GREEN DEAL

Greenhouse devices in the urban voids of historical fabrics

The case of Cuenca-Ecuador

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ABSTRACT

The Latin American cities, generally with significant budgetary restrictions, have faced an accelerated growth during the last years. The current interventions aim to solve problems of climate change, pollution, unemployment, gentrification, overcrowding, hunger, among others. Unfortunately, the global crisis due to the COVID-19 pandemic and its subsequent crisis, has alarmingly worsen the percentages related to unemployment, poverty and hunger. The emergency has proven the urgent need to develop public policies to foster resilience and ensure food sovereignty and the necessity to encourage the design of livable public spaces with social and environmental responsibility.

The current challenge of governments is to transform the contemporary cities within a comprehensive and sustainable scope. The introduction of urban agriculture in locations strategically selected has the potential to tackle many of the current needs of the cities and its citizens. The urban agriculture approach through urban acupuncture method can integrate a healthy, self-sufficient and socially cohesive scenario, with a positive environmental impact.

The expansion of cities has been following for years a logic of dispersion and extension. Since 1950, the growth of the urbanization rate has reached 93% and by 2050 about 70% of people will live in urban areas (UN World Urbanization Prospects, 2018). The rural to urban migration, affects the food production sector: "migration has been empirically linked with the structural transformation process: as urban population shares increase, employment tends to shift from agriculture towards industry/manufacturing, or services" (Michaels et al., 2012). Therefore, a possible lack of quality local food supply over time and a change in consumption towards imported processed foods.

The current food system in modern cities which generally depends on resource imports, involves extensive transportation routes and high-energy necessities for the storing, cooling, and packaging of agricultural products (Specht et al., 2016). "*Urban agriculture has been acknowledged as a strategy for spatially and temporarily reconnecting food production, waste disposal, and consumption to strengthen the city resilience, improve community relations and skills and the capacity to adapt to climate change*" (De Zeeuw et al. 2011)

In the current scenario, the path of urban agriculture as an urban industry seems feasible for promoting employment, micro economies, and traditional communal exchanges like barter.

On the other hand, the urban acupuncture has had successful results as a regeneration method for complex urban fabrics. Based in the Chinese medicinal therapy, is a multi-layered theoretical approach that strategically intervenes in small-scale, precisely targeted areas with big scale effects in the urban environment and have the potential to integrate a new urban system.

The use of urban acupuncture method as a regeneration tool to "heal" specific areas in a delicate historical built context located in Cuenca with urban agriculture, may be an alternative to create a green productive landscape and regenerate the city, through sustainable initiatives to boost local food production and small economies with the adaptative use of greenhouses as urban agriculture "needles".

Cuenca, the third in importance in Ecuador, is considered as an intermediate city. Its historic center was declared as a Cultural Heritage of Humanity in 1999 by UNESCO, thus it has undergone many public policies and interventions in order to conserve its heritage and increase its touristic attractions (Cabrera, 2019). However, the city has been facing processes of gentrification, which led to the abandonment of spaces, or on the contrary, buildings with historical value converted into overcrowded degraded slums, whose occupants, generally face precarious socioeconomic situations and segregation.

The agriculture is part of the city´s tradition. Cuenca has an all-year mild climate and its vast soil allows the sowing of different crops on its surrounding areas dedicated to farmland. Moreover, in the traditional architectural typologies, a private patio devoted to family farming was always considered, nevertheless, over time, the new needs of the citizens and the outstanding prices of land, have diminished (or extinguished) areas for communal or individual farming in the urban areas. Over time, the old typologies have been changing to give space for rental parking lots or to build new spaces for commerce.

Consequently, from a bird view of the historical center, it is easy to find some left "in-between" spaces in the middle of the orthogonal blocks, in which, a kind of small-scale interventions could have the potential to impact the dynamics of the city.

The thesis is composed by five parts. It begins with a brief overview of the current situation of urban planet and the situation of Ecuador. As well as the impact of the global pandemic. Secondly, it makes a theoretical approach to the urban agriculture and relates it to the use of urban acupuncture method as a tool to insert urban food cultivation in a delicate historical context. The third part analyses the basic concepts and strategies for the design of greenhouse devices and on the other hand, a research about soil culture and soilless cultivation methods, especially hydroponic techniques in order to have a broader perspective of intervention possibilities according to the local needs. The fourth chapter analyses two case studies at different scales. The first project is related to the application of urban acupuncture for urban regeneration as a Municipal strategy to change the neighborhood dynamics. The second case study shows technical and technological opportunities for urban agriculture. Both projects involve community participation in different levels. The last part is the analysis of the local needs of the city and he application of the previous research into a new project located in the urban historical tissue of Cuenca, Ecuador. The proposal focuses in the implementation of modular urban greenhouse devices with the use of the urban acupuncture method in two urban voids with different environmental conditions, in order to create an adaptative, sustainable and replicable system of urban agriculture originated in the cores of the blocks and spread into the city.

1

INTRODUCTION

the urban planet and the food system

THE URBAN PLANET
GENERAL OVERVIEW

The accelerated growth of cities in developing countries in the global south, specifically in Latin America, has been following for years a logic of dispersion and extension. Commonly, these cities grow organically, -without planning– and are characterized by marked features of social exclusion, this type of expansion is environmentally and even economically unviable in the long term. (United Nations, 2019).

Cities are the places where climate change effects are more visible, due to gas emissions, energy consumption, waste production, heat islands and rainfall events (Commission of the European Communities, 2007). Besides, the reduction of open spaces and the rising demand for resources such as water, energy and fresh food supply contribute to increase social conflicts and segregation (Saporito, 2017).

With these conditions, the necessity to face a variety of development, rehabilitation and preservation challenges arises, generally with significant budgetary restrictions. Most of interventions in today´s cities aim to solve problems related to elevated prices of land, unemployment, urban gentrification, overcrowding, hunger, among others.

In terms of environmental pollution and use of natural resources, "cities are responsible for 70% of the global greenhouse gas emissions from burning fossil fuels, and will need to become carbon neutral if the world is to achieve the targets contained in the Paris Agreement." United Nations [UN], (2019).

Furthermore, "the water footprint of cities – their water source area – accounts for 41% of the Earth's surface, while their physical footprint – their land area – covers only 2%; the land occupied by cities in the developing world will triple by 2050" United Nations (2019).

The contemporary cities are facing transformations that demonstrate that the traditional methods have to be updated in order to adapt to the new urban phenomena, thus the challenge of governments is to transform the modern cities within a comprehensive and sustainable scope that could adapt to new ways of land use, alternative mobility systems, safe environment, clean energies, stimulation for social cohesion, collectivity, micro-economies, new technologies, etc.

Since 1950, the growth of the urbanization rate has reached 93% and if the current trends continue, by 2050 about 70% world's population will live in urban areas and produce 85% of global economic output (United Nations, 2019). On the other hand, the rural to urban migration, affects the food production sector. Migration has been empirically linked with the structural transformation process: as urban population shares increase, employment tends to shift from agriculture towards industry/manufacturing, or services (Ritchie, 2018). Therefore, a possible lack of quality local food supply over time and the change in consumption towards imported processed foods.

1. United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision.

FOOD SYSTEM
HUNGER AND ENVIRONMENTAL IMPACTS

Generally, cities have a limited role in ensuring access to sufficient, adequate, affordable, nutritious and safe food to all its inhabitants. Factors that limit the access include the unstable food prices, disruption in food supply due to natural disasters, and climate change effects (RUAF, 2019).

The current food patterns are insufficient for the world's population, it is estimated that more than 820 million people still face hunger. At the same time, rising obesity and overweight can be seen in almost every region of the world (United Nations, 2019).

Regarding with the environmental impact of food related activities, the data shows that nowadays billions of hectares of land have already been degraded, and an additional 12 million hectares of agricultural land are likely to become unusable for food production every year. Furthermore, agricultural practices can lead to eutrophication of the aquatic environment, groundwater contamination, soil acidification and atmospheric pollution (United Nations, 2019).

The health problems, as a consequence of environmental damages are actually measurable and result into a call for attention and action to private and public actors. About 90% of people living in cities breathe air that fails to meet WHO standards of air quality (10 micrograms per cubic meter (µg/m) of particulate matter) (United Nations, 2019).

Wiskerke (2009) defines the food system:

> The whole array of activities, ranging from input distribution through on-farm production to marketing and processing, involved in producing and distributing food to both urban and rural consumers. The food system of an urban area includes all processes that food passes through, from its production over processing, transportation, retail, consumption to disposal of kitchen and table waste, -including food waste- as well as all actors and institutions that influence these processes. This system is governed by the (global) market mechanisms, influenced by and embedded in the local, regional, national and international policy frameworks. Furthermore, it is placed in different public domains, predominantly in agriculture, public health, environmental issues and the economy, but there are also other policy fields that are, in one way or another, related to food.

The current global food system, results unsustainable because of its climate and environmental impacts and deficiencies in safe and healthy nutrition. Thus, the challenge of cities is to foster a sustainable food system for the current and future generations. It means, a system with the "*capacity over time to provide sufficient healthy, sustainable and fair food to all in the face of chronic stresses and acute shocks, including unforeseen circumstances.*" (Carey et al, 2016)

A resilient food system can withstand disturbances without losing food security, besides, the elements of the system are replaceable and can absorb the effects of stresses and shocks. It is flexible, can quickly recover lost food security and can adapt to changing circumstances. (Carey et al, 2016).

According to RUAF (2019), in a resilient food system, it is expected to have some of the following features:

- *the capacity to monitor and address threats and reduce disaster risks in food systems, including impacts on natural (green) and human-made infrastructures, including other systems on which the food system depends (e.g. transportation, roads, fuel access, electricity grid, communications);*
- *the capacity to build resilience to impacts of shocks and stresses for vulnerable food systems actors (e.g. small-holder and family farmers, women, residents of informal settlements);*
- *a contribution to reducing greenhouse gas (GHG) emissions;*
- *support for effective land management and soil restoration, and protection of eco-system services;*
- *diversified food supply chains that draw on large- and small-scale systems of food production and distribution, that use a variety of approaches to production and distribution, and that draw on both commercial and community-based sources, without being dependent on one source;*
- *the capacity to draw on waste streams (wastewater, food waste and organic waste) for food production;*
- *the capacity to create synergies and achieve multiple benefits across a range of policy objectives e.g. increasing access to healthy food, and creating jobs;*
- *people-centered and inclusive – people are at the heart of the food system, benefiting from increased access to healthy, sustainable food and from employment, and engaging actively with the food system as citizen-consumers.*

In the fight against hunger and food insecurity, public policies should focus in transforming the food systems and providing a healthy and affordable diet for everyone or to create supportive food environments to encourage and teach people about healthy food choices. The cost of a diet increases incrementally as the diet quality increases and unfortunately, the cost of a healthy diet exceeds average food expenditures in most countries in the Global South (FAO, IFAD, UNICEF, WFP and WHO. 2020).

FIG 2. FOOD SYSTEM ACTIVITIES AND ACTORS
Identified components, processes and activities within food systems, which are influenced by a diversity of different drivers ranging from infrastructure to demographics. Such drivers within food systems lead to different outcomes fundamental for sustainable development including resilience, equity, sustainability, stability, security, profit, well-being, health, productivity and protection. (Niles et al., 2017).
IN https://www.cambridge.org/

AFFORDABLE DIET
IMPACTS

According to (FAO, IFAD, UNICEF, WFP and WHO. 2020) there are:

Three reference diets analyzed for cost and affordability to simulate incremental levels of diet quality, starting from a basic energy sufficient diet to a nutrient adequate diet and then to a healthy diet.

1. ENERGY SUFFICIENT DIET

   Provides adequate calories for energy balance for work each day. This is achieved using only the basic starchy staple for a given country.

2. NUTRIENT ADEQUATE DIET

   This diet not only provides adequate calories, but also relevant nutrient intake values of 23 macro- and micronutrients through a balanced mix of carbohydrates, protein, fat, essential vitamins and minerals within the upper and lower bounds needed to prevent deficiencies and avoid toxicity.

3. HEALTHY DIET

   Provides adequate calories and nutrients, but also includes a more diverse intake of foods from several different food groups. This diet is intended to meet all nutrient intake requirements and to help prevent malnutrition in all its forms, including diet-related non-communicable diseases.

The food insecurity can have nutritional consequences such as undernourishment and food but also overweight and obesity and other forms of malnutrition (FAO, IFAD, UNICEF, WFP and WHO. 2020).

The health impacts associated with poor quality diets are significant. Unhealthy diets are a leading cause of non-communicable diseases (NCDs), mainly cardiovascular diseases, cancers and diabetes, that result in death. Both overweight and obesity are significant risk factors for NCDs, and increasing healthcare costs linked to rising obesity rates are a trend across the world. Out of 56.9 million deaths globally in 2016, 40.5 million deaths, or 71%, were attributable to NCDs.

A healthy diet ensures adequate calories and nutrients. It includes a balanced, diverse intake of foods from several different food groups. It is intended to meet all requirements of nutrient adequacy and help prevent malnutrition in all its forms, as well as NCD. (FAO, IFAD, UNICEF, WFP and WHO. 2020).

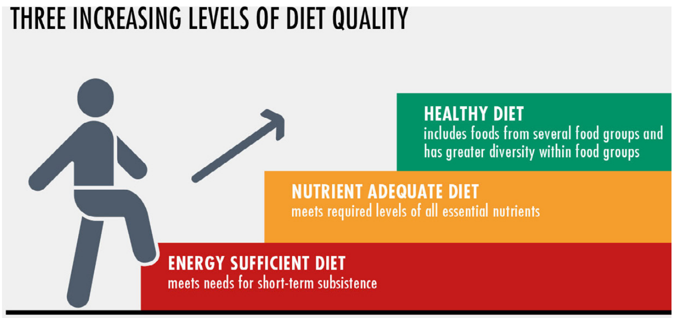


FIG: Tree increasiing levels of diet quality
SOURCE: FAO

COVID-19
POST PANDEMIC SCENARIO

Shocks like the Covid-19 pandemic, intensify social and economic problems. As a result, it makes quality and healthy diet less accessible for poor people in many regions of the world. Hunger and food insecurity worsen in 2020, emphasizing the need to redouble efforts to achieve the Sustainable developing goals until 2030.

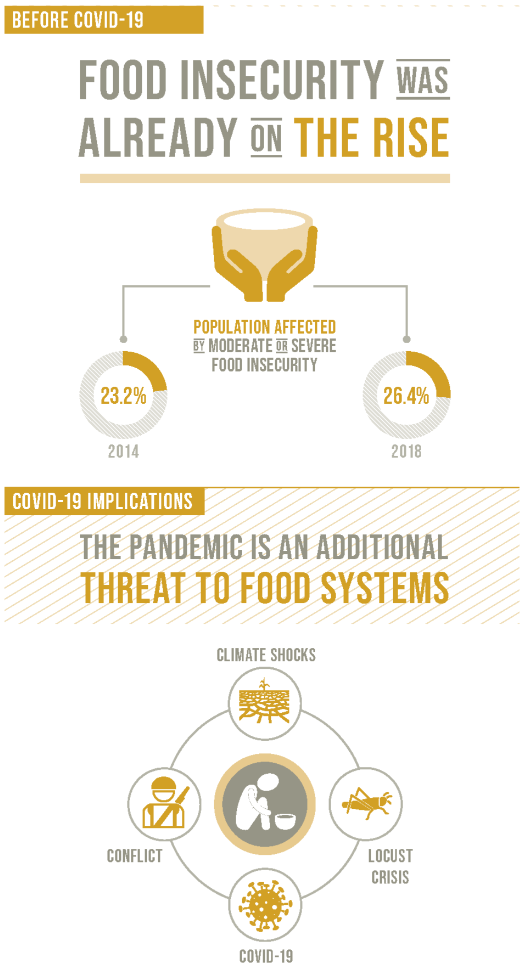
Data related to global access to food or food related activities shows that there is an significant negative impact in the situation with the COVID-19 pandemic, mostly for populations in developing countries with acute or critical food security and whose budgets and contingency mechanisms are not able to mitigate the needs and alleviate the quarantine related economic and social impacts.

According to the estimates of the Economic Commission for Latin America and the Caribbean (ECLAC, 2020), as the economy contracts and unemployment increases, an additional 29 million people in the region could be driven into poverty after COVID-19.

With the initial lockdown the breaks due to the closure of transport connections and borders, occurred several interruptions in the food supply chain distribution of goods which complicated the arrival to all regions and covering the needs of the entire population. Nevertheless, there is no agricultural supply problem in the world food market, the problem is on the demand side mostly related to the unemployment and income reduction. Thus, an increase in the food insecurity.

The isolation and social distancing measures, have reduced the employment and income of millions of people, particularly those engaged in services such as tourism, transport and restaurants, sports centers and entertainment. Trade has also suffered, especially small and micro-enterprises, together with informal and self-employed workers who are suffering not only from sudden unemployment but an acute lack of income to meet their most basic needs, beginning with food. (Lustig y Tommasi, 2020)

There is a degree of uncertainty due to lack of data about what the future of the world economy will be. Nevertheless, it is necessary to implement in developing nations a comprehensive program to relaunch small family farming, including traditional forms of local and even family-based food sufficiency. All this requires public assets, strategic seeds and inputs, credit, affordable financing and liquid guarantees; in other words, reasonable risk management that does not inhibit productive momentum (Lustig y Tommasi, 2020).



1. UN World Urbanization Prospects of 2018
2. Michaels, G., Rauch, F., & Redding, S. J. (2012).


Tenemos
Hambre


ETIHAD
AIRWAYS


CON HAMBRE
NO HAY
CUARENTENA

ECUADOR
URBAN GROWTH AND FOOD SYSTEMS

In Ecuador by 2010, the 65% of population lived in the urban areas (Instituto Nacional de Estadística y Censos – INEC, 2010). Over the last decades, the rural areas suffered profound changes thanks to the economic liberal politics of the 80´s, which weakened the familiar agriculture. The international migration became a survival strategy for rural families and redefined the logics of the agricultural duties.

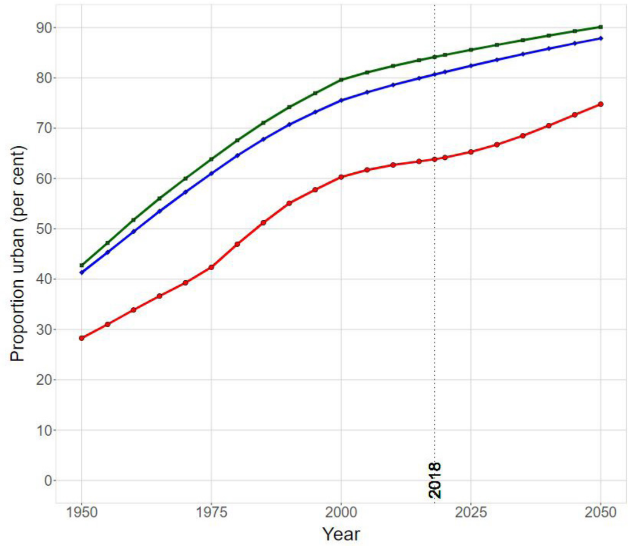
Over the past years the globalization and the changes in life patterns have significantly altered its urban landscapes. Efforts by the government and the private sector to regenerate urban areas and free up land for investments have shaped processes of privatization and socio-spatial segregation (Van Noorloos and Steel, 2016).

The economic data of Ecuador reveals that in 2019, the poverty affected to the 25% of the population and the percentage of extreme poverty raised to 8.9%. Moreover, with the pandemic, the situation was critically aggravated the social indicators such as the loss of full employment that affected to more than 1 800 000 people on June on 2020. Comparing with December of 2019, the unemployment increased alarmingly from 3,8% to 13,3%, percentages never before recorded in the country (INEC, 2020).

In Ecuador, the lockdown measures implemented to decrease the spread of COVID-19 have meant losses of income, limited access to food or even clean water. The prices also increased and it had severe health consequences for the vulnerable population as diets were incomplete and poor. Moreover, despite the government restrictions during the quarantine, an important number of people continued going to streets to work and fulfill their needs, in a country where the percentage of informal work reaches more than the 60%.

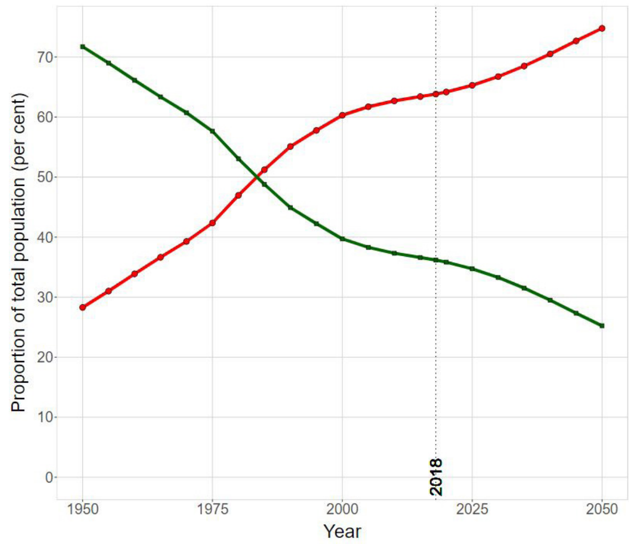
A paradox of food security is that the poorer and the more vulnerable a population is, the more necessary it is to tailor the response to meeting their food needs at the local level. The interaction with markets of these population groups is tenuous and erratic. This is a fundamental consideration when it comes to taking action and deciding how and where to implement different types of support (Lustig y Tommasi, 2020).

PERCENTAGE OF URBAN GROWTH BY REGION AND SUBREGION FROM 1950



ECUADOR
SOUTH AMERICA
LATIN AMERICA AND THE CARIBEAN

PERCENTAGE OF POPOLATION IN URBAN AND RURAL AREAS FROM 1950



URBAN
RURAL

SOURCE: United Nations (2018)

2

URBAN AGRICULTURE
THROUGH URBAN ACUPUNCTURE

theoretical approach

URBAN ACUPUNCTURE
IN HISTORICAL CENTERS

The historical centers of cities are considered as delicate built environments; their morphology and dynamics are the result of different layers of history and the transformations of the society. Besides, there is a recurrent questioning about the usability of some spaces and the possible updates according to the current and future needs.

Generally, these special urban tissues face challenges about densities, building deterioration, lack of public spaces, degradation of urban image and loose of functions. In addition, in terms of urban comfort, the spaces are increasingly conditioned by the climatic phenomena such as rainfall, heat waves and urban heat islands. The climate adaptation of public spaces therefore acquires a strong relevance on the livability of the spaces.

Thus, these built environments deserve particular attention in terms of urban renewal through a sustainable model because of their complexity. These areas are generally dense and all interventions have the risk of damaging the heritage values. An interesting concept which has been applied around the world in the last decades and can be applicable on these delicate areas of the city is the urban acupuncture.

The urban acupuncture is based in the Chinese medicinal therapy. As on its origins, the urban acupuncture works in certain areas with specific physical projects related to open space or built space. These interventions take place in order to relief the built environment in stress or malfunction. It is a multi-layered theoretical approach that strategically intervenes "heals" small-scale cores with progressive effects in big scale in the urban environment and have the potential to be integrated into a new system.

The interventions are socially catalytic in the urban fabric; they release energy flows of relief by responding to localized needs. In other words, the rehabilitation of the system being achieved by the treatment and healing of the consisting parts (strategic points). These sites are chosen after a social, ecological and economic analysis of the wider context and through an interaction with the local community (Apostolou, 2015).

"Urban acupuncture interventions contribute in stimulating dynamic, transformative forces that re-create and re-activate places through co-creation" (Houghton et al., 2015). These processes are used as a strategy for urban renewal and have achieved remarkable results around the world. The "needles" could be different types of interventions and events, from the building or park to street festival or any other positive happening in public spaces (Lerner, 2014).

According to Daugelaite & Grazuleviciute-Vileniske (2018) the potential benefits of these projects in historic urban environments are determined by the architectural-urban context, and these interventions can be beneficial for the actualization of heritage, for highlighting of its valuable features, and attracting attention of the society. The urban acupuncture can positively affect the urban landscape and influence the ecological system, can restore or create biodiversity, ecological balance and the links between humans and nature.

FIG: Urban acupuncture Hong Kong
Source: FACEBOOK-Urban acupuncture Hong Kong

URBAN VOIDS
AND THE IN-BETWEEN LANDSCAPES FOR URBAN AGRICULTURE

> The usual process of urban development treats buildings as isolated objects and sites in the landscape, not as part of the larger fabric of streets, squares and viable open spaces. Decisions about growth patterns are made from two-dimensional land-use plans, without considering the three-dimensional relationships between buildings and spaces and without a real understanding of human behavior. (Trancik, 1986, p.1)

The urban vacant land is the result of historical and temporary events, this problem is common to many cities, as well as the barriers to its redevelopment. The urban voids can be related to urban concepts associated to lacking functions and uses and aesthetic values, thus they are generally considered as unproductive spaces. Nevertheless, the interventions with sustainable strategies such as urban agriculture can transform them into opportunities for the revitalization of a built environment.

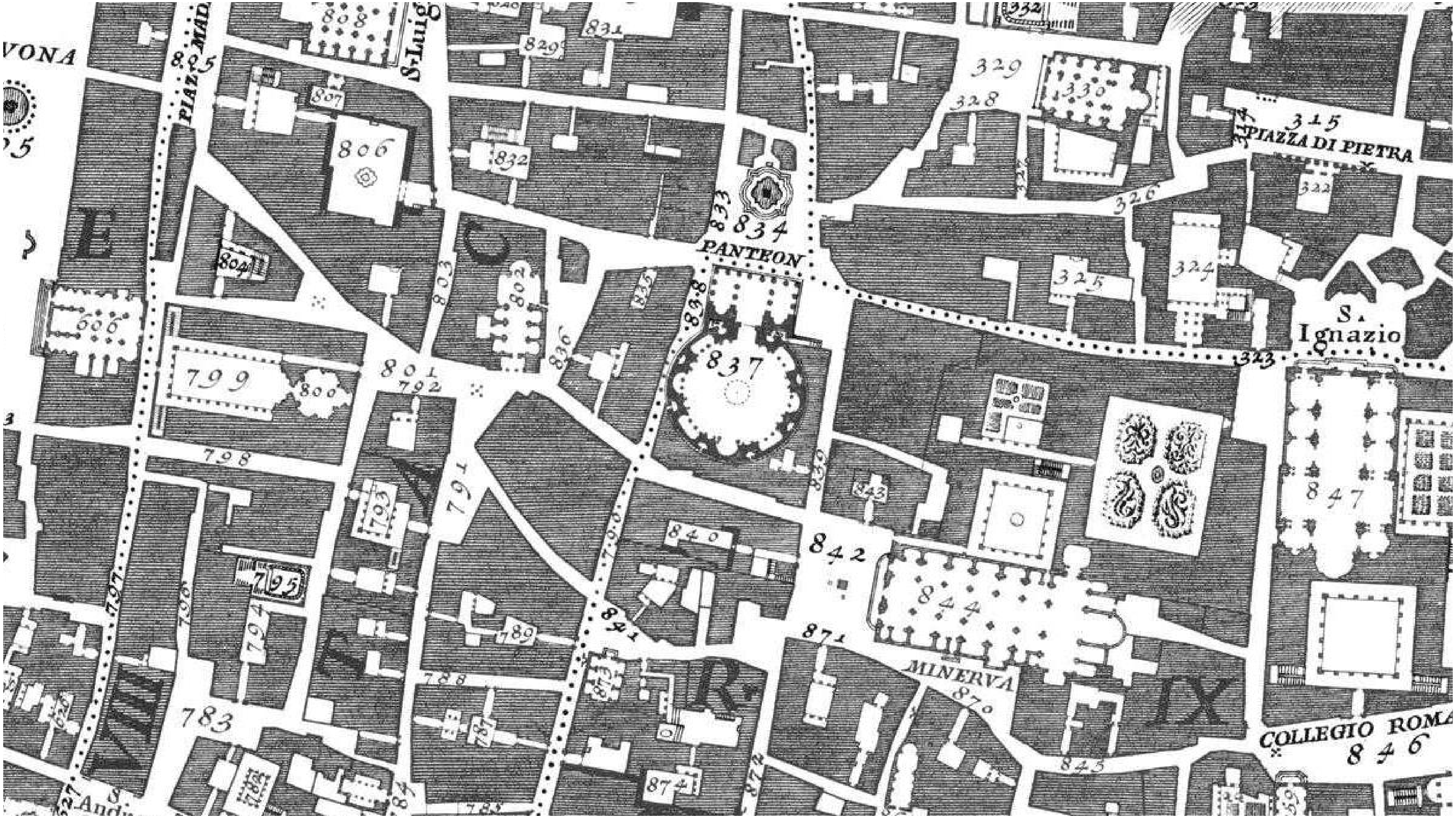
Another definition that results interesting referring to these particular spaces in the cities is the one given by Solà Morales (1995), who explains the "Terrain vague" as: "Apparently forgotten places where the memory of the past seems to predominate over the present. They are obsolete places in which only certain residual values seem to be maintained despite their complete disaffection from the activity of the city. They are, in short, external, strange places that remain outside the circuits and the productive structures".

Manuel Castells suggests that "It is necessary to delve deeper to understand the sites and their flows and identities" (Castells, 1996). The profound analysis and understanding of the logic of the voids left in the urban fabric and rethinking, recovering and reactivating rather than "occupying" empty spaces result as a challenge and an opportunity to improve the structure of the urban landscape.

Among the variety of conditions that give origin to the urban voids, some recurring types are: residual spaces (conditioned by roads and railways junctions), abandoned spaces near infrastructure (such as bands along roads, bridges and viaducts), bodies of water, residual open spaces (whose formal and dimensional conditions complicate new interventions), wild and abandoned open spaces (that separate accidentally neighboring or conterminous settlements), unbuilt plots, technical spaces (for storage of goods), inactive quarries and uncontrolled dumps, free areas (for city service activities), inactive industrial sites, areas targeted for demolition, etc. (Di Giovanni, 2018).

These spaces have the potential for rapid change of use, constituting an important element of both planned and unplanned activities. Due to the lack of use, people tend to not perceive them, and the urban voids tend to become invisible places. Moreover, the emptiness generates vague terrains in the urban tissue, with forgotten and insecure spaces, deteriorated physical conditions and garbage. Additionally, these are favorable areas for social problems and the attraction of homeless people and criminals.

FIG: La pianta grande di Roma. G. Nolli, 1748.
SOURCE: Pinterest
http://www2.ual.es/RedURBS/BlogURBS/los-vacios-urbanos-inquietud-y-posibilidad/


VONA
PANTEON
834
837
PIAZZA DI PIETRA
315
S. Ignazio
847
842
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MINERVA
COLLEGIO ROMA
846
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C
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R.
IX
VIII

A paradox of urban voids is that some of them are located in areas with high prices of land and surrounded by residential and commercial properties. Nevertheless, these portions of land lie underused and ignored. Understanding the causes and consequences of the unused or underused in-between areas in the urban tissues can lead also to innovative solutions.

> According to Trancik (1986), there are five types of urban voids (with different degrees of openness and enclosure):
>
> 1. The first is the entry foyer space that establishes the important transition, or passage, from personal domain to common territory. In form it can be forecourt, mews, niche, lobby, or front yard. In scale it is intimate. A place where one can be both public and private. (Figure 1)
> 2. The second type is the inner block void – the enclosed "hole in a doughnut" – a semiprivate residential space for leisure or utility or a midblock shopping oasis for circulation or rest. (Figure 1)
> 3. A third type of void is the primary network of street sand squares, a category that corresponds to the predominant field of blocks and that contains the active public life of the city. Historically, the streets and squares were the unifying structures of the city; in modern times, they have lost much of their social function and physical quality. As extensions of the home and places for discourse among neighbors, urban streets and squares traditionally formed a systematic hierarchy of order from locally controlled space to city-wide routes for communication. […] Too often today they do not serve this role, as the mixed-use street has been replaced by shopping centers. (Figure 2)
> 4. Public parks and gardens are the fourth type of larger voids that contrast with architectural urban forms. Acting as nodes for the preservation of nature in the city, they are incorporated into the urban grid to simulate rural settings, to provide both relief from the hard-urban environment and accessible recreation. Urban parks and gardens shape adjoining sites by enhancing property values at their edges, but they are independent landscape compositions internally. (Figure 3)
> 5. The final type of urban void is the linear open space system (Figure 4), commonly related to major water features such as rivers, waterfronts, and wetland zones. These formal and informal greenways slice through districts, create edges, and link places. (p.103-106)

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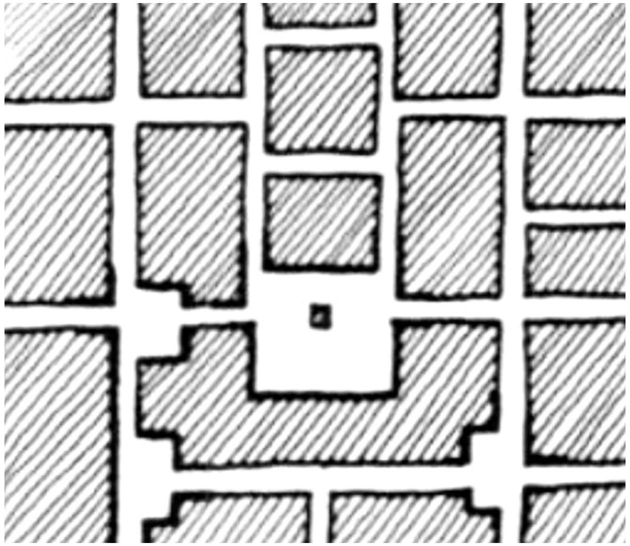
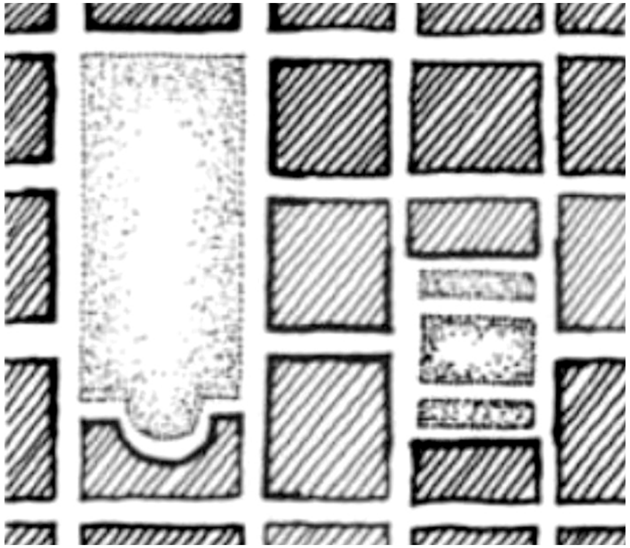
2. 

3. 

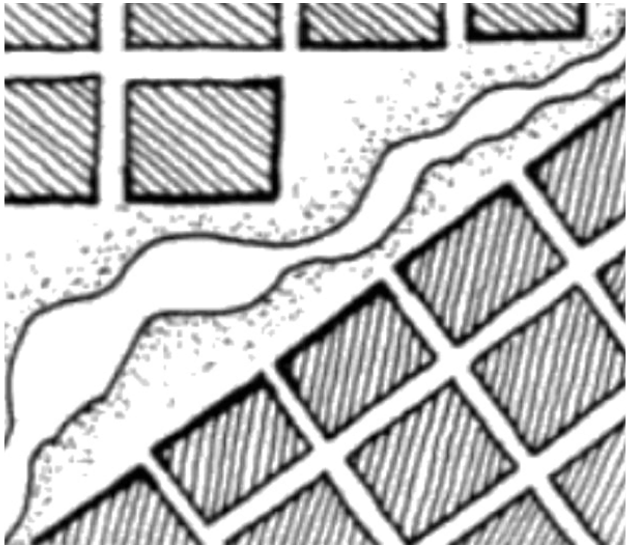
4. 

FIG 1: Typycal entry foyer and Inner block courtyard, Copenhagen, Denmark.
FIG 2: Plan diagram of streets and squares
FIG 3: The park in the city grid
FIG 4: Linear open space systems within the city
SOURCE: Trancik (1986)

CAUSES
THE ORIGIN OF URBAN VOIDS

The urban voids are the consequence of moments of crisis, related to natural, political, social and economic factors, their origin links to the permanent growth and transformation of the contemporary cities. "There are numerous causes of urban land abandonment, including decline of industrial base with corresponding job loss, increased criminal activity, and the unwillingness or inability of property owners to maintain their properties" (Goldstein et al., 2001).

Among the factors that can cause them, the following can be mentioned:

NATURAL FACTORS

Refers to the geographical conditions that generate the formation of urban voids. For instance, the presence of physical obstacles in land that can create unshaped, undefined spaces that conditions their use. On the other hand, the natural disasters that can lead to the abandonment of people, transforming the use of these spaces or buildings (Nermeen and Engy, 2019).

FUNCTION FACTORS

The urban voids can be generated due to the function of the land or its surroundings. For instance, the closure of industrial sites, the empty spaces created under bridges, the edges of highways, unused train yards, etc. (Nermeen and Engy, 2019).

POLITICAL FACTORS

Among the political factors can be cited the inefficient decision making and poor land management of public administration, besides the lack of coordination with stakeholders.

ECONOMIC FACTORS

In many cases, the origin of urban voids is related with the economic shifts and urban changes. The profitability of a property is related with the abandonment of spaces.

Moreover, the relatively higher tax rates urban residents and businesses face. Because of the demand of services, the taxes higher in the urban than in the suburban areas (Goldstein et al., 2001)

PLANNING AND DESIGN FACTORS

The change in the uses and the transformation of old typologies to solve new needs can lead also in urban voids. Another factor is the designing out of context with the surroundings, regardless of urban fabric of the city.

In addition, there are several regulatory and institutional factors, such as outdated zoning restrictions, which can inhibit mixed-use areas (Goldstein et al., 2001).

CULTURAL FACTORS

The technological development and economic growth, people moving to live in the suburbs, and the expansion in the use of automobiles, has decreased the use of city center, which become unpopular environment for living. The population has augmented but the density in central areas has decreased.

CONSEQUENCES
THE IMPACTS OF URBAN VOIDS

The consequences of left in-between spaces are as wide-ranging as their origins. The effects of the underutilization of land are multiple and contribute to a vicious cycle. Among the consequences can be mentioned the affections to the quality of life, generation of safety threats and spaces for criminal activity, effects in the aesthetics of the neighborhood, they can provide a space for vermin and other stray animals, drop of property values, and therefore, the rents of all neighborhood inevitably drop as it becomes less desirable (Goldstein et al., 2001).

POTENTIAL
OF URBAN VOIDS

The urban voids can generate complicated physical and social negative impacts. However, the adaptability of these empty open spaces becomes an opportunity for a dynamic development of the cities. Their re-use has the potential to update the urban spaces with integrated interconnected projects for the sustainable development of the city with environmental, economic, social, cultural and aesthetics values.

The progressive urbanization and congestion of the contemporary cities and the degradation of the natural environment, opens the opportunity to consider these particular urban spaces as resources and to interpretate them as available areas to welcome activities of exchange and social interaction among individuals. They can host temporary use, creative and active commercial and non-commercial activities. Moreover, in terms of community participation, the appropriate treatment of urban voids can encourage people to join and reinforce social relations.

Referring to the environmental value, the requalification can enhance the quality of urban life. For instance, the potential of the introduction of sustainable systems is significant: these spaces can be intervened as green infrastructure and ecological resources, they can improve the quality of air and reduce the pollution, and therefore, promote a healthier ecosystem. On the other hand, urban voids support the biodiversity by preserving natural habitats for living organisms and play a significant role in the management of storm water (Nermeen and Engy, 2019).

Additionally, these empty plots can be used for the production of renewable energies. For instance, with suitable surrounding and environmental conditions, the city could place turbines or solar cells for wind and solar energies.

Thus, the re-use of the urban voids and the introduction of suitable adaptative responses become a great opportunity to adapt to the contemporary dynamics of the cities. Consequently, small-scale interventions as urban agriculture can make sense of these spaces for local development with an increased awareness of the multiple variables such as food security, participation and social cohesion, education, culture, environment, and improvement of local economies.

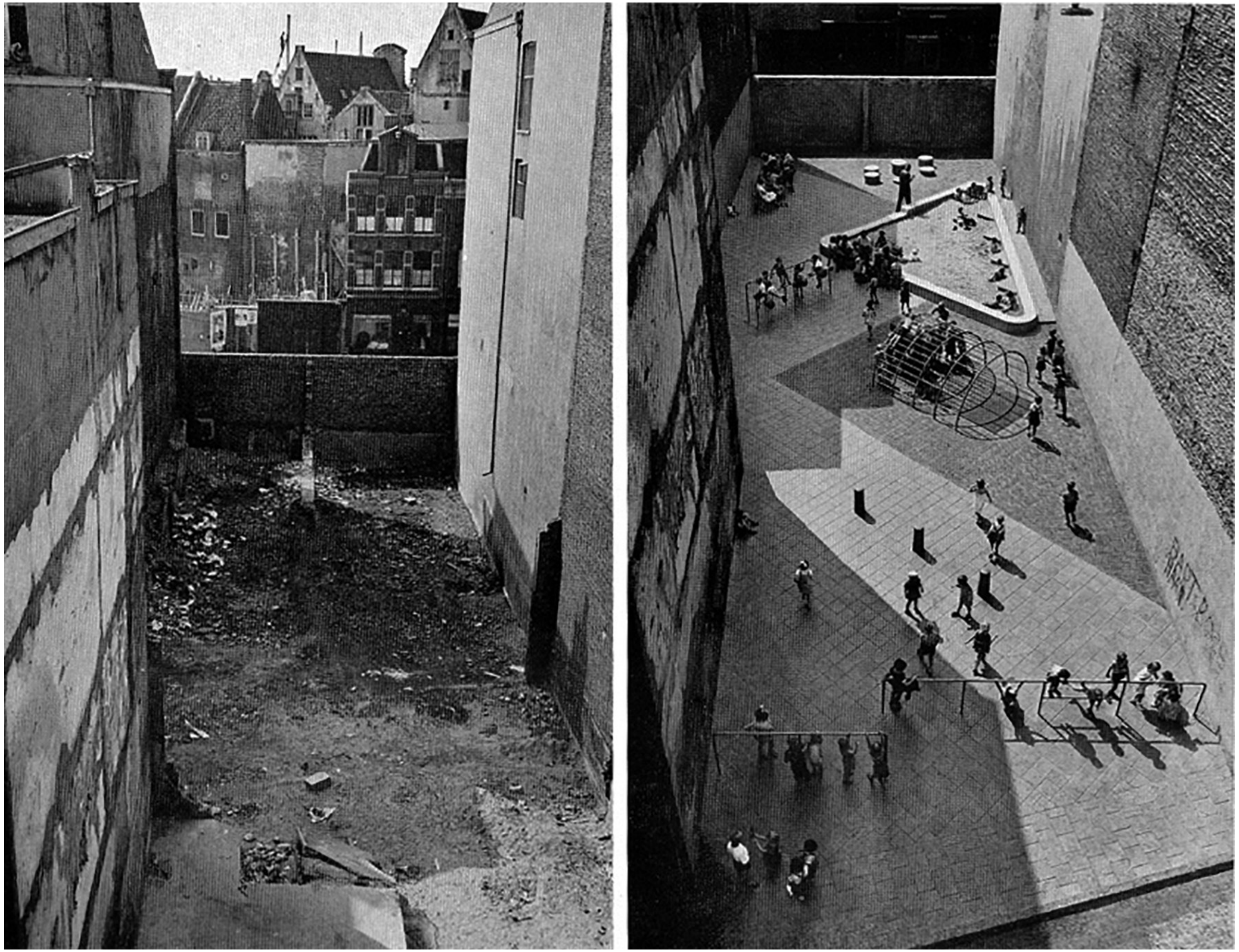


FIGURE:
Playground Dijkstraat / Before and after (1954) / Amsterdam - Netherlands
Design: Aldo Van Eyck

Aldo Van Eyck a Dutch architect and theorist, designed hundreds of public playgrounds in Amsterdam while working for the Urban Development Department after the World War II. The playgrounds where located in parks and squares of very different sizes and shapes, conveniently merging with the city's fabric.

SOURCE: https://www.archined.nl/2002/07/playgrounds-by-aldo-van-eyck/

POLICY MAKING
REGENERATION OF URBAN VOIDS

The government has an important role in fostering the urban vacant land re-development by giving clear policies and facilitating the way for properties to re-enter the land market through expedited foreclosure and property disposition. In some cases, this will require significant restructuring to coordinate functions (Goldstein et al., 2001). The measures should include property ownership, flexibility of use, participation, etc.

> The urban vacant land redevelopment may be addressed through broad policy approaches such as regional governance and land-use planning, and/or through programs targeted to address specific place-based barriers. Neither approach alone will conclusively resolve the issue of urban vacant land. Since urban disinvestment and decline is inextricably linked to suburban growth, in order to effectively address the problem, the governance structure must include both. (Goldstein et al., 2001)

Goldstein, Jensen & Reiskin (2001) enumerate four factors for plans and urban policies to redevelop the urban voids:

1. Government officials and policy makers need to understand the root causes of urban vacant and underutilized land in order to develop effective, systemic approaches to ameliorating the conditions it causes.
2. The interrelated social, political, and economic context should be considered
3. The public sector can play an important role by eliminating policy and regulatory barriers to redevelopment, by adequately maintaining publicly owned properties and facilities in distressed neighborhoods, by ensuring adequate police, fire and other municipal services and by creating an atmosphere that encourages the private sector and private-public partnerships to reinvest in the inner city.
4. The participation of local resident in open processes aimed at devising and implementing redevelopment plans and programs is critical.

FIG: Brooklyn Grange
Source: FACEBOOK-Brooklyn grange

URBAN AGRICULTURE
THE INTRODUCTION OF PRODUCTIVE LANDSCAPES

With the increasing global population, it is necessary to ensure sufficient food for everyone. Besides, the productivity growth in agriculture has the largest impact of any sector on poverty reduction (Fugle et al., 2020). Moreover, it is important to consider the current and future variables that take part on the agricultural productivity, such as climate change:

> Climate change will hit agriculture hard, particularly where large numbers of poor and vulnerable people live. Climate change models suggest warming of 1 °C - 2° C from the preindustrial level by 2050. For every 1 °C increase, average global cereal yields are expected to decline 3 %. The United Nations Food and Agriculture Organization estimates. (Fugle et al., 2020, p.21)

In order to solve the nourishment needs of the citizens, several concepts that introduce the traditional agriculture practices into the cities have arisen. The creation of farming devices as new multifunctional landscapes into dense urban tissues aligns with concepts like urban and peri-urban agriculture, rural-urban linkages and landscape development, urban food systems, and city region food systems (RUAF, 2019).

Urban agriculture is defined as “the growing, processing, and distribution of food and other products through intensive plant cultivation and animal husbandry in and around cities” (Bailkey and Nasr, 2000). Besides, the urban agriculture is multifunctional, it provides a wide range of ecological, economic, and social benefits, such as promoting biodiversity and building community (Piso et al., 2019).

The concept of urban agriculture has been expanding globally at different scales as an instrument to re-design and plan the today´s cities for resilience and to solve many social problems related to food procurement, urban poverty, urban degradation, employment opportunities, and environmental education (Saporito, 2017). “It leverages food production as a mediating function for social, environmental and social benefits” (Department of Organic Food Quality and Food Culture, 2017).

These processes are adapted to specific urban challenges and opportunities and are mostly described as smart solutions for green building, sustainable food production and ethical consumption. However, if framed within the social innovation culture and the urban acupuncture perspective, it could additionally contribute to social inclusion and urban regeneration (Saporito, 2017).

Urban agriculture plays an important role in urban regeneration. The concept of urban farming has been applied around the world in the renovation of old buildings, rooftops, or empty plots inside city and has shown successful results. It represents a new ontology that redefines relationships, that recognizes the different categories of urban spaces and activities as multi-dimensional, and includes new economic and social actors as subjects able to produce values of collective interest for the community (Saporito, 2017).

The benefits of urban agriculture include increased access to nourishment in recognition of the human right to food, the self-sufficiency and decreased transportation of food which is translated into a decrease in noise and air pollution. Besides, urban farming adds health benefits for the people living in the area, boosts local economic development, helps to decrease the effects of climate change, it has connections to broader social change such as inclusion, skill building, traditions and to improve old cultivation techniques with new technologies.

The key areas that the urban agriculture faces are "*the high land prices, opportunities and risks of applying recycled urban water and nutrients, food safety and risks of exposure to urban contaminants, the need to adapt and intensify production in space-constrained conditions, opportunities for agro-enterprises in accessing nearby markets, combining multiple functions; social inclusiveness, and the need to engage with a dense and often intrusive regulatory, policy and planning environment*" (Prain and de Zeeuw, 2007).

The urban agriculture includes small-intensive urban farms, land sharing, rooftop gardens and beehives, schoolyard greenhouses, restaurant-supported gardens, public space food production, guerrilla gardening, allotments, balcony and windowsill vegetable growing, among others (Bailkey and Nasr, 2000).

