

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

Original

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1 **Ecologically-oriented business strategy for a small-size rice farm:**
2 **integrating wetland management for the improvement of environmental benefits**
3 **and economic feasibility.**

4

5 **Abstract**

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

26 *Keywords:*

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

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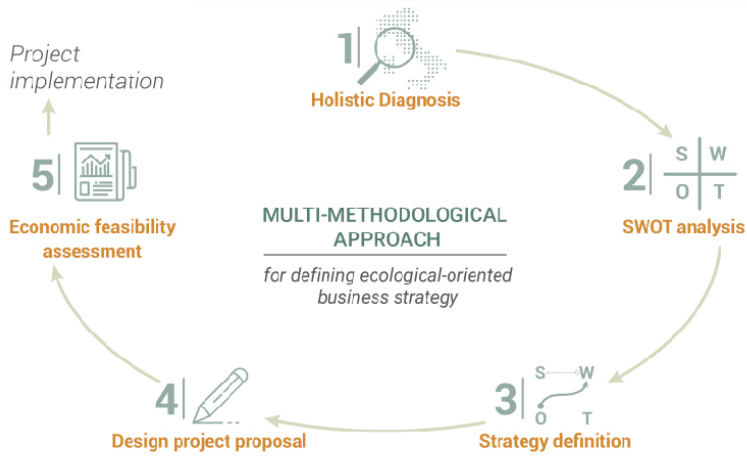
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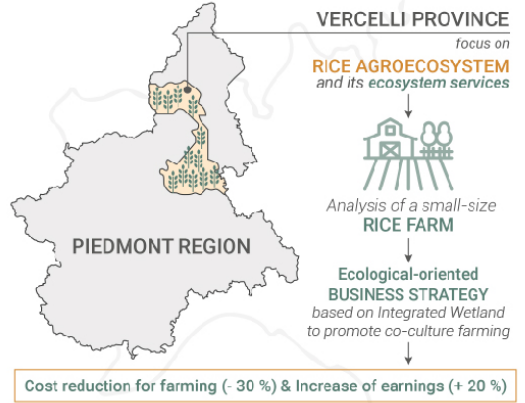
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36 **Graphical Abstract**

THE DESIGN OF ECOLOGICAL-ORIENTED BUSINESS STRATEGY FOR AN AGRIFOOD COMPANY



APPLICATION OF MULTI-METHODOLOGICAL APPROACH TO A REAL CASE STUDY



37

38

39 **1. Introduction**

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

47
48 A rice agroecosystem is considered a temporary wetland characterised by an hydroperiod that
49 alternates floodings during the summer and droughts during the winter. It is a highly dynamic man-
50 made ecosystem characterised by rapid changes of physical and chemical parameters and water levels
51 that affect the development of its biological community. As semi-natural temporary ponds, rice
52 paddies represent 15% of global wetlands. They play a valuable role in providing several ecosystem
53 services (Lawler, 2001; Chivenge et al., 2019; Preez et al., 2019), and offering a habitat for aquatic
54 fauna (Toffoli and Rughetti, 2017). Ecosystem services (ES) are described as the “benefits produced
55 by a healthy ecosystem that positively influence human well-being” (Millennium Ecosystem
56 Assessment, 2005) and they are classified into provisioning, regulating, supporting and cultural
57 services. The assessment of ES could be a useful tool to evaluate the benefits derived from
58 ecosystems (Ajwang’ Ondiek et al., 2016). Although rice paddies cannot be considered as fully
59 substitutes of natural temporary ponds, they significantly contribute to produce marketed ES, such as
60 rice and straw as by-products, and non-marketed ES, such as soil formation, mineralisation of plant
61 nutrients and nitrogen fixation (Nayak et al., 2019; Buresh et al., 2008). Moreover, rice
62 agroecosystems as temporary wetlands create the ideal habitat to support the life cycle of numerous
63 living organisms such as algae, fish, amphibians, reptiles, molluscs, crustaceans, worms, insects and
64 a variety of avifauna (Strada Del Riso Vercellese, n.d.; Toriyama et al., 2004). Many different human
65 transformations and adaptations of the terrain for rice cultivation have led to the creation of a unique
66 geometric landscape characterised by a high aesthetic value. Rice paddies are a distinctive landmark
67 of the agro-cultural system of the Piedmont region. A number of ecologically-oriented farms are
68 currently investigating co-adaptation strategies to promote the sustainable development of the
69 territory (Min & He, 2014; Banino & Matrone, 2016). Water is the essential element for rice
70 cultivation and the alternating submersion and dryness stages in rice paddies influences the
71 ecosystem’s dynamics as a temporary wetland. The flooding of rice paddies during the summer
72 creates the habitat for migratory avifauna, providing the opportunity to develop ecotourism and

73 educational activities, such as birdwatching or citizen science projects (Dem et al., 2018), in order to
74 promote the importance of ecological conservation and biodiversity in agroecosystems (McInnes &
75 Everard, 2017).

76
77 Rice agroecosystems are also affected by a series of criticalities. Their high level of biodiversity is
78 often negatively affected by modern cultivation techniques (Luo et al., 2014). The adoption of the
79 alternate submergence and drying technique, for instance, can lead to the creation of an ecological
80 trap for some species, such as the arthropod or amphibian communities, which cannot complete their
81 whole breeding cycle (Travisi and Nunes, 2010). Ecological traps usually occur when living
82 organisms form an inaccurate representation of a habitat that is not able to support a stable or growing
83 population (Robertson and Hutto, 2006). Environmental habitat are defined as ecological traps if they
84 lead to the direct mortality of individuals as result of rapid changes in the characteristics of the
85 territory (e.g. hydrological, geomorphic, chemical changes) with a reduction of environmental quality
86 (Hale and Swearer, 2016). Stormwater ponds, polarised light pollution, game farms or bird nesting in
87 grasslands or agricultural landscapes are some examples of ecological traps and maladaptive
88 behaviour (Schlaepfer et al., 2002).

