4% out of 76.3%), followed by Ukraine, the United Kingdom, France and a few other countries from the rest of Europe. The second main category with participants who responded to our survey was from the Central American countries, mainly the Dominican Republic, with 20% of responses, and, finally, the third category was from North African countries, mainly Morocco, with 3.7% of responses. These results underline the broad geographical distribution of our survey (Figure 2).

3.1.3. Knowledge of UA and FS

In order to address our research question about the public's perception of UA and FS, numerous questions were asked to our interviewees, including their knowledge of UA and FS, the link between the two concepts and their importance in ensuring healthy and sustainable food systems, their willingness or not to support the implementation of these practices in cities and their level of interest in participating in such projects, etc. These findings are presented below:

- Definitions and concepts

One of the main questions asked to our respondents as part of the survey concerned their knowledge of UA and FS. Indeed, we presented a series of definitions relating to each of the two concepts, and they had to choose the right ones. According to the results obtained, 78.80% of responses concerning the definition of UA were correct, meaning, according to Olsson et al., in 2016: "an agricultural production system that is integrated into urban and peri-urban landscapes and is in line with the perspective of sustainable development" [32]. Regarding FS, only 57.40% of the population surveyed knew the correct

answer, which is, according to Capone et al., in 2014, "having access for all people at all times to enough food to lead an active and healthy life" [33], while 42.60% had the wrong answer, thinking it was an international law or organization;

- Link between UA and FS

Respondents to this survey were asked a series of questions to better understand their perception of the link between UA and FS, along with their opinion on the importance of UAP in ensuring a sustainable food system. These findings will enable a better understanding of our audience's attitudes towards these two concepts, and will, therefore, allow to draw relevant conclusions. This information is presented in Figure 3.
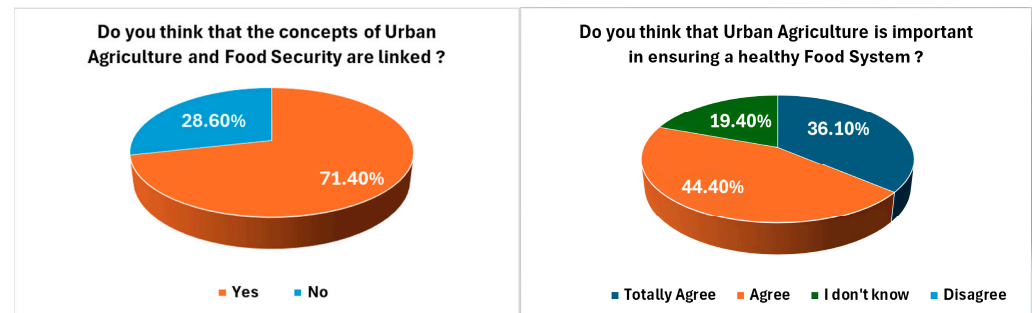
Figure 3. Urban agriculture and its link to food security (**left**); urban agriculture in ensuring a healthy and sustainable food system (in %) (**right**).

Regarding the link between UA and FS, Figure 3 shows that 71.40% of the respondents confirm agreement that both concepts are linked, while 28.60% believe that this link does not exist. Moreover, 80.50% of the respondents agree that this link will ensure a healthy and sustainable food system, while 19.40% disagree with this achievement. The percentages of disagreements present quite a small percentage compared to the majority, but this should still be considered and evaluated;

- Implementation of UA in cities

Another important aspect that needs to be addressed in this study is the integration of UA in cities and whether our respondents have ever participated in such projects. The results are presented in Figure 4.
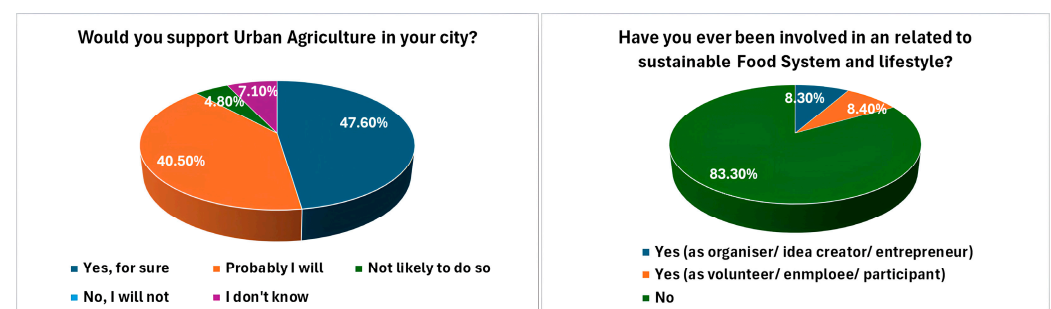

Figure 4. Supporting urban agriculture within cities (in %); involvement in urban agricultural practices and projects (in %).

Figure 4 shows that almost 47.60% of respondents are willing to support the inclusion of UA areas and practices in their city, and 40.50% are likely to do so (88.10% in total). However, 11.90% of respondents would not be ready to do so, which is a fairly low percentage compared to the rest of the responses. Moreover, Figure 4 shows that most of the responses would support the implementation of initiatives in their cities, but most of them have never been involved in an UA initiative.

Recognizing the differentiations of all the above-mentioned results enables greater understanding of the attitudes and multiple perspectives surrounding the involvement of UA in cities, allowing for better-informed decision-making and policymaking in this area.

3.2. Results from the Interviews

In order to make our results more concrete and realistic, we selected two UA initiatives from Spain, in order to evaluate their objectives, benefices, improvement and obstacles and, therefore, to draw conclusions and recommendations. The selection of the two urban agriculture initiatives was based on their compatibility with the objectives of our research problematics, respecting criteria that were aligned with our inquiries into the transition to sustainable food systems, as well as on the availability of relevant data and institutional contacts, which enabled an in-depth qualitative analysis. The following sections illustrate the previous points in further detail, enabling us to gain a better understanding of each of the two initiatives and to draw appropriate and relevant conclusions.

Interviews were carried out with the project managers of two initiatives, namely "Alimenta Conciencia" in the city of Segovia" and "Estrategia Alimentaria de Valladolid" in the city of Valladolid. These interviews allowed us to obtain a considerable amount of information about two projects in Spain, which allowed us to gain a general ideal about the situation in Spain, as well as gathering, through the project managers' own statements, information about the activities carried out, the objectives they would like to achieve and the obstacles they are encountering.

3.2.1. "Alimenta Conciencia" in Segovia City

Segovia is an active city in terms of health and equity, education and participation. To achieve a sustainable and healthy food system, Segovia's sustainable food strategy has the objectives of coordinating between the different administrations and promoting better administrative coordination

- Presentation of the initiative

The "Alimenta Conciencia" initiative was launched in 2019. However, due to the far-reaching effects of the COVID-19 pandemic, the expected timeframe for completion of the project was postponed from 2022 to the end of 2023. This delay was imposed due to major unexpected challenges posed by the pandemic, such as limited access to resources, restricted supply chains and the necessity to adjust project activities to ensure the safety of the participants. The interview was conducted with the coordinator of the "Alimenta Conciencia" project, who was very helpful and who agreed to answer to our questionnaire without any problem;

- Objectives and motivations

The main objectives of this initiative are to better know what is produced and consumed and how this affects the local economy and depopulation, as well as promoting a more sustainable, local, healthy and seasonal diet. Indeed, with the aim of combating food insecurity and promoting awareness, it was necessary to ask our interviewee about the motivation of creating and working on such an initiative. The motivations are therefore the following: "I am aware of the importance of food in this area", which means to ensure a sustainable development and: "I have a conception of the university academy as an information transfer", which means to contribute as much as possible to a better world for all, along with reconnecting people with nature and eating locally. Indeed, these statements by the project manager show and explain the reasons and motivations that led them to get involved and manage such urban agriculture projects, as well as the implementation

and its benefits, something that allowed them to fight for its realization and thus have this motivation to implement it in the best possible way.

These challenging objectives are being achieved through a carefully designed framework, consisting of four key steps that are presented in the following Table 2:

Table 2. Four key steps to achieve the challenging goals of the "Alimenta Conciencia" initiative.

Key Steps	Explanation
Collaboration and Cooperation	Between all social actors involved in the project; strong cooperation and collaboration are needed; building a network of interconnected social actors
Increase organic production	Organic farming; eco-friendly environment; production of healthier food for consumers
Consumption	Encourage local consumption; priority given to products grown in the city or nearby "Km 0"; supports the local economy
Communication and education	Raise awareness and encourage inhabitants to adopt sustainable practices; organize educational activities

From Table 2, we can clearly see that the "Alimenta Conciencia" initiative has many objectives that can be classified into four aspects. Collaboration and cooperation are the first main step, which should be enacted among all the social actors involved in the projects, as the success of such an initiative depends on collective efforts, and meaningful engagement and partnerships are essential for the overall impact of the project. Next comes the step of increasing organic production, as it offers many benefits, including environmental sustainability, improved soil regeneration and healthier food production for consumers (Table 2). Then comes the consumption aspect, where this UA initiative encourages citizens to prioritize products grown in or near the city, known as "Segovia Eco Kilo 0", along with supporting the local economy, contributing directly to the livelihoods of local farmers and producers, sustaining rural communities and creating jobs. Finally, there is the communication and education aspect, which is considered a fundamental aspect and where the project aims to raise awareness and encourage people to adopt sustainable practices, ensuring a more sustainable and healthy future for current and future generations.

In terms of motivations, our interviewee mentioned that "I am aware of the importance of food in this area", which means helping to ensure sustainable development, and she also mentioned that she would like this to be available for "current and future generations". Indeed, these motivations are aligned with the objectives of sustainable development, in particular improving nutrition (SDG 2), the promotion of sustainable and resilient cities (SDG 11), the promotion of sustainable consumption (SDG 12), and being able to strengthen social inclusion and equitable access to food resources (SDG 10);

- Activities carried out

In order to promote a sustainable and healthy food system in and around the city of Segovia, "Alimenta Conciencia" is deeply involved with a series of actions and activities, which are presented with further details in Figure 5.

The "Alimenta Conciencia" initiative aims to implement actions and activities to ensure a more sustainable and healthier food system. This objective is being achieved through a number of activities shown in Figure 5. Indeed, the aforementioned initiative has established three local stores in Segovia, encouraging farmers in the province to sell their local produce in these stores, and encouraging consumers to avoid traveling to other distant markets, while still having access to healthy local groceries. In addition, "Alimenta Conciencia" is committed to ensuring sustainable gastronomic tourism by organizing

various awareness-raising activities to improve local knowledge, while encouraging local production and consumption. Finally, our interlocutor stressed that "it is necessary to carry out numerous educational activities with students to clarify the importance of healthy, local food" (Figure 5);
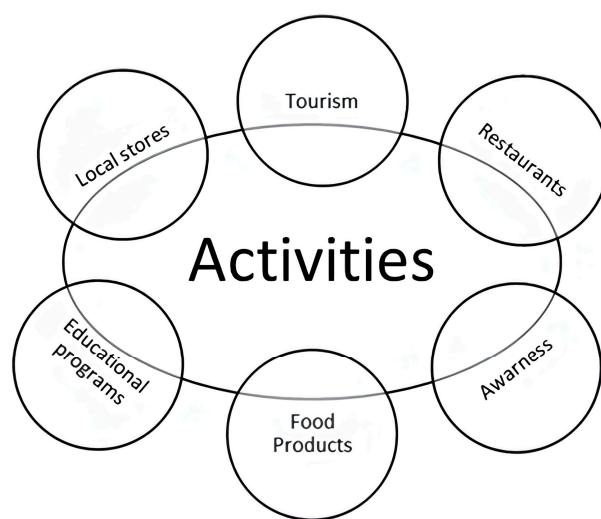

Figure 5. Activities realized in "Alimenta Conciencia" initiative.

- Main challenges and problems encountered

In addition to all the positive impacts that the "Alimenta Conciencia" initiative is bringing to the residents and the city of Segovia, it faces some challenges that are worth highlighting, and which are presented in Figure 6:

Main Challenges that "Alimenta Conciencia" initiative in Segovia has encountered	
Share knowledge	Knowledge-sharing towards urban agriculture and sustainable food systems is still a major challenge.
Lack of economic resources	Such initiatives are confronted with this problem, which represents first and foremost a problem of action.
Human factor	Lack of people willing to work on such projects, or people who are committed and not fully involved.
Geopolitical tensions	Conflicts between countries caused a global food crisis and led to an increase in product prices.

Figure 6. Main challenges that "Alimenta Conciencia" initiative in Segovia has encountered.

Figure 6 emphasizes that, in addition to the activities carried out, knowledge-sharing and a more positive attitude towards food systems are still a major challenge. Furthermore, our interviewee pointed out that "it's difficult to change people's consumption patterns, switching to the consumption of local and nearby products", which means that the "Segovia Eco Km0" is still a work in progress and should be further promoted and shared with everyone.

Regarding the problems encountered, our interlocutor emphasized the lack of economic resources, which the current and other similar initiatives face, and which is, above all, a problem in the conduct of action. Another important factor is the human factor; there is a lack of people willing to work on such projects or people who are committed and not

fully involved. One other major aspect that was mentioned was the geopolitical tensions. Indeed, our interlocutor mentioned that "this has caused a global food crisis and led to an increase in product prices". It is currently necessary to find alternatives and create a healthy and comfortable environment to provide people with local produce (Figure 6).

3.2.2. "Estrategia Alimentaria de Valladolid" in Valladolid City

The city of Valladolid has developed a process of reflection on the local agri-food system. This process of research and reflection has led to a participatory process to draw up a food strategy for the city, which will then be translated into an action plan. Meanwhile, the strategy evaluated in this research study has entered its implementation phase, which is currently underway.

- Presentation of the initiative

The Valladolid City Council, the Entretantos Foundation and the University of Valladolid, joined in 2019 by the MercaOlid and VallaEcolid associations, launched the project "Estrategia Alimentaria de Valladolid" Project in 2016. Regarding the conducted interview, it was carried out with the Councilor of the Environment and the fourth Deputy Mayor of the Valladolid City Council (Ayuntamiento de Valladolid, in Spanish), to whom we would like to thank for the warm welcome and for answering all our interview questions in a smooth and efficient way. Moreover, the city of Valladolid and its surroundings have been developing a process of reflection on the local agri-food system over the last few years to start launching a participatory process for the development of a food strategy of its own and ensure new strategies such as "Valladolid's Agri-Food Strategy: participatory process";

- Objectives and motivations

According to our interviewee, the main aim of the "Estrategia Alimentaria de Valladolid" is to promote a space for collective processing of the food system, to work with other sectors for a more prolonged use of processed foods, along with broadening sales channels. Moreover, opening up a niche in catering with the possibility of developing new allergen-free products and innovation is considered one of the main objectives of these initiatives. Indeed, achieving these objectives would generate very positive learning, relationships and synergies for the local food system.

Regarding motivations, our interviewee mentioned many aspects, such as "People who work the land are the local producers of Valladolid and the surrounding area of Castilla y León and can develop their activities in a politically responsible manner". Indeed, this aspect is fundamental since farmers complain about this issue, and always mention that they wish to have more facilities from local authorities. Another aspect was mentioned: "People can have access to food close to their homes, without having to travel, called "Km 0"." Indeed, this aspect is nowadays necessary since ensuring local and closed products to the inhabitants is benefitting both the city and its inhabitants.

Furthermore, these objectives and motivations are entirely in line with a number of SDGs, which cover improving nutrition (SDG 2), promoting sustainable and resilient cities (SDG 11), fostering sustainable consumption (SDG 12) and strengthening social inclusion and equitable access to food resources (SDG 10);

- Activities carried out

The "Estrategia Alimentaria de Valladolid" is carrying out numerous activities to achieve its objectives and improve the progress of the project. Table 3 below gives a more detailed description of the activities carried out:

Table 3. Main activities realized at the "Estrategia Alimentaria de Valladolid".

Main Activities	Explication
Local markets	Organization of a local market once a month that brings together several local producers in the city of Valladolid.
Pedagogical activities	Organization of pedagogical activities within educational systems to ensure participation of children within dialogue about the importance of eating healthy and locally and also to show them how to plant a certain fruit or vegetable
Encourage local consumption	Organization of activities and workshops open to the public to explain the importance of eating locally for health and wellbeing, as well as to encourage people to start cultivating their own fruits and vegetables in their gardens and/or on balconies etc., if possible.

According to our interviewee, the main activity organized is the setting up of local markets. This market will connect the community by highlighting the diversity of the town's products, creating a thriving and dynamic local market for visitors and guests alike. Secondly, educational activities will be organized to highlight the importance of good nutrition. These activities will enable students to learn more about good nutrition and the positive impact it has on our well-being. To this end, a number of practical exercises are organized, such as practical advice on meat planning from experts, nutritional information and healthy cooking techniques and how these can improve our health and daily lives. The final main activity of "Estrategia Alimentaria de Valladolid" is to encourage local consumption in the community, supporting local businesses and raising awareness of the benefits of buying local produce. To achieve this, various events, open days and activities are organized to show the local population the positive impact on the environment and its impact on our daily lives (Table 3);

- Main challenges and problems encountered

Based on interviews with our initiative representative, it was possible to identify the main challenges facing the project during its implementation and progress. These aspects are further illustrated in the following Figure 7, which lists each challenge along with its explanation.

Figure 7. Main challenges that "Estrategia Alimentaria de Valladolid" has encountered.

Figure 7 clearly demonstrates that one of the major challenges of "Estrategia Alimentaria de Valladolid" is the creation of permanent local markets within the city where local farmers can sell their produce to local consumers. The project will also encourage them to open their own businesses in the city, securing land to make it easier for them to own

property and start marketing to the community. Furthermore, the project seeks to organize more knowledge-sharing and awareness-raising activities, to emphasize the importance of local food and to encourage residents to buy at local markets, instead of traveling, and thus respect the "Km0" concept (Figure 7).

