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PINECUBE: Technologies for sustainable plant production and urban renewal in Belluno (Italy)

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Abstract

Under the international challenge UrbanFarm2019, a requalification program was designed for the former Elementary School of Orzes (Belluno Province, Italy). Since the post-WW2 period and until the 80's, this historical building guaranteed an education to the children that used to live in the surrounding agricultural neighborhoods. Orzes village is surrounded by the rural areas of Belluno Province, which lays at the bottom of the Dolomites Mountains, a landscape featuring elevate biodiversity. In 1987, Orzes School was declared unfit for use, and regional authorities slowly but inexorably lost interest on it. To design its requalification, the planimetry of the building was considered first; then it was re-adapted for hydroponic indoor cultivation system (NFT) targeting the production of aromatic and officinal herbs. A market survey in Belluno province was conducted, aiming at evaluating the current sales channels and the market demand for plants, highlighting the request for local production of aromatic species. A literature survey and the creation of a business model canvas allowed to compile a SWOT analysis that supported the definition of optimal features for sustainable food production and the requalification of the abandoned building. The research also confirmed that in addition to the production of raw materials (to be sold as fresh or after being proceeded on-site), other complementary activities (including services for social inclusion) would be suitable to integrate the core activity of production. Among identified strengths, a strong cohesion within the territory and the active involvement of local (and non-local) actors allowed for generating new job opportunities, including consultancy services specialized for agricultural businesses and possible partnerships with research institutions and universities.

Keywords: international student challenge, soilless cultivation, nutrient film technique, teamwork, urban regeneration, circular economy, aromatics, nickel free

INTRODUCTION

Orzes is a small village located in Veneto in the province of Belluno (Italy) in the heart of the Dolomites. The Dolomites area has different climatic and morphological characteristics in every single valley and until the late 1990s the agriculture was widespread and very diversified; although in the last decades the mountain farming has been progressively abandoned. The workforce moved towards the factories and the successive generations have lost interest for the rural life. The subsistence agriculture is nowadays the typical form of tenure in Belluno rural area, whereas mechanization is not always possible because of the slope of the land. Forestry, livestock, viticulture and the cultivation of few cereal-crops are the main activities ([Chamber of Commerce of Belluno, 2001](#)). However, in the last years, young generations are rediscovering the agricultural sector: youngsters are understanding the importance of the innovation and the need to produce a diversified crop range with new technologies. It seems important to invest in those crops that are more suitable for the

mountain conditions with a preference to autochthonous crops. The cultivation of medicinal plants could be an answer; in the last twenty years medicinal plants have gathered so much interest to be studied by the Regional Agricultural center with the OFFMONT project (VenetoAgricoltura, 2008). Concurrently, recent studies addressed urban agriculture as a tool to re-appropriate a range of abandoned or unused spaces (Gasperi et al., 2016). According to this study, Orzes school could be an example of unused building in the context of the northern climate. Within the framework of the international student challenge UrbanFarm2019 (Orsini et al., 2020), the team PINEcube elaborated and designed a plant for the regeneration of the old school building to host an innovative farming system. As in the plant factories approach (Pennisi et al., 2019), the cultivation system is based on indoor soilless closed-loop system (i.e. Nutrient Film Technique, NFT with artificial led light (Pennisi et al., 2019b, c). The vertical evolution of the NFT system can be adopted vertically, allowing to fit to the structural characteristics of the Orzes School building (Salas et al., 2010). The following principles guided the choice of medicinal herbs: not to create a competitive business against Belluno agriculture but introducing a niche product with new characteristics; to consolidate the market of officinal/aromatic plants increasing in Italy in the last decade; to meet the expectations of a new type of consumer that is more sensitive to ecology and environmental issues related to the production processes. In this way, the Hydro-Officinal Library project was designed as an innovative solution to contrast the population loss and fostering at the same time the renewal of the rural areas in Belluno province. Considering a merely agricultural point of view, the project described in this paper may be linked with several other benefit for the local dwellers. Indeed, the design approach reflects various functions in order to guarantee sustainability. Moreover, a multifunctional approach was adopted in order to explore aesthetic, recreational, social, ecological and educational services (Rupprecht et al., 2015).

