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DolomiNet: building a network of vertical farms in the heart of Italian Alps

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Abstract

In 2019, the international student competition Urban Farm invited students from all over the world and different disciplines to join forces in order to reconvert three abandoned buildings into productive structures using soil-less technologies. One of the target locations was the abandoned school of Orzes village, in the Italian Alps, a mountain area that, along the last decades, has experienced lack of job opportunities and depopulation processes. Building on these social and economic obstacles, a landscape and collective re-generation project was designed in order to offer a new local economic identity, creating a network of indoor farms within abandoned buildings and targeting the production and processing of medicinal mushrooms and herbs. Such a network, called DolomiNet, defined the Orzes School as an administrative reference and productive model to be replicated and exported on the several abandoned buildings within the region. Furthermore, it allowed for the creation of a training and research center within the former school, where future network members could be trained and investigation on new pharmaceutical products and lighting technologies could take place. The three pillars of innovation of the project stands on the following elements:

-The forest biosystem: a sustainable productive model inspired by forest connections and based on CO_2-O_2 exchange among mushroom and plant growing chambers.

-The green Exoskeleton: a bioclimatic greenhouse applied on the building external shell with the double function of increasing productive volumes and provide thermal insulation to the building.

-Coofarming App: an immediate communication system between farmers and administrative center, which concurrently guarantee a remote control of cultivation parameters.

Keywords: urban agriculture, indoor farming, soil-less, building reconversion

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INTRODUCTION

For almost 10,000 years, agriculture has been practiced as derived by original farmers, basing the production on soil use and natural lighting. Recent technological improvements, as well as necessities related to global food security and environmental issues, have led to the introduction of innovative farming practices beside traditional ones, which made cultivation possible not only in the traditional open-field or greenhouse environments. Particularly, these new forms of agriculture have found their development thanks to the coming out of LED lights, soil-less productive systems and computer-assisted control of cultivation parameters and inputs, enabling a high productive efficiency in limited spaces such as those of urban buildings and skyscrapers (Despommier, 2013). The combination between agriculture and architecture has been declined in different ways including rooftop gardens, rooftop greenhouses, indoor farms and productive façades (Specht et al., 2014). This building-based agriculture can be named with the general term of Zero-acreage farming (Z-farming), when it refers to any kind of urban agriculture independent from land use (Specht et al., 2014; Thomaier et al., 2015), or Building-Integrated Agriculture (BIA), when more related to high-tech hydroponic farming systems that use local and renewable resources (Caplow, 2009; Sanyé Mengual, 2015).

Agriculture based in or on urban buildings can offer a number of opportunities to different stakeholders, which may benefit among the several of an easier access to food and new job opportunities (Specht et al., 2014). Potentialities can be also related to the reconversion of abandoned buildings into productive structures, therefore allowing the redeveloping of underexploited city areas with economic capability (Thomaier et al., 2015). Furthermore, buildings "retrofitting" (Castleton et al., 2010) can be a valid solution to bypass the problem of high investment costs for farms installation (Specht et al., 2014). A notable example is represented by *The Plant,* a community based food business and aquaponic farm obtained by the reconversion of an 8.600 meter squared abandoned meat packing building located in the Southside of Chicago (Chance et al., 2018). During its renovation, *The Plant* used about the eighty percent of building existing materials, therefore significantly saving money for initial costs, estimated to be half of the price if the farm was constructed entirely new (Tomlinson, 2017).

Attention on building retrofitting for farming purposes and territorial revaluation is currently becoming a theme of interest at academic and municipal level. On this trial, in 2019 the Universities of Bologna and Florence, in collaboration with the Italian Municipalities of Belluno, Bologna and Conegliano, invited students from all over the world and with agriculture, biology, architecture, design, economics, engineering, humanities and social sciences backgrounds, to redesign three abandoned buildings for productive aims. More than 130 students organized in 35 teams took up the challenge. The three structures object of reconversion where represented by an abandoned school, a rural house to ruin and a disused industrial area respectively located in Orzes (Belluno district), Bologna and Conegliano. The final aim of UrbanFarm2019 challenge was to design innovative urban agriculture systems that integrate the best architectural and technological innovations to produce food in urban environments. It also aimed to promote multidisciplinary and international cooperation between universities all over the world (Orsini et al., 2019).

The present article focus on one of the projects that redeveloped the building of Orzes village, about 5 kilometers away from Belluno city in Veneto region. Until 1992, the structure hosted a primary school, but has been abandoned ever since. The site is located on Dolomites, an area of Oriental Italian Alps that is currently facing an overall abandonment process due to its peculiar orographic conformation. The UrbanFarm2019 vision proposed for the reconversion was a vertical urban farm devoted to the cultivation of medical spices and herbs, possibly supplying the local cosmetics or pharmaceutical industry.

MATERIALS AND METHODS

The challenge phases were divided in two rounds followed by a Grand Finale, the ending dispute of finalist teams and winners selection. The first phase had the aim to carry out a preliminary selection of groups. The early evaluation took in consideration a 3-minute video sharing the reason of challenge participation, as well as a summary of the project with the maximum length of 6 pages (3 pages of text plus 3 pages of annexes). Teams had also to send the certifications to attest the student status of members (e.g., University certificate, booklet, receipt of University enrolment). All the materials had to be delivered to the institutional e-mail with the anonymous number assigned to each team at enrolment phase and within the deadline of 1 December 2018. After the transition to second step, the 35 selected teams had 45 days to send a second 3-min video, a proof of the concept, a written document and a team photo. The sending procedure had to follow the indications of first round, respecting the deadline of 15 January 2019.