FOOD SECURITY

The Vision for the Urban Food Agenda-FAO for 2030 for resilient, integrated, sustainable and inclusive food systems, is directed to ensure that all people in all places are free from hunger and all forms of malnutrition (FAO, 2019). In transitioning towards sustainable food systems, the focus must be on enabling more equitable global access to nutritional foods while minimizing the climate and environmental impacts of production (United Nations, 2019). Nevertheless, despite the efforts, the fight against hunger is still an important task that is still far from been solved.

The urban agriculture contributes to food security because of the increased availability and stability of the overall fresh food supply: horticulture, eggs, fruit, milk and poultry.

The use of communal land for urban agriculture counteracts the elevated prices and pressure on land and the impossibility to access to safe fresh food in the cities. On the other side, considering that the geographical location influences in different scales the staple food production, the adaption of new technologies for urban farming can reduce the seasonal gaps and therefore, contribute to the stability of urban food supply for self-consumption and for small scale entrepreneurship.

In terms of communal participative processes, an important aspect is that because of the cultural and symbolic meaning of food, it can act as a "common good" (Ciaffi et al., 2016) and a medium for social inclusion through which it is possible to create new civic bonds between urban actors and facilitate collaborations among them (Mela, 2016) in (Saporito, 2017).

With the reduction of distances and the physical accessibility improvement for food production, the relation between producers and consumers is closer and the products tend to be cheaper because most of the fresh products are sold immediately following the harvest.

The correct management of urban agriculture can prevent hunger and malnutrition and ensure food security. It is needed the participation of all actors, from of urban authorities, stakeholders and citizens through an interdisciplinary approach (authorities, agronomists, nutritionists, food technologists, health workers, home-economists) and the correct assistance about the benefits and potential risks, general hygiene and quality control along the food chain (production, purchasing, processing, storage, preparation and distribution), the management of fertilizers and organic wastes, etc.

SKILL BUILDING AND SOCIAL INCLUSION
WHO ARE THE URBAN FARMERS?

Due to the cross-cutting and multi-dimensional nature of urban agriculture, policy development and action planning should involve various sectors and disciplines. Urban farmers, the community organizations and NGOs, must be involved in the planning process. In particular, the urban poor should themselves participate in situation analysis, priority setting and action planning and implementation. (RUAF, 2019)

The urban agriculture has the potential to tackle many of the needs of the citizens and to integrate a self-sufficient, and socially cohesive scenario.

The introduction of urban farms for social inclusion is an instrument to give opportunities and basic rights among social groups that are generally left behind in their own territories. These groups include women, indigenous people, ethnic minorities, persons with disabilities and others. Gender inequality, limits the opportunities and capabilities of half the world's population, further exacerbates the condition of women in poverty. Vulnerable groups often experience lower levels of education, higher rates of unemployment and economic inactivity, and a lack of social protection (United Nations, 2019).

Cities around the world are transforming and renewing themselves in order to deal with multiple and complex issues. In this sense, from a top-down approach, arises a conflicting relationship between public and private actors and the use of resources and the role of citizens in urban design is often seen as a formality where generally the citizens are "informed" rather than "engaged" in the processes.

Nevertheless, according to the paradigm of urban resilience, the role played by urban communities is crucial, as they can collaborate with the public administration in maintaining and regenerating urban goods for the collective interest (Ciaffi & Saporito, 2017).

With the obsolescence of old models with lack of participation, new grassroot movements have encouraged "bottom-up" local experiments with community engagement through localized urban interventions. These new projects "hack" the known public space by changing the sensation of a place, promote awareness around civic issues and encourage the participation in decision-making process of city making (Fredericks et al., 2018) and the use of new tools such as IT, online resources and social media.

Parallel to theorizing and policy making from public sector and urban specialists, the global trend towards the model of social innovation in order to reduce the dependence from public sector promotes the mobilization of human talents and resources.

Nowadays municipalities, nonprofit organizations, developers, and entrepreneurs are bringing agrarian practices into the city, ensuring food security and educating people about gardening practices, and reconnecting citizens to the source of their food. These urban regeneration processes are signs of the capability of the current cities to invent themselves in the form of social innovation, new technologies and sharing for place-making and urban resilience.

These processes also require new forms of leadership and the implementation of appropriate social environments and networks that support innovation. The use of multi-actor planning methodologies and consultative processes can make the outcomes of policy development and action planning more robust, comprehensive, accepted and sustainable (RUAF, 2019). All stakeholders should work to make substantial changes to existing infrastructure, policies, regulations, norms, and preferences so as to transition towards food and nutrition systems that foster universal good health and eliminate malnutrition while minimizing environmental impact (United Nations, 2019).

FIGURE: UNION STREET URBAN ORCHARD. (2010) / London - UK

Design: Heather Ring /WAYWARD Plants
Key partners: Lake Estates, Openvizor, Bankside Open Spaces Trust and ProjectARKs

The community garden with a temporary use was the main feature of the London Festival of Architecture 2010 and had a duration of 6 weeks.

It demonstrates the value and potential of the re-development of empty sites within neighborhoods.

The intervention regenerated an abandoned site in Bankside and was built with recycled materials by over 100 volunteers. The space contained within 85 fruit trees, and countless wayward plants and consisted in a place for exchange between local residents and visitors.

The intervention hosted workshops and discussions on urban agriculture about biodiversity and urban food growing. Moreover, it included film screenings, musical performances, and local community meetings.

SOURCE: https://www.architectsjournal.co.uk/practice/culture/the-union-street-urban-orchard


The Union Street
URBAN
ORCHARD

LOCAL ECONOMICAL DEVELOPMENT

The public space has always had an important role in the life of citizens and as the center of different activities. The creation of new public spaces or the requalification of the existing ones according to the current needs, has the potential to chance the dynamics of the neighborhood and to improve the local economies based on sale and self-production.

The urban agriculture in the cities of the Global South, is an instrument for self-sufficiency and for fighting poverty. Besides, in areas impacted by social an economic crisis, it often has a relatively informal "do it yourself" character. Nevertheless, the introduction of an organized system or communal urban farming seeks to include social values in the development of innovative businesses at the local level with an impact in the urban-rural regional food systems.

There are important benefits of creating a synergy between small economies goals and well-being of the community and environment. They are inclusive and can create opportunities and employment and at the same time, foster the communal networks and relations. An innovative system of urban agriculture has the model of energy-saving, recycle waste streams, and optimizes the energy-water-food-nutrient nexus.

Although current cities are considered as consumptive, the new approaches promote converting cities into "productive" systems (Specht et al., 2016). Scholars visualize the "edible city" and theorize about the incorporation of interconnected "Continuous Productive Urban Landscapes (CPUL)" into cities as essential elements of urban infrastructure (Bohn and Viljoen 2010).

During the last years, the development of successful entrepreneurships in the field of urban farming has attracted the interest of people who aim to emulate these practices. There have been developed new business models from subsistence to large scale projects for private and social sectors, policymakers, researchers, and local and global stakeholders.

The orientation of urban agriculture has different aims according to the localization. In the case of developing countries, the urban agriculture is related to subsistence farming dedicated to family nourishment and micro-level enterprise to large urban agriculture business operations. It means, that the major motivation on emerging countries is to increase food security levels and health conditions while generating family income (Specht et al., 2016).

The agronomic productivity is becoming a trend, the experiences from many interventions demonstrate that the acceptance and involvement of community and consumer preferences of the projects and products represent important keystones for the success of entrepreneurships related to urban gardens (Specht et al., 2016).

According to Lucke (1995), "innovation is not only an economic mechanism or technological process but also asocial phenomenon that reveals the demands of both individuals and society as a whole".

A TOOL AGAINST CLIMATE CHANGE
GREENING THE CITIES

The main aspect that causes climate change and global warming is the increase of global carbon emissions produced by human activities such as deforestation and burning of fossil fuels. In order to tackle these issues, the change of the societal metabolism towards low/no fossil-carbon economies is required. However, it needs essential changes in the design, production and use of products as well as the development of suitable policies (Huisingh et al., 2015).

> The climate change and environmental problems become day by day in a challenge for cities, especially for those who have been facing an accelerated growth of urbanization and population. Many poor developing countries are among the most affected by climate change, people living on these countries often strongly depend on their natural environment and they have the least resources to cope with the changing climate (European Commission, 2020).

A sustainable urban agriculture is a great strategy for environmental management, it has a strong influence on the carbon sequestration within cities. Besides it can be used as a tool to prevent the greenhouse effect and therefore helps to regulate the temperatures.

The increase of green areas within the urban environment thanks to the re-introduction of urban farming in the cities decreases the direct solar radiation by providing shade and can help lower temperatures through evaporative cooling (RUAF, 2019). In the case of rooftop farming, it helps to increase thermal comfort in the interior areas under the gardens.

Another issue that some cities face is the increasingly intense rainfall and flooding, it is generally common in places that lack of adequate drainage systems. Thus, the use of agriculture in strategic zones, can help to mitigate flood risks, to reduce runoff and to store and infiltrate the excess water (RUAF, 2019).

On the other side, the reduction of chemical fertilizers and their replacement by organic waste has beneficial effects on both emission reductions as well as city waste management.

Finally, the use of sustainable innovative systems, in terms of resources and renewable energies can help also to reduce the impact of climate change. The inclusion of these strategies in the production systems and technologies for irrigation, mechanization, processing and transport of food should be facilitated and promoted.

COMMUNITY HEALTH
WELLBEING, POLLUTANTS

There are numerous factors to take into account to analyze the positive and negative impacts of urban agriculture in health.

On the positive side, the devices devoted for urban gardening have the potential to contribute as a public health system. Firstly, the proximity of a new food system increases the awareness of the nutritional benefits of choosing fresh vegetables and fruits over highly processed foods. Besides it promotes the exercise, psychological and communal wellbeing.

The possible risks should be considered as well with the aim to control and solve the issues at an early stage. There should be attention of the pollutants to which urban agriculture can be exposed, these are related to the location where crops are grown, the type of crop, or the characteristics of the soil and pollutants (Aubry and Manouchehri, 2019).

In this sense it is necessary to analyze the sources for the pollution of food, it can be from soil which transfers the pollutants via the root system, and could be absorbed by the parts of the plant that lie above ground level. Water can also be a source of bacteriological or phytosanitary pollution from the use of harmful pesticides (Aubry and Manouchehri, 2019).

> Depending to the type of crop, the sensibility to soil or air pollution fluctuates. Lead pollution has very little impact on the edibility of fruit, but it does diminish the edibility of some vegetables. For example, leafy vegetables (lettuce, cabbage, spinach, etc.) that have a large area exposed to atmospheric particles, and root vegetables (carrot, radish, beetroot, etc.), are more exposed to risks than fruiting vegetables (tomato, pepper, eggplant, etc.). Certain garden herbs, such as parsley, are heavily exposed to soil and air pollution alike. In urban agriculture, great care must therefore be taken when choosing the location for cultivating such plants. The time it takes for a crop to grow is another consideration. The longer a plant is in the soil, the more it is at risk of being impacted by a range of pollutants. (Aubry and Manouchehri, 2019, p109)

It means, the longer the exposure, the bigger the possibilities to be affected by pollutants. On the other side, the best crops should be selected according to the type of cultivation, it means products high added value, such as micro greens, mushrooms or exotics that might benefit from urban heat islands.

After the above, it is important to point out that the type of urban agriculture has an impact on the amount of pollutants that the crops would be exposed to. For instance, indoor agriculture tends to minimize the risk of air pollution, nevertheless the energetical and economical impacts of this type of agriculture are elevated comparing the open-air agricultural systems.

FIG: Indoor urban agriculture
SOURCE: https://stories.rbge.org.uk/?s=polytunnel&searchsubmit=

POLICY MAKING
THE INTEGRATION OF URBAN FARMING

Achieving sustainable urban agriculture depends on policies and regulations as well as social norms and rules, which collectively compose a city's urban governance (Piso et al., 2019).

In other words, the regulatory processes should consider the state and market actors as well as the community members and their organizations. Though urban agriculture practices are expanding globally, the policies and regulations are still emerging, specially in developing countries.

The motivational frames of urban agricultural stakeholders' processes include eco-centric and entrepreneurial purposes, among them the participation of state, market, community formal and informal institutions, farming and community gardening to food-related organizations and education centers as Universities. Understanding the motivational frames of all participants, is vital for allying urban sustainability with governance. Policy makers not only have to anticipate how stakeholders will respond to interventions, but to legitimate the policies with the recognition and engagement of the community (Piso et al., 2019). The tools for inclusive participative processes for sustainable urban agriculture include demographic survey, interviews, among others.

UN-HABITAT (2002) stablishes the good urban governance is characterized by sustainability, decentralization, equity, efficiency, transparency and accountability, civic involvement and citizenship, and security and that these norms are interdependent and mutually reinforcing.

The wise governance mechanisms consider the environmental knowledge and social-ecological memory developed through collective activities. Besides, the urban farmers have the potential to develop valuable understandings of the local social-ecological system through their day-to-day agricultural practices (Piso et al., 2019). Regarding to communal participation and empowerment, the regulations should foster and facilitate the integrated work of transdisciplinary actors.

On the other hand, the governments should invest in building human capabilities so that all people are empowered and equipped to shape their lives and bring about collective change (United Nations, 2019). In other words, it is essential to create policies that promote skill building to empower the community in order to boost the productivity of urban farming and improve access to education and training, technical advice, and financial support.

The orientation of the policies related to sustainable urban agriculture should include the formal acceptance of urban agriculture as an urban land use and also facilitate the access to vacant open urban spaces through urban planning.

The urban agriculture system should facilitate and promote the public and private investments in technology and innovations to sustain agricultural productivity growth.

Moreover, the policies, should take measures that prevent/reduce health and environmental risks associated with urban agriculture, including sectoral coordination between health, agriculture and environmental departments. The legislation should give appropriate tools about nutritional values and risk management about food safety standards that consider the contaminants and pollutants related to urban agriculture.

The urban agriculture policies must consider the current and future environmental challenges and regulate the production of sustainable food in the face of climate change.

3

SUSTAINABLE STRATEGIES FOR URBAN AGRICULTURE

theoretical approach

URBAN AGRICULTURE SYSTEMS
OVERVIEW

> *The invention, adaptation, and dissemination of new technologies in order to grow the agricultural productivity depends on farmers adopting a steady stream of new farm practices and technologies that enable them to raise yield, manage inputs more efficiently, adopt new crops and production systems, improve the quality of their products, and conserve natural resources.* (Fugle et al., 2020)

Nowadays, urban agricultural (UA) systems appear in many forms and technologies with the potential win-to-win scenarios related to societal and environmental benefits. "Thanks to technological devices such as sensors, LED and systems connected remotely, it is possible to recreate an environment dedicated to agricultural production in the total absence of soil and with reduced water consumptions up to 80%" (Negrello, 2018).

Furthermore, with the evolution of dynamic systems and the globalization of a sustainable "urban farming culture", the cost decreases, more renewable energy sources appear and food grown in the urban cores may become accessible to more people, with a year-round production.

Among all commonly used urban agriculture systems, different levels of efficiency and costs. One of the most widely known is the Greenhouse system, whose introduction in urban tissues and proper local adaptation, can ensure food security with significant social effects.

GREENHOUSES
FOR URBAN AGRICULTURE

The use of solar greenhouse systems for agricultural purposes has been used around the world for many years. Its primary objective is the production of high value crops outside the cultivation seasons, without relying on favorable weather conditions. This is possible by controlling the optimum light, temperature, fertilization, and other growing conditions in all stages of the crop in an enclosed area.

Traditionally, most of greenhouses consisted in low-investment controlled environments with basic structures with simple plastic covers in open fields. However, modern greenhouses operate as a system, therefore, they are more sophisticated and equipped with new computerized technologies such as Controlled Environment Agriculture (CEA), controlled environment plant production system (CEPPS), or Phytomation systems. (Shamshiri et al., 2018). The aim is to control temperature, humidity, light and gases to maximize the production of particular crops, with the potential to reduce (or eliminate) the need of pesticides and herbicides.

“Successful deployment of CEA for urban agriculture requires many components and subsystems, as well as the understanding of the external influencing factors that should be systematically considered and integrated” (Shamshiri et al., 2018).

The introduction of urban greenhouses has the potential to allow people that live in the city with limited space, to be more self-sufficient and to have a closer access to fresh food with more efficiency, minimizing environmental production impacts and optimizing unused space.

“Several factors to be considered in designing of a viable greenhouse system for producing year-round crops and vegetables are the structure frame, landscape, topography, soil, climate conditions, microclimate control system, light condition, intercepted solar radiation, windbreaks, the availability of electricity, and labor force” (Shamshiri et al., 2018). When incorporated within an integrated food program, urban greenhouses have the potential not only to provide food security, but also to increase social benefits related to employment, social cohesion, participation and leaning about gardening, from seed to harvest.

The common metabolism of greenhouse devices is directly connected in terms of energy, water and CO2 flows. Besides the use of new technologies and calculations go towards systems with more environmental benefits, such as reuse of water, application of residual heat and absorption of carbon dioxide.

FIG: Greenhouse 2.0
SOURCE: https://lahuertadigital.es/invernadero-2-0/

GREENHOUSE CLASSIFICATION

- WORKING PRINCIPLES
  - a) Passive
  - b) Active
- SHAPES
  - a) Spherical dome
  - b) Hyperbolic paraboloid
  - c) Quonset
  - d) Modified quonset
  - e) Gothic arc
  - f) Mansard roof
  - g) Gabic even span
  - h) Gabic uneven span
  - i) Modified arch
  - j) Modified IARI
- COST FACTOR
  - a) Low cost
  - b) Medium cost
  - c) High cost
- MATERIAL
  - a) Glass
  - b) Plastic film
  - c) PVC
  - d) Polyethylene
- UTILITY
  - a) Garden
  - b) Research
  - c) Parks

FIG: Classification of greenhouses based on different parameters.
SOURCE: (Sahdev et al., 2019)

CLIMATE CONTROL
WORKING PRINCIPLES

“The design of a greenhouse needs to have a balance between the structural design, the mechanical and physical properties of the materials and the specific agronomic requirements of the crop” (D. Briassoulis et al., 1997).

“The greenhouse microclimate is the result of heat and mass exchanges between the greenhouse layers, including heat transfers by conduction, convection, solar radiation and thermal radiation, as well as the latent heat exchanges” (Mashonjowa et al., 2013). **(figure).**

A greenhouse acts as a solar collector, in which heating is caused in part, by the selective transmission of solar energy and the reception of the infrared radiation from the soil and plants in the greenhouse by the covering material (Mashonjowa et al., 2009, Sethi and Sharma, 2008). For the greenhouse climate control, it is necessary to evaluate the potential climate dynamics inside the device during varying climatological conditions such as ventilation, temperature and solar radiation and the specific needs of the crops for their growth and development. Especially with regard to naturally ventilated greenhouses; the climatic conditions inside depend directly on the solar radiation intensity, the covering material, the external air temperature, the overall heat transfer coefficient, and the external wind velocity (Mashonjowa et al., 2013).

Regarding to air quality, factors such as air and root-zone temperature, humidity, carbon dioxide, air movement, dust, odors and disease agents should be considered.

It is required to have a proper ventilation, not only for temperature control but also to replenish carbon dioxide and control relative humidity. Relative humidity above 90% can originate disease problems and condensation on the internal roof.

Based on their working principles, these devices can be classified into active and passive greenhouses. The new trends tend to design the geometrical dimensions of greenhouses using computational fluid dynamics (CFD) by taking external weather data from local meteorological stations as reference boundary conditions.

The active greenhouses adapt the interior microclimate though greenhouse climate and crop technological models and the use of energy in order to enhance the properties and test the efficiency of design and climate conditions for an optimal production.

The passive greenhouses base on the local weather data and the use of sustainable strategies such as ventilation and coverage properties for the design and disposition of elements in order to improve the microclimate inside the device. To improve the greenhouse air temperature, including the cooling effect of crop transpiration in unheated greenhouses.

An appropriate heating or cooling system has substantial impact on the cultivation time, quality and quantity of the products. Thus, a proper understanding of the thermal behavior of greenhouses is critical in the selection of the most appropriate climate control strategies that give satisfactory performance in the agricultural production.

Based on the characteristics of the thermal control systems can be classified as heating systems, cooling systems and composite systems.

- *A heating system is used to increase the thermal energy storage during the day or to transfer excess heat from inside the greenhouse to the heat storage area. This heat can be recovered at night to satisfy the heating needs of the greenhouse. (Sethi & Sharma, 2008).*
- *A cooling system is used to lower the thermal energy from inside the greenhouse by various techniques such as ventilation (natural and forced), shading/reflection, evaporative cooling (fan-pad system, mist/fog and roof cooling) (Sethi & Sharma, 2008).*
- *The composite system is used heating the greenhouse in winter and cooling in summer. Currently, earth-to-air-heat exchanger system (EAHES) is the most successfully used composite system for agricultural greenhouses, it utilizes the underground constant temperature of earth mass to transfer/dissipate heat to/from the greenhouse. Recently, aquifer coupled cavity flow heat exchanger system (ACCFHES) has also been developed. It utilizes the constant temperature of deep aquifer water at the ground surface through an irrigation tube well for heating as well as cooling of the greenhouse (Sethi & Sharma, 2008).*

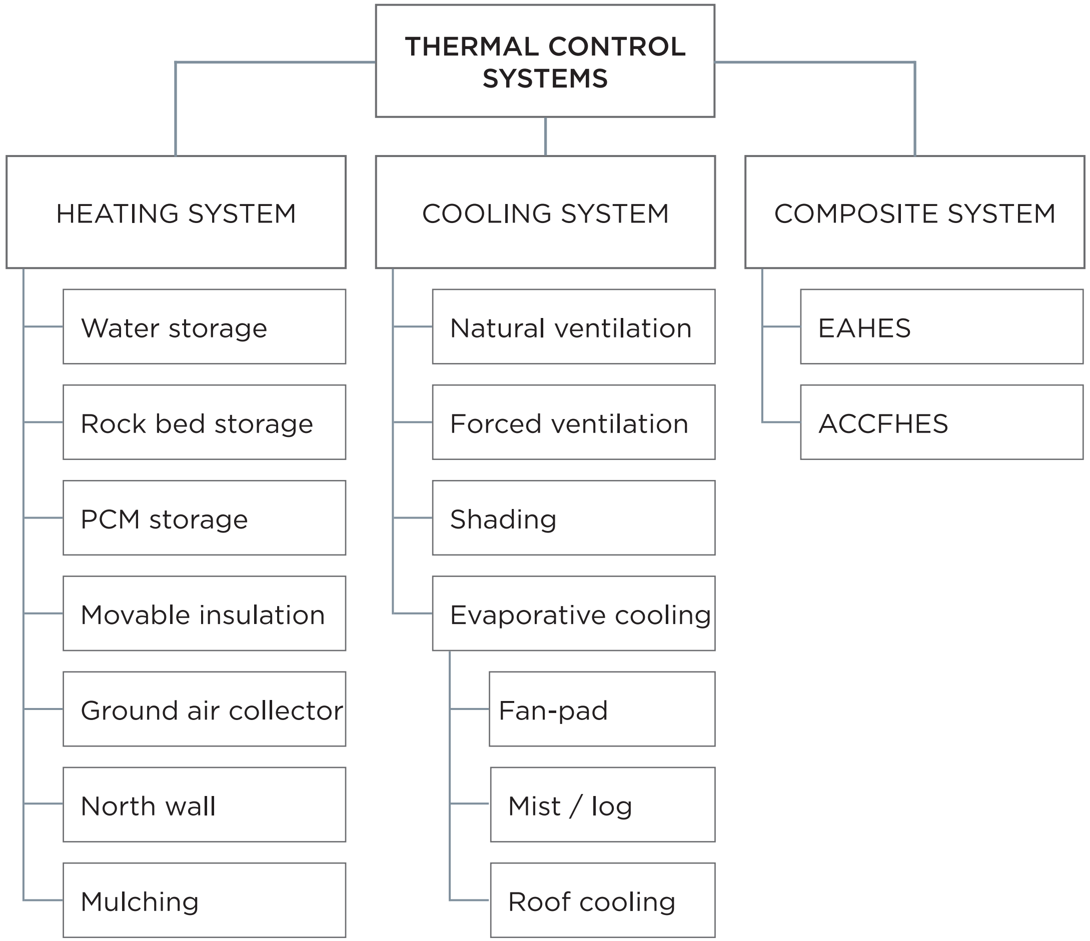


FIG: Classification of various thermal control systems for agricultural greenhouses
SOURCE: (Sethi & Sharma, 2008)

COVERING
MATERIALS

To obtain air temperature regulation during daytime, several options are available, among which ventilation (natural or forced), painting of the greenhouse cover, use of secondary covers, like a second film or shading nets and adding NIR-shielding products to the cover. All solutions except ventilation reduce PAR transmission into the greenhouse and, in turn, decrease photosynthetic activity. Therefore, the ideal target is a NIR absorber/ reflector, with a high PAR-transmittance. (Kempkes et al., 2008).

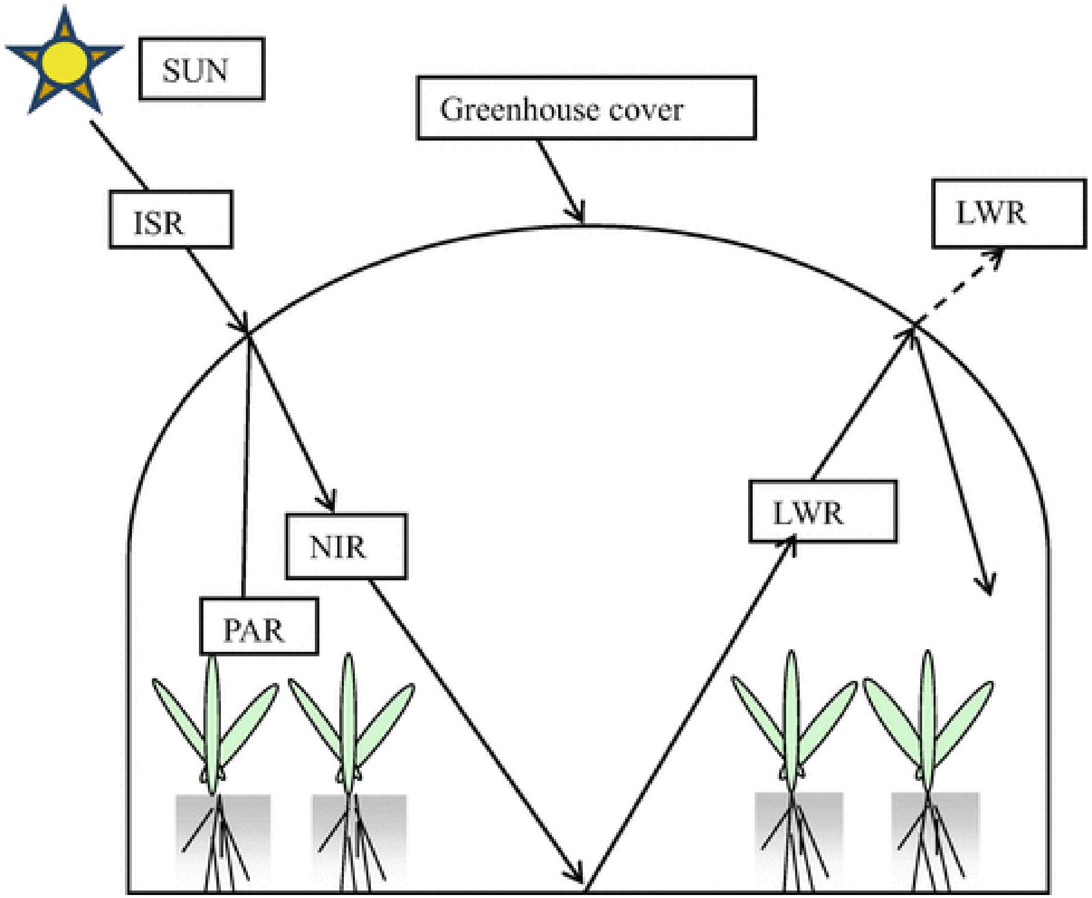
The cover material turns into a barrier to the outside conditions, the solar radiation intensity is decreased by reflection and absorption of the covering material. The selection of the covering materials of greenhouses represent an important decision in terms of efficiency and costs, it depends on its application, the type of crop to be cultivated, and the climate conditions.

"Considerations for greenhouse covering materials involve supporting foundation, shape and framing materials, geographical direction for optimal light entrance, the load of equipment, factors for static and dynamic loads (i.e., hanging plants, structure weight, and wind speed), dimension ratio, and volume" (Shamshiri et al., 2018).

Global radiation entering the greenhouse can be divided into ultraviolet radiation (UV, 300-400 nm), photosynthetically active radiation (PAR, 400-700 nm) and near infrared radiation (NIR, 700-2500 nm). Of the PAR waveband 95% is absorbed by the crop for photosynthesis and crop growth. NIR is partly (50%) reflected by the crop but will be absorbed by the construction elements of the greenhouse and indirectly increases air and plant temperature and contributes to transpiration. More than 80% of PAR energy is not used for photosynthesis but is dissipated as heat. The heating effect from global radiation in greenhouses is fully beneficial during cold periods, but in warm periods the air and plant temperatures can increase to undesirable levels so that crop growth and production will be affected or even become impossible (Kempkes et al., 2008).

In fact, as only about half of the energy that enters a greenhouse as solar radiation is in the wavelength range that is useful the plant's growth and development (PAR, Photosynthetically Active Radiation), lowering greenhouse temperature which is the main aim, may be achieved by excluding the NIR, thus, some materials or additives for greenhouse covers that reflect or absorb a part of the NIR radiation have recently become commercially available (Kempkes et al., 2008).

Nevertheless, there are several side-effects, that may become relevant in the passive or semi-passive greenhouses, such as a higher energy use in winter and a smaller impact on reduction of heat load as expected because of the high NIR reflection of the crop itself (Kempkes et al., 2008).



GLOBAL RADIATION ON A GREENHOUSE
SOURCE: (Thipe et al., 2017)

The condensation, radiation transmittance and diffusing properties of different types of covering materials condition the crops development inside a greenhouse. According to Shamshiri et al., the most dominant transparent materials in use are 2-3 mm glass panels, net-screen film, and 0.1 mm and 0.2 mm Polyethylene (PE) plastic films, and ultraviolet (UV) stabilized PE-filmm.

Among the available materials for covering there are:

SIMPLE COVERS
- One-layer plastic
- Double-wall plastic
- Glass

MORE DEVELOPED COVERS
- Fiberglass
- Double-wall plastic
- Acrylic sheet
- Polyethylene film
- Polyvinyl chloride (PVC)
- Copolymers
- Polycarbonate panels

With the development of solid materials with NIR-filtering, like plastic films or glass for greenhouses or sheets to be used as moveable screens or "whitewash" painting of the cover, the heat load of the greenhouse can be reduced (Kempkes et al., 2008).

On the other hand, the device requires protection against insect infestation with screens in the ventilating openings; however, in order to restrict the needed ventilation, there should be an optimal balance between of restricted natural ventilation and adapted optical cover properties.

	POLYETHYLENE PLASTIC FILM	GLAZING	ACRYLIC	FIBERGLASS	POLYCARBONATE
					
TYPES	simple double face with air space	single, double and triple layers, tempered or laminated glass	double wall 8mm, 16mm and 32mm	simple double	flat layer, twin-wall, or corrugated single-layer
DURABILITY	3-5 years	>30 years	15-20 years	5 years	10 years
INFRARED HEAT TRANSMITTANCE	50%	<3%	<3%		<3%
R-VALUE THERMAL EFFICIENCY	simple film R=0.87 double film 5mm R=1.5 double film 6mm R=1.7	4mm glass R=1.0 double layer R= 1.5-2.0 Triple layer + air space R=2.13	double wall R = 1.82	single layer R = 0.83 fiberglass bat insulation (15cm) R=19	6mm Twinwall R=1.54
U-FACTOR (heat loss rates)	single glass: 1.1 double layer: 0.7	single glass: 1.1 double layer: 0.7	double wall: 0.6	single: 1	Twinwall: 0.6
LIGHT TRANSMITTANCE (PAR)	single 85% - 87% double 74%-77%	single 88% - 94% double 77%	87%-93%	single 90% double panel 60-80%	single 94% double panel 83%
*OBSERVATIONS OF LIGHT TRANSMITTANCE	Diffused light prevents burning and aids photosynthesis	Potential to burn plants due to the level of clarity			Slightly diffused light prevent burning/scorching
ULTRAVIOLET (UV) wavelenghts (300-400 nm)	80%	60-70 %	44 %		18 %
RESISTANCE	Prone to rips and tears	Fragile to impacts	It is easily scratched	Vulnerability to sun exposure	Very tough and durable
CHANGES OVERTIME	sunlight and air pollution makes it brittle, causing it to shred and tear	Does not change its high light transmittance	Naturally UV resistant so it does not yellow with age	tend to swell and reduce light transmission	depending on quality, can be prone to clouding, or yellowing
PRICE	+	+++	+++	++	++++

DIFFERENCES BETWEEN MOST COMMON MATERIALS

LIGHT CONTROL

Light condition and air temperature are the two most significant environmental factors for plants growth, in fact, analyzing the data related to air temperature without considering lighting and plant evapotranspiration does not generate any useful data for maximizing yield and producing high-quality foods. It means that light and air temperature are intrinsically related, one cannot be optimized without considering the other (Shamshiri et al., 2018).

Greenhouses use natural or artificial light to get optimum growth conditions for producing horticultural crops. A proper design of light control also offers greater predictability, reduces the cost and increases the production for the year-round production of fresh vegetables in urban areas. The main methods for controlling lighting level are through planted density, shading screens, and artificial lights.

PLANTED DENSITY

Designing a suitable planting density has the potential to increase crop water output and improve light capture.

SHADING SCREENS

With these elements, the amount of solar radiation and light intensity that reach the plants is limited, creating a reduced difference between air temperature inside and outside the greenhouse. Shading also decreases leaf surface temperature significantly. While a 20% to 80% light decrease can be expected depending on the shading materials, the sufficient light reduction for most applications is between 30% and 50% (Shamshiri et al., 2018).

Moreover, shading facilitate the natural ventilation process and protects plants from excessive exterior conditions such as sunlight, wind, and heavy rains, etc.

ARTIFICIAL LIGHT

The most common are incandescent/halogen lamps, discharge lamps (such as fluorescent light tubes, Metal Halide, and high-pressure sodium lamps), and the Light-emitting diodes (LEDs).

Among the artificial lights, LEDs have gained popularity due to their advantages related to cost efficiency by reducing the cost of electricity, compact design that allows to structure vertical layer of plan production while decreasing the costs of cooling, durability, light quality, and low thermal energy generation (Shamshiri et al., 2018).

The benefits of using LEDs in urban agriculture have being debated because of the necessity of using information and communication technology (ICT). Nevertheless, the incorporation of ICT into urban agriculture is economically viable because the decreasing costs of information processing, storage, and transfer. Moreover, electricity can be generated from renewable resources such as solar energy and biomass. (Kozai, 2016)

FIGURE:
The Terramera Greenhouse
SOURCE: https://www.greenbiz.com/article/we-need-think-beyond-urban-farming

STRUCTURE AND SHAPE

Microclimate, ventilation, and light transmittance are mainly influenced by the properties of the net-screen mesh and the greenhouse shape. While these structures enhance natural ventilation in hot and humid climate conditions, they still require strong shelters for protecting plants from extreme solar radiation, rain, and strong winds.

It is important to consider the structural characteristics that enable greenhouses to carry out their specified functions, following the stablished conditions related to construction and operation costs, efficient mechanical properties, efficient ventilation systems, low heat consumption, and allowance of high light transmittance. Furthermore, the design of a greenhouse has to consider the particular geographical requirements, in order to be adapted to the vital specific needs. And, to avoid losses or damages, standard maintenance or repairing methods based on technical requirements should be followed. (Maraveas, C. & Tsavdaridis K.D., 2020).

The structural set-up can be realized with steel or aluminum structures which are designed based on standards, and low-cost greenhouses designed by farmers with wood frames.

The structural layout of a greenhouse is designed according the covering material. For instance, the use of glass panels as a covering material requires a compact network of the main structure to make the roof, since glass panels are small and heavy, with a limited capacity to resist significant displacements and deflections of the supporting system. Alternatively, using flexible plastic films or other similar materials, can be combined with lightweight steel structures that can be designed to give different geometric types of covering materials. (Maraveas, C. & Tsavdaridis K.D., 2020).

The geometry of a greenhouse affects both the structure and the microclimate. The most common shapes are showed in the **figure**, being the even-span roof and the Quonset shape the most commonly used for crop cultivation. This is because, it has been proven that for passive systems, these shapes receive optimum solar radiations during winter and summer.

There are two main forms of geometries with relation to single and multi-span greenhouses. Thus, single-span greenhouses have duo-pitch or vaulted roofs, whereas those with a multi-span geometry have vaulted or planar pitched roofs (Maraveas, C. & Tsavdaridis K.D., 2020).

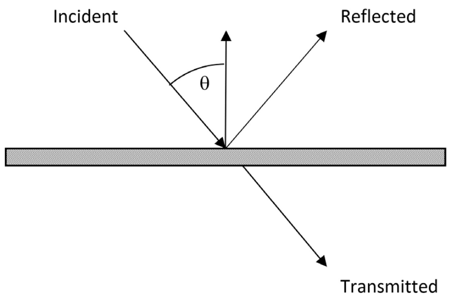
The selection of the proper orientation is of vital importance. It also depends on the geometry and slope of the roof, the latitude where it is located and the sun elevation. Specially for greenhouse systems that may depend in different levels on the natural sun light and air circulation.

For a maximum optimization of solar radiation, the orientation of greenhouses is generally east–west for the year round. It receives more solar radiation in the colder months, when radiation particularly is lower, and less solar radiation in the summer.

The greater the angle of incidence of the sun, the lower the percentage of reflected radiation and therefore the greater the percentage of radiation that penetrates inside the greenhouse.

TABLE:
Angle of incidence of light on the roof and percentage of reflection of incident light

Angle of incidence	% of reflection
90°	0
70°	8 - 16
30°	30 - 40
0°	100



Another aspect to be considered is the expected life of the design, moreover, the life span of the cladding may vary from the working life of the structural system. Besides the level of technologies used and the dependance on natural resources have an impact in the cost of the greenhouse. Based on Cost factor or technology involved, the greenhouse systems can be classified by:

- Low cost / Low-tech greenhouse.
- Medium cost /Medium - tech Greenhouse
- High cost / Hi-tech Greenhouse

However, the cost of increased automation level, may be balanced with the increases in production, quality and profitability.

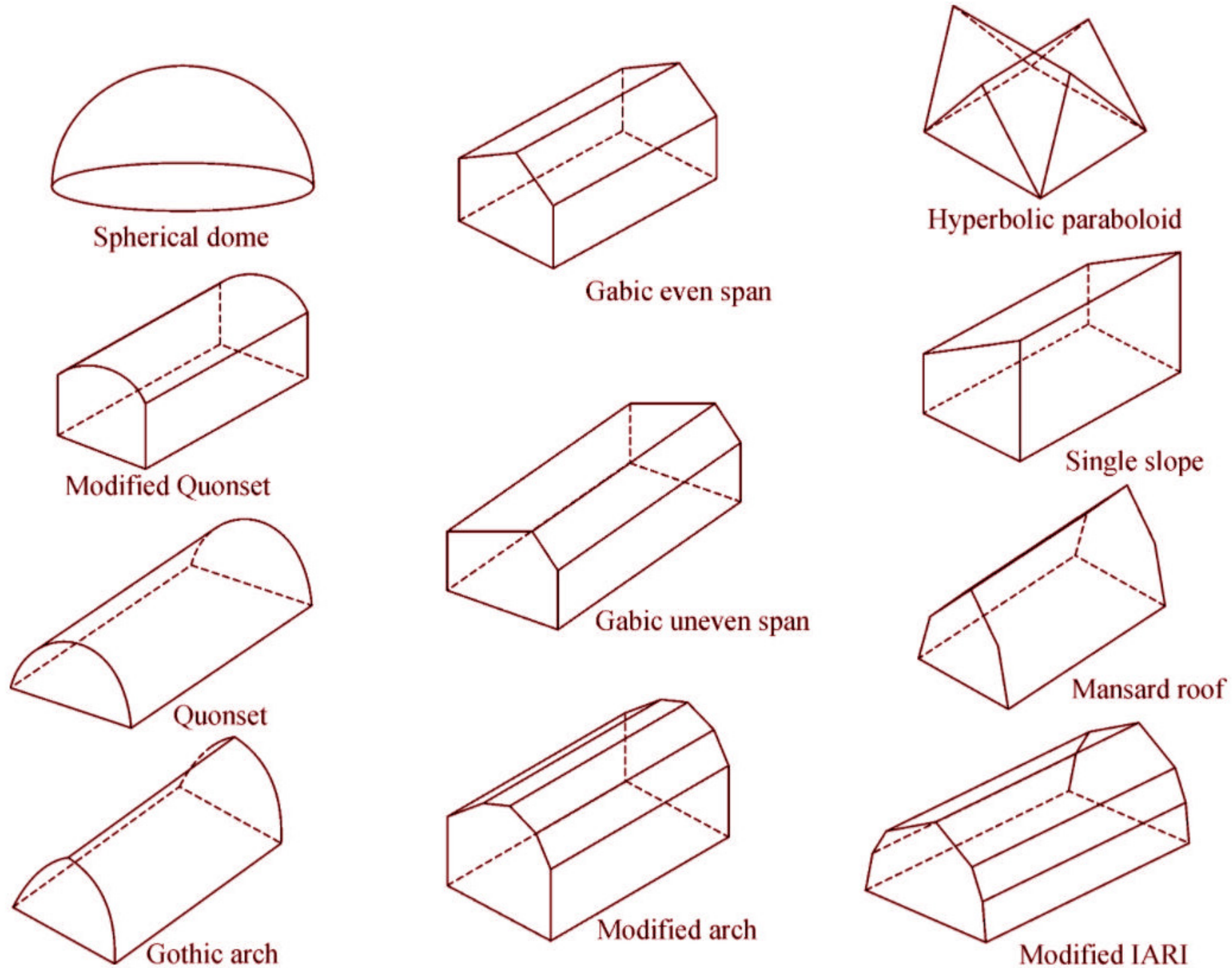
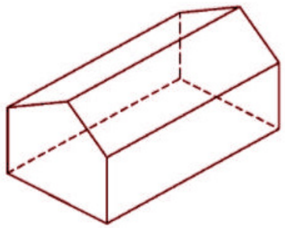
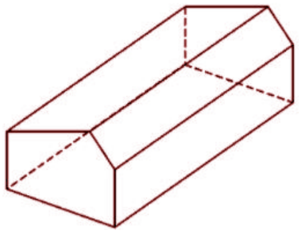


FIG: Different shapes of greenhouses
SOURCE: (Sahdev et al., 2019)

CHARACTERISTICS OF THE MAIN SHAPES OF GREENHOUSES

	GABIC EVEN SPAN	GABIC UNEVEN SPAN
		
STRUCTURE	Metallic or wood	Metallic or wood
CLADDING	Rigid or flexible	Rigid or flexible
HEIGHT	Lateral: 2,0-2,5m. Ridge: 3.00-4.00 m	
WIDTH	12.00 - 16.00 m	
WIND RESISTANCE	Good resistance to winds	Good resistance to winds
RAIN RESISTANCE	Easy snow and water runoff	Easy snow and water runoff
LIGHT DISTRIBUTION	Good distribution of light inside but more shadows	Good distribution of light inside but more shadows
VENTILATION	Vertical ventilation in walls can be done on large surfaces, with simple mechanization. Overhead windows can be also installed.	Vertical ventilation in walls can be done on large surfaces, with simple mechanization. Overhead windows can be also installed.
INSTALLATION	Fast installation	Medium installation
FUTURE EXTENSION	Can always be extended in length Allow the attachment of several greenhouses in battery	Can always be extended in length Allow the attachment of several greenhouses in battery
RAIN WATER	Allows rainwater collection	Allows rainwater collection
COST	+	++

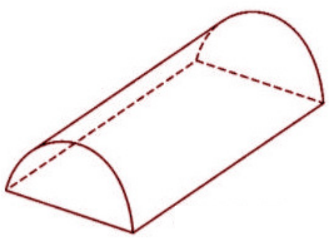
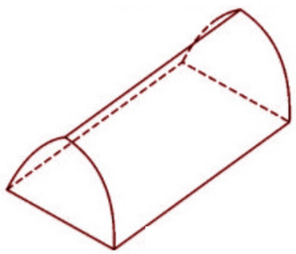
	QUONSET	GOTHIC ARCH
		
STRUCTURE	Metallic prefabricated structure	Metallic structure. *This method eliminates the need for structural trusses.
CLADDING	Flexible	Flexible *Less construction materials
HEIGHT	3.50 - 5.00 m	Ridge: 3.50 - 5.00 m. * Sidewall height is low, which restricts storage space and headroom
WIDTH	6.00 - 9.00 m	6.00 - 9.00 m
WIND RESISTANCE	Great resistance to strong winds	Great resistance to strong winds
RAIN RESISTANCE	Easy snow and water runoff	Easy snow and water runoff
LIGHT DISTRIBUTION	Good distribution of light inside	Good distribution of light inside
VENTILATION	Allows the installation of overhead ventilation to leeward and facilitates its mechanized operation	Allows the installation of overhead ventilation to leeward and facilitates its mechanized operation
INSTALLATION	Simple and fast installation	Simple and fast installation
FUTURE EXTENSION	Can always be extended in length Allow the attachment of several greenhouses in battery	Can always be extended in length Allow the attachment of several greenhouses in battery
RAIN WATER	Does not take advantage of rainwater	Does not take advantage of rainwater
COST	+++	++

FIG: Soil cultivation of vegetables
SOURCE: EcoValley

CULTIVATION SYSTEMS
GREENHOUSES

The ultimate objective in the cultivation techniques is to achieve high yield and high-quality products at minimum possible cost. For the cultivation of crops, there should be considered morphological and physiological conditions such as multiplication, rooting, transplanting, pruning, water and nutrient delivery, pesticide application, harvesting, etc.

Factors such as CO2, soil pH, nutrients, light, water, are an important part of growing systems.

Plants transform light energy to chemical energy by the process of Photosynthesis. Regardless the growing system, the plant roots need oxygen for respiration of photosynthate, some plants, have roots that are able to get enough oxygen while growing in standing water. Nevertheless, most of the plants have higher oxygen requirements.

Among the several ways of cultivation in greenhouses, the traditional one is the use of the existing soil on site, also known as in-ground culture, where crops are raised on ground level as well as in mounted beds.

The plants derive water, nutrients and minerals from soil; thus, it can be improved by applying sufficient amount of organic matter such as compost. Moreover, soils must be well-drained and to have a medium to light texture.

For the cultivation in greenhouses, fumigation or pasteurization of the soil should be done before each crop or at least once a year. This will help to fight against diseases, nematodes and weeds. Production techniques used in soil culture are similar to intensive crop production methods used in the field.

However, it has been demonstrated that plants can also grow without soil if they are provided with a nutrient-rich solution and fulfil their oxygen demand, this technique is called hydroponic.

COMPARISON BETWEEN HYDROPONIC SYSTEMS AND SOIL-BASED CULTURE

SOURCE: (Lee & Lee, 2015)

ISSUES	HYDROPONIC SYSTEM	SOIL CULTIVATION
Land usage and effect of environment	Less affected by soil and external factors Indoor system; easy nutrient control; control of the environment such as temperature, humidity and lighting time; cultivation all year round everywhere.	Unsuitable if soil is contaminated with heavy metal and plant disease; Limited by nutrients in soil; hard to control external environments; cultivation all year round is limited in certain areas.
Labor	Traditional practices are largely eliminated.	Cultivating, weeding, watering, tilling and additional practices.
Sanitation	Easy handling of medium and all materials and maintaining sanitary conditions.	Difficult to sanitize soil and equipment; hard to maintain sanitation conditions consistently.
Water	Efficient water usage; water can be recycled or reused; no nutrient waste due to water runoff; Water goes directly to root areas; possibility of controlling water-holding ability by using different kinds of medium.	Inefficient water usage; water cannot be recycled or reused; eutrophicastion of the environment due to run-off; hard to control water-holding capacity.
Fertilizers and nutrient solution	Even distribution to crops; efficient use of fertilizers and saving the cost; easy control of pH and amount of nutrient.	Uneven distribution to crops (partial deficiency); often use of excessive amount of nutrient; high variation, hard to control pH and amount of nutrient.
Quantity and quality of crop	Stable and even amount of production; tomato,14–74 kg per m2; cucumber, 6900 kg per m2; lettuce, 5200 kg per m2; bean, 5 kg per m2; even quality of production	Unstable and uneven amount of production due to pests/soilborne pathogens; tomato, 1.2–2.5 kg per m2; cucumber, 1700 kg per m2; lettuce, 2200 kg per m2; bean, 1.2 kg per m2; uneven quality of production

HYDROPONIC CULTURE

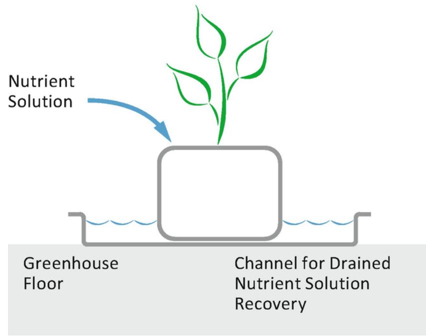
The definition of hydroponics involves all the systems that provide plant production in soilless conditions in which the supply of water and of minerals is carried out in nutrient solutions with or without a growing medium (e.g. stone wool, peat, perlite, pumice, coconut fiber, etc.) (Maucieri, et al., 2019). According to the hydroponic system, oxygen is pumped through, pH level is regulated and sufficient light is provided to carry out photosynthesis, creating a system that is more efficient than soil systems. It is the fastest growing and second generation of crop production system in agricultural industry.

