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Sustainable refurbishment of abandoned urban areas: the case study of former SIAPA area, Galliera – Bologna, Italy

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Abstract. This study presents a conceptual vision of an innovative approach to refurbishing the vacant urban spaces and abandoned buildings of the former SIAPA area in Galliera – Bologna, Italy, transforming it into a liveable, productive, and sustainable park through applying the recent technologies in urban farming. The methodology depends on two approaches: an assessment of the current site and an applied study incorporating technologies that are based on soilless solutions to reduce the consumption of irrigation water, wastes, and increase production. The upgraded park named ‘‘Galliera Kitchen Park’’ (GKP) integrates urban farming technologies for the outdoor farms, whereas, the vertical zip-grow technologies are exploited in indoor farms, generating fresh kitchen crops. GKP works on linking the industrial area with the residential area as well as connecting citizens to vibrant places where food and memories are derived from. A business plan includes marketing strategy, operation management, SWOT, financial analysis, and a business model study to predict the worst-case and best-case scenarios for the project running. Finally, requalifying the area would benefit back the entire town; it could be once again an economic centre for Galliera. The results highlight the potential of the proposed intervention to attain SDG 4, 7, 8, 11, 12, 13 and 17.

Keywords – Sustainability; innovation; urban refurbishment; food production; low-carbon city.

Acronyms

GDP	Gross domestic product	DDT	Dichloro Diphenyl Trichloroethane
UF	Urban farming	GKP	Galliera Kitchen Park
UA	Urban agriculture	ZGTs	zip grow towers
CR	Climate resilience	NFT	Nutrient film technique
SIAPA	Società Italo Americana Prodotti Antiparassitari	ROI	Return on Investment
SDGs	Sustainable development goals	SD	Sustainable development

1. Introduction

Cities play a major role in nations’ gross domestic product (GDP) [1]. Wastelands, gaps between buildings, and unused constructions are great opportunities to be integrated with the city's fabric to create new functions that confront today’s global challenges. Deserted urban spaces are usually a result of a decline of a specific activity or industry used to occupy such spaces in the past. According

to the former function of these buildings and areas, it could be located at the heart of cities, next to river or lake, occupy an attractive spot with good accessibility for the citizens of the city, where most the industrial factories used to be located [2][3].

Abandoned buildings and vacant urban spaces can be refurbished in different ways depending on the cities' needs, such as community gardens, culture centres, markets, and recreational spaces. Such refurbishment can contribute to enhancing the social and cultural activities as well as boosting cities economy through creating new jobs' opportunities, yet improving the city's liveability and viability. According to the United Nations Food and Agriculture Organization, the agricultural land use per person is considerably declining [4].

The rapid increase in population also requires the provision of additional houses infrastructure and services. Hence, cities are expanding to accommodate more population than rural areas, converting more the 1000 km^2 of land, every year, to residential, industrial, and recreational uses [5]. Such a population increase equates to high food demand. Thus, abandoned buildings and vacant urban spaces become a distinctive opportunity to bring back urban agriculture to cities through Urban Farming (UF) projects [6].

Urban Agriculture (UA) and UF have become a prime interest for policymakers and planners in many cities due to climate resilience (CR), food production, business interventions, and community development [7]. UF provides fresh vegetables and fruits to cities' citizens with low-carbon emissions resulting from almost zero energy use in transporting and packing such crops [8].

By considering the advantage of both non-constructed areas, e.g., vacant urban spaces, green areas, and interstitial spaces, and the abandoned construction through transforming the concrete into urban green infrastructure, i.e., indoor vertical farms and rooftop gardens, would be an excellent solution [9]. These strategies were successfully implemented in various cities across the world, e.g., River park outdoor urban Farm in Manhattan, Brooklyn grange, Sky vegetables in New York City, and Plant Chicago [10]. Thus, this study focuses on examining the former SIAPA (Società Italo Americana Prodotti Antiparassitari) area to convert the site and its abandoned buildings into a sustainable and liveable productive park by applying innovative technologies in UF and sustainability aspects [11].

