

Article

Introducing Agroforestry into Urban Planning: A Procedural Approach for Italian Cities

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Abstract

This study aimed at developing a procedural approach to introduce agroforestry in urban planning and to provide governance orientation. The proposed approach focused on understanding: (i) the key stakeholders that can promote agroforestry; (ii) their orientations towards the integration of agroforestry in urban planning documents; and (iii) the most suitable urban planning documents in which agroforestry-sound norms can be incorporated. The approach was tested in the town of Sesto Fiorentino, in Central Italy. A total of 170 stakeholders among municipal officials, schoolteachers, farmers, gardeners, citizens frequenting city parks, associations, and researchers were identified and involved in a questionnaire-based survey. The results showed that respondents opted for gradually introducing agroforestry in the green infrastructure. Educational food forests and alley cropping were preferred as the most suitable agroforestry elements in urban and peri-urban contexts. The municipality was considered a pivotal actor for introducing agroforestry, also involving associations and citizens in a multistakeholder perspective. Decision makers introduced agroforestry in city technical implementation standards, equating it to urban forestry. However, no mention was made in the city development plan as urban planners were reluctant to incorporate agroforestry at the strategic level. Associations may facilitate municipalities in this sense and assist in implementing agroforestry-sound norms.

Keywords: edible landscapes; policy framework; urban forestry; sustainable cities; urban agriculture



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1. Introduction

Urban green spaces play a key role in assuring quality of life for city dwellers by providing several benefits such as food production, climate regulation and heat mitigation, biodiversity conservation, social cohesion, aesthetic, recreational and cultural services [1,2]. However, the increasing land exploitation due to urbanization threatens the establishment of new green areas and decreases the productive agricultural surface in the peri-urban belts [3]. At the same time, municipalities face different challenges. On the one hand, peri-urban areas are under increasing pressure to provide productive land capable of supporting urban food systems; on the other hand, they are expected to create social and economic

opportunities for local communities [4]. In this regard, urban agriculture, defined as food production within or on the fringe of cities, offers a valuable means to strengthen local value chains, diversify food and non-food products, and enhance the circulation of human, material, and service resources within urban areas [5]. There are many models of urban agriculture that can be applied and the attention by policymakers and urban planners towards pathways that contribute to feeding the urban population and making healthier and more sustainable cities is definitely increasing [6].

Alongside urban agriculture, an ever-growing body of literature has highlighted the role of agroforestry in urban and peri-urban settings to address the above-mentioned issues [7–10]. According to Nair [11], agroforestry is defined as the deliberate integration of trees with agricultural crops and/or animals either simultaneously or sequentially in the same land unit as a multifunctional practice that integrates trees, crops, and other productive components to enhance both ecological and social outcomes. In temperate areas, Alavapati and Mosquera Losada [12,13] included windbreaks, alley cropping, silvo-pasture, riparian buffers and forest farming in agroforestry. By diversifying urban food systems, agroforestry improves soil health, regulates microclimates, supports biodiversity, and contributes to carbon sequestration and stormwater management. Beyond its environmental functions, it strengthens community engagement and fosters landscape connectivity between urban and peri-urban areas. As such, urban agroforestry constitutes a nature-based solution that advances resilient, productive, and socially inclusive cities [14]. In this paper, the urban and peri-urban agroforestry (UPAF) definition provided by Borelli [15] was adopted: urban and peri-urban agroforestry systems—associated with the integration of urban food systems into urban planning—that can support the improvement of urban sustainability and resilience, particularly in terms of enhancement of urban ecosystem services provision and urban communities' livelihoods. Among the practices that can be implemented in UPAF, we included those listed by Alavapati and Mosquera-Losada [12,13], i.e., windbreaks, alley cropping, silvo-pasture, riparian buffers and forest farming—as well as underplanted orchards and food forests [7]. The latter are tree-based edible systems structured on multiple layers and composed of trees, shrubs, herbaceous crops, vines, ground cover plants and root crops [16].

UPAF [15] can be considered as a complementary management option to urban agriculture and urban forestry for urban green infrastructure (UGI). Despite recent favourable policy context and growing academic interest, UPAF suffers a substantial lack of presence in cities' strategies and practices [17,18]. In the literature, many studies have focused on urban food forests in urban planning and regulations, such as in the USA [19], and in Europe (i.e., in the Netherlands, Slovenia and Sweden) [20–22]. Conversely, few research studies considered governance and planning implications for introducing agroforestry in urban contexts. Kowalski [23] and Kowalski and Conway [24], analyzing the integration and governance of food trees in Canadian urban forest plans, underlined as major drivers the increase in biodiversity and the role of associations and “site champions” who promoted the inclusion of fruit-bearing trees into planning tools. The importance of grass-roots organizations was confirmed by Riolo [25]. Similarly, Focacci [26] underlined the relevance of so-called “knowledge hubs”—associations, universities and research centres—in favouring the introduction of UPAF in voluntary planning tools such as green technical regulations. In the Netherlands, the Ministry of Agriculture, Nature and Food Quality (2020) has recently published the National Forest Strategy [27], wherein the government aims to have 25,000 ha of agroforestry and 1000 ha of food forests specifically by 2030. In Serbia, Živanović Miljković and Crnčević [28] found that agroforestry in general does not have a legal and planning basis to be applied in a systematic and organized way, despite the potential to be integrated in many different forms. Therefore, it is important that spatial and

urban planning consider the value of urban agroforestry, even if economically less valuable, primarily in terms of food production, as well as micro- and meso-climate improvements. In Italy, following and accompanying the Picasso Food Forest experience, the municipality of the city of Parma included a food forest in the technical green regulations and in the strategic green plan [25] as a UGI management option. However, there is a consistent knowledge gap about how to connect spatial planning and governance models to UPAF at the urban level. Hence, the aim of the present study is to develop a procedural approach for introducing UPAF in urban planning and for contributing to providing governance orientations. The approach focused on understanding: (i) the key stakeholders that can promote agroforestry in urban contexts; (ii) the orientations and perceptions of stakeholders towards the integration of agroforestry in urban planning documents; and (iii) the most suitable planning documents in which agroforestry-sound norms can be incorporated. This approach was tested in the case study of the town of Sesto Fiorentino in Tuscany, Italy.