MATERIALS AND METHODS

The International Student Challenge UrbanFarm2019 requested students to redesign the abandoned building of Orzes (Belluno, Italy) (Orsini et al., 2020). The municipality envisioned a project that would include a vertical farming system for growing spices and herbs, which could be lately used in the local cosmetics or pharmaceutical industry. Also, a small laboratory should be integrated, where participants could dry plants, prepare extracts and package the products. The key principles for the evaluation of the project where its multifunctionality and the overall sustainability (in its economic, environmental and social spheres). Among the scholars, the tool of the survey is widely used to solicit people's opinions as it is the most direct and time/cost effective (Hui et al., 2019). In order to target the needs from local residents and stakeholders, in the month of December 2018 and January 2019, an online survey through Google Forms was created targeting the population in Belluno province, in order to acquire direct information and forecast consumption tendencies in the Province. The survey was addressed to 3 macro types of stakeholders: consumers, local farms (with or without direct sales) and herbalists. Building on the survey and the challenge guidelines, the team PineCUBE elaborated the project proposal hereby summarized. In the coming sections, the overall concept of the Hydro-officinal Library prepared by the team PINEcube will be illustrated, specifically targeting the definition of the social and economic innovation and providing a focus on the adopted farming technologies.

OFFICIAL PLANTS IN ITALY

There is a wide range of herbal medicinal products ranging from food supplements and cosmetics, to the pharmaceutical production. In many developing countries, the use of medicinal plants for medical treatment is still widespread and it is handed down from generation to generation through the different popular traditions (FAO, 2005). Today many

studies confirm the pharmacological properties of many of these plants. As an example, some species (e.g. *Artemisia dubia*, *Datura stramonium*, *Justicia adhatoda*, *Justicia procumbens* and *Taraxacum officinale*) were shown effective against coughs, fever and respiratory disorders (Marshall, 2011). Similarly, a plant widespread in the Mediterranean basin such as *Portulaca oleracea* is an exceptionally rich source of α -linoleic acid, a fatty acid essential in reducing the incidence of coronary diseases and some tumors (Palaniswamy et al., 2000). A study conducted by the Italian Institute of Services for the Agricultural Food Market (Fichera et al., 2013), within the Economic observatory of the officinal plants sector, revealed some difficulties to obtain analyses of the Italian medicinal plants' market. There is a lack of official statistics regarding the primary production phase; it is a niche sector where traditionally the productions are represented by spontaneous species and still characterized by a high number of products but with low production volumes. In addition, many species used by processing industries are not traditionally produced in Italy: the need for a strong import of raw material has reduced the policy maker's interest in this sector (Fichera et al., 2013). However, the framework of the CAP (Common Agricultural Policy) in the last twenty years has changed (Cortignani et al., 2017): the farmers began to receive a single farm payment decoupled from the production of traditional crops on hectares admitted to the European support. This change allowed the farmers to invest in the production of new cultivations which in some cases are more profitable and with more dynamic market outlets than traditional crops. Accordingly, the Italian National Institute of Statistics (ISTAT, 2010) recorded between the years 2000 and 2010 an increase by 217% of the national surface invested in the cultivation of medicinal plants. Despite the low level of economies of scale in this sector, the ISMEA study (Fichera et al., 2013) claims there is a rather fierce competition in this market and an increase in the demand for herbal medicinal products. The difficulty for farmers is to produce medicinal plants in environments where climate trends are unfavorable. Yet, to obtain a sustainable and uniform growth of medicinal plants, their cultivation within protected environment may turn out a sustainable solution for growers (Giurgiu et al., 2017).