89 Moreover, fertilizers, pesticides and herbicides produce negative consequences not only on soil and
90 water quality, but also on flora and wildlife. Indeed, the rice agroecosystem is characterised by a wide
91 range of insects, some of which are rice pests (Norton and Heong, 2010), such as the *Sypha glyceriae*
92 and the *Rhopalosiphum padi* which are widely extended in Italy (Süss et al., n.d.). Pests and weeds
93 are usually controlled by farmers using chemicals in order to avoid huge harvest and profit losses
94 which however cause a degradation of the local biodiversity, as well as water and soil pollution
95 (Ferrero et al., 2016). Moreover, the alternate submergence and dryness conditions cause the emission
96 of methane (CH₄) in the atmosphere, while the use of nitrogen-based fertilizers is responsible for the
97 increasing release of nitrous oxide (N₂O) due to microbial nitrification and denitrification which occur
98 in the soil (Park et al., 2012; Arpa Piemonte, 2014; Ferrero et al., 2008).

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

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109 ***1.1 Research goal***

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

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

135

136

137 **2. Materials and methods: a multi-methodological approach**

138 A multi-methodological approach was adopted to analyse the case study. It combines tools from
139 Systemic Design (SD) methodology (Battistoni et al., 2020), such as the Holistic Diagnosis (HD),

140 and the SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis used as flexible model
141 in decision-making and strategic planning processes (Benzaghta et al., 2021).

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

155 During the second stage of HD, data collection was performed using surveys with the farm manager
156 or through field visits in order to understand the farm structure and its management of natural
157 resources and raw materials. Data were organised using giga-maps and flow charts in order to define
158 the state of the art of the case study and to visualise the company's relationships with other local
159 economic realities and its connections with the local know-how and material culture (Sevaldson,
160 2018). The production process was investigated using an energy and material flow analysis that
161 explores characteristics of the raw materials (inputs) that enter the production flow, and by-products
162 and waste (outputs) that are generated. The holistic approach applied to the material and energy
163 analysis is already adopted in permaculture and agroecology to move towards more sustainable
164 agrifood systems that ensure social and economic equity, conserve biodiversity and restore ecosystem
165 services (Didarali and Gambiza, 2019; Mollison, 1988). All the significant information on the
166 territory was collected in order to define the background scenario, which was structured in existing
167 correlations, criticalities and potentialities in order to design a project proposal for business
168 innovation (Gaiardo, 2016).

169 The economic status of the case study was also analysed using a conceptual matrix developed by
170 Deloitte for SD methodology to describe its business core strategy (Battistoni et al., 2020). This
171 conceptual matrix was implemented as a part of the HD, based on organization, financial statement,
172 trading relationships and market dynamics. Each indicator was allocated weights in collaboration

173 with the farm owner in a focus group. The indicators on the y-axis describe the company's philosophy,
174 while those on the x-axis provide information about trading relationships which characterise the core
175 business. The three indicators on the x-axis were adjusted and adapted considering previous studies
176 conducted using this matrix (Battistoni et al., 2020), in order to provide a more accurate and adequate
177 description of the company's current business strategy and market position in the agrifood sector.
178 The first step of the focus group is the allocation of a percentage value to each of the five indicators
179 of the y-axis, that must weight 100% in total. The second step consists in the analysis of each indicator
180 on the y-axis using those on the x-axis. The percentage value assigned to each y-axis indicator is
181 considered as the reference value to assign a percentage to each indicator on x-axis. The matrix
182 provide a qualitative description of the business strategy of the farm by defining three areas of
183 business investments. The "*focus area*" is the core business of the farm composed by all factors with
184 a percentage > 12%. The most of economic investments are held considering these factors. The
185 "*attention area*" describes secondary investments of the farm composed by those factors with
186 percentages between 5% and 12%. The "*hinted presence area*" consists of those factors (< 5%) that
187 are not considered in the core business of the farm. Factors included in the "attention area" and in the
188 "hinted presence area" are potentialities that can be considered for the development of new business
189 strategies.

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

202 The integration of the SWOT analysis into the SD methodology helped to organise a qualitative
203 scenario and to outline alternative options for the business development (Davis, 2007). The SWOT
204 also considered possible implication (positive or negative) with provisioning, regulating, supporting
205 and cultural ES (as shown in the Figure 4). Main critical issues identified (weaknesses and threats)

206 were analysed and affordable solutions were explored with the reference to the literature on how to
207 reduce the environmental pressure and sustain ecosystem services. A list of significant priorities for
208 the company was defined using results obtained from the HD and SWOT analyses. The list was used
209 to combine the four strategies in order to move towards the desired ecological-oriented business
210 vision. Sustainable improvement was the main driver in the decision-making process. The strategy
211 adopted defines the strategic vision, main goals, detailed technical actions, and patrimonial and
212 financial planning (Beale et al., 2012).

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

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

223

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

$$230 \quad (1) \text{ EBITDA} = \text{Net income} + \text{Interest} + \text{Taxes} + D + A$$

231

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

238 immediately. Operating cash flow was considered an important benchmark tool to evaluate the
239 financial success of the business plan (McLaney and Atrill, 2012).