Regarding the challenges, the urban initiative "Estrategia Alimentaria de Valladolid" pointed out that it is very difficult to share knowledge with residents, to enable them to change their way of thinking about consumption and where they produce. Another aspect that was mentioned was increasing the number of participants in events and how to make these concepts more mainstream in cities, where one interviewee mentioned that "today we need more initiatives on UA and growing food in cities while consuming it, in order to make a change in citizens' daily diets" (Figure 7).

4. Discussion

This investigation focuses on two main research lines. The first one is related to the public's perception towards UA and its implementation, and the second was conducted through interviews with project managers. These investigations resulted in many findings that respond to our problematics. Indeed, from the in-depth analysis of the results presented above, there is clear evidence that there is an urgent need for action to create a healthy and sustainable urban environment that meets the needs of current and future generations.

The results of the survey brought the total number of respondents to 250 from all over the world, most of whom were women, living in cities, single and with university and higher education. In terms of their responses to the questions, one very impressive result is that the majority of respondents are familiar with the concept of UA, but this remains at a theoretical level, since when it comes to practical implementation, there is a notable lack of active engagement but the respondents are, nonetheless, interested. This is in line with the work carried out by Kirby et al., in 2021, in many European cities and in the United States, assessing the gap between theoretical knowledge of urban agriculture and practical commitment, where the results of their investigation revealed that many urban participants express a motivation to engage in these practices, but that structural obstacles or a lack of know-how limit their real involvement [34]. This can be considered along with the research carried out in Malaysia by Azmi et al. in 2024, highlighting the gap between theoretical knowledge of UA and practical engagement, which could an obstacle to future project implementation [35]. Another aspect is that most interviewees associate UA with sustainability and bio-products, which is correct, but less so with personal well-being and health issues, which is an essential aspect of UA, since it is seen as a public good for society rather than an individual good. This is fully in line with the work carried out in France by Boukharta et al. in 2023, underlining the impact that the implementation of urban agriculture projects has on both the population and the city, all linked to sustainable development and its goals, along with the connection that exists between these aspects [5]. Furthermore, Hallett's findings in 2013 also highlight the importance of implementing urban agriculture in cities, which guarantees a really important social impact in people's daily lives and for their psychological selves [36], something that was also founded in 2023 by Nicholas et al., thanks to an investigation carried out in Singapore, underlining the social benefits that urban agriculture brings to the population, such as creating new friendships and learning to communicate more effectively with people from different backgrounds, as well as the psychological benefits that enhance self-awareness, gratitude and stress reduction [37].

The survey results also showed that rural residents tend to be more familiar with agricultural concepts, as they are often directly involved in food production, and are aware of their daily benefits and advantages. Urban respondents, on the other hand, may not yet

be fully aware of the need for this daily link, but the growing awareness and interest in urban agriculture and its influence on moral and physical well-being is now influencing their perception of its value; this finding has also been made by many researchers across different developed and developing countries [34].

Regarding FS, we can see that it is a term that is not well understood by our population, contrary to UA. Indeed, according to the survey outcomes, only half of the respondents understand exactly the definition of FS, something that attracts our attention in this research, since it is a term that should be very common, given its importance and usefulness in our daily life. These findings are in line with the work carried out by Gallegos et al. in 2023 in high income countries, notably Australia and the United States, and in 2017 by Arcari in Australia, which underlines the fact that the general public's understanding of FS is very limited and/or vague, and that it needs to be more effectively explained to the public at large [38,39]. Another important dimension underlining the results of this survey assessment through our respondents is the link between UA and FS, and most responses agree that the two concepts are linked and believe that this link will guarantee a healthy and sustainable food system. This was explained and proven by Siegner et al. in 2018, through a systematic review highlighting that UA and FS are complementary and that their link is really important for having access to food produced in urban areas [40,41], and also by Optiz et al. in 2016, who analyzed the existing link between the contribution of urban and peri-urban agriculture to food security in the Global North countries [42].

Secondly, from the interviews conducted with project managers from the Spanish urban initiatives "Alimenta Conciencia" in Segovia city and "Estrategia Alimentaria de Valladolid" in Valladolid city, it emerged that the two Spanish initiatives had several points in common and some differences that concern more ways of implementation and solving issues. Indeed, both initiatives are willing to implement UAP within the cities, while combating food insecurity and providing local produce from local farmers and local cultivation, without having the need to go far to other cities. This fact is totally aligned with the work carried out in Canada, United States and United Kingdom by Sonnino (2016) and in various American cities by Siegner (2018), which emphasizes the importance of UA in tackling food insecurity, and which links it directly to both local food production and the resilience of cities [40,43]. Another objective that has been mentioned by both initiatives' project managers is awareness, considering that it is the key to success of the progress of such an initiative. This progress should start with children, since they are the future generations, so they can influence their parents. This is related to the findings of Russ and Gaus carried out in the United States, underlining the importance of UA education in raising young people's awareness, commitment and understanding of the benefits to their moral and dietary health [44].

In terms of activities, the two initiatives have set up local markets, enabling local farmers to sell their produce directly to city consumers on the one hand, and allowing residents to buy their produce nearby on the other, thus supporting the local economy while eating healthily and properly. In 2001, Trobe carried out a study in the United Kingdom on the creation of local markets by urban farmers, and also found that most customers visit markets firstly out of curiosity, and then to buy fresh, healthy food, expressing a preference for organic produce [45]. Moreover, awareness-raising is a key activity that both initiatives and other similar ones carry out as much as possible in order to share knowledge about UA, FS and the importance of eating healthy, local food. A similar conclusion is drawn by Orsini: in urban gardens, children spend time playing and helping their parents grow plants, acquiring knowledge about agricultural practices and enabling an intergenerational transfer of knowledge [46]. These activities therefore encourage residents to consume locally, thereby contributing to making cities more resilient [47,48]. This is in line with the

findings of Ferreira et al. regarding an investigation carried out in Portugal, who point out that UA and support for local consumption contribute to raising levels of food sovereignty and resilience, as well as implementing new strategies for education, participation and citizenship [49,50].

Many challenges have been mentioned in our analysis; sharing more knowledge is considered the main one for both initiatives, as well as organizing more activities and engaging as many participants as possible. In addition, another aspect is the economic one: the initiatives hope to receive more financial contributions in order to improve these projects and implement other related initiatives. Another aspect is to involve more participants in these UAP and to make them aware of the benefits of setting up urban farming areas in the city, thus ensuring more sustainable and resilient cities. Finally, both initiatives confirmed that they want to help people to open their own business, so that needs to be considered, as well as encouraging the km0 consumption, instead of having to travel to another city.

5. Conclusions

Urban agriculture has become a key research area and a sustainable solution due to its relevance to the current challenges of urbanization, continued population growth, drought and climate change [46,51]. A number of studies underline the importance of urban agriculture in reinforcing food security in urban areas, guaranteeing food self-sufficiency, reconnecting with nature and acquiring new knowledge in this field and, therefore, ensuring self-sufficient and resilient cities [52,53]. Integrating urban agricultural practices has thus been recognized as a strategic approach to promoting sustainable urban development, while encompassing its various objectives, including promoting food security and improved nutrition (SDG 2) and promoting sustainable and resilient cities (SDG 11) with the preservation of terrestrial ecosystems (SDG 15) [20,21]. Furthermore, the involvement of these urban practices within cities fosters sustainable consumption and, to a wider extent, sustainable production patterns (SDG 12) and strengthens social inclusion and equitable access to food resources (SDG 10) [22,23].

Through a survey distributed worldwide, this study assessed the public's perception of urban agriculture and food security, its implementation, integration and knowledge of the subject. Although the majority of respondents are young, urban and highly educated, the geographic diversity of the sample mitigates potential biases and provides valuable information on general perceptions of urban agriculture, particularly for this category, which represents the future generations. It would therefore be very interesting to hear from them in order to improve their knowledge on the subject. However, the fact that certain demographic groups are over-represented may limit the direct generalization of results to other populations with different demographic profiles, such as people with low levels of education or others who are not in this field. Regarding the interviews, they were conducted with two urban agriculture practices in Spain, namely "Alimenta Conciencia" and "Estrategia Alimentaria de Valladolid", both located in the Castilla y Leon region (Spain), in order to assess in a concrete and precise manner how these urban practices operate, the obstacles they face, their main challenges and limitations, etc.

Using this combination of approaches resides in the fact that, while the global survey identifies general trends and awareness gaps, the interviews provide concrete and complementary information in specific contexts. This dual approach is considered a strength, as it enables a broad, multi-angled understanding of key terms and thus addresses our problematic issues. Indeed, in this context, this mixed approach has shown that both the global survey and the local case studies indicate a common recognition and affirmation of urban agriculture as a valuable contributor to food security, given its various benefits linked to its role in improving access to fresh food, promoting social links between citizens, protecting

the environment and so on. In addition, both approaches emphasize the need for local authorities to support these initiatives and back them up to ensure their long-term viability.

This qualitative and quantitative analysis highlighted a number of conclusions that should be emphasized, and which are as follows. First, education and awareness-raising initiatives are needed to highlight the importance of urban agriculture and its role in achieving food security. These could include school courses, community workshops and public open days to disseminate information and promote understanding among the population, and so on. Second, there should be encouragement of the creation of local stores by local producers, as their creation can make a significant contribution to the development of urban agriculture and the improvement of food security. To achieve this, it is important to ensure financial support, provide training and technical assistance and stimulate new calls for projects. Finally, expert urban planning is crucial to the successful integration of urban agriculture and the creation of sustainable urban environments. For this, urban planners need to draw on their expertise as well as that of architects, designers and other skilled professionals to integrate agriculture into urban spaces, as collaboration is essential to developing inclusive and sustainable urban plans.

Local authorities and urban planners have an important role in integrating urban agricultural practices in cities. Indeed, based on the results of this study, we recommend that municipal authorities and NGOs give high priority to supporting urban agriculture in land-use planning by allocating dedicated spaces, encouraging urban farming zones and community gardens. Moreover, they should provide support by offering technical training, facilitating access to funding and acting as intermediaries between local communities and public institutions, thus integrating urban agriculture into climate adaptation and food security plans, all aligned with the Sustainable Development Goals. Furthermore, the results underline that urban planners should implement participatory approaches and strategies that include urban agriculture professionals in the decision-making process, and design multifunctional green spaces that fulfill both an ecological and a food production function.

This study enabled us to gain a general understanding of people's perception of urban agriculture, its effects and its contribution to the population, as well as to deepen our understanding of this concept in relation to food security and self-sufficiency. Furthermore, the interviews highlighted several common points, such as the desire to ensure good education and awareness of the value of integrating the food sector into cities, as well as the appropriate organization of activities and workshops. It should be noted that the evaluation of these two urban agricultural practices provides lessons and a better understanding of the implementation of urban practices, not only in these cities, but also in other areas of Europe and the world, as the results of this investigation provide a better understanding of the changes that may have occurred in citizens' lives during the implementation of these initiatives, across all three dimensions of sustainable development—social, economic and environmental—while emphasizing their experiences and techniques as part of a collective learning process.

The responses from the interviews with the project managers of the two urban agriculture projects in Spain and the global pilot survey are positive in terms of knowledge of the subject, but the survey still needs to be developed to make it more accessible and understandable to all, particularly by encouraging small organizations and start-ups linked to local production. Finally, this investigation can be considered as a basis for future studies aimed at assessing the general public's perception of urban agriculture, as well as for conducting interviews with experts in the field, since this methodology allowed responses to our problematic, and could provide the basis for other investigations in Spain or worldwide.

Abbreviations

The following abbreviations are used in this manuscript:

UA	Urban Agriculture
UAP	Urban Agricultural Projects
FS	Food Security
SDG	Sustainable Development Goal

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Article 6:

Authors: Fabiana Fabri, Loïc Sauvée, Ouiam Fatiha Boukharta, and Maguette Demba.

NB: This article is not included in the compendium. However, it made a significant contribution to the thesis by generating valuable results and guiding key conclusions.

Cahiers
Costech

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> Loïc Sauvée
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> Maguette Demba

Requalification territoriale soutenable par l'agriculture urbaine

Etudes de cas au Havre et à Rouen

Citer cet article

Résumé

L'importance de l'agriculture urbaine pour une transition soutenable des milieux urbains est largement reconnue et diverses initiatives de projets d'agriculture urbaine se développent dans de nombreuses villes. L'agriculture urbaine est en effet une forme d'agriculture permettant d'assurer de multiples fonctions : sécurité alimentaire, services écosystémiques, services éducatifs et pédagogiques, amélioration de la qualité de vie. De plus l'utilisation et la transformation des zones en friches, sous utilisées ou abandonnées, s'avèrent être un excellent moyen pour densifier le foncier et recréer du lien entre activités socioéconomiques et la population urbaine tout en améliorant le cadre de vie. Néanmoins l'identification des bénéfices de projets d'agriculture urbaine (PAU) reste souvent mal connue et l'impact global sur la qualification des territoires du point de vue de la soutenabilité demeure incomplet. Cet article propose, à partir de quatre études de cas de projets d'agriculture urbaine conduites dans les agglomérations du Havre et de Rouen, une évaluation des bénéfices et des obstacles des pratiques d'agriculture urbaine, ainsi qu'à une évaluation des avantages qu'elles apportent en termes économiques, sociaux et environnementaux. La recherche a été faite grâce à des entretiens avec les parties prenantes impliquées dans l'opération, les agriculteurs, les citoyens, les gestionnaires de projet et les collectivités territoriales, utilisant une analyse empirique à l'aide du logiciel NVivo. Les résultats montrent que les PAU, s'ils souhaitent prendre part à dans une vision de transition soutenable des territoires urbains, doivent identifier clairement les indicateurs économiques, sociaux et environnementaux en intégrant à la fois les caractéristiques des contextes locaux et les nécessaires alignements, en termes de gouvernance, entre objectifs à différents niveaux des chaines de décisions ainsi qu'entre bénéfices escomptés et coûts induits par les actions.

Abstract

The importance of urban agriculture for a sustainable transition of urban environments is widely recognized, and various urban agriculture project initiatives are being developed in many cities. Urban agriculture is in fact a form of farming that can perform multiple functions : food security, ecosystem services, educational and pedagogical services, and improved quality of life and so on. What's more, the use and transformation of wasteland, underused or abandoned areas is proving to be an excellent way of densifying land and recreating links between socio-economic activities and the urban population, while improving the living environment. Nevertheless, the benefits of urban agriculture projects (UAP) are often poorly identified, and the overall impact on the qualification of territories from a sustainability point of view remains incomplete. Based on four case studies of urban agriculture projects in the urban agglomerations of Le Havre and

Rouen in Fance, this article proposes an assessment of the benefits and obstacles of urban agriculture practices, as well as an evaluation of the advantages they bring in economic, social and environmental terms. The research was conducted through interviews with stakeholders involved in the operation, farmers, citizens, project managers and local authorities, using empirical analysis with NVivo software. The results show that UAPs, if they are to become part of a vision of sustainable transition for urban territories, must clearly identify economic, social and environmental indicators, integrating both the characteristics of local contexts and the necessary alignments, in terms of governance, between objectives at different levels of the decision-making chains, as well as between expected benefits and costs induced by actions.

Plan

« Les opérations de requalification jouent un rôle clé dans la naissance du landscape urbanism, en montrant que les pratiques paysagères permettent concrètement de réarticuler et de redonner une cohérence à des territoires décousus, hétérogènes, souvent en déshérence ». Antoine Picon, in
« Natures urbaines : une histoire technique et sociale 1600-2030 » 2024,
p. 175.

1. Introduction

En abordant le thème du développement durable, il est important de considérer spécifiquement la question urbaine car actuellement les villes accueillent plus de 50% de la population mondiale et le processus

d'urbanisation semble amené à se développer encore puisque la prospective annonce plus de 6 milliards d'urbains à l'horizon 2050 contre 3 milliards de ruraux (Chaouad et Verzeroli, 2018).

Cette concentration de population est bien entendue associée à une concentration de consommation, à une pression sur les ressources et à la dégradation de la qualité de vie en milieu urbain. L'accroissement continu des villes et des agglomérations entraine également une pression foncière qui est devenue encore plus importante avec l'objectif d'atteindre le Zéro Artificialisation Nette (ZAN) des sols en 2050, dans le cadre de la loi « Climat et Résilience ».

Associer la notion de durabilité à l'architecture et à l'urbanisme devient un défi important, car le processus de transformation de l'environnement naturel en espaces bâtis pour la constitution des villes passe nécessairement par un processus spontané de dissociation entre le naturel et l'artificiel. La durabilité urbaine doit donc proposer de nouvelles formes d'appropriation de l'espace, cohérentes avec les besoins urgents de la société contemporaine, et cohérentes également avec la synergie et l'équité entre les sphères sociale, environnementale, économique et de gouvernance (figure 1).
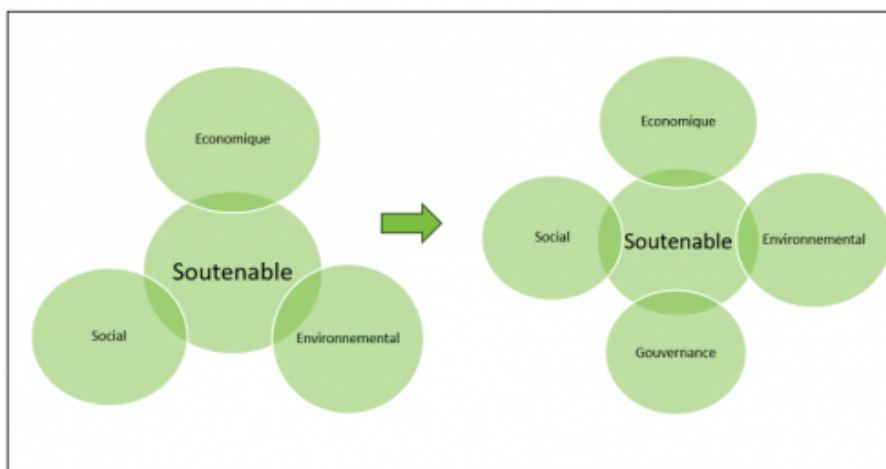
Figure 1. Evolution du concept de la durabilité à partir de l'insertion de la « gouvernance » intégré aux aspects social, économique et environnemental. Source : Adapté de Silva et Romero, 2015.

