Assessing Ecosystem Services and Job Opportunities in Peri-urban Agriculture Start-Up Projects

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Abstract

Significant socio-economic changes have occurred in the last decades: among all, increased migration from rural to urban areas. It appears clear that there is a need for resilient cities, capable of combining economic and environmental sustainability. Agroecological practices, as a reduction in agrochemicals input and extended use of living fences and tree rows, can improve environmental quality, assuring ecosystem services and urban food systems, and foster local productions and socio-economic tissue, improving the overall quality of life. That is the approach of the "Urban Innovative Action" OpenAgri project, aimed at the restoration of a 35-ha peri-urban area in Milan (Italy), thanks to the creation of a start-up incubator focused on food production and at the agroecological transformation of the area. This work focuses on the quantification and the evaluation of strategies for enhancing ecosystem services and investigating their link with job opportunities. Thanks to the Pareto Front algorithm and Principal Component Analysis, we were able to understand which start-up approach could provide both new job positions and better ecosystem services. In the research, OpenAgri emerges clearly as one of the first case studies which combine urban

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requalification with socio-economic issues, representing a scalable strategy in other areas, to solve the increasing need for sustainability. Our results highlight that a multidisciplinary approach is needed, both to stay on the market and to supply ecosystem services, combining productive, social and environmental initiatives, resulting in the more suitable solutions to enhance the value of urban and peri-urban ecosystems, while addressing the actual socio-economic themes and creating new jobs.

13.1 Ecosystem Services

In recent years, the concept of ecosystem services (ES) has gained primary attention in scientific communities, and, after the publication of the Millennium Ecosystem Assessment (MEA 2005), an increasing body of research is focusing on the quantification of ES in various environments (Bagstad et al. 2013; Costanza et al. 1997; Malinga et al. 2015).

We adopt the MEA definition of ES that, "Ecosystem services are the benefits people obtain from ecosystems. These include provisioning, regulating, and cultural services that directly affect people and the supporting services needed to maintain other services" (MEA 2005). This classification, updated recently, recognises at least 22 types of ES, divided into four categories: supporting, provisioning, regulating, and cultural services (Fig. 13.1) (Daily 1997; MEA 2005; TEEB 2010).

The classification of ES into unique categories is useful to understand how deep and vast are the benefits we receive every day from our natural environment. Indeed, different habitats and environments can provide multiple ES at the same time. For example, forests are crucial for carbon storage and sequestration, while agroecosystems, definable as a system characterised by both ecological and agricultural processes, are crucial for food production and supply. Therefore, it is clear that urban ecosystems are essential to improve the livability of our cities, assuring services with a direct impact on human health and well-being: e.g. air purification, climate regulation and noise reduction, as well as indirect and less tangible services, such as recreational and cultural activities dependent on the presence of nature in our urban agglomerate. Many researchers have now focused their attention on urban ES. The reason is logical apparent: since 2008, more than half of the world's population lives in cities. Moreover, by 2050, the percentage will grow up to 70%—compared to only 13% in 1900 (Salbitano et al. 2016)—due to increased migration from rural to urban areas, which is one of the significant socio-economic changes and the main challenge of our time (Kovats et al. 2014).

In order to reduce the disservices of the urban area (i.e. waterproofing, air quality problems) which affect both socio-economic conditions and natural capital, there is
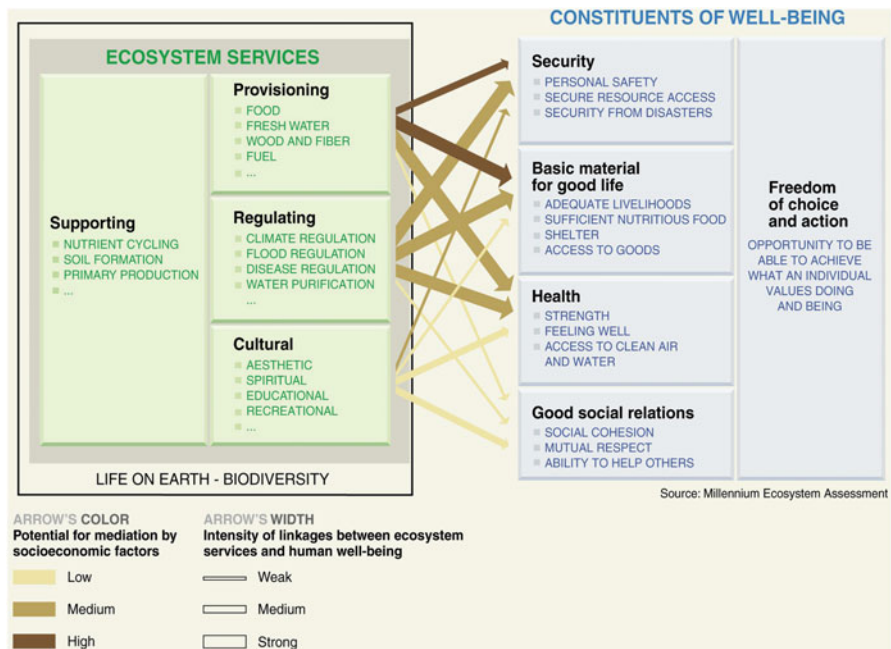
Fig. 13.1 Ecosystem Services classification and link with Human Well-Being. The figure highlights the MEA classification of ES and several links with human life (Millennium Ecosystem Assessment 2005)