2. Objectives and scope of work

The innovative approach adopted in developing the former SIAPA site – Galliera is part of the UrbanFarm 2020 Challenge, organized by Alma Mater Studiorum University of Bologna, Italy. The research work focuses on the refurbishment of a deserted urban site to be a sustainable and cultural hub that provides indoor and outdoor food production systems – fresh kitchen crops for citizens, creates job opportunities, and establishes a sustainable eco-system for researchers, yet brings the buildings and the site at a low-carbon footprint and climate resilience as well. This work intends to address how restoring deserted buildings and the former urban site can be socially viable as well as creating architecture and urban development to reach the best outcomes of the site, yet transforming the landscape use, maintaining the district's role in attaining sustainable development goals (SDGs), and addressing the socio-economic aspect by generating new employment for the city's citizens.

3. Methodology

The methodology depends on two approaches: the first is an assessment study of the site and city needs; and the second approach is an applied study on the transformation of the vacant site and existing buildings utilizing smart and green technologies, including urban farming (UF) that incorporate soilless solutions to reduce the consumption of irrigation water, wastes, and increase production. The methodology includes a) Inductive – a theoretical approach that includes a literature review and highlighting the case study before upgrading its impacts on the city's liveability; and b) The applied study is based on-site visits to collect data in terms of the sustainability dimensions, including environmental, economic, social, and cultural sustainability.

Although the work does not directly concern historical buildings as such, it relevantly contributes to the methodology to choose future uses and sustainable refurbishment of wide urban areas. Also, the project is in the planning and development phase, but data were gathered from the several site visits conducted between October and November 2019 to inform the research work.

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4. The case study

The former SIAPA site extends about 194,000 m^2 as shown in figure 1; and it is located in the metropolitan city of Bologna, in the municipality of Galliera, north Italy. In the late 1940s, the site was a company for producing DDT, a plants' protection product, then the area was taken by the chemical industry Caffaro till 1999 [11].

During the site visits, many interviews (10 in nos.), with the residents around the site, were conducted to understand their view, vision and suggestion to refurbish the case study area, in turn, will accordingly develop the entire city. The existing buildings' photos, some measurements and data gathered as well as mapping of the site were carried out during these visits.

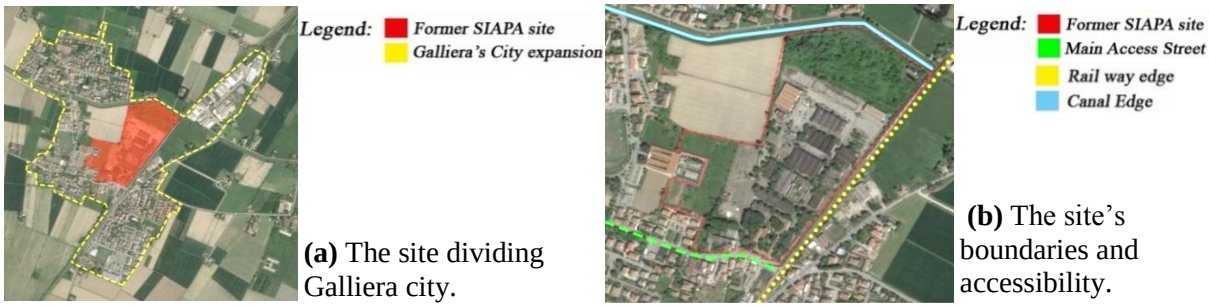
5. Project refurbishment's vision and design concept

Various typologies can be integrated in the site. These complex typologies (figure 2) are all developed for the proposed project, which is "Galliera Kitchen Park". It is a prototype for an innovative UF park, where visitors can cultivate, sell, cook, and eat organic crops through social activities, and connecting the city's residents in one place that was once the centre of Bologna.

5.1. Unused Urban spaces

It was imperative to assess the unused site spaces in terms of viability and function, the site is converted into a UF productive area. Main spaces were developed with innovative solutions: Environmental Street, Community Garden, Floating garden, and the market street (figure 2):

a) Environmental Street: The main spine of the site, which links the two sides of the city, is redesigned to allow social interaction through the urban nodes and seats. Visitors can also cycle on the spine's bike lanes, running and enjoying the open spaces and urban farms.
b) Community Garden: A deserted landscape area is converted to a green hydroponics area, a smart technological UF method to grow soilless plants [12]. This sustainable solution transformed the deserted area into a liveable productive area; visitors rent hydroponics units and benefit from their crops. In this neighbourhood garden; residents work together and know their neighbours more.
c) Floating Garden: A green area, on the canal side, is converted to be public, entertainment, and fruitful space with several ponds for fish, ducks, and growing plants. The finishing materials of paths and ponds are made of recycled concrete of demolished buildings. The plants are grown by the UF technology, "Aquaponics" (figure A1 in Appendix A). It is a combination of aquaculture, growing aquatic animals, and hydroponic. In this process, the plants are fed by the fish waste; thus, the soil of plants cleans the water for the aquatic animals [13]. A greywater treatment system is utilised to collect used water from the buildings and mix it with fresh water in the garden ponds.
d) Market Street: Small warehouses, which were in poor condition, are demolished and replaced with a grocery market, in which the UF crops are grown inside the park, are sold to local citizens. Such a market street connects the park with the external community since it serves all the city residents.