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242 **3. Results: application of the multi-methodological approach to a case study of a rice farm's** 243 **management**

244 ***3.1 Holistic Diagnosis: territory, company's vision and cultivation techniques***

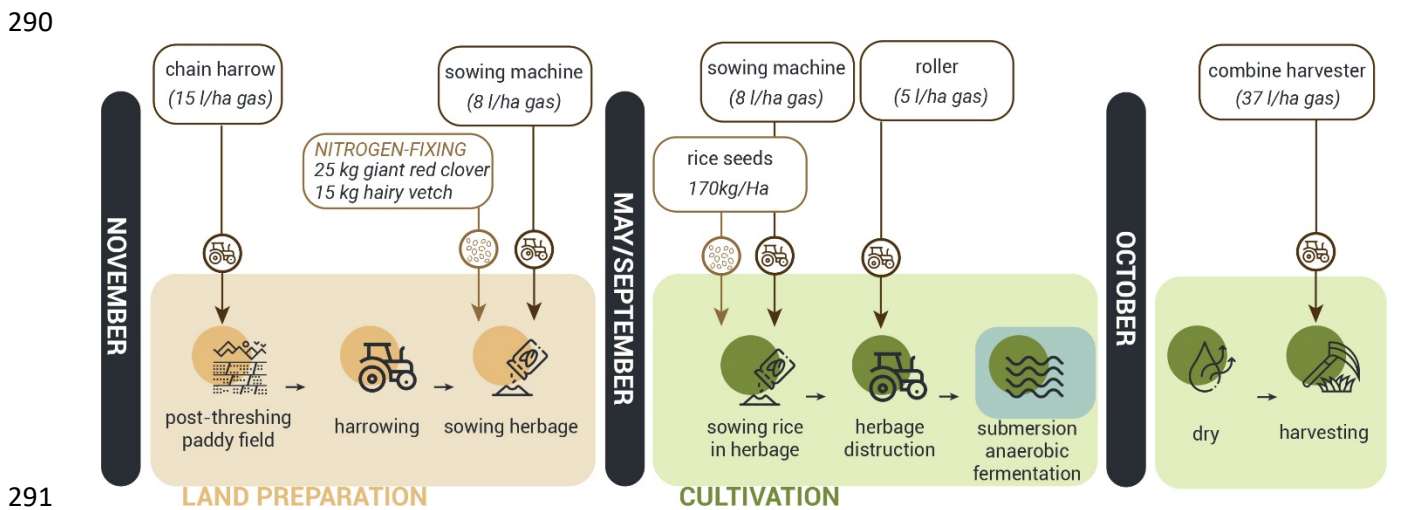
245 Italy is the leading country that counts about the 51% of European rice paddies. It cultivates a unique
246 range of *Oryza sativa* L. ssp. Japonica and Indica varieties, such as the Arborio, the Carnaroli, the
247 Vialone Nano (Italian Parliament, 2020). More than two-thirds of European rice is produced by Italian
248 farms and about 60% is exported to other Mediterranean countries and Eastern Europe (Kraehmer et
249 al., 2017). Approximately 4200 companies, mainly located in Piedmont and Lombardy regions, in the
250 huge area known as the “Golden Triangle” between Vercelli, Novara and Pavia provinces, cultivate
251 about 132 rice varieties (Istat, 2020). Rice cultivation was introduced in Italy at the end of the 15th
252 century and its development is strictly linked to the construction of the most important irrigation
253 network, Canale Cavour, done by Camillo Cavour at the end of the 19th century (Arcieri and Ghinassi,
254 2020). The construction of Canale Cavour allowed the development of rice cultivation, especially in
255 Vercelli, Alessandria, Novara and Pavia provinces. The province of Vercelli is one of the most
256 productive area concerning rice cultivation that counts the 58% of total rice farms (almost 917 local
257 producers) of Piedmont Region and 70.000 ha of land cultivated with more than 100 different rice
258 varieties (Sistema Piemonte, 2020). Extensive rice crops are the landmark of the territory
259 characterised by flooded plains symmetrically divided by rows of poplars. many protected areas and
260 parks, such as the Po River Park, the Alta Valsesia and the Lama del Sesia Natural Parks, promote
261 wetlands preservation in order to maintain habitat for avifauna and wildlife. Four varieties of rice
262 cultivated in this area are Protected Designation Origin (PDO), such as the “Arborio” and the “S.
263 Andrea di Baraggia”. The origin of these varieties is linked to the geographical features of Baraggia.
264 Baraggia area is close to the mountain chain (150-340 m altitude) between the provinces of Vercelli
265 and Biella and it is characterised by large prairies and heaths. Baraggia is also the northernmost place
266 in the world where rice is cultivated and this *terroir* offers distinctive organoleptic features of rice
267 grains.

268

269 Priorato Farm was founded in 2017 and it is composed by the owner and a seasonal employee. Rice
270 cultivation is the core business of Priorato Farm that cultivates 65 ha of rice paddies. Since the
271 beginning, the farm tested both traditional and biological rice cultivation techniques and it obtained

272 the biological Biodiversitas certification in 2020 thanks to the adoption of green mulching (GM)
 273 technique for the management of 27 ha of rice paddies. The implementation of GM technique refers
 274 to the practical experience reported by Masanobu Fukuoka, a Japanese botanist and philosopher,
 275 known as the pioneer of natural farming. Following the Fukuoka's model, the farm developed a non-
 276 invasive farming method which minimises the human intervention and fosters biological processes
 277 getting inspiration from natural ecosystems (Fukuoka, 1985). Fukuoka's method does not require the
 278 use of chemicals and agricultural machineries reducing soil and water pollution and the use of fossil
 279 fuels (Fukuda, 2018). GM technique consists of covering the ground with a mulch derived from
 280 herbaceous plants that maintains the fertility of soil and prevents proliferation of weeds, avoiding the
 281 use of chemical fertilizer and herbicide (Jabran, 2019).

