Ecologically-oriented business strategy for a small-size rice farm: Integrated wetland management for the improvement of environmental benefits and economic feasibility.

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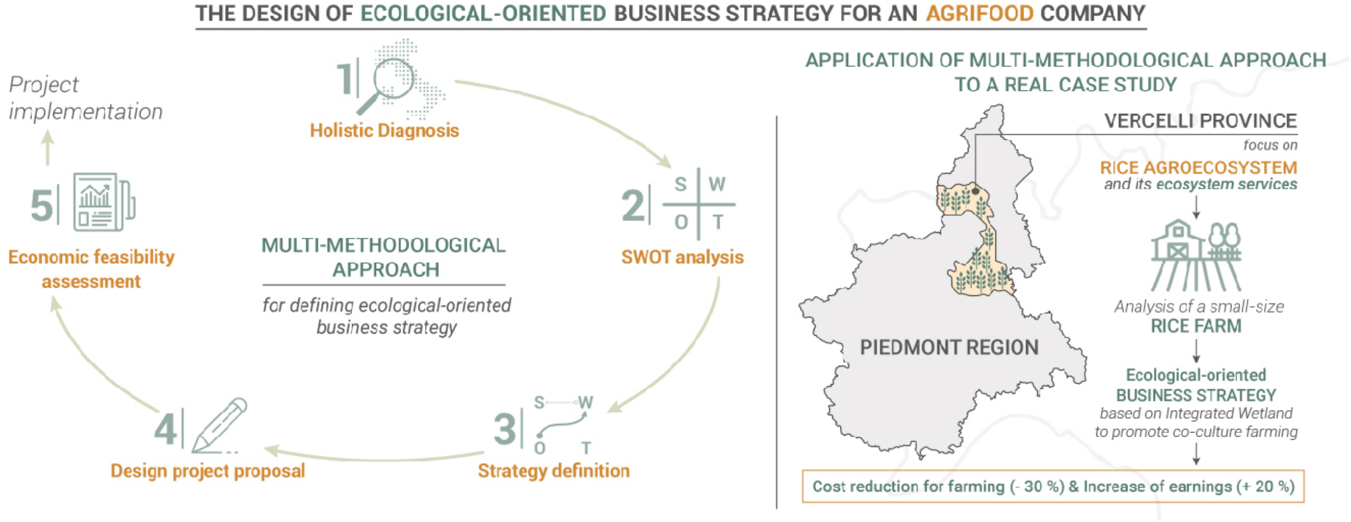
Abstract

The Italian rice agroecosystem plays a key role in the European production and provides a unique range of rice varieties. As productive man-made wetlands, rice paddies are strategic and economic components in the habitat provision for migratory wildlife at the European scale. However, the characteristic of being a "temporary wetland" causes the creation of an ecological trap for a number of living organisms. For this reason, agricultural practices adopted for the management of rice paddies are essential to move towards more sustainable cultivations capable of promoting biodiversity and to minimising negative environmental impacts. This study proposes an ecologically-oriented strategy to implement a circular and self-regulating farming system designed considering the role of constructed wetlands in providing ecosystem services in rice agroecosystems. It demonstrates the economic feasibility and benefits provided by a self-regulating biosystem based on an integrated wetland for a small-size rice farm of the Vercelli province (Piedmont Region, Italy). The study was conducted in collaboration with the rice farm, which already experiments with organic farming techniques. The investigation focuses on the current management structure of the farm and develops an ecologically-oriented business strategy to sustain local biodiversity. This strategy rediscovers and improves the traditional co-culture technique through the development of a permanent pond. It explores the potential benefits generated by the approach, in terms of biodiversity conservation, biological control of pests and weeds and habitat provision for wildlife. The study presents a real case study of economic sustainability of the business strategy through financial analysis. The findings highlight promising economic outcomes compared to the conventional rice cultivation systems. The diversification of marketing strategy and the reduction of operating costs are key factors in the success of the strategy. The ecologically-oriented design methodology presented in this article can easily be applied to other small-scale farms in the agrifood sector.

Keywords:

Wetland agriculture, Biocultural diversity, Ecological-oriented design, Co-culture farming, Ecosystem services, Economic sustainability

Graphical Abstract



1. Introduction

Rice plays a pivotal role for human nutrition for nearly half the global population and it has become an important aspect of the cultural and local identity in many countries, especially in the Asia (Prasad et al., 2017). At the global scale, approximately 155 million ha of land are cultivated with rice crops and the worldwide rice production is dominated by China, India and Indonesia as the biggest producers (Food and Agriculture Organization of the United Nations, 2019). Overall, Asian countries are the largest consumers of rice per capita (Statista, 2020). In Europe, Italy plays a significant role in the European and global market in terms of rice production and exports.

A rice agroecosystem is considered a temporary wetland characterised by an hydroperiod that alternates floodings during the summer and droughts during the winter. It is a highly dynamic man-made ecosystem characterised by rapid changes of physical and chemical parameters and water levels that affect the development of its biological community. As semi-natural temporary ponds, rice paddies represent 15% of global wetlands. They play a valuable role in providing several ecosystem services (Lawler, 2001; Chivenge et al., 2019; Preez et al., 2019), and offering a habitat for aquatic fauna (Toffoli and Rughetti, 2017). Ecosystem services (ES) are described as the "benefits produced by a healthy ecosystem that positively influence human well-being" (Millennium Ecosystem Assessment, 2005) and they are classified into provisioning, regulating, supporting and cultural services. The assessment of ES could be a useful tool to evaluate the benefits derived from ecosystems (Ajwang' Ondiek et al., 2016). Although rice paddies cannot be considered as fully substitutes of natural temporary ponds, they significantly contribute to produce marketed ES, such as rice and straw as by-products, and non-marketed ES, such as soil formation, mineralisation of plant nutrients and nitrogen fixation (Nayak et al., 2019; Buresh et al., 2008). Moreover, rice agroecosystems as temporary wetlands create the ideal habitat to support the life cycle of numerous living organisms such as algae, fish, amphibians, reptiles, molluscs, crustaceans, worms, insects and a variety of avifauna (Strada Del Riso Vercellese, n.d.; Toriyama et al., 2004). Many different human transformations and adaptations of the terrain for rice cultivation have led to the creation of a unique geometric landscape characterised by a high aesthetic value. Rice paddies are a distinctive landmark of the agro-cultural system of the Piedmont region. A number of ecologically-oriented farms are currently investigating co-adaptation strategies to promote the sustainable development of the territory (Min & He, 2014; Banino & Matrone, 2016). Water is the essential element for rice cultivation and the alternating submersion and dryness stages in rice paddies influences the ecosystem's dynamics as a temporary wetland. The flooding of rice paddies during the summer creates the habitat for migratory avifauna, providing the opportunity to develop ecotourism and educational activities, such as birdwatching or citizen science projects (Dem et al., 2018), in order to promote the importance of ecological conservation and biodiversity in agroecosystems (McInnes & Everard, 2017).

Rice agroecosystems are also affected by a series of criticalities. Their high level of biodiversity is often negatively affected by modern cultivation techniques (Luo et al., 2014). The adoption of the alternate submergence and drying technique, for instance, can lead to the creation of an ecological trap for some species, such as the arthropod or amphibian communities, which cannot complete their whole breeding cycle (Travisi and Nunes, 2010). Ecological traps usually occur when living organisms form an inaccurate representation of a habitat that is not able to support a stable or growing population (Robertson and Hutto, 2006). Environmental habitat are defined as ecological traps if they lead to the direct mortality of individuals as result of rapid changes in the characteristics of the territory (e.g. hydrological, geomorphic, chemical changes) with a reduction of environmental quality (Hale and Swearer, 2016). Stormwater ponds, polarised light pollution, game farms or bird nesting in grasslands or agricultural landscapes are some examples of ecological traps and maladaptive behaviour (Schlaepfer et al., 2002).

