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INNOVATIVE URBAN FARMING TECHNIQUES FOR SUSTAINABILITY OF CITIES: FROM FARM TO FORK – CASE OF THE CITY LANUVIO, ROME, ITALY

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Abstract— Urban areas and cities globally encounter many challenges to confront vast urbanization and climate change impacts. Urban farming is one of major responses to some of these defies. Such challenges are manifested in Lanuvio, a municipality near Rome situated in ‘Castelli Romani Regional Park’, use to have high cultural, historical, archeological and naturalistic values, but the site of ARES (once served as a fire station) is now vacant land, hence considered a waste of resources that decreases its value economically, socially and environmentally. Urban farming can assist in transforming cities to be generative, resilient and sustainable. This paper presents a project (Green Symphony) transformation that provides the citizens of Lanuvio with smart and sustainable technologies focusing on urban agriculture. The objective of the study is to transform the abundant site to be a generative urban farm while making people aware of the importance of healthy food and creating connectivity between citizens and tourists. Indeed, aquaponic systems, permaculture, green walls, vertical farming, combined with energy harvesting from footsteps, solar panels, water close circuit, and rainwater collection are incorporated. Organic waste is also transformed into fertilizer, which contributes to the creation of a self-sustained farm. The site has been developed as a social hub and a business model, including: strategy, marketing and operations plans are developed to estimate the operation costs and labour management. Results show that the developed site can generate 7 tons yearly of vegetables, fruits, herbs and fish, besides creating 3 stable jobs. The investment costs are paid off after a maximum of 5 years and the financial balance is annually positive and 1.7 tons of produce. Finally, the vacant land is transformed into a social hub

and multi-functional green gardens to increase livability and targeted SDG 3, 7, 9, 11, 12, 13 and 15.

Keywords— Sustainable cities, social sustainability, SDGs, urban farming, Lanuvio city, Italy.

I. INTRODUCTION

Cities generate over 80% of the global GDP and attract more people due to their economic growth [1]. Rapid growth in population leads to a huge increase in energy demands, CO₂ emissions, and food requirements in cities [2-3]. Climate change (CC) is considered as one of the biggest challenges nowadays. It affects the environment and cities negatively in various forms (severe events, storms, floods and health) [4-6]. The global temperature has increased by 1.4°F in the last 140 years and the CO₂ level in the atmosphere has become 400.71 parts per billion.

Also, the cover of the world's forest has decreased by 1.5 million km² in 12 years [7]. In Italy, CC increased air pollution, floods, droughts, coastal erosion and caused reduction in agriculture. This affects food and water security in most regions [8].

Urban farms play an escalating and crucial role in food security and in generating clean and local food [9, 10]. Urban farms also create new job opportunities, boost the economic growth, and contribute to the GDP, while eventually becoming green spots of the cities and acting as social catalysts [11-12]. Urban farming is a key component in improving local economy, increasing social integration, and achieving environmental sustainability [13]. Urban farming has been increasing in cities. For instance, more than 21,000 ha in Cagayan de Oro City, Philippines, 12% of urban land in Havana, Cuba and more than 11,000 ha in Jakarta, Indonesia



Fig. 1 (a) Urban farming in Uganda's schools



Fig. 1 (b) Urban farms, Singapore

is dedicated for agriculture production [14-16]. Figure 1 presents some examples of urban farming in different cities.

According to the Food and Agriculture Organization of the United Nations (FAO), one quarter of the world's population is provided by food through urban and peri-urban farms and this number is expected to rise as shown in Box 1 [17]. With urban farms starting to be integrated to the city fabrics such as rooftop urban farms, their economic, social, and environmental values increase as well. Urban farming provides the community with organic and clean food mainly vegetables, herbs, and fruits [18]. Hence, it ensures food self-sufficiency and security, as well as it creates solutions to organic waste and improves the air quality mitigating CO₂ emissions.

New technologies in agriculture have been developed to deal with areas with low soil fertility and water availability, cultivation in limited spaces, and minimize the production impact to the environment and human health [13]. Some of these technologies are aquaponic and hydroponic systems, green walls, vertical farming (Figure 2) as well as permaculture, energy from renewable sources, transforming organic wastes into fertilizers and rainwater harvesting [19-22].

Lanuvio is not far from the challenges of climate change (CC) and the need for food security. It is a village situated in "Castelli Romani Regional Park" close to Rome, in the region of Lazio, Italy. The area has high cultural, historical, archeological and naturalistic values that should be maximized and promoted. It is a popular and touristic place with festivals and social events promoting local-food and traditionalism [23]. The site of ARES 118 (2,500 m²) was once used as a fire station. However, it is now a vacant land with no social or economic value. It is located next to the city center, 800 meters away from the main square and is reachable by train from other parts of Italy.