ADVANTAGES	DISADVANTAGES
- Pathogen-free start with the use of substrates other than soil and/or easier control of soil-borne pathogens. - Growth and yield are independent of the soil type/quality of the cultivated area. Plants can be grown anywhere, underground, rooftops and greenhouses - Better control of growth through a targeted supply of nutrient solution. - The potential for reusing the nutrient solution allowing for maximizing resources. - Efficient use of fertilizers - High quality of products due to the better control of other environmental parameters (temperature, relative humidity) and pests. - Use of less space for cultivation. It achieves up to five times more productivity in less space due to the reduction of substrate and therefore the lightening of the crop weight, reducing loads of cultivation. - Reduction of water consumption, due to water recirculation. The irrigation water is supplied directly to root areas - Plants grow faster, so the yield is higher	- Higher initial costs for setup supplies and continuous maintaining costs. - Technical problems can lead to plants death within hours - Contamination spreads quickly and affects a lot of plants - Investment in an efficient ventilation system - Use of artificial lights increase electricity costs - Hydroponic system requires follow-up and maintenance all the time. Moreover, requires experts to maintain the systems for optimum production. - System setup needs extensive technical knowledge - Growth of unwanted algae and fungus in nutrient solution - Not all plants are available for hydroponic systems - Generation of waste materials and hydroponic waste solution containing high nutrients

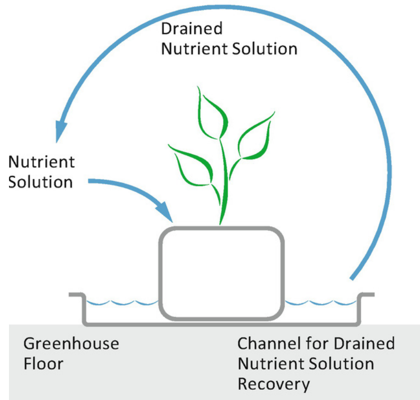
The hydroponic systems, can be divided into open systems (figure 1), where the surplus nutrient solution is not recycled, and closed systems (figure 2), where the excess flow of nutrients from the roots is collected and recycled back into the system (Maucieri, et al., 2019).

Types of Hydroponic Systems:

1. DRIP SYSTEM
   This is the most commonly used system. The water reservoir is separated from the rest of the system by using a container in which excess solution is stored. The solution is pumped from the reservoir and is controlled by a timer. Besides, plants are held in individual containers and its substrate material. Solution in excess falls through plant roots to the bottom of the grow tray, and through an overflow drain that leads back to the reservoir. Nutrient concentrations and pH levels must be monitored during the growing progress.
2. EBB & FLOW (FLOOD & DRAIN) SYSTEM
   It is similar to the previous system, with the exception of how the plants receive the solution with nutrients. On this system, all the nutrient solution is pumped up from the reservoir and is delivered directly to the bottom of the grow tray. For this type of cultivation, the containers should have the same type of plant, because of the possible different requirements of solution that may need each crop.
3. NUTRIENT FILM TECHNIQUE (NFT)
   Plants are also placed in individual containers in a grow tray separated from the reservoir and the system operates by pumping the solution from the reservoir into the grow tray. However, the grow tray is fixed in a slightly slanted position to enable continuous flow across the tray, forming a thin film of nutrients that flows over the roots. The solution drains back into the reservoir, where the water is oxygenated. Besides, the system requires far less maintenance than the previous systems.
4. WICK SYSTEM
   It is the most-cost effective type of hydroponic systems. Even though a reservoir and grow tray are used as in the systems above, no pump is used to take the solution from the reservoir to the grow tray. Instead, the solution is "wicked" constantly by using a highly absorbent material from the reservoir to a growth medium, such as s perlite, vermiculite, and coconut fiber.
5. DEEP WATER CULTURE (DWC) SYSTEM
   It is also a simple system to build and maintain. There is no separate grow tray and each plant is held in its own container. The containers are built into a floating platform on top of the reservoir, on this way, the roots grow downward directly into the nutrient solution.
   Air stones are essential for oxygenation because the solution is not circulating, moreover, as roots are submerged all the time, just specific plants are suitable for this system, among them water-rich vegetables such as lettuce and tomatoes.

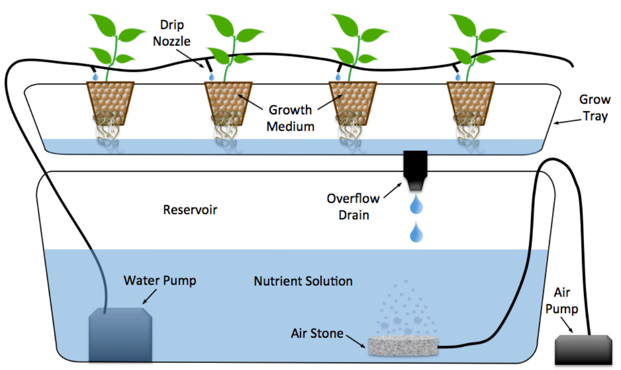


OPEN CYCLE SYSTEM

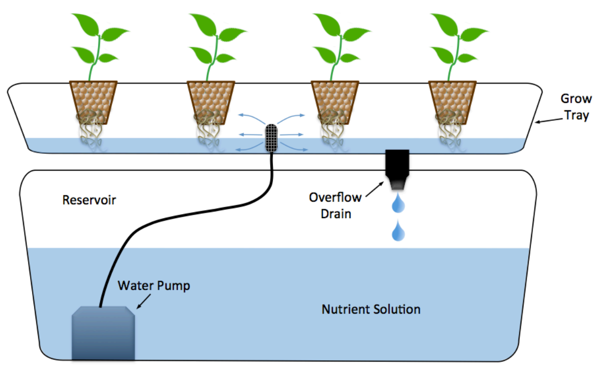


CLOSED LOOP SYSTEM

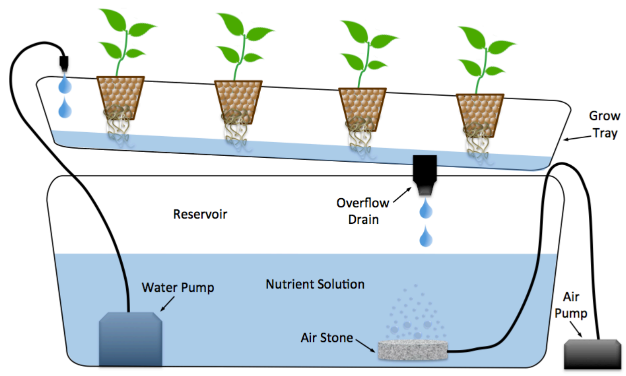
SOURCE: (Maucieri, et al., 2019).



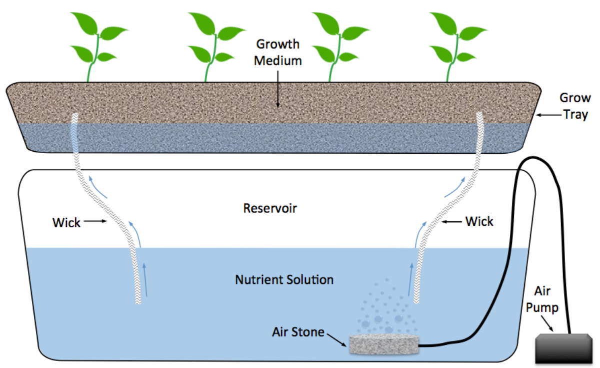
1. DRIP SYSTEM



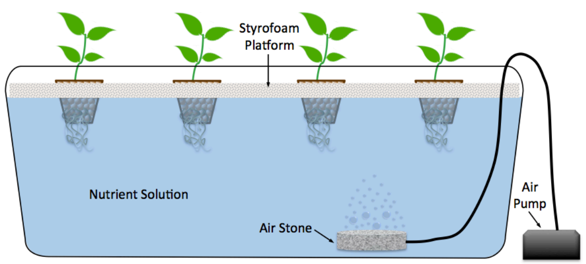
2. EBB & FLOW (FLOOD & DRAIN) SYSTEM



3. NUTRIENT FILM TECHNIQUE (NFT)



4. WICK SYSTEM



5. DEEP WATER CULTURE (DWC) SYSTEM

FIGURE 1: DRIP SYSTEM
FIGURE 2: EBB & FLOW (FLOOD & DRAIN) SYSTEM
FIGURE 3: NUTRIENT FILM TECHNIQUE (NFT)
FIGURE 4: WICK SYSTEM
FIGURE 5: DEEP WATER CULTURE (DWC) SYSTEM
SOURCE: https://offgridgorilla.com/off-grid-systems/food/hydroculture-hydroponics/

CLASSIFICATION OF HYDROPONIC SYSTEMS ACCORDING TO DIFFERENT ASPECTS

SOURCE: (Maucieri, et al., 2019).

CHARACTERISTIC	CATEGORIES	EXAMPLES
Soilless system	No substrate	NFT (nutrient film technique)
		Aeroponics
		DFT (deep flow technique)
	With substrate	Organic substrates (peat, coconut fibre, bark, wood fibre, etc.)
		Inorganic substrates (stone wool, pumice, sand, perlite, vermiculite, expanded clay)
		Synthetic substrates (polyurethane, polystyrene)
Open / closed systems	Open or run-to-waste systems	The plants are continuously fed with "fresh" solution without recovering the solution drained from the cultivation modules.
	Closed or recirculation systems	The drained nutrient solution is recycled and topped up with lacking nutrients to the right EC level.
Water supply	Continuous	NFT (nutrient film technique)
		DFT (deep flow technique)
	Periodical	Drip irrigation, ebb and flow, aeroponics

PLANTS FOR HYDROPONIC AND SOIL CULTIVATION

HYDROPONIC	SOIL
- Strawberries	- Watermelon
- Potatoes	- Squash
- Tomatoes	- Corn
- Mint	- Pumpkin
- Basil	** Plants that are not self-pollinated
- Lettuce	**Flowering plants
- Cabbage	
- Green beans	

FIG: Hydroponic growing
SOURCE:https://www.portalfruticola.com/

4

CASE STUDIES

1 CASE STUDY

EstoNoEsUnSolar - 2010
/this is not a plot

PATRIZIA DI MONTE
IGNACIO GRAVALOS LACAMBRA
/ GRAVALOS DI MONTE ARQUITECTOS

Zaragoza - Spain

ESTO NO ES UN SOLAR
/this is not a plot

PATRIZIA DI MONTE
IGNACIO GRAVALOS LACAMBRA
/ GRAVALOSDIMONTE ARQUITECTOS

Year: 2010
Location: Zaragoza - Spain
People involved: Local municipality (Zaragoza), architects (Patrizia Di Monte e Ignacio Grávalos), citizens, and community groups.

The programme takes place in Zaragoza, which was struck simultaneously by two problems: the abundance of underused public spaces that triggered anti-social behavior, and an economic crisis that caused high rates of unemployment.

The project was originally launched as an employment programme to boost the local economies affected by the crisis. Despite its very low budget, "estonoesunsolar" pursued to reintegrate the unemployed citizens back into the labor by recycling abandoned plots in the historic center of the city.

The empty sites in the Old Town are mostly located in the districts of San Pablo and La Magdalena, areas with progressive deterioration and a high degree of social conflicts. The abandonment of plots, generally converted into garbage dumps, contributes to the degradation of the streets and public space, which affects not only the aesthetics of the urban landscape but also presents very low health and sanitary conditions, insecurity, etc. With the above, several associations of residents asking the Municipal Government for solutions.

The programme is the result of the proposals from architects, groups and associations of residents, and was channeled thanks to the institutional support, the Municipal Board of the Old Town and being managed by Sociedad Municipal Zaragoza Vivienda.

The proposal for the solution of the addressed problems was the program "estonoesunsolar", which base is the socio-spatial regeneration through the employment of citizens to collaboratively regenerate the public spaces. Re-cycling vacant lands in temporary public space through citizens engagement (esto no es un solar).

The programme began in 2009 in 14 plots in the Old Town and then in 2010 was extended to the all-city, recycling other 14 urban voids in public space. In total, the project was implemented in 29 empty plots, resulting in 42,000 m² of public space added to the city (Franco, 2014b).

With the participation of private and public actors, it promotes the temporary occupation of the urban voids left in the city in order to reach a 100% of use. The aim is the cleaning, recovering, maintenance and rehabilitation and the resulting products are lively communal spaces with a new meaning that offer the possibility for collective learning and urban sustainable development.

As on urban acupuncture projects, all the sites -public and private- have been strategically chosen. From the long list of interventions, all of them have a concept that responds to the necessities of landscape and the residents.

FIG: SAN PABLO C DISTRICT/ ARMAS 94 / Urban agriculture
SOURCE: Esto no es un solar

In terms of social dynamics, the plots were planned as places for participation and exchange through the revitalization of specific depressed areas of the city with new uses and parallel activities. Despite the complexity of managing social relations, the project has empowered the citizens and originated a sense of belonging and participation in all stages. Besides, since its creation, 110 people have found a job thanks to a plan destinated vulnerable citizens.

The new projects not only promoted the communal participation in tasks as cultural, educational, agricultural, artistic, etc. But also created the opportunity to share experiences and bring together with citizens from different backgrounds in order to think together about the future of their neighborhoods.

There have been built recreational areas for children, urban farms, sport tracks, leisure areas, parks, pétanque courts, ping-pong sites, resting places for the elderly, etc. Fomenting alternative way of transportation and sustainable development with the management of collective groups interested in their use.

Regarding with the environmental impact of the interventions, more than 160 trees have been added to the urban voids converted into parks and children playgrounds. Besides, due to the very low budget (only 24 euros x m²), the use of recycled materials as pallets and wood was part of the process.

With respect to urban agriculture, thanks to the participation of citizens, new vegetable gardens are grown, and nowadays, neighbors have their own vegetables and use these areas as a place where to meet, where their children can study while they are planting (Citymart, 2014).

"Something very important regarding the temporality, is that it allows you to take more risks; people are very afraid of being wrong, but if it is temporary, they show a lot of flexibility to experiment" Grávalos in (Muzzi, 2020).

Nowadays some of the projects have suffered deterioration in different levels due to the vandalism, the consequent discontinuity of citizen participation and the lack of maintenance from the public administration.

PHOTOS:
SAN PABLO C DISTRICT/ SAN BLAS 94/
Botanical garden + green wall
SOURCE: Esto no es un solar


1


estonoesunsolar
LANTANA

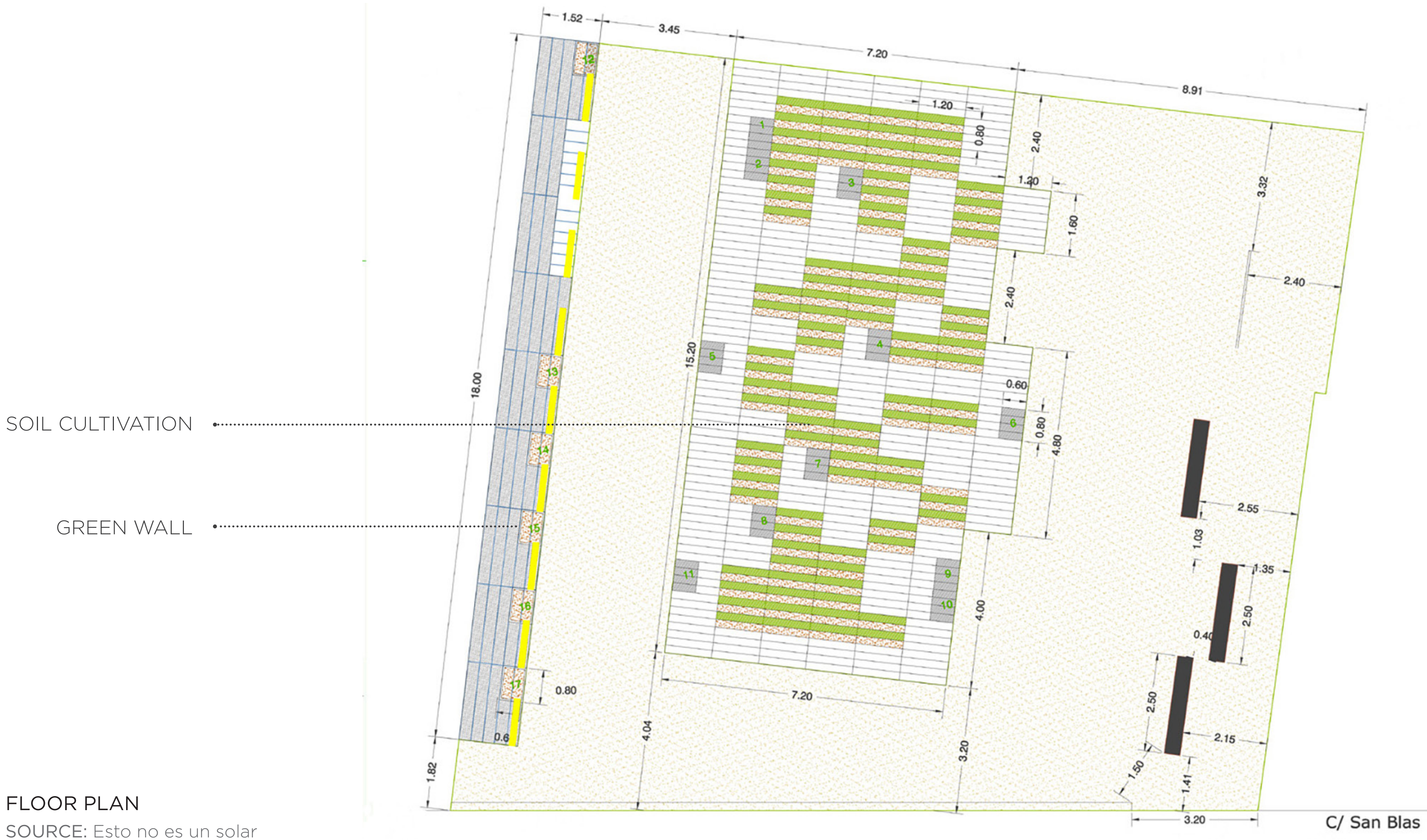
PROJECT: **SAN BLAS 94**
Botanical garden + Green wall

This intervention had a special character because it was the first experimental intervention and the first approach with the citizens. The proposal is emplaced in an empty plot surrounded by buildings along three sides and opens to the street on one side.

The project was achieved first by the collocation of a green carpet built with wood pallets that configure a thematic garden with four areas with different characteristics, shrubs, plants with flourishes that will alternate according to the seasons and aromatic plants of lavender, rosemary and thyme which contribute with their perfumes to the space. Secondly, the intervention includes a light structure mounted on a scaffold to house hanging plants. Besides, the project has some benches and bicycle parking.

This project is linked to education centers for the promotion of educational and recreational activities.

Green wall / SAN BLAS 94
SOURCE: Esto no es un solar



FLOOR PLAN

SOURCE: Esto no es un solar

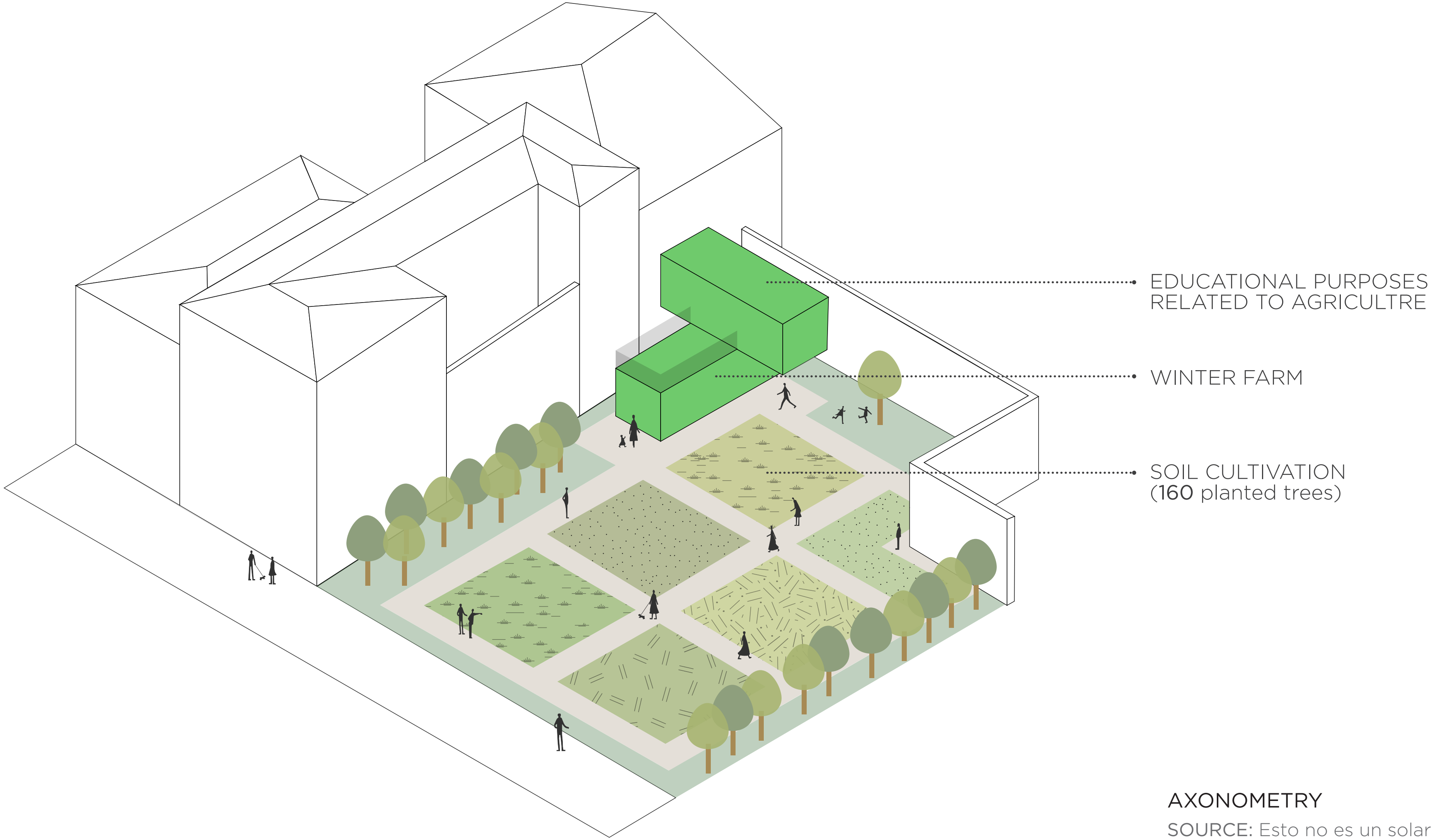
PROJECT: **ARMAS 94**
Urban agriculture

The idea of this urban vacant lot is the creation of a shared urban orchard. There were two superimposed green metal containers in one corner of the lot, which serve as storage space, winter small crops and with an area destinated for recreational and educational purposes related to horticulture

In order to guarantee the potential advantages of having heterogeneous citizens from different backgrounds working towards one common objective, a selected a group of users was selected: the public-school Santo Domingo, the children´s association Cadeneta y Gusantina and the Elderly Center San Blas.

The proposal creates a net on a small scale with green spaces with the aim of giving cohesion to the neighborhood. The lot is fenced and is used exclusively by the neighbors and the owners of the gardens.

VIEW FROM CONTAINER / ARMAS 24
SOURCE: Esto no es un solar



AXONOMETRY

SOURCE: Esto no es un solar

FRONT VIEW

SIDE VIEW

POSITIVITE LEARNINGS:

- MUNICIPAL POLICY
  for urban voids transformation
- MULTIPLE STAKEHOLDERS:
  Schools, elderly community, children
- Neighborhood cohesion
- Job generation
- Educational purposes
- CULTIVATION SYSTEM:
  Traditional soil cultivation

PHOTOS AND VIEWS:
SAN PABLO C DISTRICT/ ARMAS 94 /
Urban agriculture
SOURCE: Esto no es un solar

2 CASE STUDY

Vertical Harvest - 2016

NONA YEHIA / PENNY MCBRIDE

Jackson, Wyoming

VERTICAL HARVEST

NONA YEHIA / PENNY MCBRIDE

Year: 2016
Location: Wyoming - US
Partnerts: Town of Jackson and Vertical harvest

Vertical Harvest is an innovative tree story greenhouse located in the built urban environment of the town of Jackson Hole, Wyoming. A region with a 4-month growing season and characterized by its high elevation (6200 ft above sea level), and extreme climate conditions with temperatures far below zero and snowstorms.

The greenhouse contributes to food security by ensuring constant food supply that does not depend on weather and environmental conditions and on the other hand, it fosters self-sufficiency in communities.

The Vertical Harvest is an impact-driven business that builds and runs cost-effective and profitable hydroponic farms and grows over 30 different crops the 365 days of the year (100,000 pounds of fresh lettuces, tomatoes, herbs, and microgreens annually).

The Vertical Harvest is a startup greenhouse whose building is emplaced in 4,500 square feet of land owned by the city. The construction is property of the city and the business is managed by the organization which is registered as a “low-profit” limited liability company, meaning that it has stated social goals outside of simply maximizing income.

This indoor urban agriculture system has positive effects considering the water and land shortages and the impacts related to climate change in the traditional outdoor agriculture production. According to the co-founders, the Vertical Harvest is able to grow five acres worth of vegetables on 1/10th of an acre compared to traditional agriculture systems.

The project is based in a scalable Controlled Environment Agricultural (CEA) operation that increases productivity and production using small urban land. Furthermore, by decreasing the external food supply, this sustainable agriculture method reduces the negative environmental impacts of transportation.

In order to adapt to the necessary conditions, the interior ecosystem of the building is complex and adapts the microclimates according to the specific needs of the crops. The model functions as three greenhouses stacked on top of each other, thus, each floor has its own microclimate. For instance, the greenhouse grows lettuce and microgreens on the first floor and the hotter, top floor is for vining crops like tomatoes.

FIG: Vertical harvest building
SOURCE: https://verticalharvestfarms.com

The Vertical Harvest utilizes 50% less energy than traditional vertical farming by using greenhouse methods and optimizing natural light. Its success is based on the innovation of the infrastructure in one hand it is configured by hydroponic farming system, meaning that the roots of the crops sit in water infused with the nutrients needed and no soil is used. Moreover, the amount of water and fertilizer needed to grow the plants is minuscule compared to traditional agriculture systems.

On the other hand, the green house has vertical growing carousels. Since the system doesn't rely only on LED artificial lighting; the system uses conveyor belts to keep moving the plants around and maximize natural sunlight exposure, balancing natural and artificial light and resulting in important cost savings. Moreover, the conveyor belt system brings the plants to the workers, for harvesting and transportation.

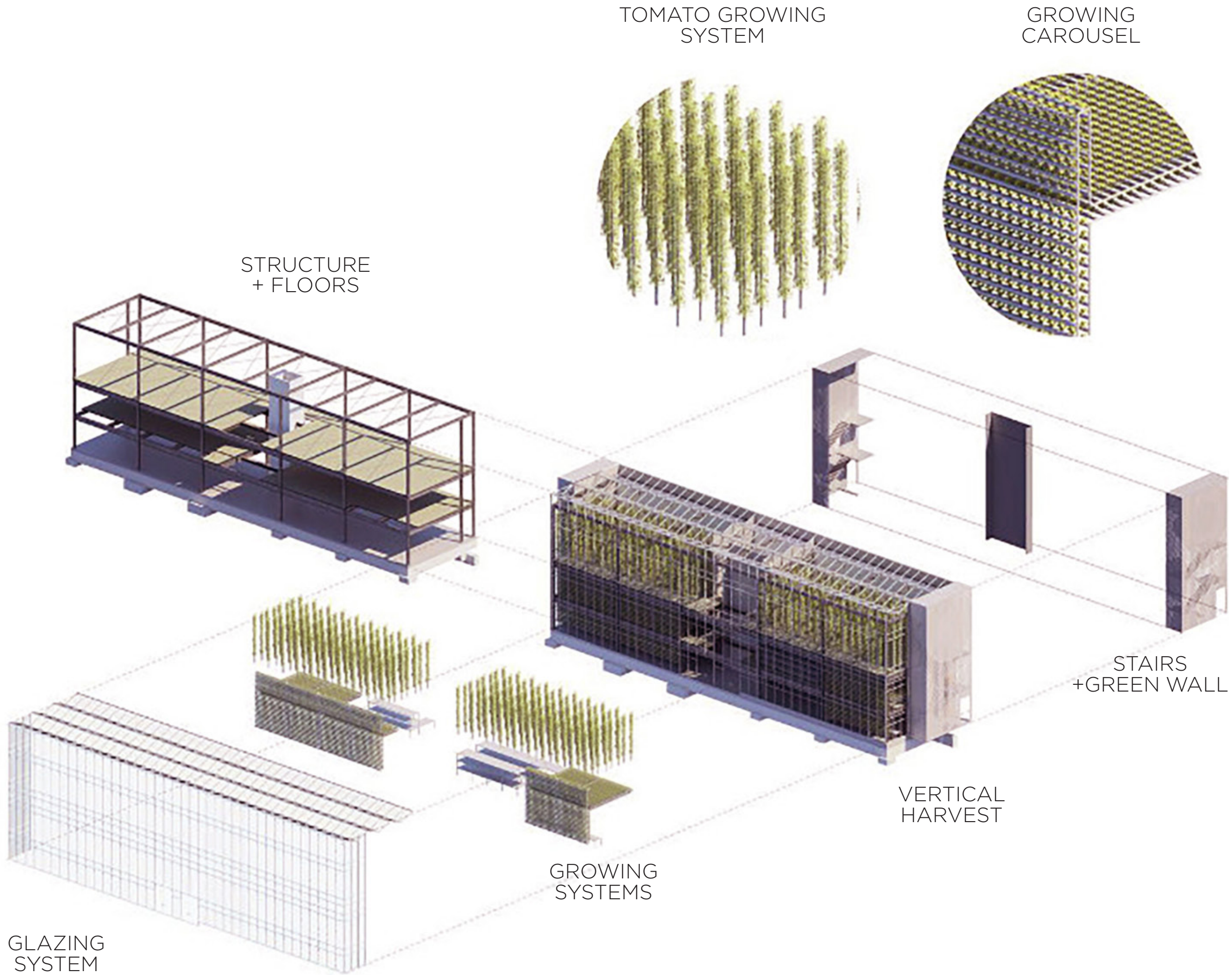


FIGURE: VERTICAL HARVEST SYSTEM
SOUCE: https://verticalharvestfarms.com

The peculiarity of this project is its social impact. The Vertical Harvest drives a “Grow well” employment to address career development model, focusing on the inclusion of the underserved and forgotten community members and people with developmental disabilities such as Autism and Down Syndrome to run the operations for the production of fresh food with a sustainable emphasis.

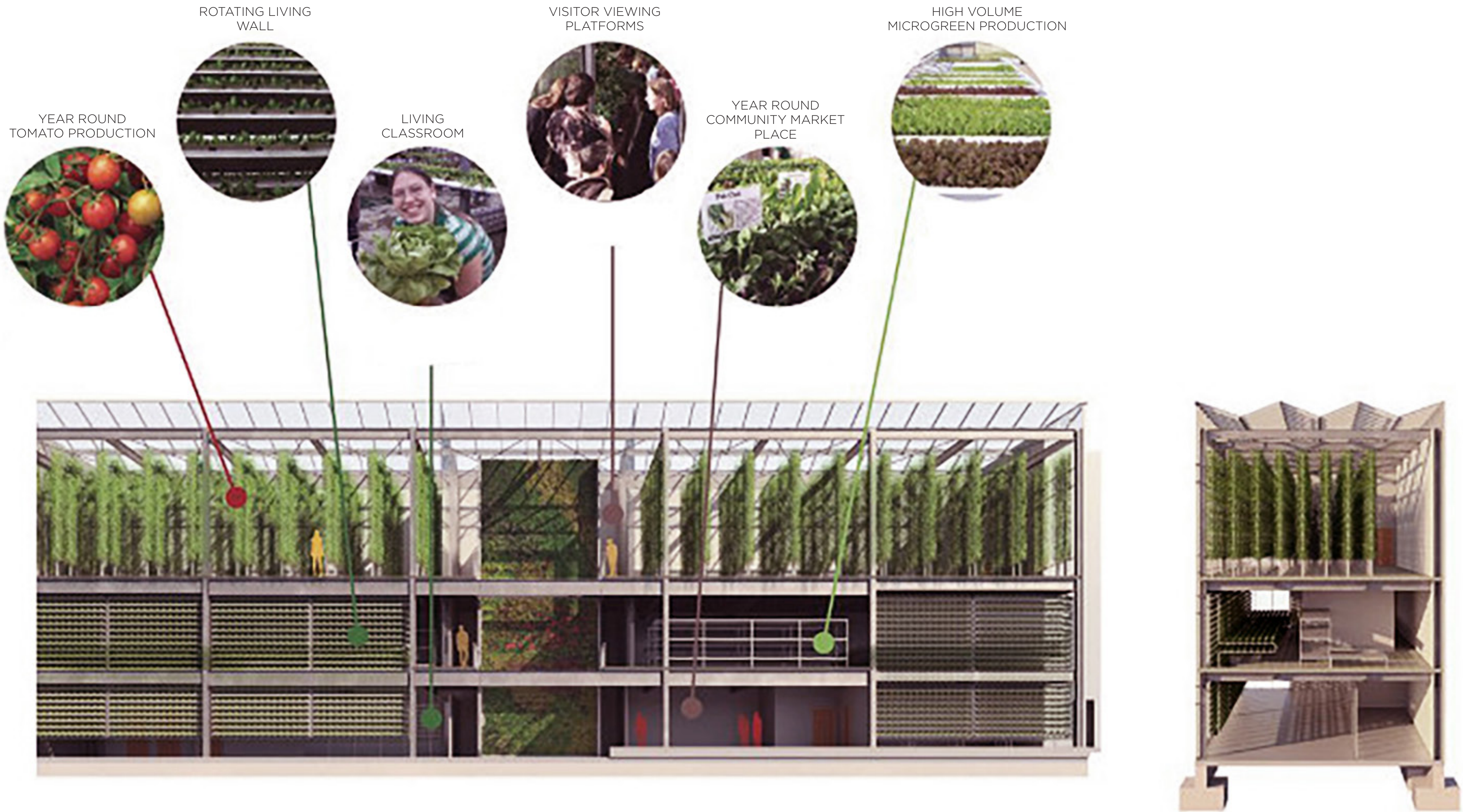
The Vertical Harvest has a diversified crop portfolio and grows local food for local communities, and manages a multichannel distribution of food, being able to sale direct to consumer, wholesale to more than 80 groceries and restaurants in 3 states, and food services.

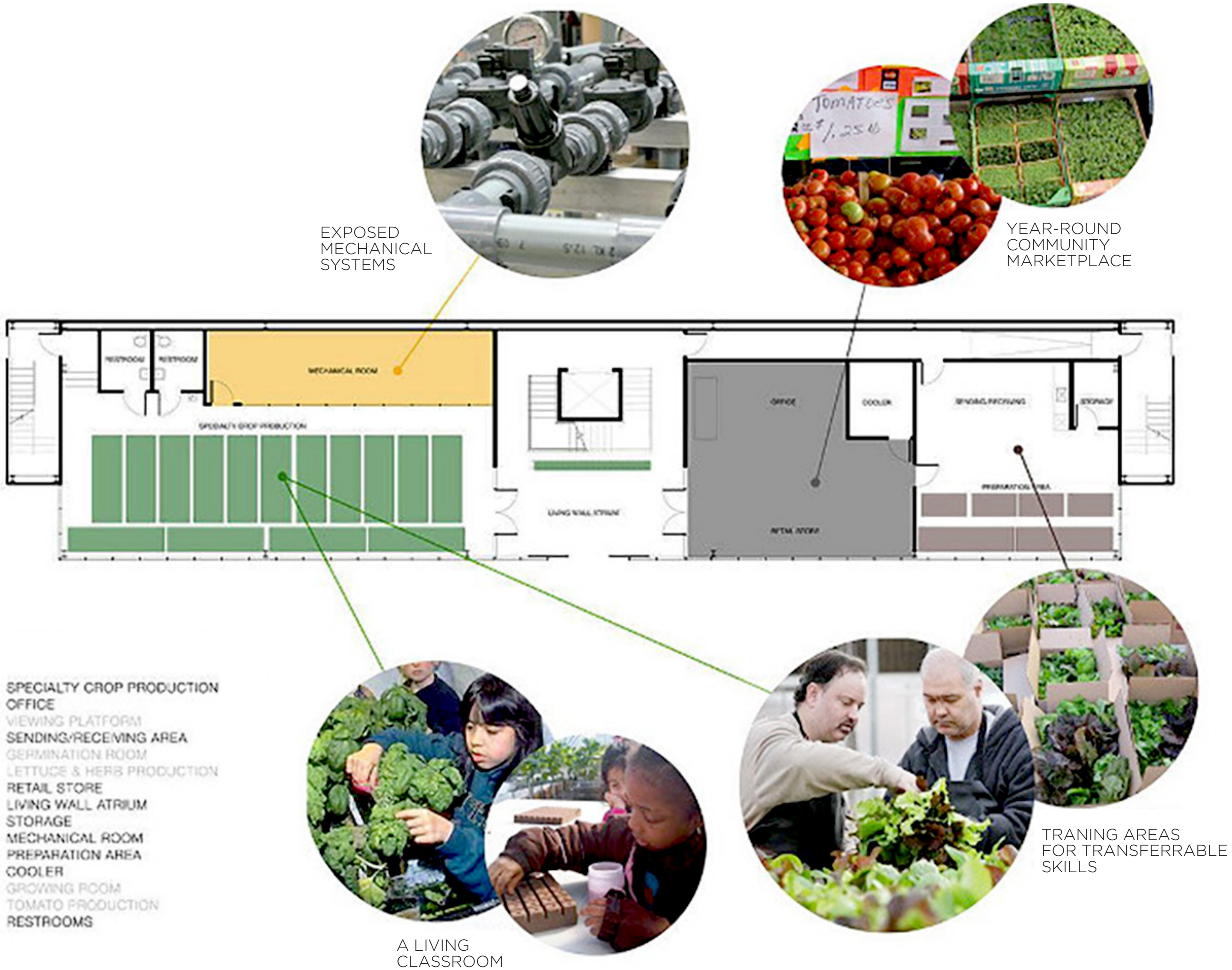
Furthermore, the vertical farm is a way to supplement the existing food industry by promoting food transparency. By bringing the food production process closer to the community, the learning and participative processes have the potential to help communities become healthier and cities more resilient.

The Vertical Harvest has also an area dedicated for public space and community gathering as well as a section dedicated for educational initiatives about urban crops, moreover it has become an attraction point of the city with guided tours inside the infrastructure. The ultimate goal is that indoor agriculture model could be scaled and replicated by other communities around the world.

FIG: Red tomatoes hanging near the ceiling on the 3rd. floor.
SOURCE: © Taylor Glenn

LONGITUDINAL AND CROSS-SECTION



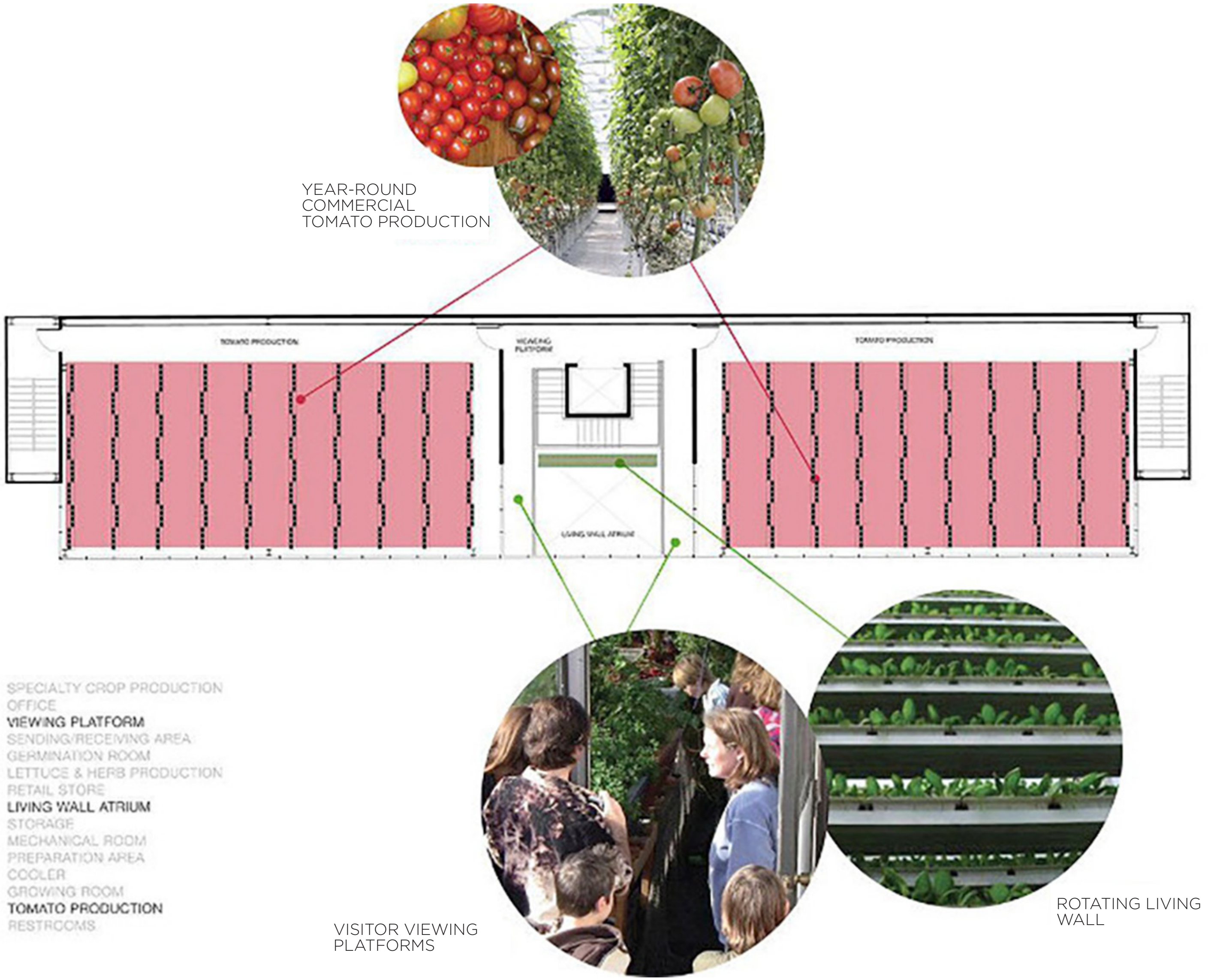


VERTICAL HARVEST 1ST FLOOR

SOUCE: https://verticalharvestfarms.com

VERTICAL HARVEST 2ND FLOOR

SOUCE: https://verticalharvestfarms.com



VERTICAL HARVEST 3RD FLOOR

SOUCE: https://verticalharvestfarms.com

POSITIVITE LEARNINGS:

- PARTNERSHIP:
  Town of Jackson Hole, Wyoming and Vertical harvest
- Tree story greenhouse startup
- Integration of vulnerable groups
- Job generation
- New technologies integration for optimization
- CULTIVATION SYSTEM:
  Hydroponics

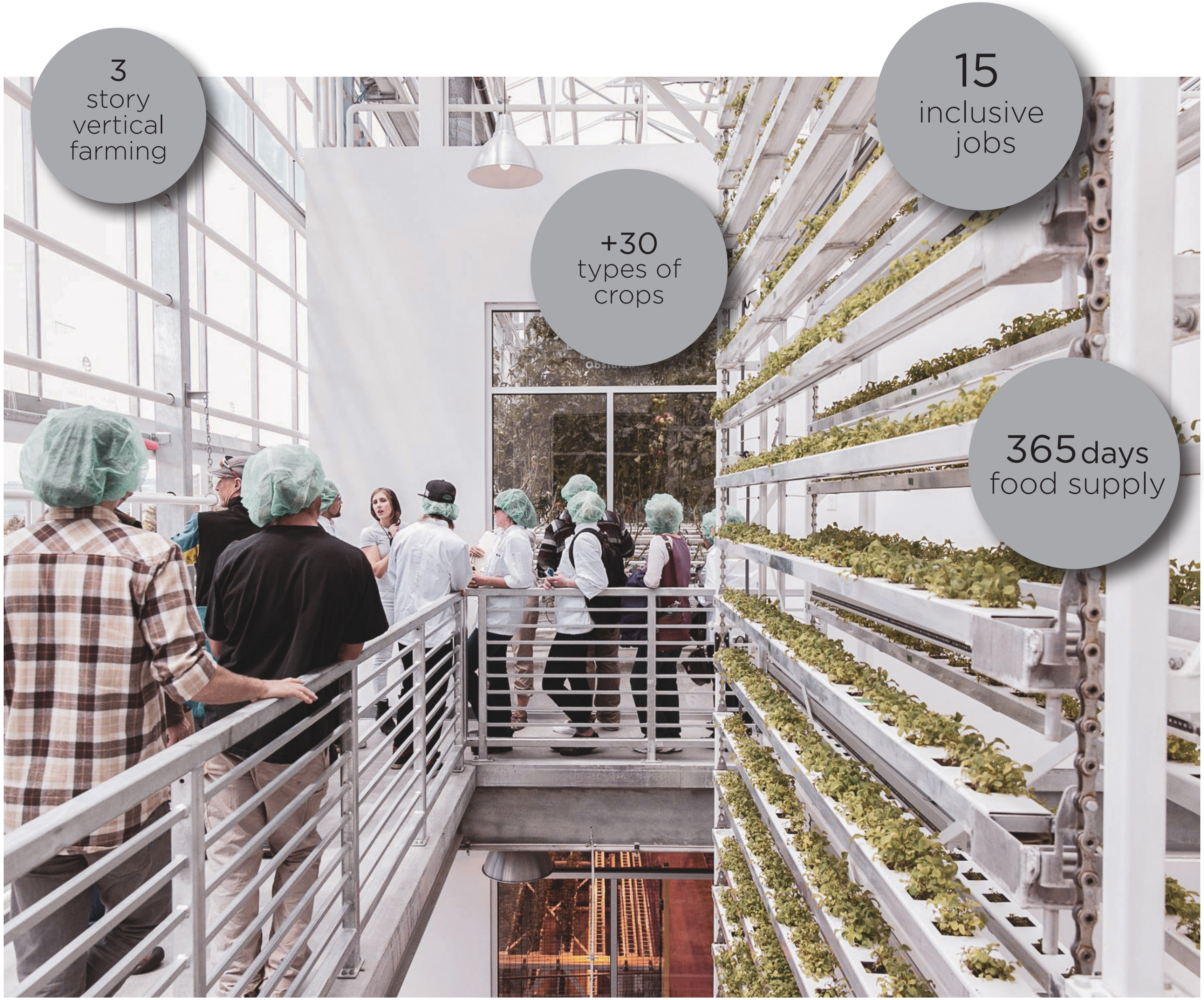


FIG: Guided tours on Vertical Harvest
SOURCE: © Taylor Glenn

5

PROJECT

introducing urban agriculture in the urban voids of the historical center of Cuenca-Ecuador

FIG. Aereal view of Historical center of Cuenca
Source: Ph_Felipe Cobos

CUENCA: GENERAL OVERVIEW

Cuenca is an inland city and the third in importance of Ecuador. It is considered as an intermediate city and is located close to the equator. The city is located at the intersection between the Western mountain range and the southern inter-Andean valley of Ecuador, at about 2500 meters above the sea level, with a whole year mild climate. The city is irrigated by four rivers, three of these rivers are originated in the paramo of the Cajas National Park located in the west of the city.

The geological and climatic characteristics of the area where Cuenca and its surroundings are located, have allowed a great variety of landscapes and plant communities, which have generated an image of the Cuenca related with the greenery of its landscape and mountains.