Moreover, fertilizers, pesticides and herbicides produce negative consequences not only on soil and water quality, but also on flora and wildlife. Indeed, the rice agroecosystem is characterised by a wide range of insects, some of which are rice pests (Norton and Heong, 2010), such as the *Sypha glyceriae* and the *Rhopalosiphum padi* which are widely extended in Italy (Süss et al., n.d.). Pests and weeds are usually controlled by farmers using chemicals in order to avoid huge harvest and profit losses which however cause a degradation of the local biodiversity, as well as water and soil pollution (Ferrero et al., 2016). Moreover, the alternate submergence and dryness conditions cause the emission of methane (CH_4) in the atmosphere, while the use of nitrogen-based fertilizers is responsible for the increasing release of nitrous oxide (N_2O) due to microbial nitrification and denitrification which occur in the soil (Park et al., 2012; Arpa Piemonte, 2014; Ferrero et al., 2008).

A number of studies and practical experiences are currently exploring the implementation of sustainable agro-management techniques in temporary wetlands, such as organic farming (Verhoeven & Setter, 2010; Xu et al., 2020). The aim of these investigations is to reduce the impact of intensive rice cultivations and to meet the wildlife conservation goal (Calhoun et al., 2017). One area of interest is the co-culture techniques, which is based on constructed wetlands integrated in agriculture to support agroecosystems in providing ES. However, few studies explore the opportunities offered by these technique in the Italian context.

1.1 Research goal

This study presents the application of a multi-methodological approach for redesigning the business management of a small-scale farm. The multi-methodological approach is applied in order to support local biodiversity, as well as improve economic profit. The study was conducted at the Priorato Farm, located in the province of Vercelli (Piedmont, Italy), which is one of the most important site for rice production in Europe (Sistema Piemonte, 2020). The business management of the Priorato Farm was analysed using a multi-methodological approach that integrates tools from Systemic Design methodology (Battistoni et al., 2019) with tools from strategic planning and financial analysis. The investigation through a multi-methodological approach led to the definition of an ecologically-oriented strategy aimed at the creation of a self-regulating biosystem. This strategy responds to the urgent need of improving the sustainable use of natural resources in farming (Dominati et al., 2019). The self-regulating biosystem was based on integrating constructed wetland into rice paddies for the implementation of new business opportunities at local scale. The business strategy developed in this study considers ecological restoration principles (Newton et al., 2021) and promotes biodiversity conservation as opportunities to move towards a multifunctional agroecosystem. The ecologically-oriented strategy was defined taking into consideration research outcomes of previous scientific studies, in terms of food productivity and improvement of ecosystem health.

This study also analyses the economic feasibility of the new business plan in order to validate the profitability of the proposed ecologically-oriented business strategy when applied to a small-scale rice farm. The study demonstrates that the adoption of the multi-methodological approach can fill the knowledge gap regarding the economic feasibility of the ecologically-oriented business project. This aspect that is often overlooked in the field of study. It also addresses the urgent debate concerning the adoption of sustainable practices to support ecosystem services in the Italian rice agroecosystem. The multi-methodological approach presented in this case study produced promising results suggesting that it can be implemented to re-design business strategies on other rice farms and companies in the agrifood sector, not only in the Italian context.

2. Materials and methods: a multi-methodological approach

A multi-methodological approach was adopted to analyse the case study. It combines tools from Systemic Design (SD) methodology (Battistoni et al., 2020), such as the Holistic Diagnosis (HD), and the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis used as flexible model in decision-making and strategic planning processes (Benzaghta et al., 2021).

In the first stage, the HD was conducted in order to collect information about the case study's farming and business management, and about the surrounding environment, following the methodology described in (Battistoni et al., 2019). HD was adopted as an analytical tool useful to outline a complete overview of the case study based on the analysis of the context, products, services and processes. Quantitative and qualitative data were collected on the local territory (e.g. demography, geography, agriculture, vegetation and wildlife, services, local enterprises) and on the company itself through field and desk research. HD consists into two stages: HD of the local territory and HD of the production process (Battistoni et al., 2020). The HD analysis of the territory aims to highlight geographical, cultural, and economic features to identify the main drivers of the design process. Territorial information was gathered consulting different official databases, such as the Italian National Institute of Statistics (Istituto Nazionale di Statistica – ISTAT). Information was collected to describe territories using data about population density, cultivated area, number of farms and enterprises, principal and secondary production sectors, presence of natural and protected areas.

During the second stage of HD, data collection was performed using surveys with the farm manager or through field visits in order to understand the farm structure and its management of natural resources and raw materials. Data were organised using giga-maps and flow charts in order to define the state of the art of the case study and to visualise the company's relationships with other local economic realities and its connections with the local know-how and material culture (Sevaldson, 2018). The production process was investigated using an energy and material flow analysis that explores characteristics of the raw materials (inputs) that enter the production flow, and by-products and waste (outputs) that are generated. The holistic approach applied to the material and energy analysis is already adopted in permaculture and agroecology to move towards more sustainable agrifood systems that ensure social and economic equity, conserve biodiversity and restore ecosystem services (Didarali and Gambiza, 2019; Mollison, 1988). All the significant information on the territory was collected in order to define the background scenario, which was structured in existing correlations, criticalities and potentialities in order to design a project proposal for business innovation (Gaiardo, 2016).

The economic status of the case study was also analysed using a conceptual matrix developed by Deloitte for SD methodology to describe its business core strategy (Battistoni et al., 2020). This conceptual matrix was implemented as a part of the HD, based on organization, financial statement, trading relationships and market dynamics. Each indicator was allocated weights in collaboration with the farm owner in a focus group. The indicators on the y-axis describe the company's philosophy, while those on the x-axis provide information about trading relationships which characterise the core business. The three indicators on the x-axis were adjusted and adapted considering previous studies conducted using this matrix (Battistoni et al., 2020), in order to provide a more accurate and adequate description of the company's current business strategy and market position in the agrifood sector. The first step of the focus group is the allocation of a percentage value to each of the five indicators of the y-axis, that must weight 100% in total. The second step consists in the analysis of each indicator on the y-axis using those on the x-axis. The percentage value assigned to each y-axis indicator is considered as the reference value to assign a percentage to each indicator on x-axis. The matrix provide a qualitative description of the business strategy of the farm by defining three areas of business investments. The "*focus area*" is the core business of the farm composed by all factors with a percentage > 12%. The most of economic investments are held considering these factors. The "*attention area*" describes secondary investments of the farm composed by those factors with percentages between 5% and 12%. The "*hinted presence area*" consists of those factors (< 5%) that are not considered in the core business of the farm. Factors included in the "attention area" and in the "hinted presence area" are potentialities that can be considered for the development of new business strategies.

Data concerning the company organization and management, as well as information about the local territory were organised using a SWOT analysis. The SWOT matrix clarifies how strengths and weaknesses could be matched with opportunities and threats defining four strategies that provide drivers for gaining an initial idea and to develop a business plan (GÜREL, 2017; Vlados, 2019). The SWOT helped to recognise internal (strengths and weaknesses) and external (opportunities and threats) factors which may influence the achievement of the company's goals, to address main gaps and to define new developing strategies. SWOT analyses have already been applied in the agricultural field with the aim of defining potential strategies to improve the use of water resources or to define promising alternatives for farm enterprises and new product development (Diamantopoulou & Voudouris, 2008; Ommani, 2011; Wardhono & Wibowo, 2020; Zhang et al., 2020). Therefore, SWOT analyses are performed during the initial stage of a pilot project as they afford in-depth knowledge about all aspects of the current business framework.

The integration of the SWOT analysis into the SD methodology helped to organise a qualitative scenario and to outline alternative options for the business development (Davis, 2007). The SWOT also considered possible implication (positive or negative) with provisioning, regulating, supporting and cultural ES (as shown in the Figure 4). Main critical issues identified (weaknesses and threats) were analysed and affordable solutions were explored with the reference to the literature on how to reduce the environmental pressure and sustain ecosystem services. A list of significant priorities for the company was defined using results obtained from the HD and SWOT analyses. The list was used to combine the four strategies in order to move towards the desired ecological-oriented business vision. Sustainable improvement was the main driver in the decision-making process. The strategy adopted defines the strategic vision, main goals, detailed technical actions, and patrimonial and financial planning (Beale et al., 2012).

