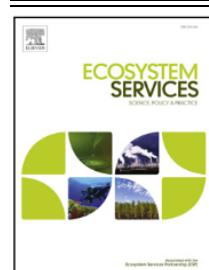




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Ecosystem Services

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Contributions of small farms to ecosystem services and the challenges for future rural transition: evidence from Garfagnana area

Author: Youmin Li ^a *

^a. Lab 8206, Department of Agricultural Economics and Rural, 1 Gwanak-ro, Seoul National University, Gwanak-gu, Seoul 08826, Republic Korea.

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ABSTRACT

Ecosystem services were an explicit part of the research agenda of ecological economics from the beginning. The persistent decrease of agricultural activities in the Garfagnana region has been identified to cause major environmental problems, such as loss of biodiversity, reduced carbon sequestration and soil preservation and degradation of cultural and natural heritage. We identified three main challenges that foster this trend. To tackle these challenges, the paper uses the Ecosystem Assessment framework to analyze the root causes of problems and the relationship between ecological services and human well-being, summarize the development trends, and propose solutions.

* Corresponding author is a student of Erasmus Program study in IMRD.

Tel.: +49-1768864239; e-mail: Leesnu1@snu.ac.kr

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1. Introduction

Rural transition has become a key issue in the world, especially in European countries and it is also on the agenda of relevant United Nations organizations. Garfagnana, a valley located in Lucca Province, is a mountainous forest area located in northern Tuscany that spreads over a surface of 620 km² (Grando et al., n.d.). Local agricultural development is currently dominated by small scale farms, and these small farms are turning to multifunctional agriculture instead of only depending on agricultural products (Treakle, 2019). So, small farms are necessary to engage in territorial valorization, sustainable tourism, ecosystem service¹ and agricultural innovations.

The capacity of Grafnagna to protect, valorize, and enhance the natural resources offered by the local environment, in a balanced demand and supply ecosystem services. In addition, the local agro-ecological forest of chestnuts is a cultural heritage, landscape and natural capital that promote sustainable development (Schröter et al., 2015). The paper researches local regulations, farmer associations, and multiple stakeholders' participation in agricultural policy to acquire insights into the region's specific challenges and trends. Garfagnana has been increasingly recognized for its family-farming sector and approach to ecological services and community-oriented development as a potential model for other regions. But, after several decades of total abandonment - in Tuscany alone, there are estimated to be around 17,000 hectares of abandoned chestnut trees (Felici et al., 2020).

There is a growing recognition that agriculture can contribute to providing agroecosystem services, defined as the multiple benefits provided by ecosystems (i.e., storage of CO₂, soil formation, primary production, food production, water purification, economics, cultural heritages and genetic resources) (Maes et al., 2013). The most representative of the local agro-ecosystems and the one with the most obvious benefits in terms of

ecological services is the chestnut grove. These small farms' chestnut forests are vital in preserving the local cultural heritage, the regional landscape, the autochthonous genetic resources, traditions, and production methods (Costanza et al., 2017). Multifunctional agroecosystems are the result of complex adaptive interactions between humans and nature where trade-offs between food production and other ecosystem services are key (Bernués et al., 2019).

Firstly, this paper illustrates the contribution of this local multifunctional agricultural model of small farms to ecological services based on a literature review and field research. But the development of these multifunctional small farms is currently facing many challenges due to social and economic factors that impede rural transition. Based on investigations of 8 local farms, the results of the MOVING² project (Felici et al., 2020), and a literature review, this paper summarizes the following challenges that hinder the development of socio-ecological services: 1) Unclear policy motives for ecological subsidies cannot maintain or even improve current biodiversity and ecological landscapes. 2) Available funds are not adequate and adapted to local small farms benefit from policy agendas. 3) Lack of skilled labor available for innovation. 4) How do small farms engage in sustainable tourism, territorial valorization and protect local natural resources?

As small farms operate in rural environments, small farms are part of rural dynamics that influence the rural transition and impact sustainable rural transition while contributing to ecosystem services. To analyze how small farms contribute to ecological service and challenges in Garfagnana, the paper will approach MAES (Mapping and Assessment of Ecosystems and their Services) from social, ecological, economic and environmental angles. Then the paper will discuss future trends and give policy recommendations based on qualitative studies results.

¹ Ecosystem services are the ecological characteristics, functions, or processes that directly or indirectly contribute to human wellbeing.

² MOVING: Mountain Valorization through Interconnectedness and Green Growth.