an urgent need for new strategies to improve the ES provided by our urban environments to reach the sustainable urban development goals as defined in Agenda 2030 (UN 2015). However, if compared to natural ecosystems, it is only recently that the scientific community has turned attention to the urban condition. Thus, the research in urban ES quantification is still in an initial phase (Gomez Baggethun and Baron 2013).

Starting from these assumptions, in this chapter, we analyse the link between the provision of ES and job opportunities in the urban and peri-urban context. Until today, few researchers have investigated this relation, which, in our opinion, is crucial in our cities, where the need for new jobs grows as fast as the demand for local food supply. This study focuses on the EU-funded project "OpenAgri" in Milan, in order to:

1. Explore the trade-offs and synergies among the different start-ups of the project
2. Estimate the potential contribution to the provision of ES by the start-ups under the OpenAgri within the Urban Innovative Action program
3. Quantify the ES provided by the ecological requalification of the project area.

13.2   Urban Agriculture and Ecosystem Services

Human-dominated ecosystems, as cities are, consist of urban ecosystems that include naturalised spaces—parks, urban forest, yards and gardens, wetlands, rivers, lakes, and ponds—that are directly managed or affected by the urban core and suburban lands, including peri-urban forests and cultivated fields. In the urban context, naturalised ecosystems are highly modified and fragmented, and the components, such as individual trees, water and soil surfaces, are simultaneously involved in the delivery of ecosystem services (Nowak and Crane 2002).

In public opinion, urban ecosystems that provide human health and well-being in cities are the so-called green infrastructure (EEA 2011; DG Environment 2012). This term suggests the primary role, in an anthropic environment, that water and vegetation play in delivering ES at different spatial scales. However, crucial areas of the urban ecosystem are the urban agriculture (UA) areas which are often left out in analyses since it is non-typical of urban green infrastructure.

Uncontrolled urban sprawl leads to increasing slum populations, inequalities, underemployment, sprawl and high demand for services and infrastructures (UN Habitat 2014), as well as issues of food security and safety; cities are very dependent on surrounding ecosystems (Mörtberg et al. 2013; Bolund and Hunhammar 1999). To balance these effects, urban and peri-urban agriculture allows providing ecosystem services, increasing the resilience of cities and enhancing human well-being (Alberti and Marzluff 2004). Urban and peri-urban agriculture provides cities with their local market of goods and services (Antrop 2000), having an impact on the mitigation of climate change, biodiversity loss, and land system change (Larondelle and Haase 2013).

This study explores the provision of ecosystem services provided by a case study of peri-urban agriculture in Milan, connecting with those studies that aim to assess the success of attempts to reduce the growing urban ecological footprint.

13.3   Urban Agriculture: New Opportunities

Urban agriculture plays a potential primary role in providing food supply to expanding cities while connecting urban populations to the rural landscape. UA considers area within the cities; instead, peri-urban agriculture is a form of agriculture at the fringes of growing cities, characterised by the transition zone between urban and rural areas (Piorr et al. 2011). Peri-urban agriculture refers to as "metropolitan agriculture" (Kittinger et al. 2016) or "urban fringe agriculture" (Adams et al. 2016). Data on the increasing role of UA are available all over the world (Orsini et al. 2013). Indeed, today, as estimated by the Food and Agriculture Organization (FAO) in the initiative "Food for Cities", UA is practised by 800 million people worldwide (FAO 2010), helping low-income urban residents save money on food purchases, often in still informal and disorganised ways.

In developing countries, UA is a strategy to address urban poverty improving health conditions and providing a more sustainable and stable economic growth at both family and community levels. In this context, the production derived by UA is

complementary to the traditional agricultural production, since poor citizens can obtain perishable products such as vegetables, milk, and eggs (van Veenhuizen 2006). In the poorest context, urban farming is an activity mainly practised for subsistence reasons, improving food systems for city supply. In fact, with the rise of food demand in cities, small-scale farming is conducted for the commercial purpose creating new job opportunities for the enterprises related to food production, processing, and distribution (Cour 2001; Agbonlahor et al. 2007).