Second round was the most consistent phase, determining the higher accumulation of points. The video had to include a general presentation of the project and short introduction of team members. With proof of concept was meant a document reporting an evidence derived from an experiment or pilot project, which demonstrated that a design concept was feasible (e.g., a prototype, a video, an architectural model). It was possible to provide multiple proofs of the concept. Finally, the written document had to describe the whole concept of the project mentioning its associated benefits. For this reason, proof of sustainability, feasibility, reliability, attractiveness and added value for society, economics and environment had to be highlighted. The maximum range of the document was 60 pages and had to contain a concept (summary of the total concept, main aim and main innovations used in the project), the urban farm design (architectural and agricultural solutions included in the project), an analysis of the City/District functionality (social and environmental value of the project), the economic feasibility and sustainability including Business model and all Annexes (including design, renders, growing technologies uses).

The Grand Finale took place the 13 and 14 February 2019 at NovelFarm Expo in Pordenone, Italy. During this occasion, teams had to present their projects to the public in order to obtain extra points. Each team had at their disposal an exhibition booth where to expose materials such as prototypes and posters. The final dispute consisted of a 5-min power point presentation in front a jury, ended up with the selection of three finalists, one for each location, which obtained the higher amount of scores. A 3-min dueling debate between finalist teams, explaining the reasons why the team should have won, sanctioned the first, second and third prize that respectively consisted in 6.000, 1.000 and 500 euros.

During the whole challenge evaluation, teams gained points for a maximum amount of 100 scores. Evaluated materials, maximum scores and type of evaluators for each phase of the challenge are reported in Table 1. The International jury, which valuated the second round and Grand Finale, included specialists in the field of agricultural sciences, architecture, economics, environmental and social sciences. Rating criteria considered general indications, as well as unique priorities defined for each of three locations. General indications included: choose of particular crops connected to neighborhood and city; scalability of the project on similar locations; technological innovation of cultivation systems; productive systems appropriated for the typology of workers; circular flow of resources; social inclusion and community enforcement. The specific indications defined for Orzes School reconversion included: indoor cultivation of medicinal herbs; involvement of disadvantaged users; inclusion of a desiccation room for drying plant extracts and a small laboratory for preparing and packaging the products. Overall attention on evaluation was paid to the combination of economic, environmental and social sustainability of the project.

Table 1. Evaluated materials, scores and judges per challenge phase

	Evaluated material	Maximum score	Evaluator
Round 1	Summary + Video	10	Scientific committee
Round 2	Full project + Video 2 + Proof of concept	60	International Jury
Designers Market	Booth at the fair	5	General public
Grand Finale Pitch	5’ presentation + 3’ pitch	20	International Jury
Online voting	Summary + video	5	General audience

RESULTS AND DISCUSSION

Project concept and main innovations

In the last years, Belluno province has assisted to a depopulation process also determined by a drop of job opportunities, which left behind an elderly population and high amount of abandoned buildings. Staring from this problems contextualization, the aim of the project was identified in the creation of a new economic identity for Belluno district, based on a network of indoor farms specialized on the production and processing of medicinal mushrooms and herbs, and obtained by the reconversion of local abandoned buildings. In order to achieve this long-term project, Orzes School was proposed as the starting and reference point for the network, as well as a sustainable productive model to export in other disused structures. The basic idea was to revive the original educational function of the school, making it a training and research center where to educate the future network members and investigate on new products and technologies related to medicinal herbs and mushrooms production. After network creation, the structure was planned to cover the role of project administrative center, therefore acquiring the name of DolomiNet Center (Figure 1).

The innovation brought by the project was related not only to the network strategy (“DolomiNet”), but also to an immediate communication system between farmers and administrative center (“CooFarming”), a sustainable productive model (“The Forest Biosystem”) and the use of a bioclimatic greenhouse applied on building original façade both for farming and thermal insulation (“The Green Exoskeleton”).

1. Connect network producers: CooFarming

Orzes School has been conceived not only as structure to reconvert, but also as an opportunity for entire Belluno territory. For this reason, the network has been imagined in the form of a cooperative where every member may obtain work and social inclusion opportunities. After a first training phase within the school, new entrepreneurs would become able to initiate their own companies, therefore involving other trained members to become farm employees. Once achieved network formation, Orzes structure was planned to add an administrative function to training and research, offering constant consultation to farmers, innovations updating and coordination with the local pharmaceutical industry requests. In order to cover this function, the communication between administrative center and farms would be facilitated by the application CooFarming, enabling to connect and monitor (through sensors within farms cultivation areas) productive parameters and immediately allow cooperative agricultural technicians to provide advice. The application was supposed to include a platform where farmers have the possibility to share doubts and information, while a technological integration would allow to support remote fertigation control.

2. Design a multifunctional structure: The Green Exoskeleton

Orzes School will have to cover different functions including training, research, processing, production and network administration. For this reason, the structure has been designed to accommodate laboratories, a classroom and offices, as well as productive areas both located inside and outside the building. In order to expand production to outside area, the project included a bioclimatic greenhouse applied on original façade, whose design is easily adaptable to other productive structures of the network. The façade extension accomplish not only cultivation but also thermal insulation purposes, therefore helping energy saving and emissions reduction. Thanks to these double productive and environmental benefits, this external application has been named The Green Exoskeleton.