The economic feasibility assessment of the project proposal was conducted to evaluate its profitability over a five-year period. The financial analysis of the new business plan was performed using:

- the balance sheet report that summarises the expected operating activities, based on assets, liabilities and shareholder equity over the accounting period adopted,
- the profit and loss (P&L) statement, also known as the income statement, that presents the business's financial position on a specific date focusing on the type of resources available for business operations and for achieving the goals. It provides information about the ability of the company to generate profit by increasing revenues, reducing costs, or both,
- the operating cash flow forecast that provides a projection of changes in the business's cash during the accounting period focusing on cash inflow and outflow transactions.

These methods are well known tools for the assessment of the economic and financial profitability of a new business (Cunningham et al., 2015). The information in the balance sheet and in the income statement was used to calculate the earnings before interests, taxes, depreciation, and amortization (EBITDA). The EBITDA shows the company's overall earnings before the influence of accounting and financial deductions (as shown in Equation (1)) (Friedlob and Schleifer, 2003), where *D* is the depreciation and *A* the amortization.

$$(1)\ EBITDA = Net\ income + Interest + Taxes + D + A$$

In addition to the EBITDA, interest and tax payments were also calculated as cash outflows to provide a more realistic overview of the financial and economic health of the business plan. The operating cash flow was adopted a key tool to demonstrate the company's ability to generate cash over the accounting period, thus maintaining itself and increasing its operations. Cash and cash equivalent (CCE) at the end of accounting period (4 years) was calculated to evaluate the value of the farm's assets that were cash-obtained from operating activities or that could be converted into cash immediately. Operating cash flow was considered an important benchmark tool to evaluate the financial success of the business plan (McLaney and Atrill, 2012).

3. Results: application of the multi-methodological approach to a case study of a rice farm's management

3.1 Holistic Diagnosis: territory, company's vision and cultivation techniques

Italy is the leading country that counts about the 51% of European rice paddies. It cultivates a unique range of *Oryza sativa* L. ssp. Japonica and Indica varieties, such as the Arborio, the Carnaroli, the Vialone Nano (Italian Parliament, 2020). More than two-thirds of European rice is produced by Italian farms and about 60% is exported to other Mediterranean countries and Eastern Europe (Kraehmer et al., 2017).Approximately 4200 companies, mainly located in Piedmont and Lombardy regions,in the huge area known as the "Golden Triangle" between Vercelli, Novara and Pavia provinces, cultivate about 132 rice varieties (Istat, 2020). Rice cultivation was introduced in Italy at the end of the 15th century and its development is strictly linked to the construction of the most important irrigation network, Canale Cavour, done by Camillo Cavour at the end of the 19th century (Arcieri and Ghinassi, 2020). The construction of Canale Cavour allowed the development of rice cultivation, especially in Vercelli, Alessandria, Novara and Pavia provinces. The province of Vercelli is one of the most productive area concerning rice cultivation that counts the 58% of total rice farms (almost 917 local producers) of Piedmont Region and 70.000 ha of land cultivated with more than 100 different rice varieties (Sistema Piemonte, 2020). Extensive rice crops are the landmark of the territory characterised by flooded plains symmetrically divided by rows of poplars. many protected areas and parks, such as the Po River Park, the Alta Valsesia and the Lame del Sesia Natural Parks, promote wetlands preservation in order to maintain habitat for avifauna and wildlife. Four varieties of rice cultivated in this area are Protected Designation Origin (PDO), such as the "Arborio" and the "S. Andrea di Baraggia". The origin of these varieties is linked to the geographical features of Baraggia. Baraggia area is close to the mountain chain (150-340 m altitude) between the provinces of Vercelli and Biella and it is characterised by large prairies and heaths. Baraggia is also the northernmost place in the world where rice is cultivated and this *terroir* offers distinctive organoleptic features of rice grains.

Priorato Farm was founded in 2017 and it is composed by the owner and a seasonal employee. Rice cultivation is the core business of Priorato Farm that cultivates 65 ha of rice paddies. Since the beginning, the farm tested both traditional and biological rice cultivation techniques and it obtained the biological Biodiversitas certification in 2020 thanks to the adoption of green mulching (GM) technique for the management of 27 ha of rice paddies. The implementation of GM technique refers to the practical experience reported by Masanobu Fukuoka, a Japanese botanist and philosopher, known as the pioneer of natural farming. Following the Fukuoka's model, the farm developed a non-invasive farming method which minimises the human intervention and fosters biological processes getting inspiration from natural ecosystems (Fukuoka, 1985). Fukuoka's method does not require the use of chemicals and agricultural machineries reducing soil and water pollution and the use of fossil fuels (Fukuda, 2018). GM technique consists of covering the ground with a mulch derived from herbaceous plants that maintains the fertility of soil and prevents proliferation of weeds, avoiding the use of chemical fertilizer and herbicide (Jabran, 2019).

Priorato Farm applies the GM technique (Fig.1) sowing herbaceous and legume plant such as *Trifolium pratense*, *Vicia villosa* and *Lolium perenne* as nitrogen fixers in November, at the end of the rice harvesting and soil harrowing . Rice seeds are usually sown at the beginning of May, while herbaceous and leguminous species are cut down and left on the field in order to create an organic mulching layer. Sometimes, the farm integrates the GM technique with the use of the horn-hoof based organic fertilizer (12%-14% N) as soil conditioner before sowing. After sowing, rice paddies are usually flooded until harvesting in October.

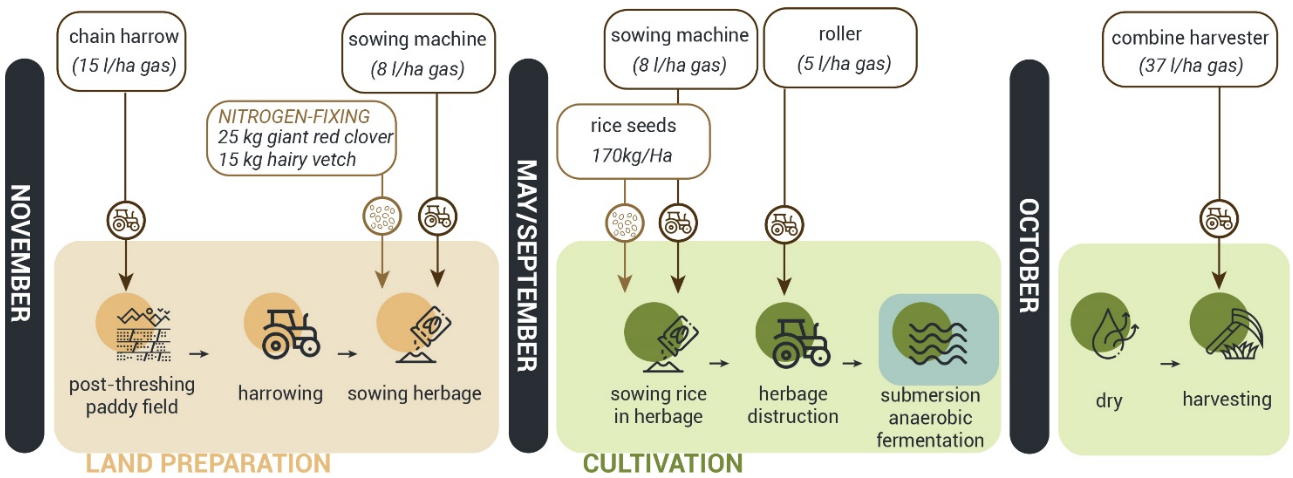


Figure 1.: *Green mulching technique management of rice paddies (27 ha): the graph shows quantitative data referred to raw materials and agricultural machinery that enter into the agricultural system as inputs, and the 12-month timeline of main activities.*

The others 38 ha of rice paddies are cultivated using conventional agronomic methods (Fig.2) that include rice water-seeding and permanent submersion. In this case, the GM technique is not appropriate for managing rice paddies due to soil characteristics, such as the gravel-based structure and the high percentage of clay. The gradually transition towards organic farming implies to test varied agronomic techniques in order to select the most appropriates for soil characteristics (structure, texture and permeability).