Les enjeux associés à la question des villes soutenables sont nombreux. Il est possible de les classer en deux échelles spatiales d'analyse (Darly, 2020). Les premiers enjeux (qui font l'objet de notre attention dans cette recherche) seraient des enjeux que l'on pourrait qualifier d'internes ou d'endogènes, si l'on considère la ville dans son environnement, comme

un milieu de vie. En considérant la ville comme un environnement, les thématiques qui émergent sont celle du métabolisme urbain (l'ensemble des flux d'énergie et de matières qui sont nécessaires au fonctionnement des villes), la biodiversité urbaine et le besoin de préserver du vivant dans la ville. Les échelles et les proportions d'appropriation de l'espace public et privé, l'identité culturelle, sont également des attributs qui doivent être présents dans la ville du futur, car la ville durable doit être démocratique et participative.

Les seconds enjeux pourraient être qualifiés d'externes et de globaux si l'on considère la ville dans la biosphère. Ce sont des évènements extrêmes comme les inondations, canicules, tempêtes, etc., influencés par des facteurs externes et qui ont la tendance à s'aggraver avec le changement climatique. Par conséquent il est important pour les villes de mieux se préparer à ces événements.

L'urbanisme durable vise la diversité des usages et des fonctions qui se chevauchent dans un tissu dense et compact. Il est donc nécessaire de « recycler » les espaces urbains déjà construits. Dans cette perspective la requalification urbaine est un mode d'urbanisation consistant à modifier les qualités physiques d'un espace en lui attribuant une nouvelle vocation et en lui offrant de nouveaux usages. La requalification joue en rôle important dans ce scénario comme moyen de lutter contre des phénomènes comme l'étalement urbain et l'artificialisation des sols. En redéveloppant et en modernisant le tissu urbain des villes, il est possible de rétablir la qualité de vie et d'offrir de meilleures opportunités pour ses habitants, en mettant en œuvre une innovation qui permet une approche consciencieuse et raisonnée des ressources. Mais comment faire pour requalifier cet espace urbain de manière durable ?

L'agriculture urbaine n'est pas un sujet récent mais grâce à sa multifonctionnalité, elle connait un regain d'intérêt face aux défis de la ville durable. Concernant l'origine des projets d'agriculture urbaine (ci-après noté PAU), et comme condition essentielle à leur pérennité, ces projets apparaissent généralement dans les interstices de la ville et dans des espaces que des acteurs (collectivités, acteurs économiques, associations, citoyens etc.) décident de conserver, de protéger ou de réhabiliter au travers de pratiques environnementales, et qui peuvent en même temps favoriser de nouveaux liens sociaux. Ainsi l'agriculture urbaine est devenue depuis une dizaine d'années une des composantes de la « fabrique de la ville durable », répondant à la fois aux besoins des citadins comme la demande sociale de la nature en ville, de la sécurité alimentaire, de la relocalisation des produits agricoles, etc. (Cerema, 2019).

Au niveau politique, un certain nombre de villes françaises ont inscrit « l'agriculture urbaine » dans leurs projets et leurs stratégies politiques, telles que Strasbourg, Rennes, Nantes, Lyon ou Grenoble (Granchamp-Florentino, 2012). Dans ce cas, il est également important de comprendre comment les agglomérations intègrent les PAU dans les stratégies du territoire et quels sont les modes de gestions et d'organisation de ces projets, en lien au territoire urbain pris dans sa globalité.

Cet article prend comme référence des PAU situés dans les agglomérations de Rouen et du Havre, qui sont des villes fortement marquées par leur héritage industriel. Dans ce sens cette recherche cible les PAU localisés dans les milieux industriels, tels que les friches industrielles, les zones en reconversion et les projets d'agriculture urbaine situés à proximité des usines. L'objectif est de comprendre comment s'établissent les articulations entre la problématique de l'agriculture urbaine et celle de villes historiquement industrialisées, et au final d'analyser comment appréhender la contribution d'un projet (d'agriculture urbaine ou autre) à la soutenabilité de la ville.

2. Méthodologie de recherche

La démarche de recherche s'est faite en trois phases :

– La sélection des PAU à étudier. Identification et géolocalisation des différents types de PAU sur les deux territoires (Le Havre et Rouen), et sélection de quatre cas situés dans les territoires industriels, tels que les friches industrielles, les zones en reconversion et à proximité d'usines en activité.

– La collecte de données et la constitution d'un corpus de données quantitatives et qualitatives, avec entretiens basés sur un grille d'analyse comprenant des indicateurs sociaux, environnementaux et économiques (pour permettre la collecte et l'analyser les données) près des acteurs directement concernés par les projets : porteurs de projet, habitants, consommateurs, visiteurs, municipalité, experts, universitaires, partenaires et agriculteurs (sources : ADEME 2017 et AULAB 2022).

– Enfin l'analyse de données, à partir d'un logiciel d'analyse de données qualitatives NVivo, qui permet d'organiser les informations grâce à sa fonctionnalité de codage des entretiens. Le logiciel NVivo a ainsi facilité le codage et la classification des données selon les dimensions et les indicateurs d'analyse afin d'identifier les grands thèmes à aborder.

L'intérêt des cas de PAU pour aborder cette question de la qualification soutenable de territoires industriels, et plus largement pour cette question de transition vers des villes plus durables, est corroborée par

plusieurs éléments (Madelrieux et al., 2018) :
– une configuration d'acteurs potentiels très large : producteurs, consommateurs, multi-usagers (récréatifs, éducatifs, expérimentations…)
– une utilisation renouvelée et étendue du foncier urbain et de ses usages
– un lieu de multiples innovations : agrotechnique, sociale et territoriale, organisationnelle…
– un lieu d'apprentissage de nouvelles formes de socialisation, et plus généralement de liens entre ville et nature.

	Enjeux économiques	Enjeux sociaux	Enjeux environnementaux
Types de flux analysés	Flux et stocks monétaires, flux et stocks d'emplois…	Densité et pérennité des liens sociaux	Flux et stocks d'énergie, d'eau, de matières
Ancrage territorial	*Ancrage économique*	*Ancrage social*	*Ancrage environnemental*
Interdépendances	*Niveau d'autonomie économique* *Centres de décisions locaux, globaux*	*Dynamiques sociales* *Inégalités sociales, territoriales*	*Aires et distances d'approvisionnement* *Milieu environnant*
Empreintes territoriales	*Mesures des impacts sur l'emploi, la croissance*	*Mesure de la cohésion sociale, territoriale*	*Impacts positifs sur la biodiversité* *Services écosystémiques*

D'après Madelrieux et al., 2018

Tableau 1. Flux et enjeux pour le développement durable des PAU

3. Résultats

3-1 Le diagnostic agricole et urbain du territoire et les trajectoires d'accès au foncier

Du fait de l'absence de massifs montagneux, d'une faible présence de forêts et d'une urbanisation modérée, la Normandie est la 1[re] région française pour sa part de surface agricole, avec 2,06 millions d'hectares. Près de 69% de l'espace normand est valorisé par l'agriculture. Cependant la pression foncière est singulièrement forte dans la région, en particulier autour des agglomérations et sur l'axe de la Seine. La Normandie se classe au 3e rang des régions dont le rythme d'artificialisation est le plus élevé. Les surfaces agricoles ont diminué de 20 880 ha entre 2008 et 2020, soit une baisse de 1 % en l'espace de 12 ans. Les terres qui quittent l'agriculture sont majoritairement dédiées à l'habitat (Chambre d'Agriculture 2024).
La recherche d'un équilibre entre le développement urbain et la protection des espaces agricoles et naturels représente un enjeu majeur pour la Seine-Maritime au cours des dernières décennies. La Seine-Maritime est considérée comme un département à forte densité (200 habitants/km²

contre 118 en moyenne en France) avec 60% de la population localisée dans les grandes agglomérations de Rouen et du Havre (Chambre d'Agriculture, 2022). Selon les données de la Chambre de l'Agriculture de 2008, le développement des agglomérations comme Rouen et Le Havre et des pôles urbains secondaires s'est traduit par un phénomène de périurbanisation du département, dans lequel 80% de la population vit en zone urbaine. Plus récemment, malgré une faible évolution du nombre d'habitants (autour de 1,25 million), la concentration s'est essentiellement faite dans les couronnes des pôles urbains et les communes rurales péri-urbaines, qui voient leur population s'accroitre. Ces nouveaux habitants sont à la recherche de tranquillité, d'un cadre verdoyant et d'une meilleure qualité de vie (Chambre d'Agriculture, 2022). Les territoires de la Métropole Rouen Normandie et Le Havre Seine Métropole sont caractérisés par l'importance de sa surface dédiée aux activités agricoles. La métropole de Rouen rassemble près que deux fois plus d'habitants que Le Havre Métropole, alors que ce dernier possède une surface agricole plus importante (Tableau 2).

	Rouen Métropole Normandie	Le Havre Seine Métropole
Communes	71	54
Habitants	498 822	270 000
Surfaces (km2)	724	495.8
Surface agricoles (km2)	241.3	299.9

Tableau 2. Tableau de relation entre nombres d'habitants et surfaces agricoles disponibles à Rouen Métropole Normandie et Au Havre Seine Métropole

Dans la métropole de Rouen on observe des attentes plus fortes en termes de renouvellement agricole en raison de la pression foncière et aussi de la très faible autonomie alimentaire, qui est de seulement 10,6% (Métropole Rouen Normandie, 2019). Dans ce contexte, nous pouvons citer par exemple le dispositif « Observatoire foncier agricole » qui a été a mis en place par la métropole de Rouen pour favoriser les systèmes agricoles (Métropole Rouen Normandie, 2021).
Dans le cadre leur stratégie agricole et alimentaire, les deux métropoles ont mis on place des projets pour soutenir une alimentation de proximité, mais avec des approches différentes. Dans le contexte de son Projet Alimentaire Territorial, la Métropole Rouen Normandie propose depuis 2021 des projets « Métropole Nourricière ». L'objectif est de développer de l'agriculture urbaine citoyenne et solidaire, contribuant ainsi à augmenter le taux d'autosuffisance alimentaire du territoire, à travers l'accompagnement financier des projets d'espaces nourriciers collectifs

comme les jardins partagés, les vergers participatifs, etc. De plus Rouen a mis en place une charte de jardinage urbain pour mieux organiser les pratiques agricoles en ville, basée sur trois axes structurants du développement durable du territoire (environnement, société et économie). La Ville de Rouen est également engagée dans un programme majeur de rénovation urbaine pour la période 2020-2030, le Nouveau Programme National de Renouvellement Urbain (NPNRU), dont l'agriculture urbaine représente un des dispositifs d'accompagnement spécifiques.

Au Havre, le scénario est un peu différent, car il y a moins de pression foncière. On observe un certain effort de la part de la métropole pour développer une agriculture de proximité, comme avec le « Projet Alimentaire de Territoire », qui organise la mise en réseau des acteurs de la chaine alimentaire locale. On peut citer également le dispositif appelé « La Ceinture verte », qui a été mis en place pour promouvoir la création de fermes maraîchères dans le périurbain avec un accompagnement technico économique des agriculteurs. Mais, différemment de Rouen, les actions de la métropole autour des projets d'agriculture urbaine sont plus orientées vers l'aspect économique.

A partir des résultats des entretiens avec la Métropole du Havre, il semble que l'agriculture urbaine n'est pas une véritable nécessité, du fait que la métropole dispose de suffisamment de terres agricoles :

« On a la chance d'avoir un territoire qui est très agricole. Du coup, quand on pense au Havre, à l'agglomération, après on pense souvent au port. Finalement, on a encore plus de la moitié du territoire qui est plutôt utilisée et qui a une vocation agricole. Donc en fait, on a encore quand même un terrain de jeu assez important au niveau de l'agriculture traditionnelle, quoi » (Métropole du Havre).

Source : Demba et al, 2023.

3-2 Le contexte politique de la requalification des friches et les projets d'agriculture urbaine

Il existe depuis une dizaine d'années des initiatives importantes, tant au niveau des agglomérations qu'au niveau national, pour requalifier les friches, ce qui ouvre la voie à des projets de valorisations économiques et sociales, dont l'agriculture urbaine. Ci-dessous quelques exemples :
• Au niveau national, « Cartofriches » élaborée par le CEREMA, qui est un dispositif conçu pour recenser les friches, pour les qualifier et pour faciliter leur réutilisation (CEREMA, 2023).
• L'Appel à Projets pour la reconversion d'espaces d'activités ou

industriels en friche, à destination des zones urbaines, dans le cadre du Programme Opérationnel FEDER FSE+ FTJ Normandie 2021-2027.
• L'Appel à Projets sur la stratégie de développement urbain intégré de la Métropole Rouen Normandie Action 3, Traitement intermédiaire des friches, dans le cadre du Programme Opérationnel /FEDER FSE 2014-2020 - Axe 4 : développement des espaces urbains durables.

A partir d'une analyse quantitative il est possible constater qu'il y a une relation différente entre le nombre de friches industrielles et les PAU dans les deux métropoles, possiblement en fonction de leur histoire d'industrialisation, de leur diagnostic de l'agriculture et de l'ensemble des politiques menées. A partir de la base de données « Cartofriches », on observe que Rouen Métropole a presque quatre fois plus de friches que Le Havre (Tableau 3 et figure 2).

	Nombre de friches industrielles	Nombre de projets d'agriculture urbaine
Métropole Rouen Normandie	86	45
Le Havre Seine Métropole	26	23
Normandie	250	-
France	1047	-

Tableau 3. Nombres de friches industrielles et de PAU dans les deux métropoles étudiées

Le diagnostic de l'agriculture et les trajectoires d'accès au foncier se distinguent dans les deux métropoles, ce qui explique sans doute la disparité des PAU entre les deux territoires. Concernant le nombre de projets d'agriculture urbaine, il a été identifié presque deux fois plus de projets dans la métropole de Rouen (45) qu'au Havre (23). Il est important de souligner que le nombre de PAU identifié dans les territoires industriels (passés ou présents) à proprement dit était très limité par rapport au nombre total de cas trouvés dans les métropoles. Dans la métropole de Rouen sont identifiés cinq PAU dans les milieux industriels et au Havre le total est de quatre PAU.
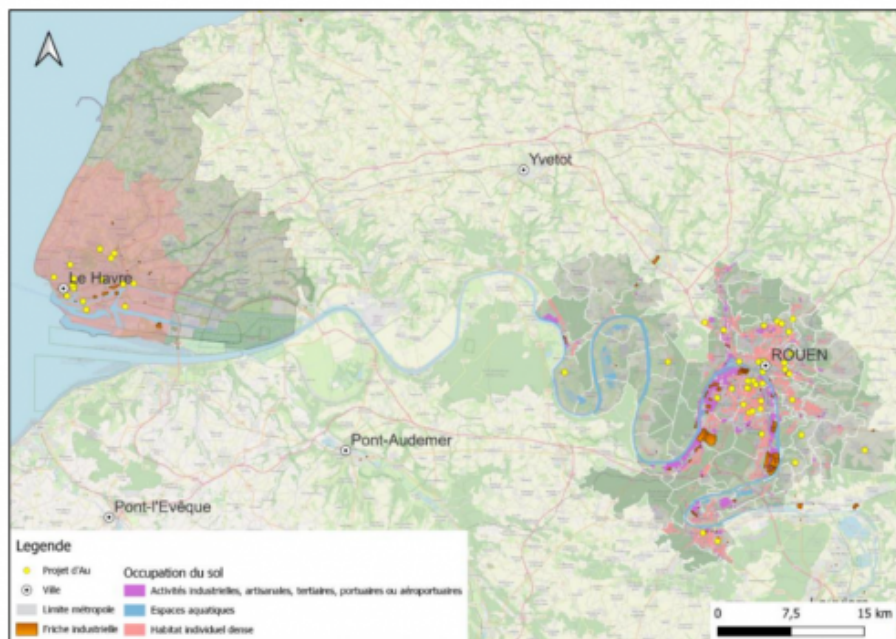
Figure 2. Carte de localisation de projet d'agriculture urbaine dans les métropoles étudiées

3-3 Caractérisation des PAU étudiés

Localisation et contexte géohistorique
Les deux métropoles détiennent une histoire qui remonte à la première Révolution Industrielle en Haute-Normandie, sur l'axe Seine (1800-1870). L'urbanisation de la région est liée aux différentes phases de la Révolution Industrielle. La première Révolution Industrielle en Haute-Normandie est essentiellement textile et se situe principalement sur l'axe de la vallée de Seine : Le Havre importe le coton, Rouen est centre de négoce, et les filatures s'établissent essentiellement dans les vallées, utilisant la force motrice des rivières jusque vers 1860 (vallées du Cailly, de l'Aubette, du Robec et de l'Andelle) (Cremnitzer, 1980).
Les projets étudiés sont situés dans des zones historiquement industrielles. Les deux sites étudiés à Rouen « Jardin de Repainville » et « Jardin du Prince de l'astéroïde » sont localisés dans les vallées textiles de l'Aubette et du Robec, respectivement (Figures 3 et 4).
Le jardin de Repainville se situe dans le site naturel de Repainville, dans la Vallée des Deux Rivières à l'Est de Rouen. Sur le site existait déjà une casse automobile, une station essence, un lavage de voiture et un espace de jardins ouvriers sur dix hectares de superficie.
Le Jardin du Prince de l'astéroïde est situé à Rouen, aux Petites Eaux de Robec. Le site a un fort passé industriel permettant le développement

commercial de Rouen qui remonte à l'époque médiévale avec des moulins et des teinturiers. On dispose d'images datant des années 1700 comme la teinturerie AUVRAY, témoin de l'industrie textile de l'agglomération rouennaise et construite entre 1784 et 1787 à Robec.