3. Offer a low Impact and reproducible productive system: The Forest Biosystem

Orzes School indoor productive area has the aims to guarantee part of economic feasibility, offer research opportunities, train network members and propose a reproducible productive model that may ensure a sustainable and closed use of farming resources. In order to achieve the last purpose, an innovative production system has been designed taking inspiration by forest natural connections and therefore named The Forest Biosystem. It is represented by a modular closed structure with full recycle of farming residues, which especially finds its innovative power in the mutualistic cultivation of medicinal plants and mushrooms, as well as in the reuse of local waste woodchips as growing substrates. Thanks to CO_2 and O_2 circulation between cultivation rooms, plants and mushrooms respectively benefit from CO_2-enriched and CO_2-reduced air environments, determining an increase of productive capacity and reuse of wasted gases. As in a forest environment, waste woodchips are used as mushroom growing substrate, as well as a support for seedlings to transplant within an aeroponic system. Once exhausted, woodchips and other farming organic wastes are composted and reintroduced within the production, or used to produce heat and energy by a gasification system. Solar energy and rainwater collection is also fundamental in order to ensure use of renewable resources for artificial lighting and irrigation. A comprehensive SWOT of the project is included in Figure 1.

Deepening of constitutive elements

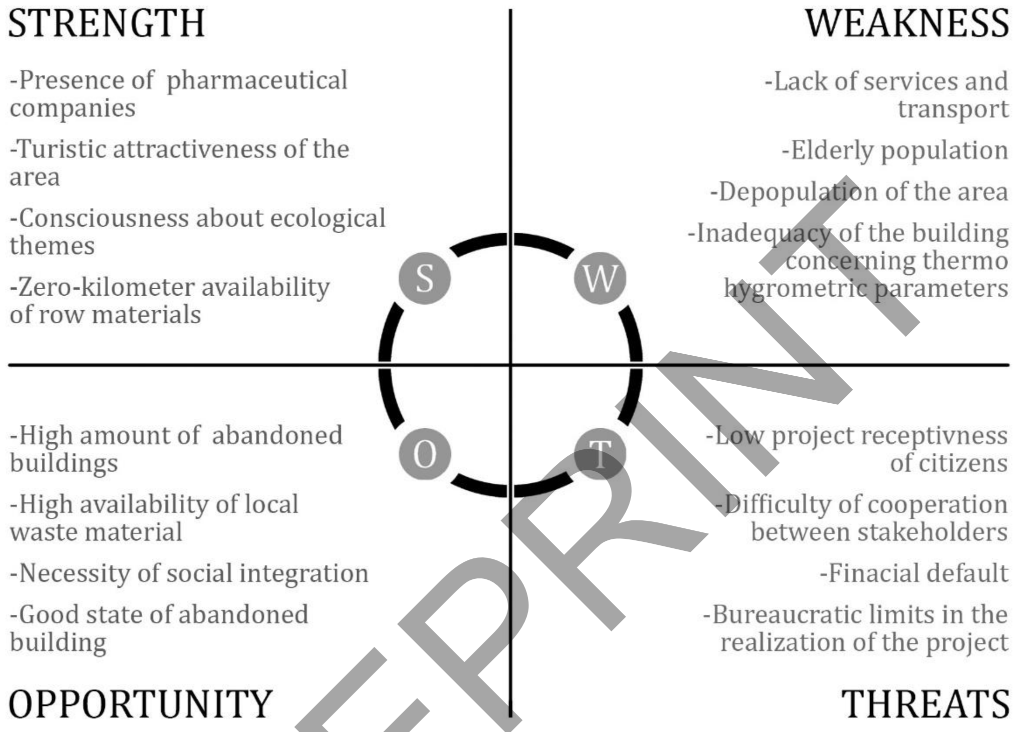

Figure 1. SWOT analysis of the project.

1. Architectural Aspects

The Green Exoskeleton is the result of the adaptation of original structure to a new function and aesthetics, projecting a "C" shaped double skin façade for east, south and west sides. This extension is the combination of a bioclimatic greenhouse and a "tabià", a traditional agricultural wood construction of Dolomites that help to better insert the structure within the mountain landscape. This association aims to enhance productive capacity and thermal insulation, furthermore giving the façade a project showcase function to make Orzes School an immediate symbol, while also recalling local agriculture. Due to a simple and reversible application on original façade, this structure can be easily adapted to other buildings as an integrative productive area.

In order to mediate between future and tradition, as well as between aesthetic and productive objectives, the outside design of the structure is focused on materials and geometries use, mixing wood and glass surfaces with metallic parallelepipeds going out from the structure. These geometric shapes have the function not only of structure accesses and openings, but also of telescopes focused on specific landscape elements creating a sort of conceptual link between the building and surrounding area (Figure 2). The choice of the exoskeleton constructing materials, as well as its internal functionality, have been especially determined by solar exposition. In fact, while south and east façade extensions will be covered in glass to fulfill a greenhouse function, west side will be overlaid with wooden planks to create a separate and covered area for a wheelchair ramp and elevator. North side will be let free from any outside extension and will represent the working heart of the building, characterized by a net of ducts externally applied on wall surface and painted in different colors depending on transported growing inputs (water, gases, heat and electricity) (Figure 3).

The exoskeleton represent an ecologic value for the building thanks to its effect on heat dispersions, particularly interesting for an area with very low temperature during wintertime. The effect of thermal insulator is determined by the retention of solar radiation and creation of a heated air stratum around the structure, which can help to contain and reuse heat dispersions during cold months. Instead, summer ventilation can be ensured by a system of automatic openings providing a natural ventilation through the exploitation of temperature and pressure differences and contemporary subtracting heat from the building. In order to optimize greenhouse climate control, winter heating and summer ventilation should be respectively supported by heating conduits and fan ventilation. Protective curtains should also be installed to limit excessive irradiation. Furthermore, in order to avoid the entrance of insects and other pests, openings should also include a system of double doors as well as a net covering for the windows. The original façade will be waterproofed to avoid structure damages and degradation determined by humidity.