As in many Latin American cities, Cuenca has faced an accelerated growth during the last decades, according to the last population census in 2015, the number of inhabitants was around 580 000, from which 400 000 are settled in the urban area. (INEC). This expansion has been transforming from a compact to a scattered city, the current city is the result of its industrialization, migration from countryside to the urban area, oil boom, the influence of the neoliberal model, etc.

HISTORY AND HERITAGE

The challenges for Cuenca aim to solve problems of pollution, vehicular congestion, gentrification, over-crowding, among others. It could be feasible to transform contemporary cities through urban agriculture into a more sustainable, self-sufficient, and socially cohesive scenario for the present and future generations.

The urban tissue of the city is the product of different layers of history. The city still shows the conception and territorial organization of the pre-Hispanic cultures: the first settlement was the Cañari, which was founded around 500 BC. Later it was conquered by the Incas, who, in the expansion of the empire brought their own architecture typologies but nevertheless, assimilating the learnings from the settlements they were conquering. This Indian settlement was called Pumapungo and became the second capital of the Inca empire for around half century until the Spanish arrival.

The Spanish founded “Santa Ana de los Ríos de Cuenca” in 1557 with the rigorous planning guidelines issued by the king Charles V 30 years earlier, those rules called “Leyes de Indias” refer to a checkerboard trace with 84 m square blocks around a central square.

The city became independent in 1820, and nowadays, it still conserves its orthogonal trace, respected for more than 400 years.

In the 19th century, especially between 1870 and 1950, the city faced an economic expansion, thanks to becoming the major exporter of quinine, straw hats

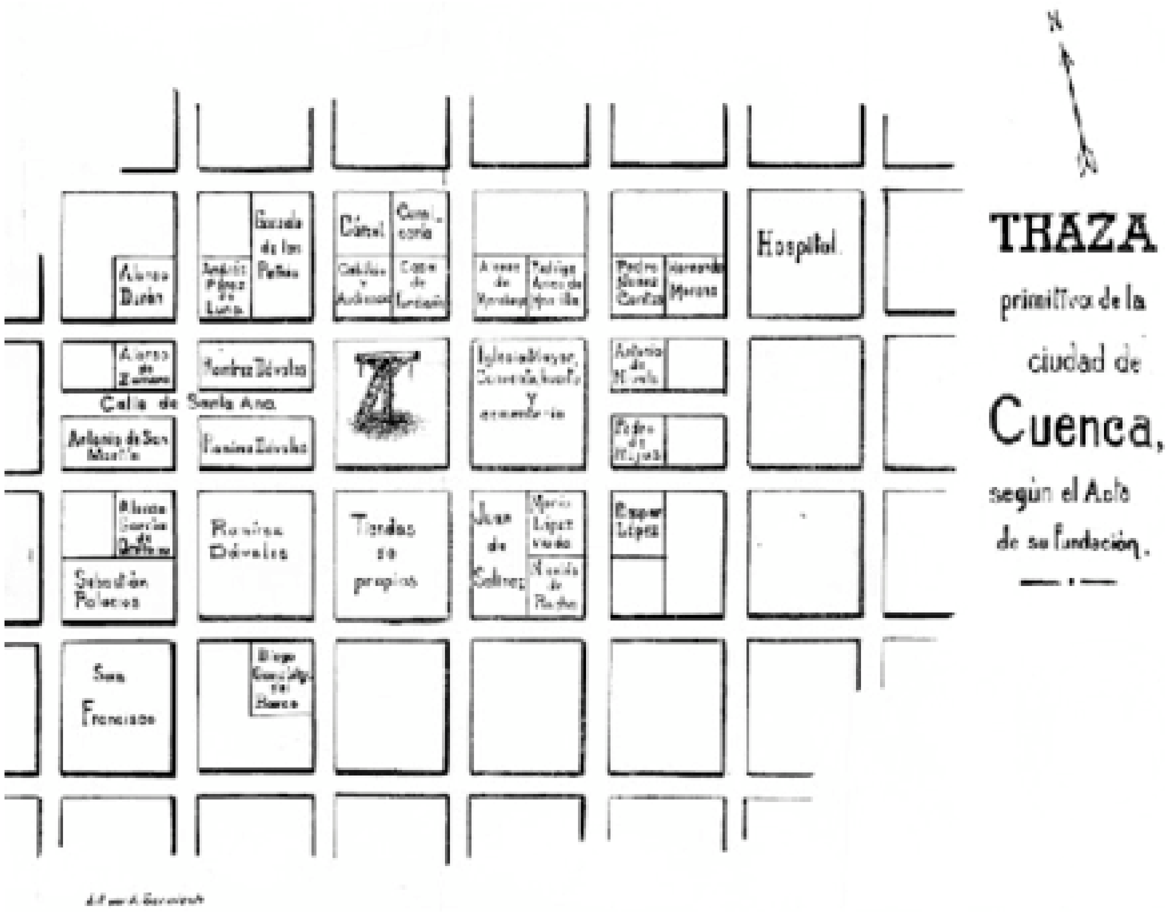


FIG. Primitive trace from the Foundation of Cuenca
SOURCE:

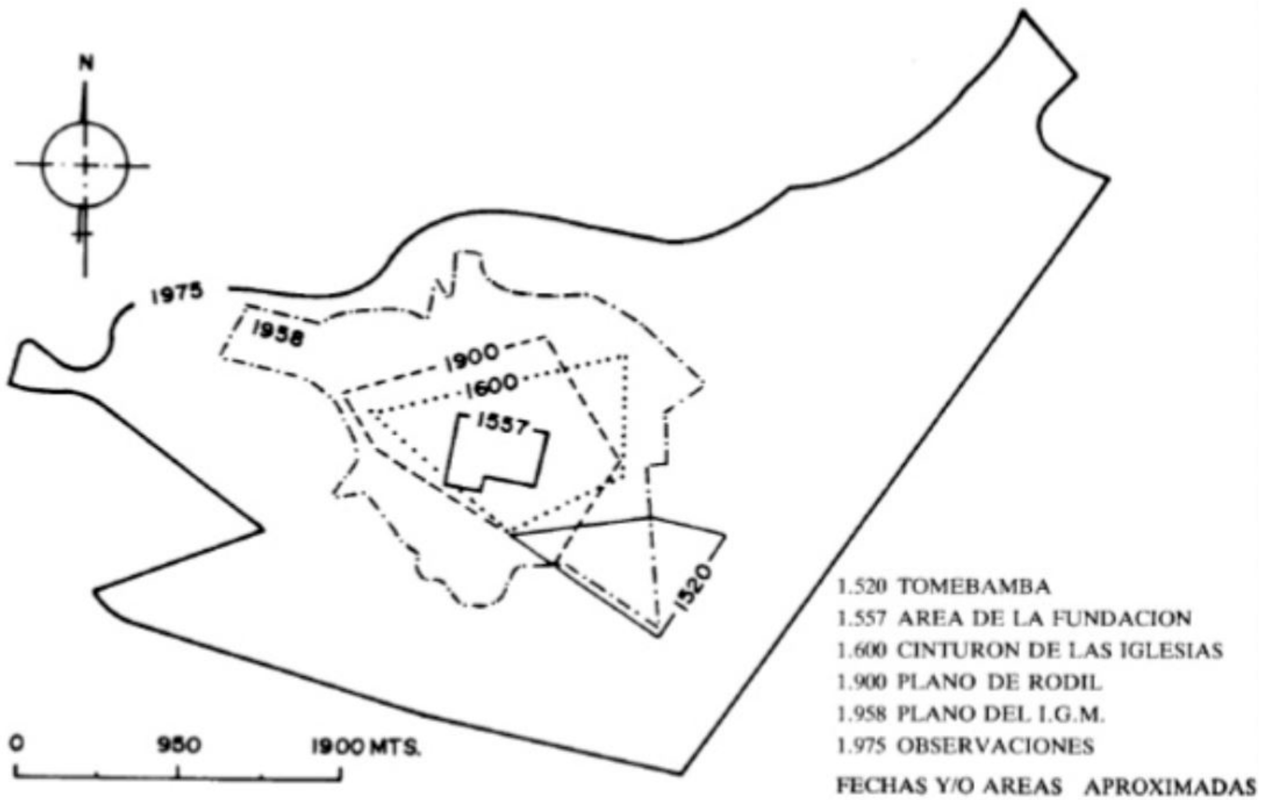


FIG. Urban profile growth in Cuenca through approximate years
SOURCE:

and other products. Therefore, many of the colonial buildings, were transformed with the new international trends. Resulting in a particular language that combines the colonial architecture with the European influence (World Heritage List – UNESCO).

The urban tissue of the Historical Centre of Cuenca is the result of a dynamic modernization process that consists of system of squares, parks, churches and other public spaces, it has hundreds of heritage buildings, works of art, archaeological remains and cultural manifestations that make up the identity of its people.

The city was declared National Heritage in 1982 and its Historical center was listed as an UNESCO World Heritage Site in 1999. Cuenca has undergone new policies and public and private interventions in order to preserve its heritage and enhance its tourism. However, the city has been facing processes of gentrification, which led to the abandonment of spaces, or on the contrary, buildings with historical value converted into overcrowded degraded slums with serious problems of habitability, functionality and safety and whose occupants, generally a socially vulnerable community who face precarious socioeconomic situations and segregation.

CLIMATE

Ecuador has four regions, Sierra, Coast, Jungle and Insular region. Depending on their specific characteristics, it is possible to pass in a short time from the cold Andes mountains to spring climates of the valleys of the Sierra, from there, it is one step away from the beaches of the Ecuadorian coast, and in a few hours find the Jungle with its exotic vegetation.

The area where the city is located presents two climatic units: high mountain equatorial and semi-humid mesothermic equatorial.

Due to its position in the globe (equator), there are not four seasons as in the northern and southern countries, the year divides into two seasons: winter with temperatures that fluctuate from 7 °C to 16 °C and summer with temperatures from 12 °C to 25 °C. Moreover, the city can present important fluctuations of temperature during the day, especially on sunny days

The precipitations vary due to due to its complex orographic configuration, which origins considerable climate variations in short distances.

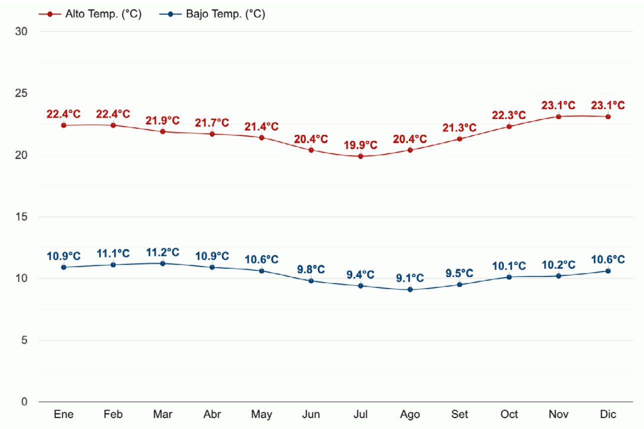
The average of annual precipitations is about 858 mm (INAMHI, 2015). The months with higher amount of rain are between February and April. The dry season is between June and August.

The amount of clouds varies during the year, approximately from May to October the sky is clearer, meanwhile, about seven months of the year, the sky seems cloudier.

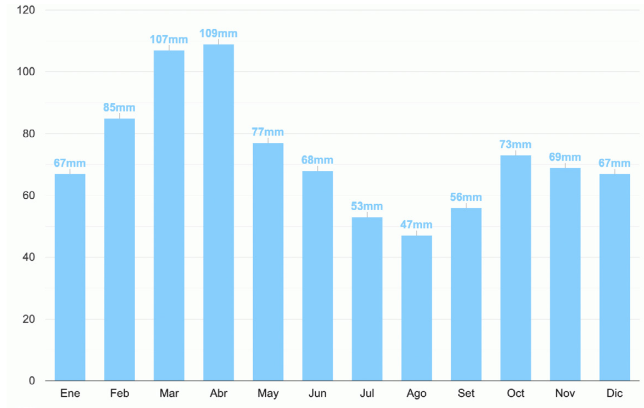
The wind generally depends in the local topography and in other factors, thus the velocity and the wind direction have considerable variations during the year.

In the windy season (from May to September), the average wind velocity is about 9.7 km/hour meanwhile, in the less windy season that lasts about 8 months, the average of wind speed is about 5.10 km/hour.

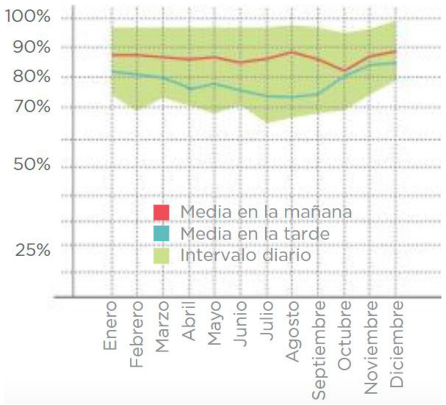
AVERAGE ANNUAL TEMPERATURES



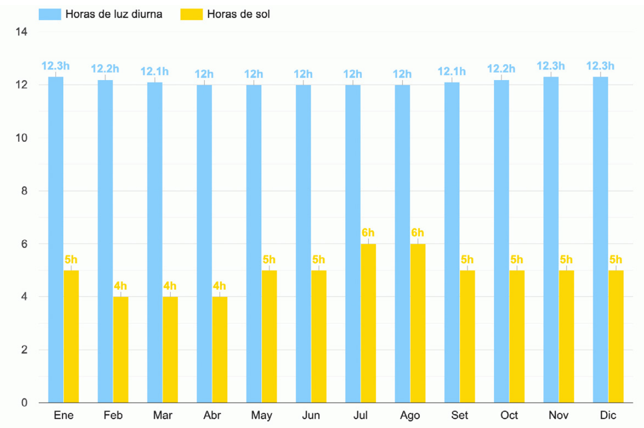
AVERAGE ANNUAL PRECIPITATIONS



HUMIDITY



DAYLIGHT HOURS / SUN HOURS



AVERAGE PRECIPITATION DAYS

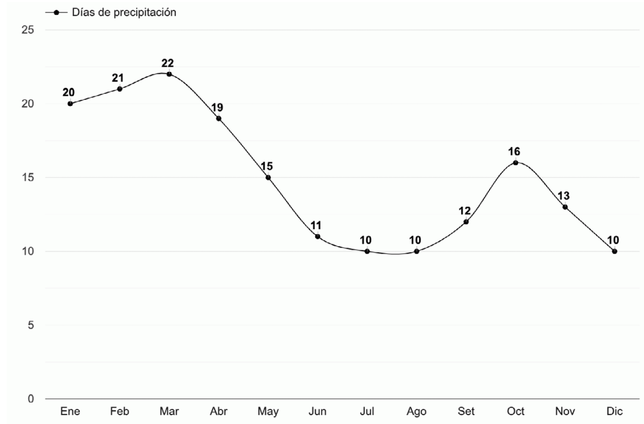
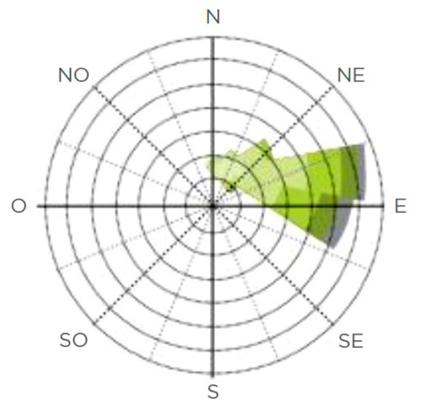


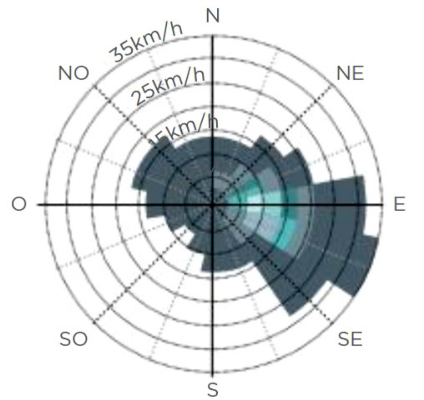
FIG. Annual climate data graphics
SOURCE: https://www.weather-atlas.com

COMPASS ROSE BY SPEED



The radios show % of total amount of wind
+ 14 m/s
11-14 m/s
9-11 m/s
3-9 m/s
-3 m/s

COMPASS ROSE BY FREQUENCIES



+ 1 010 h
808-909 h
707-808 h
606-707 h
404-606 h
202-404 h
-202 h

CLIMATE FIGURES:
Compass rose Cuenca Ecuador
SOURCE: Cuenca RED_Plan de Reactivación del espacio público de Cuenca, Ecuador. (2015)

NATURAL RESOURCES

The fertile soil of the zone facilitates agricultural practices. In its central valleys people grow corn, cereals, vegetables and a great variety of fruits, besides, tropical products such as sugar cane, cotton, coffee, among others, are obtained at the western end of the mountain range. The livestock sector is characterized by the raising of sheep, cattle and pigs.

With regard to mining there are deposits of marbles and clays. Moreover, the region has other minerals such as gold, silver, and zinc.

The city has four rivers that go through the city, the most important is called Tomebamba (figure). The four rivers formed from lagoons with glacial origins in the Cajas National Park located 30 km west of the city.

The main rivers and streams of Cuenca flow into the Paute river, which empties into the Amazon River, and other small streams to the Jubones, which runs to the Pacific Ocean. Besides, due to its hydric resources, the most important Hydroelectric Power Plant in the country was built on the Paute River, 45 minutes from Cuenca.

PICTURE: Tomebamba river view
SOURCE: © 2020 www.fotofeeling.com


Fotofeeling

AGRICULTURE TRADITION

The agriculture tradition is still, despite its reduction, an important income in the city. Its vast soil allows the sowing of different crops on its surrounding rural areas dedicated to farmland. Some of its characteristic crops are corn, barley, wheat and rye, besides, Cuenca exports flowers to many countries around the world. Beekeeping has also increased in the last decades.

Moreover, many years ago, in the traditional republican architectural typologies of the city, a private patio devoted to family farming called "minifundio" was always considered. Nevertheless, over time, the new needs of the citizens and the outstanding prices of land, have diminished (or extinguished) areas for communal or individual farming in the urban areas. The old typologies have been changing to give space for rental parking lots or to build new spaces for commerce.

Consequently, from a bird view of the historical center, it is easy to find some left "in-between" spaces in the middle of the orthogonal blocks, in which, a kind of small-scale interventions could have the potential to impact the dynamics of the city.

FIG. Urban profile growth in Cuenca through approximate years
SOURCE:

AGRICULTURE PRODUCTION

Even though Ecuador barely occupies the 0.19% of the planet's continental mass, it is one of the seven countries with the greatest biodiversity in the world thanks to its innumerable variety of species of animals, plants and microorganisms (ANDES, 2010).

Cuenca is located in the Inter Andean valley of the Sierra and there is a varied cultivation of crops in the city and its surroundings. Nevertheless, the production relies on the climatic conditions so the cultivation of some foods is seasonal.

Through the elaboration of organic fertilizers, the farmers can foster the adequate crops development using sustainable low-cost natural systems with easy access and free of chemicals.

In order to avoid the utilization of pesticides, the traditional natural pesticide can be made with the use of rue plant, mugwort, garlic, chili pepper, milk, panela and nettle.

ORNAMENTAL PLANTS

Begonias
Geraniums
Conchas
Azaleas
Astromeliads
Hydrangeas
Jasmine
Orchids
Roses

MEDICINAL PLANTS

Lemon Balm
Ataco
Chamomile
Absinthe
Dulcamara
Stevia
Escancel
Borage
Violets

FRUITS

Strawberries
Tree Tomato
Uvillas
Blackberries
Peach
Apple
Pear
Custard apples
Avocado
Citrus

VEGETABLES

Pumpkin
Onion
Garlic
Cabbage
Lettuce
Potatoes
Ocas
Mellocos
Carrot
Coriander
Parsley

CEREALS AND LEGUME

Corn
Barley
Habas
Wheat
Beans
Peas

SOCIO-ECONOMIC ANALYSIS

Overtime, the city has had unstable moments on its economy. From times of great economic growth, to times with serious crisis. However, during the 90´s the country suffered a serious economic shock due to bank closures, changing the structure of the local economy and increasing the emigration of Ecuadorians around the world.

The Ecuadorian economic growth is based in the public investment and spending. Its exportation model hasn't changed significatively on its republican history, the country depends mainly on natural resources such as petroleum, banana, shrimp, cacao, coffee, flowers and mining raw materials. Basically, the country exports raw materials and imports elaborated and semi-elaborated products.

The economy of Cuenca is based on its industrial and agricultural development. From the 50´s, a diversification of the economic structure of the city started to evolve towards industrialization substituting in part the artisanal manufacture, being the straw hats the main exported product.

Nowadays, the city has a mixed development of industrial and artisanal products such as tinsmith, saddlery, basketwork, ironwork, ceramics, textiles, crafts, car tires, shoes, among others. Besides, industries of mining and logging are also developed on its surroundings.

Another important income of the city is based on its touristic attractions, specifically in heritage areas such as lodging, food and touristic services.

CUENCA OCCUPATION PERCENTAGES
SOURCE: INEC 2010

- 19.63% Agriculture, livestock, forestry and fishing
- 21.21% Manufacturing industry
- 13.81% Construction
- 13.68% Wholesale and retail trade
- 2.59% Accommodation and food service

FIGURE 1:
The straw hats were the main product for exportation in 1950.
In fact, the products known as "Panama hats" are made in Cuenca.
SOURCE:

FIGURE 2:
Plaza de las flores. (Flowers square open market)
SOURCE

AIR POLLUTION

The air pollution is a constant threat for human health and the environment, requiring decision making regarding the prevention, control and mitigation of its impacts. The land use, the location of sources of emission such as industries and gas stations and the increase in the population, and some of day to day city activities such as vehicular traffic, consumption of fuels, among others generate deterioration of air quality.

The industrial sector has a significant impact in the pollution of water and air. Referring to this, the city has an Industrial park with around 145 industries located in the Nord-Est zone. (Jerves & Armijos, 2016)

Cuenca, as an intermediate city, does not yet present the negative environmental effects of a dispersed model with the same intensity as other cities, nevertheless according to the Red de Monitoreo de la Calidad del Aire de Cuenca (Cuenca Air Quality Monitoring Network) the biggest source of emissions is the vehicular traffic. The highways with major vehicular traffic have an average of 25 000 cars/day to 40 000 cars/day and concerning about the historic center, the roads have an average traffic of 10 000 cars/day. (GAD Municipal de Cuenca, 2013).

INVENTARY OF EMISSIONS IN CUENCA 2011

Carbon monoxide (CO)	91,9%	vehicular traffic
Nitrogen oxides (NOx)	76,4%	vehicular traffic
	11,8%	thermal
Volatile organic compounds other than methane (COVNM)	34,4%	vehicular traffic
	25,3%	solvents
	21,4%	vegetation
Sulfur dioxide (SO_2)	48,2%	industries
	30,2%	vehicular traffic
	21,1 %	thermal
Fine particulate matter ($MP_{2,5}$)	42,7%	vehicular traffic
	40,9%	artisan brick kilns
	9,8 %	thermal
Fine particulate matter (MP_{10})	39,9%	vehicular traffic
	36 %	artisan brick kilns
	11,6 %	industries
	8,6 %	thermal

FIG:
Inventary of emissions of Cuenca in 2011
SOURCE: (EMOV EP, 2014a)

1.

2.

FIGURE 1:
La Condamine street. (05/08/2019)
SOURCE: https://ww2.elmercurio.com
FIGURE 2:
General Torres street. (02/01/2017)
SOURCE: https://www.canartelevision.com

MOBILITY

The traffic congestion in the historic center, where some of the main public institutions and services are emplaced, faces serious congestion problems, because of the increased saturation levels in the road structure. As the historical urban trace was logically not designed for the modern transportation modes, it exceeded the capacity to accommodate the demand at peak hours of the day. Moreover, over time, a high number of historical buildings have been demolished and several interior courtyards have been converted into parking plots to satisfy the needs of the modern city.

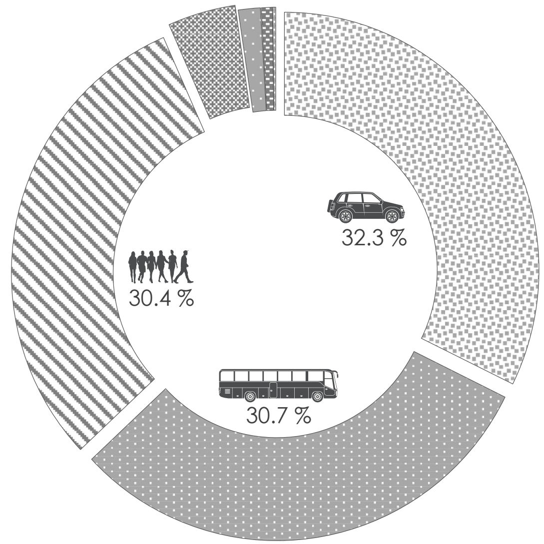
The urban transportation services in Cuenca lack of financially, socially and environmentally sustainability. Traditionally, the public transportation in the city is provided by private individual bus owners, who in addition to the state subsidy, have to achieve sufficient income to maintain or upgrade the buses. Resulting in a transportation system in regular conditions, with detrimental impacts on air quality and traffic safety.

On the other hand, the use of private car as priority transport mode is one of the main conflicts with the misuse of public space, traffic congestion and environmental pollution. Being the pedestrian and the cyclists the most affected. In other words, the road infrastructure lacks of adequate inclusive sustainable mechanisms adapted to the needs of the citizens.

In the last years, the city is running important transformations in the mobility system that prioritizes pedestrians and soft mobility, shifting towards a new model of city. The Municipality launched a Tram project which has being inaugurated in 2020. The trace of the Tram lines has changed the dynamics of some main streets in the historical center that may originate changes in the function of many parking plots in disuse.

The new mobility plan will allow the accomplishment of a new city model where the balance of the productive, cultural, economic and social systems with guaranteed daily displacements. The aim is to integrate the transportation systems into one system of comprehensive mobility, where the traditional technical analysis of flows is incorporated into a new vision in which mobility patterns and their cause allow to identified the demands (Plan de movilidad y espacios públicos de Cuenca, 2015).

TRANSPORTATION MODES IN CUENCA

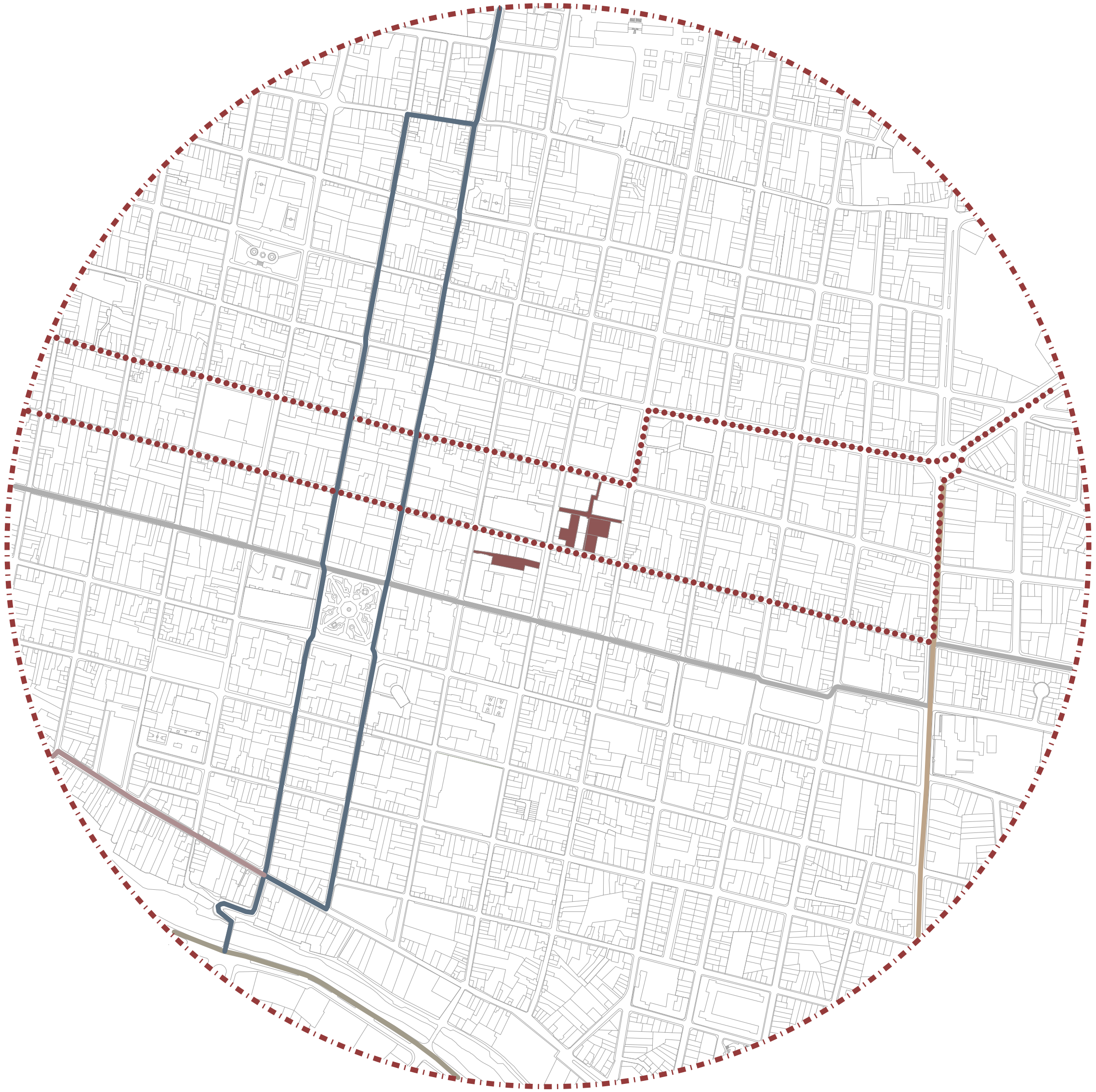


LEGEND

Private	32.3 %
Bus	30.7 %
Walking	30.4 %
Taxi	4.3 %
Others	1.4 %
Motorcycle	0.7 %
Bicycle	0.2 %

FIG: DISTRIBUTION OF TRANSPORTATION MODES IN CUENCA
SOURCE: Plan de Movilidad y Espacios Públicos de Cuenca (2015)

MOBILITY PLAN (2015) FOR THE HISTORIC CENTER



LEGEND

Tram

PEDESTRIAN CORRIDORS

12 de abril

Barrial blanco / Huayna Capac / Herrerías

Loja

Luis Cordero / Benigno Malo / Solano

Ordoñez Lasso / Gran Colombia / González Suárez

N

FIG: Mobility Plan 2015
SOURCE: Cuenca RED_Plan de Reactivación del espacio público de Cuenca, Ecuador. (2015)

MAPPING THE INFLUENCE URBAN AREA
15-MIN CITY

Several cities around the world are looking forward to reduce their carbon footprint and to increase quality of life by transforming the dynamics. The idea of the "15 minutes city" was conceived by Carlos Moreno, a professor at the Sorbonne in Paris.

The concept of "la ville du quart d'heure" refers to the accomplishment of six basic social functions (living, working, supplying, caring, learning and enjoying) within a 15-minute reach on foot or by bike, in order to cut down unnecessary journeys. The "15 minutes city" is based on four principles: proximity, diversity, density and ubiquity. It is based in the work of Jane Jacobs, who related the proximity with the vitality of cities.

The analysis of the actual state of the influence area of the urban voids inside the Historical Centre of Cuenca which are intervened on the thesis, considers the 15 minutes city concept.

The objective is to identify the needs of the zone within an updated sustainable development scope, related to the access of the neighbors to goods and services, the impact of the current mobility systems, density, public spaces, greenery, etc. But, above all, the idea is to identify spaces of opportunity for a potential comprehensive intervention.

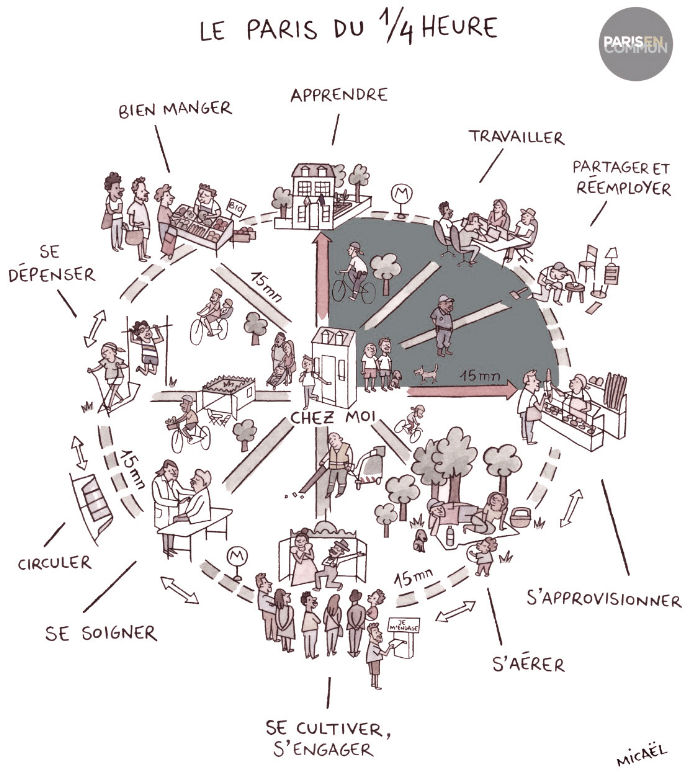
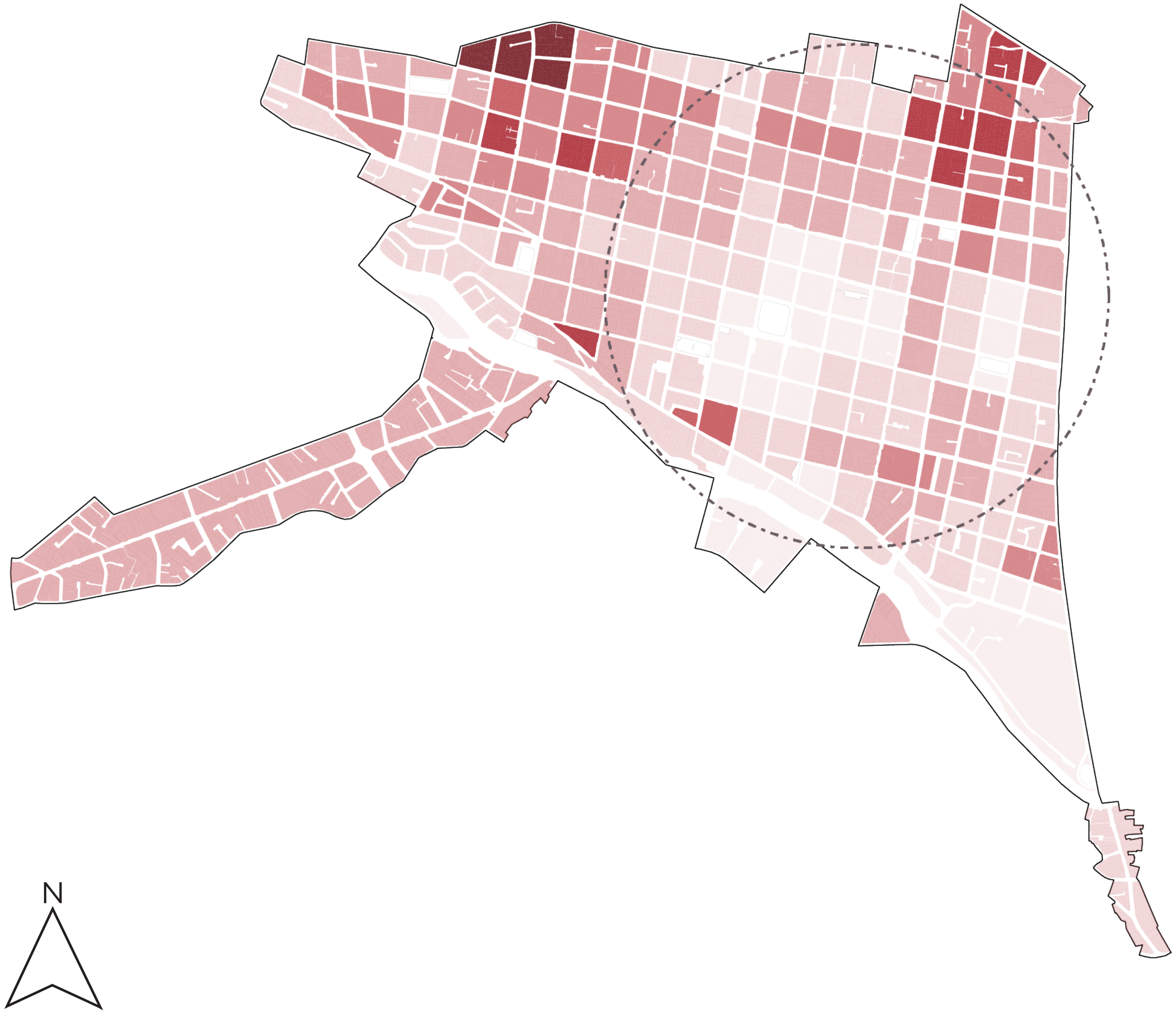


FIGURE:
Anne Hildalgo, the mayor of Paris, has embraced the idea of "la ville du quart d'heure," or the 15-minute city
SOURCE: https://360.here.com/15-minute-cities-infrastructure

DENSITY DISTRIBUTION IN THE HISTORICAL CENTER OF CUENCA



LEGEND

- 0-50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- 350 - >

FIG: Density map of the Historic Center of Cuenca based in the Population census of population and housing Ecuador 2010
SOURCE: Bermeo Silva (2015)

PROTECTED BUILT HERITAGE
OF THE HISTORICAL CENTER OF CUENCA

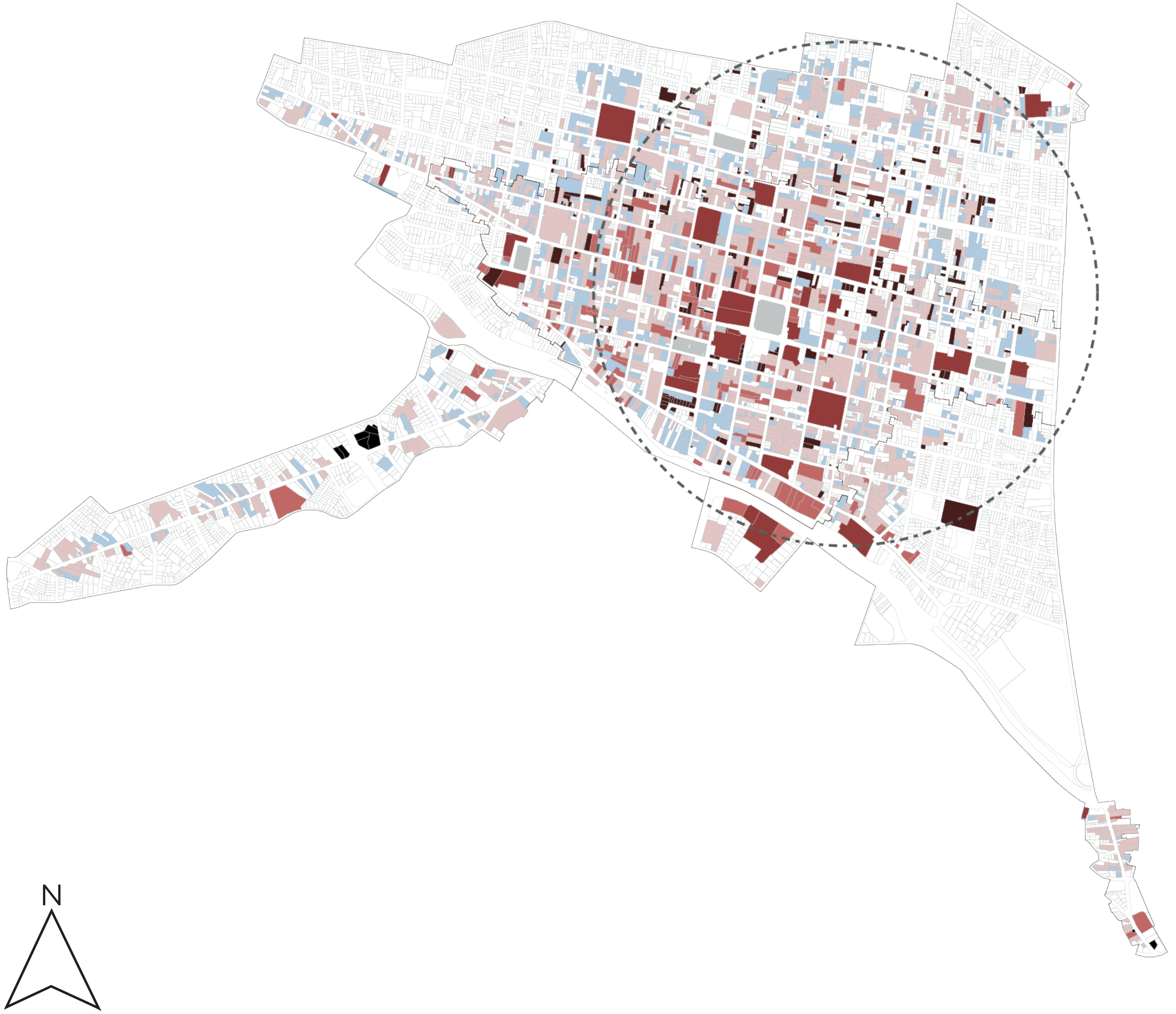


FIG: Map of inventoried edifications from GAD Municipal de Cuenca, 2011
SOURCE: Bermeo Silva (2015)

MAIN PUBLIC FACILITIES
15-MIN

FIG: Map of public facilities
SOURCE: Google Earth 2020

OPEN PUBLIC SPACES AND GREEN AREAS
15-MIN

LEGEND

- Squares
- Small squares
- Green areas
- Park
- Project site

FIG: Map of open public spaces and green areas
SOURCE: Cuenca RED_Plan de Reactivación del espacio público de Cuenca, Ecuador. (2015)

FUNCTIONS MAP
HOUSING & COMMERCE

ONLY HOUSING | ONLY COMMERCE | COMMERCE AND HOUSING

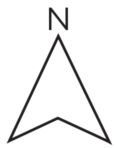


FIG: Edifications with housing use, commerce use and mixed use housing+commerce
SOURCE: Cuenca RED_Plan de Reactivación del espacio público de Cuenca, Ecuador. (2015)

URBAN FULL AND EMPTY MAP
INFLUENCE AREA 15-MIN

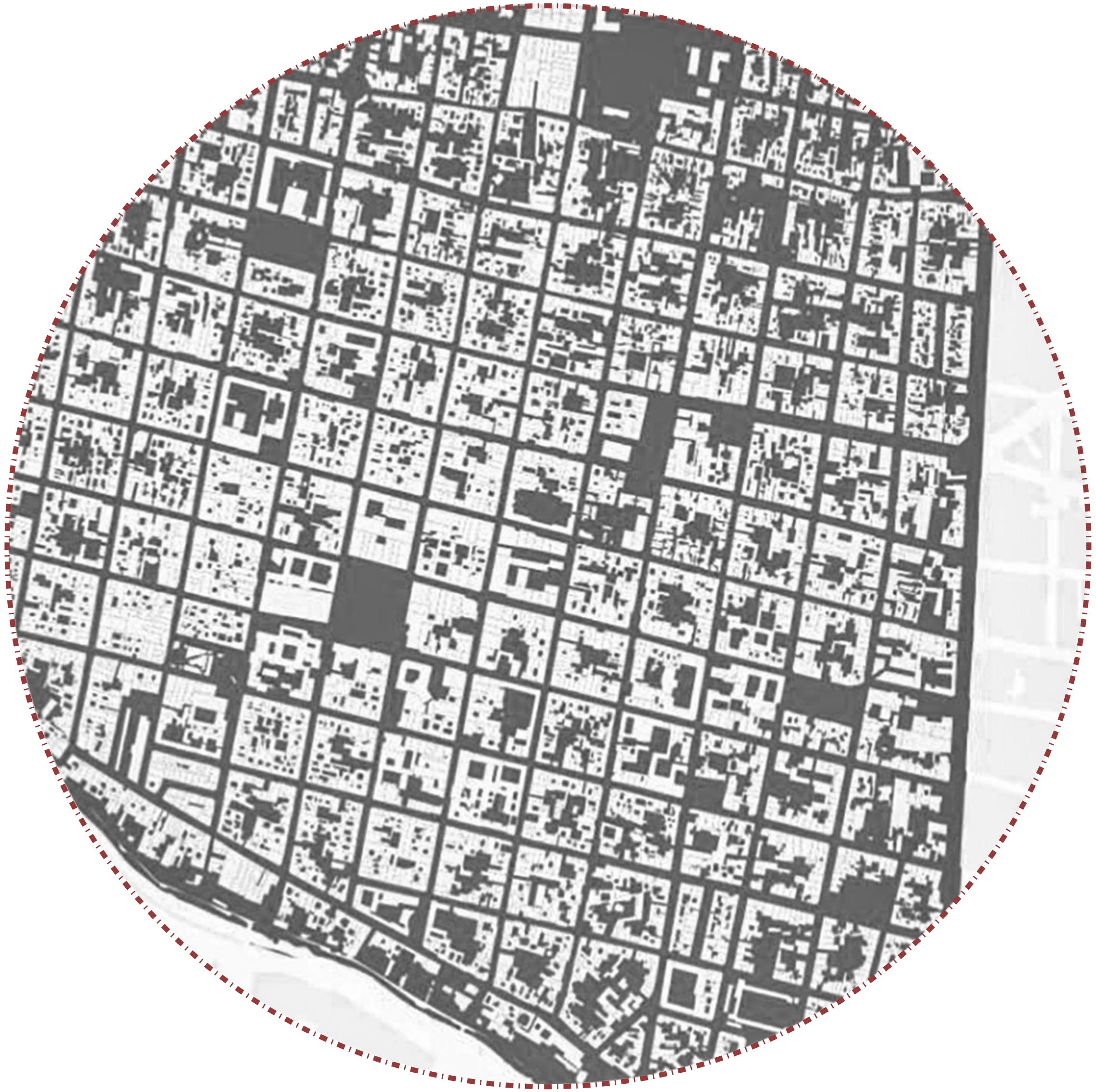
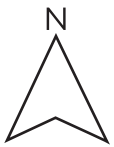
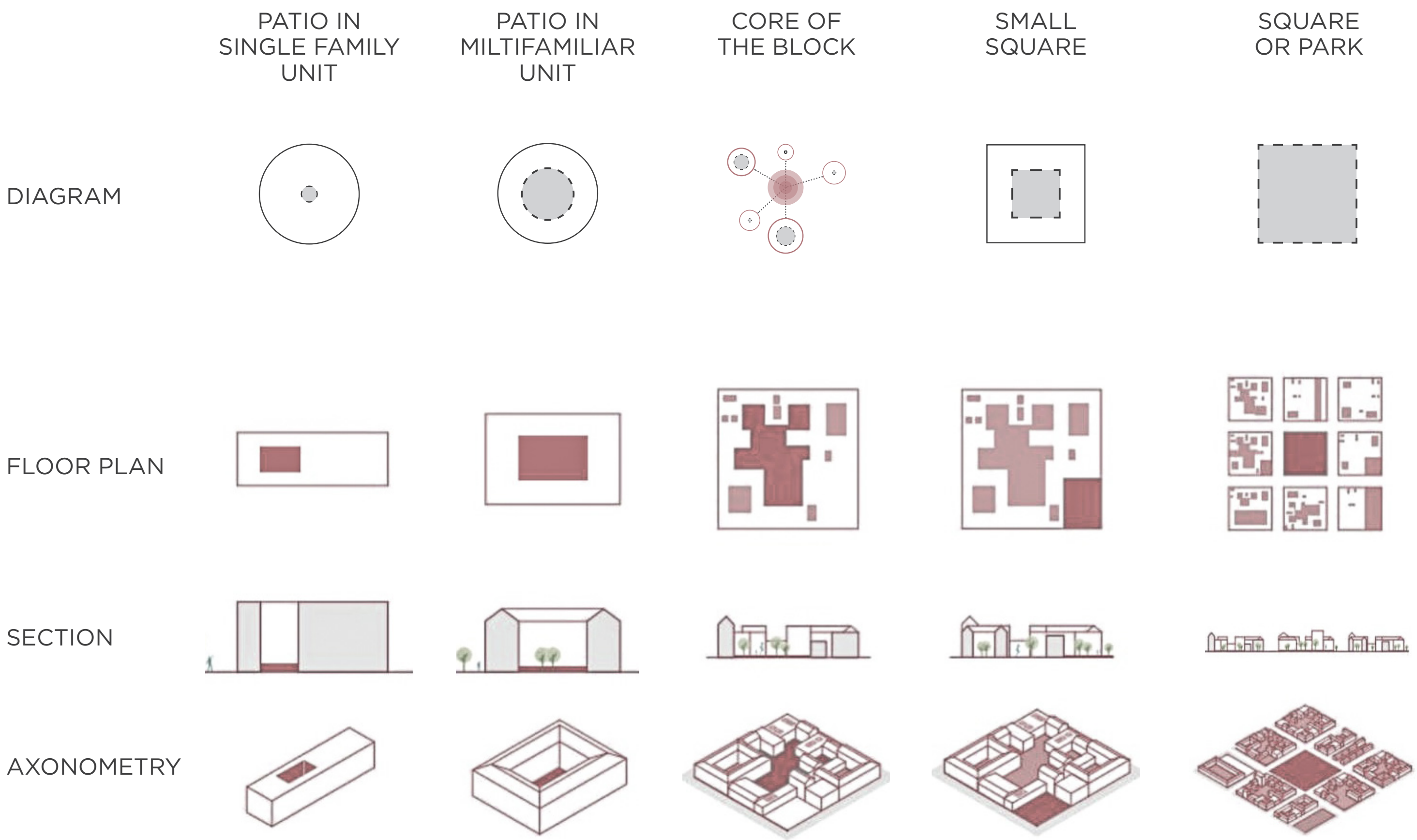


FIG: Map of full, empty and streets
SOURCE: Cuenca RED_Plan de Reactivación del espacio público de Cuenca, Ecuador. (2015)



TYPOLOGIES OF URBAN EMPTY SPACES (WITHOUT BUILDINGS) IN THE HISTORIC CENTER OF CUENCA

SOURCE: CUENCA RED_PLAN DE REACTIVACIÓN DEL ESPACIO PÚBLICO DE CUENCA, ECUADOR. (2015)

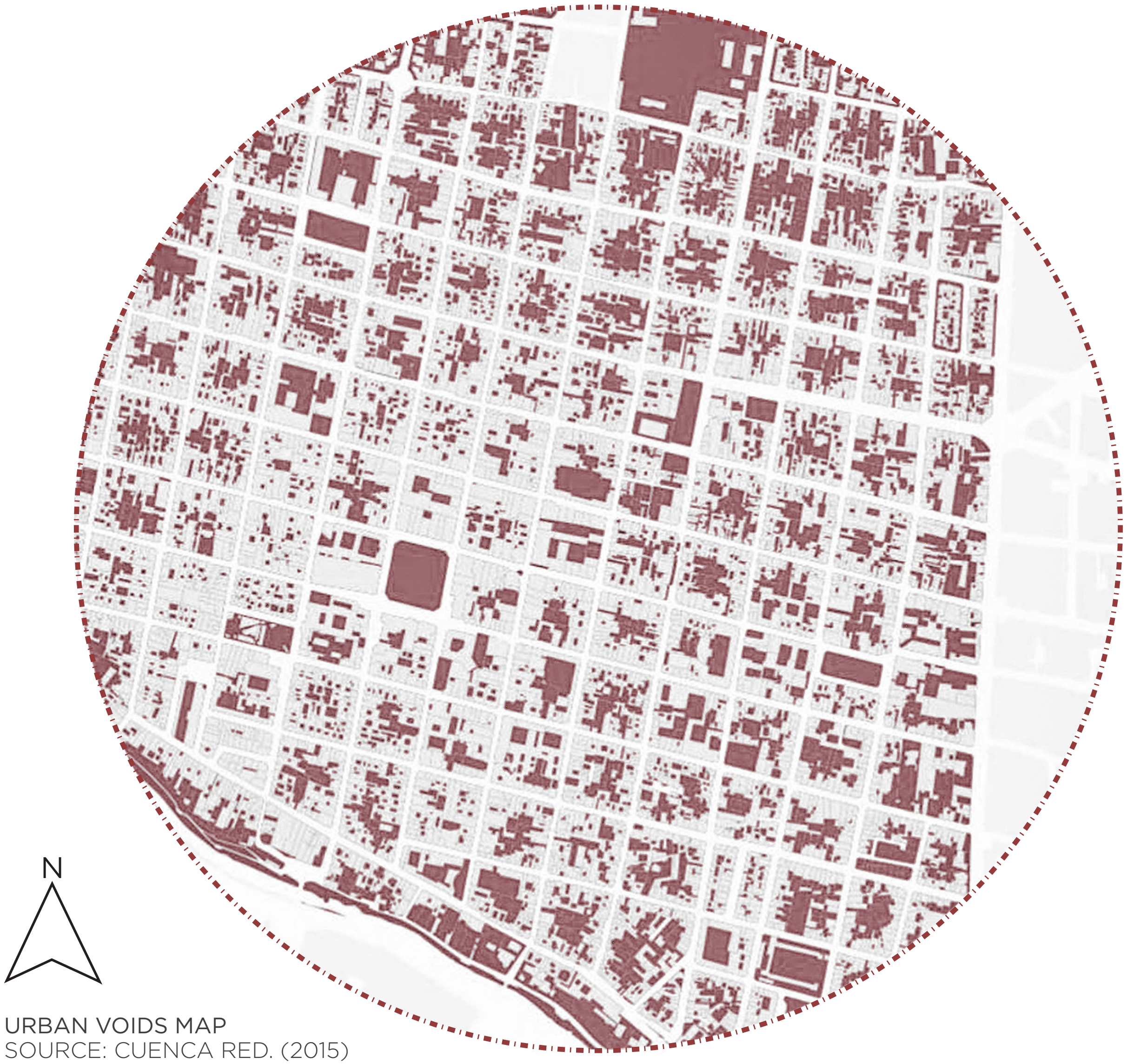


The patio is an important element around which many of the activities of the city are performed. Its morphology, use and scale vary according to the typology and its nature.