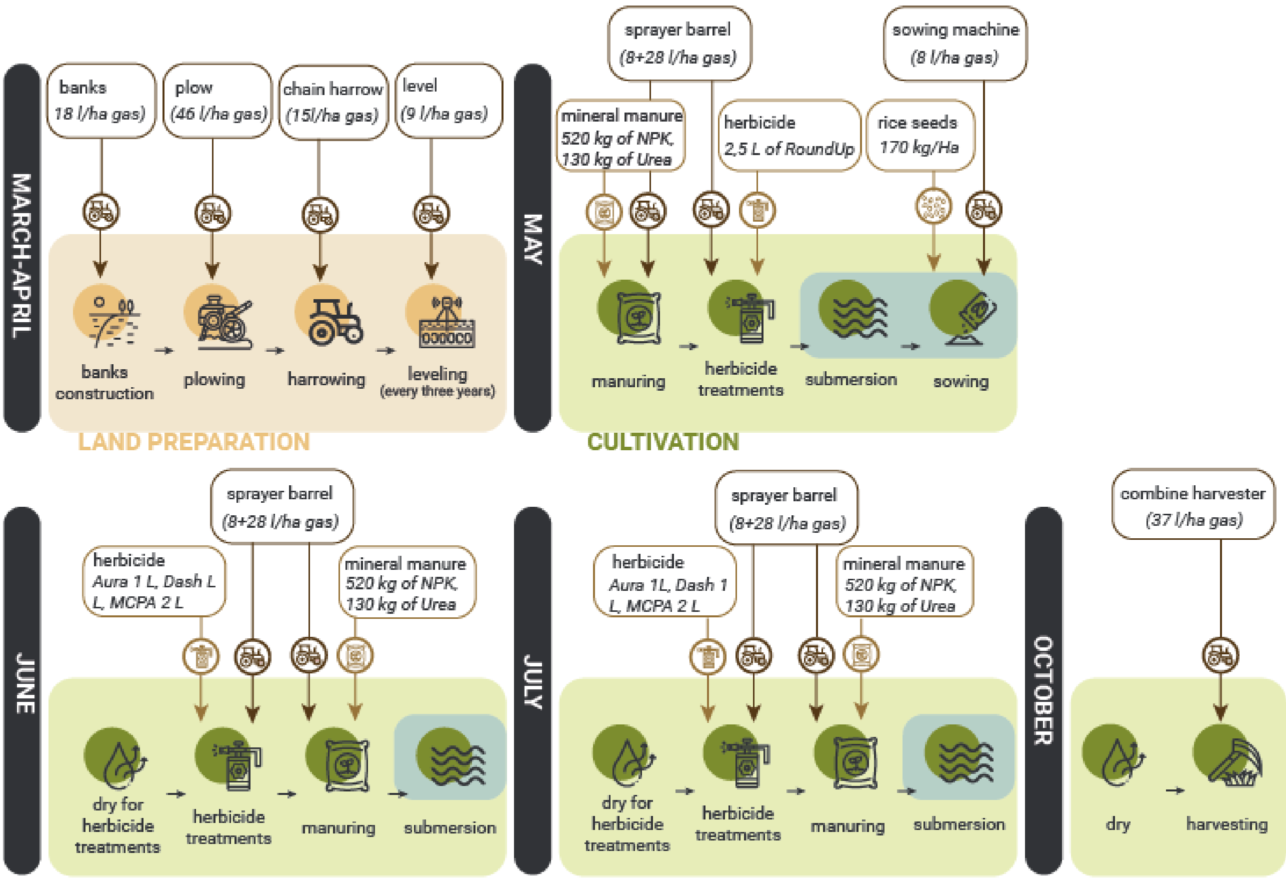


__Figure 2.:__ Traditional management of rice paddies (38 ha): the graph shows quantitative data referred to raw materials (including pesticides, herbicides, and mineral fertilizers) and agricultural machinery that enter into the agricultural system as inputs, and the 12-month timeline of main activities.

Banks are constructed before rice seeding and rice paddies are usually prepared through ploughing, chain harrowing and laser levelling before the application of herbicides and fertilizers such as mineral manure. Rice paddies are flooded in May and consequently rice seeds are sown. During summer rice paddies are usually dried twice in order to carry out fertilizing and weeding cycles, firstly in June and secondly in July, and re-flooded again after each treatment. At the end, the rice is harvested in October.

3.1.1. The current company's business strategy

The current business strategy of Priorato Farm is shown in Figure 3. The company presents a good ability to combine traditional knowledge and innovation, also considering the strong inclination of the owner for the adoption of changes and solutions towards sustainability. Moreover, the farm owner is a founder member of the Polyculturae Association, composed by local producers, that acts as a cultural hub to disseminate basic concepts of agroecology and good practices to promote biodiversity in rice agroecosystems. . Priorato Farm focuses on creating a business strongly connected to the local territory thanks to the active engagement in building bridges between citizens, local farmers, public and private research institutions.

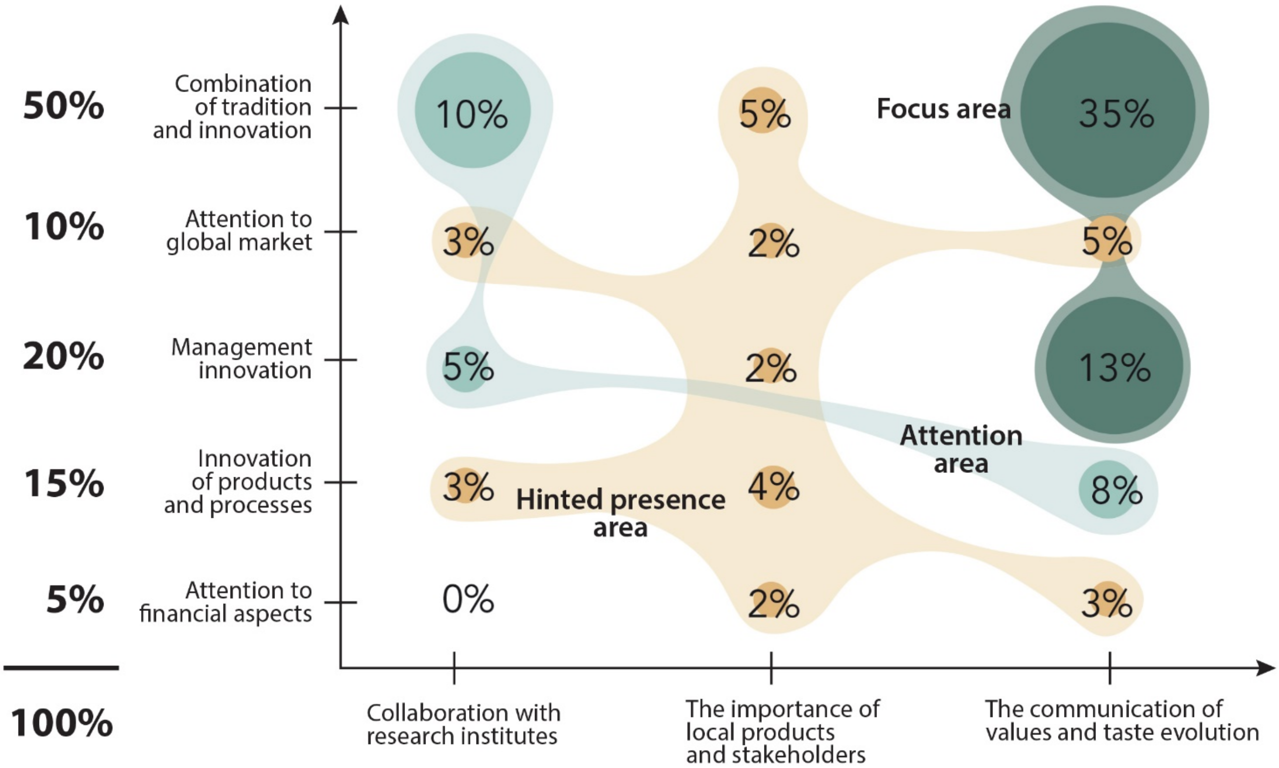


Figure 3.: *Matrix of the company current business strategy. In the x- and y-axes the evaluation parameters are positioned. The focus area is highlighted in dark green with a percentage > 12%. The attention area is represented in light green with percentages ranging between 5% and 12% and the hinted presence area is pointed out in light orange with percentages < 5%.*

3.2 Analysis of the company organisation through SWOT matrix

Data collected during interviews with farm owner were organised in strengths and weaknesses, as internal origin factors, and opportunities and threats, as external origin factors in order to highlight potentialities or risks addressed to the surrounding environment (Figure 4). Aspects that describe each factor were analysed considering possible implications within ecosystem services.