(a) The site dividing Galliera city.

(b) The site's boundaries and accessibility.

Figure 1. The site of former SIAPA in Galliera near Bologna, Italy.

5.2. Refurbishment of abandoned buildings

The former SIAPA site has about 10 deserted buildings and small warehouses, which were conserved, developed and reused by using smart innovations. The new functions are created to serve the refurbishment's vision as illustrated in figure 2 and table 1.

Figure 2. The refurbishment zoning and innovative layout (Image source: Developed by authors).

5.3. New Added Buildings

The newly introduced functions need new buildings to be added, these functions are working as an economic foundation for the park. Most of these buildings were built by using recycled concrete from the demolished unused buildings on the site. The buildings, shown in figure 2, are as follows:

a) Innovation studios: Rented studio units are provided by the park for local companies and start-ups. These units, built with reused shipping containers, are in form of two overlapping shifting floors to illuminate the ground floor with natural light via skylights to reduce energy use.
b) Market units: the units' roofs are inclined to have maximum sun exposure. Cross ventilation is provided via upper back windows, to make a good airflow and refreshment during the crowd of the market in the time of COVID-19. Solar shades with galvanized glass, various finishing colours, are used to reduce glare and to enhance the visitors' experience and spaces' liveability.
c) Restaurants: In the floating garden these serve fresh food, using the kitchen crops that grow inside the GKP's farms. The roofs have projected shades to maximize the area of UF.

Table 1. Innovative reuse: abandoned buildings' refurbishments.

a) Water tank	(b) Community centre	b) Research centre	c) Indoor farms	d) Cooking media studios	e) Hall of narrations
The site and buildings before refurbishments [a]					
The historical water tank is preserved, as a landmark for the park, with a surrounded node for social interactions.	The administration building of the ex-plant and its façade is kept as an element for the territory; the inner spaces need to be redesigned for hosting workshops and classes.	The administration building of the ex-plant and its façade is kept as an element for the territory; the inner spaces need to be redesigned for hosting workshops and classes.	It is a 4-building cluster in moderate condition, warehouses with a huge height, large area, and light wells for daylighting, for vertical UF.	A warehouse, with a wide-span structure and a double-height, is an opportunity to be renovated as media studios for cooking, using GKP crops.	Large areas with a wide-span structure and suitable height are used as a hall for visitors to trace the city's historical background.
					
The site and buildings after refurbishments [b]					
					

[a] Images' source: https://site.unibo.it/urban-farm/en/cities-and-locations-2020/galliera-former-siapa-area
[b] Images' source: Developed by authors.

6. Assessment of sustainability and results

Achieving sustainability is one of the main aspects that need to be accomplished in refurbishment projects, therefore, the GKP's main goal is linking its interventions with SDGs and achieving them through the project's strategy that included the environmental, social, economic, and cultural aspects.

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6.1. Environmental sustainability

The GKP is designed to be smart, sustainable, while the environmental sustainability approach is attained by using UF technologies. The GKP also achieved those environmental sustainability goals through the following solutions.

6.1.1. Consuming less water using urban farming. This was through s the following main points:

- Aquaponic integrated greywater treatment system: This is a highly sustainable method of Agriculture. It has been decided that Aquaponics is the perfect choice for the site since the system is environmentally viable with low water and power usages. Aquaponics could also be used to grow multiple crops and fish in the same system, utilizing non-harmful chemicals, no synthetic fertilizers, and few pesticides [13]. In the GKP floating garden ponds, a greywater system is used to reduce the need for fresh water in the aquaponic system. Recycled greywater incorporates supplements that are supposed to be good for the growth of the plants [14]. Both fish like tilapia, bass, salmon, etc., and kitchen crops, are harvested to be utilized in the GKP restaurants or sold in the market. By applying this system, about 30,000 liters of greywater are recycled from the water use of 1000 visitors daily.
- Hydroponic UF systems: The hydroponic system is a type of hydro-culture gardening technology, and it is the method of cultivating soilless plants. Instead, nutrients to the water are added and used a soilless medium. This closed-loop system uses up to 97% less water than a traditional garden because it is continuously recycled [12]. For the plant analysis, the GKP plans to get back to daily Italy kitchen crops through the park. The parks' production will be used in researches, restaurants, and markets inside and outside the park. Most of the crops cultivated in the GKP can grow all year, such as lettuce, tomatoes, spinach, cucumbers, and pepper, which take the range of 50-90 days to maturation. Some Italian herbs, like mint, rosemary, parsley, and oregano, take the range of 20-70 days to maturation.