Starting from the bigger scale. Since the configuration of the Spanish colony city, the most important functions and the city where settled around the main square. Furthermore, over time with the expansion or the urban area, new centralities where originated, generating squares in different scales. Secondly, the orthogonal configuration of the blocks also generated large scale open areas in the cores. Generally, these spaces are permeable and have more than one access from the public roads.

In a smaller scale, there are several interior courtyards around which a house or villa is built.

Finally, the smaller open spaces are the patios located at the back of the houses. Their use is more related with the services of the house and habitability conditions such as illumination and ventilation.



URBAN VOIDS MAP
SOURCE: CUENCA RED. (2015)

URBAN VOIDS MAP

The urban voids in the city can be analyzed according to their nature. There were identified ten typologies:

1. LARGE SCALE COURTYARD: Open spaces configured as the core of large scale buildings. Commonly found in schools, multi-familiar buildings, etc.

2. CORES OF BLOCKS: Open spaces located in the hearts of the blocks. Specific characteristic of the urban trace, due to the morphological conformation of the plots.

3. PASSAGES: Pedestrian routes surrounded by buildings that are connected to the main road infrastructure.

4. VACANT LOTS: Refers to plots with no builds emplaced.

5. INTERIOR PATIOS: Small scale open spaces in the lots surrounded by the edification. Mostly, with a private character.

6. SQUARES: Public open spaces in different scales and with diverse uses. Among them: greenery, shadow zones, staying areas, pedestrian connections, etc.

7. STREETS AND ARCADES: Public road infrastructure and the covered pedestrian passages located on the ground floor of a building. Commonly with shops or market stalls on one or both sides.

8. FACADES: Lateral or rear facades of buildings.

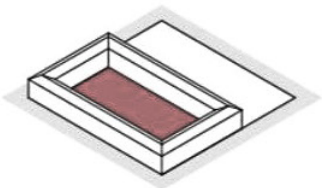
9. UNDEROCCUPIED BUILDINGS: Underused or disused edifications, commonly with heritage value. Whose positive conditions have potential for new interventions.

10. NEGATIVE IMPACT BUILDINGS: According to the building inventory performed by the Municipality of Cuenca. There are several buildings with a negative architectonical impact in the historical context.

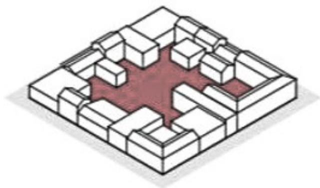
CLASSIFICATION OF URBAN VOIDS IN THE HISTORIC CENTER OF CUENCA

SOURCE: CUENCA RED_PLAN DE REACTIVACIÓN DEL ESPACIO PÚBLICO DE CUENCA, ECUADOR. (2015)

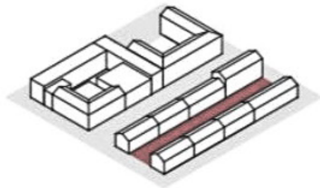
01 LARGE SCALE COURTYARDS



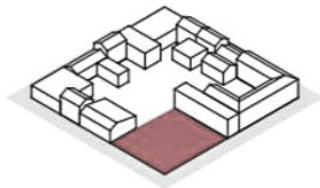
02 CORES OF BLOCKS



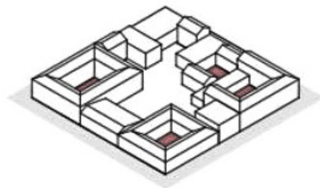
03 PASSAGES



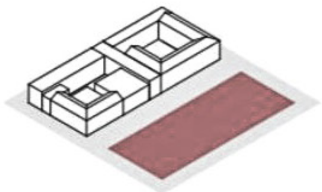
04 VACANT LOTS



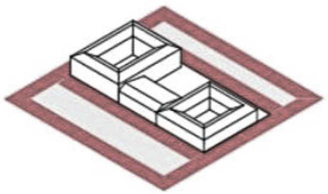
05 INTERIOR PATIOS



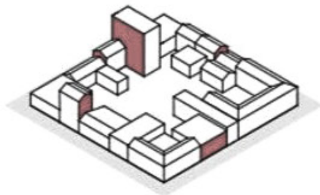
06 SQUARES /SMALL SQUARES



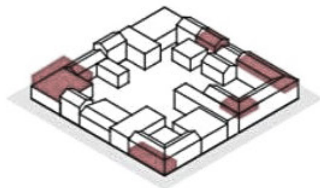
07 STREETS AND ARCADES



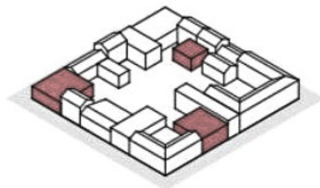
08 FACADES



09 UNDER-OCCUPIED BUILDINGS



10 NEGATIVE IMPACT BUILDINGS



URBAN AGRICULTURE SYSTEM
SELECTION OF URBAN VOIDS THROUGH URBAN ACUPUNCTURE

The Municipality of Cuenca, within the program Cuenca RED (2015) identified following a strict methodology, some spaces that have the potential to be intervened in the future. These spaces are a combination of underused plots in the block´s cores, an important number of plots dedicated for parking services (which are or will be changing functions due to the transformation of mobility systems in the historical center), the plots that are occupied by buildings with negative impact on the heritage, among others (figure 1).

With the available information and after the analysis of the urban and architectural conditions of the zone, the projects consist in identifying opportunity in-between urban spaces within the selected influence area in order to show the possibility to create in a bigger scale a comprehensive interlinked urban ecosystem with urban agriculture devices that give people the possibility of achieving quality of live.

Bohn and Viljoen (2011) define the “edible city” and introduced the concept of Continuous Productive Urban Landscape (CPUL), promoting the coherent introduction of interlinked productive landscapes inside cities as a vital element of sustainable urban infrastructure.

For the research, the proposal analyzes and designs two of the identified blocks with different environmental and physical conditions. The aim is to demonstrate the possibility of creating a new green urban system that emerges from the cores of the blocks of the consolidated tissue as a solution for climate change adaptation, with a significant role in improving the urban climate, while stimulating sustainable practices, reducing the energy footprint and promoting new social relationships.

IDENTIFIED SPACES WITH POTENTIAL

There are several spaces of opportunity identified in the selected influence area. These spaces have the potential to be part of an urban green system that could host activities related to urban agriculture, orchards, education activities, leisure activities, etc.

The selection include open areas, parking lots affected by the new tram routes and disused buildings. As well as some heritage buildings that were identified with potential use as residencial buildings for university students inside the Plan "Cuenca city of science and knowledge" from the Agencia Cuencana para el Desarrollo y la Integración Regional (ACUDIR).

LEGEND

- Buildings with negative impact
- Disused buildings
- Open spaces with potential
- Parking lots with direct access from tram line trace
- Parking lots with other access points
- Municipality parking lot
- Heritage buildings destinated for student residence
- Intervention areas
- Tramway

SOURCE: Cuenca RED_Plan de Reactivación del espacio público de Cuenca, Ecuador. (2015)


A
B

URBAN VOIDS INTERVENTION
SELECTION OF URBAN VOIDS THROUGH URBAN ACUPUNCTURE

The proposal consists in the analysis and integration of urban agriculture in two blocks from the urban system. The two "urban voids" have specific environmental conditions, thus the simulations and analysis help to select the most consistent and efficient cultivation techniques in order to ensure food security and reduce the energy footprint of the interventions.

The project demonstrates the possibility to create a sustainable agriculture system inside the city, in harmony between the economy, social and environmental issues.

The introduction of greenery in zones that were abandoned or only had concrete, promote the biodiversity in consolidated urban tissues. For instance, birds and butterflies are attracted to green spaces where the community is cultivating vegetables, medicinal plants and flowers. Besides the reduction of the environmental impact of cities.

A BLOCK

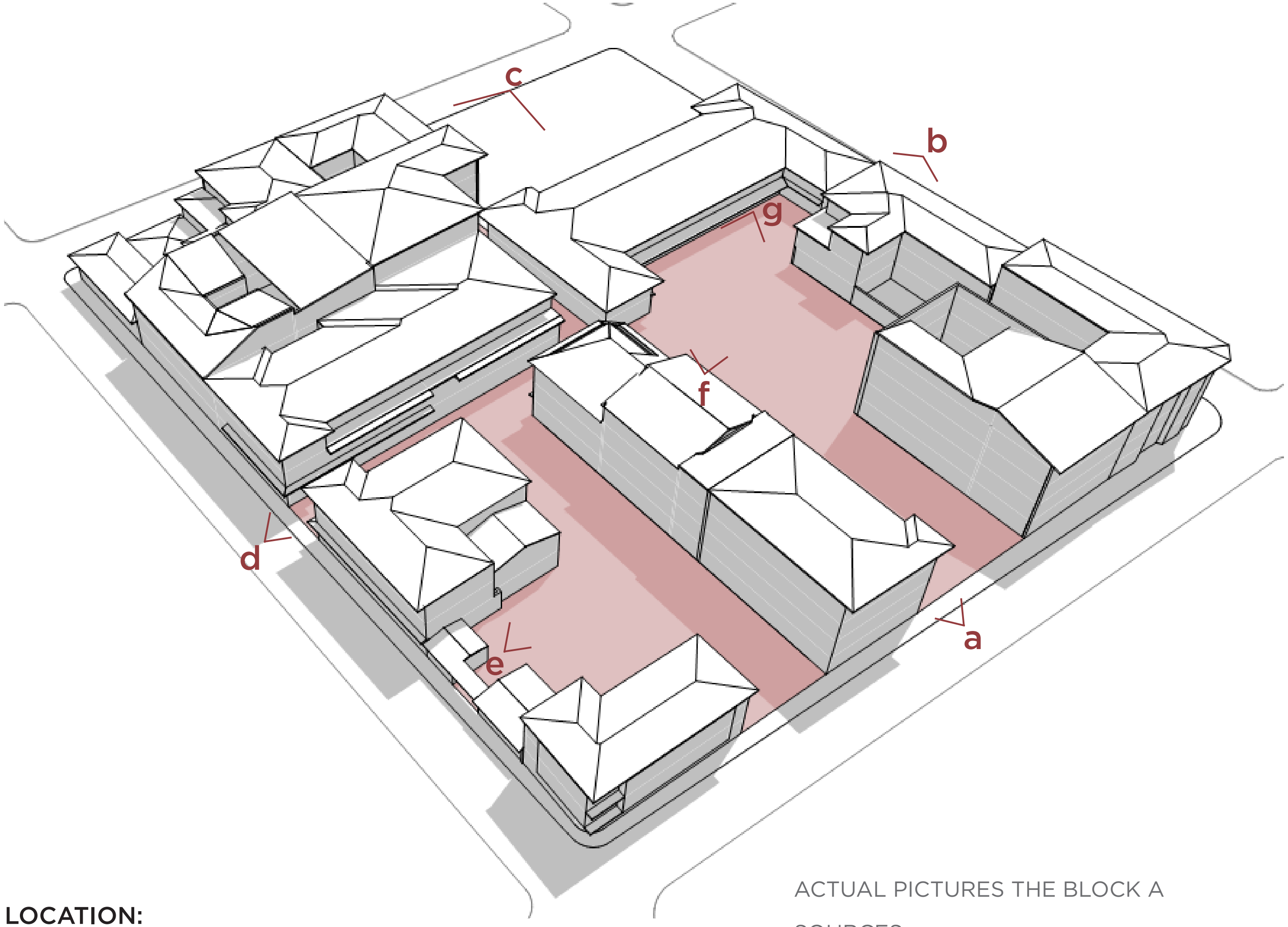
ACCESIBILITY

a.

b.

c.

d.



LOCATION:
LATITUDE: 2°53’46.11”S
LONGITUDE: 79° 0’4.47”W

ACTUAL PICTURES THE BLOCK A

SOURCES:
- Ecosistema Urbano / Emilio P. Doiztúa(2015)
- GOOGLE EARTH 2020


e.


f.


g.

B BLOCK

TYPOLOGY OF SPACE

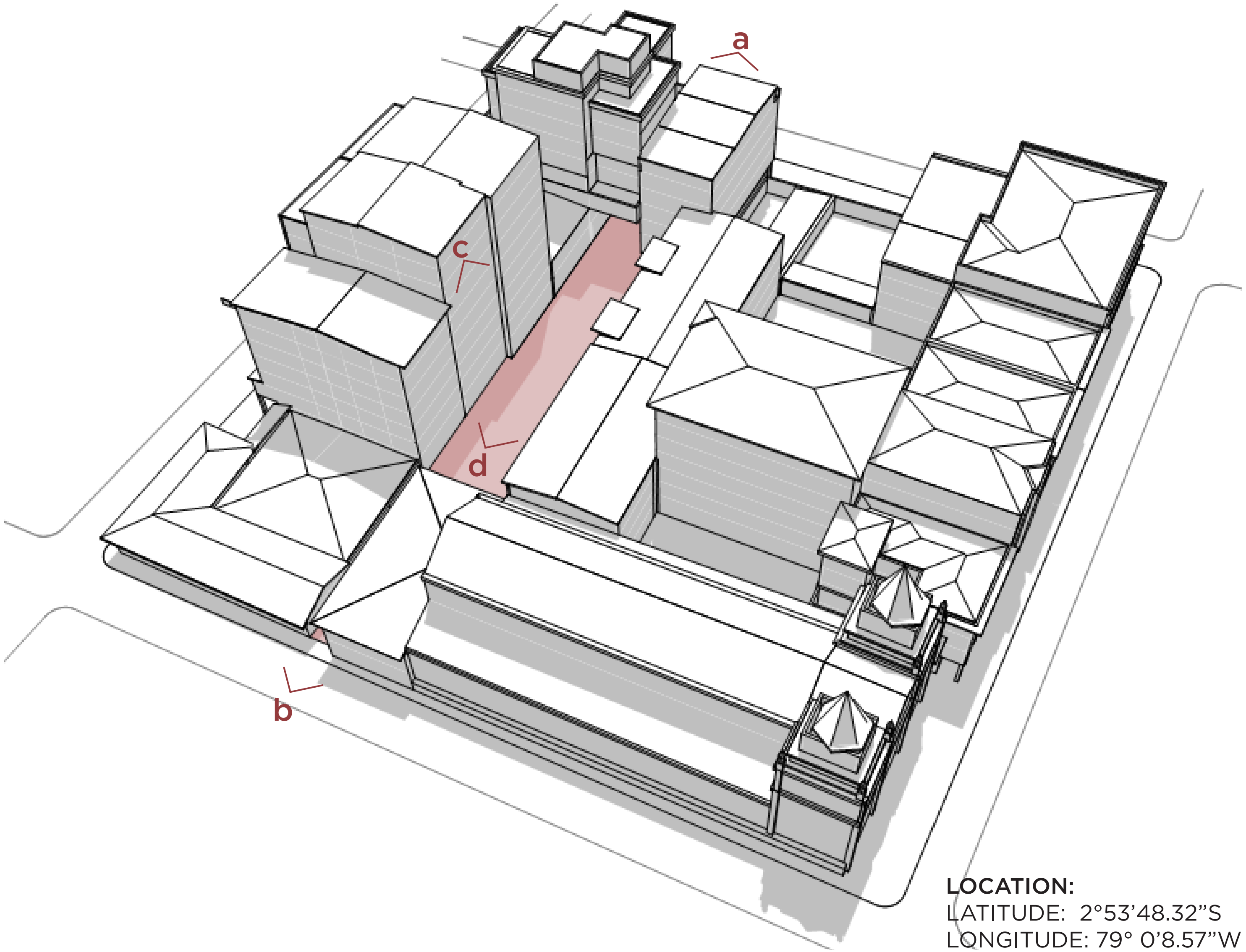
ACCESIBILITY

a

b

ACTUAL PICTURES THE BLOCK B

SOURCES:
-Ecosistema Urbano /Emilio P. Doiztúa(2015)
-GOOGLE EARTH 2020



LOCATION:
LATITUDE: 2°53'48.32"S
LONGITUDE: 79° 0'8.57"W

c.

d.

BUILDING INVENTORY
scale: 1:2000

LEGEND

- Ed. type E (emergent value)
- Ed. AR A (architectonic value A)
- Ed. VAR B (architectonic value B)
- Ed. A (environmental value)
- Edifications SV (no value)
- Edifications N-1 (negative impact)
- VAC Vacant plot
- P Parking lot
- Disused edif. negative impact

SOURCE:
Map of inventoried edifications from GAD Municipal de Cuenca, 2011

LAND USE PLAN
(ground floor)
scale: 1:2000

LEGEND

- pharmacy
- newspaper
- bank
- barber shop
- public social security offices
- restaurant / food
- stationery, photography, printing
- consultant service
- commerce: clothing, beauty, home appliances, shoes, etc.
- services: internet, laundry, etc.
- hotel
- hotel + restaurant
- handicrafts
- pastoral / religious services
- chuch
- VAC vacant plot
- P parking lot

HEIGHT ANALYSIS
s c a l e : 1:2000

LEGEND

- 1 floor
- 2 floors
- 3 floors
- 4 floors
- 5 floors
- 6 floors
- 7 floors
- 9 floors
- 10 floors

GREEN AREAS
scale: 1:2000

LEGEND

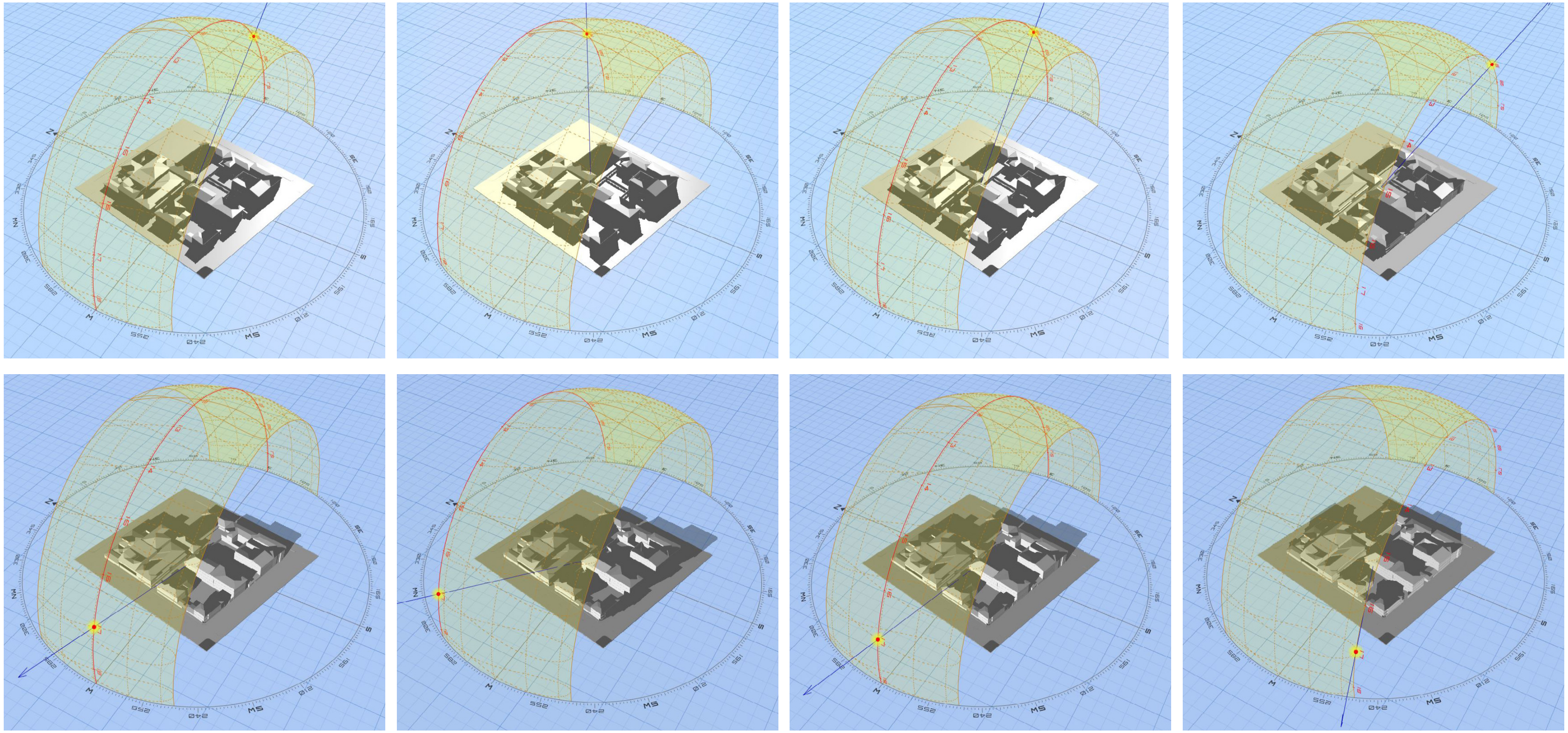
private green areas

public green areas

SUN-PATH SIMULATION BLOCK A

SOURCE: © Dr. Andrew J. Marsh, 2020

	AUTUMN/ FALL EQUINOX 20 MARCH	WINTER SOLSTICE 20 JUNE	SPRING/ VERNAL EQUINOX 22 SEPTEMBER	SUMMER SOLSTICE 21 DECEMBER
9 AM				
5 PM				

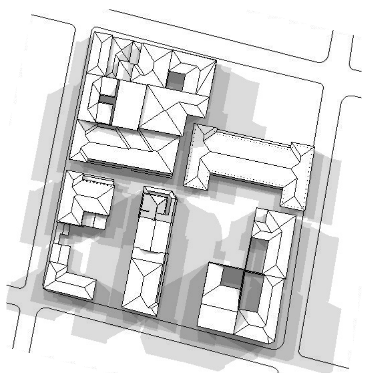


SUN STUDY BLOCK A

SOURCE: Simulation REVIT 2020

DAILY SUN STUDY

20 MARCH

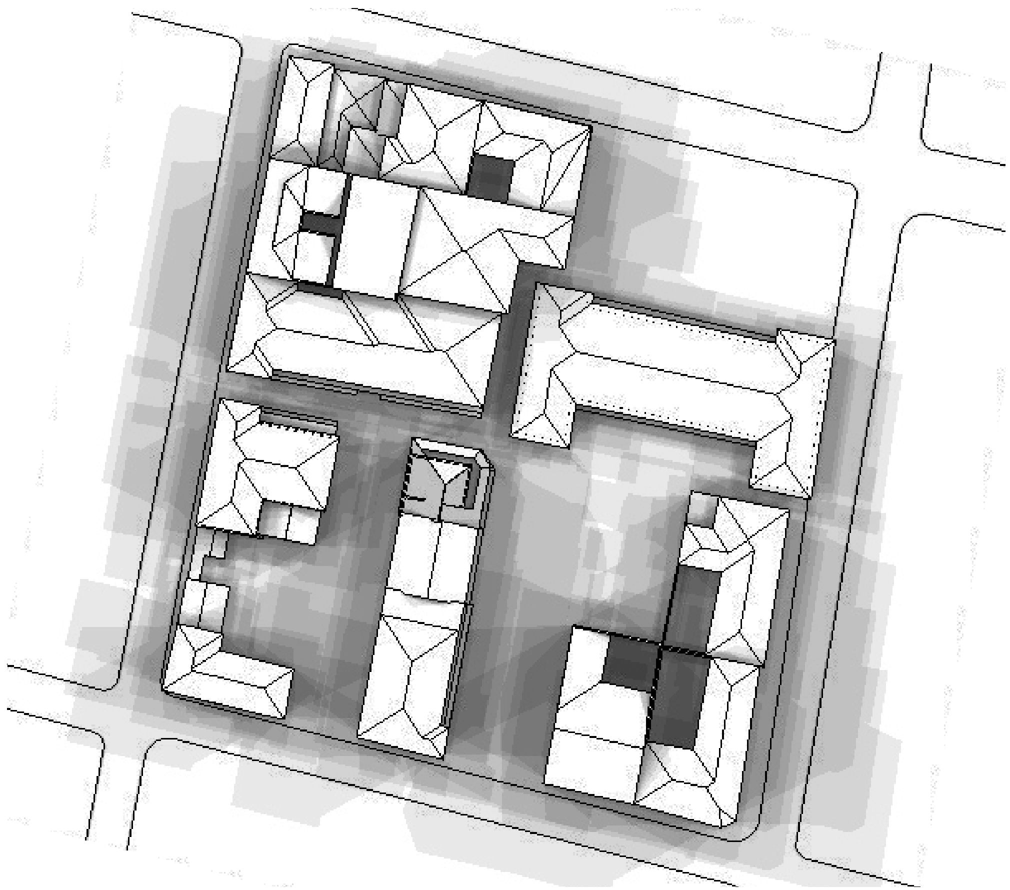


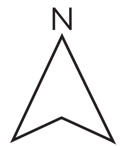
20 JUNE

22 SEPTEMBER

21 DECEMBER

YEARLY SUN STUDY





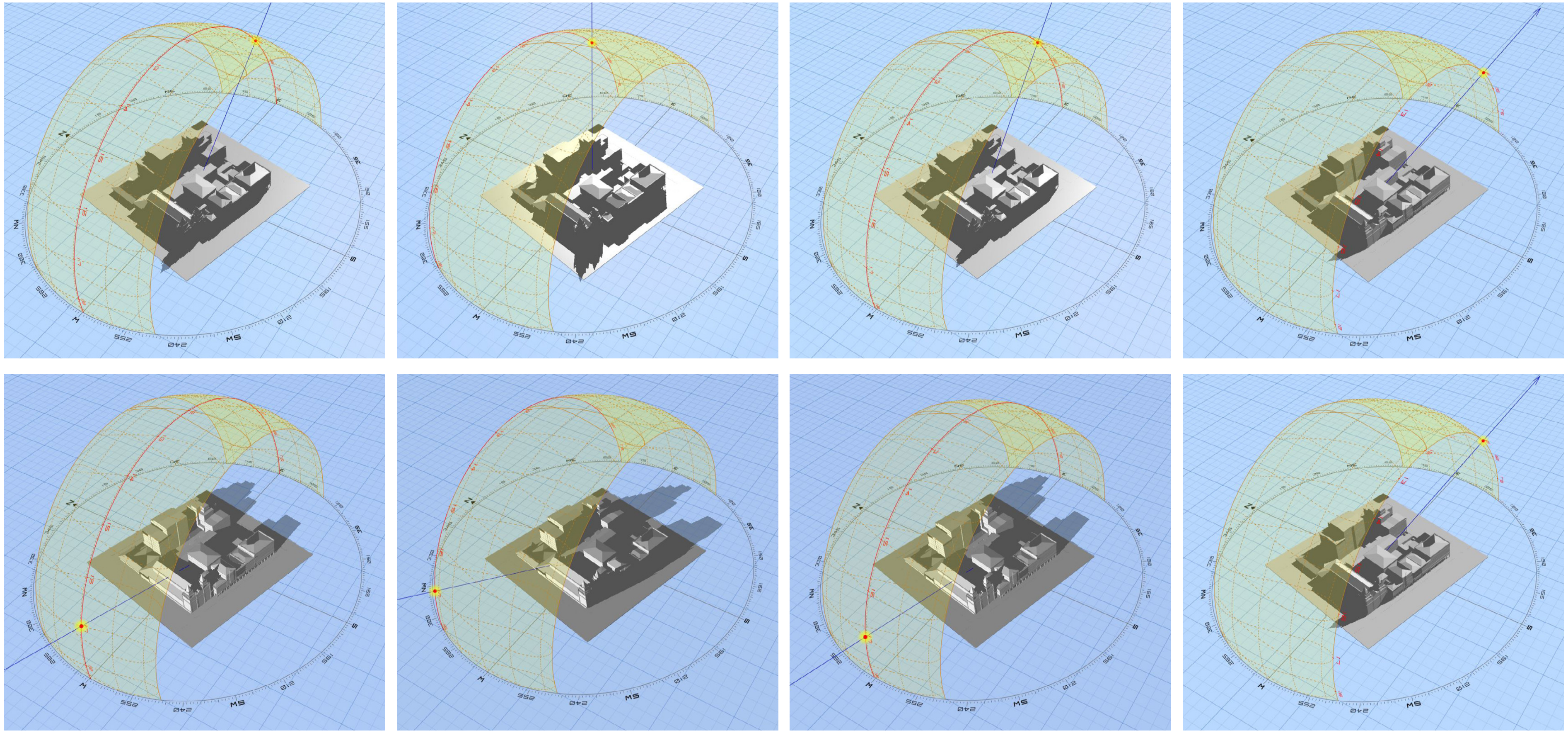
SUN-PATH SIMULATION BLOCK B

SOURCE: © Dr. Andrew J. Marsh, 2020

AUTUMN/ FALL EQUINOX 20 MARCH | **WINTER SOLSTICE** 20 JUNE | **SPRING/ VERNAL EQUINOX** 22 SEPTEMBER | **SUMMER SOLSTICE** 21 DECEMBER

9 AM

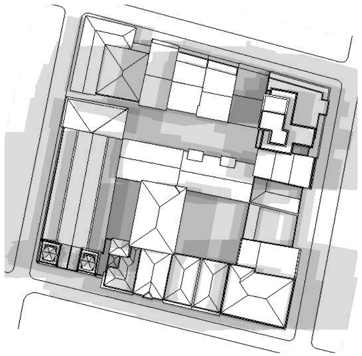
5 PM



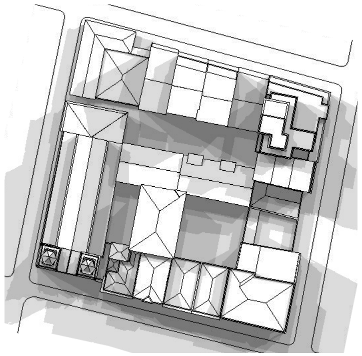
SUN STUDY BLOCK B

SOURCE: Simulation REVIT 2020

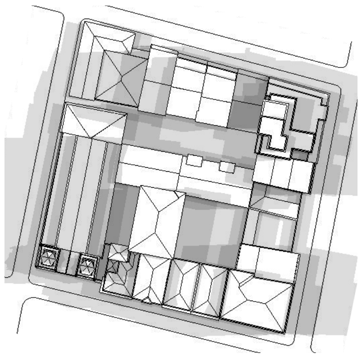
DAILY SUN STUDY



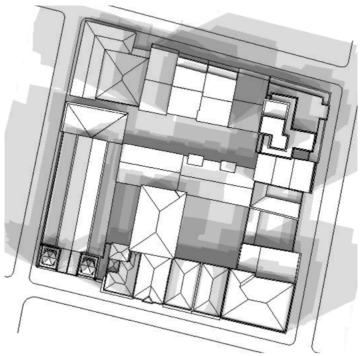
20 MARCH



20 JUNE

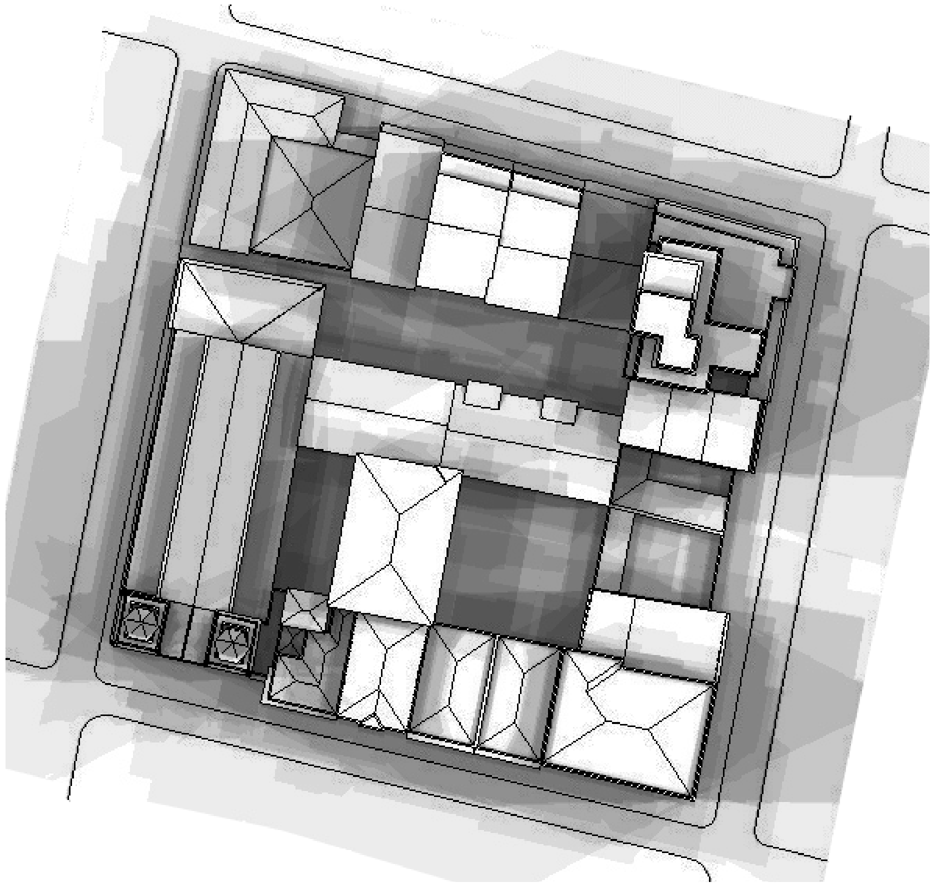


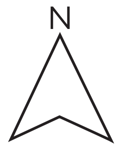
22 SEPTEMBER



21 DECEMBER

YEARLY SUN STUDY





MICROCLIMATE MATRIX

SOURCE: Shadow simulation REVIT 2020

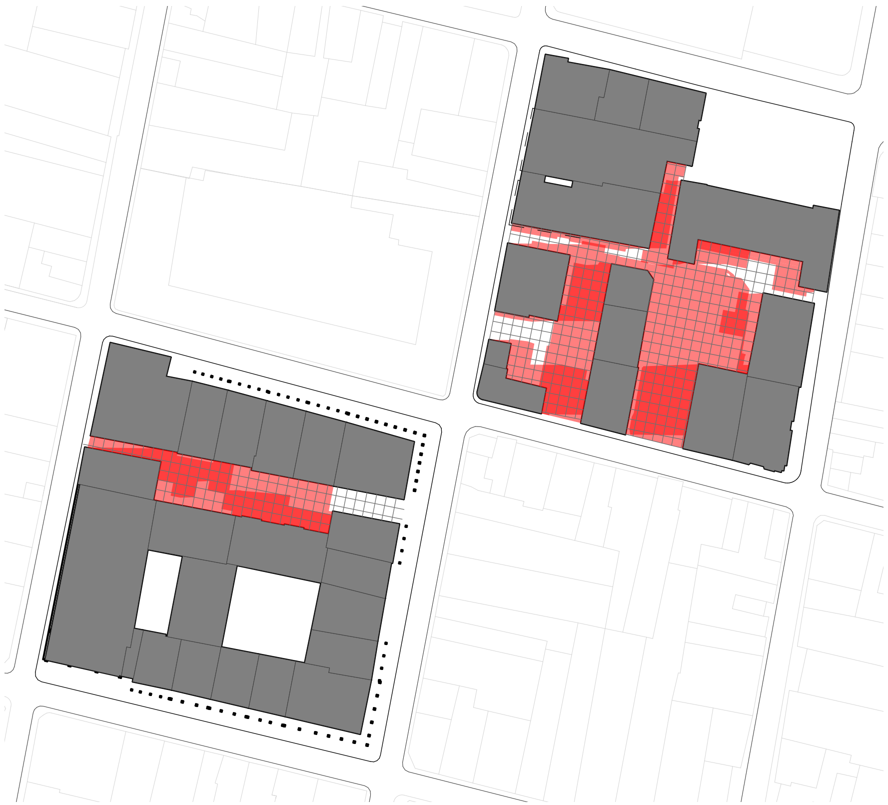
LEGEND

N

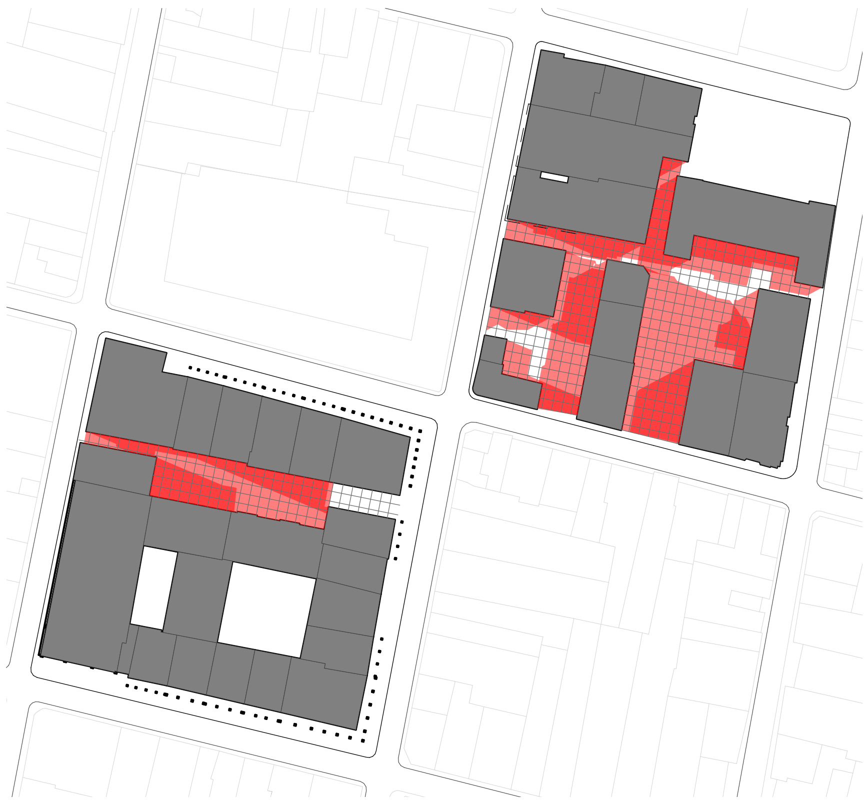
>6 hours of solar exposition

<6 hours of solar exposition

AUTUMN/ FALL EQUINOX
20 MARCH



WINTER SOLSTICE
20 JUNE



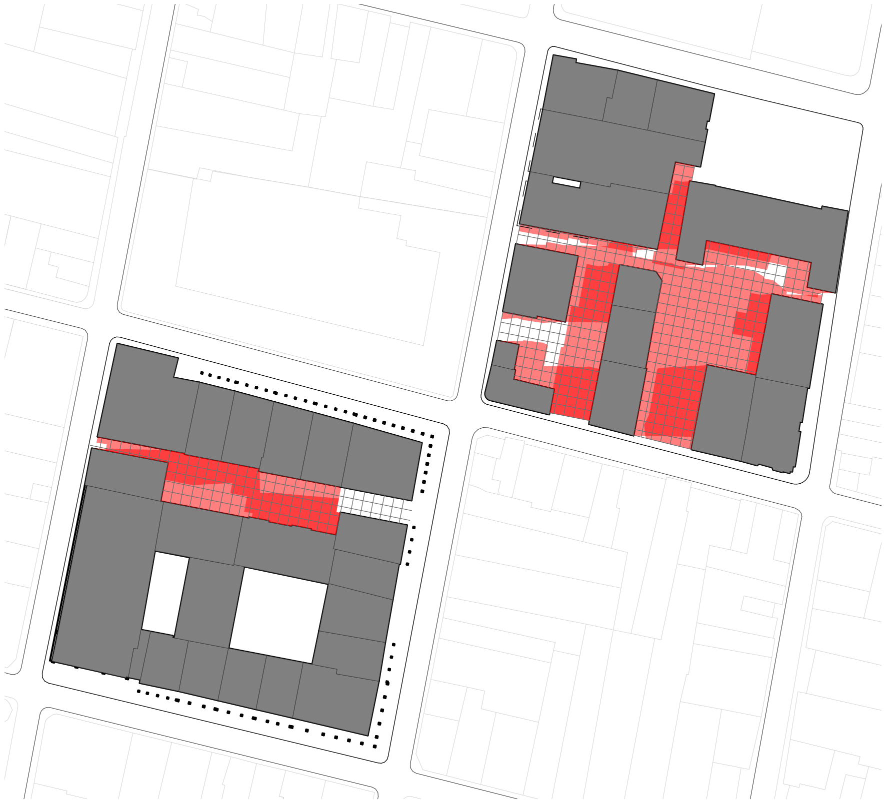
LEGEND

N

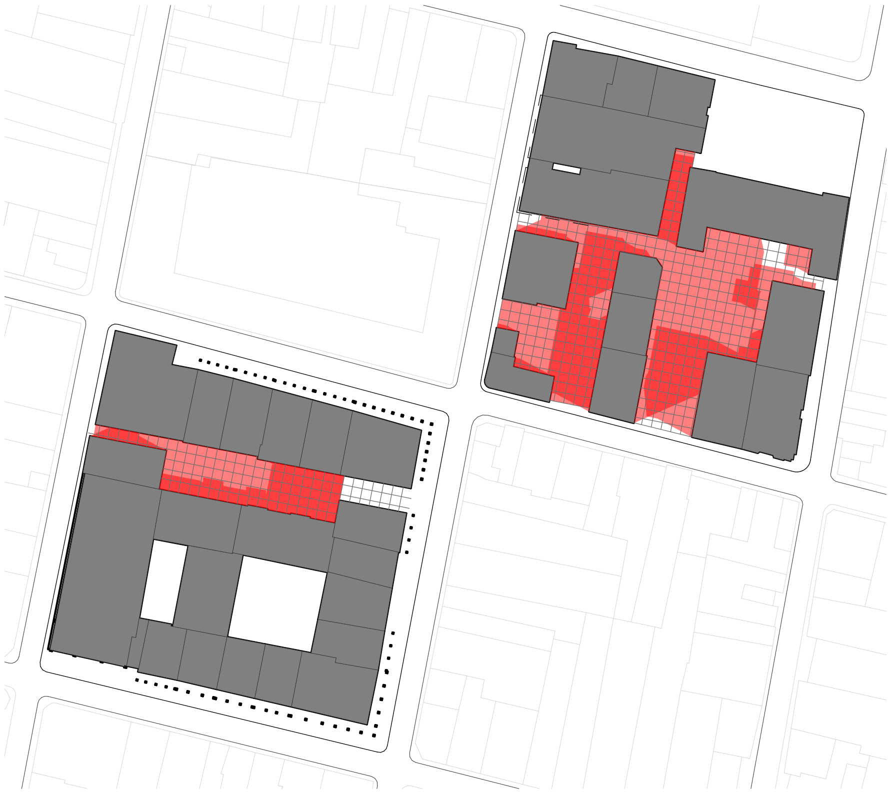
>6 hours of solar exposition

<6 hours of solar exposition

SPRING/ VERNAL EQUINOX
22 SEPTEMBER



SUMMER SOLSTICE
21 DECEMBER



DESIGN STRATEGIES

The project evaluates the conditions of two blocks in the historical center of Cuenca and the intervention of their existing urban voids for the integration of urban agriculture and the creation of a green system that goes from the cores of blocks towards the city.