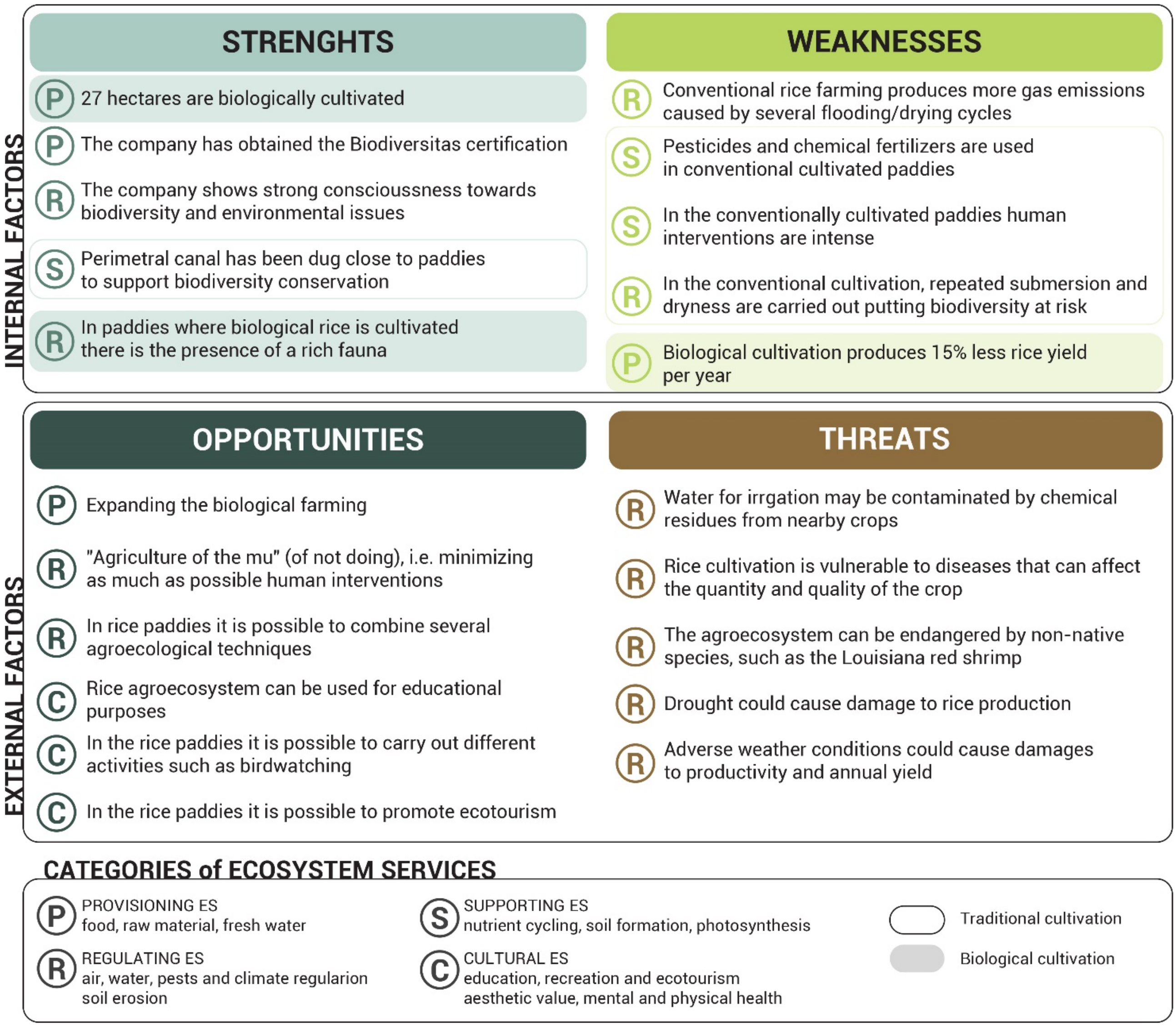


Figure 4.: *S.W.O.T. analysis that shows internal factors (strengths and weaknesses) and external factors (opportunities and threats) with reference to possible implication with the four categories of ecosystem services.*

The most significant strength of Priorato Farm is the attention focused on preserving biodiversity and investigating alternative and more sustainable agricultural techniques. Moreover, the company constructed in 2019 a ditch for water storage close to rice paddies to provide suitable habitat and avoid the creation of ecological trap for some aquatic species which can complete their life cycle. Thanks to the implementation of these practices, the company reported the presence of many wildlife species where rice paddies are managed using the GM method, such as *Threskiornithinae*, *Ardea cinerea*, *Ardea alba*, *Bubulcus ibis*, *Alcedo atthis*, *Botaurus stellaris*, *Odonata*, *Amphibia*, *Reptilia*. Despite many environmental benefits produced by the adoption of biological practices for cultivating rice, the productivity of biological rice paddies is 15% less than those managed using conventional method.

The most significant company's weaknesses are the use of chemical herbicides, pesticides and fertilizers, andthe intensive use of water resource for flooding-drying cycles. The application of conventional agricultural practices causes water and soil contamination, biodiversity degradation, gas emission and the creation of an ecological trap for several aquatic species during the drying phase.

, The company has the great opportunity to expand the cultivation of biological rice applying the GM method to all rice paddies supported by fundings provided by the Rural Development Program (RDP). Moreover, natural farming suggests to improve and combine different agroecological practices, such as the co-culture technique which consists of the integration of agriculture and animal husbandry, where animals are reared together with the crop (Bashir et al., 2020; Chinese Academy of Sciences, 2010; Furuno, 2001). Rice agroecosystem creates a unique landscape rich of fauna, especially where biological cultivation methods are adopted to manage rice paddies as temporary wetlands. The enhancement of local biodiversity provides the opportunity to develop educational activities, ecotourism, and recreational initiatives.

A significant threat that may negatively affect the quality of final products is the water used for irrigation that could be contaminated by chemicals released in nearby crops where biological cultivation techniques are not applied. This aspect could also damage the wildlife sustained and promoted by the adoption of biological cultivation. Adverse weather conditions such as drought and plant disease or infestations of exotic animals such as by *Procambarus clarkii* are harmful aspects that cannot be directly controlled by the farm.

3.3 Business strategy definition based on opportunities provided by literature review

The strategy was defined in order to exploit the opportunity to combine different agronomic techniques, focusing on co-culture farming based on integrated wetland management, considering the farm attitude towards biodiversity conservation (Bashir et al., 2020). The aim of the strategy is to further improve farm strengths by using a part of the biologically cultivated field to improve its productivity. The strategy proposed was obtained as a combination of a SO strategy, in which opportunities are used to enhances strengths, and a WO strategy, which consists of exploiting opportunities to reduce weaknesses. The strategy is based on the development of co-culture of rice, fish and ducks. Co-culture methods introduces animals in flooded paddies for breeding and then they are gathered in a permanent constructed wetland before rice harvest. Rice-duck-fish co-culture would bring numerous benefits to the entire rice ecosystem such as the reduction of gas emissions, the improvement of water and soil quality, the retention of nutrients. All of these benefitsare offered by the adoption of *wetlaculture* (Jiang and Mitsch, 2020) and biodiversity conservation techniques.