Au Havre, le projet « Jardin partagé 76 » se localise à Gonfreville-l'Orcher, une ville industrielle qui a pris son essor au 19ᵉ siècle. De nombreuses usines telles que la fonderie Bassot et les usines Schneider (aujourd'hui Safran) furent implantées. Après la Seconde Guerre mondiale, l'installation du camp américain Philip Morris a permis le développement de Gonfreville l'Orcher avec la création de cités provisoires pour les familles sinistrées de la région havraise.

Le projet « Symbiose » est une ferme d'aquaponie implantée sur une friche industrielle, un ancien hangar de stockage situé sur les quais de Seine dans le quartier de l'Eure au Havre. Suite à l'industrialisation et à la désindustrialisation, le quartier a connu des changements importants. Au début du 20ᵉ siècle, le dock, appelé aujourd'hui Hangar Zéro, a été construit au bord d'un bassin fluvial et a été utilisé pour différentes activités commerciales, notamment pour le café, le cacao, et le bois, avant d'être finalement abandonné. Une vaste opération de réaménagement et de requalification est initiée grâce à son acquisition par la ville du Havre (Demba et al, 2023).

A partir de l'interprétation des cartes, les sites sont actuellement localisés dans les zones urbaines denses et sur des fonciers publics (Figure 3).

Figure 3. Localisation des PAU dans la Métropole de Rouen
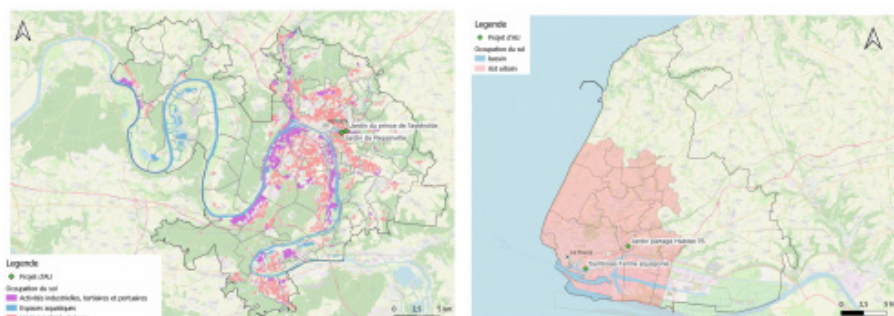
Figure 4. Localisation des PAU étudiés à Rouen et au Havre

Informations générales sur les PAU étudiés : typologie, insertion, objectifs et techniques utilisées

Les quatre projets sélectionnés dans le cadre de cette recherche ont été identifiés comme porteurs d'enjeux et en phase avec une démarche de ville plus soutenable. Ils peuvent être subdivisés en deux types : 3 cas étudiés s'intègrent dans la catégorie dite « AU non-professionnelle : collective » et 1 cas « AU professionnelle : sociale et solidaire » (Figure 5).

Figure 5. Caractéristiques des PAU étudiés

Jardin de Repainville

Dans le cadre de sa politique de préservation et de mise en valeur, la ville de Rouen a donné en location un espace de 2 hectares à l'association « Le Champs des Possibles » pour la création d'une ferme maraîchère. Mise en place en 2015, cette ferme maraîchère sur le site de Repainville a pour vocation de sensibiliser et de guider les habitants de l'agglomération rouennaise pour une expérience de transition écologique et alimentaire. L'objectif de ce projet est de « donner accès à tous au mieux manger par l'éducation ». Le projet du jardin de Repainville met en avant l'aspect pédagogique pour participer aux enjeux de transition alimentaire. Pour ce faire des activités sont planifiées : il s'agit des chantiers qui sont organisés les jeudis matin avec les bénévoles. En outre, les chantiers sont une occasion d'apprendre aux participants comment semer des graines et comment entretenir les plantes. Au jardin, des ateliers pédagogiques sont également organisés autour de différentes thématiques écologiques. De même, l'association vend des prestations, réalise des animations « de la terre à l'assiette », des ateliers grand public

(payants) et des journées portes ouvertes.

Le Jardin du prince de l'astéroïde
Les acteurs initiateurs du projet « Le jardin du prince de l'astéroïde » l'ont nommé ainsi parce qu'il se situe entre le stade Saint-Exupéry et le centre d'accueil du Petit Prince, faisant référence au livre Le petit prince de Saint Exupéry. Il a été créé en 2015 par l'association de gestion de l'astéroïde. Le jardin du prince dispose de trois parties : une partie maraîchage, une prairie et une partie humide pour la gestion de la biodiversité. Leur objectif est de « créer du lien social entre les habitants du quartier et préserver l'espace naturel ». L'association a un bureau composé d'un président, d'un trésorier, d'un secrétaire et des adhérents. L'association organise des chantiers participatifs et des repas communs pour favoriser l'échange entre les acteurs du projet.

Le Jardin Habitat 76
Au Havre, l'objectif du projet « Jardin habitat 76 » à Gonfreville l'Orcher est de « favoriser la biodiversité ». Le personnel de l'Office Public et les habitants se sont réunis pour rendre possible le projet, qui a été mis en place en 2021. Avec la collaboration de l'association « On va semer », des activités sont organisées pour les locataires de la résidence pour qu'ils apprennent à jardiner.

La ferme d'aquaponie « Symbiose »
La ferme aquaponie s'insère dans un projet de tiers lieux « le Hangar Zéro ». Ce dernier est né d'une réponse à un appel à projet en mars 2016 : « Réinventer la Seine ». Cet appel à projet a été lancé par les autorités publiques des régions de Paris, de Rouen et du Havre avec l'objectif d'« inventer de nouvelles façons de vivre sur et au bord de la Seine sur l'axe Paris-Rouen-Le Havre ». Le projet, initié par des acteurs locaux, s'inscrit dans une approche globale et systémique pour apporter des solutions à la crise écologique. Dans l'objectif de participer à la gestion de la crise écologique, un jeune havrais a collaboré avec l'association Hangar Zéro pour mettre en place une ferme d'aquaponie sur le site. Un espace lui a été loué pour son activité d'agriculture urbaine. Mais il est important de noter que la ferme d'aquaponie est un projet individuel géré par le jeune entrepreneur. Il a été aidé et accompagné par Hangar Zéro, des partenaires techniques et commerciaux, des stagiaires et des bénévoles.

3-4 Modes d'organisation des projets et gouvernance

Les projets dits non-professionnels sont pilotés (Jardin de Repainville) ou en collaboration avec des associations (Jardin du Prince de l'astéroïde et Jardin partagé Habitat 76). Concernant les modes de gestion, les projets ont en général des bureaux administratifs bien structurés, notamment le Jardin de Repainville, puisque cette forme de gouvernance est nécessaire pour répondre aux conditions d'accès au financements (tableau 4).

En effet l'association des Champs des possibles répond souvent à des appels de projets pour mettre en place des activités. « La Métropole Nourricière » est un exemple de programme dont l'association a bénéficié d'une subvention. Les décisions à prendre émanent du bureau mais cela n'exclut pas la prise en compte des avis et des suggestions des bénévoles et des stagiaires. L'association est l'acteur principal du projet du jardin de Repainville. Son atout est principalement lié à la forte coopération avec les acteurs politiques : la métropole de Rouen et la ville de Rouen.

La Ferme d'Aquaponie qui est gérée par une entreprise dépend également de l'aide financière publique dont les subventions jouent un rôle clé face aux difficultés financières auxquelles est confronté le jeune entrepreneur. Ce projet a l'avantage de s'insérer dans un projet de tiers lieu qui incite les populations à adopter un nouveau mode de vie. Dans un cadre innovant et amusant, le Hangar Zéro attire l'attention de la population havraise qui se mobilise pour participer aux chantiers participatifs. Ce sont par ces chantiers que les habitants découvrent le projet « Hangar Zéro » et la Ferme d'Aquaponie, ce qui favorise ainsi la participation voire l'acceptabilité sociale du projet. Bien que le porteur du projet soit le seul responsable et exploitant de la ferme, des bénévoles et des stagiaires l'aident dans la mise en place de ses activités. Tout ceci témoigne d'une participation active des différents acteurs.

	Rouen		Le Havre	
Nom du projet	**Jardin de Repainville**	**Jardin du Prince de l'astéroïde**	**Jardin partagé Habitat 76**	**Ferme d'aquaponie Symbiose**
Pilote	« Le Champ des Possibles », porteur du projet	« Association pour la gestion de l'astéroïde du Petit Prince », porteur du projet	Partenariat Habitat 76 (OPH) et l'association « On va semer »	Enterprise Sociale et solidaire (ESS), en collaboration avec Hangar Zéro
Modes de gestion et organisation	Un président, un secrétaire, un délégué, une responsable de communication, des maraichers, des stagiaires, des bénévoles.	Un président, un trésorier, un secrétaire et des adhérents.	Les résidents du quartier et collaboration de l'association « On va semer »	Les partenaires techniques et commerciaux, des stagiaires et des bénévoles. => Collaboration avec les usines qui tentent de mieux gérer les déchets : plastiques et verres
Modèles financiers	Subvention Ville Rouen /Paris, ex: appel projet « La métropole nourricière » ; dons de participants	Pas de subvention Dons de participants (financement initial de la ville de Rouen pour démarrer le projet)	Pas de subvention Collaboration de l'association « On va semer ». Des activités sont organisées pour les locataires de la résidence pour qu'ils apprennent à jardiner	Subvention Aide publique pour le lancement et fonctionnement actuel (RSA)

Tableau 4. Résumé des modes d'organisation et de gouvernance des PAU

Dans les PAU où l'atteinte d'un objectif financier n'est pas visée, les dépenses et investissements sont moindre, ce qui fait que nous n'avons pas noté un manque de subventions de la part des acteurs politiques. C'est également le cas du Jardin du Prince à Rouen et du jardin partagé d'Habitat 76 au Havre. En effet, au niveau de ces deux projets, la recherche de moyens de subventions n'est pas capitale parce que le jardinage ne se fait que pour une autoconsommation. Les acteurs de ces projets ne font aucune activité économique, ce qui favorise leur autonomie financière.

Néanmoins des besoins de matériels existent et nécessitent une collaboration entre le porteur de projet et l'acteur politique (la ville). Cette dernière fournit des subventions et des matériels pour le fonctionnement. Au niveau de la région Normandie, il existe des dispositifs d'aides pour les porteurs de PAU. Toutefois ces dispositifs sont très sélectifs et concernent principalement les agriculteurs professionnels, ce qui fait écho à la dichotomie entre le PAU professionnel et amateur en agriculture urbaine (Nahmias & Yvon, 2012). Nous retrouvons ce problème de légitimation des acteurs de l'agriculture urbaine par les acteurs politiques.

Pour bénéficier de subventions, la métropole du Havre exige un changement de pratiques agricoles. L'adoption de pratiques agricoles durables est nécessaire pour les agriculteurs qui veulent en bénéficier :
« Après en tant que tel, on n'a pas de dispositif financier sur l'agriculture urbaine. Aujourd'hui, on a deux dispositifs financiers directs aux agriculteurs qui s'appellent le fonds d'initiatives agricoles locales et le fil de l'aide directe aux agriculteurs. Mais ça s'adresse aux agriculteurs qui sont pour le soutien à l'élevage globalement, c'est effectivement pour aider les agriculteurs qui veulent changer un peu de pratique, qui veulent sortir de l'agriculture conventionnelle et essayer de s'orienter vers des pratiques plus vertueuses. On essaie de promouvoir un changement de pratiques via du soutien financier » (Métropole du Havre) ».
Source : Demba et al 2023

4. Atouts et freins à la requalification territoriale par l'agriculture urbaine

L'objectif de cette analyse est de présenter un descriptif des points positifs et des faiblesses de la requalification par l'agriculture urbaine,

selon les enjeux économiques, socio-humains, environnementaux ainsi que les modes d'organisation des projets et gouvernance. La figure 6 montre la distribution de l'ensemble des indicateurs par PAU.
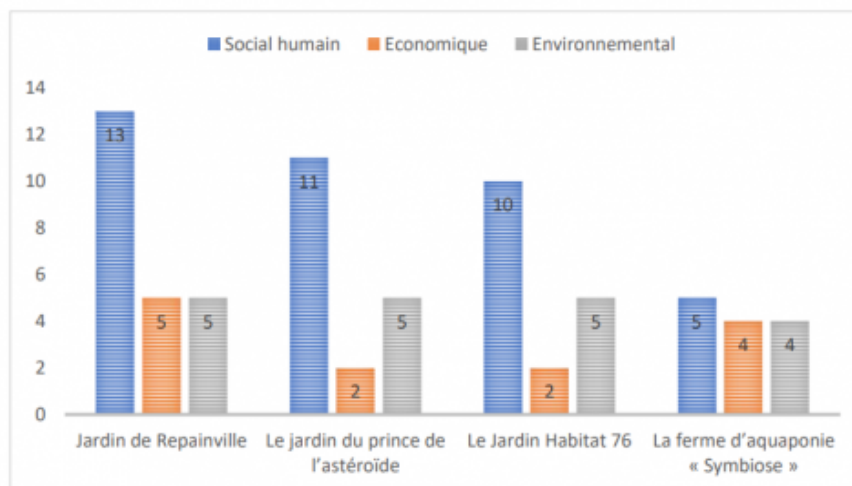

Figure 6. Graphique de la distribution des indicateurs économiques, socio-humains et environnementaux concernant les PAU

Enjeux socio-humains
Concernant les enjeux humains et sociaux, des effets bénéfiques importants et majeurs sont observés notamment de part des PAU non professionnels (Figure 6). Les effets bénéfiques cités parmi les acteurs participants des projets sont spécifiés ci-dessous :

• Fonctions d'amélioration de la sécurité alimentaire et de bénéfices pour la santé mentale et physique
Différemment de la ferme d'Aquaponie, les PAU non professionnels, à partir de la pratique du jardinage, présentent des capacités majeures de productions d'une variété d'aliments et la possibilité d'autoproduction alimentaire des participants. Ces projets n'assurent pas complètement la sécurité alimentaire mais elle peut y contribuer, ainsi qu'à la santé mentale et physique des acteurs. Le fait de se nourrir, de s'instruire, d'avoir des activités de loisir et de socialisation permet aux jardiniers de créer les conditions de reconnexion avec la nature et d'avoir un meilleur niveau de bien-être. Par contre un travail sur les indicateurs du bien-être serait très utile pour mieux identifier ces effets.

• Fonction d'éducation et de formation
En général tous les projets offrent divers aspects éducatifs à la société

autour de la question du bien se nourrir et de la sensibilisation environnementale. Cependant le rôle pédagogique est plus marquant dans les PAU non professionnels. Le projet Jardin du Repainville offre des programmes de sensibilisation et de formation ouvert aux habitants pour leur apprendre à mieux se nourrir. Les associations organisent des chantiers participatifs et des repas communs pour favoriser l'échange entre les acteurs du projet. L'ensemble de ces activités jouent un rôle dans la transmission des connaissances sur la nutrition et le partage de compétences culinaires afin de pousser les participants « à mieux manger » et « à manger autrement ».

• Fonction urbaine et d'amélioration du cadre de vie
Les quatre projets ont en commun la création d'une identité autour d'une alimentation saine à travers l'agriculture, favorisant l'attractivité et le rayonnement du quartier. Les trois projets de jardins collectifs ont comme fonction urbaine de végétalisation du quartier. En créant des espaces verts, ces projets concourent à embellir la ville.
L'appropriation des espaces publics, y compris des espaces non-utilisés comme les friches industrielles, requalifie et valorise les territoires industriels en milieu urbain. Ces exemples ont monté que ces PAU sont en général capables d'améliorer le paysage urbain et la qualité de vie des citadin(ne)s.

• Fonction de cohésion sociale et d'émergence d'une communauté résiliente (ancrage social)
Les PAU non professionnels sont marqués par une forte vocation sociale dès lors qu'ils sont capables de développer des liens sociaux, de promouvoir l'inclusion sociale (âge, sexe, classe sociale) et une forme de gouvernance démocratique. Les PAU collectifs permettent de découvrir le système associatif et politique et entraine une prise en compte des enjeux sociétaux plus larges.
Cependant les PAU non professionnels rencontrent souvent des problèmes relationnels, comme par exemple le manque de communication interne et de collaboration, ainsi que des risques de conflits d'usage. Ces problèmes sont notamment identifiés dans le projet Jardin du Repainville, malgré sa structure organisationnelle bien développée. Il semble que ces difficultés soient générées par l'absence de règles et de consignes claires au sein de l'association.

Enjeux économiques
Bien que les PAU n'aient pas un objectif purement économique, leur

développement a un impact non négligeable sur le plan économique urbain. A la différence de l'agriculture professionnelle, les acteurs de l'agriculture non-professionnelle ont mentionné comme avantage la réduction des dépenses d'achats alimentaires dans les marchés.