2. Materials and Methods

2.1. Study Area

The town of Sesto Fiorentino (43°50' N; 11°12' E) belongs to the metropolitan city of Florence, Tuscany Region, in Central Italy (Figure 1). This settlement was chosen as the study area since it gathers in its territory several characteristics that are normally scattered among Italian municipalities. From the orographic point of view, it presents both mountainous, hilly and plain areas, whereas Italian municipalities normally have one or two altimetric zones [29]. The land uses are distributed as follows: 40.6% forest, 30.9% agriculture, 27.2% built-up area, and 1.3% wetland. The population is 49,147 inhabitants [30] and according to OECD classification [31], it falls in the medium-size cities category, but very close to the lower limit for large-size cities (population > 50,000 inhabitants). In terms of urbanization degree, the Sesto Fiorentino municipality is included in the class of “small cities and suburbs” [32] and it is part of the metropolitan area of Florence, facing its urban sprawl pressure.

Rural areas are characterized by olive production on hill slopes, while in the alluvial plain cereals are intensively cultivated in large fields in rotation with sunflower and canola. Likewise, in other Italian plains [33], until 1960 the landscape was fragmented into plots of land where agroforestry was extensively practiced. Some traces of these features are represented by mulberry hedges, which were mainly cultivated to integrate the family's income by silk cocoon sale. On the contrary, in the hilly part, the landscape preserved the terraced olive orchards typical of Central and Southern Italy [34]. Public parks are well distributed in the town, accounting for around 9% of the total urbanized area.

2.2. Procedural Approach

The municipality of Sesto Fiorentino started the process for a new city development plan in July 2020 (Figure 2). Restrictions due to the COVID-19 pandemic emergency hampered the participatory process that took place in a reduced form in 2021–2022. In January 2023, the first version of the new plan was released, and a period of three months was made available for citizens to submit proposed amendments. Between January and April 2024, official approvals/denials on proposed modifications were ratified by the city council and the final version of the new city development plan was eventually approved in May 2024.

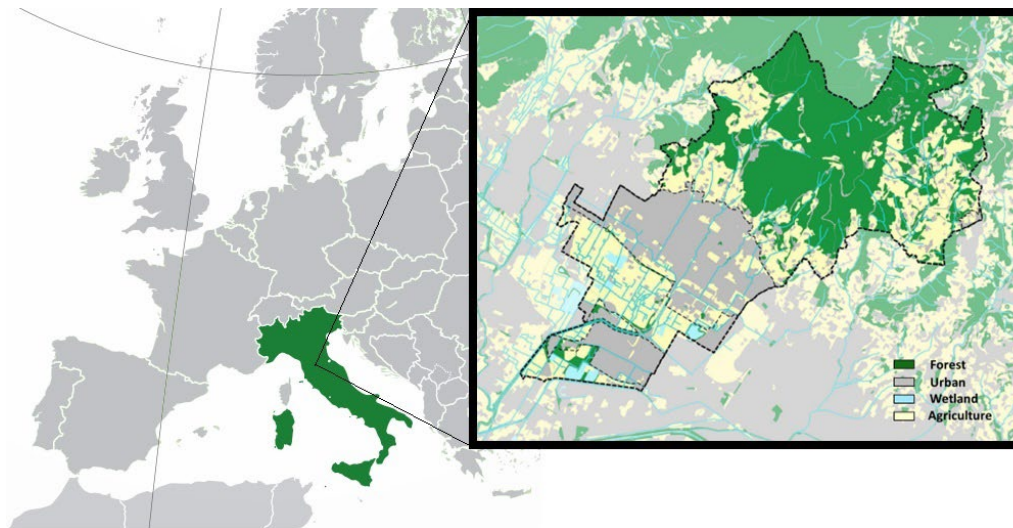


Figure 1. Land use in the study area (Sesto Fiorentino town, Italy) from the municipal Operative Plan [35].

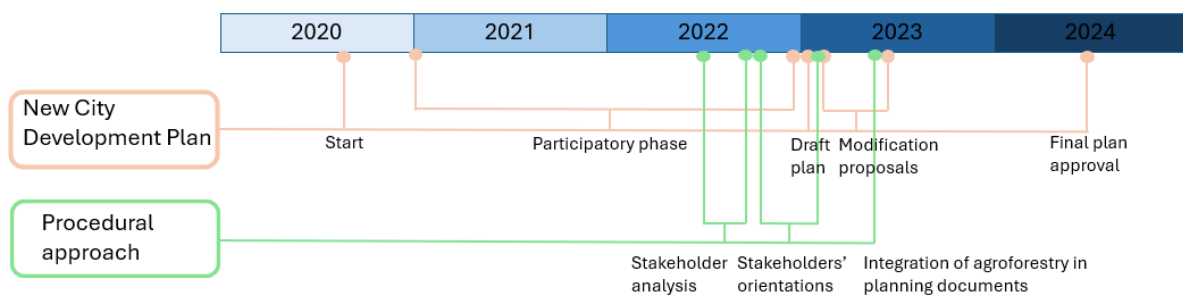


Figure 2. Flowchart of the timeline for the approval of the new city development plan in the Sesto Fiorentino town and the proposed procedural approach for introducing agroforestry-sound norms.

Within this framework, in April 2022, the authors had their first meeting with local policymakers belonging to the planning and green departments aimed at presenting agroforestry as an innovative option to be incorporated into UGI.