2. Literature Review

2.1. *The previous studies*

Ecosystem services have great potential to influence environmental policy decisions because they link ecosystem functions to human well-being that resonate with a broad spectrum of people (Villamagna et al., 2013). The critical importance of ecosystem services challenges the conventional approach to growth and development while paving the way for a different approach to prosperity based on well-being (de Groot et al., 2010).

Small farms in Garfagnana often prioritize the cultivation of locally adapted crop varieties that contribute to both ecological services and economic development (Arcuri & Tomasi, 2022). Local small farms contribute to ecological services through multifunctional agricultural operations including multiple crops, husbandry, agrotourism and chestnut forest conservation. By continuing to grow and preserve genetic resources such as spelt (a kind of ancient rice), small farmers help maintain biodiversity and safeguard unique plant genetics that is well-suited to the region's specific climate and soil conditions. Natural capital contributes to human well-being through ecosystem services (Pardini & Nori, 2011).

Multifunctional agriculture farming practices represent a range of adaptive shifts away from production trends and toward a more diversified farming approach (Treakle, 2019). It demonstrated how these multifunctional agriculture practices relate to the distinct socio-ecological landscape and function of Garfagnana, uniquely rooting these farms in the territory (Balvanera et al., 2017). For example, chestnut forests in Garfagnana play a crucial role in sequestering carbon dioxide from the atmosphere. Through photosynthesis, chestnut trees absorb carbon dioxide and store carbon in their biomass, mitigating the impacts of greenhouse gas emissions and contributing to climate change mitigation (Suwarno et al., 2016).

A conceptual framework for EU-wide ecosystem assessments provides the entry points for different stakeholder groups and different assessments of ecosystems (Maes et al., 2013). The Millennium Ecosystem Assessment framework provides an indispensable baseline of information for researchers, scholars, and students, as well as informs public decision-making for decades to come. And it can be used to demonstrate adaptive shifts away from agricultural production trends, and toward a diversified farming approach oriented around non-capitalistic practices (Treakle, 2019).

Recent 10 years, family farmers and local institutions have increasingly focused on place-based development initiatives, such as revalorizing native livestock breeds and promoting agro-ecological practices, as ways to strengthen small-scale agriculture and the local rural economy. This place-based turn is now reshaping the development trajectories of many family farms and communities in Garfagnana (Treakle, 2019).

Above all, there is a need to broaden public discourse and participation in integrating ecosystem services and natural capital into mainstream economic policy.

2.2. *The research gap*

There is a lack of place-based social–ecological research in Garfagnana to illustrate how social–ecological systems evolve and respond to policy interventions through the exchange of knowledge across disciplinary boundaries and among different stakeholders to address sustainability challenges at a particular place (Treakle, 2019; Balvanera et al., 2017).

Some research concluded that the substantial contributions of ecosystem services to the sustainable wellbeing of humans and the rest of nature should be at the core of the fundamental change needed in economic theory and practice if we are to achieve a societal transformation to a sustainable and desirable future (Costanza et al., 2017; Butler et al., 2003). And Costanza et al., (2017) pointed to the weakness of the mainstream

economic approaches to valuation, growth, and development.

The present proposal is based on the ecosystem services cascade model, the TEEB framework, and the UK National Ecosystem Assessment. It also contains elements of the DPSIR framework¹⁷ and is adapted to better fit the needs of ecosystem assessments (Maes et al., 2013). A much more integrated, dynamic connection between natural systems and human systems is needed to assess overall progress and wellbeing. This becomes more critical in the wake of the adoption of the UN Sustainable Development Goals, which ought to affect the way economic statistics are used to drive policies in the 21st century (Butler et al., 2003). Their findings provide a state-of-the-art scientific appraisal of the condition and trends in the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve and use them sustainably (*Millennium Ecosystem Assessment*, n.d.).

Knowledge of ecosystem diversity is currently limited and dispersed. In particular, some sectors, regions and specific driving forces are not well studied and cross-linkages among them have been insufficiently analyzed (Grando et al., n.d.). In addition, the local chestnut forests are currently declining, and policy incentives for ecological compensation are unclear. Few studies address local ecosystem service compensation mechanisms, challenges, and future trends. Most of the applications of the Mapping and Assessment of Ecosystems and their Services and MA theoretical framework are national or global macro studies, and there are no applications to the micro level of the Garfagnana (Hien et al., 2014).