Concerning internal division, the structure is divided in three floors, with a useful surface around 200 m² for ground and first floor, and 150 m² for basement floor. The functional division imagine the use of basement and first floor as productive and research areas, while ground floor will cover the administrative and public relation function, also including a processing area. Specifically, ground floor will host two offices for administration and cultivation parameters remote control; a classroom for work trainings and workshops; a relax area with services and a locker room; a processing laboratory containing dryer, distiller, extractor, a packaging zone and a storage area. A small merchandising area will also be included near the main entrance. First floor is supposed to contain a research laboratory, which will be used for investigations on products quality. The floor will also include three separated growing rooms for medicinal herbs production: one dedicated to germination and seedlings cultivation, and two rooms for plant growth. Each one of three rooms will be accessible through a common sanitization area based on air shower. Basement floor has been identified as the medicinal mushroom productive area due to the supposed higher humidity and lower sun radiation. The production will be distributed in two rooms, while a third room will be divided in two further areas used for substrate pasteurization and consecutive spawn inoculation. As in the case of plant production areas, also mushrooms cultivation rooms should be separated by a sanitization area in order to avoid contaminations.

Cultivation areas should ensure an easy management and cleaning. For this reason, each room should present cement floors with drains and be equipped with water lines and fertirrigation tanks.

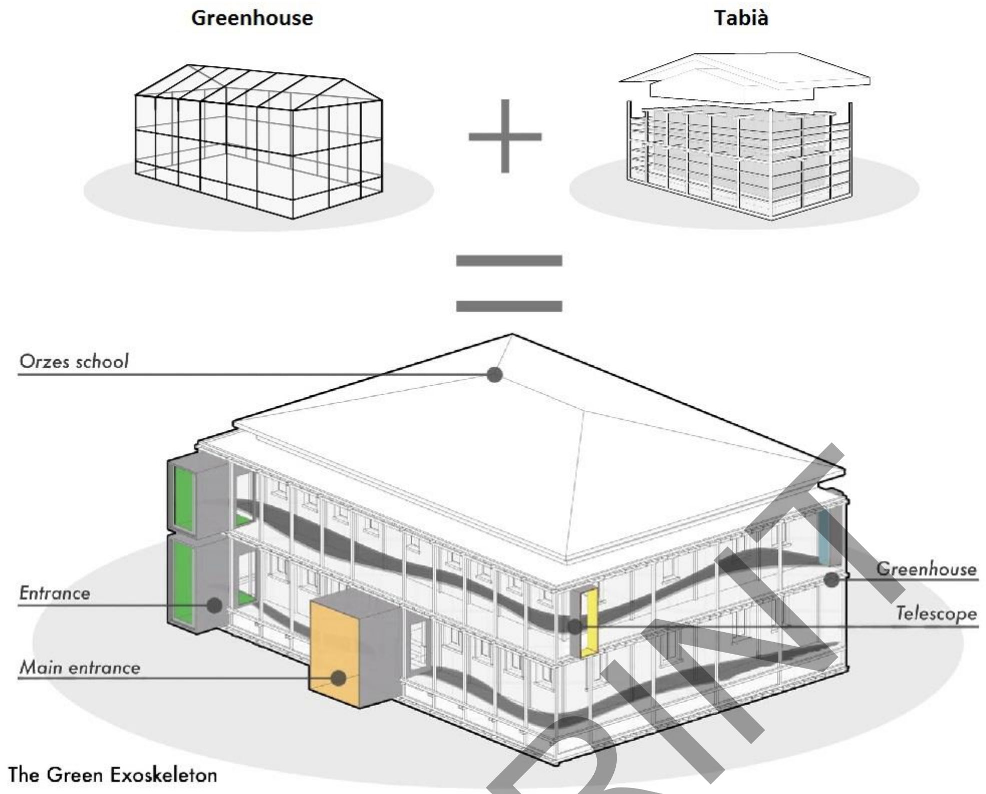

Figure 2. Orzes school new appearance obtained by the combination of a wood Tabià and a glass greenhouse to create an outside extenation on orginal façade for production and thermal insulation (The Green Exoskeleton).