6.1.2. Using less energy. The total electrical energy demand of the project is estimated 102,038 kWh/ month. The solar PV panels – a total of 1600 solar panels on an area of 4000m^2 to be installed on 2.1% of the site areas (each PV panel generates 0.35 kWp) – are proposed for installation on the innovation studios and the other buildings' roofs to generate power, hence, reduce the use of electricity. The solar PV system can be tied to the city electric grid to produce energy while "Urban Batteries" zinc-air batteries are utilized to store energy. Due to low installation cost and long life cycle, the batteries were used [15]. This leads to a saving of 65.9% (67200 kWh/ month) from the total electrical energy demands.

6.1.3. Materials. The GKP's newly added buildings are developed by integrating recycled materials such as shipping containers and recycled concrete from demolished buildings, while on-site broken trees are used in hardscape furniture, to reduce the waste and construction waste.

6.1.4. Efficient use of land. The indoor farming system uses zip-grow towers (ZGTs) and vertical farms (VFs) technologies to produce more crops using less land. The mobile ZGT-carrying Zip Racks save time and labour, using high-efficiency LED lights to maximize crop production. Water recirculation design saves 90% of water more than other normal farming systems. Tailored plumbing kits with automated water management systems take the stress out and ensuring that plants are healthy – even if there is no one in the farm. The ZGT is similar to NFT hydroponic farm, but it is flipped 90° to multiply the amount that can grow in a given space. The ZGTs are 2-3 times more productive per square foot compared to traditional horizontal production methods, without increasing production costs [16].

6.2. Social sustainability

Sustainable communities meet the diversity of residents, provide safety, equality of opportunity, and good service for all [17]. This definition shows the role of the social aspect in the communities' SD; hence, the project is driving several social values related to loyalty, liveability, safety, and equality of opportunity. The main social values, which are depicted in the park's spaces and activities, these are:

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- Building Loyal Community: Raising the inhabitants' loyalty and sense of belonging towards their environment and community through encouraging them to buy local and organic products from the project market, growing the plants by themselves, as in a community garden. Subsequently, this sense of belonging increases their participation and involvement in the GKP;
- Raising awareness: Increasing the awareness of social responsibility towards the environment, how to manage environmental urban resources such as water, energy, etc. This awareness will be enriched by the GKP tours, the community centre, research centre, and conferences;
- Enhancing physical and mental health: Eating fresh food and practicing sports through the GKP public spaces. This exposure which is provided to plants and nature has a positive effect on mental health, attitude, and behavior; and
- Children's involvement: The simplest meaning of sustainability is working on developing the future. Therefore, the park is working on children inside the community centre by sessions, camps, etc. This value drives the equality of opportunities and providing services for all ages.

6.3. Economic sustainability

GKP is a social enterprise that aims to "Connecting a local community of Bologna's inhabitants using shared urban farms". Such development restores the economic base of the city by creating a local productive community with a great sense of belonging to its city and environment.

6.3.1 SWOT analysis: It is imperative to conduct a SWOT analysis of the project. Figure 3 exhibits an analysis of the uniqueness of the GKP idea by integrating UF technologies and innovative solutions.

6.3.2. Costs and Revenues: The project is planned to be finished in 3 consecutive phases, and each will take around 12-16 months, to be fully opened in 4 years. European funds can reach around 50% of the initial costs due to following the sustainable procedures of the revitalization of the site; waste and water management, materials recycling, social inclusion, research, and education programs, (Leonardo da Vinci funds, FEASR funds, The World Bank green bond, Green Climate Fund, and LIFE projects). Nevertheless, the production activities and services have an ROI between 25% and 35% (table 2).