3. Theoretical Framework

Ecosystems are shaped by the interaction of communities of living organisms with the abiotic environment. Multifunctional agriculture theory is used to analyze how farming

practices represent a range of adaptive shifts away from production trends and toward a more diversified farming approach. It is used to demonstrate how these multifunctional agriculture practices relate to the distinct socio-ecological landscape of Garfagnana, uniquely rooting these farms in the territory (Balvanera et al., 2017).

Millennium Ecosystem Assessment (MA) assessed the consequences of ecosystem change on human well-being (Maes et al., 202; Hien et al., 2014). The conceptual framework links socio-economic systems with ecosystems via the flow of ecosystem services, and through the drivers of change that affect ecosystems either as a consequence of using the services or as indirect impacts due to human activities. MA provides a framework for organizing and categorizing ecosystem services (Maes et al., 2021). In the following Fig.1 outline the overall framework and then present its elements, how humans have altered ecosystems, and how changes in ecosystem services have affected human well-being, how ecosystem changes may affect people in the future.

EU Ecosystem Assessment is based on an operational framework developed by the MAES Working Group (Mapping and Assessment of Ecosystems and their Services) (Maes et al., 2013). The conceptual framework is based on the integrated ecosystem assessment, linking ecosystems and biodiversity to people through drivers of change and ecosystem services (Arcuri & Tomasi, 2022). The theoretical framework is based on the EU Ecological Services Assessment (ESA), therefore, is more appropriate to the research context of this paper (Maes et al., 2013; Garrod et al., 2006). The results of the analysis applying the generalization framework will be presented in the conclusion section, and relevant policy recommendations and reflections on future trends will be given in the conclusion and discussion section.

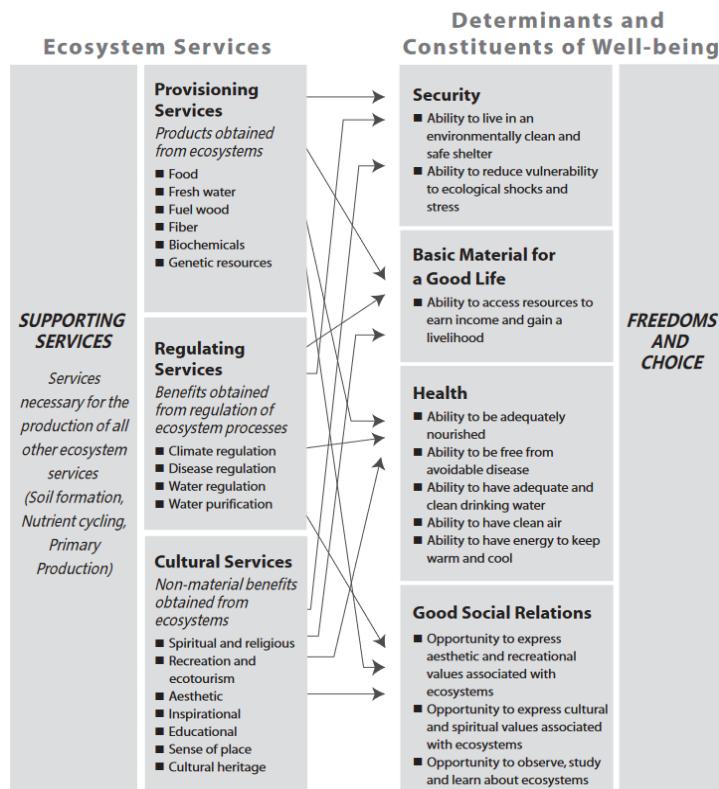


Fig 1. The Millennium Ecosystem Assessment Framework
Source: (Butler et al., 2003)

3.1. The ecological benefits

The governance of the coupled socio-economic-ecological system is an integral part of the framework: Institutions, stakeholders and users of ecosystem services affect ecosystems through direct or indirect drivers of change (Grando et al., n.d.). Policies concerning natural resource management aim to affect drivers of change to achieve a desired future state of ecosystems. Fig. 1 recognizes the intersectionality of farming in providing environmental benefits to producers and rural communities. In Garfagnana, the chestnut value chain provides many ecological services, such as the storage of CO₂, preservation of the soil, control of water flow, and production of edible fruits and mushrooms (Sapiens, 2018). In local social farms, the ancient spelt contributes to

both genetic diversity conservation and food provision. Multiple crops and unique chestnut forests broaden the income source of small farms and preserved cultural heritage (Pellegrini et al., 2021). That heritage could promote agro-tourism development. Multiple stakeholders' participation in continuous improvement in regulation services. Appropriate regulations can help with ecological and economic trade-offs and promote sustainable development.