Smart and resilient city governance increasingly promotes a better range of activities for redesigning degraded peri-urban areas—a location where ecosystem restoration can provide more benefits than costs (De Groot et al. 2013). UA demonstrates the emerging ability of local start-ups and enterprises to develop new job skills that more efficiently connect the countryside with the city and better preserving diminishing patches of biodiversity (Kowarik 2011). Start-up incubators and labs can shape not only the economy of urban and peri-urban areas but can also provide several ecosystem services related to their activities, including providing local food supply (Gerster-Bentaya 2013).

13.3.1 Peri-urban Agriculture Case Study

The European Union, within the "Urban Innovative Action" program, has funded the "OpenAgri" project in the Milan urban area. The main scope of the project is to create an open innovation centre dedicated to the theme of peri-urban agriculture and the agri-food chain. Milan is known as the "financial capital" of Italy, rich in cultural and social activities, and leading many economic sectors in Italy. Anyhow, despite this economic energy, there are clear signs of inequity. For example, the youth unemployment rate is high (28.6%), but still, 10 percentage points below the national average; and the percentage of NEETs, defined as young population (aged 15–29) not Engaged in Education, Employment or Training, in the metropolitan area is at 17.6%, which is 2.0% below the national figure (UIA 2020).

The OpenAgri project study area considers the strategic peri-urban landscape, between the urbanised part of the city and the Parco Agricolo Sud, an agricultural and forested area connecting 61 municipalities, for a total 47,000 ha (Fig. 13.2). The improvement of the OpenAgri area will create an open innovation hub focused on peri-urban agriculture, including an ancient farm named Cascina Nosedo. Therefore, our case study deals with the agroecological requalification of an urban fringe area to serve as a living lab for social inclusion, jobs, and skills creation along the food supply chain while increasing the level of resilience and sustainability of the city (UIA 2020). In this context, agroecology is considered an approach and discipline that seeks to integrate science (e.g. agronomy, sociology, history), practices, and participation of the society (e.g. local knowledge, active indigenous participation) to guide research, policy, and action towards the sustainable transformation of the current agri-food system (Wezel and Soldat 2009; Gliessman 2015; Méndez et al. 2016).

The OpenAgri project attracts resources to address the challenges formulated in the Food Policy promoted by the City of Milan, following the goals of the Milan

Fig. 13.2 Project area. OpenAgri is taking place in a 35 ha area, in the south part of Milan metropolitan area, which is in the central part of the Lombardy region

Urban Food Policy Pact (MUFPP). In 2015 the Municipality of Milan adopted the MUFPP to develop a sustainable food system to assure healthy and accessible food, while reducing food waste in order to make urban food systems more inclusive, resilient, safe, and diverse. Therefore, OpenAgri aimed to connect four different aspects: (1) sustainability, by fostering a local food production and providing new ecosystem services in the project area; (2) system innovation, by the creation of a start-up incubator and to the requalification of a lost peri-urban area; (3) creation of new job opportunities; and (4) multidisciplinary approach since it reconciles food production, peri-urban requalification, and economic upturn. This economic upturn is needed both in the agricultural sector and in the Milan suburban social context. Indeed, even if the sector only represents 2% of Italy's Gross Domestic Product (GDP), it directly occupies more than 20% of the workforce and contributes substantially to Italian exports (ISTAT 2017).

However, Italian agriculture has witnessed a contraction, both in production and in the workforce, by losing more than 100,000 people employed in the period 2013–2015 (ISTAT 2018). That situation is in the European trend, where in the last 10 years the agricultural workforce has marked a substantial decrease—with the loss of the 17.5% jobs (ISMEA 2018). The OpenAgri project in Milan can serve as an example of acceptable replicable practices to combine urban requalification, ecosystem services provided, together with the development of job opportunities and positive financial returns. This study opens a new field of research to better understand the relationship between economic performance and environmental aspects. The OpenAgri case study area consists of a network of agricultural fields, farms, and historical buildings, including the Maedieval Chiaravalle Abbey, linked together by the Vettabbia river. Thus, the area, with its long history, has witnessed many transformations, especially in the last century, influenced by urban sprawl and in a general abandonment and degradation (UIA OpenAgri report 2018). This scenario led to the quality decay for both the environment and lifestyle for the resident population, also causing the crisis of contraction of local farms and agricultural production. For these reasons, it is urgent the requalification of the area to pave the way for the revitalisation of peri-urban agriculture.

13.3.2   OpenAgri Ecosystem Services and Job Opportunities

We analysed the performance of the start-ups selected by Milan municipality during the selection of the OpenAgri projects (Table 13.1). In this section, we use a practical example to explain how we evaluated ecosystem services and job opportunities carried out by start-ups.