The introduction of fish and ducks in to rice paddies helps to regulate CH_4 and N_2O emissions. Bhattacharyya et al. (2013) reported that the introduction of fish leads a decrease of N_2O emissions by 9% but, at the same time, it causes an increase of CH_4 emissions by 26%. On the other hand, the introduction of ducks leads to a decrease of CH_4 emissions by 8,80-16,68% and an increase of N_2O emissions by 4,23-15,20% (Xu et al., 2017). The integrated rice-duck-fish farming leads to an increase of soil nutrient content such as soil organic carbon, total nitrogen, available nitrogen, available phosphorus and available potassium, more specifically total nitrogen level increase by about 126%. Moreover, values of dissolved oxygen and oxidation reduction potential are higher in co-culture systems than in conventional ones, respectively by 8,4% and 31,8% (Nayak et al., 2018).

The study conducted by Wan et al. (2019) in China assess that the integration of fish farming in rice paddies decreases the presence of insects pests, such as rice plant-hopper and leaf roller, by 24,07%, weeds by 67,62%, while, it increases the presence of predators by 19,48%. While Teng et al. (2016) assessed that the implementationof the rice-duck co-culture farming produces a reduction of rice pests population such as leaf rollers (- 39,19%), stem borers (-18,6%), planthoppers (-57,40%), and sheath blight (-16,09%). The same study also reported that the presence of weeds is lower in the rice-duck co-culture farming than in conventional cultivations, with a decrease of 91.9% in number and 75% in the variety of weed species.

Different studies also focuses on the evaluation of consequences of the co-culture farming on productivity of rice paddies and on farm overall profit (Sheng et al., 2018; XIANG et al., 2006; Xu et al., 2017; YUAN et al., 2009). Hossain et al. (2005) demonstrates that the adoption of rice-duck co-culture leads to 20% increase per year of rice yield and to 50-60% increase of farm economic income compared to conventional rice cultivation system. Moreover, Halwart & Gupta (2004) reports that the rice-fish integrated farming generates an increase of 14-48% of rice yield and an increase of 50% of profit. These studies demonstrated that co-culture methods lead to a consistent reduction of the use of chemical fertilizers, pesticides and herbicides thanks to foster self-regulating processes. Co-culture methods produce benefits on the quality of soil and water and on the biodiversity of rice agroecosystem (Halwart, 2008; Luo et al., 2014).

3.4 Description of the pilot project and new business proposal

The proposal focused on implementing co-culture farming based on integrated constructed wetland, or *wetlaculture* (Boutin et al., 2021; Jiang and Mitsch, 2020). The project proposal designedfor Priorato Farm considers current European and regional policies, and characteristics of local market. Approximately 5 ha of rice paddies, already cultivated with GM, are involved in the pilot project based on designing a permanent constructed wetland as refugee for animals in order to foster co-culture farming. The pilot project consists of digging two lateral channels (1 m deep and 1 m wide) and approximately 9500 m^2 of pond which provide overall 1 ha of water surface and about 4 ha of fields for rice cultivation as shown in Figure 5.

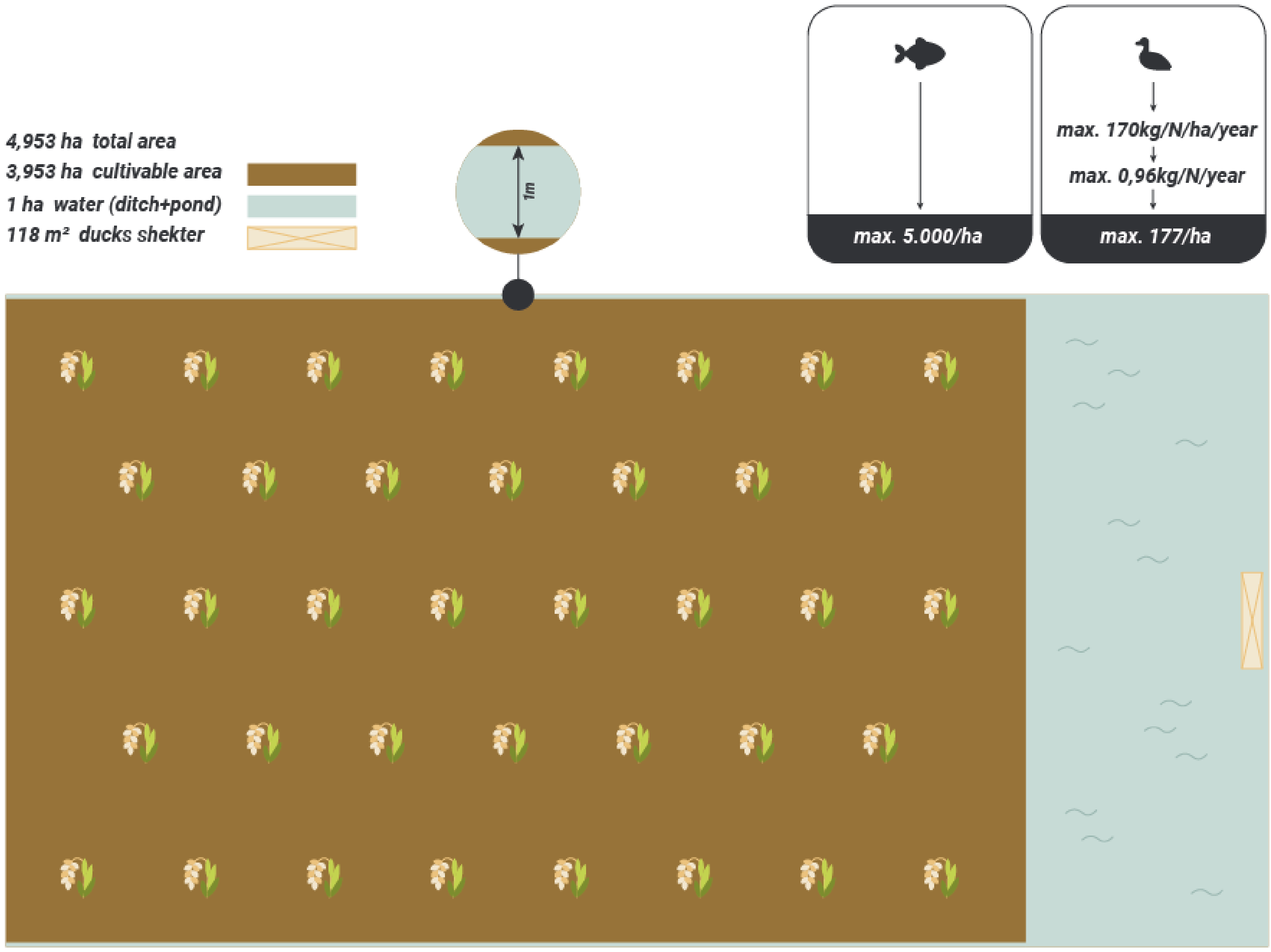


Figure 5.: *Details of the 5 ha pilot project.*

Approximately 168 ducks (*Anas platyrhynchos*) and 500 fishes (*Tinca tinca*) are introduced considering current regulations for animal breeding and organic integrated farming techniques (Senato della Repubblica, 2021, Consiglio regionale del Piemonte, 2020; Ferrucci & Marcone, 2017). Moreover, the introduction of *Anas platyrhynchos* and *Tinca tinca* also is regulated by the limited space available during winter (about 1 ha of pond’s freshwater) for animal breeding due to the drying of rice paddies.

Both species are currently bred in Piedmont Region and their meat is widely used in the local cuisine. *Anas platyrhynchos* is the most popular duck species bred for meat and eggs that reaches a maximum weight of 3.5 kg for males and 3.0 kg for females after six months and produces 130-200 eggs per year. On the other hand, *Tinca tinca*, that usually reaches a medium length of 20-40 cm and a medium weight of 600 g, is one of the most important fish species bred in Piedmont Region, well known as the "Tinca Gobba Dorata del Pianalto di Poirino PDO" (Pagliarino and Pavone, 2012). The co-culture farming that involves *Tinca tinca* and rice was a common practice usually adopted in the provinces of Vercelli, Novara and Pavia until the 1970s when it was replaced by modern techniques of rice cultivation (Dees et al., 2003; Russo, 1987).