Les indicateurs de création d'emploi, comme la création de nouvelles activités et d'emploi d'insertion ou de reconversion, ne représentent pas les points forts des PAU étudiés. Ces indicateurs ont été identifiés uniquement dans les projets « Jardin de Repainville » et la « Ferme d'aquaponie », puisqu'ils présentent un mode d'organisation plus structuré et bénéficient d'une aide financière de l'Etat (subvention). L'économie circulaire a été soulignée comme étant un point commun pour les quatre cas d'étude, notamment en fonction de leurs pratiques vertueuses en lien à l'environnement, avec la gestion des matières organiques et non organiques, la gestion de l'eau, la pratique du compostage etc.

Les freins économiques des projets sont liés au mode d'organisation des projets. Il a notamment été observé la dépendance à la collectivité pour les projets qui sont subventionnés, comme le Jardin de Repainville et la Ferme d'Aquaponie. La charge de travail de la collectivité a été mentionnée par les acteurs politiques des deux métropoles, en fonction de la demande croissante en PAU.

Enjeux environnementaux

Dans la globalité des sites étudiés, ces PAU apportent des bénéfices environnementaux grâce à des pratiques vertueuses, même si l'impact est très local :

o Gestion de l'eau

o Gestion des matières organiques et non organiques

o Qualité des sols (pratiques qui permettent de protéger et d'améliorer les sols)

o Réhabilitation de vie dans les sols (fonction biologique)

En revanche, ce sont des effets souvent difficiles à évaluer, principalement si l'on ne connait pas le diagnostic de la qualité et les caractéristiques des sols avant à l'implantation des projets.

Concernant les freins identifiés, bien que les deux métropoles rencontrent des difficultés liées à la contamination du sol pour ces projets agricoles, les approches diffèrent. Au Havre la pollution du sol est une vraie contrainte pour la « Ferme d'Aquaponie », et les acteurs ont essayé de trouver des solutions alternatives en hors sol pour contourner la problématique de contamination. Dans les cas de Rouen, les porteurs des projets ont eu certaines précautions et ont effectués au préalable des

analyses spécifiques pour évaluer le niveau de contaminants des sols.

5. Les projets d'agriculture urbaine : contributions à la requalification territoriale soutenable

La qualification territoriale soutenable suppose la prise en compte simultanée de deux dimensions : les indicateurs de la soutenabilité appréhendés par trois piliers et la gouvernance des projets en lien aux acteurs territoriaux du milieu urbain.

5-1 Les trois piliers de la soutenabilité au prisme des PAU

Tous les projets étudiés montrent qu'il y a une forte contribution à une vision plus soutenable des territoires. Globalement les projets sont bien alignés avec les objectifs de leurs typologies (PAU professionnels ESS et non professionnels collectifs), qui présentent des enjeux différents. La Figure 7 montre l'ensemble des grands objectifs de l'agriculture urbaine identifiés comme dispositifs potentiels de requalification urbaine.
A travers l'analyse des indicateurs (cf. Annexe), les points en commun entre ces deux types de projets sont :
− la possibilité de créer des emplois (économie) ;
− l'économie circulaire à travers la gestion des matières organiques/inorganiques (économie & environnement) ;
− la sensibilisation sociale avec des actions diverses d'éducation à l'environnement et à l'alimentation durable et plus saine (aspects socio-humains).
Pour les fonctions urbaines et d'amélioration du cadre de vie, on peut également mentionner la capacité de ces projets à requalifier des espaces publics non ou sous utilisés, en leur donnant une nouvelle identité autour d'une alimentation saine grâce aux pratiques agroécologiques.

Figure 7. Les grands objectifs identifiés comme potentiels dispositifs de requalification urbaine par l'agriculture urbaine. Source : Auteurs

Du point de vue économique, la création d'emplois ne représente pas un point fort ou même une priorité pour les projets analysés. Les projets de « La Ferme d'Aquaponie » et du « Jardin de Repainville » qui emploient des travailleurs dépendent de l'aide financière de l'État.

La contribution économique sans doute la plus importante à considérer est la réduction de dépenses d'achats alimentaires parmi les utilisateurs des jardins des PAU non professionnels, puisque ces activités peuvent contribuer à l'amélioration de la sécurité alimentaire à l'échelle des ménages et des quartiers. Cette constatation est corroborée par la littérature (Darly, 2020), avec une grande partie de la production de fruits et légumes en ville, qui ne correspond pas à des activités professionnelles mais à des PAU non-professionnels, collectifs et individuels.

« Cette catégorie d'AU joue en rôle sur la réduction des inégalités d'accès à l'alimentation. Mais il était constaté aussi qu'elle est fortement diminuée par rapport aux années 60 et que jusqu'à une période récente elle a plus reculé dans les zones urbaines que dans le reste du pays. Cette constatation n'a pas suscité des réactions particulières car nous avons une tendance à considérer que ces agriculteurs non-professionnels ne contribuent pas vraiment à la croissance économique, et sa disparition, notamment sur l'effet de la pression foncière, n'a pas d'impact sur le développement économique en général » (Figure 11) (Darly, 2020).
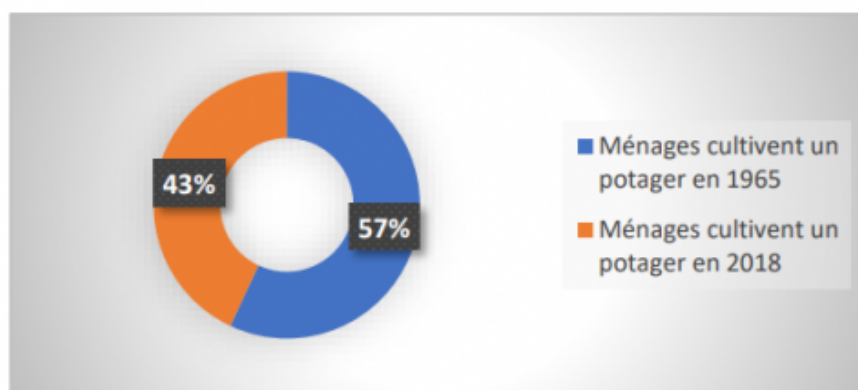
Figure 8. Ménages cultivant un potager en 1965 et 2018. Source : adapté de Darly, 2020

Malgré cette tendance à la disparition de la catégorie d'agriculture urbaine non professionnelle constaté entre 1965 et 2018, l'agriculture urbaine, en général, est actuellement considérée en tant que dispositif face à la crise alimentaire et au changement climatique dans plusieurs agglomérations. Les conditions pour bénéficier des subventions par les deux métropoles est notamment l'adoption de pratiques agricoles durables. Les quatre PAU étudiés essayent de limiter leur empreinte à travers des pratiques vertueuses en lien aux démarches d'économie circulaire, même s'ils ne reçoivent pas de subventions de l'État.
Compte tenu d'une plus forte pression foncière et d'une crise alimentaire plus accentuée qu'au Havre, la Métropole de Rouen propose davantage de possibilités pour développer l'agriculture urbaine, basées sur les trois axes structurants du développement durable. Ainsi il est possible de constater que le « Jardin de Repainville » situé à Rouen est celui que présente le plus d'indicateurs durables (Annexe).
Le nombre de cas de PAU identifiés dans les territoires industriels, qui ont fait l'objet de notre analyse, est limité, probablement en raison du risque plus élevé de contamination alimentaire pour la population. On peut considérer que le projet agricole peut être avantageux dans les milieux industriels à condition qu'il ne présente évidemment pas de risque de contamination. L'agriculture hors sol est souvent considérée comme une alternative (exemple de la Ferme d'Aquaponie), mais ne résoudra pas la problématique de la qualité des sols en milieu urbain. Dans ce cas d'autres pratiques durables peuvent être envisagées, visant à décontaminer les sols, puisqu'il s'agit d'une demande forte dans ces territoires.
L'aspect éducatif proposé globalement pour ces projets peut être considéré comme un facteur important d'ancrage territorial. Il favorise

l'attractivité sociale de ces activités et la création d'une identité autour d'une alimentation saine au travers l'agriculture. La création d'espaces verts peut jouer un rôle important dans l'acceptabilité de ces projets, compte tenu de l'impact positif dans le paysage urbain. Le rapport entre l'homme et la nature, souvent observé dans les PAU non professionnels, semble jouer un rôle très important également dans le développement des facteurs socio-humains, comme la création de liens sociaux, d'inclusion sociale et de gouvernance démocratique.

Dans une optique du développement soutenable, ces projets impliquent la modification des modes de production et de consommation, en introduisant des actions pour que la croissance économique ne se fasse pas au détriment de l'environnemental et du social. Au-delà des personnes employées, les citoyens sont souvent fortement impliqués, que ce soit pour le financement (coopérative, financement participatif), pour le fonctionnement (bénévolat) et bien sûr pour la consommation. L'appropriation de ces espaces vient de la volonté collective d'un groupe d'individus motivés pour se nourrir et pour être en meilleure santé grâce à leur alimentation, mais aussi pour trouver une nouvelle façon d'être en ville, avec de meilleures conditions de travail et de vie, en contraste avec les contraintes liées au mode de vie urbain traditionnel.

5-2 Vers une gouvernance territoriale intégrée des projets d'agriculture urbaine

De nombreux auteurs ont mis en évidence les fortes potentialités ouvertes par les PAU pour la transition soutenable des villes, mais ils en soulignent également les limites. Un des aspects essentiels de la contribution des projets d'agriculture urbaine à la transition soutenable des villes reposent sur les questions de gouvernance. Ainsi, Prové et al. (2019) soulignent que l'efficacité des projets d'agriculture urbaine est fortement dépendante de la prise en compte du contexte local et de ses spécificités. Les pratiques d'AU, les parties prenantes impliquées et leurs objectifs doivent trouver écho au niveau de la ville dans son ensemble pour avoir un impact positif et significatif.

Ainsi, pour Prové et al. (2019), une politique intégrée doit « stimuler la formation de réseaux d'agriculture urbaine larges et socialement inclusifs ». Il est nécessaire pour cela de « mettre l'accent simultanément sur l'adoption d'une approche multiscalaire des systèmes alimentaires locaux et sur la justice procédurale comme principe de gouvernance fondamental afin d'intégrer les multiples revendications de durabilité formulées dans l'agriculture urbaine » (Prové et al. 2019 : 180). Cette notion de justice procédurale renvoie à la diversité intrinsèque des modes

de constitution et d'organisation des PAU, garantissant un accès à toutes les parties prenantes aux processus de décision et de gouvernance.

On retrouve cette même préoccupation chez Piso et al. (2019). Les parties prenantes diffèrent par les valeurs qu'elles incarnent : développement de la communauté, importance des questions de santé et de bien-être, compléments de revenus, développement d'emplois locaux etc. Les modes de gouvernance des PAU doivent ainsi ancrer leur légitimité dans la façon dont les diverses parties prenantes donnent de la valeur à leur actions (Piso et al., 2019). A l'alignement entre les visions à différents niveaux d'échelle des processus de décisions doit s'ajouter un alignement entre valeurs locales et visions des politiques publiques, à l'échelle de la ville et de l'ensemble de la communauté urbaine.

Cette question de l'alignement propre aux modes de gouvernance des PAU apparait comme centrale pour la requalification soutenable des territoires urbains : alignement à différents niveaux d'échelle des chaines de décision ; alignement des objectifs et des valeurs des parties prenantes impliquées. A l'inverse un non-alignement de ces modes de gouvernance réduirait considérablement les potentialités des PAU à la transformation durable des territoires urbains.

Dans le cas des quatre PAU étudiés dans cet article, nous avons identifié une nette dichotomie entre projets professionnels, privilégiant une entrée commerciale, et projets non professionnels. Le point essentiel à prendre en compte est donc cette diversité organisationnelle, qui ne se limite pourtant pas à une dichotomie simple entre ces deux catégories. Seule une cartographie sociale et socioéconomique des acteurs ancrés territorialement peut permettre une caractérisation précise de la nature organisationnelle des formes d'agriculture urbaine. Ainsi une phase de diagnostic territorial (Tanguay et al., 2018) s'appuyant sur une identification des acteurs, des réseaux à différents niveaux d'échelles territoriales, et de leurs interactions (Frimpong Boamah, 2024) est nécessaire pour s'extraire d'une vision au cas par cas et centrée uniquement sur le contexte local, au détriment d'une perspective territoriale.

Au final on peut avancer le constat que les PAU ne seront efficaces d'un point de vue de la requalification territoriale soutenable que si un certain nombre de conditions sont remplies :

− ces projets s'intègrent dans une vision d'une gouvernance territoriale soutenable appréhendée dans le territoire urbain dans son ensemble,
− ils prennent en compte la diversité organisationnelle des modes de gouvernance des PAU, et notamment la diversité des parties prenantes, de leurs objectifs, de leurs valeurs, de leurs trajectoires,

– ils combinent les dimensions de projets locaux et d'insertion avec une planification urbaine à l'échelle de la ville et/ou de la métropole.

Les limites et les écueils sont nombreux car les trajectoires des acteurs sont multiples, leurs objectifs peuvent être en synergies, complémentaires, mais parfois aussi en contradiction. Seule une vision intégrée dans une optique de justice procédurale pourra permettre d'en surmonter les difficultés.

6. Conclusion

Les projets d'agriculture urbaine sont abordés dans cet article du point de vue de leurs potentialités de requalification soutenable des territoires industriels. La multifonctionnalité des projets d'agriculture urbaine apparait clairement dans les cas étudiés dans cet article, et de ce point de vue ces projets peuvent constituer un trait d'union entre les activités industrielles en milieu urbain et la ville, et orienter ces territoires vers davantage de soutenabilité. Aussi compte tenu de cette multifonctionnalité la tentation est grande d'assigner d'emblée aux PAU plusieurs objectifs en lien à la soutenabilité du milieu urbain. Néanmoins dans cette perspective il apparait aussi que les territoires industriels limitent les activités sur sols et sont souvent contraints lorsque l'on prend en compte la question par exemple de leur contamination potentielle. Dans le cas de ces situations, d'autres projets, d'autres activités pourraient être plus indiqués que l'agriculture urbaine. De même le problème de la disponibilité foncière est généralement bien présent et la concurrence avec d'autres usages (pression immobilière notamment) est souvent forte. Enfin les questions de possibilités agronomiques et agrotechniques, de compétences des parties prenantes, voire d'acceptation et d'appropriation par l'environnement urbain, peuvent également être des facteurs limitatifs.

L'approche de la requalification des territoires par les PAU, au-delà de ces contraintes, a montré que la thématique de la soutenabilité met en évidence la multiplicité des moyens existants. Il est donc indispensable d'évaluer les PAU en prenant en compte leurs impacts positifs dans une démarche multicritères sur les trois piliers de la soutenabilité que sont les dimensions économiques, sociales et environnementales.

Par ailleurs il est souligné l'importance d'une analyse territoriale intégrée à l'échelle des agglomérations urbaines et de l'aménagement urbain. Cette analyse territoriale permet notamment de prendre en considération les dimensions stratégiques en lien aux attentes sociétales : avis des citoyens, besoin d'insertion des populations, nécessité de maintenir les

emplois industriels, potentiels de reconversion industrielle etc.
Les perspectives de recherche sur ce thème reposent essentiellement sur une meilleure appréhension de la complexité du territoire vu dans cette approche de transition soutenable. Si le territoire ne peut définitivement plus être abordé comme simple déclinaison et recomposition, à une échelle élargie, de questionnements locaux (Theys, 2002), le dépassement d'une vision simple de gestion des ressources communes soulève d'importantes difficultés méthodologiques. Quelques pistes peuvent être suggérées, comme par exemple le recours à des mesures quantitatives et cartographiques basées sur les SIG des indicateurs de durabilité et leur modélisation, et les approches intégrées territorialement de cartographies sociales (Andersson et al., 2014 ; Andersson, 2021 ; Frimpong Boamah, 2024). Cette perspective pourrait notamment permettre de s'affranchir d'une vision strictement centrée sur les projets (d'agriculture urbaine ou autres) pour développer une méthodologie étudiant les infrastructures vertes au travers de leurs multiples fonctions et s'insérant dans une continuité territoriale ville-nature.

Remerciements

Annexe

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NB: This article is not included in the compendium. However, it made a significant contribution to the thesis by generating valuable results and guiding key conclusions.

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Article

Daily Estimation of Global Solar Irradiation and Temperatures Using Artificial Neural Networks through the Virtual Weather Station Concept in Castilla and León, Spain

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Abstract: In this article, the interpolation of daily data of global solar irradiation, and the maximum, average, and minimum temperatures were measured. These measurements were carried out in the agrometeorological stations belonging to the Agro-climatic Information System for Irrigation (SIAR, in Spanish) of the Region of Castilla and León, in Spain, through the concept of Virtual Weather Station (VWS), which is implemented with Artificial Neural Networks (ANNs). This is serving to estimate data in every point of the territory, according to their geographic coordinates (i.e., longitude and latitude). The ANNs of the Multilayer Feed-Forward Perceptron (MLP) used are daily trained, along with data recorded in 53 agro-meteorological stations, and where the validation of the results is conducted in the station of Tordesillas (Valladolid). The ANN models for daily interpolation were tested with one, two, three, and four neurons in the hidden layer, over a period of 15 days (from 1 to 15 June 2020), with a root mean square error (RMSE, MJ/m^2) of 1.23, 1.38, 1.31, and 1.04, respectively, regarding the daily global solar irradiation. The interpolation of ambient temperature also performed well when applying the VWS concept, with an RMSE (°C) of 0.68 for the maximum temperature with an ANN of four hidden neurons, 0.58 for the average temperature with three hidden neurons, and 0.83 for the minimum temperature with four hidden neurons.