Introducing agroforestry into city policies requires a gradual approach considering its novelty for both agricultural and urban contexts. Hence, agroforestry-sound norms should be included in a flexible manner considering the peculiarities of each specific urban environment. The proposed procedural approach is structured into three steps: (i) analyzing the categories of local stakeholders that may have a direct or indirect role in supporting UPAF; (ii) understanding stakeholders' awareness and orientations regarding the possibility to introduce agroforestry in urban policies; and (iii) revising in-force urban planning documents and integrating them with agroforestry-sound norms.

Step 1: Identification of stakeholders

The literature review and meetings with the local policymakers permitted us to find out the main stakeholders' categories relevant for UPAF. Through the literature review, the criteria to be used to identify and categorize stakeholders were chosen. The results of the literature review highlighted a broad set of possible criteria to be used for stakeholder analysis, such as proximity, interest, influence, power, legitimacy, level of knowledge, and urgency [36,37]. Based on the objectives of this study and the context (agroforestry at municipal level), the following three criteria were chosen: level of knowledge, power and influence. Power is considered the potential to influence and is a basic force in social relationships [38], while influence can be considered the exercise of power [39]. During the meetings, the research team, with the support of the local policymakers, prepared a

preliminary list of potential stakeholders. Subsequently, a stakeholder analysis matrix was elaborated according to Al Mamun [40] to assess actors' level of knowledge, their potential involvement and supposed interest in agroforestry, their power to directly introduce agroforestry practices in the city and their influence in the planning processes. Rankings were attributed based on researchers' knowledge of UPAF [22,25] combined with relevant papers describing the importance and roles of different actors [7,8,23,24]. A 3-point Likert scale (1—low, 2—medium, 3—high) was used to rank the expected level of knowledge, power and influence.

Step 2: Identification of stakeholders' knowledge and interest towards agroforestry

A questionnaire-based survey was successively performed to understand stakeholders' awareness and orientations. The preliminary version of the questionnaire was designed by the research team based on the study objectives and research questions. The first version of the questionnaire was pre-tested in September 2023 with eight inhabitants of the Sesto Fiorentino town to highlight difficulties in understanding the questions and the use of misinterpreted terms. At the end of the pre-test, two questions were simplified, and one question was eliminated because it was considered redundant.

The final version of the questionnaire had the following structure divided into six sections. Section S1, "Stakeholder Information", collected specific data according to different actors (e.g., typology of farm and production for professional farmers). Section S2, "Interest for Urban and Peri-Urban Agroforestry", investigated respondents' choices towards agroforestry. Section S3, "Personal Participation", focused on potential personal engagement towards agroforestry. Section S4, "Suggestions for Urban Agroforestry and Planning", focused on respondents' proposals for the introduction of agroforestry into city policies. Section S5, "Social Network", sought to identify key stakeholders that could facilitate the implementation of agroforestry in the town. Section S6, "Personal information", collected personal data of respondents (Supplementary Materials). Ethical review and approval were not required for this study because the research consisted of an anonymous, non-interventional and minimal-risk survey in which no identifiable or sensitive personal data were collected.

The questionnaire was administered face-to-face with single structured interviews lasting 20 min on average. No personal identifiers or sensitive personal data were collected. Participation was voluntary, and respondents were informed about the aims of the study and about data storage and treatment before providing their responses. Data collection started in October 2023 and ended in January 2023. To set up the meeting, stakeholders were contacted by telephone or email. Gardeners and citizens were directly met in allotment gardens and public parks. The questionnaire used closed-ended questions in the form of multiple choice or, in a few cases, a 3- or 9-point Likert scale format. Cronbach's alpha was used to test reliability, considering that a score between 0.701 and 0.902 can be considered a good indication of internal consistency reliability. In particular, Cronbach's alpha was adopted to validate each area of the questionnaire with special regard to the information collected using Likert scales. The results of Cronbach's alpha showed values between a minimum of 0.736 and a maximum of 0.874. Collected data were processed, analyzed and reported exclusively in aggregate form.

Step 3: Integration of agroforestry in planning documents

The new city development plan comprised four narrative documents and 46 thematic maps. The narrative documents were: (i) Conformity Plan (CP) describing the compliance of the City Plan to hierarchically superior territorial planning; (ii) Strategic Development Plan (SDP) describing the general strategy for the development of the city; (iii) Technical Implementation Standards (TIS) containing the prescriptive norms for urban development;

and (iv) a descriptive document on general city features such as population density by neighbors, road network, etc.

All documents were carefully read and analyzed in order to select the paragraph that had relevance for the management of the UGI. In this way, it was possible to understand to which extent agroforestry could be integrated into norms and strategies. In particular, the study focused on SDP and TIS being the documents with more prescriptive power. In revising and modifying the planning documents, orientations and perceptions of stakeholders emerged from questionnaires (step 2) were taken into consideration and included in the new proposal. A meeting with policy makers was also organized to explain the proposed modification. Then, agroforestry-sound revised documents were officially submitted to the municipality for approval.

2.3. Statistical Analysis

The data collected with the questionnaires were analyzed in aggregate form, preserving the anonymity of the respondents. The main descriptive statistics were calculated for questions that used Likert scales, while for multiple-choice questions, the percentage of frequency distribution (%) was computed. The software XLStat 2020 (Lumivero, Denver, CO, USA) was utilized for this purpose.

Additionally, the Kruskal–Wallis non-parametric tests were used to observe statistically significant differences between categories of stakeholders in reference to the Likert scale format questions.