The permanent pond was equipped by a 118 m^2 stilted duck shelter as refugee. The duck shelter is large enough to accommodate maximum 354 ducks (3 ducks/m^2) during summer according to current regulations (Commissione Europea, 2020). The pilot project required the installation of a modular fence along the pilot site for ducks and nets at the entrance of lateral channels for tench fish, while an incubator for breeding the duck's eggs is required for population growth. The pilot project should start in November with the introduction of ducks and fish into the constructed wetland. Ducks and fishes can be bred directly in rice paddies from May onwards when they are flooded. Then ducks should be gathered into the constructed wetland in August when rice is blooming, while fishes must be channelled in October when rice paddies are dried for harvesting.

The new business strategy of the Priorato farm is shown in Figure 6 that highlights changes obtained by the implementation of the integrated co-culture method.

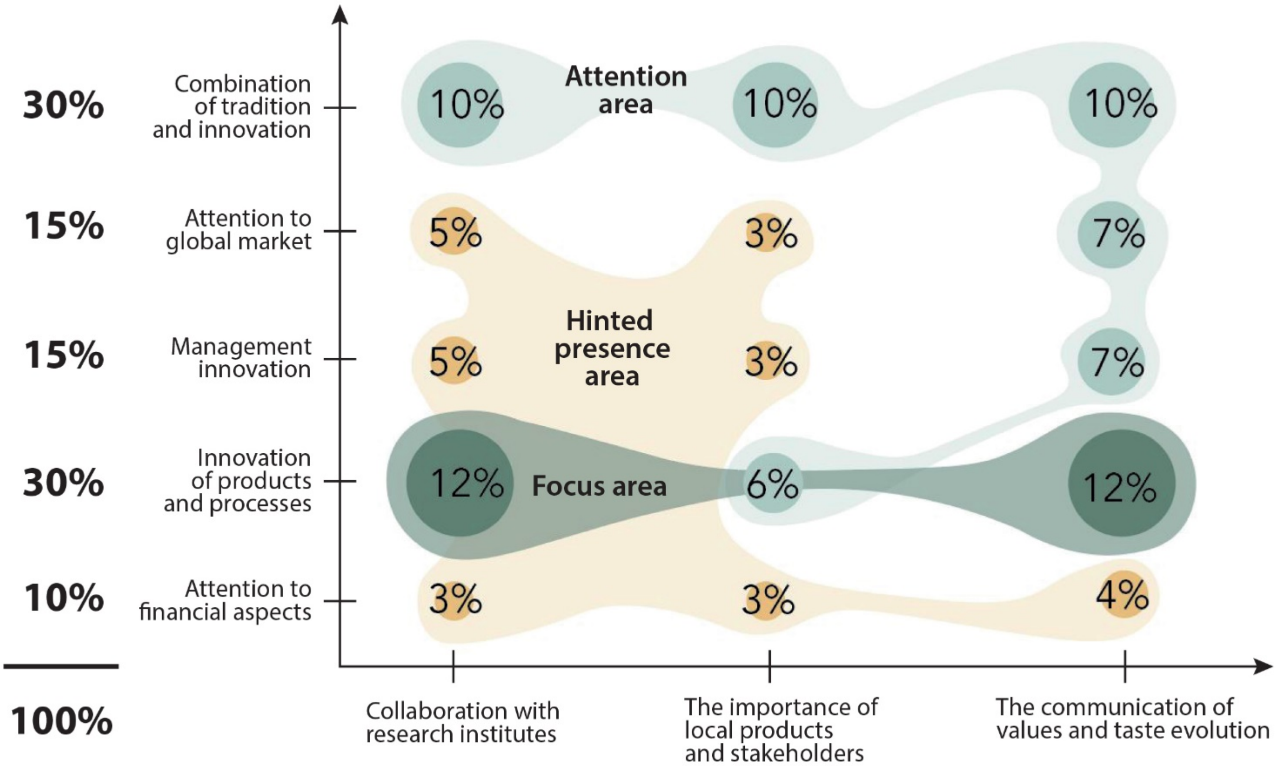


Figure 6.: *Matrix of the new business strategy that shows the core on innovating farming processes looking at the adoption of agro-ecological techniques that integrate new breeding activities, and at the attention to promote and restore the habitat for wildlife through the permanent pond and lateral canals.*

3.5 Evaluation of potential economic outcomes

At the end, the fiancial feasibility aims to demonstrate the economic sustainability of the business plan applied to the Priorato Farm. In order to establish overall investment for the implementation of the project proposal, costs for constructions and raw materials were defined based on the price list of agriculture provided by the Piedmont Region (Regione Piemonte, 2021) and on the analysis of local market, as shown in Table 1. Moreover, the implementation of new breeding activity requires the employment of a part-time worker with an annual cost for the company equal to 16.000 €.

Materials and works	**Quantity**	**Total Costs**
Wetland construction	1	25.246 €
Ditch construction	2	1.330 €
Duck’s shelter	1	1.900 €
Fence	1	2.856 €
Incubator	1	140 €
Duck eggs	168	487,2 €
Tench	500	900 €
Nets for the channel drain	2	28,90 €
Total costs		32.888,1 €

Table 1. *List of total expected costs for system implementation.*

Cost and revenues were analysed into the business plan and financial statement was defined for the first four years of operation in order to evaluate the economic feasibility of the project. The most of costs are borne by the farm during the first year (Year 1) for infrastructural operations and for supporting fish-duck breeding. Thanks to the local market research, the Table 2 shows potential earnings obtained by selling new food products of the implemented rice-fish-duck co-culture to other local food processing companies.

New saleable products	
Dack meat	10 €/kg
Tench meat	15 €/kg
Duck eggs	0,50 €/piece

Table 2. *Potential earnings from the rice-fish-duck integrated farm.*

Projections based on literature review supposed a rise in rice productivity by about the 30% (Halwart and Gupta, 2004; Hossain et al., 2005). Therefore, the farm should start to increase earnings due to the implementation of the new farming system from the second year, as shown in Table 3. The potential increase of rice yield was taken into consideration based on data reported by Halwart & Gupta (2004) and Hossain et al. (2005). Following these outcomes, the profit obtained by the pilot project from the second year should increase by the 50% if compared with the same area of rice paddies cultivated only with the GM technique.

	Year 0	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Receivables	191.087 €	191.087 €	225.151 €	225.151 €	225.151 €

Table 3. *Projection of sales and services revenue for the four years of business plan extracted from the P&L statement. The Year 0 shows values obtained at the current farm's management status, while the Year 1 represents the financial year in which investments carried out in order to implement the co-culture farm system.*

Furthermore, the project could receive fundings from Piedmont Region, as shown in Table 4. During the second year, the farm could receive fundings (31,093 €) for the construction of permanent pond and two ditches. , The total costs for initial operations can be supported by local government that promotes the transformation of conventional agricultural fields into semi-natural areas with restored wetlands thanks to the measure 04.4.01 of RDP (Regione Piemonte, 2020). Also, the regional council could dispose1000 €/ha/year for ten years for maintaining and managing natural areas for wildlife, such as vegetated banks. Moreover, 600 €/ha/year for the first three years, then reduced to 450 €/ha/year for the fourth and fifth year, can be allocated for the construction of a pond as a constructed wetland. The transition of rice paddies towards integrated agriculture could be also financed of 210

€/ha/year for five years, and 100 €/ha could be allocated for sowing winter (Giuliano et al., 2017; Regione Piemonte, 2020).

The Table 4 shows a part of the P&L statement that focuses on the EBITDA progression. It highlights an increase of earnings from Year 2 without the influence of fundings above-mentioned.