Box 1: Scale of urban farming in providing clean food

'One quarter of the world's population is provided by food through urban and peri-urban farms and this number is expected to rise.'

Food and Agriculture Organization (FAO) - United Nations



Fig. 1 (c) Urban farm in South Africa



Fig. 1 (d) Urban farming in India

Fig.1 Examples of urban farming in different cities [24-27]



Fig. 2 (a) Aquaponic systems



Fig. 2 (b) Hydroponic system

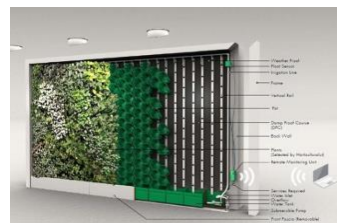


Fig. 2 (c) Green walls

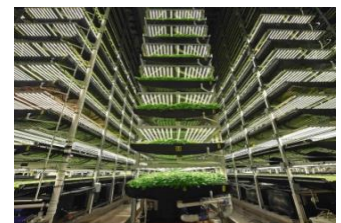


Fig. 2 (d) Vertical farms

Fig. 2 Examples of urban farming types and technologies in cities [28-31]

This paper presents a study conducted on an abundant site in Lanuvio – Rome, Italy utilising urban farm innovative technologies and integrating smart solutions to make this site a green hub in the city, generative and sustainable (economically viable, socially viable and environmentally viable). It also presents a conceptual project – named Green Symphony – that provides a social hub for the citizens of Lanuvio with smart and sustainable technologies focusing on agriculture.

II. OBJECTIVES

Focusing on the needs of the citizens and the necessity to restore the site (There is a train station 28 minutes away on foot next to the site as shown in Figure 3), the objectives of Green Symphony project were to transform the

abundant site of ARES 118 to be a sustainable node, an educational hub, and a social innovation area to increase the livability of the city. The conceptual project links arts, like music, and agriculture creating a community-focused farm. It reaches out to the community while using innovative environmentally-friendly approaches, smart technologies to preserve energy, water and to produce pesticide-free food while focusing on the UN 2030 Agenda and SDGs, mainly SDG 3, 7, 9, 11, 12, 13 and 15 as illustrated in Figure 4.

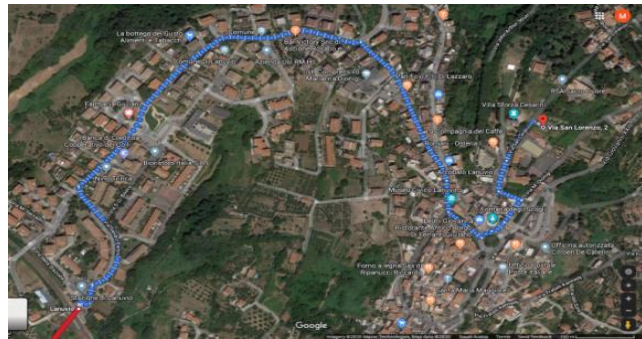


Fig. 3 (a) Route to the site



Fig. 3 (b) Site's surroundings

Fig. 3 Accessibility to the site on foot and the surroundings

Image source: Authors based on Google Maps, 2020



Fig. 4 Sustainable development goals for 2030 and the project targets

Image Source: UN Global compact, 2018

III. ISSUES AND CHALLENGE

With the increase in population and damages due to climate change, cities are lacking the resources to support their citizens. Therefore, cities are usually thought of as congested places lacking natural life and green sites. To change this situation, action is required, that ensures the sustainability of the city and meets the needs of the community. The site of the study is located in the city of Lanuvio, Italy at coordinate: 42°14'20.29"N 13°42'56.04"E as illustrated in Figure 5. There are several challenges concerning the site of the study, there are as follows:

- The site being small (2,500m² only) with one usable building;
- The land being abandoned and the building in a poor state (Figure 5);
- Located along only one road and the only entrance;
- Being a dull spot among the historic sites around it;
- The main building being wall bearing with minimal possible changes

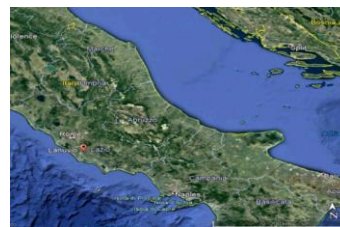


Fig. 5 (a) Satellite footage of Lanuvio's location



Fig. 5 (b) Satellite footage of the site

Fig. 5 Satellite footage of Lanuvio and the site location in Rom metropolitan, Italy

Images source: Google Earth, 2020

IV. METHODOLOGY

This project study is a product of the participation of the team "FENICE" in the international competition of UrbanFarm2020. The methodology depends on two approaches: a) a theoretical and analytical approach; and b) an applied approach. The analytical approach depends on the evaluation of the given site and its surroundings, and it produces a number of solutions to achieve its goals and objectives. These solutions include architectural, agricultural, social and ecological ones [32]. The applied approach is centered on integrating the environmental and energy systems as well as smart technologies including the urban farming systems. Figures 6 and Figure 7 show the exterior state of the deserted building and the site shed.