Strengths	**Weakness**	**Opportunities**	**Threats**
The efficiency in terms of water use and plant growing time is minimized.	Product in the VFs is narrow, and the selling price is high. High initial investment cost would make profitability challenging.	Increase awareness of Galliera citizens by producing and selling locally. The GKP supports city's economic growth.	Fresh foods are always sold and served inside.

Figure 3. SWOT analysis of the project in Galliera near Bologna, Italy.

6.3.3 Operation management. According to the three phases of execution and the operation, about 180 jobs are generated in the first phase and another 180 in the second one, and around 200 workers are needed in the last phase. This shows how the project is economically viable and achieves social aspects in SD and SDGs.

6.3.4 Marketing strategy. For such complex, different activities targeting diverse users utilize various approaches, including; social media platforms, universities' partnerships, and joining mega-events that are related to UF.

6.3.5 Circular economy. The GKP applies an alternative method of moderating the economic process in which maintaining the resources as much as possible in a circular loop, by extracting the maximum benefit out of each resource like water, wastes, and materials, by reusing, recycling, reducing, and repairing. This system helps to design a liveable, resilient, and sustainable site [18]. As an example of this moderation, 40% of the used water in the aquaponics bonds is treated greywater from the GKP water daily consumption, also 60% of the newly added buildings are built from recycled concrete of the demolished buildings.

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6.4. Cultural sustainability

The GKP cultural sustainability aspect revives the node of Galleria using heritage as a cultural artefacts in city development. It creates a prototype of small-scale urban farming projects to be spread all over the city, with the aim to present the imaginative and the generative utilize of urban heritage, for the expansion of cultural and traveller offer of the city liveability in physical, social, and financial terms for the community. The GKP will be an excellent example of the adaptive refurbishment.

Table 2. Cost, revenue analysis and project phases (Source: Developed by authors).

Criterion	No.	Project	Project Details	Initial Cost (€)	Revenue Stream	Revenue Avg./yr €	[c]
Site Preparation	1	--	Buildings Removal (7 in nos.)	350,000	--	--	
	2	--	Site infrastructure (electrical water)	300,000	--	--	
Building Refurbishment	3	Water Tank (GKP Landmark)	Building maintenance raising efficiency & refurbishing (5 in nos.)	50,000	--	--	
	4	Community Centre		150,00	Subscription fees	100,000	
	5	Research Centre		150,00	--	--	
	6	Hall of Narrations		50,000	Ticket/ visit	100,000	
	7	Media Studios		100,00	Renting contract	800,000	
	8	Indoor VF	Building Restoration (4 in nos.)	200,000	Crop Selling	250,000	
			Indoor Zip grow structure include LED light, plumbing for 4 buildings [16]	200,000			
	9	Outdoor VF	Outdoor Zip grow structure	150,000	Crop Selling	200,000	
Newly added buildings and activities	10	Floating Garden	Ponds dwelling	200,000	Crop Selling	100,000	
			Water pumping	60,000			
			Finishing and furnishing	40,000			
	11	Community Garden	Hydroponic (400 Unit)	200,000	Renting by Community	100,000	
	12	Restaurants	Building works using recycled concrete (4 Restaurants)	80,000	Renting Contract	2,000,000	
			Finishing Materials	20,000			
	13	Innovation Studios	Building works using recycled shipping containers (2 containers multiply by 2 studios)	60,000	Renting Contract	1,600,000	
			PV Cells	30,000			
	14	Market Units	Building works using recycled concrete (34 Kiosk)	136,000	Renting Contract	half are rented: 384,000	
			Finishing Materials	68,000			
			PV Cells	140,000			
Other	15	Website, and Mobile Apps	--	10,000	--	--	
Total				**2,735,000**	--	--	
				Fixed Cost Avg./yr (€)			
	16	Water use	By the end of Phase 3	35,000	--	--	
	17	Energy use (0.184Euro/kWh)	By the end of Phase 3	76,922			
	18	Workers	By the end of Phase 3	500,000			
	19	Amortization	--	40,000			
	20	Seeds		20,000			
Total				**672,000**		**5,634,000**	

[c] Colour code (Phase priority) Phase one | Phase two | Phase three

6.5. Mapping the project with SDGs

To assess how the project's conversion key aspects in integrating UF strategies and sustainable innovative solutions will be successful in attaining the SDGs, it is important to map the projects' elements against the contribution to SDGs, mainly goal 4, 7, 8, 11, 12, 13, and 17 as listed in table 3.