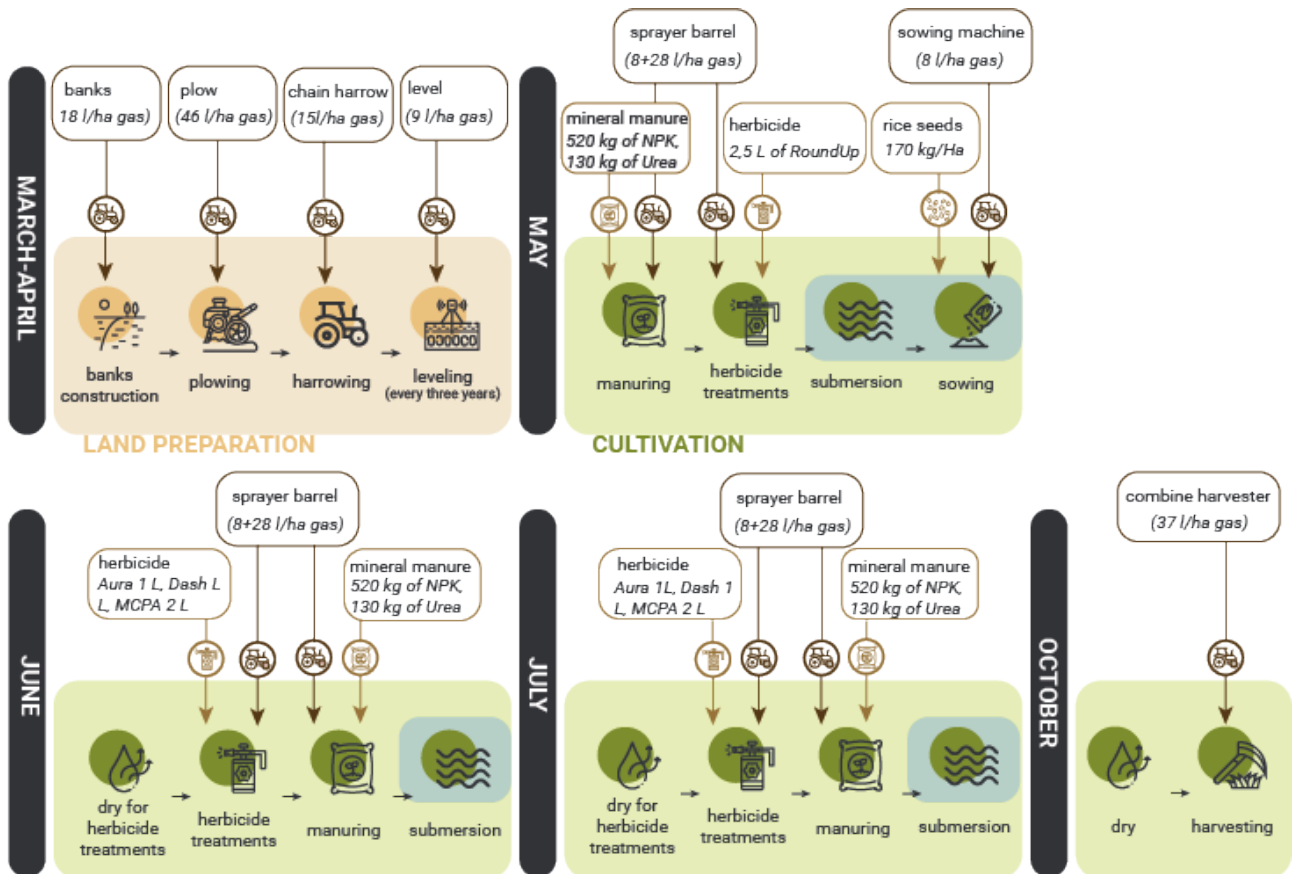
282
 283 Priorato Farm applies the GM technique (Fig.1) sowing herbaceous and legume plant such as
 284 *Trifolium pratense*, *Vicia villosa* and *Lolium perenne* as nitrogen fixers in November, at the end of
 285 the rice harvesting and soil harrowing . Rice seeds are usually sown at the beginning of May, while
 286 herbaceous and leguminous species are cut down and left on the field in order to create an organic
 287 mulching layer. Sometimes, the farm integrates the GM technique with the use of the horn-hoof based
 288 organic fertilizer (12%-14% N) as soil conditioner before sowing. After sowing, rice paddies are
 289 usually flooded until harvesting in October.



291
 292
 293 **Figure 1.:** Green mulching technique management of rice paddies (27 ha): the graph shows quantitative data referred to
 294 raw materials and agricultural machinery that enter into the agricultural system as inputs, and the 12-month timeline of
 295 main activities.

296
 297
 298 The others 38 ha of rice paddies are cultivated using conventional agronomic methods (Fig.2) that
 299 include rice water-seeding and permanent submersion. In this case, the GM technique is not
 300 appropriate for managing rice paddies due to soil characteristics, such as the gravel-based structure