The evaluation of start-ups allowed us to address the following questions: (1) what are the ecosystem services (ES) and economic opportunities offered by start-ups in peri-urban areas? (2) Which start-up strategies can enhance the provision of multiple ecosystem services as well as economic incomes? In this chapter, we describe eight start-ups that were analysed to understand their potential contribution to ES provision and the relationship between ES and job opportunities.

We followed the Millennium Ecosystem Assessment (MEA) scheme (Fig. 13.1), considering the four ES categories. In our study, we have chosen to select and analyse several ES: in particular, six ES in order to investigate the link between their provision and job opportunities, and three ES supplied by the requalification of the area, thanks to the implant of new trees and shrubs (Table 13.2).

We evaluated one provisioning ES, primary production, measured as the planned monetary value produced by each start-up after 3 years of activity. The data were collected based on the business plans presented by each start-up during the selection process. We also evaluate one provisioning ES, secondary production, obtained from minor incomes of each start-up, i.e. cultural activities and training courses.

We started evaluating the link between regulating ES and job opportunities, by focusing on two out the five regulatory ES under overall analysis: crop pollination dependency and water use saved. Crop pollination dependency is an essential ES to agriculture as almost 65% of plant species need pollination by fauna (Klein et al. 2007). Concerning the essential animal-pollinated crops, over 40% depends on wild pollinators, highlighting how crop production depends mainly on pollinators. Pollinator dependency is an ES proxy already well used for financial terms (ISTAT 2018; Losey and Vaughan 2006; Gallai et al. 2009) and production level (ISTAT 2017; Aizen et al. 2009). We combined long-term data on global crop production and cultivated area provided by the FAO of the United Nations (FAOSTAT 2007) for assessing the pollinator dependence on crop types. As defined by multiple authors

Table 13.1   List of start-ups working in the OpenAgri area and description of activities

Start-up	Activities and target market
Start-up 1	Spirulina algae production
Start-up 2	Agri-technologies for crops and vegetable production
Start-up 3	Wildflowers production and retail
Start-up 4	Wheat cultivation for local bakers
Start-up 5	Snail production
Start-up 6	Seed production for local organic farmers
Start-up 7	Wildflowers and edible plants production
Start-up 8	Old cereal, hemp, and *Paulownia* sp. cultivation for the local market

Table 13.2 Indicators and measurements of different ES types by category

ES category	ES type	Indicators/methods for measurement/sources
Provisioning	Primary production	The monetary value of the products
Provisioning	Secondary production	The monetary value of the training sessions, cultural activities
Regulating	Pollination dependency	Klein et al. (2007), Aizen et al. (2009)
Regulating	Water use saved (WUS)	Ostrom et al. (1999), Hess and Ostrom (2007)
Regulating	Air pollution removal	i-Tree software (Nowak and Crane 2000)
Regulating	Carbon storage and sequestration	i-Tree software (Nowak and Crane 2000)
Regulating	Oxygen production	i-Tree software (Nowak and Crane 2000)
Cultural	Job opportunities	Data obtained from the start-up's business plan
Cultural	Start-up cooperation	Data obtained from the start-up's business plan evaluating the sharing of working force and/or materials, using the same selling systems

(Klein et al. 2007; Aizen et al. 2009), we defined five classes of pollinator dependence: (a) none (production does not increase with animal pollination; class 0), (b) little (0–10% production reduction; class 1), (c) modest (10–40% reduction; class 2), (d) high (40–90% reduction; class 3), and (e) essential (90% reduction without pollinators; class 4).

For water used saved, we considered water as a common resource shared by a group of people with constraints associated with its management. Common-pool resources, as indicated by E. Ostrom, refer to natural resources where one person's usage can subtract from another usage (Ostrom et al. 1999; Hess and Ostrom 2007). Highlighting the importance of water availability as an ES, we developed a "Water Use Saved" (WUS) indicator as a proxy. We assumed that water usage varied with crop water irrigation and that lower usage indicates the lowest irrigation data. We also assumed that by reducing water use, farmers not only saved money but also benefited from more efficient human/environmental resource management. The water requirement for each start-up was calculated, and then as suggested by E. Ostrom protocol, WUS was calculated as follows:

$$\text{WUS}_i = (\text{WU}_{max} - \text{WU}_i) \times 0.1 \qquad (13.1)$$

where WUS_i is water use saved (m^3), WU_i is water use by a start-up project i, and WU_{max} is the highest water use recorded among the start-ups participating in the study. The quantity of water used by each start-up was estimated using the business plans, where each start-up declared cultivated crops and extensions. The obtained value was further multiplied by 0.1 for computational convenience.