Fig. 6 Building's exterior situation



Fig. 7 Site and Shed's situation

IMAGES' SOURCE: URBAN FARM 2020 [32]



Fig. 8 SWOT analysis of the study project
 Source: Authors

V. SWOT ANALYSIS

It is imperative to conduct a SWOT analysis of the study project to assess the strengths, weaknesses, opportunities and threats. Figure 8 summarizes the SWOT analysis that was carried out for per-assessment. It is clear from the figure that project strengths and opportunities are of added value, but nevertheless the threats and weakness were addressed in the project assessment in the following parts.

VI. THE STUDY

The study's concept of architectural innovative and smart solution includes 6 fields: a) environmental systems; b) energy; c) water; d) materials; e) emissions; and f) urban farming are presented in Figure 9 and discussed in the following section.

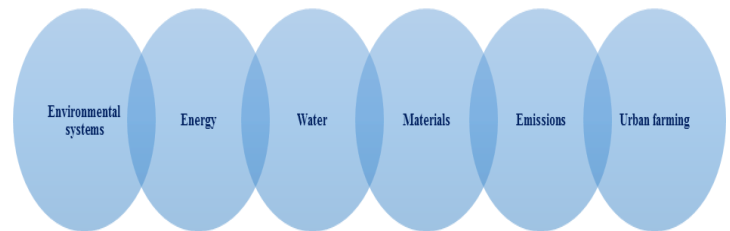


Fig. 9 The 6 sections examined in the study

6.1. CONCEPT

The name FENICE was inspired by the phoenix where in ancient Greek folklore, a phoenix is a long-lived bird that cyclically regenerated or is otherwise born again [33]. The study approach and slogan is basically to rebuild from ashes. We therefore, rebuild the current land from its own ashes into an urban farm, which has a community focused approach. In order to create a farm that is fulfilling to the citizens' needs and making use of the abandoned site of Lanuvio, the project study focuses on linking arts (music) and agriculture through creating a community-focused farm. Thus, the urban farm is called 'Green Symphony' to emphasize this link and create social synergy. The project has an area to host events and allow for social interaction. It also reaches out to the community while exploiting innovative environmentally-friendly approaches, smart technologies to conserve energy, water use, yet produce pesticide-free food as well as focusing on 2030's sustainable development goals (SDGs).

6.2. ARCHITECTURAL SOLUTIONS

The project consists of 4 main spaces: workshops, a permaculture garden, outdoor recreational spaces, and a kitchen. The two buildings are developed to be well-insulated to save energy (heating/ cooling). The remaining space will host a number of recreational activities with primary views of the historic sites and area dedicated to hosting events in the farm as shown in Figure 10; and details are in Table 1.

6.3 ENVIRONMENTAL SOLUTIONS

The restoration and valorization of degraded sites is part of the Regulation L. 29/97 that protects the regional park; thus, it is one of the main goals of the region of Lazio. Within this scope, Green Symphony could be a solution, as it provides local food and hosts events with economy of energy, water,



the use of low impact materials, and a negative carbon footprint (avoidance of impact).

Table 1: Illustration for the Architectural areas, locations and functions

Area	Location	Function
Workshop area	Under the old shed that was used formerly for ambulances.	Seminar area enclosed by glass walls, equipped with a wide screen and speakers.
Office	Main Building	Developed for the management of the farm's activities.
Green house	On the roof of the main building	Aquaponics system of agriculture is used where columns and trays are rented to the community.
Kitchen	The heart of the main building.	Sharing, collaborating, co-creating, and raising awareness are the main purposes for teaching the community the basics of using fresh produce to prepare traditional Italian dishes.
Eating area	Attached to the kitchen in the main building.	The community can order food according to the produce of the farm and the kitchen.
Storage room	Next to the kitchen in the main building.	The produce could be stored for a short time to be packaged and sent out to be sold.
Outdoor spaces	—	An events area and interactive space in the landscape is designed to host different activities to boost the social dimension, in addition to a bike park.
External booths	Attached to the outer fence facing the main street.	For selling the excess products of fruit and vegetables.