301 and the high percentage of clay. The gradually transition towards organic farming implies to test
 302 varied agronomic techniques in order to select the most appropriate for soil characteristics (structure,
 303 texture and permeability).
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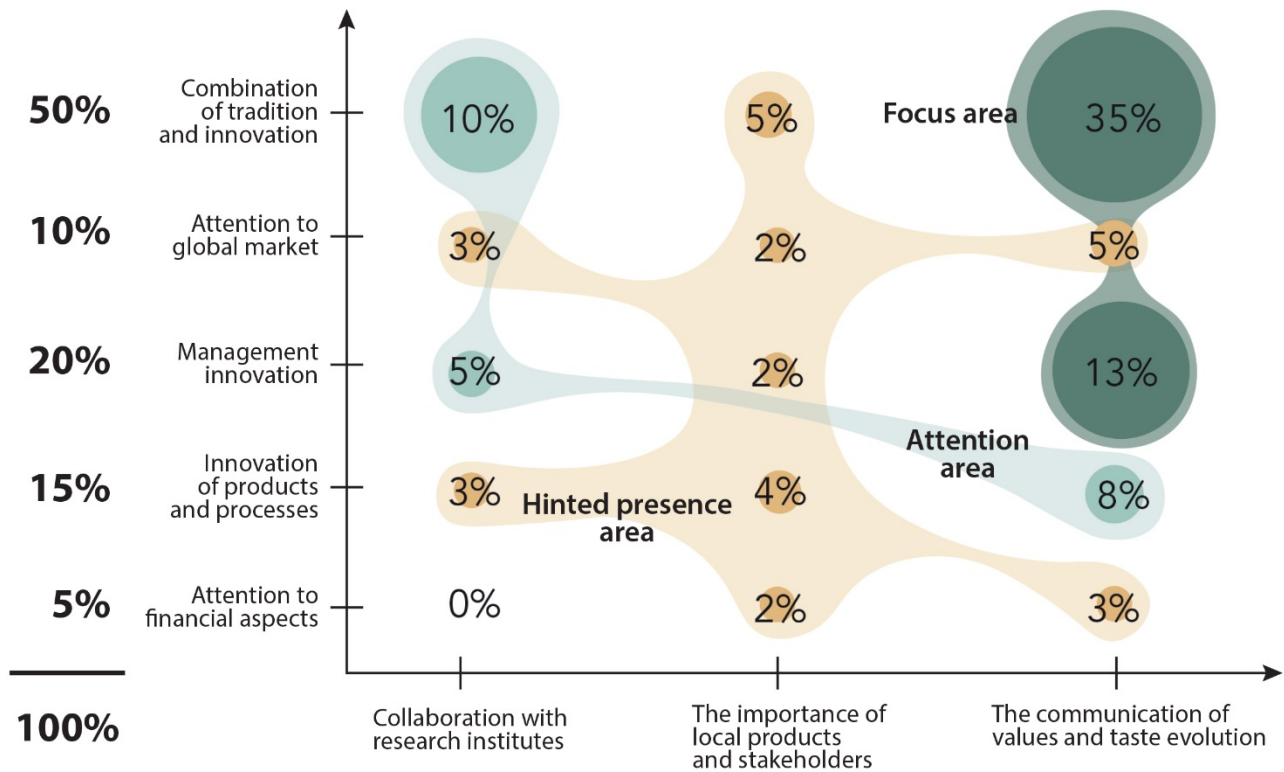
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 306 **Figure 2.:** Traditional management of rice paddies (38 ha): the graph shows quantitative data referred to raw materials
 307 (including pesticides, herbicides, and mineral fertilizers) and agricultural machinery that enter into the agricultural
 308 system as inputs, and the 12-month timeline of main activities.
 309

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

316
 317 **3.1.1. The current company's business strategy**

318 The current business strategy of Priorato Farm is shown in Figure 3. The company presents a good
 319 ability to combine traditional knowledge and innovation, also considering the strong inclination of
 320 the owner for the adoption of changes and solutions towards sustainability. Moreover, the farm owner

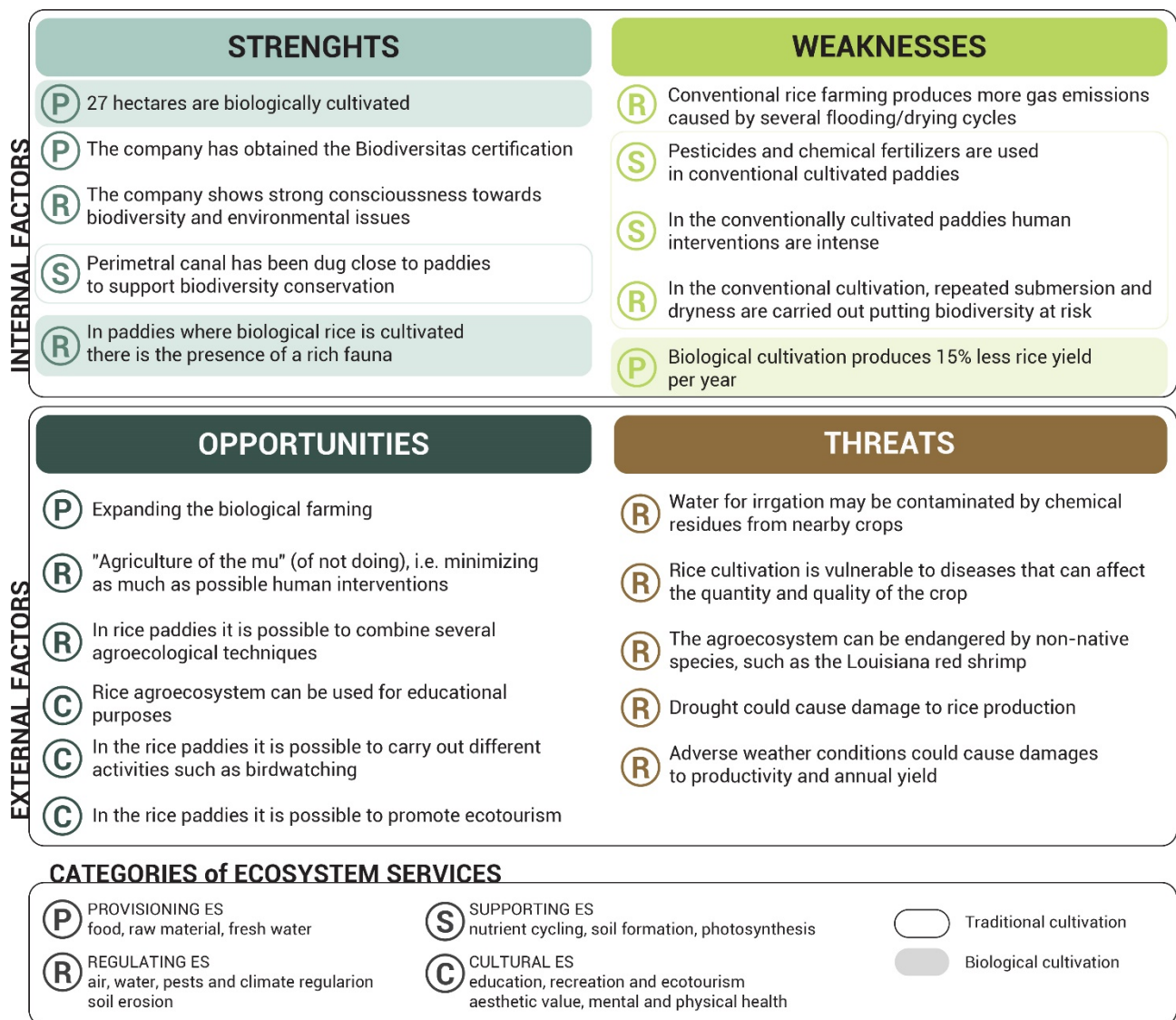
321 is a founder member of the Polyculturae Association, composed by local producers, that acts as a
 322 cultural hub to disseminate basic concepts of agroecology and good practices to promote biodiversity
 323 in rice agroecosystems. . Priorato Farm focuses on creating a business strongly connected to the local
 324 territory thanks to the active engagement in building bridges between citizens, local farmers, public
 325 and private research institutions.
 326