Finally, we evaluated two cultural services: job opportunities and start-up cooperation, which could enhance opportunities such as saving money by sharing

materials cooperatively. Job opportunities data were obtained from each start-up's business plan. We defined four ranges of job security: (a) 1–3 workers employed; (b) 3–6; (c) 6–10, and (d) more than 10 people employed. The start-ups' cooperation within OpenAgri different projects, e.g. sharing the working force and/or materials or using the same selling systems, was evaluated from data declared in the business plans or which emerged in the first 2 years of the project.

13.4 Data Collection

Data were collected from November 2017 to March 2019—concurrent with the OpenAgri project. Data were collected using two sources. First, we had access to the business plans presented by each start-up during the public selection process. As official documents, this source provided economic data for each project. Second, we followed the selected start-ups by actively participating in debates and reunions with the representative of each of them. This informal participation was helpful to understand the actual and real state of action of each project, and to collect data about management organisation.

To formalise and track collected data, we prepared a short questionnaire that we sent to each start-up. The questionnaire had three sections: (1) the economic dimension, i.e. asking the aimed economic turn-over and the employed force labour; (2) the environmental dimension, useful to understand ES contribution, i.e. cultivated species, required amount of water, type of agronomic management (organic or conventional); and (3) the socio-relational dimension, to understand the start-ups' cooperation levels and the potential for conducting activities in addition to food production, i.e. recreational and cultural activities.

We then compared the data obtained from the business plans and the questionnaire. Assuming the questionnaire to be more accurate and up to date, we used this data for our study. In cases of incomplete responses, we assumed the data and information presented in the business plans.

To estimate the ES provided by the ecological requalification of the area, we built an internal database, with a realistic hypothesis of trees—species and numbers—that will be in the area. The database of the implant was the input for the I-Tree model simulation.

13.5 Pareto Front Algorithm and ES Performance

The selected indicators were useful to understand the relation between the ES provided and economical production, as well as to understand possible ES enhancing strategies. To answer the central questions of the study, we used the Pareto Frontiers algorithm to highlight ES trade-offs and to show which start-up was able to enhance ES and incomes simultaneously. The Pareto front algorithm is a tool widely used for selecting the best theoretical scenarios based on a large number of combinations of tested factors (Lafond et al. 2017). The Pareto front algorithm
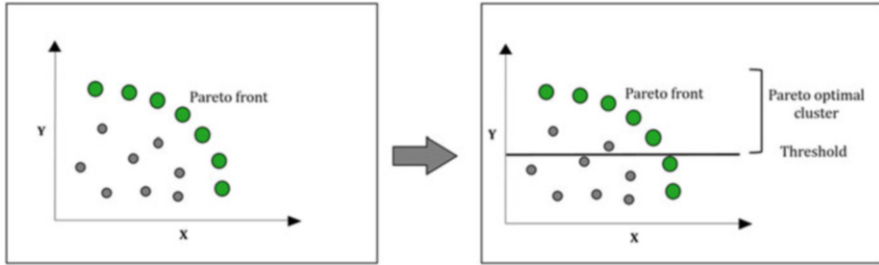
Fig. 13.3 Conceptual framework using the Pareto Frontiers algorithm. Pareto analysis conceptual scheme illustrated for two objectives (*X* and *Y* indicators). The threshold splits the cluster into two: (1) below the threshold "Pareto front" and (2) above the threshold "Pareto optimal cluster". Each dot represents a start-up, and the green colour is the Pareto front and in grey is the non-Pareto Front (Andreotti et al. 2018)

subsets groups of scenarios which dominate others by maximising or minimising multiple factors. These theoretical optimal scenarios form a "front" on which one criterion cannot improve without deteriorating the others (Pardalos et al. 2008). In this study, we kept the conceptual idea of the Pareto front algorithm, applying it to real data in order to explore putative trade-offs and synergies within the set of eight start-ups (Table 13.1). By doing so, we aimed at identifying the best "performing" start-ups, i.e. those combining maximised levels of indicators. The indicators studied were assumed to be equally essential. Consequently, we did not set any weightage on the indicators studied when executing the Pareto analysis. The computed Pareto fronts were qualified as "Pareto optimal cluster" for the group of plots maximising the levels of indicators (Fig. 13.3).

A threshold was taken into consideration, corresponding to the last 3 years' average monetary value production of all the farms in Regione Lombardia (ISTAT 2018), which amounts to 108,823 €/year (approx. USD 120,745 $/year). That value is by far the highest in Italy, with marked differences from North Milan. To the South: in the same period, the farms in Molise have an average production of 11,904 €/year (approx. USD 13,208 $/year). Moreover, to better explore the results of the Pareto front algorithm, a Principal Component Analysis (PCA) was performed. The Pareto analysis and the PCA were carried out using R 2.13.0 with the packages Multiple Criteria Organization (MCO) and psych (Mersmann 2014; Revelle 2017).