The Analytic Hierarchy Process (AHP) was incorporated in Section S2 of the questionnaire to understand the orientations for integrating agroforestry into UGI. The AHP is a hierarchical weighted decision analysis method aimed at solving complex decision problems and making accurate decisions and judgments for complex systems [41,42]. This model is composed of three levels in an upside-down hierarchy, namely “goal”, “alternatives” and “criteria” levels. The goal level, at the top, illustrates the decision problem. At the second level, criteria describe the parameters against which alternatives (third level) must be measured. A pairwise comparison is carried out in which the criteria and alternatives are quantified with respect to the goal. A 9-point Likert scale is used to evaluate the intensity of importance in the pairs, ranging from 1 indicating equal importance to 9 indicating an extremely important preference of an option with respect to the other. Each category of stakeholders compared the three agroforestry options (i.e., no agroforestry, medium-intensity agroforestry, high-intensity agroforestry) in pairs according to the following scheme:

Agroforestry option A	9	7	5	3	1	1/3	1/5	1/7	1/9	Agroforestry option B
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The results of the pairwise comparison are reported in a reciprocal matrix where the relative weight is expressed by a_{ij} located on the right side of the diagonal and its reciprocal as $1/a_{ij}$ is on the opposite side of the diagonal.

$$A = (a_{ij}) = \begin{pmatrix} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n \end{pmatrix}$$

In the matrix, the row indicates the relative weight of each agroforestry option (w) with respect to the others. The transpose of the vector of the weights is multiplied by matrix A to obtain the vector represented by $\lambda_{max}w$.

$$(A - \lambda_{max}I)w = 0$$

where λ_{max} is the largest Eigenvalue of matrix A and I is the identity matrix of size n .

Finally, the consistency of respondents' answers was tested by calculating the consistency index (CI) and the consistency ratio (CR) as follows:

$$CI = (\lambda_{max} - n) / (n - 1)$$

$$CR = CI / RI$$

The Random Index (RI) is the expected consistency index obtained from randomly generated comparisons of the same order n . The value of CR should be lower or equal to 0.1 (10%) to have consistency of matrix A .

In the present study, the goal level was intended as the preferred management option by stakeholders, in terms of agroforestry system applied to different green infrastructure typologies. Each stakeholder was associated with a certain UGI typology and was asked to judge among three different management alternatives, namely "no agroforestry", "medium-intensity agroforestry" and "high-intensity agroforestry" options. Successively, at the criteria level, stakeholders assessed the most relevant ecosystem services that the three alternatives could provide. The Superdecisions V2.10[®] software was used for the computation of collected data.

To facilitate respondents, the UGI management options were presented visually. For instance, during the survey of citizens regarding public parks, the following images were shown and compared in pairs (Figure 3):



Figure 3. Visual AHP. Different management options for public parks. Credit: Marco Focacci.

For a detailed listing of agroforestry features associated with different degrees of agroforestry intensity (alternative level), as well as the ecosystem services related to criteria level, see Table 1.

Officials of the municipality were asked to assess in Section S4 of the questionnaire positive and negative aspects of introducing agroforestry into urban planning. A S.W.O.T. analysis was chosen for this purpose since it is potentially able to evaluate all possible factors acting as bottlenecks or opportunities for prioritizing planning and developmental strategies within a certain sector [41].

Table 1. Alternatives and criteria for AHP.

Stakeholder	Goal Level	Criteria Level			Alternative Level		
	Best Management Option	Provisioning Services	Regulating Services	Cultural Services	No Agroforestry	Medium Intensity Agr.	High Intensity Agr.
Official green office	Private and allotment gardens	Food production	Microclimate regulation	Recreational and social value	Standard garden	Garden with fruit tree rows	Food forest
Official green office	Public parks	Food production	Microclimate regulation	Recreational and social value	Park with empty meadow	Meadow with sparse fruit tree	Public food forest
Official school office	Schoolyards	Food production	Biodiversity promotion	Educational value	Empty schoolyard	Didactical agriculture in boxes	Didactical food forest
Gardener	Private and allotment gardens	Food production	Microclimate regulation	Recreational and social value	Standard garden	Garden with fruit tree rows	Food forest
Citizens	Public parks	Food production	Microclimate regulation	Recreational and social value	Standard park with empty meadow	Meadow with sparse fruit tree	Public food forest
Schoolteacher	Schoolyards	Food production	Biodiversity promotion	Educational value	Empty schoolyard	Didactical agriculture in boxes	Didactical food forest
Farmers (hills)	Agricultural land on hills	Food production	Water cycle management	Landscape preservation	Standard olive orchard	Olive orchard and <i>Iris pallida</i> consociation	Olive orchard and vineyard + fruit tree
Farmers (floodplain)	Agricultural land on plain	Food production	Microclimate regulation	Landscape preservation	Standard cereal field	Cereal field with sparse trees	Cereal field in alley cropping system

3. Results

3.1. Identification of Stakeholder Categories

Three categories of stakeholders were identified through the stakeholder analysis matrix (Table 2). The first group was made up of municipal officials of the planning office, as those stakeholders who have the power to introduce agroforestry-sound policies. Knowledge hubs and environmental associations were also included in this group as actors able to assist officials in defining these norms.

Table 2. Stakeholder analysis matrix of actors involved in UPAF.

Stakeholder Category		Degree of Knowledge	Supposed Interest	Involvement	Power	Influence
		Level	Description	Description	Level	Level
Group 1	Officials—city planning dpt.	1	To improve green infrastructure management	Responsible for planning process	1	3
	Knowledge hubs	3	To promote urban agroforestry	Technical and theoretical advice	1	2
	Environmental associations	2	To promote urban agroforestry	Facilitator and technical advice Possible availability of land for urban agroforestry	1/3	2

Table 2. *Cont.*

Stakeholder Category		Degree of Knowledge	Supposed Interest	Involvement	Power	Influence
		Level	Description	Description	Level	Level
Group 2	Officials—urban green dpt.	2	To improve green infrastructure	Introduction of food forests in public parks Rules for introducing agroforestry elements in allotment gardens Technical contribution for urban planning dpt.	3	2
	Officials—school dpt.	1	To facilitate new didactical approach	Support to school	2	1
Group 3	Citizens	1	To make public parks more edible	Volunteers for public green maintenance Foraging activities	2	1
	Professional farmers	2	Shift from current productive system	Direct application of agroforestry on their fields	3	1
	Schoolteachers	1	To experiment with new didactical approach	Conceptualization, maintenance and use of school food forest	2	1
	Gardeners	2	To experiment with new cultivation approach	Direct application of agroforestry on their gardens	2	1

The second group comprised municipal officials of the green and school department who do not have the direct authority on the city development plan but have the power to favour agroforestry-sound actions in the municipality or adopt hierarchically inferior planning tools such as green plans or green technical regulations.