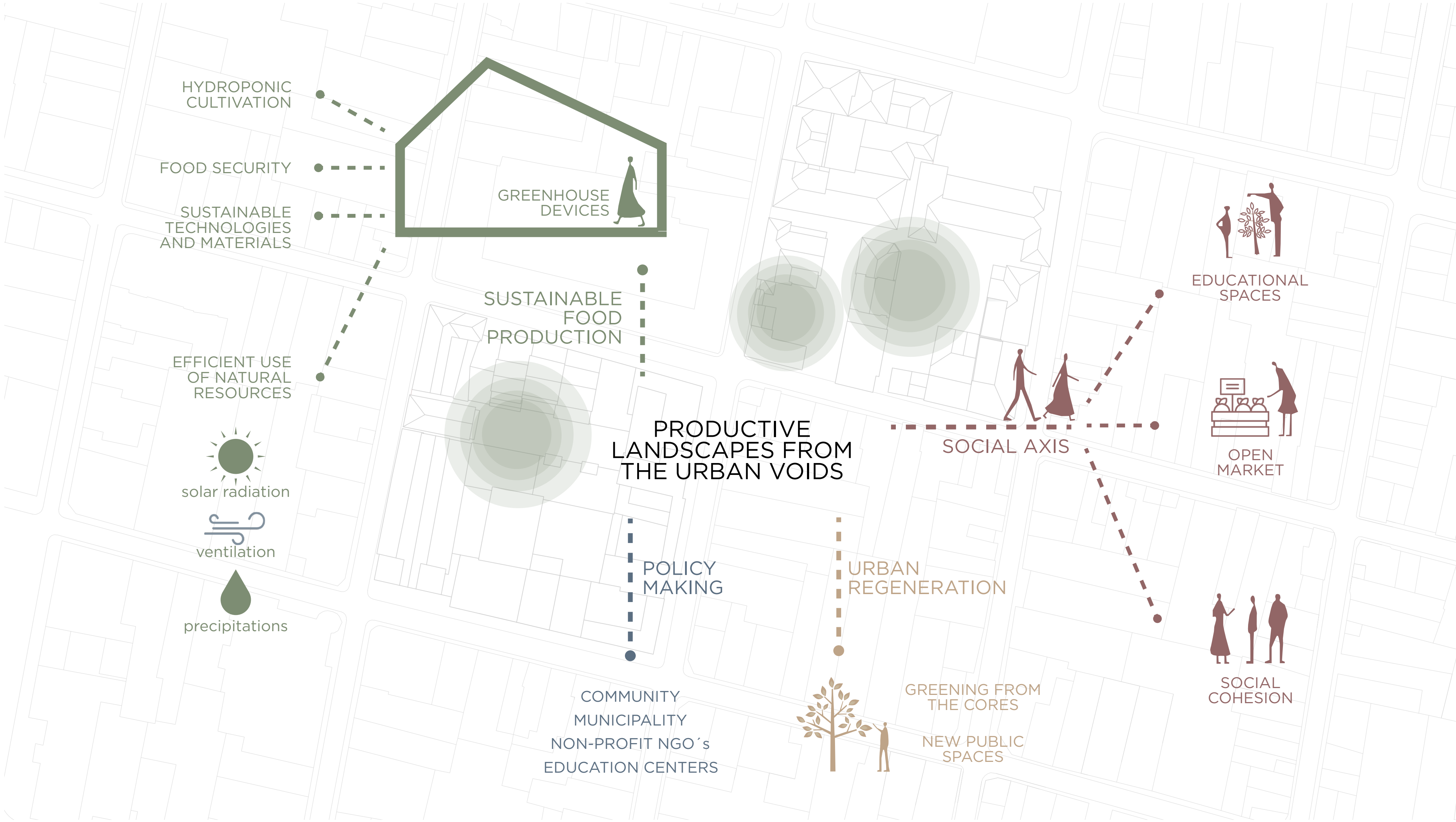
According to the research, there are four main axis of intervention that should be considered in order to have a success project.

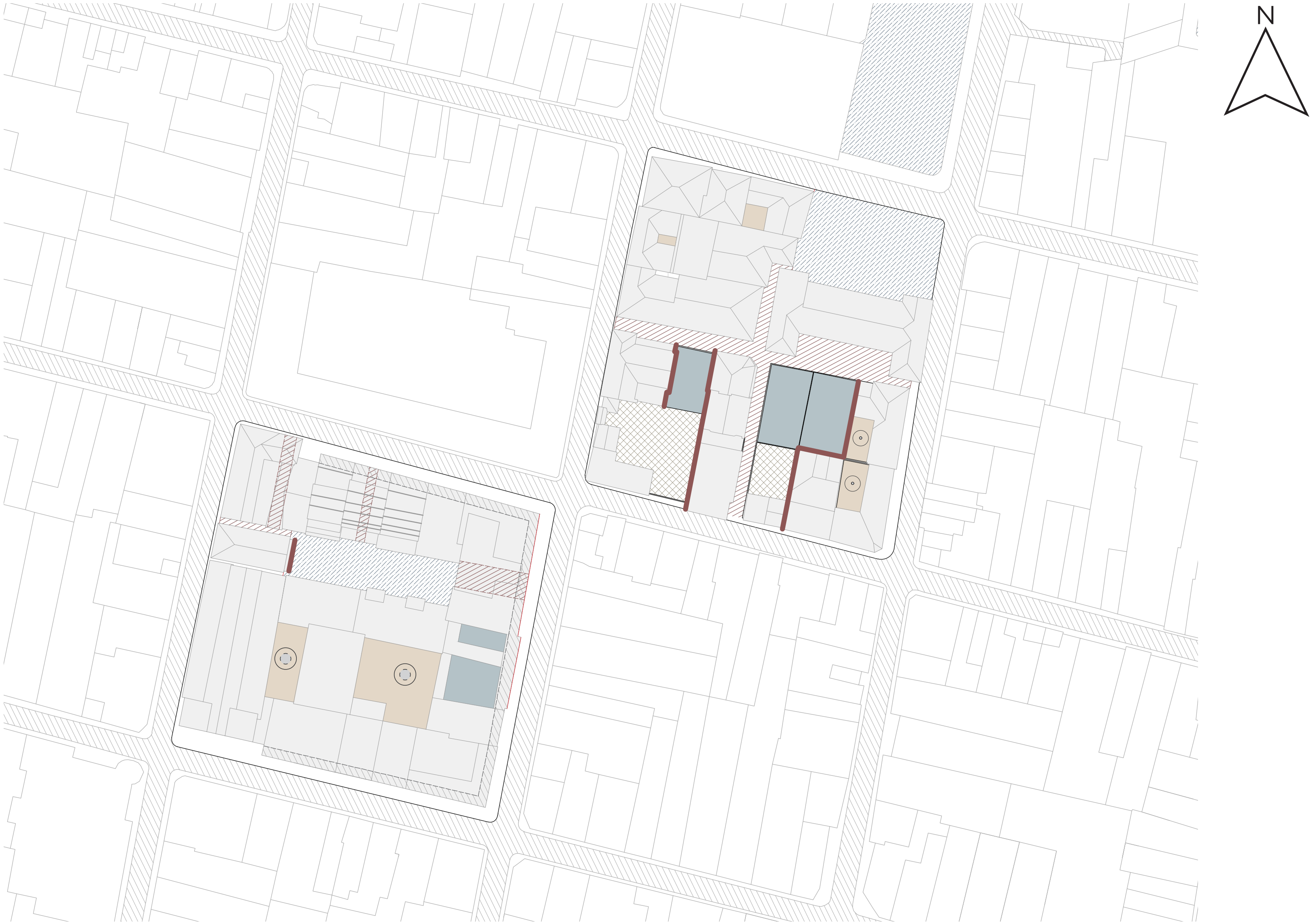
1. SUSTAINABLE FOOD PRODUCTION (greenhouse devices)
2. SOCIAL AXIS (participative processes)
3. URBAN REGENERATION
4. POLICY MAKING

The thesis emphasizes in the Sustainable food production through Greenhouse devices and gives some guides for the integration or urban agriculture systems in the urban voids. The project applies different strategies in order to create a replicable and sustainable agriculture system inside the city, in harmony between the economy, social and environmental issues.

The two blocks analyzed (Block A and Block B) have specific morphological and environmental conditions. Therefore, the aim of the thesis is the creation of an ADAPTATIVE SYSTEM that can be applied to create new productive green public spaces in the historical urban trace.

With the analysis of the different typologies of urban voids existing on each block, different solutions are applied in order to create a green core with variable urban services and promotes the social cohesion.


HYDROPONIC CULTIVATION
FOOD SECURITY
SUSTAINABLE TECHNOLOGIES AND MATERIALS
GREENHOUSE DEVICES
EFFICIENT USE OF NATURAL RESOURCES
solar radiation
ventilation
precipitations
SUSTAINABLE FOOD PRODUCTION
PRODUCTIVE LANDSCAPES FROM THE URBAN VOIDS
SOCIAL AXIS
EDUCATIONAL SPACES
OPEN MARKET
SOCIAL COHESION
POLICY MAKING
COMMUNITY
MUNICIPALITY
NON-PROFIT NGO´s
EDUCATION CENTERS
URBAN REGENERATION
GREENING FROM THE CORES
NEW PUBLIC SPACES



URBAN VOIDS CLASSIFICATION

scale: 1:2000

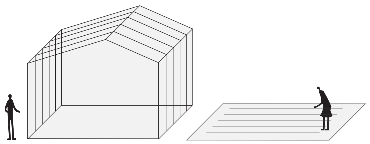
LEGEND

- Large scale courtyards
- Cores of blocks
- Passages
- Vacant lots
- Interior patios
  - Single family unit
  - Multi-familiar building
- Squares / small squares
- Streets and arcades
- Facades
- Under-occupied lots

URBAN VOID INTERVENTION STRATEGIES
FOR URBAN AGRICULTURE INTRODUCTION

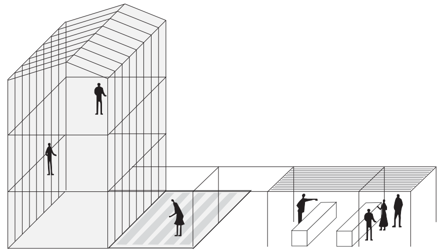
SQUARES /SMALL SQUARES

- GREENHOUSE DEVICES
- OPEN MARKET
- TRADITIONAL SOIL AGRICULTURE



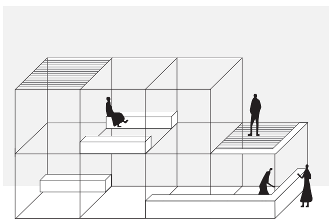
LARGE SCALE COURTYARDS

- GREENHOUSE DEVICES
- OPEN MARKET
- TRADITIONAL SOIL AGRICULTURE



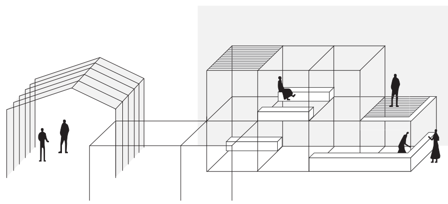
BLIND FACADES

- VERTICAL FARMING
- MARKET
- LEISURE AREAS



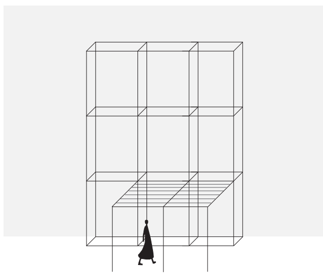
CORES OF BLOCKS

- OPEN ORCHARD
- OPEN MARKET
- LEISURE AREAS
- GREENHOUSES



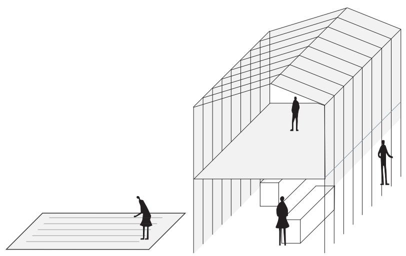
PASSAGES

- GREEN WALLS



VACANT LOTS

- GREENHOUSE
+ MULTIFUNCTIONAL SPACE
- TRADITIONAL SOIL AGRICULTURE



ADAPTATIVE GREENHOUSES

USE THE EXISTING TO INTEGRATE A NEW URBAN SYSTEM

The conditions of the urban voids vary in terms of scale, environmental and social conditions. Therefore, in order to give an adequate solution for this new public spaces, the new urban agriculture systems need to be adapted to be efficient.

The case of greenhouse devices emplacement does not differ from the above, the greenhouse selection should consider the size and dynamics of each urban void and the different urban scales. It should attract human activities, avoid dark and unsafe zones and improve the urban and social conditions of the surroundings.

The proposal consists in the creation of a modular basic greenhouse system that can be adapted to the special conditions of the urban voids in the historic center, for an efficient introduction of urban agriculture systems and the sustainable local food production and social integration.

One of the objectives is the efficient use of natural resources and the reduction of the energy consumption. Thus, the emplacement of the greenhouse devices follows the analysis of the specific conditions of the urban voids in terms of solar radiation and wind, in order to generate the proper microclimate for an efficient cultivation environment of crops.

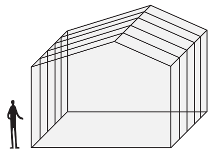
Secondly, the aim of the selection of materials and construction system follows the local logics of economy, community skills, efficiency, availability and sustainability.

The proposal the basic greenhouse has a single floor and is modulated and integrated with the specific urban system of each lot, which can include other food production systems such as traditional agriculture and vertical farming.

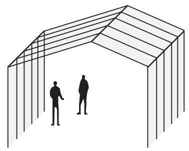
Therefore, the adaptation of the greenhouse prototype can include more floors, can become an open orchard, or include commercial, educational or exposition areas. Moreover, the model can be lengthened or placed in a row if the site conditions facilitate it.

TYPOLOGIES OF ADAPTATIVE GREENHOUSES

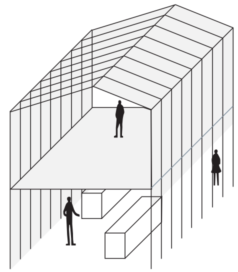
BASIC
ONE FLOOR GREENHOUSE



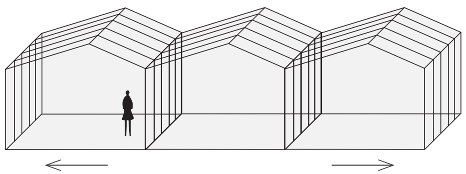
PUBLIC
ORCHARD



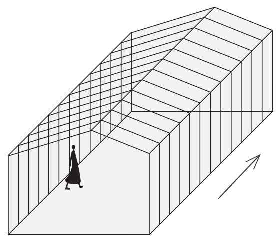
GREENHOUSE
+ MULTIFUNCTIONAL SPACE



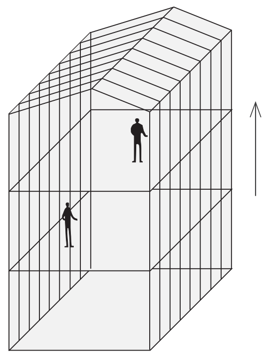
ROW
GREENHOUSES



ELONGATED
GREENHOUSE



GREENHOUSE
TOWER



STRATEGIES FOR ADAPTATIVE GREENHOUSES

1 CONCEPT AND MORPHOLOGY

Light and permeable greenhouse devices, which, introduced in the cores, do not compete with the surrounding heritage but blends in with nature.

The form responds to:
a) Coherence with the architectural typologies in the historical center
b) High average of precipitation
c) Efficient capture of solar radiation

2 COVERING MATERIALS

The sun's rays hit the earth's surface more directly at the equator,concentrating the radiation, accumulating energy and warming the area.
Herein lies the importance of covering materials, especially on the roof. In order to catch enough sun necessary for photosynthesis and to avoid excessive warming, in order to protect the crops from rain and temperature fluctuations.

3 ORIENTATION, LIGHT CONTROL AND TEMPERATURE

With the simulation of environmental conditions and the shadowing matrix. The emplacement of greenhouses follows a logic of obtaining the maximum amount of natural light. Nevertheless, the project includes obtaining energy from solar panels, in order to create a self-sufficient system and satisfy the needs of the greenhouses.

4 VENTILATION

The ventilation should ensure the proper concentration of Carbon Dioxide (C02) which is necessary for the photosynthesis.
Another aspect to consider is the water vapor which generally condenses and accumulates in the cladding of the greenhouse. Reducing radiation entry and creating conditions of humidity and fungi.

5 CULTIVATION SYSTEMS

The crops would be cultivated inside the greenhouse in a protected environment. The selected cultivation method is the hydroponic, which allows the plant production in soilless conditions with the supply of water and of minerals is carried out in nutrient solutions with an organic growing medium.

6 WATER CONSUMPTION

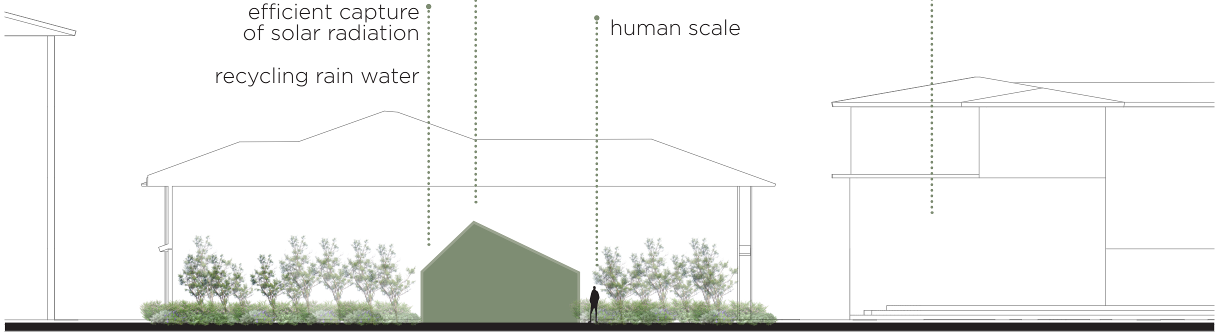
Due to the important ammount of precipitations in the city, the system provides a space for storing and reusing rainwater for irrigation of crops and basic needs of the green cores in the blocks.

1. CONCEPT AND MORPHOLOGY

CONCEPT

- The greenhouse is the medium for greening the urban voids-

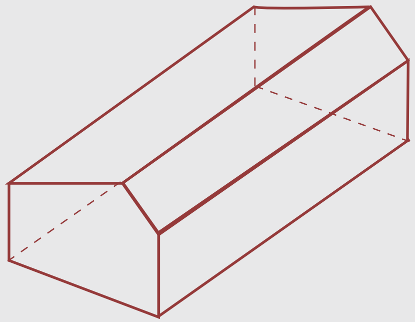
Light and permeable greenhouse devices, which, introduced in the cores, do not compete with the surrounding heritage but blends in with nature.



TYPICAL CONTEXT IN THE URBAN VOIDS OF THE HISTORICAL CENTER OF CUENCA

GREENHOUSE TYPOLOGY

GABIC UNEVEN SPAN



- Good resistance to winds
- Tilt of more than 30% facilitates interior water runoff from condensation
- Easy water runoff
- Good distribution of light inside but more shadows
- Can always be extended in length
- Allows the attachment of several greenhouses in battery
- Allows rainwater collection

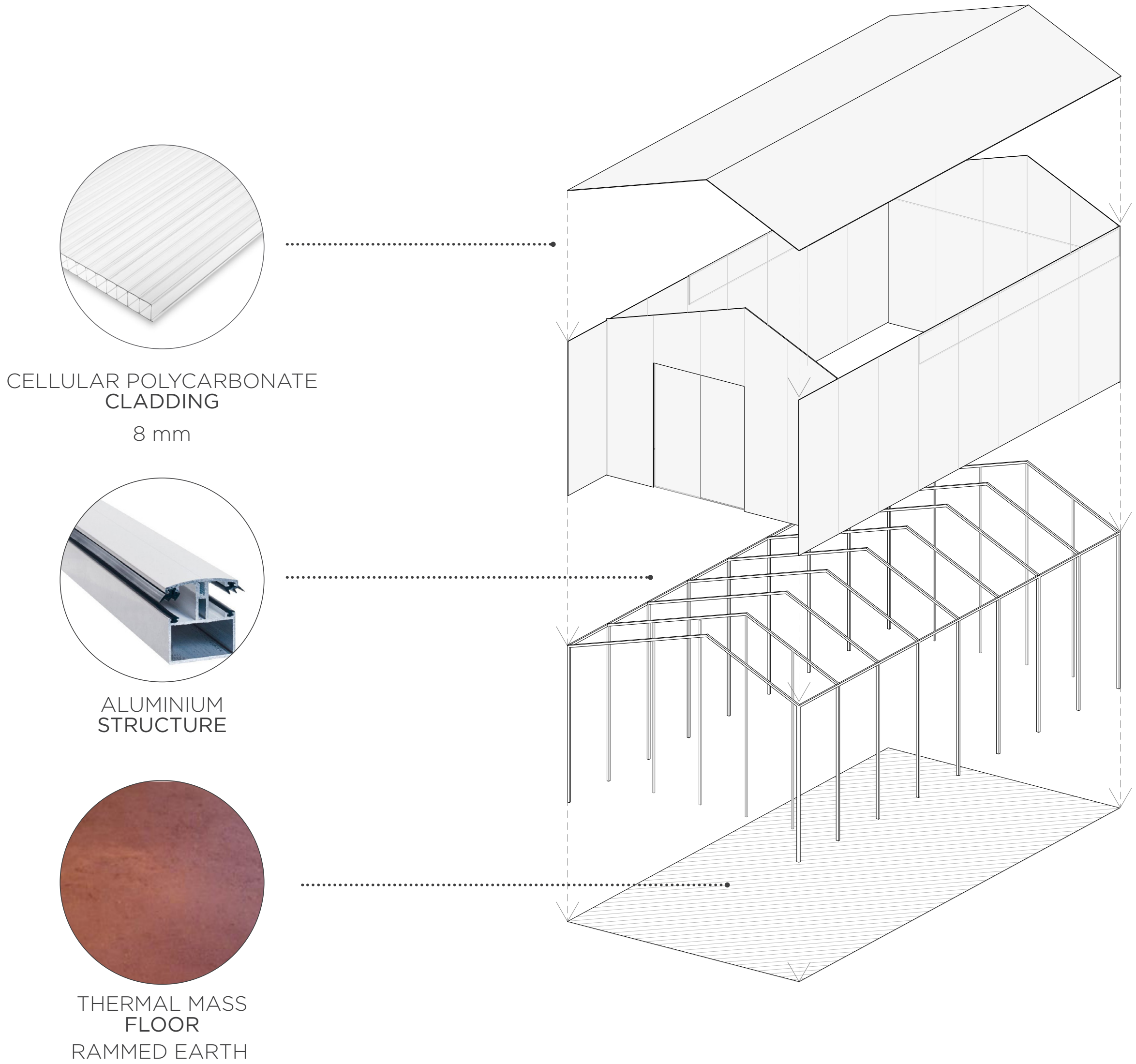
2. COVERING MATERIALS / STRUCTURE

The aim of a greenhouse is to provide a covered structure for cultivation of plants. It must be transparent to sunlight, enclosed enough to reduce convective heat loss due to the exchange of air between inside and outside.

A part of the solar radiation that travels through the covering material produces heat, and the other is used for plant photosynthesis.

The selection of the proper materials for the greenhouse to obtain an efficient environment for cultivation of native crops follow a logic of passive strategies in order to save energy and the effective use of existing natural resources. As well as avoiding possible problems related to excessive warming or cooling and the condensation, which increases the humidity levels of plants and generates the appropriate environment for the development of fungi and bacteria and the generation of disease outbreaks that are often difficult to control.

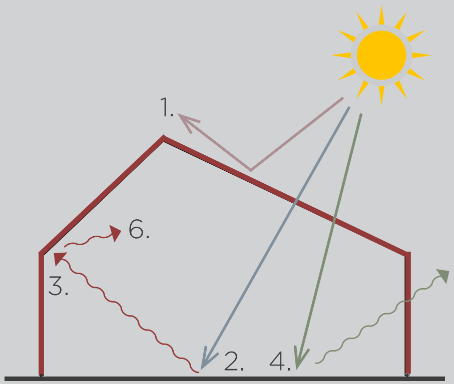
Besides, the selection of materials considers costs related to weight, costs, maintenance and duration.



MATERIALS PROPERTIES

CELLULAR POLYCARBONATE
CLADDING

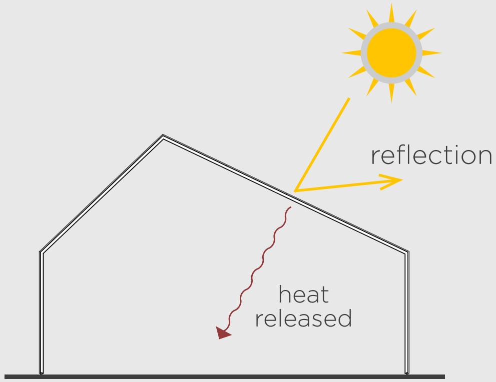
- Light material
- Light transmission: 80%
- Density: 1200 kg/m^3
- Specific heat: 0,11 - 0.17 kcal/kg · °C
- Heat capacity: 1900 -2200 kcal/m^3 · °C



1. Long-wavelength infrared light is reflected
2. Visible and short-wavelength infrared pass through
3. Short-wavelength infrared light is absorbed and re-emitted as long-wavelength infrared
4. Visible light is reflected
5. Reflected visible light passes through the cladding
6. Long-wavelength infrared light is reflected by the cladding and is trapped inside the greenhouse

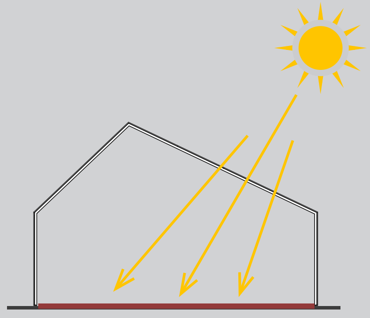
ALUMINIUM
STRUCTURE

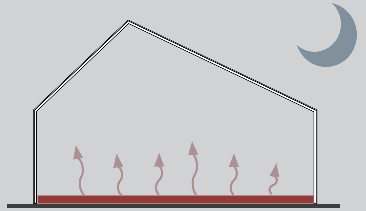
- Economical and long lasting
- Density: 2700 kg/m^3
- Specific heat: 0,215 kcal/kg · °C
- Heat capacity: 900 kcal/m^3 · °C



RAMMED EARTH
FLOOR

- Thermal mass material
- Density: 1500 kg/m^3
- Specific heat: 0,44 kcal/kg · °C
- Heat capacity: 660 kcal/m^3 · °C





3. ORIENTATION, LIGHT CONTROL AND TEMPERATURE

The orientation and roof angle of greenhouses structures have an important influence in the overall percentage of sunlight inside. With the seasonal changes in sun angle vary from one place to the other, therefore, it is necessary to optimize the greenhouse with support mecha-nisms according to the latitude.

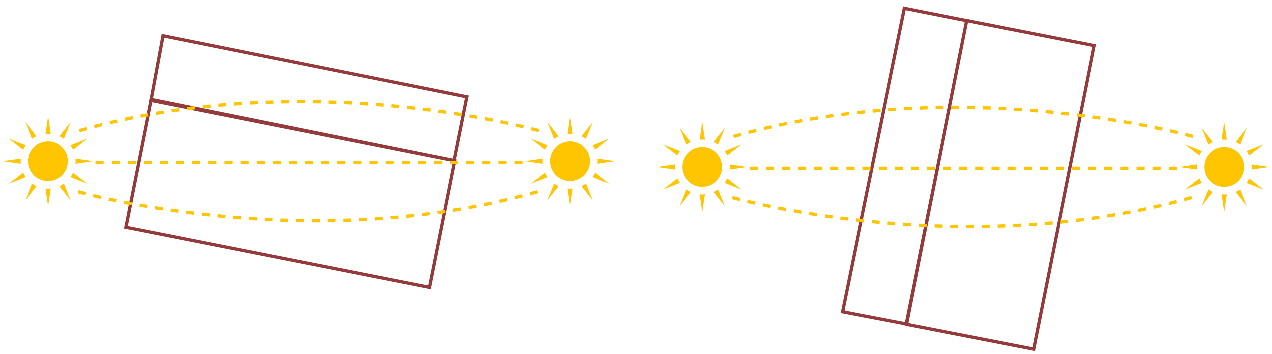
The intervention site, is located close to the equator. Due to that, the sun's rays hit more directly to the surfaces of these zones, concentrating radiation, accumulating energy and warming the area.

There are two possible types of orientation for the emplacement of the adaptative greenhouses according to the urban trace. The ideal goal could be that with the proper morphology, isolation materials and ventilation strategies, the prototype could work efficiently in both cases with decreased supplementary lighting costs.

The solar gain simulation in both scenarios (figure 1 and 2) that the lighting entry in both orientations satisfy the standard needs of some crops. Nevertheless, there could be the possibility of needing supplementary lighting systems according to the void conditions.

GREENHOUSES ACCORDING TO THEIR ORIENTATION IN THE HISTORIC CENTER

GREENHOUSE TYPE 1 **GREENHOUSE TYPE 2**



RECOMENDATIONS FOR SUPPLEMENTARY LIGHTING

Even though the proposal aim is to use as much as possible the solar radiation, and the emplacement of the greenhouses follow a microclimate matrix in order to avoid shadow areas, there will be cases where a supplementary lighting system could be required in periods of low natural light.

The sun spectrum quality is constant; however, it is variable in duration, direction and intensity. Sunlight conditions can vary rapidly, affecting temperature, humidity, and illuminance. There are several strategies used to deal with an undesirable indoor microclimate, such as ventilation, heating, shading, irrigation, humidification, and lighting equipment.

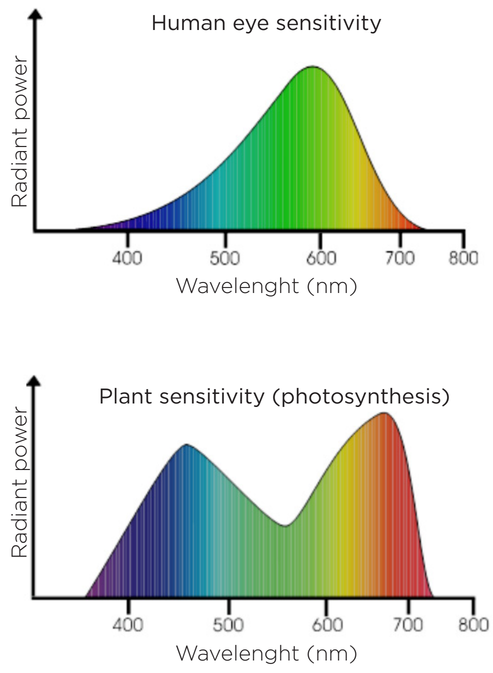
The luminaire type and the reflector design are important in the horticultural effectiveness of the lamp. Among the types of lamps, some are designed specifically for horticultural use. The artificial light source must provide a high conversion of electrical energy into light, in a spectrum optimally balanced for plant growth. Besides, the efficiency, life span, intensity, spectral quality, cost, and electrical requirements must respond to the crop demands and the application. For a supplementary light system, it is important to consider the light requirements of the crops, the natural daylight and average hours of sunlight, sun angle (latitude) and weather.

Humans perceive light in a different way than plants (figure). Humans a stronger response to light in the green/yellow part of the spectrum (600nm). Nevertheless, for photosynthesis, plants respond better to blue and red light, and to red and infrared light wavelengths for photoperiod growth responses and germination control. The intensity, duration, direction, and spectral quality inside the greenhouse has an effect on photosynthesis, flowering, climate response, and plant shape (photomorphogenesis).

The Light Emitting Diodes (LED) grow lights are a promising technology for greenhouse cultivation. They require significantly less energy and radiate less heat than HPS lights, lowering energy costs (it can save up to 80% of energy). Besides, it has a long service life (it lasts about five times compared to other lamps).

The emitted light is valuable for both photosynthesis and photomorphogenesis and the colors can be adapted according to the type of crops or the growing stage. Due to their particular light color, LEDs can generate special conditions in plants. Studies have shown that through artificial intervention, red and blue light can make plants grow stems, leaves, and roots more rapidly.

SPECTRUM SENSITIVITY



SOURCE: https://growersnetwork.org/

TEMPERATURE

1. For a year-round production, a climate control method in passive solar greenhouses in areas with important temperature fluctuations, is the use of thermal mass materials which are dense materials capable of storing large amounts of thermal energy (heat), maintaining a suitable growing environment without expensive heating and cooling systems.

The system consists in the natural exposition of the thermal mass material to the solar rays and the absorption of heat from the greenhouse during the day, and the re-radiation of the stored heat at night when the temperatures drop.

A way to storage the heat on the materials is the use of water. It has the highest heat capacity per volume and it is cheap. Moreover, with the combination of water reuse systems such as storing rain water and the hydroponic cultivation systems, it can close a sustainable cycle related to the efficient use of natural resources.

2. The use of double-glazing polycarbonate as a covering material of a closed greenhouse, combined with thermal storage methods may decrease the heating demand.

3. The use of controllable ventilation openings allow the manual control of the environment according to the changing climatic needs of the city.

4. The use of a thermal mass floor with dark colors can help as well to absorb and storage the heat during the day. Especially in areas located close to the equator, due to the important solar radiation and the angle of incidence of the sun.

A disadvantage of these systems is the lack of precise control, because on the dependency on outdoor climate, and could have a limited effect. Thus, in unpredictable situations with unfortunate climate conditions, it may be necessary to have a back-up heating system in order to preserve the cultivation development.

In order to reduce costs and to generate a sustainable system, it may be necessary to place solar panels in sun-exposed areas or roofs of surrounding buildings in order to obtain solar energy that could be used for lighting the greenhouses and the climate control of the cultivation.

SOLAR ENERGY
PHOTOVOLTAIC SOLAR COLLECTORS

Self-sufficient unit
Common solar panels for public space

Grennhouse daily need	193 kwh/month 6.43 kwh/day
Classic plus solar panel 1645x990x35mm 1.62 m2	300 Wp Efficiency= 15%

1

7 panels/unit	11.4 m2
min. (july)	213.83 kwh
max. (december)	257.7 kwh

2

14 panels/unit	22.8 m2
min. (july)	427.66 kwh
max. (december)	515.4 kwh

4. VENTILATION SYSTEM

GREENHOUSE GAS FLOW

CARBON DIOXIDE (C02)

INPUT → - ventilation entry
- breath release of crop and soil

OUTPUT → - fixation by photosynthesis of the crop
- ventilation losses

WATER STEAM

INPUT → - crop and soil evaporation
- ventilation entry

OUTPUT → - condensation in the cover
- ventilation losses

OPTIMAL ENVIRONMENTAL CONTROL

$3m^3$ /m2 of floor — air volume / volume of soil covered

floor area: 63.5 m^2
ventilation volume: 191 m^2

VENTILATION OPENINGS

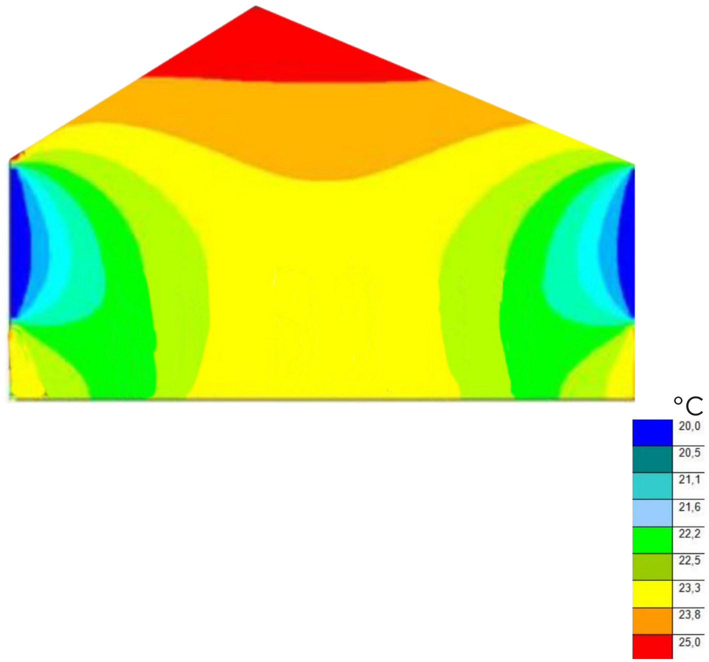
20% /of m2 roof — % of roof area for openings area

ventilation area: 12.6 m^2

OPENINGS HEIGHT

30 cm — above the crops

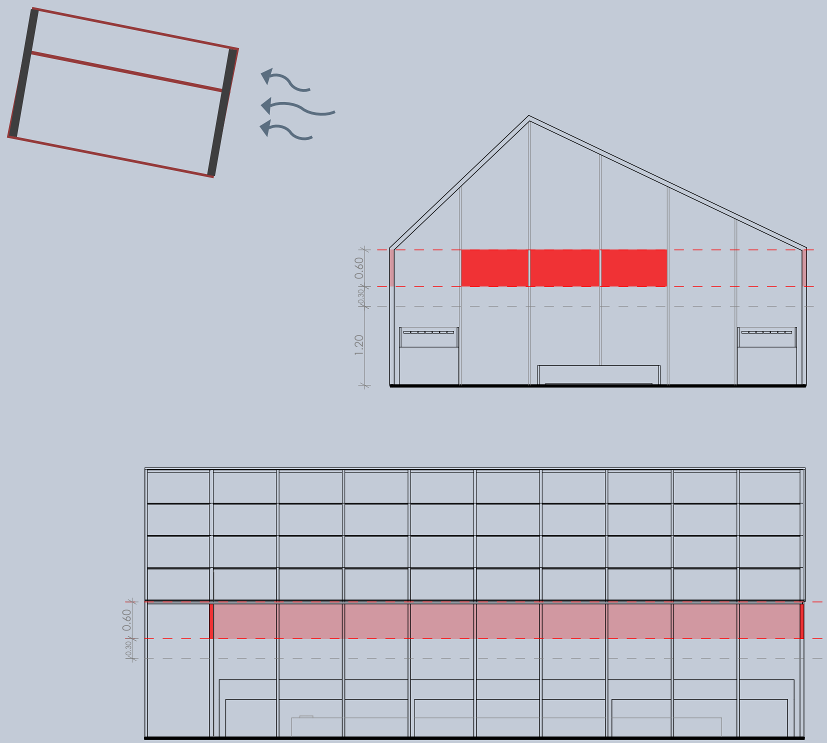
DISTRIBUTION OF AIR INSIDE AIR TEMPERATURE WITH NATURAL VENTILATION



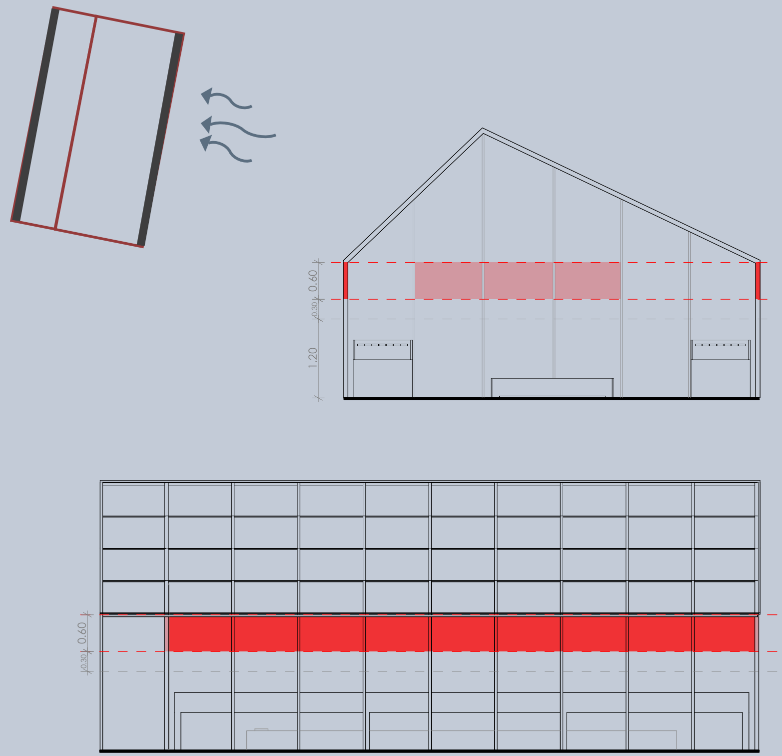
OPENINGS DISPOSITION ACCORDING TO NATURAL VENTILATION

Direction of prevailing winds: EAST

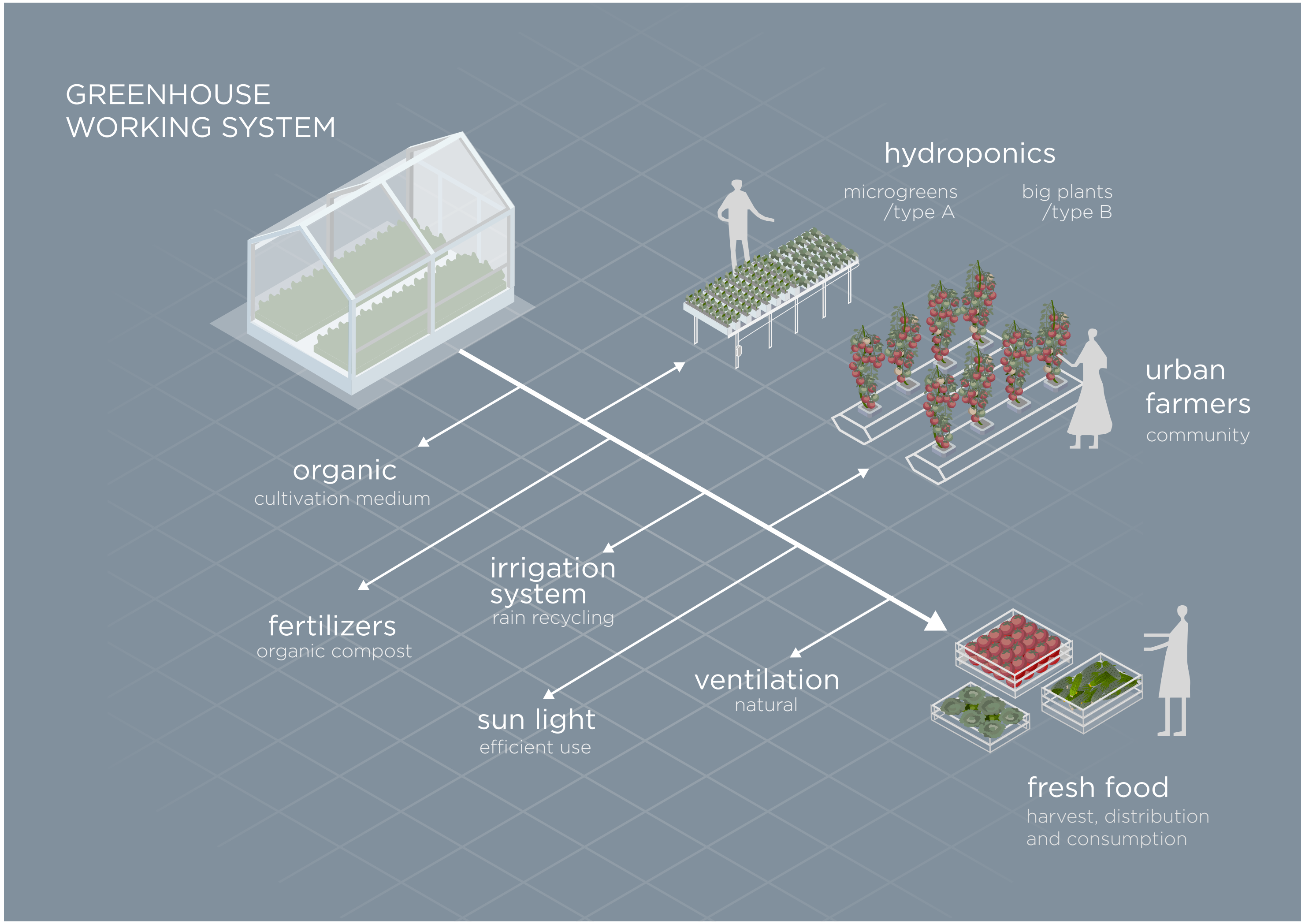
GREENHOUSE ORIENTATION 1



GREENHOUSE ORIENTATION 2



5. CULTIVATION SYSTEM



SYSTEM ADVANTAGES

80% Less water

Zero Soil use

2x Grow rate

1/4 Of the space

Less Diseases and pests

TECHNICAL SUMMARY OF CULTIVATION

LEGEND

- Table cultivation (small crops)
- Cultivation in the floor (medium crops)

HOURS OF SOLAR EXPOSITION

TYPES OF CROPS	HOURS OF SOLAR EXPO-SITION	CULTIVATION CYCLE	REQUIRED TEMPERATURES
Cilantro	<4	40 - 60 days	15-18 °C
Parsley	<4	80 days	5 - 32 °C
Lettuce	<4	20 - 65 days	5 - 23 °C
Onion	<4	3 - 4 months	12 - 23 °C
Scallions	>4	2 months	20 - 26 °C
Potatoes	<4	65 -100 days	12 - 21 °C
Medicinal plants	>4	-	15 - 30 °C
Strawberries	>6	3 - 6 months	16 - 27 °C
Eggplants	>6	2 months	18 - 27 °C
Tomatoes	>6	3 months	14 - 26 °C
Pepper	>6	2 months	21 - 26 °C

COMBINATION OF CULTIVATION SYSTEMS

In order to have a diversified fresh food production, the proposal suggests cultivation systems that can be combined inside the protected environment of the greenhouse.

Among the cultivation types there are the traditional soil cultivation and the hydroponic systems that consist in the plant production in soilless conditions with the supply of water and of minerals is carried out in nutrient solutions with an organic growing medium.