It is clear from the aforementioned sections that the development of the former SIAPA area will transform the site to be an economically vibrant and social hub that offers job opportunities for Galliera residents as well as providing education and experiences. This study also indicates that the refurbishment of the deserted urban spaces and buildings will convert the site to be a liveable and productive park by applying the recent technologies in UF, putting sustainability aspects into action as illustrated in table 3, while the GKP succeeded in many points as depicted in figure 4.

Table 3. Mapping the project's components to SDGs. (Source: Developed by authors).

	No.	Project Components	SDG 7: Affordable & Clean Energy	SDG 8: Decent Work & Economic Growth	SDG 11: Sustainable Cities & Communities	SDG 12: Responsible Consumption & Production	SDG 13: Climate Action	Number of SDGs achieved by each project component
Unused Urban Spaces	1	Environmental Street	√[d]	-	√	√	√	4
	2	Community Garden	-[e]	√	√	√	√	4
	3	Floating Garden	-	√	√	√	√	4
	4	Market Streets	√	√	√	√	-	4
Refurbishment (abandoned Buildings)	5	Water Tank	-	-	√	-	-	1
	6	Community Centre	-	-	√	√	√	3
	7	Research Centre	√	-	√	√	√	4
	8	Indoor Farms	-	√	√	√	-	3
	9	Cooking Media Studios	-	√	√	-	-	2
	10	Hall of Narrations	-	√	√	-	-	2
Newly added Buildings	11	Innovation Studios	√	√	√	√	√	5
	12	Market Units	√	√	√	√	-	4
	13	Restaurant Units	√	√	√	√	-	4
		Percentage (%)	**46.15**	**69.23**	**100**	**76.92**	**46.15**	

[d]√ **indicates** that the project component achieved this SDG [e]- indicates that the project component doesn't achieve this SDG

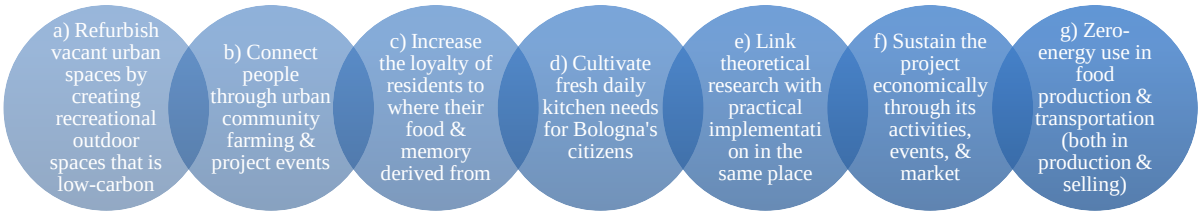
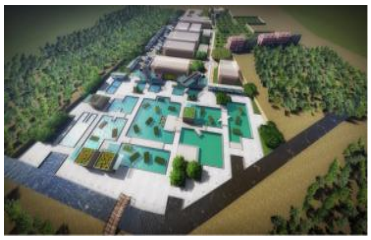
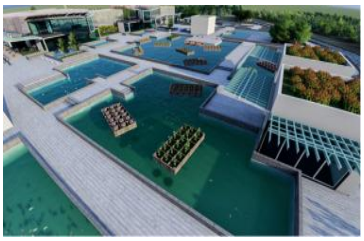


Figure 4. GKP's main results (Source: Developed by authors).

(a)   **(b)**

(a) 3-D general view of the site after refurbishments **(b)** Floating Garden

Figure 5. Former SIAPA site – Galliera after retrofitting (Images' Source: Developed by authors).

7. Conclusions

The former deserted urban site has been retrofitted as shown in figure 5. Cities are struggling from the declining of open green spaces, yet a large amount of energy is consumed to transfer food from rural areas to the city. Unused urban spaces are considered an excellent opportunity for the city's dwellers to overcome these issues. Urban farming makes people, not only, obtaining clean, safe and fresh food daily, but also mitigating CO2 emissions by decreasing the energy used in transportation and packing.

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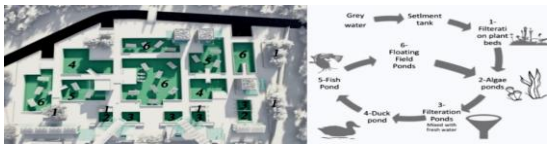
Appendix A. Figure A1. ‘Aquaponics’ UF technology integrated with greywater treatment system (Image source: Developed by authors).



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