The OpenAgri project also provided the opportunity for requalification of the ecological state of the area. Indeed, in addition to the creation of a food start-up incubator, the project's other goal was to create a net of living fences with tree rows and living hedges. The objectives of the net were: (1) better link the project area with the surrounding environment; (2) improve the provision of ecosystem services; and (3) naturally divide and define each field between the start-ups. Therefore, in our study, we quantify the ES provided by this agroecological net.

Following the project guidelines, we hypothesised a total area dedicated to the agroecological net of about 1.5 ha, planted with different plant species. Since the project was on-going at the time of writing, we created a database to be used for

simulation of the ES resulting from the agroecological requalification. The database counts 3287 trees and shrubs, covering an area of 1.6 ha with a leaf area of 4.475 ha, composed of a mix of native and exotic tree species, to ensure high biodiversity and minimise the overall impact or destruction by species-specific insects or diseases. Dominant species in the database are typical of the existing landscape in the area: *Crataegus monogyna*, *Salix campestre*, *Morus alba*, and *Acer campestre*.

For the simulation of the ES provided by trees and shrubs, we assumed an initial height of plant between 0.5 and 2 m and a diameter between 3 and 5 cm. Using these parameters, we applied the I-Tree Eco (Nowak and Crane 2000) model to the database to estimate provided ES. The model uses the database, with the addition of local hourly air pollution and meteorological data, to quantify urban forest structure and provided ES (Nowak and Crane 2000). In this study, we focused our attention on the following regulating ES:

13.5.1 Air Pollution Removal

As air quality is highly important for human health, and many urban areas have a bad quality, it is clear that urban vegetation can play a crucial role in assuring a better air quality by removing pollutants. In this study, thanks to I-Tree Eco, pollution removal was calculated for ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide, and PM2.5 (particulate matter <2.5 μm). I-Tree works estimating air pollution removal quantities calculating hourly tree-canopy resistances for ozone and sulphur and nitrogen dioxides, based on a hybrid of big-leaf and multi-layer canopy deposition models. Regarding PM 2.5, trees remove them when particulate matter lays on leaf surfaces (Nowak et al. 2013). Pollution removal by the agroecological net in the OpenAgri area was estimated using the built database and most recent pollution and weather data available, which are taken from Linate Airport weather station, close to the area.

13.5.2 Carbon Storage and Sequestration

Vegetation is able to sequester and store carbon in its tissue, thus lowering the level of carbon dioxide present in the atmosphere. In this study, the carbon storage evaluation derived from the biomass of each tree, calculated using equations from the literature in I-Tree Eco (Nowak and Crane 2000) and measured tree data, obtained from the available database. Carbon storage and carbon sequestration values were based on customised local carbon values. For this study, values were calculated based on a fixed value of USD 174 per metric ton, set as a current standard by I-Tree software.

13.5.3 Oxygen Production

As well as sequestering and storing carbon, trees and shrubs produce oxygen. The annual oxygen production of the vegetation is directly related to the amount of carbon sequestered by each tree, which is tied to the accumulation of tree biomass. The amount of oxygen produced derived from carbon sequestration based on atomic weights: net O_2 release (kg/year) = net C sequestration (kg/year) × 32/12 (i-Tree report).

13.6   Trade-Off Analysis

The trade-offs analysis indicated which start-up projects belonged (True) or did not (False) to the Pareto optimal cluster ("Belong to Pareto front" column) (Table 13.3) and if a start-up project was above the first production threshold ("Over the first production threshold" column) (Table 13.3). In general, there were no clear trade-offs or synergetic patterns between the ES indicators for the eight start-ups in the Pareto algorithm results or the principal components analysis (Fig. 13.4). On the other hand, we obtained clear clusters of start-up projects, which can belong, or not, to the optimal ones, meanwhile reaching the fixed threshold of economic turn-over.

13.6.1 Trade-Offs Analysis Results

Table 13.3 shows the findings of the eight start-ups analysed using both Pareto algorithm and the first production threshold. Only four start-ups produced more than the fixed threshold and were classified in the Pareto optimal cluster, meaning a simultaneous and positive performance in the provision of both ES and financial results. The Pareto front algorithms classified six start-ups in the Pareto optimal cluster. Using the established production threshold (ISTAT 2018), the optimisation deleted two of the six start-ups of Pareto top cluster. Regarding secondary production and pollinator dependence, the situation was not so clear as the start-ups could not have secondary production for diversification and/or crops that depend on pollination. For the Water Use Saved (WUS) indicator, differences were observed between the Pareto optimal cluster and no Pareto optimal clusters: for example, start-up #3 (Table 13.2) did not require water for its cultivation of wildflowers. Cultural services related to job opportunity guarantees from three to ten jobs for Pareto optimal clusters or not.