Source: Authors

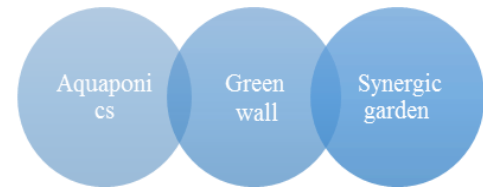


Fig.10 Elements of the study project planning in Lanuvio city, Italy (source: authors)

6.3.1. Energy

Energy production is one of the most critical factors that affect the environment. The building's envelop is insulated and the heat from the kitchen is harvested to decrease cooling loads. The pond is covered by a removable radiant barrier (TekFoil®) to preserve moderate temperatures during the winter. Dimmable LED lighting units combined with ABB i-bus® light and occupancy sensors are also used indoors to adjust light intensity and automatic turn off of the lights. Lumimotion® technology, in the landscape, is applied for turning the light on automatically when someone moves within a 10 meters radius. These technologies reduce the energy use of lighting up to 60%. Moreover, renewable energy sources are chosen according to local abundance and 25 solar photovoltaic cells (315 kWp) are installed on top roofs. Each PV cell produces 320 kWh annually so the total solar energy produced will be 8 MW/year and it can be used to operate the two buildings and the pumps [34]. However, solar energy may not be sufficient to cover all the energy needs, hence, the farm is also supplied in certified 100% green electricity. Finally, piezoelectric Pavegen® tiles generate an average of 5 watts at 12-48 volts DC per footstep. This energy is used to load the batteries of humidity sensors in the garden.

6.3.2. Water

The aquaponic and green wall systems both use water from the fish pond to feed plants. This closed circuit reduces water consumption by 90% and prevents water waste. Likewise, saving water is a key aspect of the permaculture concept, so that mulching and a drip irrigation system in the garden are essential. Since Lanuvio has had substantial rates of rainy days (827 mm/m² between 2003 and 2018, according to the Regional Agency for Environmental Issues (ARPA)); the rainwater is collected through buildings, gutters and channels in the garden, and stored in an underground tank size of 5 m³ [35]. Such water can be used for farm irrigation instead of drinkable water. During drought periods, the needs in water are supplemented by the water network. In addition, the Internet of Things (IoT) technology can nowadays be applied in agriculture and save water up to 70% [36].

6.3.3. Materials

Green Symphony farm enrolls in the "Civiltà Contadina", which is non-profit association that is fostering biodiversity

conservation by exchanging native seeds. Hence, it provides the first seeds that are restituted after one year, and then the remaining seeds are used for self-reproduction [37]. Materials used for renovations come from secondary raw materials; particularly, the columns of the aquaponics system and the irrigation system in the garden are built with recycled tubes. In the kitchen, no disposable tableware is used and food is stored into glass containers or jars. Wastes generated by the activities of the site are collected, carefully separated, and sent to the municipal waste treatment.

6.3.4. Emissions

The carbon footprint (CF) of the life cycle of materials used in the study project has been computed based on data from the ADEME database – a French Agency for Environment) since no equivalent were found for Italian figures and similarity [38]. Table 1 (Appendix – A) lists the results of the project when is already implemented. The total CF generated is -77 tCO₂/yr mainly due to the good yields of both permaculture and aquaponics without any pesticides or fertilizers industrially produced. The CF of energy consumption is estimated at a maximum 8 tCO₂/year. This is due to heating, kitchen activities and pumps functioning, thus, the overall farm CF is -69 tCO₂/yr. However, the renovation of the site has a CF estimated at 100 tCO₂ according to a computation suggested by the ADEME for housing renovation (2 tCO₂/yr). All in all, Green Symphony allows it to produce food and to enjoy recreational and didactical activities with a life cycle negative carbon footprint (-67 tCO₂/yr).

VII. URBAN FARM DESIGN

7.1 Surroundings and Indoor area

Green Symphony farm consists of a kitchen with an aquaponic farm on the rooftop, a workshop room, a synergic garden, a green wall and outdoor recreational spaces including a pond. The kitchen is situated in the main building offering cooking training using vegetables harvested from the farm and fish from aquaponics (refer to Table 2 in appendix A for the number of sessions per year). Different innovative systems for agriculture are applied in the project (Figure 11).

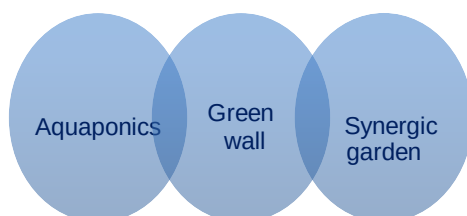


Fig. 11 Elements of the plan of the study project

7.2. The Aquaponic system

The aquaponic system is a new agricultural technique used to grow plants, and it combines the hydroponic system (soilless agriculture on columns) with the aquaculture (fish breeding). An aquaponic closed-cycle system, that starts from an external pool containing fish and nutrients, and arrives inside the rooftop greenhouse, where hydroponic columns are present with plants, is developed in this project. A vertical farm system that allows for good production in the project's space (about 65 m²) is created.