Small farms contribute to soil conservation and water regulation and can provide essential resources for pollinators, such as bees and other insects (Galli, 2020). For example, practices such as agroforestry, mulching, and cover cropping can help prevent soil erosion and improve water infiltration, thus enhancing water availability and quality in the region. Chestnut forests and diver-

sified small farms can act as carbon sinks, capturing and storing carbon dioxide from the atmosphere. This helps mitigate climate change and supports the region's efforts to reduce greenhouse gas emissions.

3.2. The social-economic benefits

Social-economic benefits are prerequisites for human happiness. The diverse links between ecosystem services and the determinants and constituents of human well-being are illustrated in Figure 1. The spatial and temporal forms of these links are complex and great. Some relationships are immediate; others are lagged (Schröter et al., 2015). For instance, impairment of food production causes hunger today and malnutrition before long, bringing lassitude, impaired ability to concentrate and learn, and increased vulnerability to infectious diseases. Examples of longer time lags include the clearing of mangroves, salinization created by badly managed shrimp aquaculture, depletion of groundwater for irrigation, and the impact of introduced species (Butler et al., 2003). Small farms and chestnut forests provide economic opportunities for local communities. They support rural livelihoods and contribute to the socio-economic fabric of the region, fostering a sense of community and connection to the land.

For the purpose of this framework, ecosystem services also encompass the goods derived from ecosystems. People benefit from ecosystem services. These benefits increase human wellbeing, which is the key target of managing the socio-economic systems.

4. Methodology

4.1. Study site context:

Garfagnana is a mountainous region in Tuscany, Italy, located between the Apuan Alps and the Northern Apennines. Administratively divided into 16 small municipalities (Fig. 2). Chestnut tree conservation has emerged as a crucial

concern in the Garfagnana region due to several stress factors (Agnoletti & Santoro, 2018; Sapiens, 2018; Battisti et al., 2014). Reviving currently abandoned chestnut groves would not only contribute to improving environmental performance through biodiversity and land conservation but also address the other two sustainability dimensions, leading to improved chestnut output, creating jobs, retaining the rural identity and knowledge and developing social capital trust and collaboration between people (Falk, 2015, Agnoletti & Santoro, 2018, Vanni, 2020).

It is essential to create a comprehensive policy framework that is adapted to the unique requirements and difficulties of the region's chestnut production to overcome the current limitations. In conclusion, it is crucial for preserving biodiversity, guaranteeing food security, and advancing sustainable farming methods in the Garfagnana region to assist small farms and save chestnut trees. Garfagnana's initiatives can serve as an example for other regions looking to conserve their cultural heritage and promote resilient, localized food systems (Bernués et al., 2019).

Besides, recognizing the role that geography plays in shaping farming activities, as described by: "farms in countries with substantial mountainous and other agriculturally disadvantaged areas are more likely to be strongly multifunctional (in the developed world)" as an adaptive strategy when there are fewer opportunities (Wilson, 2008). Choosing EU Ecosystem Assessment Map to analyze is driven by the Geographic specificity and practicality of the theoretical framework.

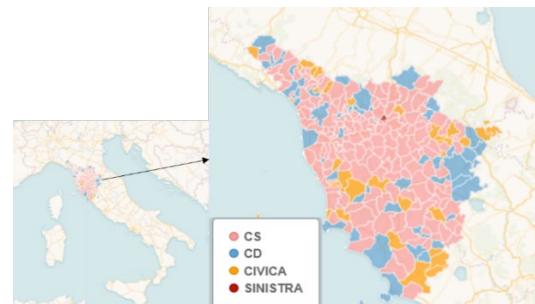


Fig. 2 Map of municipalities in Tuscany, Italy
(Sources: www.ancitoscana.it)

4.2. Data collection:

Interviews with local stakeholders, such as farmers, agronomists and policymakers, combined with a literature review to identify three major issues that impact the trend of ecosystem services in the Garfagnana region. In line with several policy documents, such as the European Union's Biodiversity Strategy, the Farm-to Fork-Strategy and the Paris Agreement explicit action to reverse this trend and guarantee a sustainable future development of Garfagnana is urgently necessary. Then, the paper chose an ecosystem subsidies policy issue based on theory and data about Garfagnana.