The third group was composed of gardeners (connected to private and allotment gardens), citizens (connected to public parks), professional farmers (connected to agricultural land) and schoolteachers (connected to schoolyards) as those stakeholders who might be directly involved in agroforestry practices.

3.2. Stakeholders' Knowledge and Interest Towards Agroforestry

At the end of the questionnaire-based survey, 170 stakeholders were contacted, of which 84% completed the questionnaire. Considering the stakeholder category, the response rate reached a maximum of 100% among officials and a minimum of 69% among professional farmers. Despite the low response rate of these actors, the representativeness of the sample was satisfactory as it covered more than 50% of total professional farmers operating in the municipal territory. The numerosity of the sample changed across the different categories of actors: the highest number of respondents were citizens (50 people), followed by schoolteachers (43), gardeners (21), professional farmers (9), officials of the municipality (9), associations (7), and knowledge hubs (4).

Overall, despite only 25% of respondents having some knowledge of agroforestry, 75% declared to be interested in actively promoting and practicing it. Municipal officials did not know agroforestry as a general concept, nor urban agroforestry. Nonetheless, the totality was willing to deepen their knowledge in this regard by attending specific courses. They were also available to promote UPAF according to their specific areas of competence. Among associations, half of the sample had knowledge of agroforestry, and the totality was interested in actively promoting it. In particular, a recently formed association that is restoring 2.5 ha of land in the urbanized part of the town was willing to establish a community food forest. Other associations were keen on participating in urban agroforestry projects and in supporting schools in managing educational forest gardens. Furthermore,

71.4% of the sample declared that they would advocate for asking the municipality to plant fruit trees and edible bushes in public parks.

Private gardeners located in the plain already spontaneously practiced a form of agroforestry with some consociations among vegetables and fruit trees. Conversely, gardeners cultivating 50 m² allotment gardens reported regulatory issues set by the municipality that hampered the potential adoption of agroforestry, such as the prohibition to plant woody species. Citizens frequenting public parks reported foraging activities in urban and peri-urban areas such as collection of wild herbs (30%), fruits and olives (8%), and mushrooms (4%). Farms were located both in the hilly part and in the plain and ranged from 4 ha to 215 ha. The biggest farm was the most important supplier of bread for local school canteens. This was the result of a farm-to-fork strategy that the municipality has started since 1996 with the creation of a municipalized company aimed at valorising local food producers. None of the respondents implemented agroforestry in their land, nor were they aware of Common Agricultural Policy (CAP) measures dedicated to agroforestry. Schoolteachers were the most interested in actively participating in educational food forests in schools, especially in harvesting vegetables and fruits for some practical activities with pupils, in visiting hypothetical food forests close to the school (67.4%) and using a school food forest for didactical activities such as observation of nature.

The results of AHP showed that the most preferred management option was a medium-intensity agroforestry approach. Officials of the green office assigned the highest weight (priority value of 0.645) for this solution in allotment gardens, followed by schoolteachers in schoolyards (0.551), citizens in public parks (0.549), gardeners in private and allotment gardens (0.424), and officials of the green office in public parks (0.369). In the latter case, the weight assigned to the medium-intensity agroforestry option was slightly above that of high-intensity and no agroforestry ones (0.317 and 0.314, respectively). Officials of the school office and farmers, instead, preferred the high-intensity management alternative, assigning a weight of 0.588 and 0.561, respectively (Table 3).

Table 3. Weights and rankings of green infrastructure management options.

Green Management Option	Citizens/ Public Parks		Officials/ Public Parks		Gardeners/ Private and Allotment Gardens		Officials/ Allotments Gardens		Schoolteachers— Schoolyards		Officials/ Schoolyards		Farmers/ Agricultural Land	
	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank	Weight	Rank
No agroforestry	0.202	3	0.314	3	0.306	2	0.184	2	0.053	3	0.048	3	0.316	2
Medium-intensity agroforestry	0.549	1	0.369	1	0.424	1	0.645	1	0.551	1	0.364	2	0.124	3
High-intensity agroforestry	0.249	2	0.317	2	0.270	3	0.171	3	0.396	2	0.588	1	0.561	1

Comparing the weights assigned by officials and citizens for public parks, a substantial convergence can be observed in preferring sparse fruit trees (0.369 and 0.549, respectively) over food forests (high-intensity alternative) or open meadows without trees (no agroforestry option). A similar trend was found with gardeners, for whom gardens with fruit trees (medium-intensity agroforestry) were preferred to standard gardens (no agroforestry) and food forests (high-intensity agroforestry). However, in this latter case, the no agroforestry option had a better ranking than the high-intensity agroforestry one. While both schoolteachers and officials of the school office agree in rejecting schoolyards without any significant green spot (no agroforestry option) by assigning very low weights (0.053 and 0.048, respectively), schoolteachers clearly preferred a more organized open space with

agricultural activities in boxes (medium-intensity agroforestry), whereas officials tended towards the “wilderness” created by educational food forests (high-intensity agroforestry). Eventually, farmers chose an alley cropping system or olive orchards in consociation with vineyard and fruit trees over no agroforestry option (conventional agricultural management of cereal field or olive orchards) and medium-intensity agroforestry alternative (cereal field with sparse trees or olive orchard with *Iris pallida* consociation), the latter considered the weakest compromise between business-as-usual scenario and new management possibilities. For all comparisons, the consistency ratio (CR) was less than 0.1.