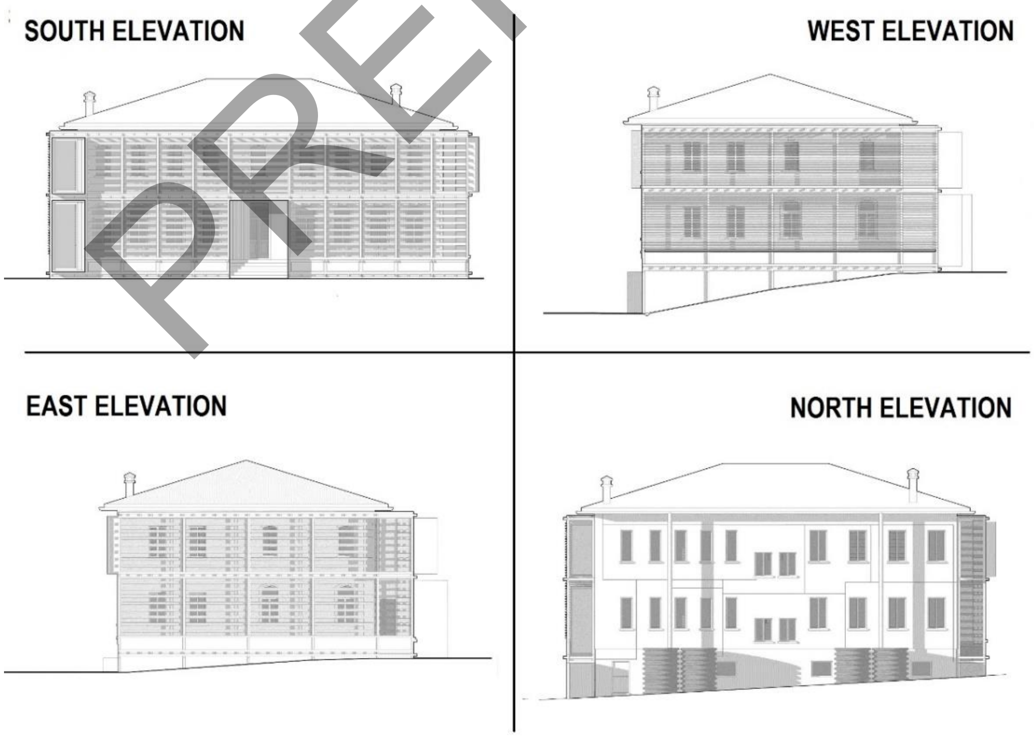

Figure 3. Orzes school south, west, east, and north elevations.

Electrical boxes and light should be waterproofed in order to avoid damages, while internal walls should be covered with non-degradable materials. Equipment for temperature, ventilation and CO_2-O_2 concentration control will also be established, as well as every sensor typology necessary for a remote control of growing parameters (e.g., relative humidity, temperature, pH, EC, CO_2) and fertirrigation. An elevator located on exoskeleton west side will facilitate the connection between floors, as well as products transportation. A rainwater collector system connected to outside tanks will be positioned near north façade and associated to a depurator for water sanitization. The north outside area will accommodate a composting area.

In order to guarantee structure environmental sustainability, a photovoltaic system has been hypothesized to be applied on south roof flap. Greenhouse façade will be also exploited using an innovative typology of photovoltaic glass containing photovoltaic cells and avoiding shade effect at the same time (Sdringola et al., 2014). Heat production and solar energy integration during night and wintertime will be guarantee by a gasification system that produces syngas from the conversion of local organic materials, such as waste timber from carpentries, farming activity residues and even urban organic wastes from Belluno recycle system. Waste CO_2 produced by gasification will be channeled and reused within the indoor productive area (Sanyé-Mengual et al., 2014; Pennisi et al., 2019a). While east, west and south façades will be thermally insulated by the exoskeleton, north façade will be covered using local products such as wool or wood fiber, in order to avoid energy waste. An air handling unit (AHU) will also be installed to regulate air circulation as part of a heating, ventilating and air-conditioning system for closed environments air treatment.

2. Agricultural Aspects

The main aim took into account while planning the growing solution was to create a closed sustainable system, which could ensure a low environmental impact through the exploitation of territory resources and recycle of growing outputs. The Forest Biosystem is the proposed solution to achieve this aim, taking inspiration by the natural connections generated in a forest, where rainwater, sun light, wood remains, humus, plants and mushrooms, interact with each other to create a self-sufficient and balanced ecosystem (Figure 4).

The productive model is especially based on the mutualistic cultivation of medicinal plants and mushrooms and on the reuse of local waste woodchips as a growing substrate. Like in a forest ecosystem, plants and mushrooms will respectively exchange CO_2 and O_2 through conduits between separated growing rooms. Both cultivations will mutually benefit from CO_2-enriched and CO_2-reduced air environments, therefore determining an increase of biomass, higher products quality and reuse of wasted gases. Waste woodchips will be used as mushrooms growing substrate as well as a support for seedlings to transplant within the productive structure where to proceed with plant growth. Once exhausted, the growing substrate and other farming organic residues can be partially composted and partially used in the energy-heating gasification system, therefore re-entering within the productive cycle. Once achieved a large-scale production, mushrooms and organic farming residues may be used for the creation of a biodegradable plastic obtain with a particular technology that exploits mushrooms chitin as an adhesive component (Manuelli, 2015). Solar energy will be exploited for artificial lighting; while, collected rainwater will be recycled and atomized on mushrooms mycelium and plants roots simulating rainforest mist.