The social role of farming is increasingly recognized in the provision of ecosystem and social services by the farm. Social farming refers both to entrepreneurial or voluntary initiatives (i.e. promoted by associations), or even by the public sector (Bruzzone et al., 2020). All these realities pursue social purposes through the development of agricultural activities, in a broad sense (crops, breeding, transformation of products, farm holidays, sale of farm products, etc.), with the explicit aim of involving persons with special needs (Pellegrini et al., 2021). The research investigated 8 social farms, a natural park, and involved a session in Garfagnana municipality. During the investigation, we use semi-structured interviews to collect data and information that are relevant to the study. Then the paper compiled conceptual and theoretical papers combined with the observations from case studies.

4.3. Analysis

After organizing the data and combining the literature summary and theoretical framework, this study classifies ecological services according to MA, then uses MAES to assess the value of local ecological services and analyze the challenges and future trends (Maes et al., 2021). The analysis is conducted both ecologically and economically and incorporates a multiple shareholder perspective. Then, the paper will interpret results according to multi-dimension views. The

analysis of the relationship between ecosystem and human wellbeing allows us to understand how sociocultural and environmental elements can be used to improve the sustainability and resilience of ecosystem services that face challenges. Biodiversity is essential to maintaining basic ecosystem processes and supporting ecosystem functions (Bernués et al., 2019).

5. Results

The MAES framework (Fig. 3) structure information for policy support. It also elaborates on the different roles of biodiversity in supporting ecosystem functions and ecosystem services. The framework connects biodiversity to ecosystem functioning and ecosystem services. The left chart contains six dimensions of biodiversity that contribute to ecosystem functioning but, importantly, which also directly deliver ecosystem services. The right picture indicates the contribution to human wellbeing from ecosystem services. Analyzing drives of changes based on farm and stakeholder responses (such as policy, and business) to summarize challenges as follows (Maes et al., 2013).

5.1 Challenges:

Rigid subsidy policies, the requirements and the mismatch between soil conditions and planting subsidies for the most adapted species with result in some farmers' lack of funding and incentive for ecosystem services. The bureaucracy with ambiguous policy incentives, and the lack of internal expertise or external support may prevent farms from applying for funding. In Garfagnana, only farms with more than 3 hectares can apply for funding projects. Most farms' chestnut forests are scattered and less than 3 hectares. The farms report several difficulties due to bureaucracy and financial barriers, that especially small farms can hardly manage, for instance, the need for beneficiaries to make the expenses in advance.

Complex and unclear bureaucratic policies pose significant challenges for farms seeking funding. Several funds for different services or accomplished requirements, such as for biodiversity protection by custodian farmers, for pruning, or for keeping forest areas clean exist and are necessary to render chestnut production in the area possible and profitable (Vanni, 2016). However, these funds are mostly not sufficient, complex to obtain, and not always adapted to the local context (Arcuri & Tomasi, 2022). For instance, according to our observations, the minimum size for obtaining a pruning fund for chestnut orchards differs between different municipalities, creating difficulties for farmers in identifying the relevant regulations. In some cases, the required threshold for pruning fund eligibility exceeds the region's average small-scale activities and therefore excludes most farmers which makes it inadequate for the region. The application process is often hampered by a complicated bureaucracy and a lack of external support. Additionally, sometimes expenses need to be made in advance, which is impossible for the unusual small-scale farms of the region (de Groot et al., 2010).

Besides, Tuscan rural areas with development problems suffer from incomplete broadband coverage, very low computerization rates and the scarce presence of websites and e-commerce. Tuscan rural areas with development problems suffer from incomplete broadband coverage, low computerization rates and the scarce presence of websites and e-commerce. As demonstrated by ISTAT data, within the 77% of families that do not have Internet access at home, 51.2% answered that in the family nobody knows how to use the Internet in 2020 (Villamagna et al., 2013).

Insufficient innovations in marketing strategies and a more organized system. The distorted market for the most common and protected origin (PDO) chestnut product. Even though the PDO standards prescribe the exact traditional production procedure that needs to be followed several producers switched to innovative but illegal cheaper, less labor and time-intense production methods which allows them to lower the market prices for their products. Additionally, many

small businesses are not registered, therefore do not pay taxes and can achieve lower product prices this way. However, these practices are currently not traceable because of lacking control and monitoring.