   On the other hand, the first production threshold assesses the possibility—credibility—for the start-up to create job opportunities. Based on this analysis, start-up #8, even if it produced the highest number of job opportunities (ten job opportunities), it would be under the fixed threshold, therefore not qualifying for the optimal cluster. While start-up #1, which offered the lowest number of job opportunities (three job opportunities), was classified in the Pareto optimal cluster and above the first production threshold.

Table 13.3 ES provision and threshold by OpenAgri start-up

| Start-up	First production	Secondary production	Water used saved (WUS)	Pollinator dependence	Job opportunities	Start-up cooperation	Belongs to Pareto front	Over the first production threshold
1. Start-up 1	15.0	0	3.75	0	3	0	True	True
2. Start-up 2	14.5	7.75	0	3	6	0	True	True
3. Start-up 3	15.0	0	6.75	0	6	4	True	True
4. Start-up 4	4.8	0	0.55	3	6	0	False	False
5. Start-up 5	4.1	1.8	2.75	0	3	0	False	False
6. Start-up 6	0.5	0.51	0.25	2	6	8	True	False
7. Start-up 7	12.4	0	1.25	3	6	4	True	True
8. Start-up 8	3.6	0	3.12	3	10	6	True	False
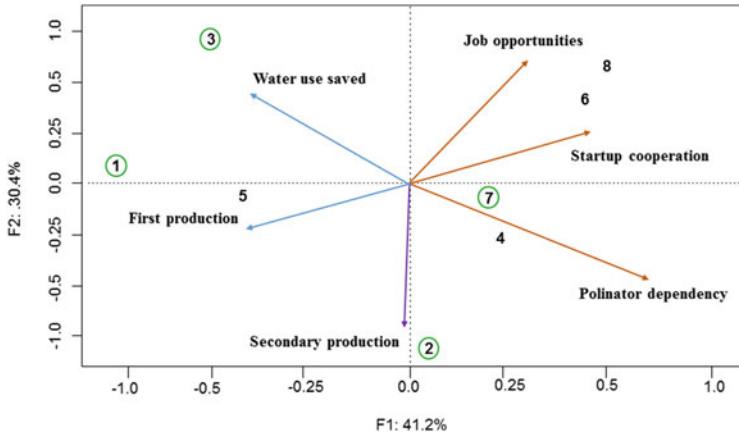
Fig. 13.4 Principal Component Analysis of the studied ES and OpenAgri start-ups. Principal Component Analysis of the studied ES and OpenAgri start-ups (n° in Table 13.2). The green circles highlight the start-ups belonging to the Pareto optimal cluster above the primary production threshold. Each number corresponds to each singular start-up

We then combined the results from the Pareto optimal cluster with Principal Component Analysis. The first and the second axes of the Principal Component Analysis explained 41.2% and 30.4% of the total variance of the start-up studied, respectively (Fig. 13.4). The Principal Component Analysis discriminated accurately between the Pareto clusters on the first axis. On the one hand, Pareto top clusters were projected on the first axis, where the first production was one of the main contributors. However, on the other hand, the non-Pareto optimal front and low-yield intermediate clusters were mainly projected on the second axis. Any explanation or further conclusion to help readers interpret this?

13.6.2 Ecosystem Services Evaluation of the Semi-natural Hedgerow Network

13.6.2.1 Air Pollution Removal
I-Tree Eco has estimated that pollution removal was highest for ozone. It was estimated that trees remove 69.71 kg of air pollution (ozone (O_3)), carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter less than 2.5 μm (PM2.5), and sulphur dioxide (SO_2) per year with an economic value of USD 3906.

13.6.2.2 Carbon Storage and Sequestration
The gross sequestration of OpenAgri trees was estimated in 2.185 metric tons of carbon per year, with a value of USD 37,987. The i-Tree model estimates the fences in OpenAgri store 6.3 metric tons of carbon USD 1093. Of the species sampled, *Crataegus monogyna* stores and sequesters the most carbon: approximately 17.6% of the total carbon according to I-Tree Eco.

13.6.2.3 Oxygen Production

Fences in OpenAgri are estimated to produce 5.825 metric tons of oxygen per year, thanks to photosynthesis. However, if we consider the overall production of oxygen and available reserve present in the atmosphere, the contribution of plants appears modest (Broecker 1970).