327
 328
 329 **Figure 3.:** Matrix of the company current business strategy. In the x- and y-axes the evaluation parameters are positioned.
 330 The focus area is highlighted in dark green with a percentage > 12%. The attention area is represented in light green
 331 with percentages ranging between 5% and 12% and the hinted presence area is pointed out in light orange with
 332 percentages < 5%.
 333
 334

335 **3.2 Analysis of the company organisation through SWOT matrix**

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



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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.

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

361

362 , The company has the great opportunity to expand the cultivation of biological rice applying the GM
363 method to all rice paddies supported by fundings provided by the Rural Development Program (RDP).
364 Moreover, natural farming suggests to improve and combine different agroecological practices, such
365 as the co-culture technique which consists of the integration of agriculture and animal husbandry,
366 where animals are reared together with the crop (Bashir et al., 2020; Chinese Academy of Sciences,
367 2010; Furuno, 2001). Rice agroecosystem creates a unique landscape rich of fauna, especially where
368 biological cultivation methods are adopted to manage rice paddies as temporary wetlands. The
369 enhancement of local biodiversity provides the opportunity to develop educational activities,
370 ecotourism, and recreational initiatives.

371

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

378

379 ***3.3 Business strategy definition based on opportunities provided by literature review***

380 The strategy was defined in order to exploit the opportunity to combine different agronomic
381 techniques, focusing on co-culture farming based on integrated wetland management, considering the
382 farm attitude towards biodiversity conservation (Bashir et al., 2020). The aim of the strategy is to
383 further improve farm strengths by using a part of the biologically cultivated field to improve its
384 productivity. The strategy proposed was obtained as a combination of a SO strategy, in which
385 opportunities are used to enhance strengths, and a WO strategy, which consists of exploiting
386 opportunities to reduce weaknesses. The strategy is based on the development of co-culture of rice,
387 fish and ducks. Co-culture methods introduces animals in flooded paddies for breeding and then they
388 are gathered in a permanent constructed wetland before rice harvest. Rice-duck-fish co-culture would
389 bring numerous benefits to the entire rice ecosystem such as the reduction of gas emissions, the

390 improvement of water and soil quality, the retention of nutrients. All of these benefits are offered by
391 the adoption of *wetlaculture* (Jiang and Mitsch, 2020) and biodiversity conservation techniques.

392

393 The introduction of fish and ducks in to rice paddies helps to regulate CH₄ and N₂O emissions.
394 Bhattacharyya et al. (2013) reported that the introduction of fish leads a decrease of N₂O emissions
395 by 9% but, at the same time, it causes an increase of CH₄ emissions by 26%. On the other hand, the
396 introduction of ducks leads to a decrease of CH₄ emissions by 8,80-16,68% and an increase of N₂O
397 emissions by 4,23-15,20% (Xu et al., 2017). The integrated rice-duck-fish farming leads to an
398 increase of soil nutrient content such as soil organic carbon, total nitrogen, available nitrogen,
399 available phosphorus and available potassium, more specifically total nitrogen level increase by about
400 126%. Moreover, values of dissolved oxygen and oxidation reduction potential are higher in co-
401 culture systems than in conventional ones, respectively by 8,4% and 31,8% (Nayak et al., 2018).