Multiple option questions on the concrete actions that the municipality should carry out for promoting agroforestry provided useful indication on stakeholders’ orientations (Section S4 of the questionnaire). Citizens clearly preferred a strong and direct intervention of the municipality for planting fruit trees and edible bushes in public parks (60%), whose maintenance should preferably be assigned to associations (54%) or citizens (50%). Similarly, about the maintenance of educational food forests, schools asked to be supported by the municipality, which should open public calls for local associations (69.8%). For farmers, the municipality should primarily fund the purchase of fruit trees (55.6%), while gardeners asked for technical training (38%).

The S.W.O.T. analysis (Figure 4) provided similar findings among officials belonging to different departments. The major strengths of agroforestry in public spaces such as parks or schools were the educational and cultural values as well as environmental aspects such as biodiversity conservation and heat islands prevention. Conversely, design, maintenance and lack of funds were the most frequent weaknesses. The opportunity to involve citizens and local associations was an important point; a lack of training for municipal actors and possible injuries were the major risks.

Strengths	Weaknesses
Educational value	Continuity of funds
Cultural value	Design of green space
Biodiversity conservation	Maintenance
Heat islands prevention	
Opportunities	Risks
Urban community involvement	Lack of training
	Injuries for users of green space

Figure 4. S.W.O.T. analysis done by the officials of municipalities regarding positive and negative effects of introducing agroforestry in urban planning.

Respondents were asked, in a 3-point Likert scale format, which actor would be potentially important in facilitating the introduction of agroforestry (Section S5). On average, respondents assigned the highest scores to farmers, municipalities, universities and schools (2.4/3). Among different stakeholders, the non-parametric Kruskal–Wallis test ($\alpha = 0.05$) showed statistically significant differences for grassroots organizations ($p < 0.014$), universities ($p < 0.005$) and schools ($p < 0.001$).

3.3. Introduction of Agroforestry Elements in Planning Documents

In the proposal delivered to the municipal planning office during the three months available for the general public to officially amend the draft plan, agroforestry was inte-

grated in planning documents considering stakeholders' perceptions and opinions. Modifications aimed both at theoretically introducing the definition of agroforestry and providing technical suggestions that could be usefully implemented for UGI management. The most relevant modification proposals regarded the SDP and the TIS. Reflecting stakeholders' opinions who opted for a smooth introduction of UPAF into urban planning, only the definition of agroforestry was included in the SDP: *"The City Development Plan introduces an innovative solution for managing the green infrastructure such as urban agroforestry. This is defined as the consociation, in the same land unit, of perennial woody species with herbaceous crops and/or livestock. Urban agroforestry provides a variety of ecosystem services, from mitigation of urban microclimate to food production and social and recreational functions"*. Silvo-arable, silvo-pastoral systems, and linear edible green infrastructures were also mentioned in this document only in a specific section dedicated to the creation of an Agricultural Park in the peri-urban plain of the town, thus following AHP orientations expressed by farmers: *"In the Agricultural Park, agroforestry constitutes an additional option for land management through the promotion of silvo-arable systems, silvo-pastoral systems, and linear systems, in which hedges, windbreaks or buffer strips at the edges of fields perform a protective function for agro-ecosystems and "defense" for agricultural surfaces"*.

In TIS, agroforestry was primarily suggested in compensation measures in case of new buildings both in rural and urbanized areas: *"Compensation measures aim at improving biodiversity, at establishing agroforestry systems and maintaining linear green hedges"*. Integrations sought also to preserve remains of agroforestry systems in the view of historical landscape conservation and for creating edible green ecological corridors: *"In agricultural areas the conservation or plantation of fruit tree hedges in consociations with edible shrubs and herbaceous crops is envisaged for preserving historic landscape conservation and improving ecologic connectivity"*. Eventually, agroforestry was proposed in the section defining the functions of urban forestry: *"Urban forestry also includes agroforestry interventions, that is, the planting, in the same unit of surface, of fruit trees with shrubs and herbaceous species, aimed at combating climate change, increasing urban and peri-urban biodiversity, mitigating the impacts of territorial infrastructures, and producing zero-mile food"*.

The final step of the entire procedural approach was the formal introduction of agroforestry-sound elements in the final version of planning documents. Once we received the modification proposals, decision makers expressed the need to adopt a prudential approach considering the novelty of this topic. According to this orientation, the municipality did not include the abovementioned modification in the SDP nor in the TIS. Nonetheless, UPAF was integrated in the TIS section *"Criteria for Urban and Environmental Quality"*: *"Agroforestry can be associated to urban forestry. Agroforestry is defined as the presence, in the same land unit, of fruit trees, edible bushes and herbaceous crops. It aims at tackling climate change, improve urban and peri-urban biodiversity, mitigate land exploitation and promote local food production"*. Therefore, in equating agroforestry to forestry, decision makers introduced UPAF in the main articles dedicated to UGI management such as green compensation measures, biodiversity and climate resilience interventions, afforestation, and green belt building.

4. Discussion and Conclusions

4.1. Stakeholders' Opinions and Practical Implementation of Urban Agroforestry

This study sought to apply a procedural approach for introducing agroforestry into urban planning and providing orientations for future governance. The first step of the proposed approach consisted of performing a stakeholder analysis that permitted the identification of key actors, the level of power, influence and interest for designing and implementing agroforestry and outcome-oriented policies [43]. The opinion and perception of agroforestry and its practical implementation by such stakeholders (i.e., citizens, farmers,

municipal officers, schoolteachers and members of associations) were investigated to assess the potential of such a practice in the urban and peri-urban context.

The results of AHP showed that stakeholders mostly chose the medium-intensity management option, which offers diverse habitats and landscapes, but also opted for a gradual introduction of agroforestry in the UGI. This preference suggests a willingness to balance innovation with the preservation of existing urban green space functions. Medium-intensity options may be perceived as easier to manage and socially more acceptable than high-intensity agroforestry systems, allowing the gradual integration of agroforestry into established planning and management practices. From an institutional perspective, these solutions may also be considered more compatible with existing urban governance and regulatory frameworks, thereby reducing potential barriers to their implementation. This result is in line with Bulkeley [44], who argued that transformation mechanisms are complex and involve a gradual and flexible process of learning-by-doing and doing-by-learning, and with the general scepticism in the agricultural sector [45] due to the complexity of work and the difficulties with mechanization despite the well-known positive environmental benefits of the practice. Officials of the planning office underlined a similar attitude in expressing their opinions about the technical, economic and social feasibility of agroforestry applied to different contexts.