The pool

In order to guarantee a good amount of nutrients to vegetables production, a 50 m³ pool is required; thus, it was decided to breed carps with a density of around 15 kg/m³.

The fishes

The study highlights that *Cyprinus Carpio* (common carp) originally from East Europe, resists a high range of water temperatures between 4°C and 34°C. Together the common carp with mirror carp (same species) and the Amur carp (*Ctenopharyngodon idella*) are generated. All these fish are edible, and their breeding is widespread in aquaculture.

The columns and big pots

The vertical hydroponic columns are pipes filled with an inert substrate like expanded clay. The typical plants that can be cultivated are presented in Figure 12. Near the columns, some big pots are integrated and filled with the same inert substrate of the columns that are used to grow bigger vegetables like tomatoes or cucumbers. Humidity sensors are present in the greenhouse to regulate the water flow.

Estimated production

An aquaponic system guarantees a faster plant growing and longer fructification time, with a reduction of water wasting of 90%. Based on a study conducted by a leading Italian company, it was found that there are some estimates which calculated a production between 6 and 11 kg/years of vegetables every 453 kg of fishes [39]. The estimated production can be found in Figure 12. By considering the data and equally dividing the surface in 4 sections, it can obtain 16.25 m² for each type of vegetables. Table 2 lists the system's anticipated vegetables production around 5.3 tons/year.



Fig. 12 Types and Production of the Vegetables and Fruits used in the aquaponic system [39]

Table 2 Summary of the yield per year of the aquaponic system

Vegetables	Production Kg/m ² /year	Surface	Kg/year	Tons/year
Lettuce	95	16.25	1543.75	1,54375
Chard	75	16.25	1218.75	1,21875
Strawberries	58.80	16.25	955.50	0,9555
Basil	97.76	16.25	1588.60	1,5886



Fig. 13 Types of vegetables, herbs and fruits cultivated in the Green Wall system [40-49].

7.3 Green Wall

At the city scale, green walls contribute to the recovery of degraded areas without occupying extra space. Thus, a green wall is developed in the project, not only for beauty, but also as an urban gardening, which increases yield of food production.

Green wall system

The green wall will be fixed to the front side of the main building. The wall consists of 64 modular trays; pots will be placed on each modular tray in this system and secured by bars. In this case, an automatic irrigation system ensures good plant growth.

Green wall plants

Vegetable seeds and stems grow in a green wall making use of sterile potting mix. Most plants will be harvested continuously. The plants include 22 types (Figure 13).

Pests and Pathogens

The biological control and mechanical removal of pests, e.g., destroying cabbage moth eggs and larvae and leaf miners by hand, yet will control pests and pathogens.

Irrigation

Water is transported to the plants by small pipes made of second-hand plastics. Every tier of planter receives irrigation from four drip emitters (2/ cell). A gutter system runs along each tier of planter, collecting excess water and draining it to the fish pond.

7.4. Synergic Garden

Synergic gardening is the Mediterranean climate version of natural farming and it is the application of permaculture philosophy. Vegetables will be associated with each other and with aromatic herbs in order to enable exchange of nutrients.

Garden structure

The surface dedicated to synergic agriculture (745m²) will be splitted in two parts: one composed of 12 raised circular shrubberies with aromatic herbs combined with vegetables and one with 24 mounds of soil where crop rotation of vegetables is applied. The shrubberies will be 1 m high and 4 m diameter. Mounds will be 0.7 m high, 2 meters wide and 8 meters long. The total cultivated area will be 540 m², hence 205 m² are left for paths (large enough to host scholar groups).

Crops combinations

Regarding the aromatic herbs combined with vegetable shrubberies, the combinations are listed below and Table 3, in the Appendix A, shows the benefits from those aromatic plants.

- Rosemary with carrots, salvia and beans;
- Salvia with carrots, beans, rosemary, fennel;
- Mint with tomato, broccoli, lettuce, carrots, and potatoes;
- Basil with fennel, lettuce, cucumber, tomatoes;
- Chamomile with onion; and
- Thyme with spinach and pumpkins.

Estimated production



The cultivated area (540 m²) is divided in 13 parts to grow different vegetables with an area of 41.54 m² for each species. Table 3 shows the calculations of the expected yield per year and results show that 1.7 tons per year could be produced from this area.