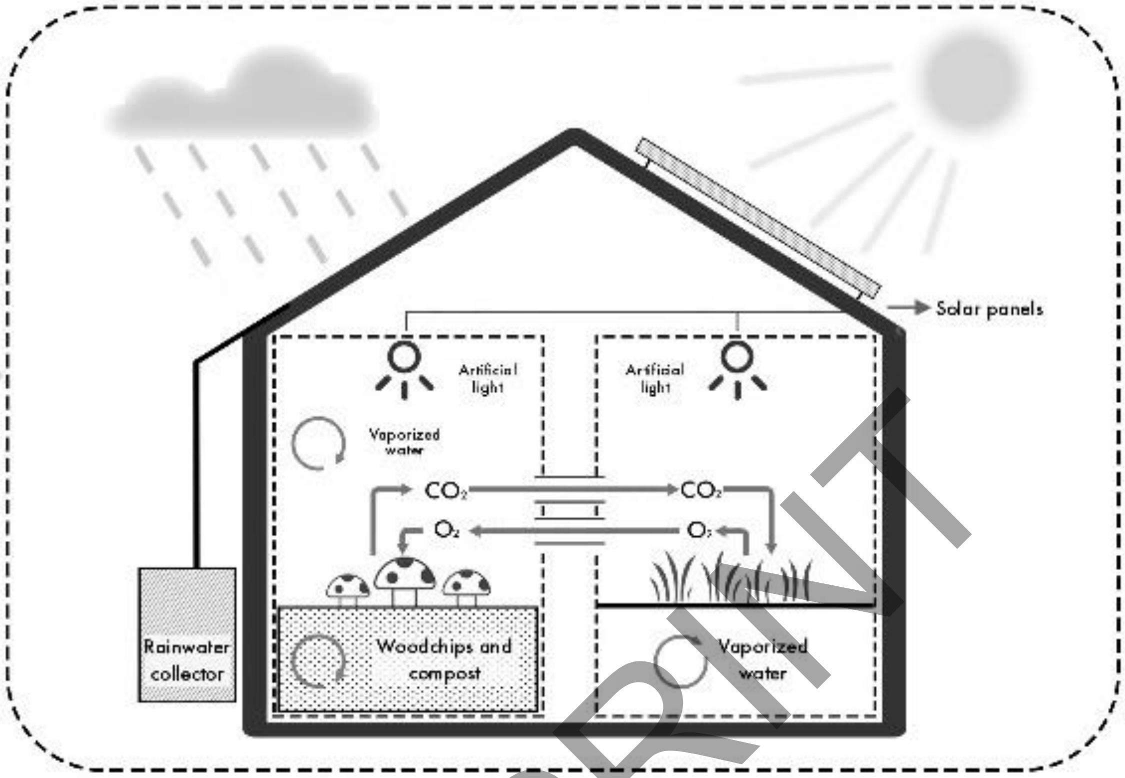

Figure 4. Graphic exemplification of The Forest Biosystem.

Since acid woodchips may determine a negative effect on plants growth, woodchips substrate may be carbonized exploiting the pyrolysis effect determined by the gasification system. Carbonization technique for organic substrate inertisation has already been demonstrated by researches on rice husk (Fecondini et al., 2009). Literature also helped to reinforce the idea behind the mutualistic productive model, giving an example of a plant-mushroom indoor factory already existing in Japan (Kozai et al., 2015), as well as confirming the possibility to use sanitized woodchips both for mushrooms (Stamets, 2011) and plants cultivation (Wright and Browder, 2005; Boyer, 2008).

In order to export this farming model to other farms of the network, the productive structure has been conceived as a low-weight and resistant module, which may be adapted to different plant heights and building dimensions using a sliding and interlocking mechanism for plant containers, contemporary helping an easy structure management and cleaning. Every module is represented by a scaffolding containing two growing containers each level, giving an easy access both from right and left side. A singular container will present a rounded designed base in order to facilitate excess water gathering. Waterproofed LED lights will be positioned above each cultivating line and will make use of improved spectral properties (Pennisi et al., 2019b). The structure will be applicable to indoor and greenhouse conditions, and will be suitable both for the aeroponic system applied in the case of plant cultivation, and for the production on organic substrate applied in the case of mushroom cultivation. The aeroponic system will use atomization nozzles inside containers in order to optimize water and nutrient supply. A plastic cover will have the functions of plant support and root protection, avoiding light entrance and overheating due to a double white-black internal and external coloring. A recirculating system will return not absorbed nutrient solution to a drainage tank, where the ionic concentration will be adjusted and reused. Mushroom production on organic substrate will maintain the same structural characteristics described for the aeroponic system, with the only difference of the growing substrate filling the container. In order to have a direct contact between water and mycelium, atomization nozzles will be located on the growing surface instead of below cultivation (Figure 5).