Keywords: daily global solar irradiation; daily maximum temperature; daily average temperature; daily minimum temperature; evapotranspiration; agro-meteorology; Artificial Neural Networks (ANNs); Virtual Weather Station (VWS) concept; spatial interpolation

1. Introduction

Agricultural productivity can be increased by knowing and predicting more precisely crop yields under various conditions. This is a key concept in both precision agriculture and agricultural modelling. Several authors have studied the different techniques applied in precision agriculture and in the modelling of crop production where they involve meteorological variables, with the objective of improving quality, profitability, resource use efficiency and sustainability [1–3]. Among these techniques, the application of variable doses of water, fertilizers and agrochemicals (while considering agrometeorological conditions), as well as the estimation of production (based on the evolution of meteorological variables and the physiological response of crops), are the most frequently used and are currently adopted by many farmers. Indeed, in most cases, crop recommendations are based on data recorded from field studies that compile their conditions (soil and environment) [4].

The impact of global solar irradiation on the Earth's surface has a significant influence on a country's economy, including, for example, agricultural productivity, renewable energy use, food security and human health risks [5], as reported in [6–10].

Prediction and estimation studies of meteorological variables focus on measured data as inputs to the model. Franco et al. [11] found that there is a lack of such studies that use ANN models, and that focus on generating data in sites where such data are not available, so that they can be used as inputs to other models.

Solar radiation is a fundamental factor for most physical and biophysical processes due to its role contributing in to the balance of energy and water. However, interpolation techniques are applied to large areas and do not capture the high variation at finer scales. Fu and Rich [12] calculated insolation maps based on regression analysis of atmospheric conditions, elevation, surface orientation and the influence of surrounding topography, by correlating ground temperature with insolation and elevation, explaining the marginal variation of other factors, such as crop canopy, in the vicinity of Rocky Mountain Biological Laboratory, Gunnison, CO, USA, which area is approximately 300 km^2 and has dramatic topographic variation, with an elevation ranging from 2500 to 4300 m.

The lack of site-specific global solar radiation data is a significant barrier to most applications of crop models. Indeed, Mavromatis and Jagtap [13] evaluated several empirical methods for estimating daily solar radiation from observed maximum and minimum air temperatures, using data from urban and rural sites in Florida (USA), and using spatially interpolated coefficients to improve the results, which are applied to estimate crop yield potential and evapotranspiration. The Donatelli–Bellocchi model [14,15] achieved the most accurate estimates with a Root Mean Square Error (RMSE) of 3.1–4.1 MJ/(m^2 d) in rural areas and 3.2–4.9 MJ/(m^2 d) in urban areas.

Spatial interpolation is a classical geostatistical operation that aims to predict values assigned to unobserved locations from a defined sample of data on specific substrates. However, the underlying continuity and heterogeneity of spatial data are too complex to be approximated by traditional statistical models. By using deep learning models, in particular the idea of conditional generative adversarial networks (CGAN) [16], deeper representations of sampled spatial data and their interactions with local structural patterns can be captured. Zou et al. [17], with a case study (global solar radiation) on elevations in southeast of China, demonstrated the model ANN capacity to achieve outstanding interpolation results compared to the benchmark methods: a model ANN (9-17-1) provided better accuracy (RMSE = 1.34 MJ/m^2, and R^2 = 0.91) compared to the improved Bristow–Campbell model (RMSE = 2.19 MJ/m^2, and R^2 = 0.83) and the improved Ångström–Prescott model (RMSE = 2.65 MJ/m^2, and R^2 = 0.68).

Environmental variables are recorded by point sampling. However, precision agriculture requires more precise and specific knowledge of these characteristic variables near or within the crop, and thus, spatially continuous data on environmental variables becomes necessary. Li and Heap [18] classified 25 Spatial Interpolation Methods (SIM) into three different categories: non-geostatistical, geostatistical, and combined methods, and provided guidelines and suggestions for selecting the appropriate method for a specific environmental dataset.

A typical spatial interpolation method, which is very efficient and simple, is Inverse Distance Weighting (IDW), for which Li et al. [19] proposed a new approach, called Dual IDW (DIDW), which takes into account the correlation of the data, to avoid unfavourable estimates with unevenly distributed samples. A case study based on Walker Lake data indicates that DIDW significantly improves interpolation accuracy over traditional IDW, and also slightly outperforms Ordinary Kriging (OK) for small data samples to capture adequate spatial continuity.

The spatial interpolation of the Earth's weather variables occupies an important role in climate studies, but most of the traditional spatial interpolation methods do not consider geographical semantics in their practical application. Wu et al. [20] proposed an improved algorithm for IDW by considering geographic Semantics (SIDW), which adds the influence of land use type on the interpolation of land surface temperature data by the Landsat 8 OLI-TIRS satellite over China, achieving generally higher accuracy and precision than IDW, Kriging, natural neighbour, and spline function interpolation methods.

Loghmari et al. [21] developed and evaluated two monthly spatial interpolation models of global solar radiation, for the purpose of predicting global solar radiation within a distance of more than 50 km in southern and central Tunisia: an artificial neural network (ANN) that obtained better results than a model based on IDW.

In order to spatially fill gaps (nowcasting) in micrometeorological data sets (wind, humidity and temperature), Gunawardena et al. [22] employed Multivariate Linear Regression (MLR) and ANN at eight locations, using measurements from three nearby weather stations, covering scales from 100 m to 5 km. These measurements were made in regions marked by complex terrain, where spatial variability is high on small length scales, which in this case is the Cadarache Valley, which is located in southeastern France, from December 2016 to June 2017, demonstrating that both methods are acceptable.

In this case [23], it is notable the interpolation of the observed weather in the centre of a 25 by 25 km grid, where the weather data is homogeneous, and the temperature, sunshine, humidity and wind speed are expected to change gradually at distances of 50 to 150 km in the European Commission's MARS (Monitoring Agriculture with Remote Sensing) Crop Yield Forecasting System (MCYFS) wiki.

Geographic Information Systems (GIS) offer different options to analyze and represent the spatial heterogeneity of the incident solar radiation in a given area. Martín and Dominguez [24] presented a description of the methods for estimating the distribution of solar radiation in geographical areas, from a sample of data, using deterministic techniques (global polynomial interpolation, local polynomial interpolation, inverse distance weighting and radial basis functions) and geostatistical techniques (kriging and co-kriging) applying them for the summer solstice 2011, from 45 stations in Spain. Indeed, the global polynomial method presents interpolations closer to the real value, the geostatistical methods, in turn, generally present very low squared errors (the universal kriging and the ordinary co-kriging are those that show the best adequacy in the results).

The data, which is collected at discrete weather stations, can only be meaningful when represented by surfaces. Spatial interpolation methods help to convert the point data into surfaces by estimating missing values for areas where data is not collected. In addition to the objective, the total number of data points, their location and their distribution in the study area affect the accuracy and efficiency of the interpolation. Keskin et al. [25] aimed to investigate the optimal spatial interpolation method for mapping meteorological data (precipitation, temperature and wind speed) in the Northern part of Turkey, using the interpolation methods (IDW, kriging, radial basis and natural neighbour). This investigation was carried out in January 2005, resulting in a three-locations average RMSE for a temperature of 0.94 °C with IDW, 0.75 °C with kriging and 0.70 °C natural neighbour.

Yazar [26] performed spatial interpolation of solar radiation with data from 81 agrometeorological stations over heterogeneous agricultural areas including different crop species, irrigation techniques, and topographical and other conditions in Southeastern Turkey, by applying Ordinary Kriging (OK) individually and to reduce the Ordinary Co-Kriging (OCK) error with solar radiation related data (air temperature, vapour pressure deficit and digital elevation model), with up to 21% accuracy, which allowed for better evaluation and management of crop development and yield.

Leirvik and Yuan [5] employed statistical methods (Random Forest (RF); Linear Regression (LR); Generalized Additive Regression (GAM); Least Squares Dummy Variable (LSDV); Ordinary Kriging (OK); and combinations, as LR + OK, GAM + OK, and LSDV + OK) to interpolate missing values in a monthly dataset spanning nearly five decades of global solar irradiation over the Earth's surface, highlighting the benefits of using Machine Learning in environmental research.

Antonić et al. [27] used ANN models for monthly mean values of meteorological variables (air temperature, daily minimum and maximum air temperature, relative humidity, precipitation, global solar irradiation and evapotranspiration) through data obtained from 127 meteorological stations in Croatia. The inputs used (elevation, latitude, longitude, month and time series of the respective climatic variables) were from two meteorological

stations. The quality of the results allows the construction of spatial distributions of the average climate for a given period, which would be useful for dendroecological analysis.

Siqueira et al. [28] performed the generation of synthetic daily solar irradiation series from spatial interpolation based on ANNs, employing geographic variables (latitude, longitude and altitude) and meteorological variables (precipitation, maximum and minimum temperature), which were easily available. The data were measured during the months of November (from 2001 to 2006) over seven locations in Pernambuco, Brazil.

Many climate studies need to generate predictions of a climate variable at a given location using values from other locations. Snell et al. [29] conducted a spatial interpolation of daily maximum surface air temperatures using ANNs, so as to generate estimates at 11 locations in the central U.S. continent, using information from a network of surrounding stations for the 4- and 16-point cases and over a 63-year period (from 1931 to 1993) that were used as input and output vectors for the ANNs. The results obtained are better than the spatial average, nearest neighbour and inverse distance methods, and the potential of using ANNs for downscaling General Circulation Models (GCMs) of temperature is discussed.

Rigol et al. [30] performed a spatial interpolation of daily minimum air temperature using an ANN trained with input variables (date, field variables and neighbouring temperature observations) for a full year, covering an area of 100 km $\times$ 100 km in Yorkshire, UK, analyzing the internal weights of the inputs to estimate the degree of spatial correlation between neighbouring stations, and the most influential variables contributing to the trend. The performance when testing ANN (33-1-1) is RMSE = 3.15 °C, of ANN (19-4-1) is RMSE = 1.26 °C, and of ANN (45-4-1) RMSE = 1.15 °C.

Zambon et al. [31] reviewed Industry 4.0 procedures suitable for the agricultural sector, while pointing out that the 4.0 revolution in agriculture is still limited to a few innovative companies. Additionally, environmental variability and stochastic events contribute to a high degree of uncertainty in the supply chain and a lack of predictability in agricultural operations. This is where recent technologies related to the digital age, such as precision agriculture, which uses positioning technologies combined with the application of sensors and data, provide digital information in all agricultural processes.

In this paper, the concept of a Virtual Weather Station (VWS) is used and employs meteorological data from real stations to estimate data from a nearby location that does not have a weather station. As part of the VWS development, the performance of ANN models for interpolating each separate meteorological variable (global solar irradiation, maximum, average and minimum temperatures) was evaluated. The performance of the models is compared with those obtained by Franco et al. [11], who proposed the use of a VWS in places where meteorological data are needed, as an alternative to their acquisition, when it is not possible to install a meteorological station. The ANN models, in this case, were used with all the variables of the same place, while in this article, the estimation of each variable (solar irradiation and temperatures) is carried out separately (an ANN model for each meteorological variable).

2. Materials and Methods

In this section, the following points are described: (1) the meteorological data used with the tested geographic interpolation models, corresponding to global daily solar irradiation and ambient temperature (maximum, average and minimum), as well as information on the location of the agro-meteorological stations where these data were recorded; (2) the ANN models designed for the estimation of the analyzed meteorological variables; and (3) the statistics used to analyze the accuracy of the results obtained by the ANN-based interpolation models that have been examined.

2.1. Daily Data on Global Solar Irradiation and Ambient Temperature (Maximum, Average and Minimum)

The daily average data of global solar irradiation and ambient temperature (maximum, mean and minimum) used in this article, for a 15-day period (from 1 to 15 June 2020, were collected in the 54 agrometeorological stations (Appendix A) belonging to the Agro-climatic Information System for Irrigation (SIAR, Sistema de Información para el Asesoramiento al Riego, in Spanish), located in Castilla and León Region, in the North-central part of Iberian Peninsula, as shown in the map presented in Figure 1 and in Table A1 (data of altitude, latitude and longitude).
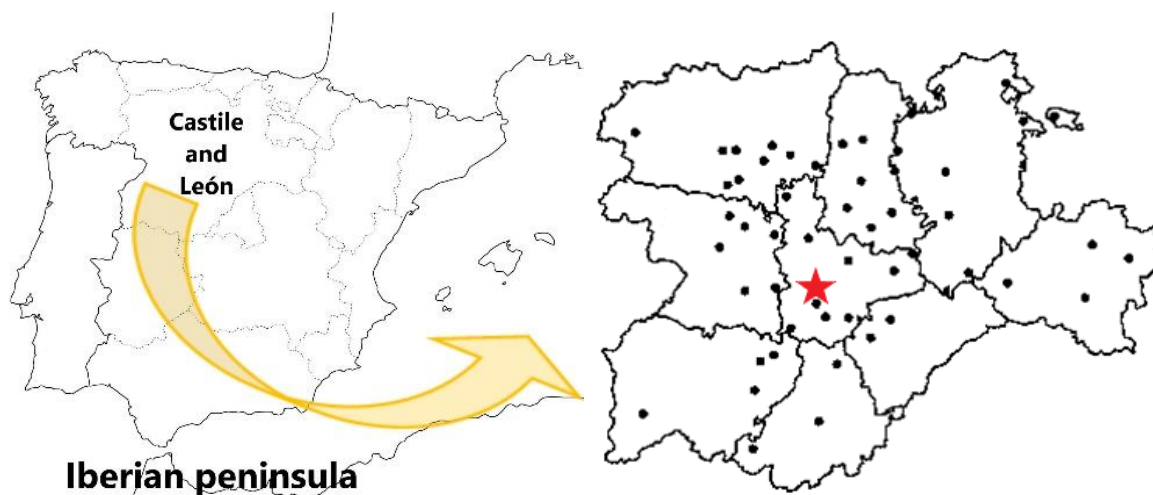
Figure 1. Location of the 54 agrometeorological stations belonging to the Agro-climatic Information System for Irrigation (SIAR) located in Castilla and León Region, Spain [32], highlighting (red star) the site of the agrometeorological station referenced for this study (Tordesillas, Valladolid).

SIAR is a project financed by the Ministry of Environment and Rural and Maritime Areas of Spain, which is managed by the Agricultural Technological Institute of Castilla and León, (ITACyL, Instituto Tecnológico Agrario de Castilla y León, in Spanish), through the Meteorological Information Service [32]. The SIAR project helps farmers to manage irrigation water in an optimal way, advising them on the doses to be applied at each time of the year, depending on the phenological stage of the crop, by calculating the reference evapotranspiration (ETo).

Within the agrometeorological stations of the SIAR network, solar irradiance is measured by a Skye SP1110 pyranometer (Campbell Scientific, Inc., North Logan, UT, USA), consisting of a silicon photocell sensitive to radiation between 350 and 1100 nm, while the ambient temperature is measured by a Pt-1000 temperature sensor, which is based on the variation of platinum resistance with temperature. The linearization and amplification electronics for these sensors are located next to a Vaisala HMP45C probe (Campbell Scientific, Inc., North Logan, UT, USA), which is used to measure ambient temperature and relative humidity, in the temperature ranges of −40 to 60 °C, and 0 to 100%, respectively.

The climatic classification for the location of most agrometeorological stations is Csb, with some located in areas classified as Cfb, Csa and BSk types [33], according to the Koppen-Geiger climate classification.

2.2. Estimation of Solar Irradiation and Ambient Temperature Using Artificial Neural Networks

The architectures of the ANNs used for the evaluated geographic interpolation models are illustrated in Figure 2. All of them contain two inputs (longitude and latitude) and one output, which can be the daily global solar irradiation, or the daily mean values of the ambient temperature (maximum, average, or minimum).

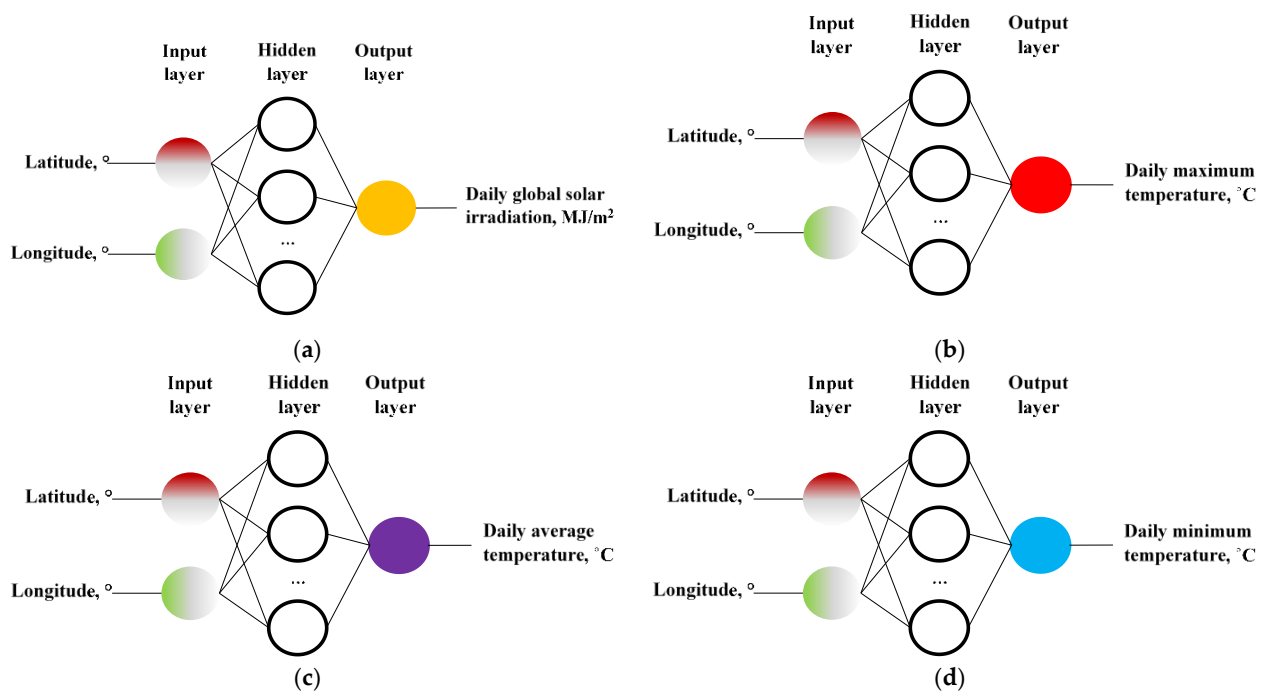**Figure 2.** The architecture of the models evaluated with Artificial Neural Networks (ANN). Layers (input-hidden-output) (2-1 . . . 4-1) based on the input variables [latitude and longitude] to individually estimate: (**a**) daily global solar irradiation; (**b**) daily maximum temperature; (**c**) daily average temperature; (**d**) daily minimum temperature.