RESULTS AND DISCUSSION

Hydroponic Medicinal Plants Production

Several benefits are associated with hydroponic technology, an intensive horticultural production method that is applied with great success for commercial purposes in both developing (Rodríguez-Delfín, 2012; Orsini et al., 2010) and developed countries (Savvas et al., 2013). The recognized benefits include higher yields in shorter time and within limited space and with moderate chemical intervention and saving up to 70% in water (Savvas et al., 2013; Orsini et al., 2019). Among the several hydroponics systems available today for commercial purposes (Savvas et al., 2013), the NFT vertical farm system is widely used for fast-growing crops as lettuce and basil, thanks to their short growth period and their limited size (Rodríguez-Delfín, 2012). NFT system may also allow to recollect the drained fertilized water and its recirculation in irrigating wings to the plants (Gianquinto et al., 2006). Accordingly, the soilless system designed for Orzes School is a NFT multiple layer system with integrated artificial light, in order to overcome the limited exposure to natural light in the enclosed spaces within the building. The adaptability of medicinal crops to hydroponics was previously addressed on *Taraxacum officinale*, where an by 1312% as total plant weight compared to the field grown plants (Dorais et al., 2006) was observed. Furthermore, the root dry weight of *Inula helenium* and *Valeriana officinalis* was 9 and 4 times higher in soilless system as compared with soil-grown plants, and a higher percentage of shoots dry weight of *Achillea millefolium*, *Artemisia vulgaris*, *Calendula officinalis* and *Stellaria media* was confirmed in soilless system by the same study (Dorais et al., 2006). Other studies recently introduced the potentialities associated with modulation of lighting conditions on the growth

and essential oil production in sweet basil (Carvalho et al., 2016; Pennisi et al., 2019). In Mexican mint (*Plectranthus amboinicus*) studies reports that light quality influences the metabolic direction of essential oil biosynthesis and moreover, blue light promotes the pathway for the sesquiterpenoid biosynthesis in Mexican mint (Noguchi and Amaki, 2016). Moreover, in a soilless system, it is possible to manipulate the nutrient solution during the whole life cycle of the plants. The regulation of nitrogen: ammonium ratio within the fertigation strategy was shown to increase some secondary metabolites, such as the increase of Omega 3 fatty acid content (an essential fatty acid beneficial in reducing incidence of coronary heart disease and certain cancers) in a specific cultivar of *Portulaca oleracea* (Palaniswamy et al., 2000). In order to obtain a low content of nitrates in basil leaves, it was also recommended to limit the nitrogen supply during the last stages of the growing period or to harvest plants after several hours of incident radiation (Orsini and De Pascale, 2006). Thanks to the technologies and management strategies adopted, it is therefore envisaged that the Hydro-officinal Library will be able to produce several medicinal and aromatic herbs ensuring year-round production and specific high-nutritional values, obtained by controlling mineral nutrition of plants and climate growing conditions. The adoption of pesticide-free management strategies (e.g. by using natural antagonists), it will be concurrently possible to target healthy conditions for the workers, as well as satisfying customer's concerns on food safety and environmental issues. Besides, controlling the plants' mineral nutrition, it is also possible to certify the products for the absence of nickel and others allergenic metal.

Targeting Sustainable Innovation

In 1987 the World Commission for the Environment and Development of the United Nations (Brundtland Commission), wrote in the report "Our Common Future" the first effective definition of sustainable development, which would refer to a development capable of ensuring "the satisfaction of the needs of the present generation without compromising the possibility of future generations to satisfy their own" (Butlin, 1987). The concept expressed by the Brundtland Commission is based on two fundamental elements: environmental protection as an essential dimension of economic development and inter-generational responsibility in the use of natural resources (Borowy, 2013). More recently, in 2015, the United Nations approved the 2030 Agenda for Sustainable Development, which outlines the seventeen Sustainable Development Goals (SDGs) (Sachs, 2012). Hydro-officinal Library was conceived with the idea of preserving natural resources over time, creating a space that could be a help for today's and tomorrow's generations, with a particular focus on creating a reality that promotes *lasting -growth and sustainable over time* (SDG 9: Resistant infrastructures, sustainable industrialization and innovation), *a decent job for all* (SDG 8: Promote lasting, inclusive and sustainable economic growth, full and productive employment and decent work for all), *leveraging on equal opportunities* (SDG 5: Achieve gender equality and empower all women and girls, and SDG 10: Reduce inequalities) and on the *sustainability of the production and consumption model* (SDG 2: End hunger, achieve food security, improve nutrition and promote sustainable agriculture, and SDG 12: Guaranteeing sustainable production and consumption patterns). Local food production was shown to have an elevate potential in fostering perception and actions toward sustainability among citizens and involved stakeholders (Sanyé-Mengual et al., 2018a, 2019). Furthermore, in a recent survey, local food production was also identified as a democratic tool to guaranty equity (Sanyé-Mengual et al., 2018b) and could target social (40% of respondents), environmental (37%) and economic (23%) functions. On the other hand, stakeholders were concerned from potential health risk associated with local food systems (Sanyé-Mengual et al., 2018b). Considering the interaction with the consumers, the Hydro-officinal Library foresees their immersion in an experiential dimension, where, before the product, the fulcrum must be the experience of the consumer himself. Thus, the concept of "experiential marketing" comes into play. Schmitt (1999)