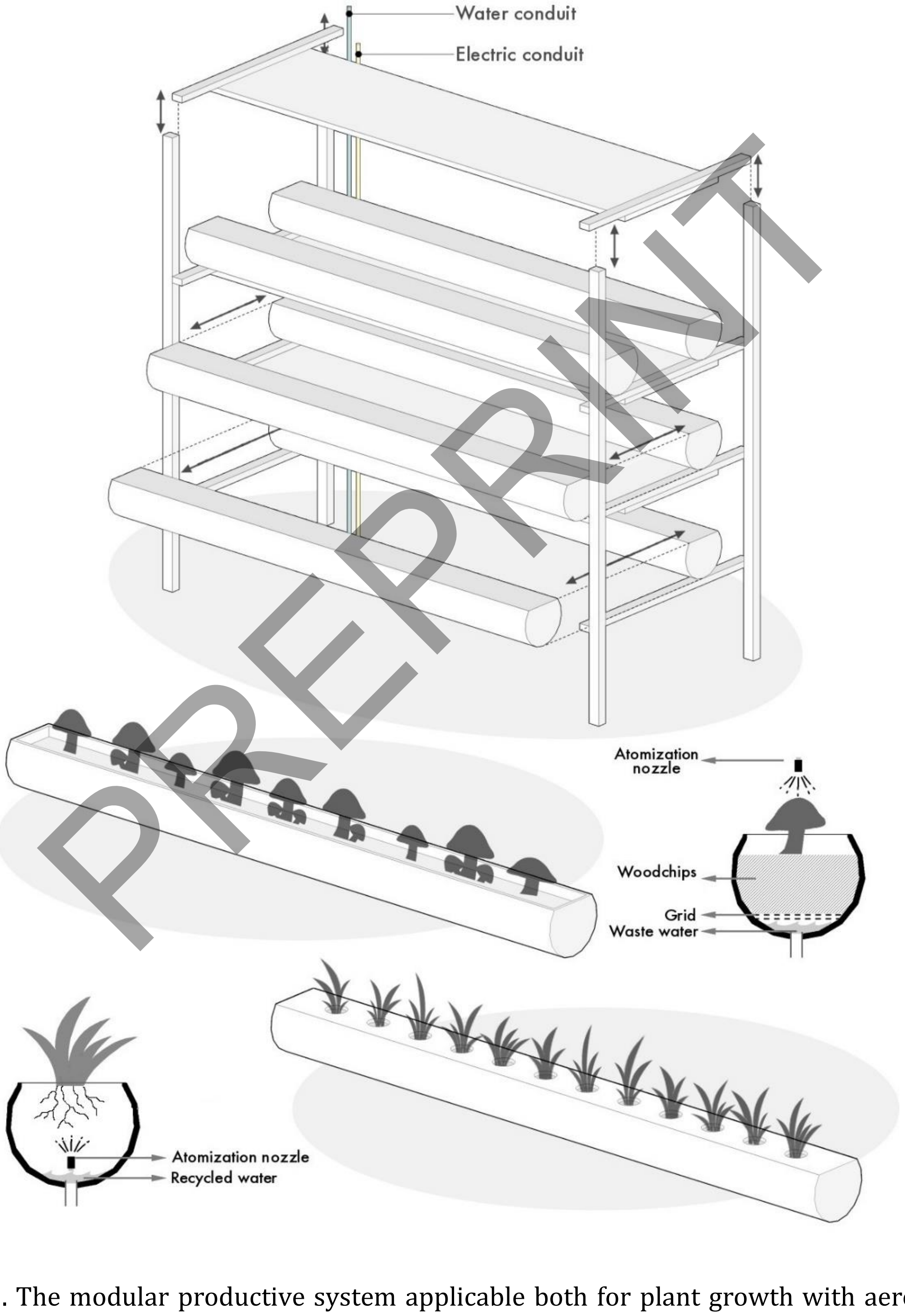

Figure 5. The modular productive system applicable both for plant growth with aeroponic and for mushroom cultivation on organic woodchip substrate.

Although the productive system may be adapted to a variety of medicinal species, the proposal particularly fell on specific plants that may have interesting implications concerning pharmaceutical industry demand and indoor quality. For these reasons, the focus went on *Perilla frutescens* and *Hypericum perforatum* cultivation. *P. frutescens* is a medicinal herb original from Asia, which can be applied for different curative purposes using seeds and leafs extractions (Bachheti et al., 2014). Since it is normally imported from China by local pharmaceutical industry, its cultivation within Orzes structure will offer a zero-kilometer product, as well as a chemical free and standardized high quality determined by indoor growing conditions. Thanks to use of blue LED lights, green perilla growth and perillaldehyde synthesis (an essential oil component) will also be improved compared to field cultivations (Lee et al., 2014; Kozai et al., 2015). *H. perforatum* is another interesting plant considering indoor cultivation. This plant native to Europe and Asia present numerous curative effects especially related to an antidepressant, antiviral antimicrobial activity (Barnes et al., 2001). Researches demonstrated that a cultivation within CO_2-enriched environments can enhance biomass and medicinal metabolites production, due to an increase of photosynthetic rate (Mosaleeyanon et al., 2005; Zobayed et al., 2006; Kozai et al., 2015).

Concerning medicinal mushrooms, although this type of products are already widely used and cultivated in Asia, western countries discovered their curative potentialities just in recent times, opening new possibilities for the pharmaceutical market. Numerous saprophyte species may be cultivated within indoor systems, including e.g. *Lentinula edodes, Hericium erinaceus, Laetiporus* species*, Grifola frondosa*. Substrate sanitization and inoculation will be fundamental productive aspects, as well as spores isolation for the obtainment of pure cultures.

3. Social and environmental value of the project

Belluno district depopulation process is an evident phenomenon since 2009, which currently reached about 206 thousand inhabitants (Voi and Forzin, 2018). Abandonment mainly refers to youngest population, leaving behind 12% of population under 15 years of age, 62% between 14-64 years and 26% older than 64 (Voi and Forzin, 2018). A cause of the phenomenon is the ongoing reduction of job opportunities. Compared to 2007, unemployed people of Belluno area have doubled from 2100 in 2007 to over 4800 in 2017 (Voi and Forzin, 2018). The business sector from 2009 to 2017 recorded 890 closed companies (Voi and Forzin, 2018), creating an entrepreneurial desertification process on the entire province. Agricultural activity is also facing an abandonment. The consequences of this phenomenon are widely visible considering the contraction of agricultural utilized area and enterprises, which from 1982 to 2010 respectively showed a decline of 50.3% and 83.7% (Zanetti, 2013).

DolomiNet, referring to the Dolomites symbol, is the proposed solution to contrast Belluno district social issues. The network of indoor farms will use Orzes School as an administrative, training and research center (DolomiNet Center). The training function of the school is to specifically address to potential entrepreneurs and employees, looking for income opportunities as well as social inclusion. After a period of skills acquisition within the center, new entrepreneurs will be able to start their own indoor farm, therefore involving other trained members as farms employees. Research opportunities are especially addressed to local and external companies that would like to develop specific lighting technologies for indoor production of medicinal plants and investigate on new natural molecules for the pharmaceutical and cosmetic sectors. Universities will also have the possibility to become research partners, relying on Orzes School laboratory and indoor productive area.

The network of DolomiNet will work as a cooperative, where every member will obtain work opportunities. New entrepreneurs will create their own farms and participating to the network with an annual fee, obtaining from DolomiNet Center different services including agronomist consultation, productive coordination depending on pharmaceutical industry exigencies and updating with recent cultivation innovations. Those farms that will not have their own processing laboratory may also rely on Orzes structure for a transformation service. Furthermore, the school may also furnish essential materials, such as growing substrates sterilized or inoculated with spores. Employees from different social backgrounds, such as young unemployed, immigrates and other disadvantaged people from social cooperatives, will be redirect to new farms after a training period within Orzes School. These subjects will also become network members with the benefit of job and social integration opportunity.

Communication between farmers and administrative center will be facilitated by the use of the application named CooFarming, which - connecting to sensors within farms cultivation areas - will send information to a central system controlled by the cooperative agronomist. The agronomist will monitor productive parameters giving immediate advice to farmers in case of anomalies. The app will also include a platform where farmers will have the possibility to communicate each other, sharing doubts and information, therefore reinforcing network connections. The integration of specific sensors will also allow farmers to manage plant fertigation simply using their smartphone and without being at their farming place.