CULTIVATION SYSTEMS AND TYPES OF CROPS:

- Traditional soil culture cultivation (vegetables, medicinal plants, ornamental plants, potatoes)

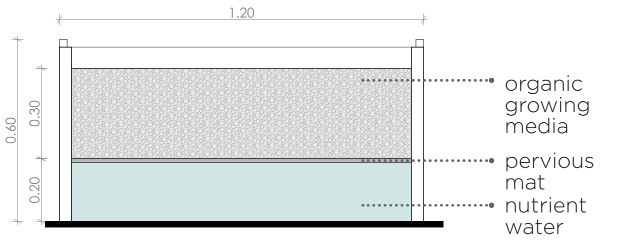
- Hydroponic methods are:

  - Drip irrigation system (tomatoes, pepper, eggplants)

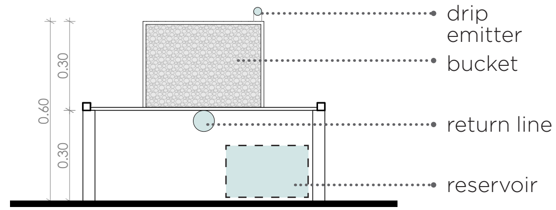
  - Wicking bed system (Microgreens, plant germination, medicinal plants)

  - Wick watering system (Lettuce, onion, basil, strawberries)

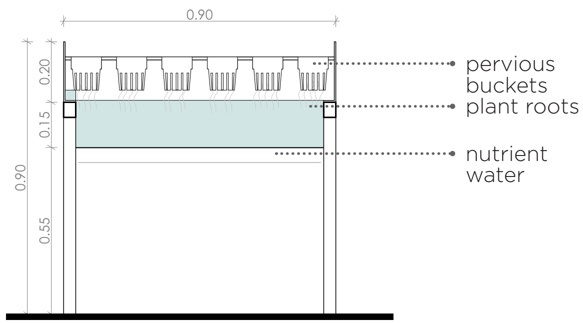
WICKING BED SYSTEM
(PASSIVE)



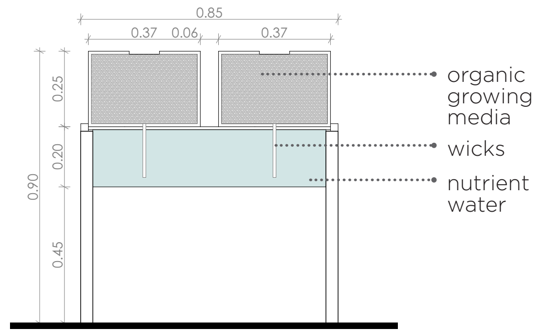
DRIP IRRIGATION SYSTEM
(ACTIVE)



WICK WATERING SYSTEM
SMALL PLANTS
(PASSIVE)



WICK WATERING SYSTEM
MEDIUM PLANTS
(PASSIVE)



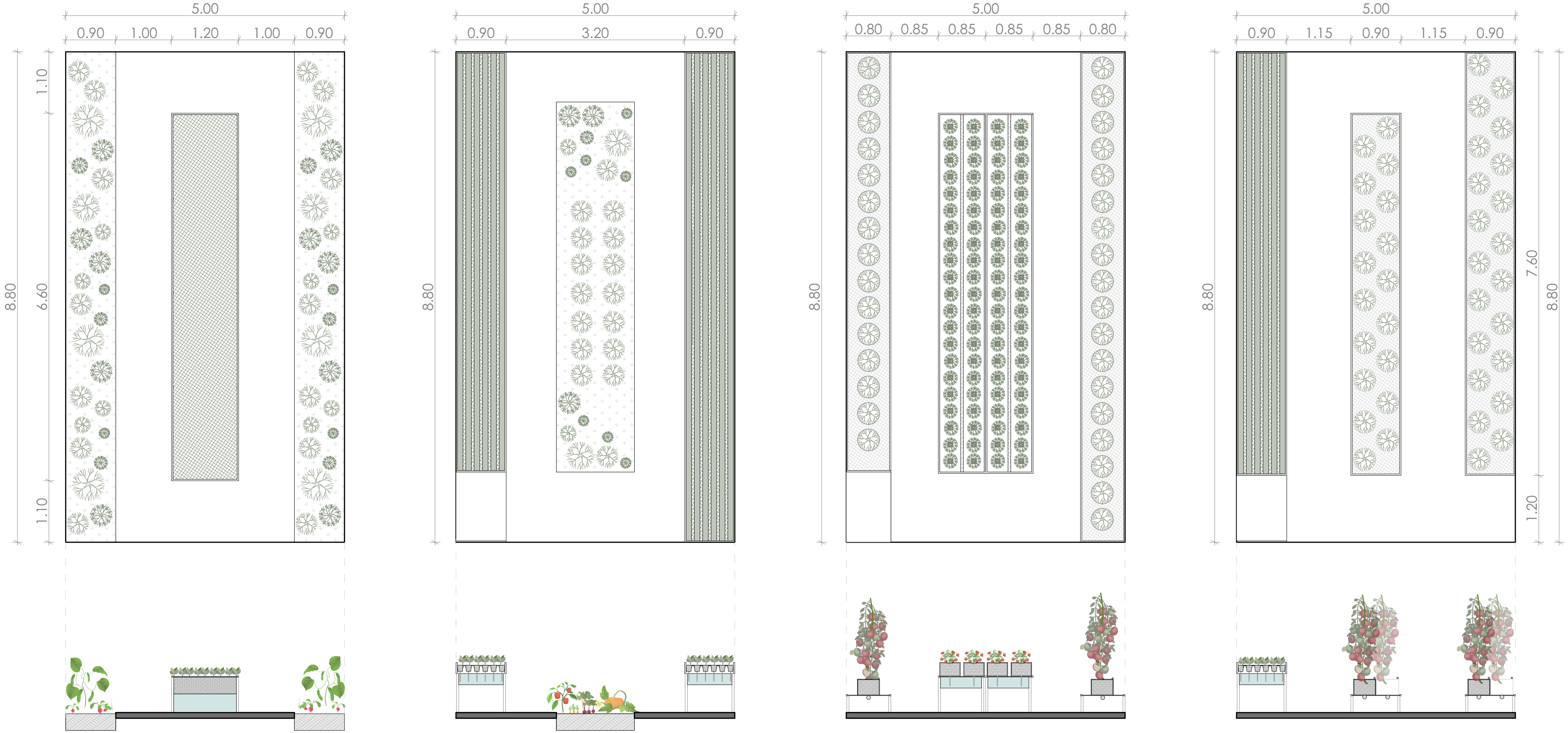
COMBINATION OF CULTIVATION SYSTEMS IN A BASIC GREENHOUSE

SOIL CULTURE + WICKING BED SYSTEM

WICK WATERING SYSTEM + SOIL CULTURE

DRIP IRRIGATION SYSTEM + WICK WATERING SYSTEM

WICK WATERING SYSTEM + DRIP IRRIGATION SYSTEM



6. WATER AND WASTE MANAGEMENT

RECYCLING RAIN WATER

Annual precipitation	858 mm /year
Roof surface.	50 m2
Unit collection	42.9 m3/year

WASTE MANAGEMENT

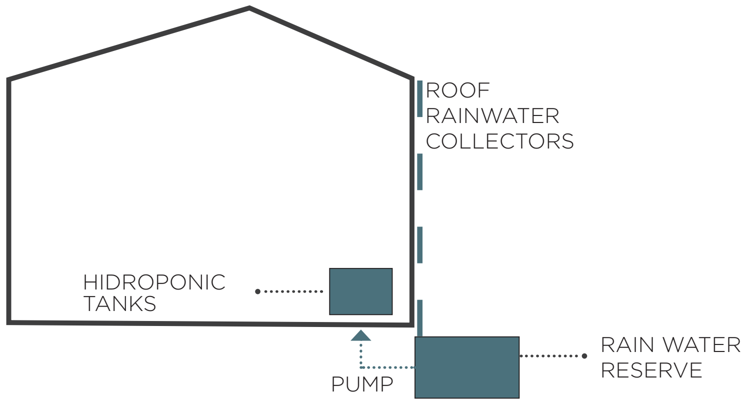
PRIMARY STORAGE-
Deposit size/block 7.5 m3

ORGANIC WASTE

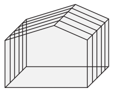
Compost production for urban farming

MANAGED BY THE COMMUNITY:
Block collection and transportation to specific spaces of the green cores

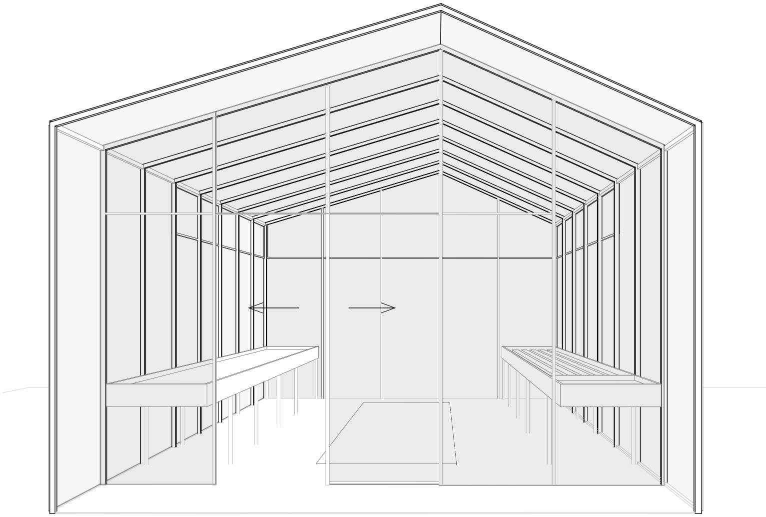
ROOF RAINWATER COLLECTORS



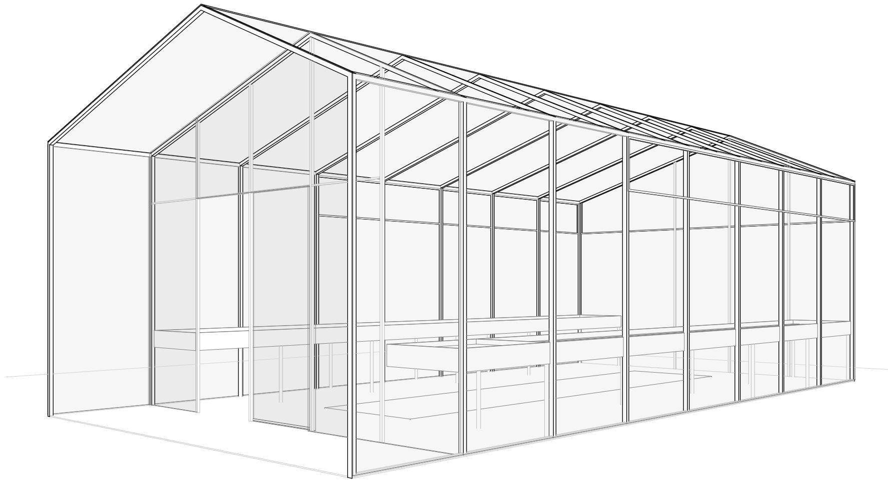
DEVELOPMENT OF TYPOLOGIES
ADAPTATIVE GREENHOUSES



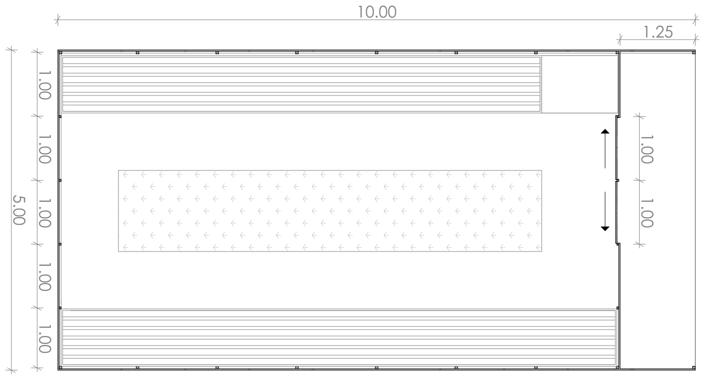
BASIC SINGLE FLOOR GREENHOUSE



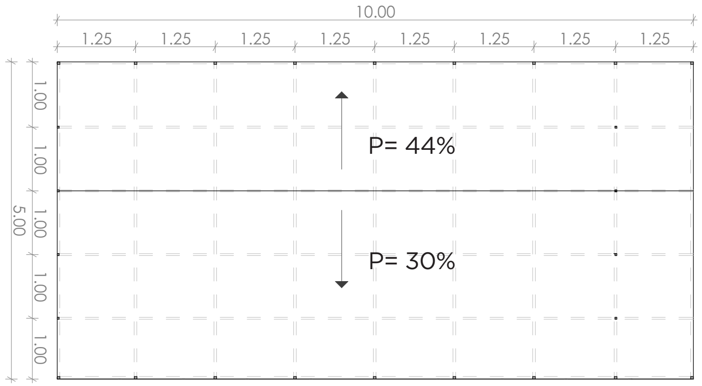
FRONTAL VIEW



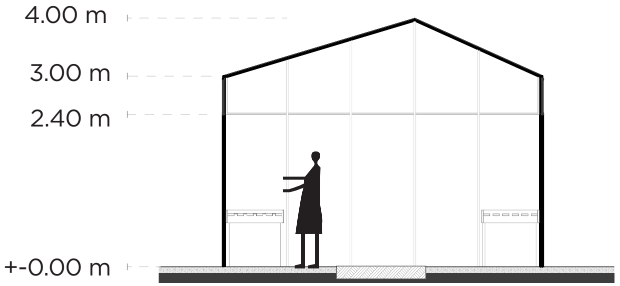
GREENHOUSE PERSPECTIVE



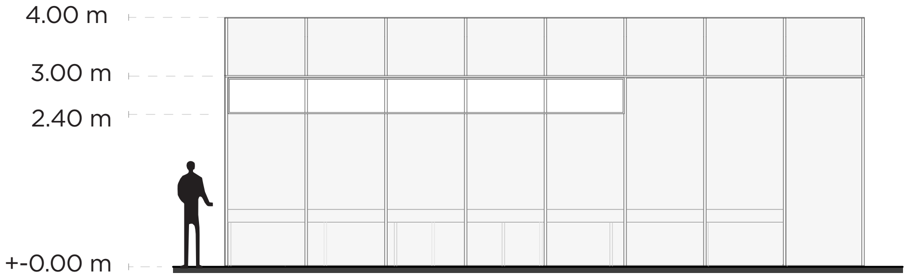
FLOOR PLAN
scale 1:100



ROOF PLAN
scale 1:100

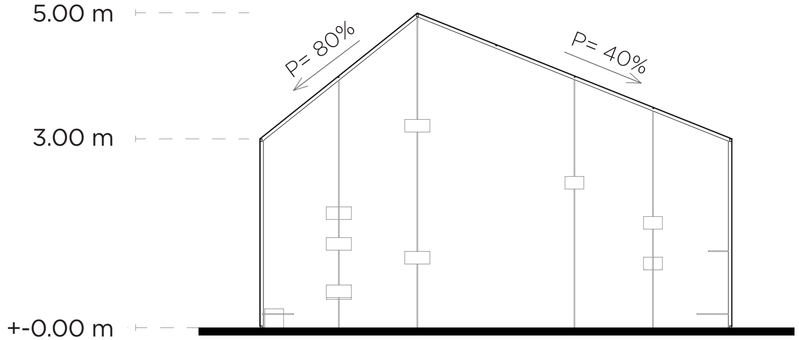


TRASVERSAL SECTION
scale 1:100

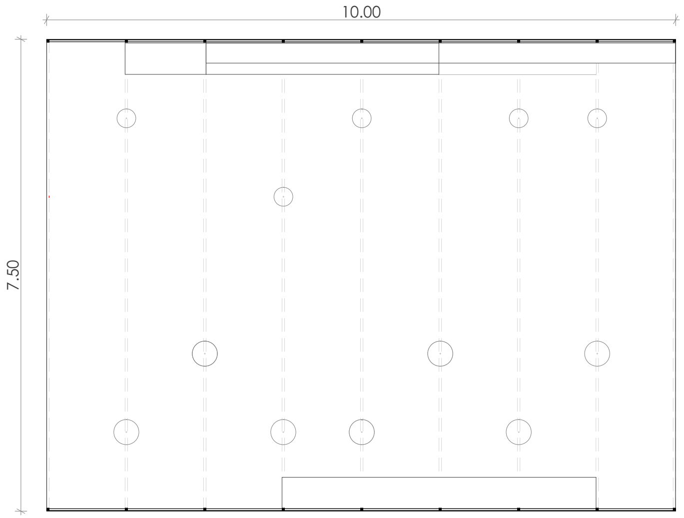


LATERAL ELEVATION
scale 1:100

PUBLIC ORCHARD

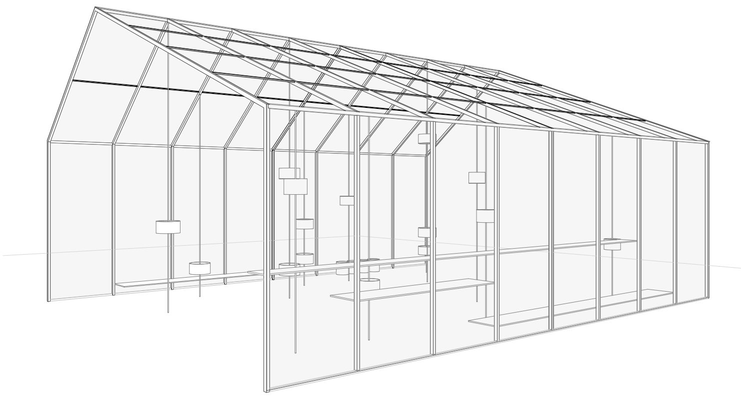


TRASVERSAL SECTION
scale 1:100

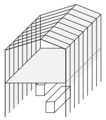


FLOR PLAN
scale 1:100

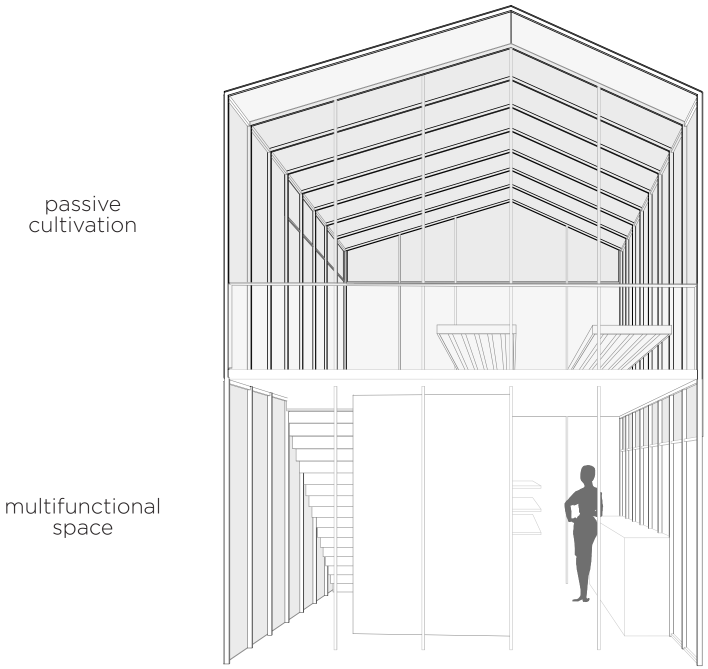
FRONTAL VIEW



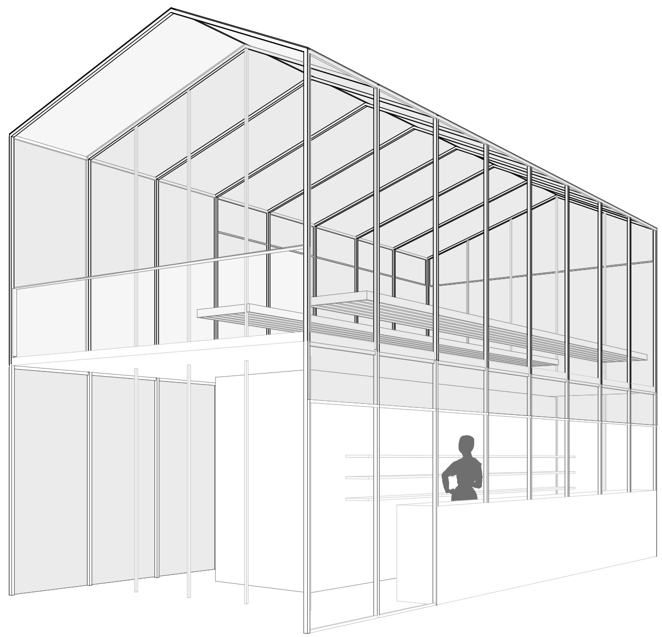
ORCHARD PERSPECTIVE



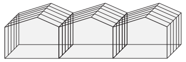
GREENHOUSE
+ MULTIFUNCTIONAL SPACE



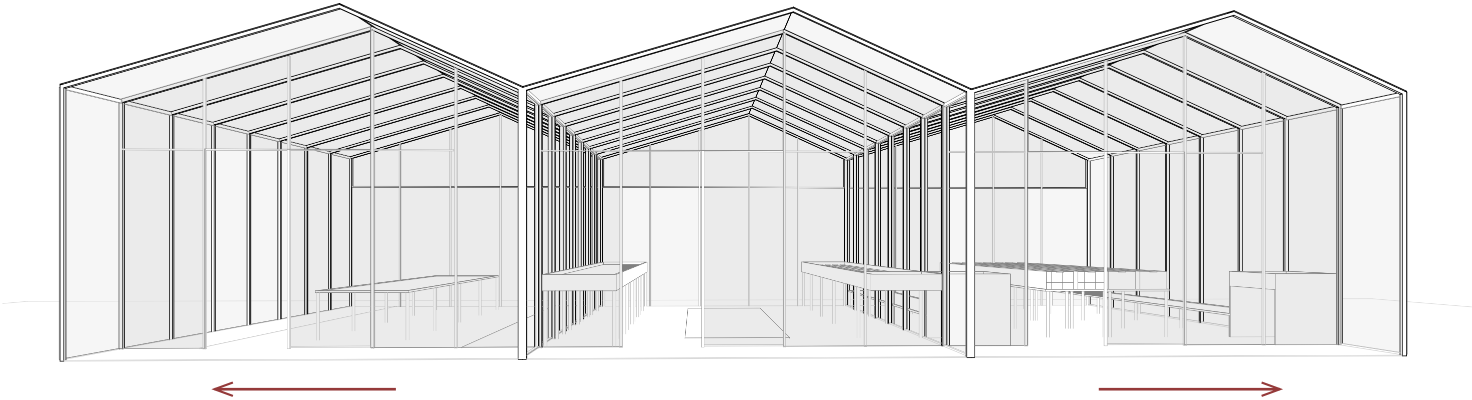
FRONTAL VIEW



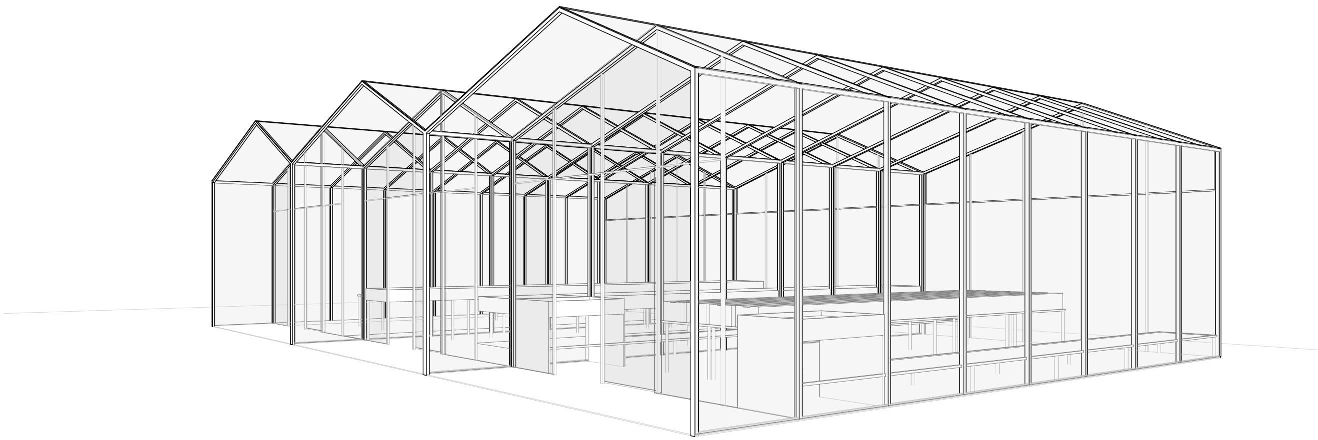
PERSPECTIVE



GREENHOUSES IN ROW

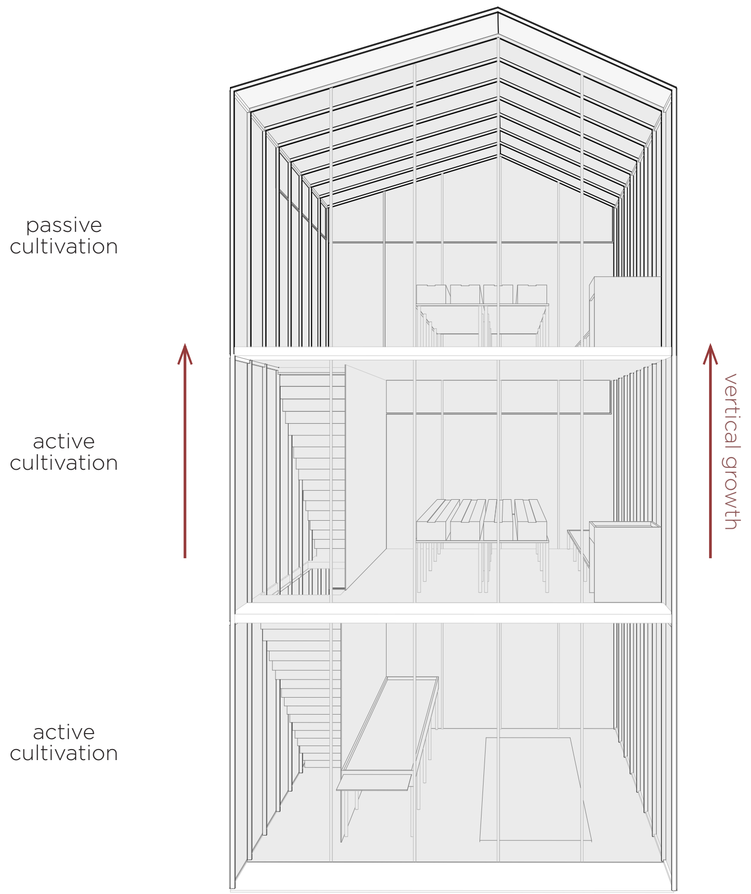


FRONTAL VIEW

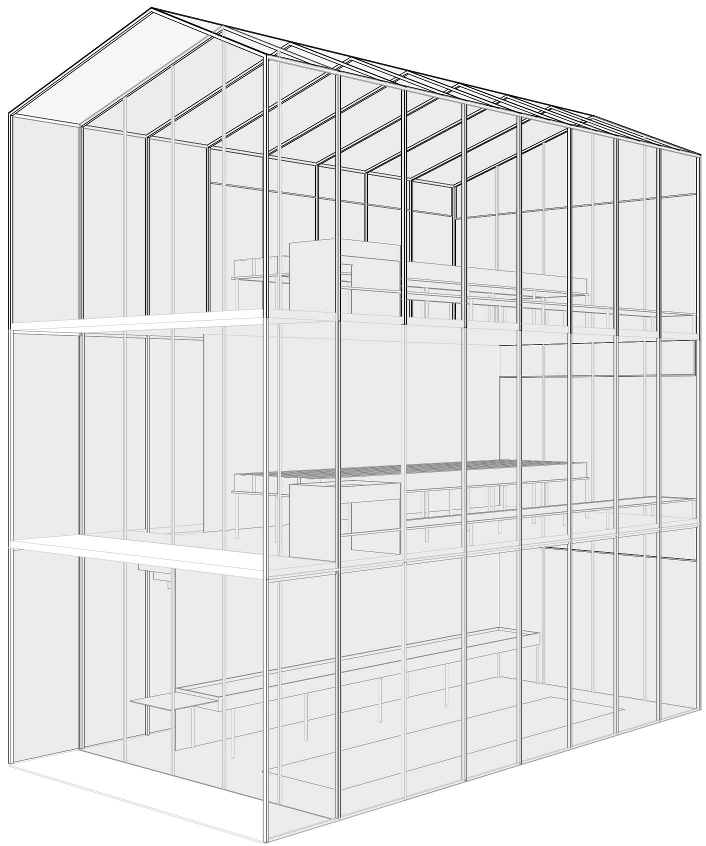


PERSPECTIVE

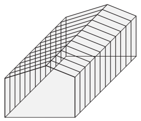
GREENHOUSE TOWER



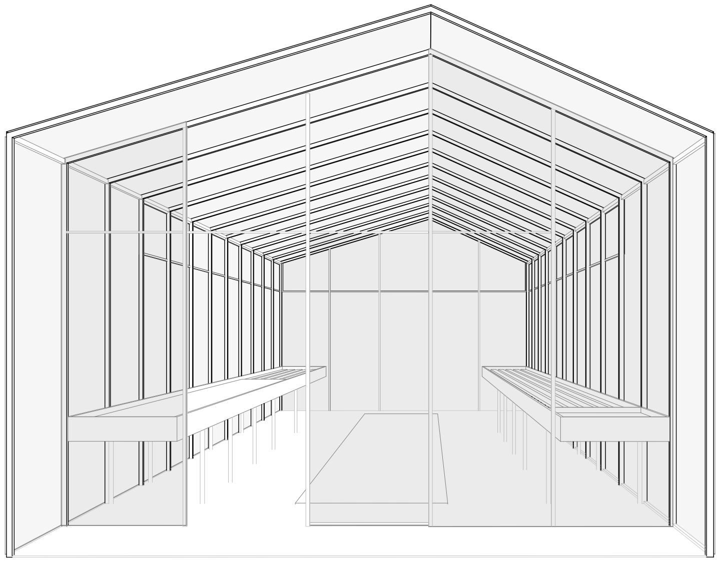
FRONTAL VIEW

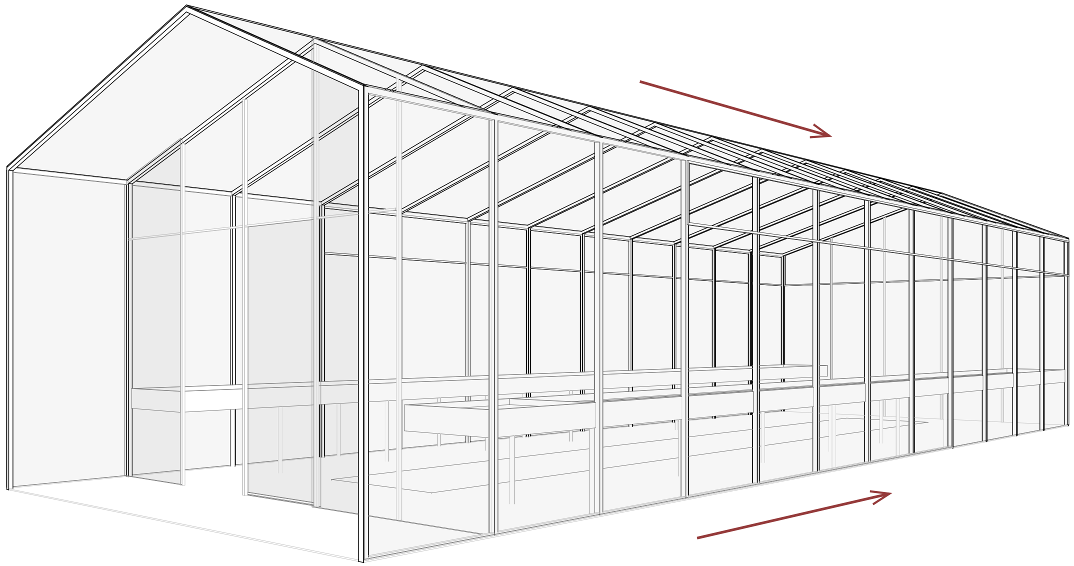


PERSPECTIVE

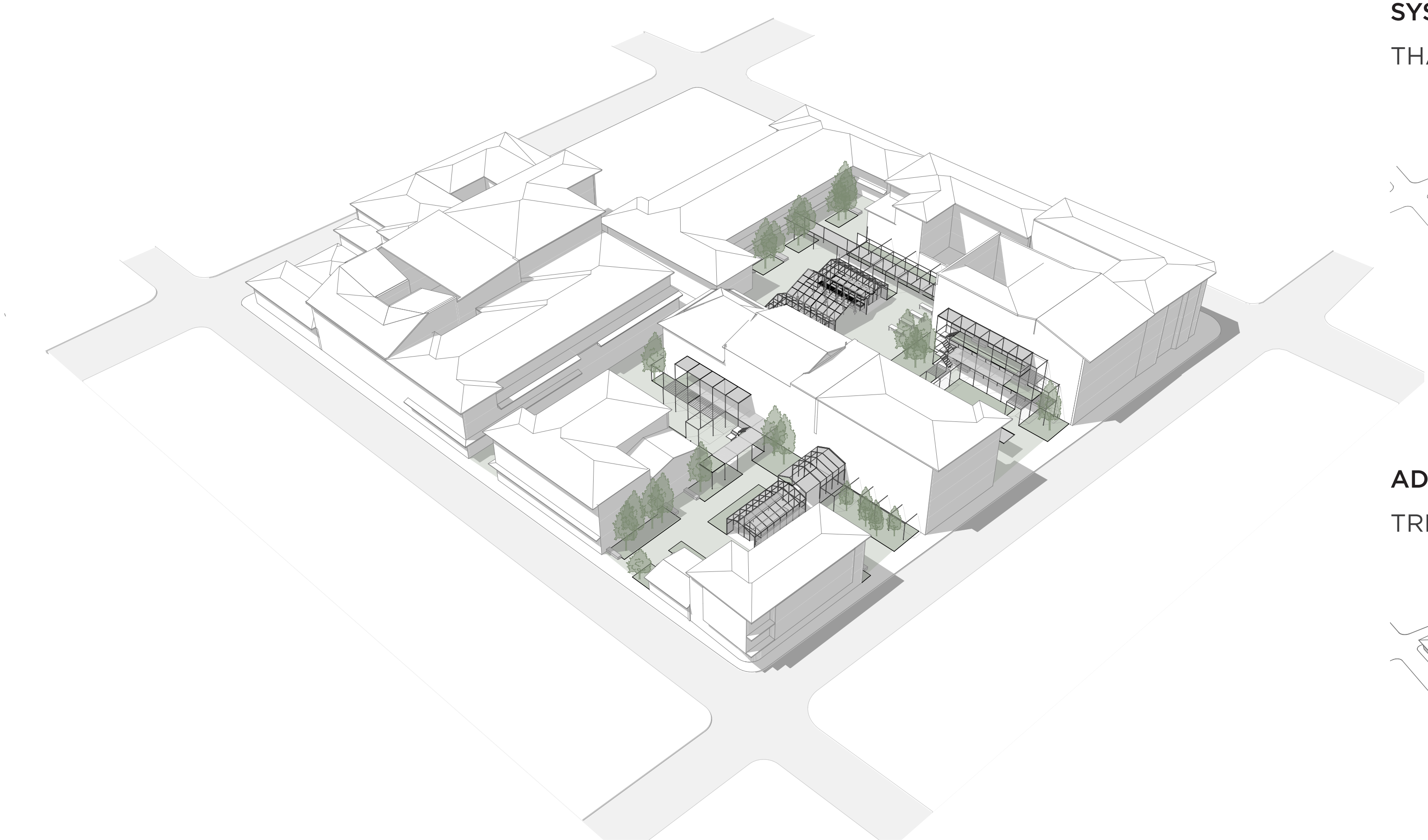


ELONGATED GREENHOUSE



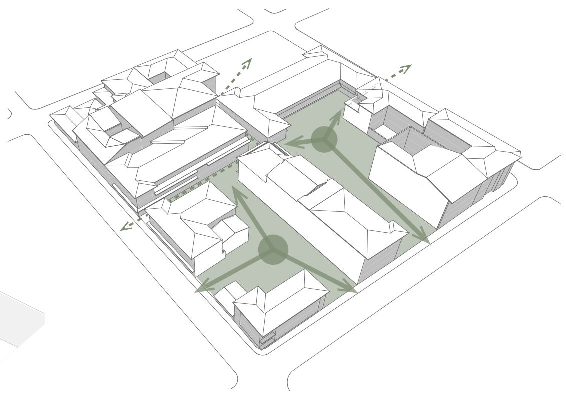


BLOCK **A**
URBAN AGRICULTURE INTERVENTION



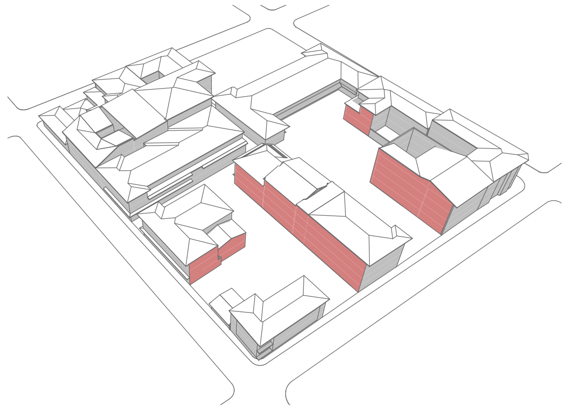
SYSTEM OF GREEN CORES

THAT EXPAND TOWARDS THE CITY



ADJACENT WALLS

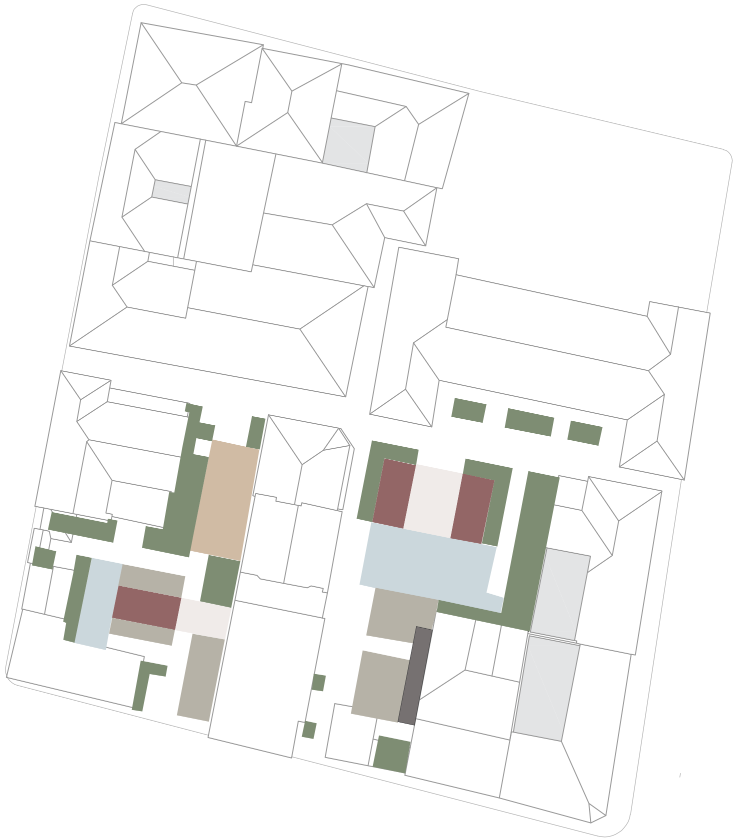
TREATMENT



URBAN REGENERATION

This empty space is the result of the union of several urban voids that nowadays work as parking lots, empty plots and pedestrian passages.

This zone of the historic center deteriorated and even though is transited by pedestrians, the perception of this space is related to unsafety perception .

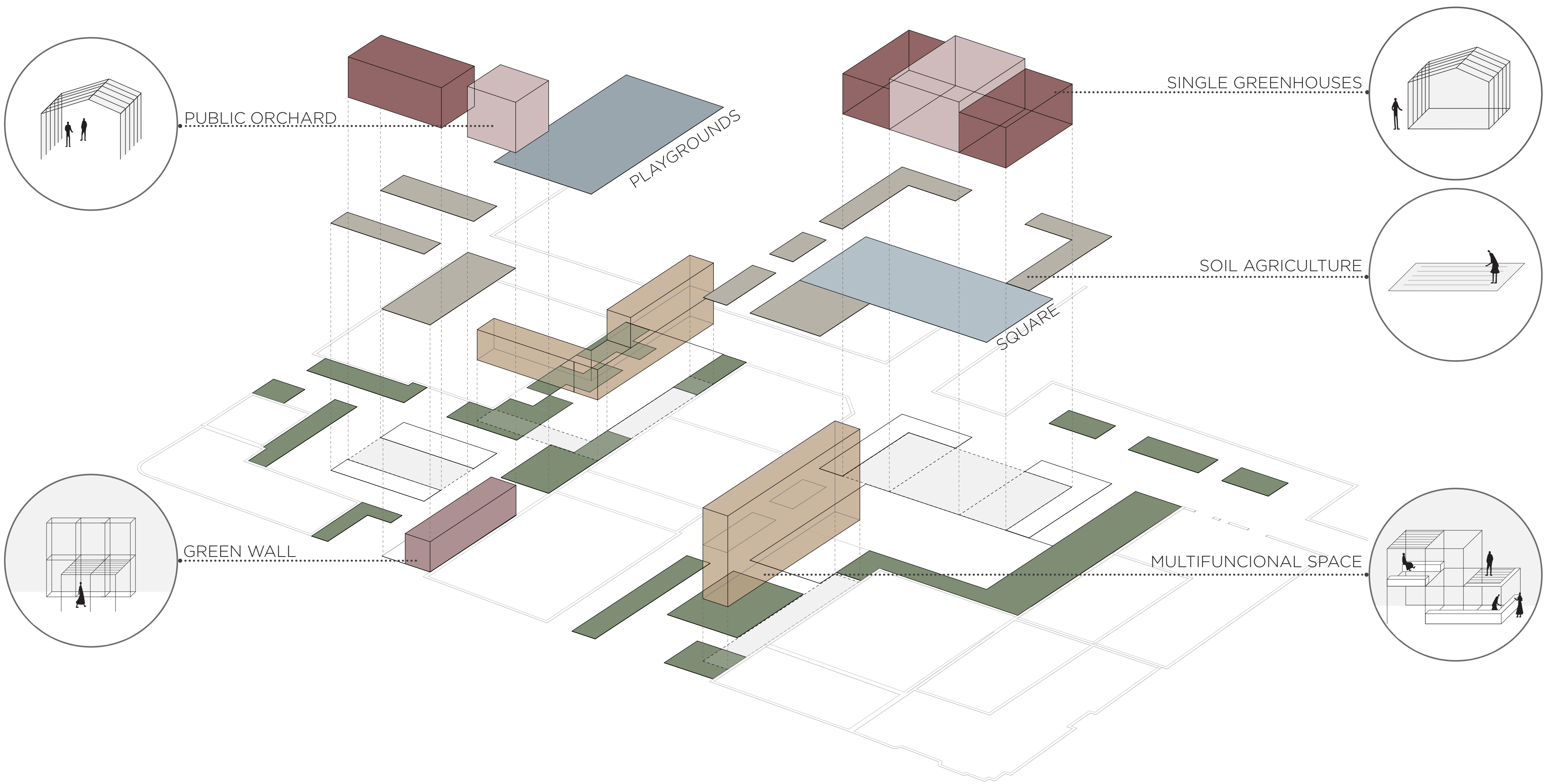


LEGEND

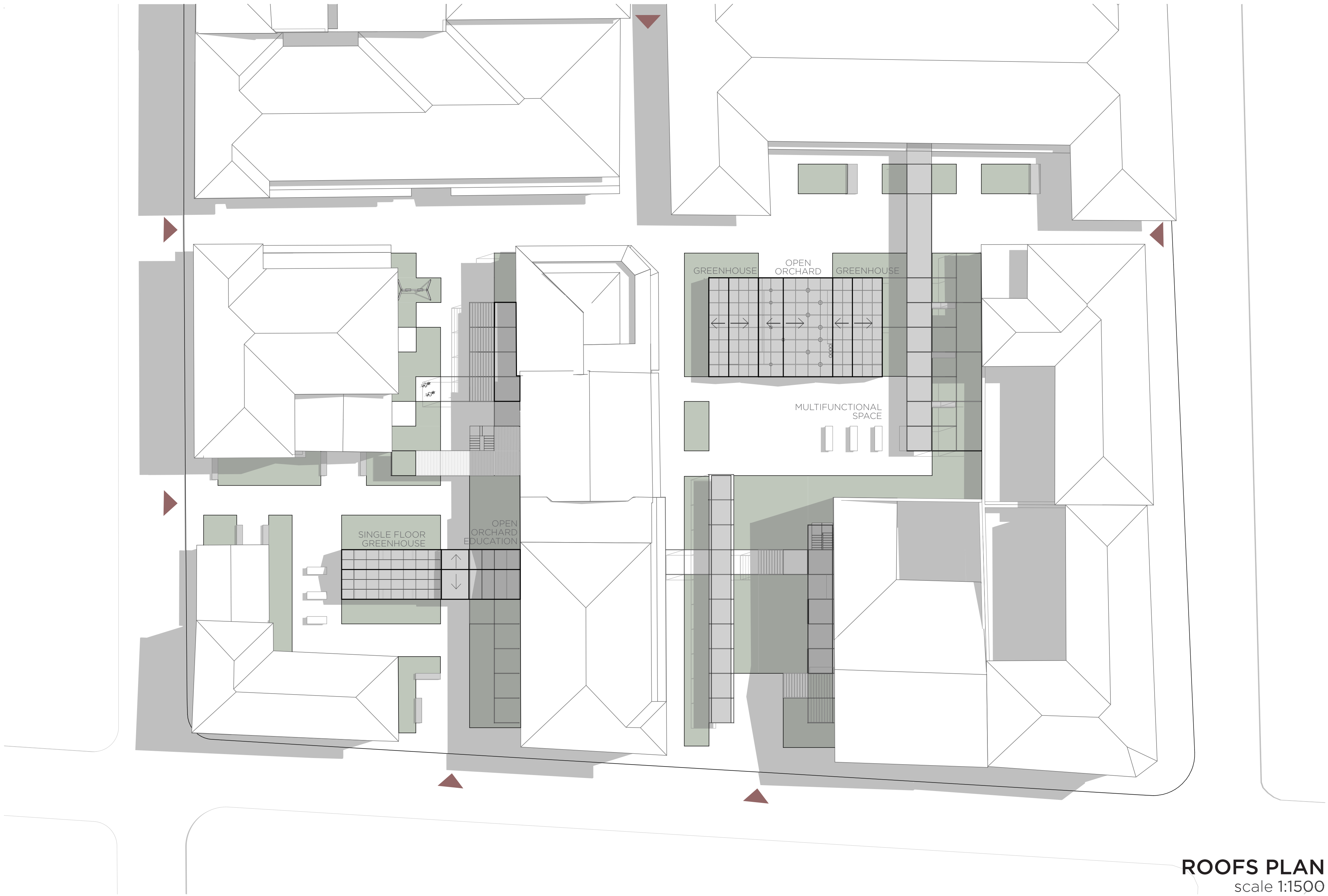
- Single floor Green-house
- Open orchard / Spaces for learning
- Soil agriculture
- Playgrounds
- Open square
- Shadow area and deck square.
- Vertical farming
- Green areas

MAIN STRATEGIES

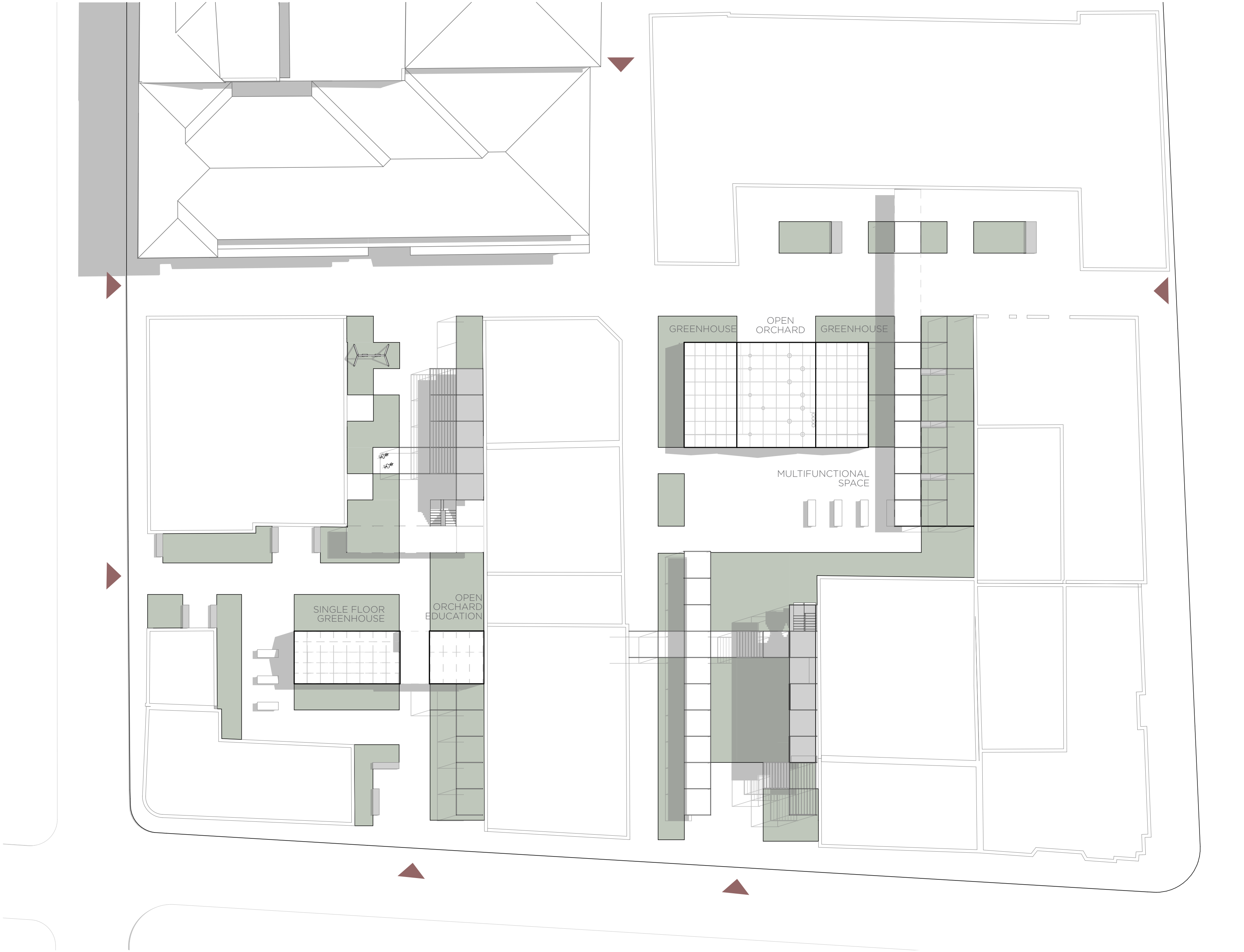
- Introduction of productive landscapes in the urban voids
- Increase attractions through urban agriculture
- Secure space
- Children and teenagers equipment
- Participation environments - spaces for learning