believes that to the intrinsic characteristics of a product or service must be added the intensity of the experience that this product or service can offer and that increases its perceived value. According to [Schmitt \(1999\)](#), the customer experience develops around five dimensions: sense, feel, think, act and relate. The Hydro-official Library lends itself to adapt this marketing vision within its context, proposing not only quality products, but real experiences, certainly sensorial and cognitive, seeing with one's own eyes the production of plants and officinal herbs, being able to choose the preferred product knowing its production processes and intrinsic features in detail, but also of social relationship with the farmers and other consumers, becoming part of a passionate community, and finally direct experiences as well, in which the participant can be actively involved in cultivation and production, further stimulating the cognitive dimension. The experiences that Hydro-official Library can offer are mainly educational experiences ([Pine et al., 1999](#)), in which the consumer get involved into the events by actively taking part in participatory and entertainment experiences, through which sensorial stimuli are passively absorbed. Considering the business model and the interaction with the stakeholders that characterize the Hydro-official Library, the use of the Integrated Reporting Framework proposed by the IIRC-International Integrated Reporting Council, has been proposed as a vision of development and reporting. Integrated reporting offers a synesthetic and global view of the organization, trying to bring out the fundamental synergy between the financial and non-financial sphere to create value in a company ([Sierra-García et al., 2015](#)). The value creation process in this framework involves the analysis of how those that are defined as "six capitals", or financial, manufacturing, intellectual, human, social and relational and natural capital, are processed by the organization in creating value for itself and its stakeholders ([Adams, 2015](#)). The most proper juridical form for the Hydro-official Library is the Social Cooperative/Start-Up company ([Travaglini, 2012](#)). The Social Cooperative is structured as a business network, in order to ensure the integration among the stakeholders. The "social" feature attributed to the business guarantees the commitment with the causes linked to the territory, especially for what concerns the implementation of highly inclusive new jobs. The cooperative form of the enterprise will reinforce the long-term sustainability of the business and functions as warranty for the investors. The Social Cooperative is one of the greatest entrepreneurial innovations in Italy: it allowed many businesses to become leaders in providing local welfare services, and, furthermore, to act both as an incubator and creator of social capital thanks to the multi-stakeholdership ([Travaglini, 2012](#)). The Start-Up feature, on the other hand, provides a dynamic and innovative element to the "classical" juridical form of the Social Cooperative. Accordingly, the Social Cooperative/Start-Up provides an answer for the environmental, social and economic issues related with depopulation and marginality in territories facing abandonment ([Cucco and Fonte, 2017](#)), as for Belluno province. The creation of an innovative business related with agriculture in Belluno, anyhow, is not exempt from difficulties that may arise, especially for what concerns the sales channels and the involvement of the local community. Indeed, the results of the survey indicate an elevate potential for allocating a local production of medicinal herbs, as well as for the creation of a Corner Shop and Pop-Up Stores in the main local events and fairs in order to promote the products.

A Survey on local demand in Belluno Province

A total amount of 120 survey interviews were collected; the survey had been conducted in November/December 2018. The majority of the survey participants lived within Belluno Province and was equally distributed among genders. Participants were requested to state their preference toward local and new food products and whether they could find them in the local market ([Figure 1](#)).