The implementation of the ANNs was performed in MATLAB Software with the *feedforwardnet* function, dimensioned with the input and output data vectors, which determine the size of the respective layers, generating a Multilayer feed-Forward Perceptron (MLP) type ANN with a single hidden layer, where the selected activation function between neurons in the hidden layer was the hyperbolic sigmoidal tangent (*tansig*), while the selected transfer function for the neurons in the output layer was linear (*purelin*). The Levenberg–Marquardt back-propagation (BP-LM) algorithm was applied to achieve fast optimization (*trainlm*) [34,35].

The training of the ANNs was performed with the *train* function, with matrices of input and output data vector, carried out daily in 53 agrometeorological stations of the SIAR network (all of them belonging to this network, except the agrometeorological station of Tordesillas, used in the validation phase of the results), over a period of 15 days (from 1 to 15 June 2020). Finally, the *sim* function was used, testing the ANNs previously trained with 1, 2, 3, and 4 neurons in the hidden layer, to estimate each meteorological variable studied separately, over the same 15 days at the station located in Tordesillas (Valladolid, Figure 1), with geographic coordinates 41°30′32″ N and 4°59′20″ W, altitude 658 mamsl, used as reference for the validation. The period from June 1 to 15 was chosen because it is the period of the year when agricultural activity is the highest in the Iberian Peninsula, coinciding with the end of winter crops and the beginning of summer crops.

2.3. Statistics for the Validation of the ANN Models

The accuracy of the results obtained by the ANN models in the validation phase was analyzed using the following statistics: Root Mean Square Error (RMSE, solar irradiation MJ/m^2 and temperature °C), using Equation (1); and the coefficient of determination (R^2), as an indicator of the level of model fit, using Equation (2).

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}\left(Y_i - \widehat{Y}_i\right)^2}{n}} \tag{1}$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n} \left(Y_i - \widehat{Y}_i \right)^2}{\sum_{i=1}^{n} \left(Y_i - \overline{Y} \right)^2} \tag{2}$$

3. Results

This section presents the results obtained by the ANN models for the daily estimation of global solar irradiation (1) and ambient temperature (maximum (2), average (3), and minimum (4)) at the agrometeorological reference station SIAR, located in Tordesillas, Valladolid, Castilla and León, Spain.

3.1. ANN Models for Estimating Daily Global Solar Irradiation at the Reference Station

The results of the ANN models for estimating daily global solar irradiation at the reference station presented in Figure 2a are shown in Table 1. The best result is obtained when using ANN (2-4-1) with RMSE = 1.04 MJ/m^2, which improves on the best ANN result of Franco et al. [11] for the summer months of 1.63 MJ/m^2, by using the rectified linear unit activation function.

Table 1. Daily global solar irradiation (MJ/m^2) in Tordesillas (Valladolid) measured for 15 days (i.e., 1–15 June 2020), estimated with the neural architectures varying the number of neurons from four to one in the hidden layer (i.e., ANN (2-4-1), ANN (2-3-1), ANN (2-2-1) and ANN (2-1-1)), and fitting of the statistics.

Tordesillas	Data	ANN (2-4-1)	ANN (2-3-1)	ANN (2-2-1)	ANN (2-1-1)
1 June 2020	27.58	26.85	27.27	27.62	26.83
2 June 2020	25.61	25.60	26.03	25.79	25.79
3 June 2020	24.38	23.16	22.23	21.90	22.77
4 June 2020	27.74	25.29	25.07	24.68	24.67
5 June 2020	31.09	30.41	30.79	29.92	30.00
6 June 2020	27.45	27.29	26.22	26.29	25.98
7 June 2020	17.94	17.58	16.14	16.92	17.10
8 June 2020	26.96	26.75	26.72	26.60	26.47
9 June 2020	24.94	26.89	27.32	27.06	26.07
10 June 2020	28.46	27.96	28.60	27.73	27.64
11 June 2020	21.55	20.72	22.33	21.74	21.07
12 June 2020	14.93	14.16	15.71	15.94	14.41
13 June 2020	21.29	20.51	21.10	20.21	20.36
14 June 2020	27.64	26.34	26.60	26.31	26.18
15 June 2020	22.21	22.30	23.11	22.43	22.69
RMSE		<u>1.04</u>	1.31	1.38	1.23
R^2		<u>0.94</u>	0.90	0.89	0.91

RMSE, root mean square error (MJ/m^2); R^2, determination coefficient. The best results are underlined.

3.2. ANN Models for the Estimation of the Maximum Daily Temperature in the Reference Station

The results of the ANN models shown in Figure 2b for the estimation of the daily maximum temperature at the reference station, are presented in Table 2. The best result obtained is the ANN (2-4-1) with RMSE = 0.68 °C, which improves the best result of the ANNs Franco et al. [11] for the summer months by 1.28 °C using the sigmoid activation function.

Table 2. Daily maximum temperature (°C) in Tordesillas (Valladolid) measured for 15 days (i.e., 1–15 June 2020), estimation performed with the neural architectures varying the number of neurons from four to one in the hidden layer (i.e., ANN (2-4-1), ANN (2-3-1), ANN (2-2-1) and ANN (2-1-1)), and fitting of the statistics.

Tordesillas	Data	ANN (2-4-1)	ANN (2-3-1)	ANN (2-2-1)	ANN (2-1-1)
1 June 2020	28.73	27.92	27.96	27.72	27.54
2 June 2020	29.73	29.01	29.34	29.05	28.57
3 June 2020	27.73	26.52	26.17	26.18	25.58
4 June 2020	21.26	20.98	20.78	21.09	20.82
5 June 2020	26.86	26.60	26.28	26.68	26.30
6 June 2020	27.13	26.12	26.48	25.92	25.59
7 June 2020	19.19	18.15	19.26	18.57	18.74
8 June 2020	20.06	20.05	19.86	19.91	19.89
9 June 2020	20.26	20.26	20.60	21.02	20.62
10 June 2020	24.8	24.33	24.14	24.11	24.12
11 June 2020	21.46	20.66	20.42	20.32	20.39
12 June 2020	18.2	17.45	16.71	16.84	16.42
13 June 2020	18.99	19.37	19.30	19.45	19.28
14 June 2020	21.79	21.98	21.18	21.29	21.17
15 June 2020	22.79	22.20	22.17	22.00	22.22
RMSE		0.68	0.77	0.86	1.04
R^2		0.97	0.96	0.95	0.92

RMSE, root mean square error (°C); R^2, determination coefficient. The best results are underlined.

3.3. ANN Models for the Estimation of the Average Daily Temperature in the Reference Station

The results of the ANNs models shown in Figure 2c for estimating the daily mean temperature at the reference station are presented in Table 3. The best result is obtained by ANNs (2-3-1) with RMSE = 0.58 °C, which improves the best ANN performance Franco et al. [11] for the summer months by 0.99 °C when using the hyperbolic tangent activation function.

Table 3. Daily average temperature (°C) in Tordesillas (Valladolid) measured for 15 days (i.e., 1–15 June 2020), estimation performed with the neural architectures varying the number of neurons from four to one in the hidden layer (i.e., ANN (2-4-1), ANN (2-3-1), ANN (2-2-1) and ANN (2-1-1)), and fitting of the statistics.

Tordesillas	Data	ANN (2-4-1)	ANN (2-3-1)	ANN (2-2-1)	ANN (2-1-1)
1 June 2020	20.39	19.71	19.40	19.47	19.26
2 June 2020	22.00	21.47	21.53	20.98	20.57
3 June 2020	19.04	18.51	18.20	18.40	17.98
4 June 2020	16.15	16.02	15.42	14.92	15.35
5 June 2020	16.83	16.13	16.50	16.80	16.57
6 June 2020	18.09	17.46	18.04	17.53	17.31
7 June 2020	14.65	13.61	13.61	13.62	13.96
8 June 2020	13.77	13.03	13.14	12.94	12.82
9 June 2020	13.83	13.06	13.83	13.09	13.05
10 June 2020	16.68	15.75	16.20	15.75	15.83
11 June 2020	15.11	14.69	14.50	14.80	14.02
12 June 2020	11.88	11.31	11.88	11.18	11.20
13 June 2020	13.45	13.37	13.15	12.84	12.72
14 June 2020	15.43	15.10	15.10	14.76	14.59
15 June 2020	15.99	15.84	15.57	15.41	15.40
RMSE		0.61	0.58	0.78	0.88
R^2		0.95	0.95	0.91	0.89

RMSE, root mean square error (°C); R^2, determination coefficient. The best results are underlined.

3.4. ANN Models for the Estimation of the Minimum Daily Temperature in the Reference Station

The results of the ANN models shown in Figure 2d for the estimation of the daily minimum temperature at the reference station, are visualized in Table 4. It obtained the best result for the ANN (2-4-1) with RMSE = 0.83 °C, which improves the best result of all ANNs Franco et al. [11] for the summer months by 1.55 °C, when using the hyperbolic tangent activation function.

Table 4. Daily minimum temperature (°C) in Tordesillas (Valladolid) measured for 15 days (i.e., 1–15 June 2020), estimated with the neural architectures varying the number of neurons from four to one in the hidden layer (i.e., ANN (2-4-1), ANN (2-3-1), ANN (2-2-1) and ANN (2-1-1)), and fitting of the statistics.

Tordesillas	Data	ANN (2-4-1)	ANN (2-3-1)	ANN (2-2-1)	ANN (2-1-1)
1 June 2020	11.93	10.80	10.57	10.93	10.67
2 June 2020	13.67	13.38	13.54	13.27	12.85
3 June 2020	13.86	13.21	13.88	13.00	13.00
4 June 2020	11.33	9.32	9.37	9.20	9.16
5 June 2020	6.19	6.58	6.10	5.77	5.86
6 June 2020	9.59	9.84	9.75	9.70	9.00
7 June 2020	10.66	9.07	9.60	8.88	9.21
8 June 2020	7.8	7.31	7.41	6.38	6.54
9 June 2020	5.99	5.80	5.76	5.24	5.16
10 June 2020	7.67	6.72	5.84	5.66	5.98
11 June 2020	9.26	9.16	8.84	8.51	8.32
12 June 2020	8.66	8.13	8.21	8.45	7.72
13 June 2020	5.99	6.49	6.74	7.18	7.29
14 June 2020	7.19	7.19	6.94	7.07	7.07
15 June 2020	8.06	7.87	8.21	8.41	7.84
RMSE		<u>0.83</u>	0.88	1.11	1.12
R^2		<u>0.89</u>	0.88	0.81	0.80

RMSE, root mean square error (°C); R^2, determination coefficient. The best results are underlined.

4. Discussion

In this paper, ANNs were used to perform spatial weather forecasts using data measured by SIAR agrometeorological stations in Castilla and León (Spain), one of the largest regions in Europe (94,224 km², where more than half of the area is agricultural land), using meteorological data from both the area near the reference station and the neighbouring areas, which achieved a better performance of the ANN models. Loghmari et al. [21] applied an ANN model using the available meteorological data in the target area with a Recorded Average Relative Root Mean Square Error (ARRMSE) of 6.4%, while the IDW model estimated the global solar radiation measured in nearby areas with an error of 5.11%.

The date set used by Franco et al. [11] to interpolate the values of the most important meteorological variables in agriculture using an ANN was daily precipitation (mm), evapotranspiration ETo (mm), mean daily air temperature (°C), maximum temperature (°C), minimum temperature (°C), mean daily relative humidity (%), maximum relative humidity (%), minimum relative humidity (%), mean wind speed (m/s) and total solar irradiation (MJ/m²) during the summer months (June, July and August) by the same SIAR agrometeorological stations in the territory of Castilla and León, Spain.

In this paper, ANN models are performed independently for each daily variable studied (global solar irradiation, and maximum, average and minimum temperatures) from the geographic coordinates [longitude and latitude] of the location to be estimated, achieving better performance in RMSE values (1.04 MJ/m^2, 0.68 °C, 0.58 °C, and 0.83 °C, respectively), compared to the ANN models. Franco et al. [11] simultaneously analyzed in the same ANN, ten meteorological variables, during the summer months, obtaining RMSE values of 1.63 MJ/m^2, 1.28 °C, 0.99 °C, and 1.55 °C, respectively, for the same variables.

5. Conclusions

Precision agriculture can improve the performance of crops, and thus increase agricultural productivity, by considering a precise knowledge of the meteorological variables that affect them in their development. The number of agrometeorological station networks is increasing, but it is still interesting to have data from the specific location of the crops, which can be obtained by interpolating the data measured by the agrometeorological station network. Strong et al. [36] assessed and evaluated the barriers to the adoption of smart agriculture through the Internet of Things (IoT) among Brazilian farmers in the Rio Grande do Sul, where they found that elements such as compatibility, complexity, testability, and visibility were the predictors of farmers' adoption of innovative solutions. As for ANN models, they were analyzed in this paper to describe the importance of their application for the adoption of climate-smart agriculture.

Kilelu et al. [37] carried out a report on the development of enterprises providing agricultural services in the context of the transformation of agricultural value chains and food systems in the dairy sector in Kenya, where they have the potential to provide innovation support to entrepreneurial farmers as well as contribute to the sustainable growth of the sector.

In this article, ANN models were used to interpolate the data measured daily by the SIAR network of agrometeorological stations in the Region of Castilla and León (Spain) for several meteorological variables: global solar irradiation, maximum, average and minimum temperatures, from the geographical coordinates of the location where the interpolation was carried out, by means of an ANN model for each of the variables studied. This study uses meteorological data available in the target region (areas close to the reference station) and in neighbouring regions (areas far from the reference station). The possibility of having synthetic meteorological data that best represent the local meteorology at each place and time is therefore very important to be able to apply advanced agricultural forecasting techniques that, for example, are related to the knowledge of the phenological behaviour of plants of productive interest, to the prediction of the necessary irrigation doses and the incidence of pests and diseases, or to the estimation of the potential product of the crops [38–40].

The results obtained from this study are more successful than those obtained previously for the same SIAR network by applying a single ANN model for all meteorological variables (10 variables). The key to this improvement in results is the use of more simplified and simpler ANN models, which provide a more accurate ANN (Occam's razor).

In addition, the results obtained from the VWS in this study can be applied to make the prediction, at the same location, of the global solar irradiation of the next day with the ANN models developed by Diez et al. [34], and to estimate the hourly distribution of the ambient temperature, during the 24 h of the day, with the ANN models developed by Diez et al. [35], as well as the prediction of the values, for the next day, of the temperature (maximum, average and minimum).

Future studies that develop these ANN models for the interpolation of meteorological variables from geographic coordinates for crop production could include a predictor variable that directly affects the variable to be estimated (in a sloping terrain, its orientation to interpolate solar irradiation, or in the case of temperatures, the type of vegetation cover) that would increase the accuracy of the ANN models.

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Nomenclature

ANN	Artificial Neural Network
ARRMSE	Average Relative Root Mean Square
BP-LM	Back-Propagation Levenberg–Marquardt algorithm
CGAN	Conditional Generative Adversarial Networks
DIDW	Dual Inverse Distance Weighting
ETo	Evapotranspiration
GAM	Generalized Additive Regression
GCM	General Circulation Models
GIS	Geographic Information System
IDW	Inverse Distance Weighting
IoT	Internet of Things
ITACyL	Agricultural Technological Institute in Castilla and León (Instituto Tecnológico Agrario de Castilla y León, in Spanish)
LR	Linear Regression
LSDV	Least Squares Dummy Variable
mamsl	meters above mean sea level
MARS	Monitoring Agriculture with Remote Sensing
MCYFS	MARS Crop Yield Forecasting System
MLP	Multilayer Feed-forward Perceptron
MLR	Multivariate Linear Regression
OCK	Ordinary Co-Kriging
OK	Ordinary Kriging
OLI	Operational land imager
RF	Random Forest
RMSE	Root Mean Square Error
R^2	Coefficient of determination
SIAR	Agro-climatic Information System for Irrigation (Sistema de Información para el Asesoramiento al Riego, in Spanish)
SIDW	Semantics Inverse Distance Weighting
TIRS	Thermal infrared sensor
SIM	Spatial Interpolation Methods
VWS	Virtual Weather Station.

Appendix A

Appendix A shows the information (altitude, latitude and longitude) of the 54 agrometeorological stations belonging to the Agro-climatic Information System for Irrigation (SIAR) InfoRiego [32], located in the nine provinces of Castilla and León Region, Spain, in Table A1.