402

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

411

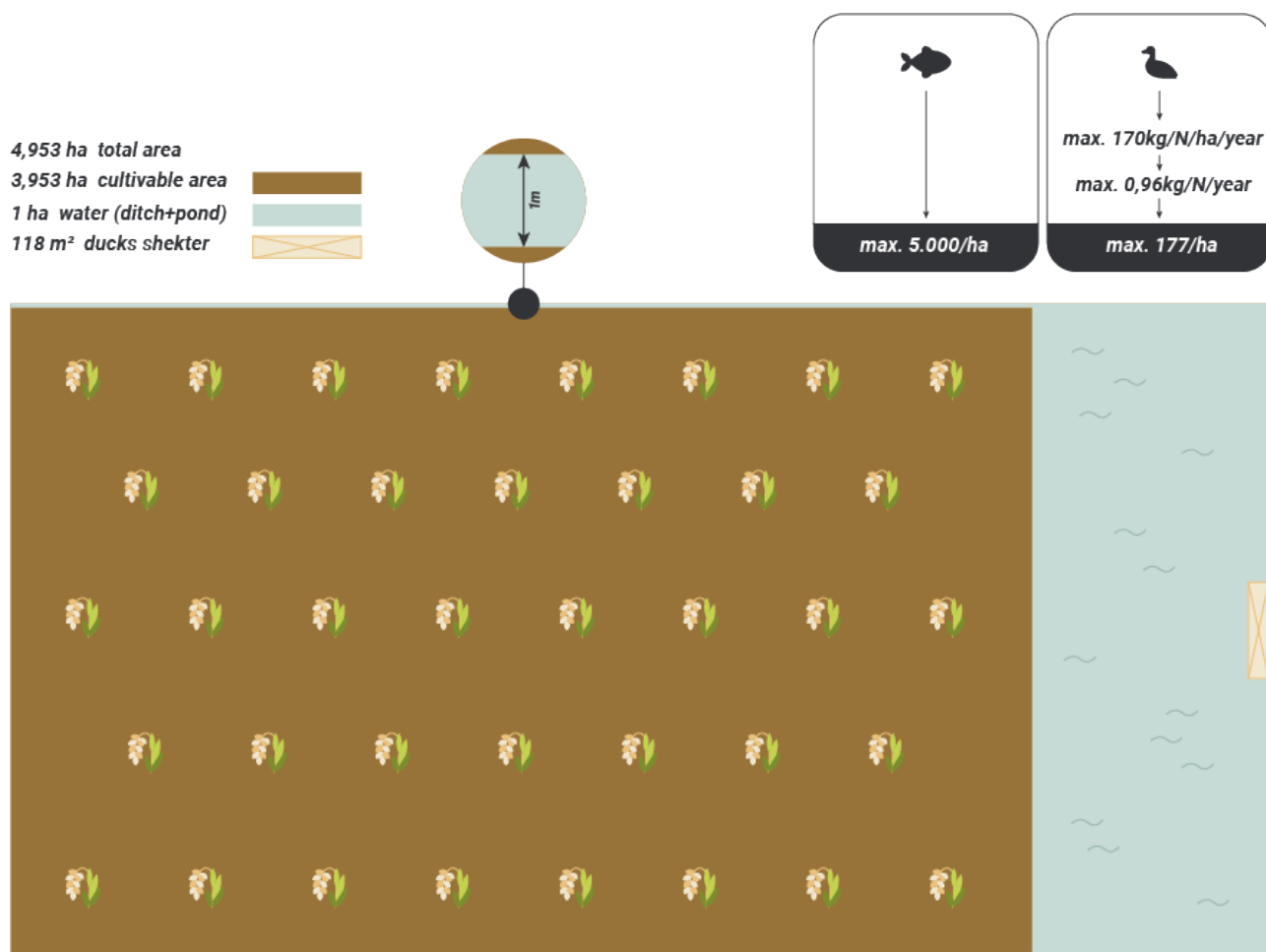
412 Different studies also focus on the evaluation of consequences of the co-culture farming on
413 productivity of rice paddies and on farm overall profit (Sheng et al., 2018; XIANG et al., 2006; Xu
414 et al., 2017; YUAN et al., 2009). Hossain et al. (2005) demonstrates that the adoption of rice-duck
415 co-culture leads to 20% increase per year of rice yield and to 50-60% increase of farm economic
416 income compared to conventional rice cultivation system. Moreover, Halwart & Gupta (2004) reports
417 that the rice-fish integrated farming generates an increase of 14-48% of rice yield and an increase of
418 50% of profit. These studies demonstrated that co-culture methods lead to a consistent reduction of
419 the use of chemical fertilizers, pesticides and herbicides thanks to foster self-regulating processes.
420 Co-culture methods produce benefits on the quality of soil and water and on the biodiversity of rice
421 agroecosystem (Halwart, 2008; Luo et al., 2014).

422

423 **3.4 Description of the pilot project and new business proposal**

424 The proposal focused on implementing co-culture farming based on integrated constructed wetland,
 425 or *wetlaculture* (Boutin et al., 2021; Jiang and Mitsch, 2020). The project proposal designed for
 426 Priorato Farm considers current European and regional policies, and characteristics of local market.
 427 Approximately 5 ha of rice paddies, already cultivated with GM, are involved in the pilot project
 428 based on designing a permanent constructed wetland as refugee for animals in order to foster co-
 429 culture farming. The pilot project consists of digging two lateral channels (1 m deep and 1 m wide)
 430 and approximately 9500 m² of pond which provide overall 1 ha of water surface and about 4 ha of
 431 fields for rice cultivation as shown in Figure 5.