PUBLIC ORCHARD
PLAYGROUNDS
SINGLE GREENHOUSES
SOIL AGRICULTURE
SQUARE
GREEN WALL
MULTIFUNCIONAL SPACE


MARISCAL LAMAR
HERMANO MIGUEL SQUARE
GRAN COLOMBIA
HERMANO MIGUEL
MARIANO CUEVA



ROOFS PLAN
scale 1:1500



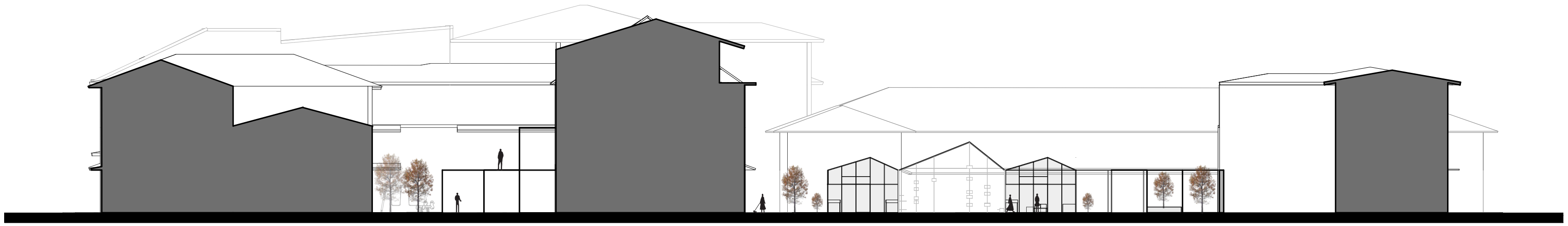
ROOFS PLAN

scale 1:1500

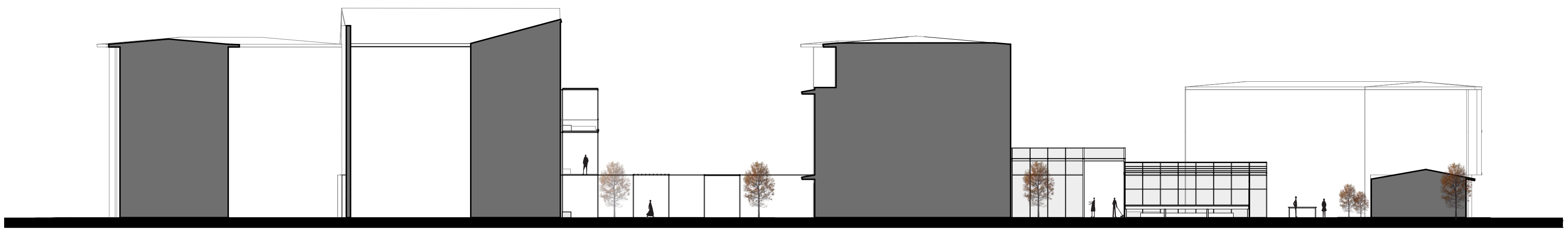
SECTIONS
BLOCK A

PLAN BLOCK **A**
scale 1:2500

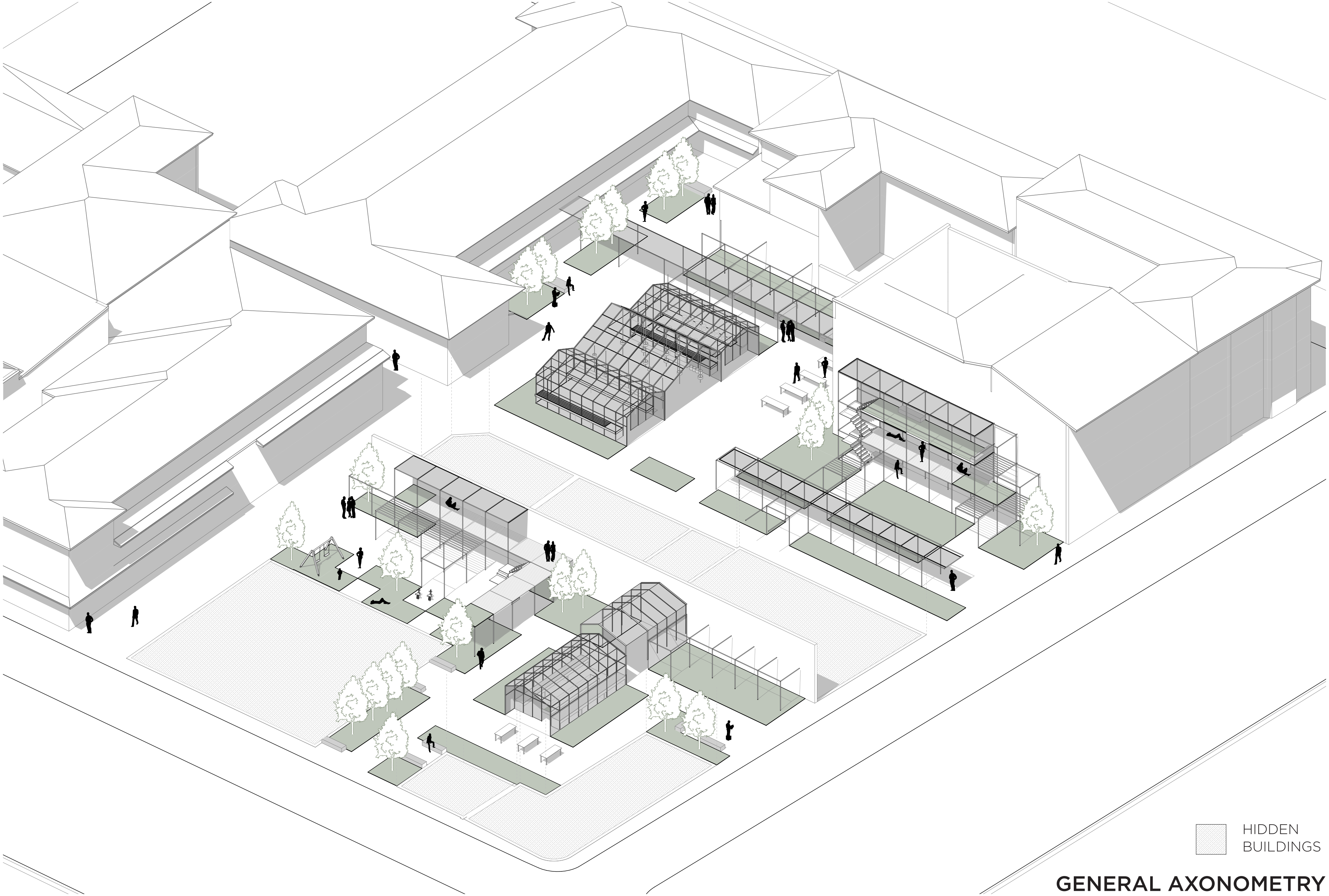
SECTION **01**
scale 1:500



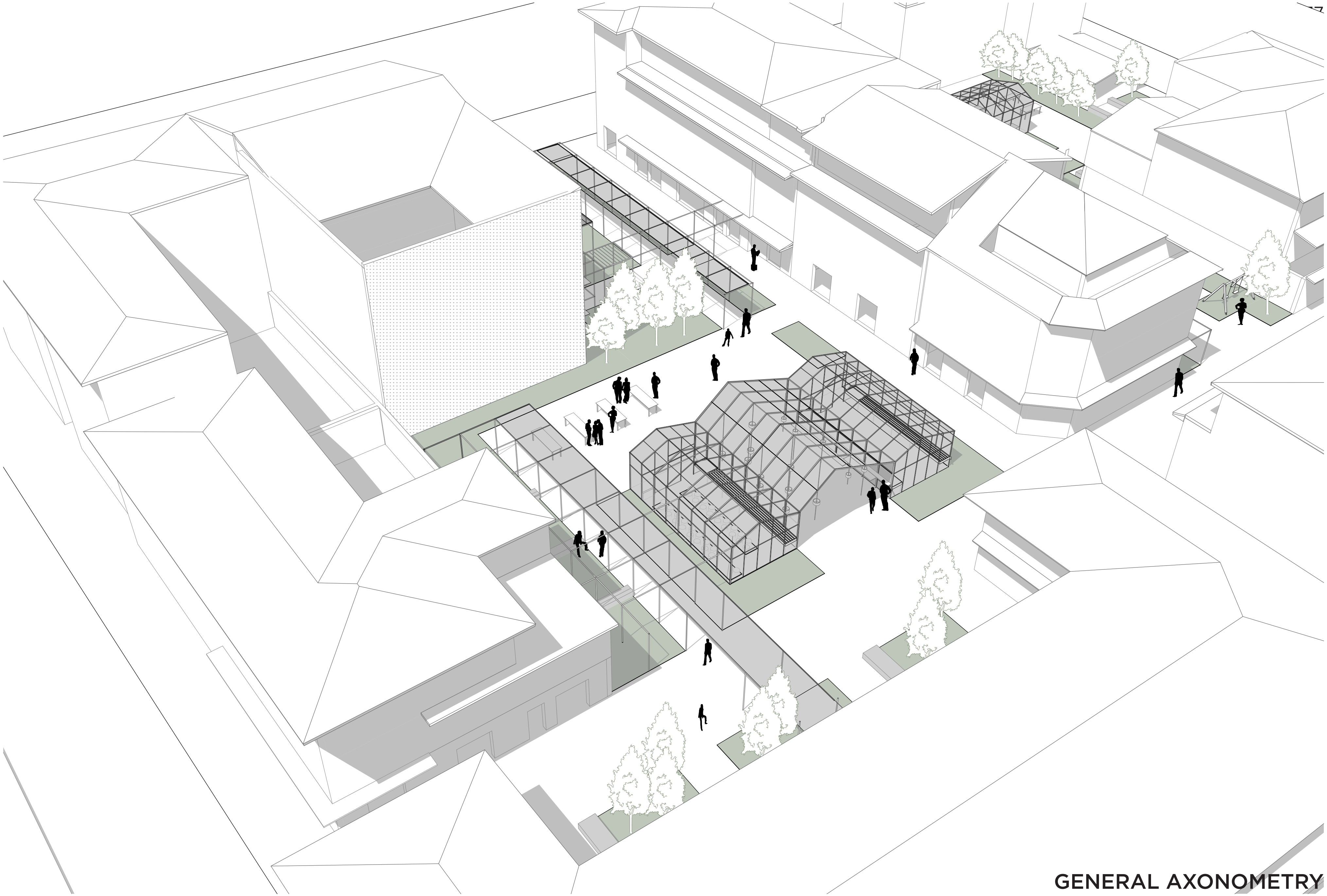
SECTION 02
scale 1:500



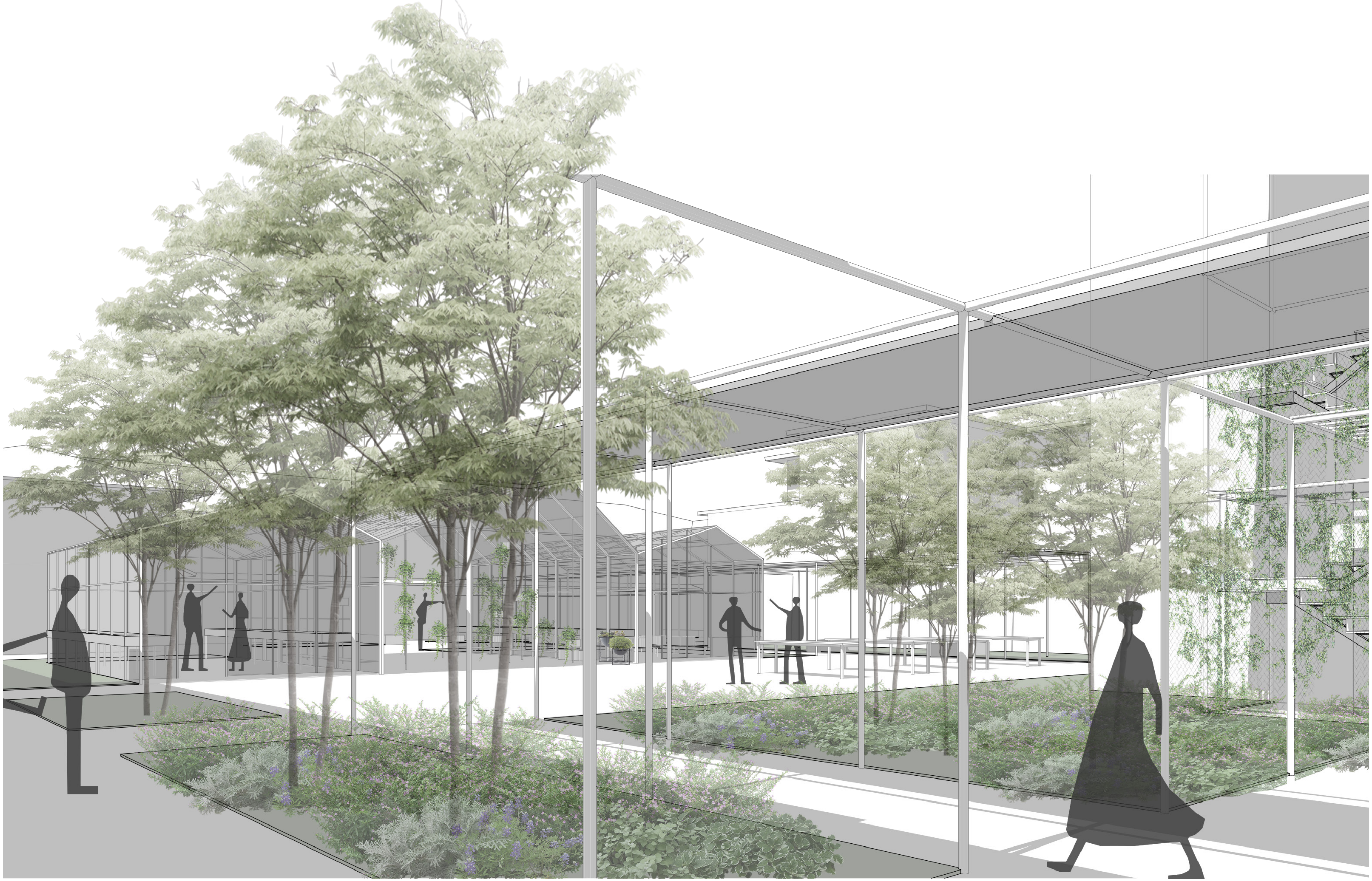
SECTION 03
scale 1:500



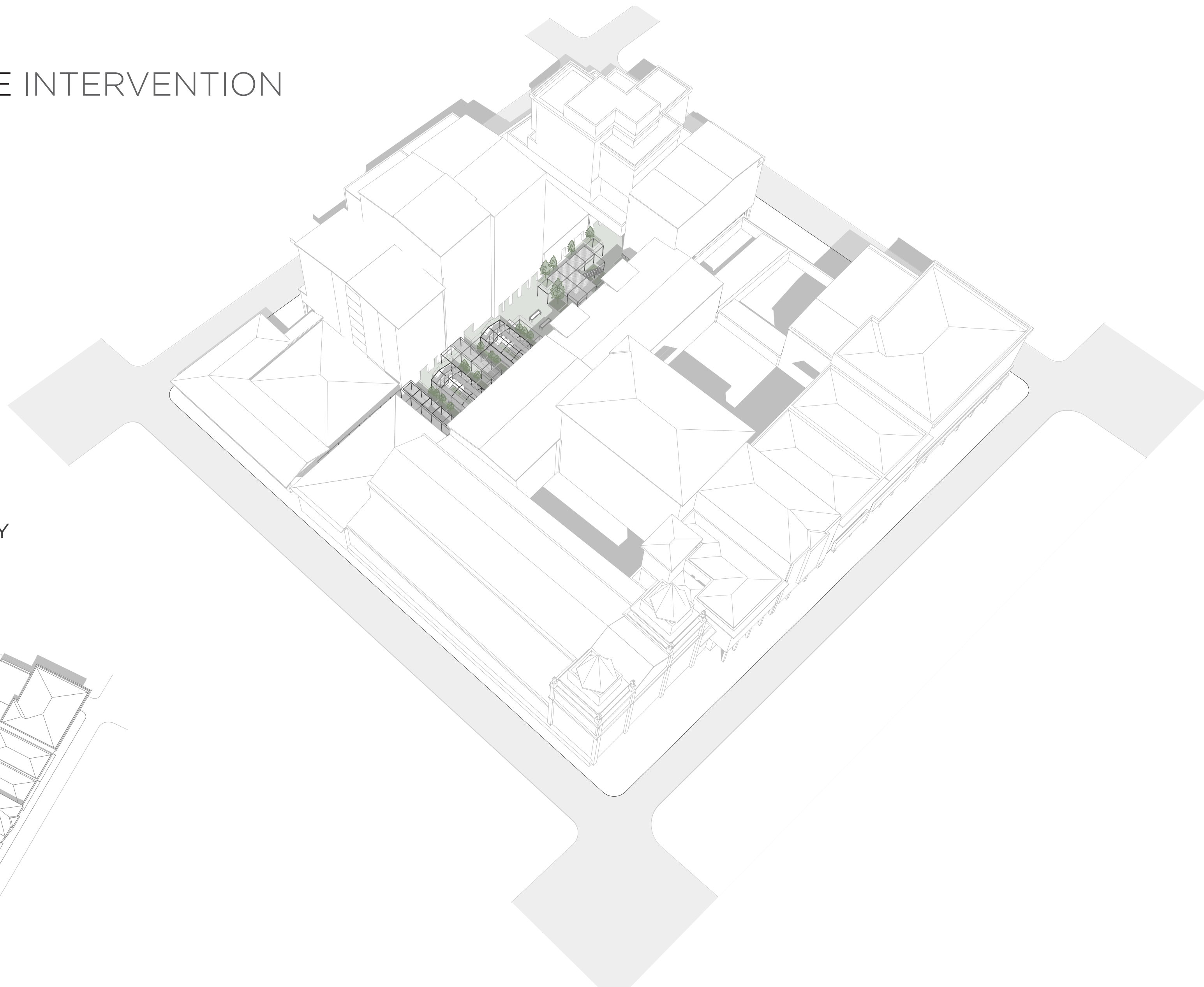
GENERAL AXONOMETRY



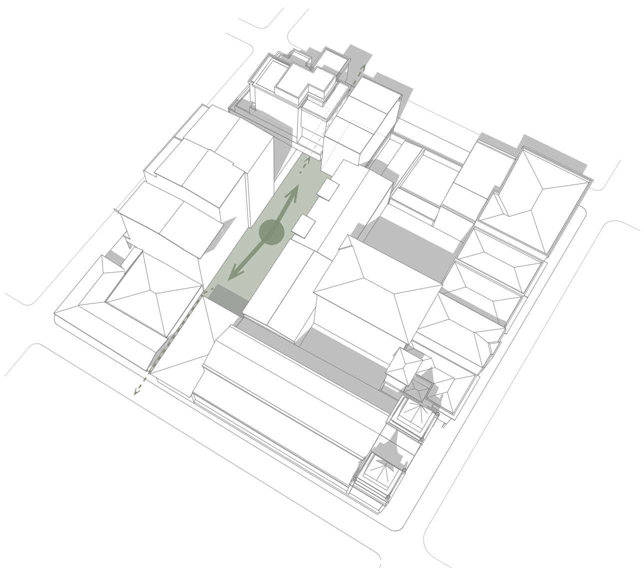
GENERAL AXONOMETRY



BLOCK **B**
URBAN AGRICULTURE INTERVENTION



SYSTEM OF GREEN CORES
THAT EXPAND TOWARDS THE CITY

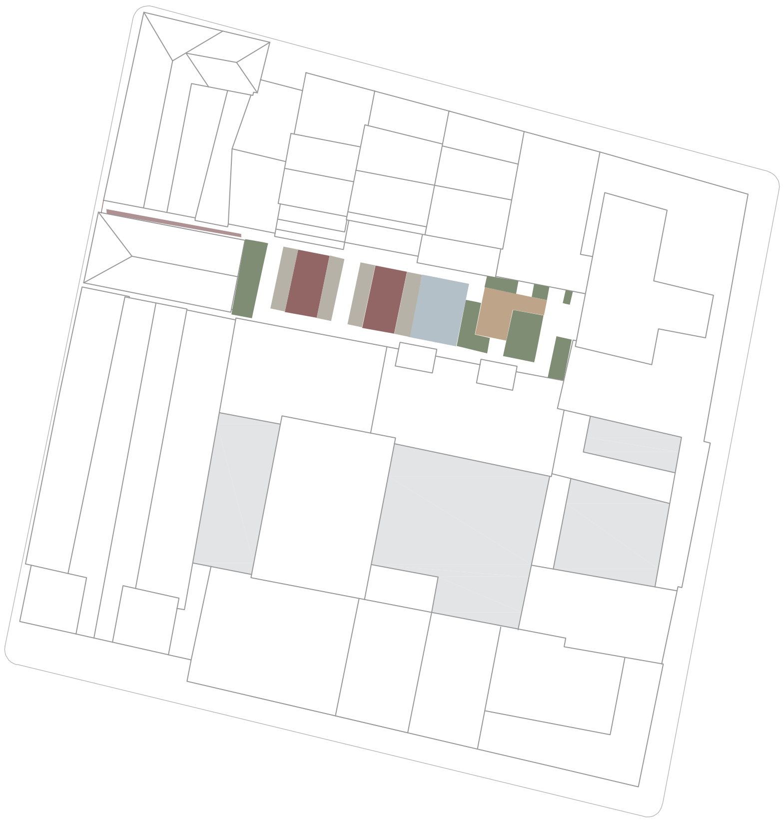


URBAN REGENERATION

This void functions as a pedestrian passage and as a small public square surrounded mainly by big scale buildings and commerce functions in the ground floor. This space is also connected by two commercial galleries that are connected to the Gran Colombia street.

Besides, due to its location, the lacking of attractions and its deteriorated situation, it has little influx of people, generating the perception of insecurity.

The square has a church and a building related to religious formation for children and teenagers, whose presence could be feasible for participatory urban agriculture processes.

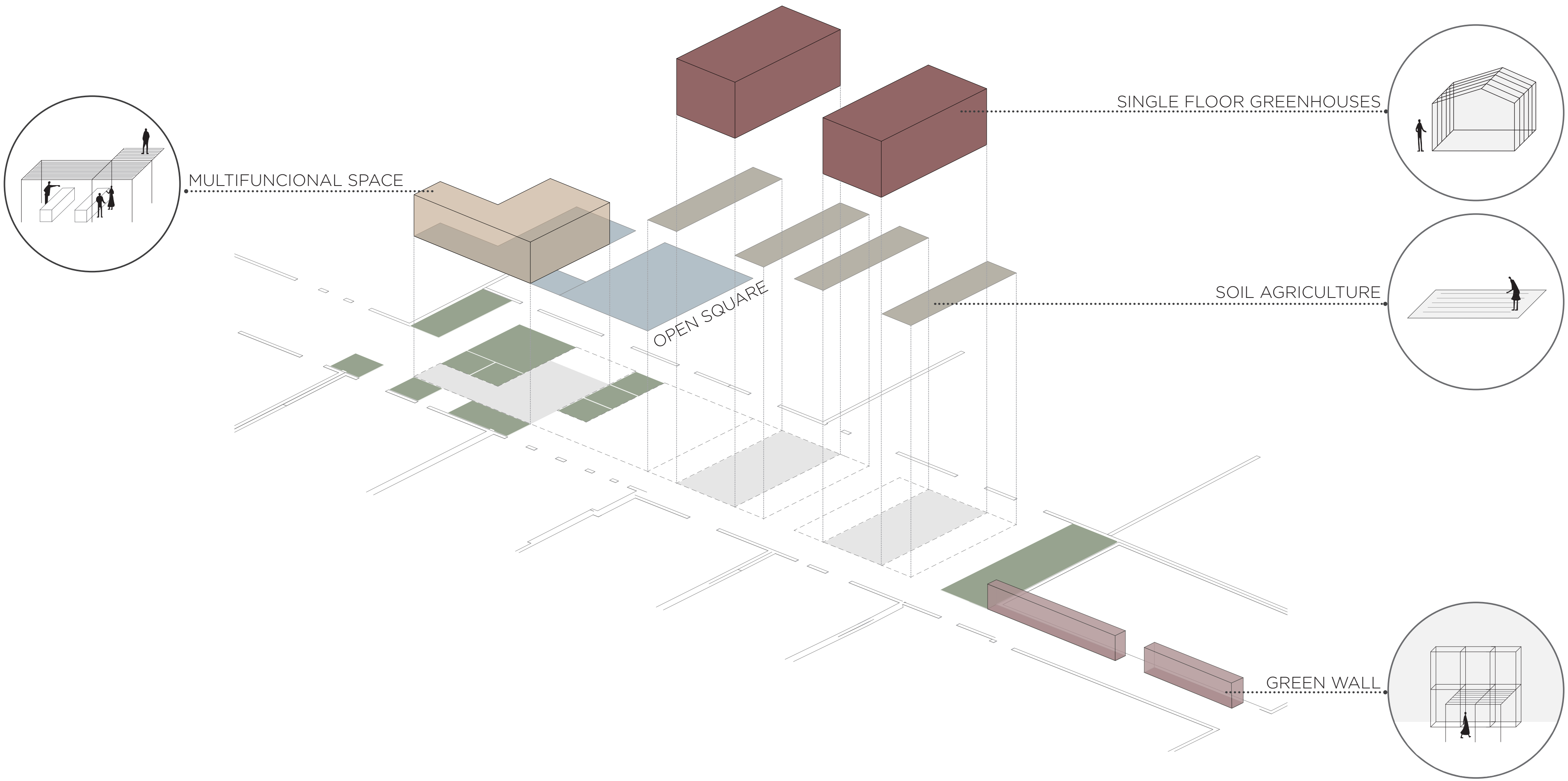


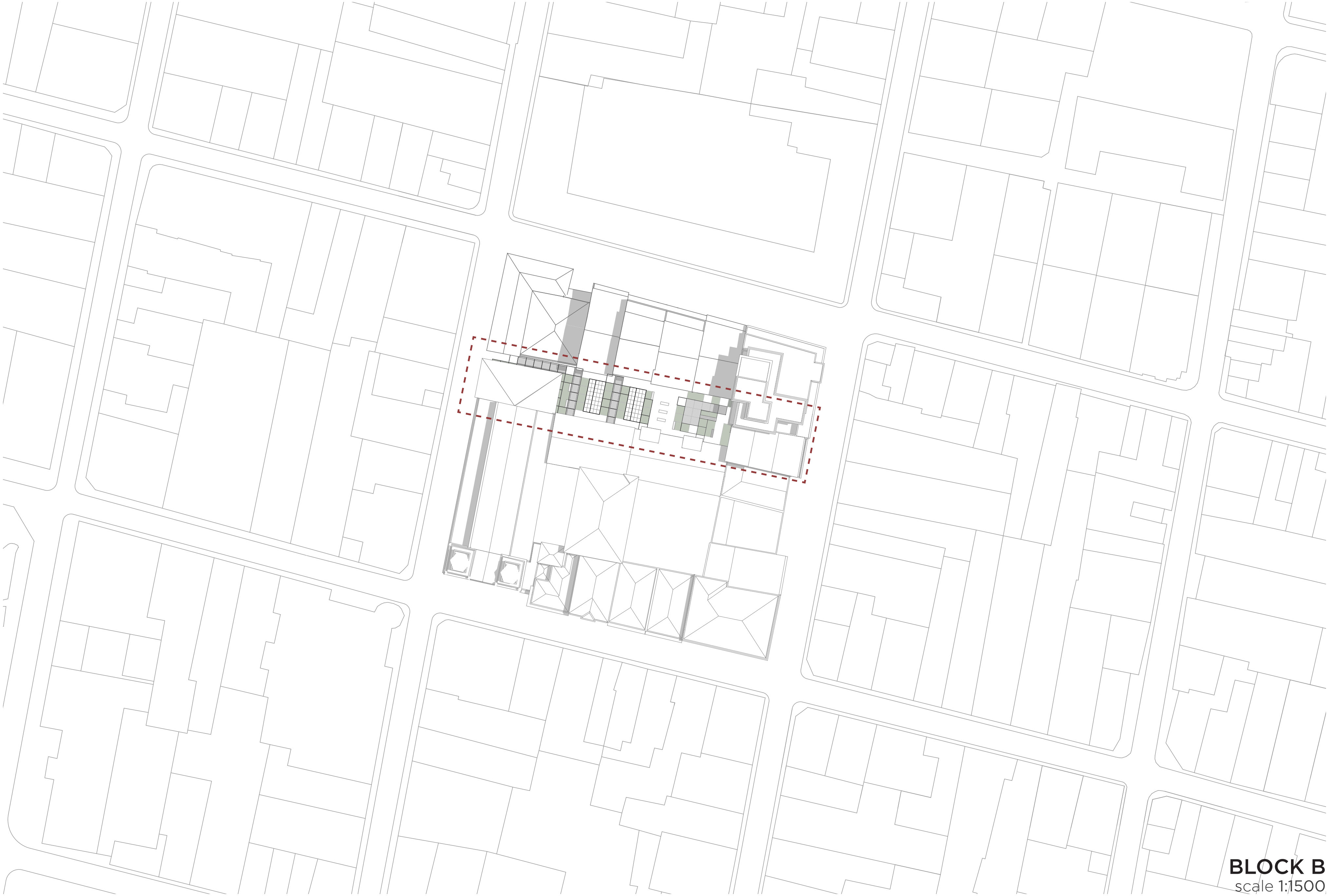
LEGEND

- Green area
- Single floor Greenhouse
- Soil agriculture
- Green wall
- Open square
- Shadow area and deck square. (Multifunctional space)

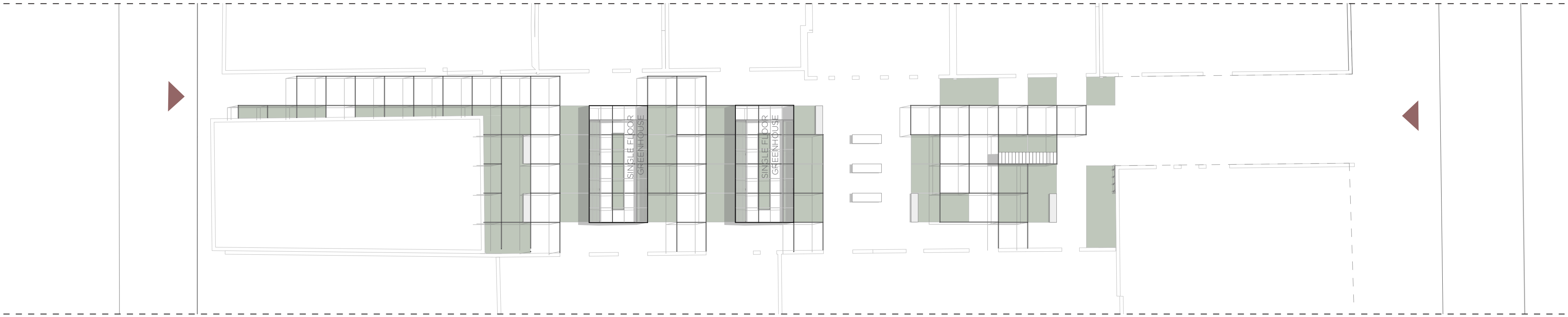
MAIN STRATEGIES

- Introduction of productive landscapes in the urban voids
- Increase attractions through urban agriculture
- Secure space
- Children and teenagers equipment
- Spaces for learning

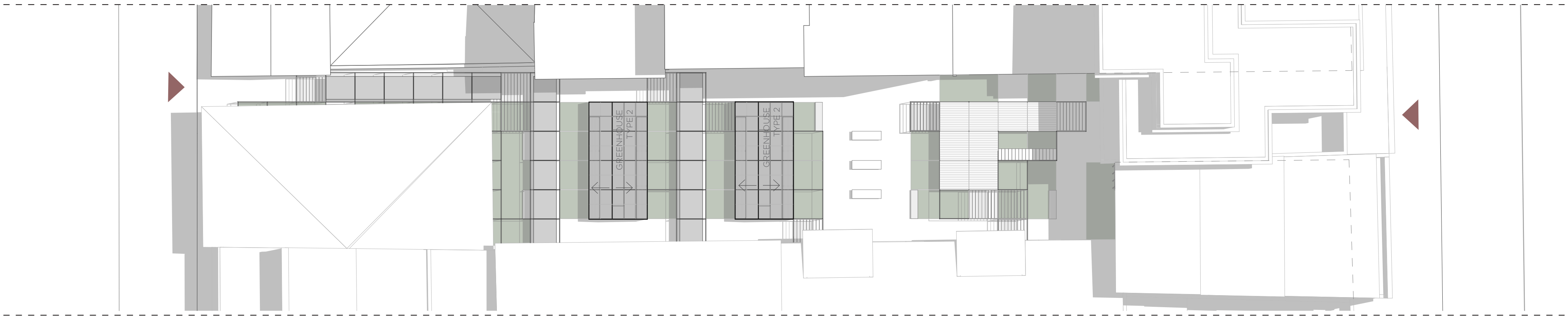

MULTIFUNCIONAL SPACE
OPEN SQUARE
SINGLE FLOOR GREENHOUSES
SOIL AGRICULTURE
GREEN WALL



BLOCK B
scale 1:1500



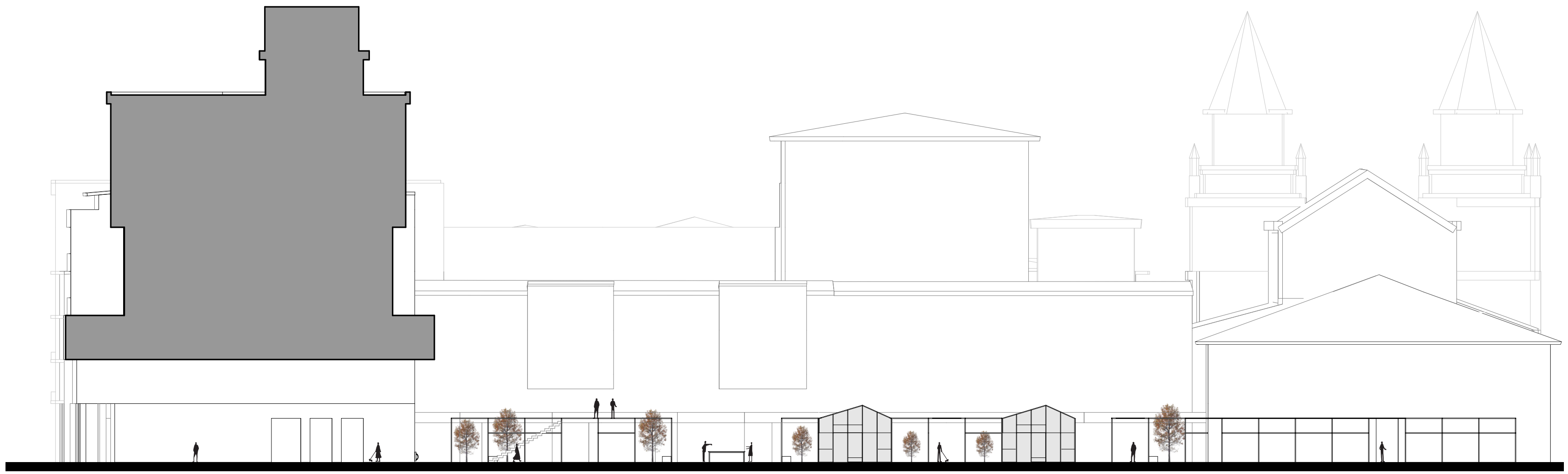
FLOOR PLAN
scale 1:500



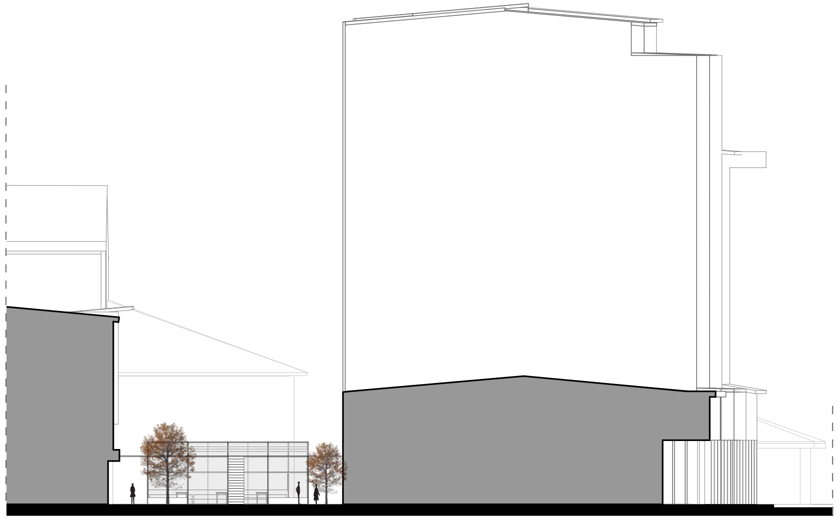
ROOF PLAN
scale 1:500

SECTIONS
BLOCK **B**

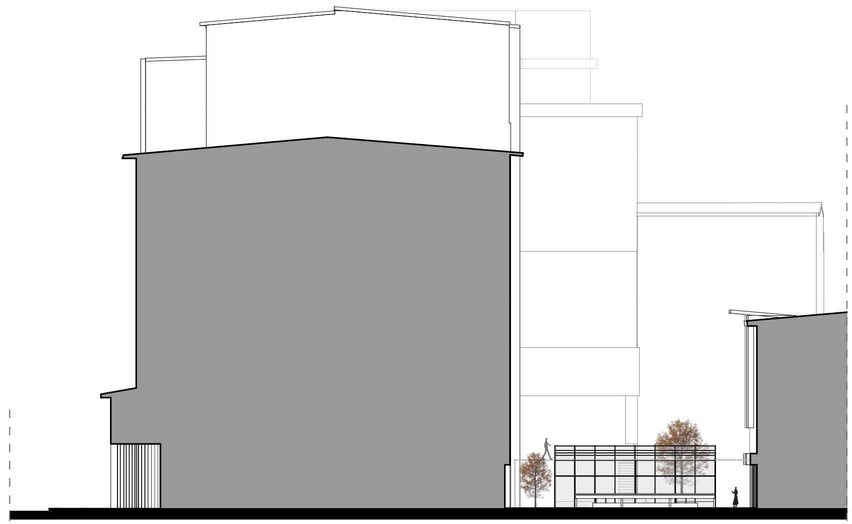
PLAN BLOCK **B**
scale 1:2500



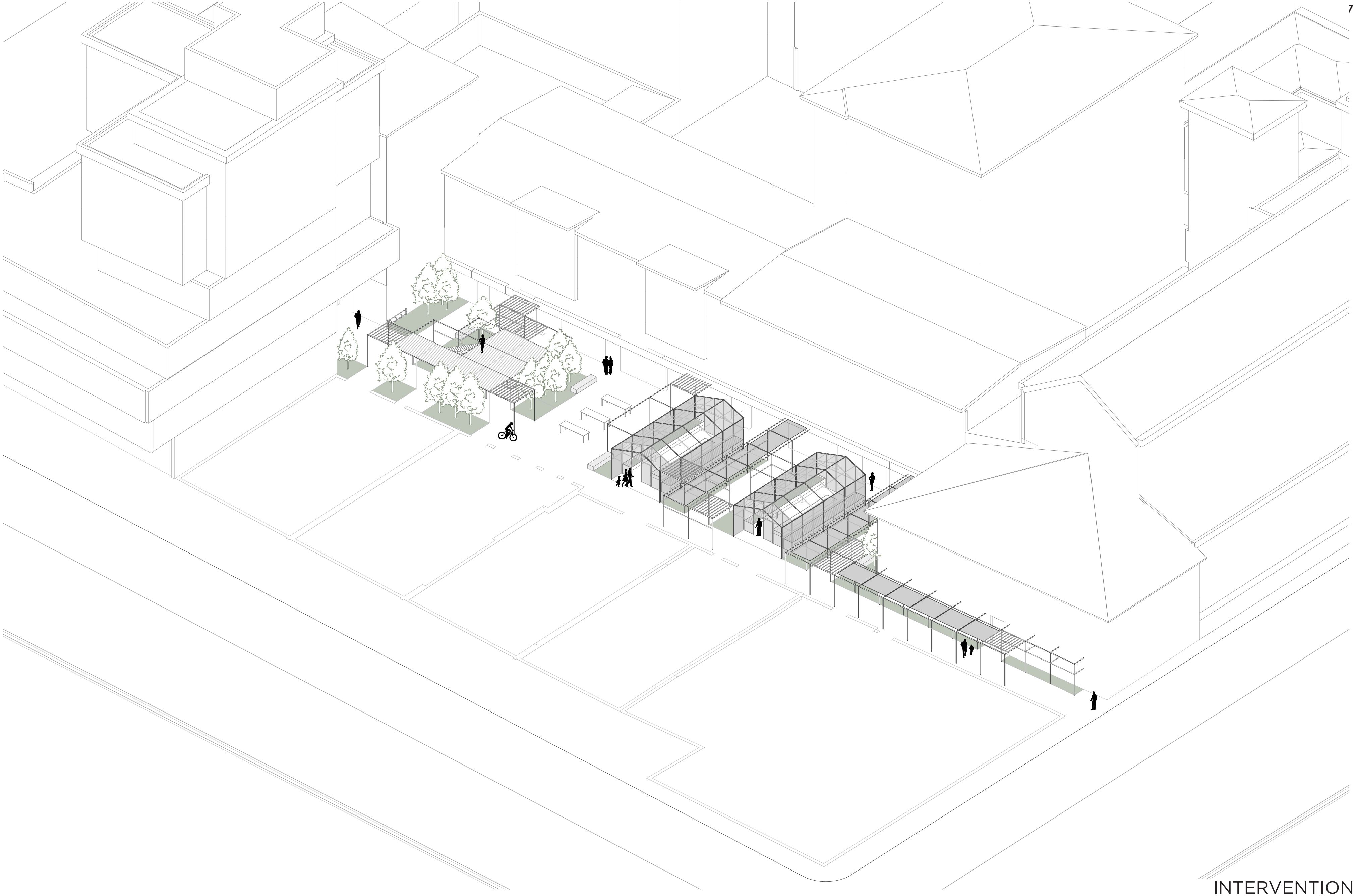
SECTION **01**
scale 1:500



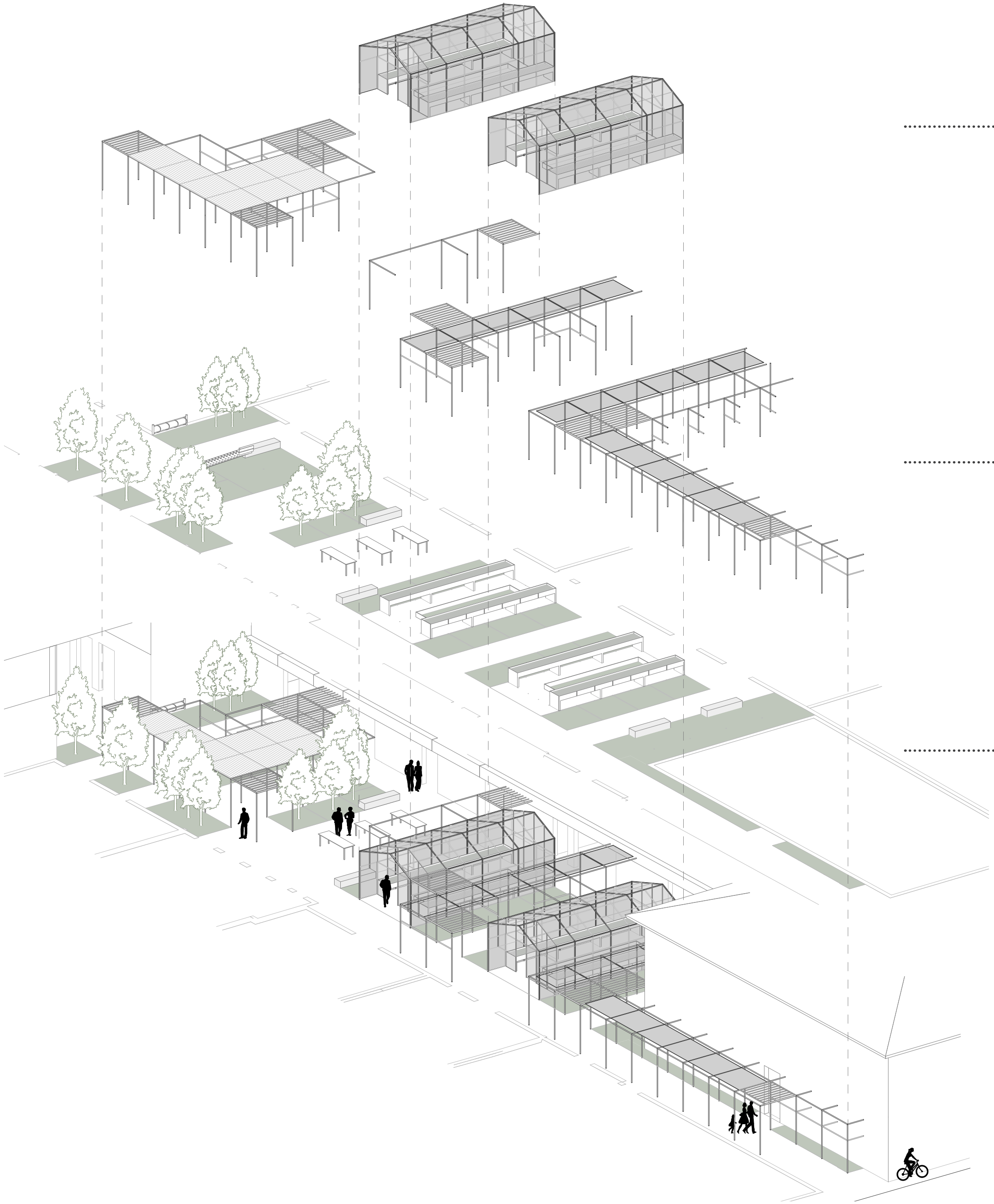
SECTION **02**
scale 1:500



SECTION **03**
scale 1:500



INTERVENTION
AXONOMETRY



ADAPTATIVE SINGLE
FLOOR GREENHOUSES

LIGHT METAL STRUCTURE
AND ROOFS

GREEN AREAS AND
FURNITURE

EXPLOITED
AXONOMETRY

CONCLUSIONS

Considering the bleak future forecasts related to climate change and its current effects on cities, the accelerated growth of the urban area, the lack of employment and the poor fulfillment of basic needs of an important amount of population, the introduction of a sustainable food system can facilitate more opportunities to citizens to have access to healthy and fresh foods, reactivate new social dynamics and improve local economies.

The link between food and social welfare can be seen as a strategy for transforming the problems into opportunities. The urban cultivation fosters the access to local fresh food and reduces the contamination related to transport, besides it reduces the water consumption if compared with traditional agriculture practices and can be considered as an entrepreneurship chance for the community. The project proposes the regeneration of the historical center through the intervention of urban voids. The aim is the creation of a productive green system that starts from the cores of the blocks and expands towards the city, and, as a consequence the improvement of the urban climate, an updated return to agricultural practices and the introduction of sustainable self-sufficiency systems in order to reduce economic and environmental impacts.

There have been some successful cases around the world in which the green intervention of the urban voids has been able to can generate productive landscapes inside the city. Following these examples, the introduction of urban and peri-urban agriculture in Cuenca, could have potential positive impacts in the city.

The analysis of the intervention area for a proper adaptation to future transformations and needs, a sort of flexibility and variability is required. It suggests a necessity to create an adaptative urban void intervention system that includes the combination of public urban services with different types of urban agriculture and public infrastructure to facilitate the appropriation and maintenance of the space.

Thus, the proposed urban void regeneration system consists in one hand to the use a modular affordable constructure system that allow the morphological adaptation of the agricultural systems considering the scale and specific requirements of each void, as well as the use of existing materials, that can be dismantled and reused in other places as a sustainable strategy to decrease the environmental and economic impacts. On the other hand, for a proper intervention in diverse urban voids, it is important to consider the conditions related to environment and social dynamics. For productive urban agriculture integration, there are several systems that can be applicated in correspondence to the void requirements. However, this thesis focuses on adaptative greenhouse systems.

When considering greenhouse devices, there are several factors that may be considered: materials and construction system, cultivation systems, solar radiation and ventilation, energy consumption and costs. One of the main aims of the proposed greenhouse prototype, is the efficient use of natural resources. Thus, the design strategies tend to be as passive as possible.

The proposal creates a basic single floor greenhouse prototype that can be adapted to the site needs, in terms of height, length, use, etc. The selected materials facilitate the light entry to the device and at the same time, isolate the interior microclimate to the temperature fluctuations. Besides, aspects related to maintenance and reuse were considered. Finally, for a proper ventilation, there are located modular windows that can be opened according to the specific ventilation requirements of the different voids.

In the process of the introduction of productive urban agriculture in the urban voids of the historic city, the public legislation and participation of the different actors and sectors is vital. In one hand the leadership, organization and technical assistance from the Municipality, which should facilitate a participative process focused in installing capacities and empowering the community for the proper functioning and self-sufficiency of the proposal. Moreover, the leaders of the process should promote the exchange of knowledge and experiences for the development of communities, between the organizations for cooperation, the community, the academy, among others.

Therefore, the current conditions suggest the necessity to develop new updated and appropriate urban policies for the introduction of urban agriculture in the urban voids of the historical center. This type of projects, if executed within a proper framework, have the potential to become a new productive system inside the traditional city, can encourage sustainable practices, ensure food security and strengthen the local development though the strengthen of a self-sufficient community.

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