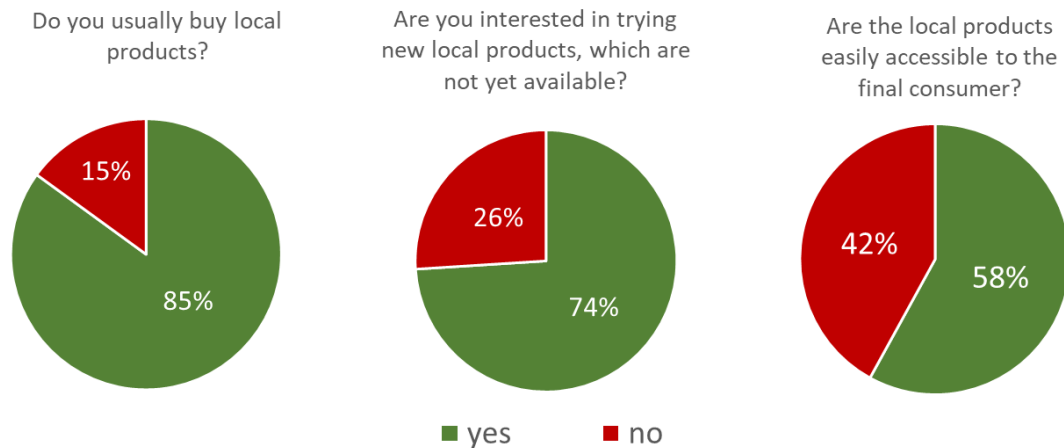


Figure 1. Summary of the results of the survey.

Among stakeholders, the 85% routinely buy local products (especially honey and local cheeses), and the 33.9% additionally declared to usually purchase herbal teas, infusions or aromatic plants produced in the area; furthermore, the 60% expressed their interest in the local production of goods derived by aromatic plants and herbs. In addition, 74% of the interviewers said they were very interested in buying new local products in their weekly shopping basket. Then, a high accessibility (58%) to the local products market (in terms of quantity, quality and price) is highlighted as a crucial feature for determining the overall acceptance. The results obtained by the survey are quite interesting, as they are showing that the preference to buy local products instead of the industrialized ones, is slowly but inevitably diffusing.

The business strategy behind the Hydro - Official Library

The business strategy is represented using the tool of the Business Model Canvas (Magrefi et al., 2018) (Figure 2).

KEY PARTNERS <ul style="list-style-type: none"> Regional and European Committees for funds Belluno Municipality Universities/High Schools Local Volunteering Associations Media Partners Network Contract parties Private investors 	KEY ACTIVITIES <ul style="list-style-type: none"> Cultivation, harvesting, drying and processing Packaging of the obtained materials (from cultivation) Shipping and Direct Selling Outsourced laboratory research activity Operations/ Administration depts 	VALUE PROPOSITIONS <ul style="list-style-type: none"> Finished products (from the cultivation of aromatic/medical herbs) Beekeeping products, derivative products from cultivation activity 	CUSTOMER RELATIONSHIPS <ul style="list-style-type: none"> Shipping services (with logistic services) In-structure Corner Shop* Pop-Up Shop (for the main local events*) Local agribusiness shops Selling of finished products 	CUSTOMER SEGMENTS <ul style="list-style-type: none"> Local and National companies Local and National herborists Private direct consumers
KEY RESOURCES <ul style="list-style-type: none"> Assets: Orzes School building and Outdoor structures; Soilless-NFT Hydroponic system plant, solar/biomass energy plants, fertigation plant, led illumination system, dryer; furniture and furnishing, IT furniture Production resources: seeds, fertilizers; beekeeping products Human capital: founders; protected categories workers, specialized personnel, interns Subsidiaries resources: packaging materials, stationery, others 			CHANNELS <ul style="list-style-type: none"> Social Media Channels (Facebook, Instagram) Before/After Sales assistance Direct Marketing (Newspapers, Radio, Online) 	
COST STRUCTURE <ul style="list-style-type: none"> Production: Seeds, fertilizers, production materials, direct utilities, periodic maintenance of the plants; packaging materials, salaries Indirect: General expenses, taxes; clerks wages (all depts) 			REVENUE STREAMS <ul style="list-style-type: none"> Sales from core business activities (finished products from cultivation) Sales from secondary business activities (beekeeping products, others) Sales of "on-demand plants" for third-parties (universities, privates) 	

Figure 2. Business Model Canvas of the Hydro-Official Library.