Innovation in the technological processes is not popular, with new technologies such as machinery to streamline the chestnut collection, optical sensors and thermometers to support the selection and to assess the level of humidity. The production of chestnut flour still follows traditional methods, the slow drying process takes place in small buildings with stone slab roofs, called "metato". The high quality of the flour with high demand compared to the scarce supply and the relatively good price (up to 15 €/kg). In their view, certain activities conducted manually represents an opportunity to exercise a higher control on the production stages, which also influences the quality of the final product (Felici et al., 2020).

The problem of the uncontrolled spread of wildlife, which for several years has been causing serious damage to agriculture (estimated 4 million euros of loss of agricultural production each year) (Costanza et al., 2017). According to data from the Tuscany division of the Italian Farmers Confederation, 400,000 wild boars currently live in the region, which prevents farmers from producing, damages the forests and the environment, and causes accidents to the populations. The density of diffusion worries farmers particularly: for every 100 hectares of territory there are at least 20 wild boars, while the Regional Wildlife Plan foresees from 0.5 to a maximum of 5 animals.

5.2 Future trends:

Shown as the right side in Fig. 3, ecological services have many positive impacts on human well-being, directly or indirectly, through a variety of channels. Future policies toward healthy and resilient systems need to acknowledge and consider this diversity (Balvanera et al., 2017).

Garfagnana faces a great trend in terms of generational renewal, as young people usually do not choose to do agriculture. Especially, employment in the chestnut sector is unattractive due to low revenues, and big uncertainties, such as market

prices and adverse climate impacts (Cavallini et al., 2022). And many skills are needed on the one hand, because of the many products that can be obtained from chestnut trees and traditionally several steps included in their production procedure (Arcuri & Tomasi, 2022). On the other hand, Garfagnana's agriculture is typically characterized by multifunctional farms which indicates the need for additional skills for pursuing other activities outside the chestnut season (Treakle, 2019). And not many young people have the necessary skills and the region offers few opportunities to acquire them. As it stands, the local population decline and aging trend will continue in the coming years. This trend is also a potential challenge for local agro-ecological development.

Increasing abandoned chestnut forests due to economic incentives. There are estimated to be around 17,000 hectares of abandoned chestnut trees orchards after several decades in Tuscany alone. Ten years ago, the local subsidy for chestnut trees was 50 euros per tree, but it was abolished due to financial constraints. Currently, the only subsidies for chestnut forests are single project funding applications under the CAP policy framework. However, the threshold for funding

applications for this project is 3 hectares or more. Most farms only have 1-2 hectares of private chestnut forests and low yields of chestnut products, so many farms have lower and lower interests in retaining chestnut forests. This is because the economic value of the chain is low, even if the ecological value is high. Therefore, if the local ecological compensation policy remains unchanged, the area of local chestnut forests will tend to decline further.

In response to these trends, the Italian government began to make an effort to broaden the policy environment of the CAP and its promotion of multifunctional agriculture across the European Union and strengthen the country's investment in small-scale and diversified farms (Treakle, 2019). The municipality focuses on revalorizing the territory's local biodiversity, most specifically the local Garfagnana chestnut trees. There is a trend that re-orientation as an educational farm and its goal of promoting a regional agricultural 'brand' for Garfagnana demonstrates the farm's strong engagement with the public and role in shaping the territory's agricultural identity (Bruzzone et al., 2020).