432



433

434

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

436

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

443

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

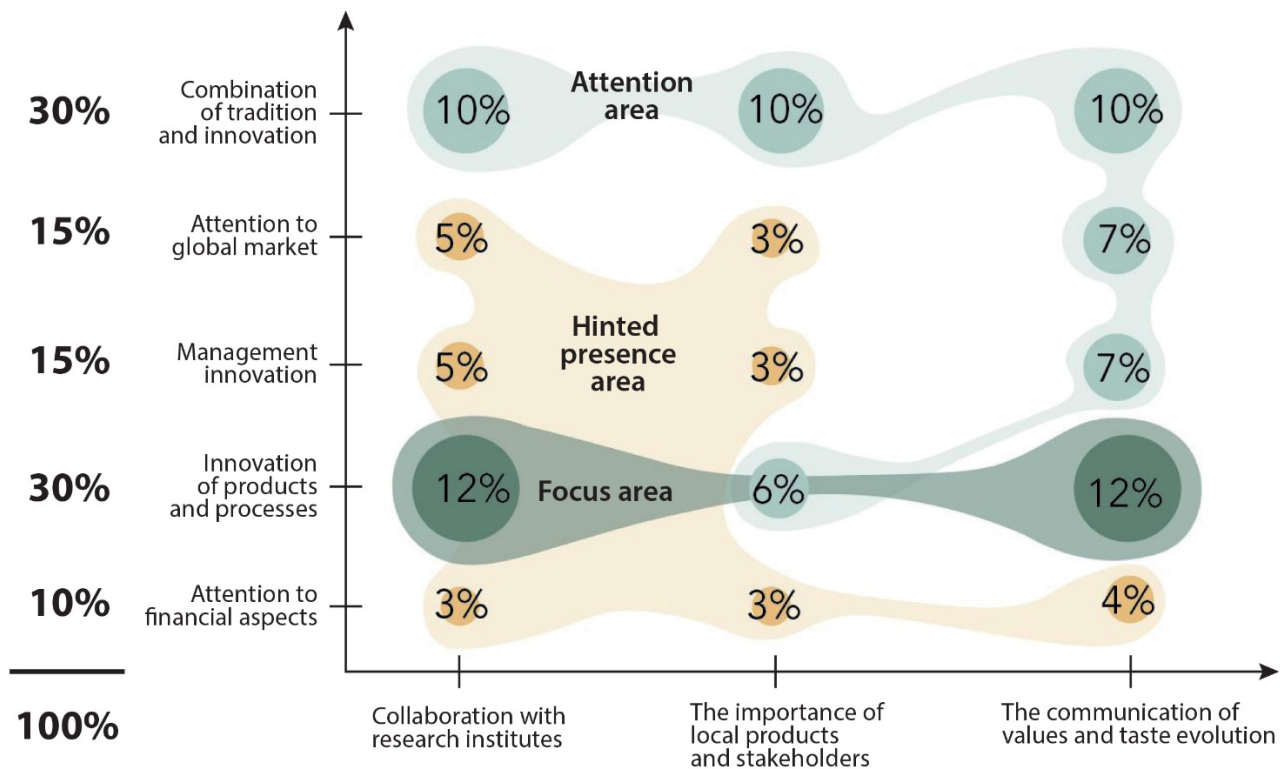
453

454 The permanent pond was equipped by a 118 m² stilted duck shelter as refuge. The duck shelter is
455 large enough to accommodate maximum 354 ducks (3 ducks/m²) during summer according to current
456 regulations (Commissione Europea, 2020). The pilot project required the installation of a modular
457 fence along the pilot site for ducks and nets at the entrance of lateral channels for tench fish, while an
458 incubator for breeding the duck’s eggs is required for population growth. The pilot project should
459 start in November with the introduction of ducks and fish into the constructed wetland. Ducks and
460 fishes can be bred directly in rice paddies from May onwards when they are flooded. Then ducks
461 should be gathered into the constructed wetland in August when rice is blooming, while fishes must
462 be channelled in October when rice paddies are dried for harvesting.

463

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

466



467

468

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

471

472

3.5 Evaluation of potential economic outcomes

473

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

479

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 €

480

481

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

482

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

489 **New saleable products**

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

490

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

492

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

500

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

501

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

505

506 Furthermore, the project could receive fundings from Piedmont Region, as shown in Table 4. During
 507 the second year, the farm could receive fundings (31,093 €) for the construction of permanent pond
 508 and two ditches. , The total costs for initial operations can be supported by local government that
 509 promotes the transformation of conventional agricultural fields into semi-natural areas with restored
 510 wetlands thanks to the measure 04.4.01 of RDP (Regione Piemonte, 2020). Also, the regional council
 511 could dispose 1000 €/ha/year for ten years for maintaining and managing natural areas for wildlife,
 512 such as vegetated banks. Moreover, 600 €/ha/year for the first three years, then reduced to 450
 513 €/ha/year for the fourth and fifth year, can be allocated for the construction of a pond as a constructed
 514 wetland. The transition of rice paddies towards integrated agriculture could be also financed of 210

515 €ha/year for five years, and 100 €ha could be allocated for sowing winter (Giuliano et al., 2017;
 516 Regione Piemonte, 2020).

517

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

520

	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 €

521

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

523

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

527

	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 €

528

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

530

531

532 4. Discussion

533 The business proposal for 5 ha of the pilot project derives from a reflection about the environmental
 534 and cultural value of rice agroecosystem and about sustainable strategies for land management. An
 535 ecologically-based approach to rice cultivation was designed together with the farm owner with the
 536 aim of reducing the environmental pressure caused by conventional rice farming. Priorato Farm had
 537 already made an important investment in organic farming. The aim of the new business plan was to
 538 build on this approach by fostering biological conservation practices through the adoption of

539 integrated wetland in rice agroecosystems. The business plan implemented was based on a review of
540 the literature which evidences the positive contribution of agricultural practices such as the co-culture
541 method on the capability of rice paddies to provide and support ecosystem services (ES) (Balzan et
542 al., 2020). The construction of a permanent pond contributes to habitat restoration and conservation
543 for wildlife and migratory birds (Supporting ES), acting as refuge for the aquatic fauna and some
544 benthonic species during draining of rice paddies. Moreover, habitat restoration creates the
545 opportunity to organise recreational and cultural activities such as ecotourism through citizens science
546 initiatives and educational farm projects (Cultural ES).

547

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

560

561 While sustainable agriculture should produce positive effects on the environment (Wezel et al., 2016),
562 it must ensure adequate annual yield and enough profitability to sustain the farm. The economic
563 sustainability of the business plan was addressed using well-known tools of financial analysis to
564 provide monetary outcomes that would be clear to funders and to farm manager.

565 The P&L statement results positive EBITDA that highlights increase of earnings (+ 22.365 €) from
566 Year 0 (84.738 €) to Year 4 (107.103 €, about 20 % more than Year 0) without the influence of
567 financing. In addition to the increase in earnings, the increase in “cash and cash equivalent” at the
568 end of each year of the accounting period demonstrates the capability of the farm to maintain itself
569 and to undertake further investments. The increase in earnings is the outcome of the introduction of
570 new food products and the reduction of operational costs, as showed in Table 6. Table 6 highlights a
571 saving of about 516 €/ha and 214 €/ha compared respectively to the conventional rice farming
572 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

574

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

577

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

596

597

598 **5. Conclusions**

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

624

625

626

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