Concerning project environmental value, the decrease of production carbon footprint was targeted by the use of zero-kilometer farming inputs, such those local wastes from forestry and wood processing sector particularly relevant in Belluno area. These waste byproducts can be used not only as a growing substrate, but also as a source of heat and energy if applied within the gasification system. Since Belluno is the Italian province with the higher recycle rate, this virtuous attitude of population can also be used as a project opportunity, introducing locally collected organic wastes within the gasification system or composting it for farming purposes. Since pharmaceutical industries of the area will not have the necessity to purchase products from other countries, these zero-kilometer products will considerably reduce carbon footprint of transportation routes with consequent benefits on the entire environment.

Belluno Municipality has been considered as the central subject and main link to connect the different partners, offering initial economic support and project communication, with the benefit of a local economic development, repopulation and recovery of abandoned buildings. Particularly, it will connect local companies, new entrepreneurs and social cooperatives for the creation of a solid economic base where to insert socially fragile subjects such as unemployed citizens, immigrates, people with disabilities or other minorities. Through training programs held within the school, disadvantaged users will be able to acquire specific skills and become high-qualified workers ready to enter the labor market offered by the new farms of the network. The classroom and garden may be used to organize workshops concerning medicinal plants and mushrooms cultivation and processing, also involving part of the disadvantaged population that could not take part to the network as a workforce, like in the case of elderly subjects or people with strong disabilities. Organized visits to the garden and greenhouse will also open Orzes structure to schools, citizens and tourists, helping the creation of strong connections between the project and entire Belluno community. Furthermore, the specialized research center will give local companies the possibility to become not only commercial but also research partners, therefore reinforcing their economic and innovative power. Unifarco and Flytech srl are two local companies identified as possible partners, respectively related to pharmaceutical-cosmetic industry and lighting sector.

4. Economic Feasibility and Sustainability

The project will have to face different costs in order to be put in place and supported after its installation. Costs can be divided in three categories: structural, productive and maintenance costs. Structural costs will be specifically related to facilities installation including heating system, water supply, electrical grid, thermal coat and photovoltaic panels and glass. This cost will also include greenhouse construction and internal renovation, as well as elevator establishment. Costs related to production refer to all those raw materials, inputs, machineries and technologies fundamental for plants and mushrooms development and processing. These materials will include, among others, seeds, productive structure, laboratory materials, irrigation system, sensors, sterilization products, extractor and distiller. Electricity, water, gas and waste disposal have also been considered within these costs, as well as labor and know-how of those subject that will administrate and work within the structure (researchers, agronomist, employees and workshop collaborators). Production costs have also to include communication with network members, citizens, companies, universities and other social subjects fundamental for project existence. Communication costs will include advertising for work trainings, workshop and visits; social media management such as Facebook, Instagram and Linkedin; web site and e-commerce platform; creation and maintenance of CooFarming application. The project will also have to face a cost for its subsistence. Maintenance costs will include machinery amortization; structural maintenance of greenhouse, growing rooms, laboratories and other structure rooms; energy efficiency costs (water, heat, energy recycle) and internal maintenance (e.g., cleaning, painting).

In order to guarantee structure creation and costs coverture primary and secondary income sources have been identified, as well as self-financing tools for project autonomy. European, Regional and National funds (POR-FESR 2014-2020) represent the primary incomes that will determine not only project set up, but also part of its durability by the time. Regional Operational Program (POR) is a tool used by Veneto Region to obtain social and economic growth in the areas of industrial development, digital agenda, environment and innovation from 2014 to 2020. It uses 600 million euros made available by European Union, Italian Government and Veneto Region itself. Concerning European founds, the European Regional Development Fund, synthetically called FESR (Fondo Europeo di Sviluppo Regionale), is one of European structural and investment funds whose objective is to finance development projects within European Union. POR-FESR 2014-2020 is divided into seven Axes with their own financial allocation, each Axe is further detailed into specific Actions that define eligible interventions. Among the seven thematic Axes, the most relevant for project development are: Axe 3 (Action 1-2-3), related to productive systems competitiveness with the aim to promote entrepreneurship facilitating economic exploitation of new ideas and creation of new companies, and Axe 4 (Action 1-2-3-4), promoting energy efficiency and renewable energy use of buildings. Beside primary funds, the project will be also supported by secondary incomes, such as annual registration fees from network members and research funds from companies and universities.

Self-financing will be determined by a business-to-business and business-to-consumer commerce. It specifically refers to trade of raw materials with pharmaceutical companies; participation fees for work trainings, workshops and visits; and sale of merchandising. Merchandising may be represented by officinal lotions, dried medicinal mushrooms, t-shirts, pens and craftworks realized by the less advantaged workshop participants. Selling of compost and spores inoculated substrate, as well as products processing service for network members can also become a self-financing source for Orzes structure.

CONCLUSIONS

The project DolomiNet aims to offer not only a recovery opportunity for a disused school, but also a wider strategy for the creation of a new economic identity that may benefit, at different levels, to entire district community. The network of indoor farms will help to overcome current depopulation problem and lack of job opportunities affecting the area, furthermore offering an environmentally sustainable productive system based on the use and recycle of local waste resources, as well as on a zero-kilometer products purchasing.

Concerning the challenge Urban Farm 2019, the active and felt participation of students all over the world and with different backgrounds, as well as the support of numerous partner Universities, is the demonstration of a new and more attentive sensibility to Urban Agriculture as tool for job and social integration through the reconversion of disused urban structures.

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