	Year 0	Year 1	Year 2	Year 3	Year 4
EBITDA	84.738 €	57.489 €	106.259 €	107.103 €	107.103 €
Financing	39.000 €	2.972 €	31.093 €	8.222 €	8.222 €
Net result	123.738 €	60.361 €	137.252 €	115.225 €	115.225 €

Table 4. *Net income extracted from the P&L statement that shows the farm's profit obtained including annual taxes.*

While the Table 5 shows the forecast of cash flow statement obtained for the evaluation period that shows operating, investing and financing activities made by the farm with and without (Year 0) the co-culture farming.

	Year 0	Year 1	Year 2	Year 3	Year 4
Cash and cash equivalent at initial of period		123.738 €	164.199 €	301.551 €	416.876 €
Net cash from operating activities	84.738 €	57.489 €	106.259 €	107.103 €	107.103 €
Investments		20.000 €			
Cash and cash equivalent before financing	84.738 €	161.227 €	270.458 €	408.645 €	523.979 €
Financing	39.000 €	2.972 €	31.093 €	8.222 €	8.222 €
Cash and cash equivalent at the end of period	123.738 €	164.199 €	301.551 €	416.876 €	532.201 €

Table 5. *Cash flow statement that reveals a positive cash and cash equivalent at the end of the period.*

4. Discussion

The business proposal for 5 ha of the pilot project derives from a reflection about the environmental and cultural value of rice agroecosystem and about sustainable strategies for land management. An ecologically-based approach to rice cultivation was designed together with the farm owner with the aim of reducing the environmental pressure caused by conventional rice farming. Priorato Farm had already made an important investment in organic farming. The aim of the new business plan was to build on this approach by fostering biological conservation practices through the adoption of integrated wetland in rice agroecosystems. The business plan implemented was based on a review of the literature which evidences the positive contribution of agricultural practices such us the co-culture method on the capability of rice paddies to provide and support ecosystem services (ES) (Balzan et al., 2020). The construction of a permanent pond contributes to habitat restoration and conservation for wildlife and migratory birds (Supporting ES), acting as refugee for the aquatic fauna and some benthonic species during draining of rice paddies. Moreover, habitat restoration creates the opportunity to organise recreational and cultural activities such as ecotourism through citizens science initiatives and educational farm projects (Cultural ES).

In addition to habitat restoration, the integrated wetland management in agriculture offers new opportunities for business to improve sustainable economies at local scale. The new business matrix (in Figure 6) shows the new business strategy that is mainly oriented to innovating the rice cultivation process by sharing knowledge about agro-ecological practices. The project proposal promotes the collaboration with private and public research institutes to foster ecological-based innovation. The new business strategy aims to strengthen the ability of farm management to rediscover and renovate traditional agricultural techniques. These are developed as sustainable practices without neglicting rice yield productivity. The communication of farm values is also an essential factor in building partnerships with other stakeholders at the local scale. The introduction of tench fish and ducks requires a collaboration with other food processing enterprises. Moreover, the communication of the entrepreneurial mission can be an important tool to foster commitment towards the sustainable development of agriculture and the ecological restoration of rice agroecosystem.

While sustainable agriculture should produce positive effects on the environment (Wezel et al., 2016), it must ensure adequate annual yield and enough profitability to sustain the farm. The economic sustainability of the business plan was addressed using well-known tools of financial analysis to provide monetary outcomes that would be clear to funders and to farm manager.
The P&L statement results positive EBITDA that highlights increase of earnings (+ 22.365 €) from Year 0 (84.738 €) to Year 4 (107.103 €, about 20 % more than Year 0) without the influence of financing. In addition to the increase in earnings, the increase in “cash and cash equivalent” at the end of each year of the accounting period demonstrates the capability of the farm to maintain itself and to undertake further investments. The increase in earnings is the outcome of the introduction of new food products and the reduction of operational costs, as showed in Table 6. Table 6 highlights a saving of about 516 €/ha and 214 €/ha compared respectively to the conventional rice farming technique (less about 30 % costs) and to the GM method.

	Conventional farming	GM method	Co-culture farming
Seeds	57.8 €/ha	57.8 €/ha	57.8 €/ha
Fertilizers	122.5 €/ha	255.1 €/ha	-
Herbicides	200 €/ha	-	-
Fuel	270 €/ha	161.25 €/ha	105 €/ha
Machinery rental	56.3 €/ha	56.3 €/ha	56.3 €/ha
Energy	35 €/ha	35 €/ha	35 €/ha
Water	161 €/ha	80.5 €/ha	80.5 €/ha
Maintenance	147.7 €/ha	147.7 €/ha	200 €/ha
Land rental	461 €/ha	461 €/ha	461 €/ha
Insurance	153 €/ha	153 €/ha	153 €/ha
Others	60.9 €/ha	60.9 €/ha	60.9 €/ha
Total	**1,725.2 €/ha**	**1,423.5 €/ha**	**1,209.5 €/ha**

Table 6*. Comparison of operating costs between the three farming methods extracted and manipulated from the balance sheet.*

Promising financial outcomes reveal that the project proposal is economically feasible, and it may inspire other enterprises to explore ecologically-oriented approaches for their business strategy. The overall cost-benefit analysis used in this study provides a focused overview of the ability of initial investment to generate profits and reduce costs. Periodical monitoring of the business plan and regular updating of the expected financial outcomes periodically (e.g. every year) are good practices in order to assess the progress of the project and to reduce risk factors. Monitoring provides an up to date overview of the status of the business plan that can be compared with expectations in order to adjust future investments. It is also good practice to assess environmental performances of the effects of the adopted wetlaculture on local biodiversity, soil and water quality, and of rice productivity (Boutin et al., 2021; Jiang and Mitsch, 2020). This investigation proposes the implementation of co-culture farming in the province of Vercelli through the involvement of local agrifood companies. The creation of a network of virtuous farms can improve local biodiversity and increase biological rice yield as well as offer a competitive alternative to rice monoculture. Local biodiversity is fostered by the introduction of *Anas platyrhynchos* and *Tinca tinca* in rice paddies, rediscovering the Piedmontese culinary tradition. The adoption of rice-fish-duck farming requires the development of the network of local companies able to process and sell new food products. Future steps for the implementation of the business should include a market analysis to identify potential partners with the aim of building a network of ecologically-orientes enterprises at the local and regional scale.

5. Conclusions

This study explores the potentialities afforded by integrated constructed wetlands in supporting the transition towards sustainable rice farming and the restoration of agricultural landscape. Economic profit is a key factor in this investigation. The study demonstrates the economic feasibility of the new ecologically-oriented business plan through the financial analysis. The aim of this research is to raise awareness among farmers about opportunities provided by an ecologically-oriented approach for business strategy going beyond mere profit. Small farms may have fewer financial resources to invest in high-risk innovative projects to improve the environmental sustainability. The outcomes obtained through the financial analysis in this study can be a valid support for decision making and for implementing eco-friendly practices in small enterprises. This study also highlights the importance of fostering collaboration and dialogue between academic and local enterprises to develop innovative business strategies adapted to local territories. The collaboration between academia and local enterprises described in this paper developed a strategy based on findings in literature that were discussed with the farmer and adapted to the Vercelli context taking inspiration from traditional knowledge. The new business plan was also designed with the purpose of rediscovering and revitalising local know-how that has been forgotten as result of the spread of monoculture. The new business plan promotes biocultural diversity (Bridgewater and Rotherham, 2019) through the transfer of cross-generational and cross cultural knowledge that enhance the role of wetlands in sustainable agriculture. This purpose is also in line with the mission of Polyculturae Association, that works to overcome the dichotomy between technocratic culture and nature. The association works to foster the sustainable development for agrifood system and eco-cultural landscapes, exploiting cultural ES related to integrated wetland ecosystems to build bridges between citizens and local enterprises. This ecological-based business strategy is an opportunity to establish a place-based nexus between cultural diversity (regarding the human sphere) and ecological diversity (regarding nature). This strategy promotes the adoption of the cultural variety of agricultural practices that may enrich local biodiversity and contribute to the conservation of natural resources.

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