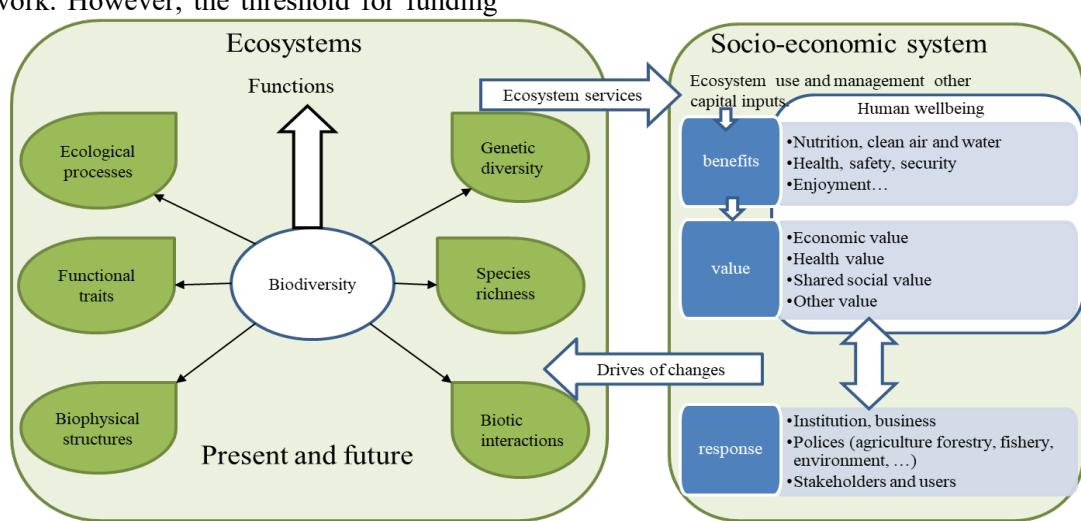


Fig. 3 EU Ecosystem Assessment framework developed by the MAES (Mapping and Assessment of Ecosystems and their Services)

Source: Maes et al., (2013, 2021)

^a The multi-faceted role of biodiversity to support the delivery of ecosystem services and to assess the status of ecosystems. Biodiversity has multiple roles in the delivery of ecosystem services and represents therefore a central component of the framework.

6. Discussions and conclusions

Small farms tend to have a lower environmental impact compared to large-scale industrial agriculture. Their practices promote ecosystem services, such as water purification, flood control, and wildlife habitat, which benefit not only the farm but also the broader environment and communities (Obst et al., 2016).

In summary, small farms in Garfagnana can make a significant contribution to the conservation of genetic resources, the promotion of agroecosystem services, and the overall sustainability of the region's agriculture. Their focus on biodiversity, traditional practices, and community engagement can lead to a more resilient and environmentally friendly farming system.

Multifunctional agriculture adaption performs various functions: productive, protective, naturalistic, landscape, recreational, and didactic. But factors such as aging, bureaucratization, and inadequate ecological compensation policies pose challenges to the development of local ecological services (Treakle, 2019).

There is a need for governmental action to preserve the small farms in Garfagnana. It is essential to create a comprehensive policy framework that is adapted to the unique requirements and difficulties of the region's agricultural development to overcome the current limitations (Pardini & Nori, 2011). Firstly, it is necessary to develop clearer incentives to reduce land abandonment and facilitate access to regional rural development policies. It is essential to merge and revise the existing governance framework instead of merely adding new layers. Secondly, it is important to adapt funds to local farming conditions and re-design the subsidies for small-scale chestnut forests.

When promoting the adoption of innovative technology and marketing practices, it needs to consider the reluctance of farmers. To avoid these issues, alternative marketing strategies like solidarity purchasing groups (GAS) and further processing of chestnuts into products like cookies or pasta have been explored successfully (Pellegrini et al., 2021). Digitalization presents opportunities for the development of the region but there is

need a more accessible skills training. It is urgent that move away from seeing place as a static topographic space to conceptualizing it as a more fluid and heterogeneous network of social relations and practices linked across geographies.

One of the important issues for maintaining the agro-food system lies in the attractiveness of agricultural activity towards young people, to guarantee the required generational turnover (Pellegrini et al., 2021). The issue of equal access to services and opportunities assumes a very significant significance both in terms of the relationship between urban and rural, and as regards social inclusion and female and youth employment in farms and rural areas. This is crucial to address the depopulation trends in rural areas that are taking place today.

If accompanied by adequate strategies, can leverage the commercial opportunities and the strengthening of the social and cultural capital contained not only in agro-food products but also in the brands referring to baskets of goods and services, in particular brands that identify thematic roads and brands related to events and shows.

Additionally, there is a need for agricultural insurance against increasingly common unforeseen risks such as wildlife and climate change. These potential risks and limited financial compensation hinder farm production decisions.

In conclusion, it is crucial for preserving biodiversity, guaranteeing food security, and advancing sustainable farming methods in the Garfagnana region to assist small farms and save chestnut trees. Garfagnana's initiatives can serve as an example for other regions looking to conserve their cultural heritage and promote resilient, localized food systems. Small farms in Garfagnana demonstrate how agriculture and forestry practices can coexist with environmental conservation and the provision of valuable ecosystem services. By promoting sustainable practices and preserving the natural resources in the region, the chestnut value chain plays a crucial role in maintaining the ecological balance and supporting the well-being of both nature and the local communities.

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Appendix:

Supplementary data to this article can be found online

www.regionetoscana.it

<https://www.moving-h2020.eu/>

<https://www.istat.it/en/>

<https://rica.crea.gov.it/>

<https://rural-interfaces.eu/resources-and-tools/rural-policy-papers/>

Part of farms notes:

Farm 1: collectio farm

Size: 40 hectare, 20 chicken, rabbits, cow, sheep, vegetable, white bean.