Table A1. Location of the 54 agrometeorological stations belonging to the Agro-climatic Information System for Irrigation (SIAR) located in Castilla and León Region, Spain.

Province	Location	Altitude (mamsl)	Latitude (°)	Longitude (°)
Ávila	Nava de Arévalo	921	40.997	−4.765
Ávila	Muñogalindo	1128	40.597	−4.905
Ávila	Losar del Barco	1027	40.397	−5.535
Burgos	Valle de Losa	635	42.988	−3.220
Burgos	Condado de Treviño	551	42.719	−2.690
Burgos	Valle de Valdelucio	975	42.724	−4.081
Burgos	Lerma	840	41.987	−3.763
Burgos	Tardajos	770	42.353	−3.814
Burgos	Vadocondes	870	41.628	−3.573
Burgos	Santa Gadea del Cid	520	42.684	−3.108
León	Carracedelo	467	42.550	−6.733
León	Mansilla Mayor	791	42.512	−5.446
León	Cubillas de los Oteros	777	42.378	−5.511
León	Zotes del Páramo	779	42.265	−5.731
León	Quintana del Marco	750	42.201	−5.862
León	Hospital de Órbigo	835	42.463	−5.883
León	Bustillo del Páramo	874	42.439	−5.800
León	Sahagún	856	42.369	−5.006
León	Santas Martas	885	42.453	−5.362
Palencia	Torquemada	868	42.039	−4.300
Palencia	Villaeles de Valdavia	881	42.576	−4.558
Palencia	Villamuriel del Cerrato	750	41.952	−4.508
Palencia	Fuentes de Nava	744	42.090	−4.767
Palencia	Villoldo	817	42.256	−4.598
Palencia	Herrera de Pisuerga	821	42.549	−4.311
Palencia	Villaluenga de la Vega	927	42.525	−4.776
Palencia	Lantadilla	798	42.336	−4.300
Salamanca	Ciudad Rodrigo	635	40.618	−6.492
Salamanca	Arabayona	850	41.047	−5.393
Salamanca	Ejeme	812	40.769	−5.525
Salamanca	Aldearrubia	815	41.004	−5.493
Segovia	Gomezserracín	870	41.287	−4.299
Segovia	Navas de la Asunción	822	41.141	−4.486
Soria	Almazán	943	41.483	−2.556
Soria	Hinojosa del Campo	1043	41.743	−2.081
Soria	San Esteban de Gormaz	855	41.535	−3.220
Soria	Fuentecantos	1063	41.843	−2.434
Valladolid	Mayorga	748	42.172	−5.300
Valladolid	Finca Zamadueñas	714	41.626	−4.740
Valladolid	Medina del Campo	724	41.320	−4.904
Valladolid	Rueda	700	41.385	−4.968
Valladolid	Villalón de Campos	788	42.100	−5.034
Valladolid	Torrecilla de la Orden	793	41.219	−5.267
Valladolid	Olmedo	750	41.292	−4.717
Valladolid	Encinas de Esguevas	816	41.754	−4.091
Valladolid	Tordesillas	658	41.509	−4.989
Valladolid	Valbuena de Duero	756	41.662	−4.284
Valladolid	Medina de Rioseco	739	41.889	−5.030
Zamora	Colinas de Trasmonte	709	42.014	−5.821
Zamora	Villaralbo	659	41.497	−5.670
Zamora	Villalpando	701	41.825	−5.406
Zamora	Pozuelo de Tábara	714	41.780	−5.907
Zamora	Barcial del Barco	738	41.935	−5.644
Zamora	Toro	623	41.489	−5.470

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3. DISCUSSION

The present thesis aims to ensure a better understanding of contemporary dynamics in the integration of urban agriculture in different countries, notably in a descriptive and comparative way between the cities, by examining the role and benefits of these urban practices for the city and its citizens on the one hand, and by defining the relationships between local authorities, project leaders and citizens (a very important factor in the success or failure of these projects) on the other, as well as analyzing and seeing whether what has been done on the ground reflects what is intended by local authorities, and whether there is any complementarity in this. By integrating the theoretical perspectives of polycentric governance, social practice theory and other qualitative and quantitative analytical models, the research defines the circumstances in which the development, emergence and sustainability of urban agriculture projects are possible in distinct institutional, economic and socio-political contexts.

The research is based on case studies of urban agriculture in Spain and France: the cities of Rouen, Paris and Le Havre in France, and the cities of Segovia and Valladolid in Spain. These two countries, although located in high-income countries and facing the same urban dynamics (land pressure, climate problems, citizen participation), differ in terms of urban policies and institutional recognition of urban agriculture. These countries were chosen because they are characterized by the importance of their vast areas dedicated to agricultural activities and by continued urban support from local authorities [50,51]. Indeed, the actions of local authorities in relation to UA projects are increasingly developed, as they have a more focused and futuristic vision of future projects [52], and this, due to land pressure and the significantly low level of food self-sufficiency (for example, only around 10.6% at the Rouen metropolis in France) [53]. All these aspects underline the need for a thorough assessment of the feasibility of implementing urban agriculture projects even in the most developed countries of the world at its various levels of governance, by analyzing the structural factors influencing its application, their present and future impacts and the weaknesses and limitations encountered, and therefore the need to address these aspects in this doctoral thesis, in order to ensure a healthier and more sustainable future.

In France, urban agriculture is emerging from the bottom up, driven mainly by citizens' associations and militant environmental and social groups. However, the role of public authorities remains very important, helping them to better manage their projects, support them financially and monitor their development. Moreover, even some municipal programs pave the way for access to land and logistical support. Indeed, this is aligned with the findings of Tornaghi and Certomà in 2019 and by Tornaghi in 2014, where their investigation has been done in different countries notably in Europe and North America, and which recognizes the need to ensure a militant and political bottom-up dynamic, while highlighting growing interactions with public authorities, notably through forms of negotiation and critical involvement [54,55]. On the other hand, in Spain, urban agriculture is distinguished by a voluntary public policy, where municipalities create and propose projects and call on interested parties to join them. In this sense, the investigation done by Campbell is fully aligned as it describes how urban agriculture has gradually joined the political agenda of New York City, showing the willingness of local authorities to integrate urban agriculture into urban planning [56]. Reflecting these outcomes, it is revealing to observe here that the urban agricultural cases in France and Spain have emphasized the different patterns of community mobilization and

governance in urban agriculture projects. In France, the dominant role is assumed by local authorities, while in Spain there is a more active citizen movement, with varying degrees of incorporation into urban policies. The analysis of these results highlights' differences in the way national institutional frameworks structure the possibilities for polycentric governance of sustainable transitions, where it can be deduced that in France, early institutional support favors vertical coordination, while in Spain, governance is often more horizontal and based on citizen engagement. In both cases, it is necessary to emphasize that both countries benefit from local authority support, whether continuous or not.

The findings of this doctoral thesis emphasized that urban agriculture is integrated into the urban planning of the cases evaluated, notably through the creation of territorial food plans and institutionalized coordination with certain local stakeholders. Indeed, this has been mentioned by several authors and found in different researches, where in 2024, Horst et al. highlighted the growing links between agriculture, food justice and planning policies [57], along with the findings of Ilieva in 2016, analyzing how cities are building territorial food plans, while integrating the way they institutionalize coordination between municipalities and local stakeholders to structure an integrated food policy, thereby integrating urban agriculture as a key component [58]. The increasingly progressive integration of urban agriculture into urban planning policies reveals a growing recognition of its multifunctionality as an element of urban policies for sustainable cities.

The implementation of urban agricultural projects within the cities ensure the realization of different benefices, where the results from the different investigations have shown that urban agriculture is becoming a multidimensional solution to many of the current problems, going far beyond mere food production. Its benefits can be felt at the individual, community and territorial levels, making it an important tool for sustainable development, and which are all aligned with the sustainable development goals (SDG) [59]:

- Social aspect, urban agriculture makes it possible to strengthen social cohesion, reduce segregation and reclaim urban spaces. It creates spaces for encounters, for the exchange of knowledge and for solidarity between generations, as well as for the integration of often marginalized groups, all in line with the social cohesion objectives of SDG 10. In fact, this has also been confirmed by Stefani et al., in 2018, highlighting supporting arguments on the role of urban agriculture in strengthening social ties, reducing exclusion, encouraging the redevelopment of unused or abundant urban spaces and promoting socio-professional integration [60].
- Environmental aspect, the results of this thesis have also shown that urban agriculture makes cities more resilient to climate change, by encouraging vegetation, reducing urban heat islands, improving rainwater infiltration and contributing to biodiversity in dense urban areas. Indeed, this is fully in line with SDG13, representing the fight against climate change, and SDG15, helping to sustain life on earth. Another important point about the effect of urban agriculture on the environmental side of the city is that the use of agroecological practices promotes the transition to more sustainable food systems (SDG12). This has also been emphasized by Lin et al., in 2017, emphasizing that urban

agriculture promotes to get sustainable cities while ensuring a deep protection of the environment, along with the protection of the biodiversity [61].

- Economic aspect, even if urban agriculture often remains a non-profit operation, it can nevertheless make a significant contribution to local food security, enabling many households to diversify their diet or cope with rising prices, while reducing dependence on long and vulnerable supply chains, especially in periods of economic crisis. This is a fundamental role in the context of both SDG 2 (Zero Hunger) and SDG 11 (Sustainable Cities). Indeed, these findings have also been found in 2020 by Lal, demonstrating the economic importance of creating such areas within cities, which has now become crucial to the economic and food resilience of urban households, and has acquired even greater prominence in the current context of the global health crisis [62].

From these insights and analysis, there is clear evidence that urban agriculture responds to very profound questions related to urban resilience, sustainable management of natural resources and climate regulation within cities. This explains the reason behind institutional stakeholders' growing recognition of urban agriculture as an essential policy tool for strategies of ecological transformation and climate change mitigation, underlining the importance of a well-defined policy approach focused on the involvement of urban agriculture projects.

It should be noted that the finding of this thesis underlines the crucial role of local authorities in the organization and planning of urban agriculture programs. As guarantors of urban planning and land use, they provide an essential regulatory framework, funding and technical support. The case studies conducted in France and Spain show that their active involvement, notably through the formulation of specific public policies and coordination with project developers, is essential to success. In so doing, they strengthen polycentric governance by enabling these stakeholders to engage in dialogue and ensure that projects are extended and pursued. Their role goes beyond that of regulation to become a genuine joint builder in the implementation of sustainable urban food systems. This has also been demonstrated by Marini et al. in 2023, analyzing how local policies are effectively organizing, planning and supporting different types of urban agriculture in several European cities, while highlighting their necessity for long-term viability [63]. Indeed, beyond the objective of food production, policies reveal an institutional interest in using urban agriculture to address a variety of challenges: climate resilience, social cohesion, development of vacant land, ecological soil management and inhabitants' health. This inclusion in planning strategies aims to localize, legitimize and even activate processes that often emanate from local stakeholders, with the guarantee of a certain coherence with broader territorial strategies for sustainable transition. However, this institutionalization can be a source of tension when it conflicts with the logic and temporality of local processes involving citizens.

This research presents certain limitations that are worth mentioning. Firstly, the study focused on case studies in selected cities, which gave a generalized perspective of urban agriculture in these cities and, more generally, in the countries to which they belong. Indeed, in this thesis, the case studies were complemented by the involvement of local authorities, leading to the conclusions and results presented above. Therefore, additional cases could help to obtain a clearer overall situation based on a larger number of urban agriculture cases. In addition, it

should be noted that one of the limitations is the time constraint, since the evaluation of the study cases was carried out at a specific point in time that may or may not be appropriate for the specific project. In fact, some study cases were evaluated more than once to obtain more concrete details and a more complete assessment over the years. This method should be applied more frequently for each urban practice, to assess the evolution and viability of projects at different stages. As with most qualitative research, some of the findings of this thesis rely primarily on the perceptions and self-reports of our stakeholders. While subjective reports provide rich and detailed descriptions of the practices and dynamics under study, they are also subject to personal biases developed through personal experiences. While this subjectivity is a necessary element of qualitative methods and does not intrinsically devalue the quality of the data, it can represent an influence on the results.

Finally, it should be emphasized that the long-term viability of urban agriculture initiatives depends on the synthesis of many variables, from governance structures to coordination between stakeholders, and the project itself [64]. It is therefore essential to strengthen multi-stakeholder governance, with municipal governments seeking flexible and supportive policies that encourage experimentation while consolidating institutional stability. In addition, it is necessary to delimit the areas in which urban agriculture projects are to be implemented, and to ensure the security required for long-term investments. Local authorities need to provide ongoing, periodic training for all project members, to enable them to enhance their skills and facilitate exchanges and networking, since facilitating exchanges between projects makes it possible to share best practices, learn from each other and solve problems together. Regarding project leaders, they need to organize more proactive actions and participate in regional and national projects, without forgetting the need to keep in touch with urban planners, in order to obtain political and societal support and thus ensure the sustainability of projects. All these aspects should be taken into consideration in present and future research, as the results found in the articles of this doctoral thesis provide a solid framework and basis for future studies on both a national and international scale.

4. CONCLUSIONS

This doctoral research, based on numerous peer-reviewed scientific articles in high-impact journals, produced a series of fundamental conclusions on the implementation, governance and long-term viability of urban agriculture projects. This thesis first examined the presence or absence of such projects through a systematic literature review, as well as assessing the relationship between institutional frameworks and citizen initiatives through a comprehensive and in-depth methodology combining multiple case studies and interviews with local authorities, project leaders and civil society organizations operating in different territories, as well as an internationally distributed questionnaire, and continuous and in-depth fieldwork. To summarize, this thesis provides the following key contributions:

1. **Urban agriculture as a multidimensional force for urban change:** The research findings confirm that urban agriculture is an important driver of ecological, social and economic change in cities in the modern world. In addition to the cultivation of food products, urban agriculture helps to redesign urban processes. Cases from France and Spain show how civil society initiatives, supported by local institutions, foster territorial resilience and contribute to sustainable lifestyles.

2. **The success of urban agriculture initiatives depends on an effective synergy between citizen action and institutional involvement:** The results from the research articles and investigation have shown that the success of urban agriculture initiatives depends on an effective synergy between citizen action and institutional involvement. Indeed, citizens are generally the driving force behind initiatives, but the commitment of local authorities is decisive for their sustainability, financing and professionalization. Effective cooperation creates a healthy environment for the development of strong, innovative initiatives.

3. **Urban agriculture contributes to strengthening social cohesion and promote a more sustainable management of urban space:** beyond its agricultural functions, urban agriculture is a key factor in rebuilding social cohesion and the efficient management of urban space for the common good. The projects investigated in France and Spain demonstrate their ability to create spaces for intergenerational dialogue, sociability and solidarity, hence the importance of urban agriculture for social cohesion and the sustainable use of space.

4. **Significant commitment to sustainable development goals:** The projects analyzed correlate perfectly with the Sustainable Development Goals, in particular the eradication of social inequalities (SDG 10), food security (SDG 2) and the creation of inclusive, sustainable cities (SDG 11). These projects demonstrate their ability to meet environmental, social and economic challenges, and make urban agriculture a lever for territorial change.

5. **Structural and economic obstacles to implementation:** The study highlights a number of recurring constraints, such as limited access to land, complex regulations and uncertainty about the quality of urban soils. In addition, financial dependence on subsidies and the economic vulnerability of initiatives are major obstacles to their long-term viability, as shown by the French and Spanish cases.

6. **Polycentric governance, a new model for resilience:** Research highlights the importance of polycentric governance, involving a variety of stakeholders -

associations, local authorities, private actors - to coordinate and finance projects. It fosters the joint production of resources and knowledge, reinforces democratic participation and territorial governance, and provides an appropriate context for considering the complexities of urban agriculture projects.

7. **Institutional integration into public policies to guarantee the long-term sustainability of projects:** Urban agriculture must be integrated into local public policies in all jurisdictions and regulated by local authorities. In fact, the cases evaluated in France and Spain, along with the questionnaire carried out worldwide, demonstrate that institutional integration enables projects to be organized, legitimized and supported over the long term. This is a key to building resilient, inclusive and sustainable cities, capable of meeting the food, social and environmental challenges of present and future generations.

Potential research trajectories

On the basis of the findings and results obtained throughout this doctoral thesis, several potential avenues of investigation can be identified. These avenues of research are designed to further improve the understanding of the phenomena examined, to expand the body of knowledge in as yet unexplored areas, and to pursue new questions raised by the current investigation:

- *Strengthen international comparative research on the integration of urban agriculture projects:* In order to better understand the dynamics of urban agriculture, studies should be extended to other cities in other parts of the world, perhaps starting with the rest of the Mediterranean countries, in order to gain a global and comparative perspective on urban agriculture in these countries. This extension would make it possible to integrate other models of governance, social innovation and integration in cities, and to test the transferability of the results of the French and Spanish results. This comparative study would highlight very concrete contextual levers that promote or hinder the development of sustainable urban agriculture.

- *Investigate how urban territorial policies can relate to urban agriculture practices:* It would be necessary to take a closer look at urban planning, land management and the financing of urban agriculture initiatives, both by urban planners and by national governments. This research could be based on longitudinal observation of existing projects, an effort to assess their sustainability, their ability to respond to urban transformation and their actual effect on regional food resilience.

- *Assessing the real socio-economic benefit of urban agriculture initiatives for vulnerable populations:* A promising approach would be to develop rigorous methodologies to measure the concrete impacts of urban agriculture projects in reducing inequalities, promoting social inclusion and creating local employment. Such a study could attempt to combine quantitative and qualitative investigations in several neighborhoods, with the aim of better understanding how these projects contribute to strengthening social and economic cohesion, particularly in priority areas and among vulnerable populations.

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