Table 3 Summary of the yield per year

Vegetables	Yield (q/Ha)	Area cultivated (m ²)	q per 41.54 m ²
Carrots	400	41.54	1.7
Beans	40	41.54	0.2
Fennel	400	41.54	1.7
Tomato	800	41.54	3.3
Broccoli	200	41.54	0.8
Lettuce	300	41.54	1.2
Potatoes	250	41.54	1
Cucumber	250	41.54	1
Onion	300	41.54	1.2
Spinach	200	41.54	0.8
Pumpkin	500	41.54	2.1
Parsley	300	41.54	1.2
Chamomile	165	41.54	0.69

Source: Authors

Irrigation system

The irrigation system used would drip irrigation linked with sensors for the humidity of the soil. A higher control of water waste is possible with this technological system:

- By raising shrubberies, it can take advantage of water drainage to irrigate plants;
- Part of water used for irrigation comes from rain collected in an underground water-tank with 5,000 L capacity (SIR5075 model, from ROTOTEC®). The choice of this capacity derives from the annual amount of rain and the estimated water needs for the garden that is 6.5 m³ for 540 m².

Composting

The area will be provided with compost bins, with a comprehensive capacity of 3000 Litres. The structure will be handmade using pallets, while initial bacteria and microorganisms will be inoculated to make the composting process faster. An opening at the bottom of the bin will be necessary to harvest the mature compost, produced after 9-12 months, to fertilize the fields. The compost bin will be filled up with vegetable waste from the synergic garden, aquaponic

and the kitchen. To cover the initial nutrient needs of plants, high quality compost from local farmers is used.

VIII. BUSINESS MODEL

One of the project's goals is to be socially, environmentally and economically sustainable. Through the business model, it is possible to set the structure of the project when in operation and to calculate the costs and revenues. The project is summarized in a lean canvas as shown in Table 4.

8.1. Products and services provided

Our project operates on a multifunctional basis that provides the community with different services. Those services could be summarized as follows:

- a. Organic Food Sales. The farm sells organic food at the same time in the premises, at Lanuvio's market and through a "mobile market" on bicycles.
- b. Rental of farming facilities. The locals can rent part of the farm's facilities annually where they can plant and harvest their own produce. While doing so, they are also revealed to farming techniques.
- c. Events and socializing area. Through the recreational and social events area, the locals can interact with each other and with the tourists.
- d. Workshops – the workshop room is where different classes and seminars are given to raise awareness about organic food planting, innovative farming techniques and permaculture, yet the kitchen gives lessons in basics of cooking.
- e. Yoga Classes. Weekly courses hosted in our facilities, thanks to a specialized teacher, opened to anyone, subject to the purchase of a ticket.

8.2. Targeted Customers

Our farm targets a wide spectrum of users who interact together and exchange ideas. Different groups could be identified as:



Table 4 Lean canvas model of the project

Lean Canvas Model				
PROBLEM 1. Basic need of fresh healthy products 2. space and technology for small innovative production 3. Lack of popularity EXISTING ALTERNATIVES At a local level: 1. Cooperatives selling and transforming products 2. Didactic farms 3. Socials	SOLUTION 1. Product Selling 2. Rent of farming facilities 3. Events 4. Workshops and kitchen lessons 5. Advertisement on the app KEY METRICS The focus is on: - Events: at least 2 - Rent facilities: 16 columns and 18 trays	UNIQUE VALUE PROPOSITION innovative way to produce or to approach environmental sustainability, thanks to: -Vanguard techniques -Sustainable environment HIGH-LEVEL CONCEPT	UNFAIR ADVANTAGE site of Lanuvio: naturalistic values to promote, closeness to villa Sforza CHANNELS - Agricultural workers associations - Social media and events	CUSTOMER SEGMENTS 1. Consumers of local markets, typically families, elders 2. Local farmers, the younger ones from 35 to 50 years old 3. Young families with children 4. Groups: students from 6 to 13 years old with teachers 5. Other social sustainable producers
COST STRUCTURE Establishment costs for technologies Labor - voluntaries (0€)		REVENUE STREAMS 1. Weekly sales, based on seasons 2. Rent 3. Tickets 4. Fee on sales		

Source: Authors

- Local Community: This is anyone who is living in Lanuvio and is looking out for consuming organic food or to learn about agriculture technologies to apply them in their backyard farms.
- Tourists: as the area is naturally full of historic sites, many tourists are visiting it.
- Volunteers: The farm welcomes all volunteers that could love new innovative experiences of work, whether they are from the direct community or international volunteers.
- School Students: Since the farm spreads awareness and learning, students are especially targeted through periodic workshops and events, in which local schools may be directly involved.