13.7   Key Findings

The study results confirm that, in a peri-urban context, start-ups can offer and provide different and multiple ES in addition to the production of food, including regulating services—crop pollination—as well as cultural and social services. This finding demonstrates the vital contribution potential of start-ups to urban agglomerates for job opportunities and better use of resources, while promoting new interactions and networking opportunities in the peri-urban framework of the area, in an overall context of urban requalification.

Multi-criteria optimisation methods such as the Pareto front algorithm were successfully applied and shown to be an effective method to support management decision-making processes (Lafond et al. 2017; Bugalho et al. 2016; Andreotti et al. 2018). It was, therefore, reasonable to further explore the potential of this methodology in various ecosystems, for example, in peri-urban areas, for which such an attempt could not be found in the literature.

While the OpenAgri project was still on-going at the time of this publication, from our results, it is clear that some of the start-ups analysed in this study (Start-ups 1, 2, 3, 7) represent best projects capable of combining the provision of multiple ES, as well as economic incomes. From our analysis, we conclude this is possible because of several aspects common to each of these four start-ups: first, a solid business plan, which tends to analyse and recognise new types of products with higher margins (i.e. spirulina production), as well as new trends (i.e. wildflowers), particularly requested by urban consumers. Second, each project promotes a more limited use of resources, and it takes into account diverse sources of income as secondary production or derived by cultural and social activities. These results are reflected by the Principal Component Analysis, which highlights the potential of start-up 7 (Fig. 13.4). Our findings highlight that a multidisciplinary approach for peri-urban start-ups is beneficial, to stay competitive in the market and to supply ecosystem services. Combining productive, social, and environmental initiatives can lead to more suitable solutions to enhance the value of peri-urban ecosystems, while answering to an increasing socio-economic issue, i.e. creating new jobs.

However, we note that for some ES—such as those regarding soil quality and the water cycle—not considered in the present study, useful results require a more extended period of data collection (5–10 years). Indeed, understanding and assessing the contribution of the project to improve the area (i.e. water cycle, air pollution removal, and several other regulating services) require that the project is complete and that all the start-ups are working and well-established. Moreover, dealing with an area with historical problems linked to environmental pollution, the results of

OpenAgri may need additional time to be visible and tangible especially for the results coming from the ecological requalification of the area. Based on the available project indication, we assumed the use of typical plant species with small-medium dimensions. The obtained results could vary if the number of plants increases and/or if the species change. It is also essential to understand that the ES provided by trees and shrubs can change during the time, also due to non-predictable factors (e.g. extreme weather events); therefore, continuous analysis of the situation should be put in place, to monitor change actively.

13.8 Conclusion

OpenAgri represents an optimal case study since it is a complex, yet familiar, peri-urban area, such as that found in many urban developed agglomerates, bringing environmental and socio-economic problems, as well as opportunities. Indeed, in the first 3 years of the project, start-ups faced significant global challenges in addressing the requalification of a lost area. Our results suggest that the requalification and the creation of start-up hubs can boost social inclusion and economic incomes, combining the provision of multiple ecosystem services and giving more value to urban agriculture, even in developed countries. However, start-ups and ecosystem services indicators should be analysed, considering a more extended time threshold in order to highlight the real economic and environmental sustainability of start-ups and the project as a whole. In this research, four out of eight start-up projects could produce more than the fixed threshold, meanwhile belong to the Pareto optimal cluster, meaning they can maximise ES provision and job opportunities. Our result depends on several factors, such as—the goodness of the business plan,—the rational use of the given resources,—the multidisciplinary approach, which allowed the start-ups to answer to the various and ever-changing requests of the local market.

Today the project is nearly concluded, and the start-ups are at the end of their training process. During the last months, the start-ups were involved in a pre-incubation process to develop their ideas and business plans. Thanks to this process, some start-ups changed their original project, adopting new strategies, in order to seize new opportunities and face unexpected problems, such as low availability of the needed amount of water to cultivate vegetables. We can thus affirm that each start-up has demonstrated a high level of resilience, being able to adapt itself to variable conditions. The requalification of the area is still on-going too, so in the next future also local citizens will benefit from the improvements, representing a scalable example in a similar place. In developed countries, at the margin of our growing cities, we can find a multitude of places that need a requalification, thanks to urban agriculture—providing in one solution several benefits. Therefore, urban agriculture in these complex contests should not be as subsistence food staple supplier, but as a single occasion to mark a socio-economic new start and to satisfy the latest urban needs in terms of sustainability, local food supply, and territorial cohesion. OpenAgri is one of the first endeavours linking together these related topics. It serves as a potential future case of study for further analysis and represents a

replicable model in other urban contexts for the redevelopment of abandoned territories.

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