Conversely, in the agricultural area located in the plain, agroforestry was recommended as a major management option by responding farmers and gardeners who would like to add more fruit trees to their own private lots.

In some Mediterranean countries, urban agroforestry initiatives are increasing. Most initiatives are tailored for specific contexts and systems, and many include citizens' participation. For instance, the Herdade do Freixo do Meio is an organic, community-run farm in the Alentejo region of southern Portugal applying regenerative agriculture and agroforestry besides the tourism offer [46]. In Spain, the food forest in Alcalá de Henares was initially planned to restore a riparian forest and increase the biodiversity in the peri-urban area [47]. The municipality, which leads and defines the project, has developed an Environmental Education for Sustainability Plan and engages citizens and local associations to volunteer in planting activities, and companies to donate. In addition, it has published environmental guidelines for its use and management. San Sebastian Municipality has also started an initiative of environmental regeneration of green spaces in different areas of the town by transforming them into edible forests to increase the urban resilience to climate change and the citizens' sociality by promoting active participation [48]. In Greece, there are also a few examples of urban agroforestry, such as the one made within the Green Sustainable Path project, which transformed a neglected urban area of Thessaloniki into a thriving food forest and engaged more than 300 participants, municipality workers and youth [49]. In all these initiatives, key factors of success are represented by community engagement and partnership with local communities and associations, but also awareness, education and training.

4.2. Orientations for Future Governance

According to stakeholders' opinions, educational food forests seemed to have the greatest potential for spreading agroforestry in the town, regardless of any specific correspondence in planning documents. Respondents referred to schools as one of the most important players, schoolteachers demonstrated high interest, and officials of the school office opted for the high-intensity agroforestry management option and declared availability of funding, only raising some technical difficulties. The educational relevance highlighted by respondents is in line with Askerlund [50], who stressed how the advantages of gardening are complemented, in terms of didactical opportunities, by those of trees

and bushes. Furthermore, food forests in schools promote ecological literacy [51], thus developing among pupils a sense of connection with natural ecosystems and responsibility for actively preserving life on Earth [52]. The different preferences assigned by officials of the school department and schoolteachers in the AHP analysis (high-intensity agroforestry option versus medium-intensity agroforestry option) testified a positive interest at the institutional level that could lead to possible investments for reshaping the schoolyards with agroforestry-sound interventions. Thus, while this misalignment would not hamper the introduction of agroforestry in school pertinences—a possible pitfall may arise from the school managerial side that could be in contrast with schoolteachers' intentions [53].

Farmers were also indicated as one of the main actors for introducing agroforestry. Despite AHP highlighting a strong interest towards UPAF, none of the respondents acknowledged agroforestry CAP 2023–2027 measures. This result is in line with Chiarabaglio [54] and Chiozzotto [55], who underlined a general failure of agroforestry measures at national and European level also in the previous CAP programs. Both CAP 2007–2013 and CAP 2014–2022 resulted in a limited achievement in terms of total area converted to agroforestry and number of farms involved, likely due to scarce subsidies to cover high initial costs. Moreover, Pisanelli [56] noted that the availability of subsidies does not always automatically promote agroforestry development; a lack of training and conflicts with other CAP measures are obstacles to its adoption. Conversely, market-oriented strategies may provide alternative paths for improving agroforestry among farmers. A positive example comes from the local municipal company for the school canteen, which is the main buyer of the largest farm in the plain of Sesto Fiorentino town. Public procurement processes may orient the production towards agroforestry systems, thereby enhancing ecological connectivity, food production and ecosystem services capacity [57,58]. Additionally, compensation norms of technical implementation standards may enter farm development plans by means of promoting agroforestry practices instead of afforestation interventions.

Interestingly, in public parks, a higher number of citizens referred to foraging behaviours, compared with other cities in the Global North [59,60]. This practice links to the population's interest in sustainability and procuring fresh food from local sources [61]. Hence, sparse fruit tree planting in public green areas, as emerged by AHP, may potentially encounter widespread recognition among city dwellers, thereby excluding concerns on social acceptability [62]. Nonetheless, constraints due to lack of specifications in the green technical regulation may hamper its effective realization. Additionally, officials of green office required to fill a knowledge gap for designing, implementing, and maintaining this new approach in green areas. These burdens—as described in the literature [63–65]—may be overcome with capacity building [18]. This would reduce the risk that the introduction of UPAF would be dependent on a single, engaged person within the municipal organization [66,67]. Then, a multi-stakeholder governance, as suggested by respondents, may be implemented to share visions and raise ownership among different actors.

Our findings expanded on previous studies of Park [68] and Cabral [69] regarding a higher presence of fruit trees in suburban garden plots than in urban allotment estates. In the latter, the introduction of agroforestry appeared quite difficult due to the small size of single plots coupled with the prohibition of planting fruit trees. The convergence between users and officials of the municipality, as suggested by AHP, may suggest updating some rules that hamper the diffusion of agroforestry elements among gardeners as well as designing new allotments with larger plots.