Main for family visitors, education for children, main from Netherland and Germany.

Booking method: direct email, agency information, no advertisement

Economic viability: Irrigation: annual fee and self-infrastructure, Jun – September irrigation period.

Ecological service subsides: 1000-1200 euro/year, not motivation.

Farm 2: Braccicorti pontecosi

Scale and history: land owner's father bought property land in 1989. 11 hectare, 2 hectare Golf course (1996), 18 clubs for hobbies

Location: 44.15 N°, 10.37E°. Typical species in Gafagnana located in main valley.

Motivation: 1990s Agro-tourism became popular in Gafagnana. This farm established in 1996 for agro-tourism.

Information: UK agency for agro-tourism-advertise. cooperation with NGOs. Local agency: Ecasuta.

For visitors: leave your car near to train station.

Enjoy landscape, short time train to farm

Agro-tourism: hiking, mountain bikes riding, Golf club

Climate: suit for chestnut forest

Structure: 1. main house, 2. Golf, 3. Independent houses

Finance: funding for younger farmers and female farmer, but not adequate, operators got female funding. Only subside for solar energy system.

Challenge: climate, geographical, no insurance for crops, risk of harvest,

Farm 3: Podere Ai Biagi

Multi-functional farms' diversity contribution to environment and ecology.

Scale and history: 8 hectares, 2 hectares for agro-tourism.

Species: chestnut forest, spelt (ancient wheat), daily diversity fruits and vegetable

Part time employ 1 person.

Food provision: information between customers and produces through Hive. Natural fertilizer, near to river soil land, irrigation plan in summer. Keeping with rural development program in EU: support agriculture promote opportunity for agro-tourism. Safeguard and promote specific resources in each region. Maintain human activity in rural. Encourage multifunctional agriculture and differentiation income of farm. Soil conservation, increase income. Support and promote traditional and local products. Promote cultural and educational nutrition. Organic agriculture. EU funding for rural development plan cover 15% instrument for farms. Social farm project fund, fund for buildings. Tuscany mountain area is 1st social farms.

Farm 4: Pradaccio di sopra

History: set up in 1999, land owner (wife) bought land in 2013. 10 years business, Husband retired 3 years ago, he has master of regional development when he start this farm.

Typical Gafagnana farm. He decided to do different thing.

Animal husbandry: cow only for meat (usually, for milk), high quality meat

Crops: ancient wheat (spelt) for genetic conservation, seed harvest sale to genetic bank (harvest point in July). Small scale corn. Hybrid crop gene resources bank (wheat and patato). Local type pear and apple. Built fence to against wild animal (wolf).

Adapt disadvantages conditions: soil texture suit olive tree, but olive tree cannot register in municipal. More than 3 hectares chestnut forest can get funding, lack of land to extend, want to keep

chestnut forest. Chestnut trees heights are usual 30-50m.

Cow stable graze in the chestnut forest. By-product of chestnut: woods, branches for fire. Processed in farm use machine.

Harvest machine is 130000 euro, shared by consortium. Spelt seed income 2000 euro/year. Vegetable is higher, cow meat 1600 euro/cow (main income).

Agro-tourism: animal(cow) visit for children. Air B&B, restaurant.

Future challenge: extend lands, increase crop,

1. Vision 2. Technology 3. Know how

Human capital, pass farm to son to get fund for younger farmer. Graze field has few shelter. CAI project for collaboration. Productivity is low, wild animal without fence, large machine cannot enter with fence.

5. National nature park: unione comuni garfagnana - Isera

More and more agro-tourism and less agriculture. Agro-tourism connected agriculture each other. Near hostels are low quality. Camps area in the park. 1980s mountain community proposed a sign for collaboration. EU evaluate possibility of marginal mountain area to develop agro-tourism. 130000 people times/year, counted only stay 1 or more nights. Second tourism mountain area in Garfagnana. Visitors number are low compared with other areas. Farmer's house for Airb&b to increase income. Hiking, climbing, camping

Strategy: hope the sector (state, municipal) could restart project and response after covid 19, Promote new investment and project. Collaboration with farms, farms collaboration synergy common strategy follow market study of agro-tourism. Collect more market evidence - public sector. Biodiversity subsides: farmers. Growth comes from synergy collaboration. Municipal make budget of tourism tax 6000-700 euro to promote/maintain for the park.