8.3. Organisational Structure

The structure that best suits the mission of our project is the so called "social cooperative", which, from the regional law, "is the one that promotes, supports and sustains human development and social integration with particular regarding of disadvantaged people", in particular the one related to the agricultural field (type B). As allowed by the law, our team

will be made of volunteers (up to a maximum of half of the entire team) and specialized workers to handle the maintenance of the plantations.

8.4. Fundings

Starting from the Region, already from last year some announcements were published offering subsidies for "social cooperative of type B" as we are, with the aim of "sustaining the social and working integration of disadvantaged people. A fund comes from the MISE (Ministry of Economic Development) that offers specific public funding's in favour of the birth of small cooperatives, with an allocated amount of 223 million €, which provide a feasible way to subscribe to the initial investment required. The Italian government also offers both non-repayable subsidies and easy credit terms loans for the initial investment. The law provides up to a maximum of 40% of the expenses for "market analysis, land, buildings, machineries and any other goods required for the production" as listed in details in Table 4 – Appendix A.

8.5. Cost Analysis

This analysis has to follow the natural path of the project itself. Initially, a critical investment would be required to cover the renovation of the buildings, the technologies, and so on, as shown in Table 5 (Appendix A). An initial investment of 380,000 € is expected, of which some expenses



would be covered by the previously explained funding's, and leave for an actually required initial investment of 250,000 € (refer to the operating margin below). Of course, every operating year, some expenses will be required for the maintenance and the activities pursued within the farm, as shown in Table 6 (Appendix A), for which we expect about 28,000 € of costs per year.

8.6. Revenue Stream Analysis

The biggest percentage of revenue is provided by the kitchen classes (74%) followed by the rent of the hydroponic columns (19%). The amount considered is the value of the yearly production from all the columns that can be guaranteed to those renting them. Details of this calculation are shown in Table 7 (Appendix A). For yoga classes, the revenue is fixed as 15% on the hypothetical fee requested by the teacher to its clients. An average yoga course could cost €60/month for 2 lessons per week, considering 20 clients per lesson. For details, refer to Table 8 (Appendix A). Moreover, tickets vary for the type of lessons proposed in the kitchen, as shown in Table 9 (Appendix A). All the different sources of revenue are shown in Table 5.

Table 5 Sources of revenue with percentage

Item	Yearly Revenues in Euro	% of Total Revenues
Rent of the hydroponic columns	19,588 €	19,4%
Sales of products from permaculture	2,269 €	2,2%
Yoga classes	2,160 €	2,1%
Kitchen classes	74,850 €	74,1%
Sales of fishes	2,100 €	2,1%
Total	100,967€	100,0%

8.7. Operation Margin and ROI

The initial investment, funding's, operating costs and revenues, were summarized previously to calculate the operating margin and return on investments (ROI). The data produced refers to a fully operating year. A positive operating margin of about €73,000 is expected, that is particularly favorable. In addition, the ROI is also in an optimum position (19%), due to the funding's that allow us to reduce the "weight" of the initial investments. Table 6 summarizes the calculation of the operating margin and ROI. Noteworthy is

that even with the first years being less benefiting, the investments are paid off after a maximum of five years.

Table 6 Operating Margin and ROI calculations

Feasibility calculation	
Initial investment - total	383,766 €
Granted initial funds	137,051 €
Costs uncovered by funds	246,714 €
Required initial investment (approximation)	250,000 €
Operation	
Operating revenues (per year)	100,967 €
Operating costs (per year)	27,954 €
Operating margin (per year)	73,013 €
ROI calculation	
Investment costs (funds included)	383,766 €
Profit of the year	73,013 €
ROI	19%

IX. RESULTS AND DISCUSSION

The results are analyzed by stating the features and the technologies implemented in the project and its impact on the economic, social and environmental sustainability. Table 7 shows a summary for all the interventions done in the project to analyze how sustainable the project is through extracting some percentages regarding the three pillars of sustainability. Also, the final results 3D visualizations are shown in Figure 14 to 19. Figure 14 illustrates the whole site being developed as a bird's eye view. Figure 15 shows the view from the main entrance. In Figure 16, the integration of greens in the project is shown where the main elevation includes green walls. Moreover, Figure 17 shows the kitchen where people can learn cooking. Figure 18 presents the main section through the main building integrating different technologies in the indoors as the one space luminous, the aquaponic and the rain water harvesting systems. Figure 19 shows the main elevation of the main building where different technologies are found as the information technology system, the green walls and the solar panels for saving energy.