Municipal officials' points of view confirmed previous studies that lack of knowledge [70–72] and budget limitations [73] are important barriers for UGI development. Furthermore, with short municipal budgets, more complex management, such as that of fruit trees in public parks, for instance, may scare municipalities in the view of possible

failures [74] or uncertainty about the delivery of benefits [62]. Nonetheless, acknowledging the importance of citizens and associations, officials opened the way to a multi-stakeholder governance model that could successfully overcome some of these barriers. In particular, the relevance of associations was advocated by many stakeholders for the joint management of educational food forests and for the maintenance of fruit trees and edible bushes in public parks. In a comparative study of seven green infrastructure projects involving municipalities, citizens and associations in Europe, Buijs [75] highlighted that an active collaboration among these actors can help authorities to realize their UGI development goals by complementing a top-down planning approach with bottom-up initiatives. The network of NGOs in the study area comprised both associations not specifically dealing with agroforestry and one grassroots organization interested in establishing a community food forest. This mix of competencies and interests may be functional in promoting agroforestry through: (i) advocating for improving agroforestry in UGI (i.e., respondents' willingness to promote fruit tree planting in public parks); (ii) scaling-out active citizenship initiatives by increasing in number or size existing practices [75]; in this regard, municipalities may facilitate the process through simple policy instruments such as subsidies [76] or in-kind support (i.e., respondents request of fruit trees); (iii) acting as innovation brokers towards local governments, thereby filling the knowledge gap at the decision-making level and, ultimately, (iv) scaling up the institutional context [77,78], and contributing to "changes on the regime-level" [79]. Universities may contribute to the latter point by assisting decision makers, as in the present study, in adopting agroforestry-sound measures and providing training opportunities for municipal officials.

As such, UPAF can successfully contribute to the European Commission Strategy on Green Infrastructures (GI), thus improving "decision-making in relation to integrating ecological and sustainability concerns into spatial planning in the rural and urban landscape" [80] as well as be part of Nature-Based Solutions (NBSs) options to bring "nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions" [81].

4.3. *Agroforestry in Urban Planning Documents*

The presence of agroforestry in the planning documents was limited to TIS. UPAF was associated with urban forestry as they both fall into the domain of urban planning norms regulation. Hence, it could be applied in a wide range of occurrences such as compensation measures in building development projects, public green areas and green infrastructure development programmes such as ecological corridors and green belts in urban and peri-urban contexts. As de Linares states [82], the tool with which agroforestry has often been introduced in urban areas is through the creation of multifunctional green corridors: nature protection, biodiversity management, water resources, recreation, and cultural/historic resource protection. In France, from 2015 until 2020, the Ministère de l'Agriculture et de l'Alimentation introduced a National Plan for Agroforestry, which does not refer specifically to urban areas, although many principles of agroforestry can be transferred to urban contexts such as in production parks, food forests, community gardens, and green belts [83]. The Plan Nature en Ville 2024–2030 (aimed at achieving the objectives of the National Biodiversity Strategy 2030) promotes the integration of nature into urban planning through green infrastructure, climate adaptation, biodiversity and the denaturalization of cities, and creates a favorable framework for the introduction of agroforestry systems in urban regeneration projects.

From decision makers' perspective, in our study, forestry was considered as the entry point for including UPAF into urban planning. As a matter of fact, urban forestry and agroforestry have developed as separate disciplines. However, they share several common

features in terms of multifunctional social, economic and environmental benefits [9], as in general UGI [84]. The inclusion of agroforestry only in technical implementation standards highlighted a reluctance in fully addressing this topic in town strategies. This outcome underlined how much urban planning is vulnerable to institutional inertia [85]. While this inertia can be beneficial by maintaining these past successes [86], it may hamper the ability of institutions to dynamically react to new problems as well as proactively include innovative approaches. In our case, urban agroforestry represents the innovative solution to multiple issues, but it faces the difficulty of entering city policies [87]. To overcome these burdens, a shift from a “government” to “governance” model is required, in which different actors participate in decision-making related to UGI [88,89].

The proposed approach promoted UPAF to main planning documents such as technical implementation standards, thus giving a stronger value to agroforestry-sound norms compared to other studies [23,25,26].

Agroforestry should then be fully integrated in town strategies in order to build coherent policies towards the development of edible green infrastructures for Italian towns.

4.4. Limitations of the Study

About the limitations of this study, this research focuses on Italian planning systems. Hence, methods and results should be carefully adapted to different contexts. Furthermore, the procedural approach was applied in a single municipality, thereby posing questions on the transferability to other contexts. Nonetheless, the main goal of the present study was to introduce in the academic debate the introduction of UPAF into urban planning through a real case study and to provide inspiration for expanding this topic to other European countries rather than to propose a rigid scheme.

The AHP method is a widely recognized tool to identify key decision factors, but concerns regarding the ability of respondents to precisely address the subject and assign ratings may arise since they were not experts in agroforestry. However, this method was part of a questionnaire-based survey aimed at combining information from AHP analysis with other closed-ended answers, thereby providing a multifaceted picture of stakeholders’ orientations.

Eventually, although private landowners in the hilly part of the study area were the majority, non-professional farmers were not included in the survey since it was not possible to retrieve contacts and addresses nor to directly access the cultivated areas that were mostly fenced. To overcome this burden, professional farmers and gardeners were considered as proxies for this category. As a matter of fact, these two categories of actors had comparable land management objectives, operational constraints, and decision-making logic with non-professional farmers. The sample of citizens was biased towards adults and elderly people since interviews were conducted in the public parks that are less frequented by young generations. Therefore, additional research could expand on the general acceptance of foraging among younger people—if there is a cultural limit—and on agroforestry and edible landscape systems among citizens who do not usually frequent parks.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land15081373/s1>, Questionnaire for schools; Questionnaire for farmers; Questionnaire for citizens frequenting public green spaces; Questionnaire for gardeners; Questionnaire for municipal officials; Questionnaire for associations and knowledge hubs.

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Abbreviations

The following abbreviations are used in this manuscript:

AHP	Analytic Hierarchy Process
CAP	Common Agricultural Policy
CP	Conformity Plan
GI	Green Infrastructure
OECD	Organisation for Economic Co-operation and Development
SDP	Strategic Development Plan
TIS	Technical Implementation Standards
UGI	Urban Green Infrastructure
UPAF	Urban and Peri-Urban Agroforestry

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