The Business model canvas is propaedeutic to make a SWOT analysis (Strengths, Weaknesses, Opportunities and Threats, Figure 3), in order to understand where the business needs to be improved and which theoretical achievements have already been made. A SWOT analysis was also conducted in order to better understand what to improve and how to manage the issues, and, at the same time, where further actions are not required (Figure 2). In the present case, the STRENGTHS (giving advantages over competitors) can be related with

the novelty and the innovative feature of the production system of the soilless technology. Furthermore, the business model structured as a Social Cooperative/Start-Up attributes undoubtedly several competitive advantages as compared with the classical agricultural businesses (the network contract allows a smart and inclusive relation among stakeholders). The WEAKNESSES (giving disadvantages if compared to the competitors) can be summarized in the limited amount of products delivered, focusing the business on quality instead of large-scale quantities.

<p>STRENGTHS</p> <ul style="list-style-type: none"> ● INNOVATIVE PRODUCTION OF NICKEL-FREE PRODUCTS ● INNOVATIVE BUSINESS MODEL 	<p>WEAKNESSES</p> <ul style="list-style-type: none"> ● LIMITED KNOWLEDGE OF THE LOCAL MARKET ● NEWNESS OF THE BUSINESS MODEL
<p>OPPORTUNITIES</p> <ul style="list-style-type: none"> ● LOCAL POLICY MAKERS INTERESTED ● PARTNERSHIPS WITH LOCAL ASSOCIATIONS ● PARTNERSHIPS WITH EDUCATION INSTITUTIONS 	<p>THREATS</p> <ul style="list-style-type: none"> ● HINTERLAND CONDITION OF BELLUNO ● FUNDINGS ● POPULATION'S LACK OF TRUST IN NEW AGRICULTURAL TECHNOLOGIES

Figure 3. SWOT analysis of the Hydro-Official Library.

Furthermore, a total understanding of the local market preferences must be achieved (currently, the only resource available, is the survey data). Finally, initially, the innovation proposed by the project might not be totally understood by the stakeholders involved. The main weaknesses, thus, might be related with the novelty of both the business model and the production technology. The OPPORTUNITIES (which may increase the project profitability) are directly matched with the external partnerships. The local policymakers first and the local associations might constitute a dynamic and core element for the development of positive externalities in the local community; furthermore, the role of the educational institutions is pivotal for the involvement of students (both from local high schools and universities in Veneto Region) and to conduct research concerning the agricultural studies within the Hydro-official-library. The THREATS (which may affect the project long-term sustainability), then, are conducive to the external environment. First for what concerns the difficulties in gathering proper funding to implement and develop the project. Secondly, the reaction and the approach of the local community that claimed interest in further connection with the local products is still unknown for what concerns the hydroponics cultivation. Indeed, the survey provides a general perspective, but in concrete terms, the reaction is quite unpredictable. Third, the specific features of the hinterland condition of Belluno Province (and Orzes village in particular) may constitute a considerable obstacle to the proper development of the business and to the engagement of customers and stakeholders outside the province, to expand the business.

CONCLUSIONS

Orzes School lies at the bottom of the Dolomites Mountains, nearby the city of Belluno, in an area which has always been penalized by its territorial condition, characterized by insulation from the rest of the Veneto region: the main provinces of the region, in fact, have a

much more dynamic social and economic fabric. This project proposes a concrete and innovative solution for the retraining of an old building, solving many contemporary problems of such territory. The re-adaptation of Orzes School introduces an innovative element in the territory, providing not only a new range of products, but a new methodology of production which is replicable in many other abandoned buildings that are locally found. A great attention to the environmental condition is given: the recycle and the reuse of the production byproducts allow not to waste precious resources and to limit the impact in the surrounding areas. Lastly, a social and inclusive feature is attributed to the business: the involvement of many associations dealing with fewer opportunities individuals, allow to promote an inclusive job - creation, promoting employment and local wellbeing. According to the SWOT analysis, further improvements need to be taken into account: the financing is not simple and the main obstacle may be attributable to the lack of trust from both the consumer and the stakeholders towards this new business model and the hydroponic cultivation technology. Accordingly, dissemination activities should be provided on the topics of the soilless cultivation in order to sensitize the consumer and the stakeholders on its potential on food quality, resource use efficiency and environmental sustainability.

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