Fig. 14 Developed site after incorporating all urban farming technologies



Fig. 15 Site entrance with various features

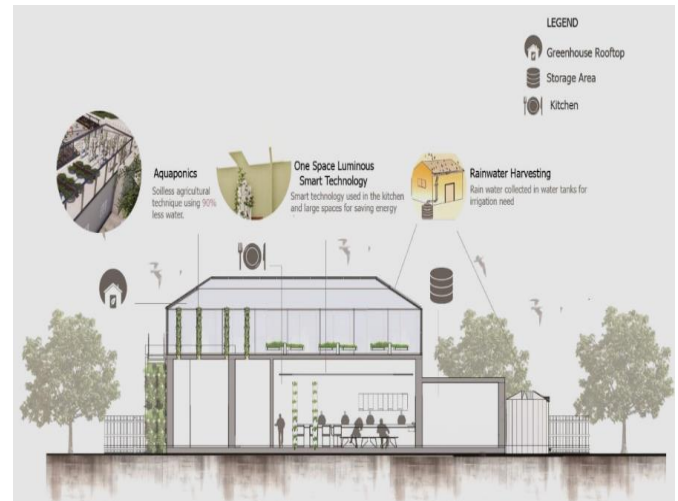


Fig. 18 Section through the main building

Image credit: Authors



Fig. 16 Shed and green wall in the restaurant

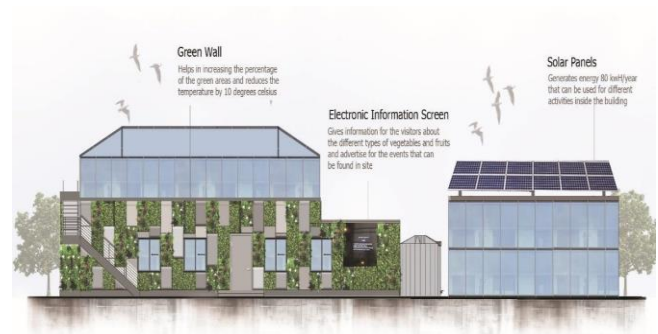


Fig. 19 The main elevation of the green walls, information boards and solar panels

Image credit: Authors

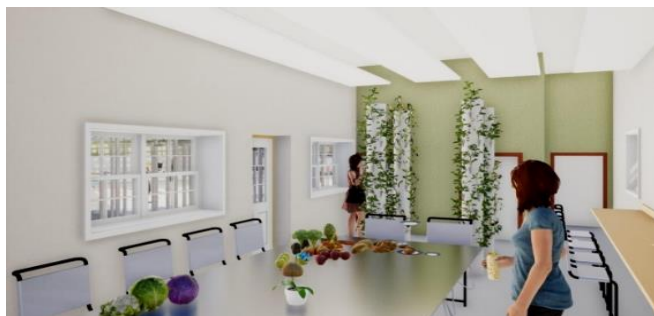


Fig. 17 Interior of the kitchen in the building
Image credit: Authors, 2020



Table 7 Sustainable development pillars assessment of the project

No.	Mission	Economic Sustainability	Social Sustainability	Environmental Sustainability
1	Presence of various functions indoors and outdoors	✓	✓	NA
2	keeping the old building structure	✓	NA	✓
3	Host music festivals	✓	✓	NA
4	Blend Music and Agriculture in one space	NA	✓	NA
5	Create workshop for raising awareness	✓	✓	NA
6	Create a space for restaurant & organic food market	✓	NA	NA
7	Integrate the production area with the selling, tasting and crafts area	✓	NA	NA
8	Create one universal space shared by all types of users	NA	✓	NA
9	Rental of farming facilities	✓	✓	✓
10	Architectural sustainable technologies	✓	NA	✓
11	Synergic garden (with permaculture technique)	✓	✓	✓
12	Green Walls	NA	NA	
13	Aquaponic system	✓	NA	✓
14	Greenhouse with hydroponic columns	✓	NA	✓
15	Redevelopment of the building	✓	✓	✓
16	Providing education for plant production, cooking & managerial skills	✓	✓	✓

Total achieved

13 /16

9/16

9/16

81%

56%

56%

X. CONCLUSIONS

Green Symphony project achieved its set of objectives by integrating the urban farm with its surrounding urban context. Also, this project covers all three pillars of sustainability; environmental, social and economic aspects to achieve a self-sustained site creating new jobs. In addition, it provides clean and safe vegetables and a productive hub for the city. Blending music, architecture and agriculture creates connectivity and social innovation through the variety of social spaces. Moreover, the project helps in creating livable, healthy and sustainable urban environments in the commune of Lanuvio, in the metropolitan city of Rome, Italy.

The project re-development contributes to attaining SDGs, particularly SDG 3, 7, 9, 11, 12, 13, and 15.

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