CULTURE AND CULTIVATION: SELF-SUSTAINING LANDSCAPES IN LA PAZ

by

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CONTENTS

ABSTRACT

The city of La Paz, in Bolivia, faces a series of food security challenges linked with the access to food during road blockings caused by protests. A promising solution to this issue is presented by a network of urban agricultural farms in the heart of the city. This thesis proposes an exploration of a self-sustaining project of urban agriculture that will inform a network of urban agricultural centres.

The proposal is to have an agricultural garden which harnesses natural water from water springs and use it combined with traditional Andean methods of cultivation, such as the terracing and raised fields systems. The project will interact closely with local communities and engage them with culture and cultivation.

ACKNOWLEDGEMENTS

To my supervisor Susan Fitzgerald, thank you for all the support, advice and input during all the stages of my thesis. You have been a great mentor during my time in this program. Ken Kam, thank you for all the help and tips. Catherine Venart, thank you for all the input on my thesis.

To all my class, for their support and good times together.

Thank you to my parents Carlos and Silvia for their unconditional support during my studies.

CHAPTER 1: INTRODUCTION

The City of La Paz

The city of La Paz, Bolivia is located between the Eastern and Western mountain ranges in the Andes in South America. Bolivia is divided into nine Departments, one of them is the Department of La Paz, which capital city is called La Paz as well. La Paz City lies among mountains and valleys, creating rough and unique landscapes, with a big diversity in altitudes in the surrounding lands (Figure 1). La Paz receives its food supplies from valleys, the amazon mountains, and high plateaus. Although the city is fortunate enough to have a great variety of supplies, all coming from within the same Department, distances and the bad road conditions are issues faced for food supply transportation. Furthermore, Bolivia is a politically and socially unstable country. People protest when there is a disagreement with the government, municipalities or other institutions. One of the most common forms of protest is road blockings (Figure 2). These road blockings bring food insecurity for the population in the city of La Paz.

Currently, in La Paz, there is not enough knowledge of agriculture in the city to tackle the issue of food insecurity. This thesis proposes a pilot project to support public awareness of urban agriculture, with a community and education component attached to a garden in the heart of La Paz. This thesis will show the impact of the problem of food insecurity in the population of the city. It will also highlight the importance and benefits of urban agriculture in cities that have already implemented it in other countries, looking at urban agriculture principles as well as case studies. Further, the thesis will position the benefits of urban agriculture in the context of La Paz, showing strategies that could be implemented to address food insecurity in the city. Next, to position the project in the city, there will be an analysis and comparisons of sites in La Paz. This will be accompanied by an analysis of the landscape of the selected site. Additionally, the thesis will go into a program chapter, where a study of the spaces for this project will be explained and developed. This will follow with a design framework, that will have a material study, as well as architectural precedents for the design. Finally, the design will be developed and explained through the design chapter,

Figure 1 is a map of South America with Bolivia highlighted with a thicker line. The Department of La Paz is highlighted in green. Vector maps by Freevectormaps.

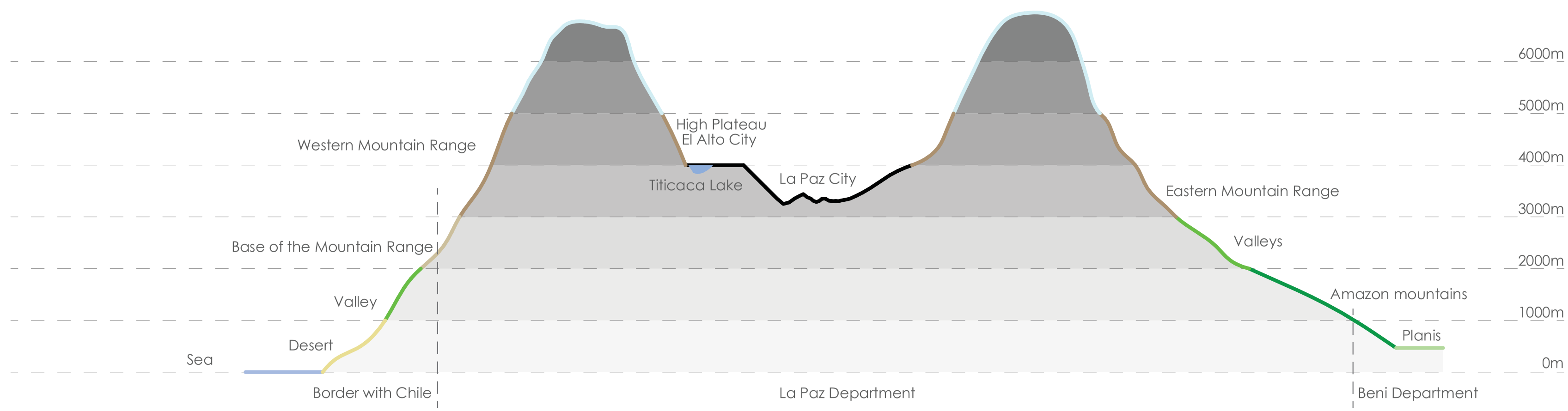

Figure 2 shows the elevations of the Department of La Paz in a diagrammatic section, with the city of La Paz in its centre.

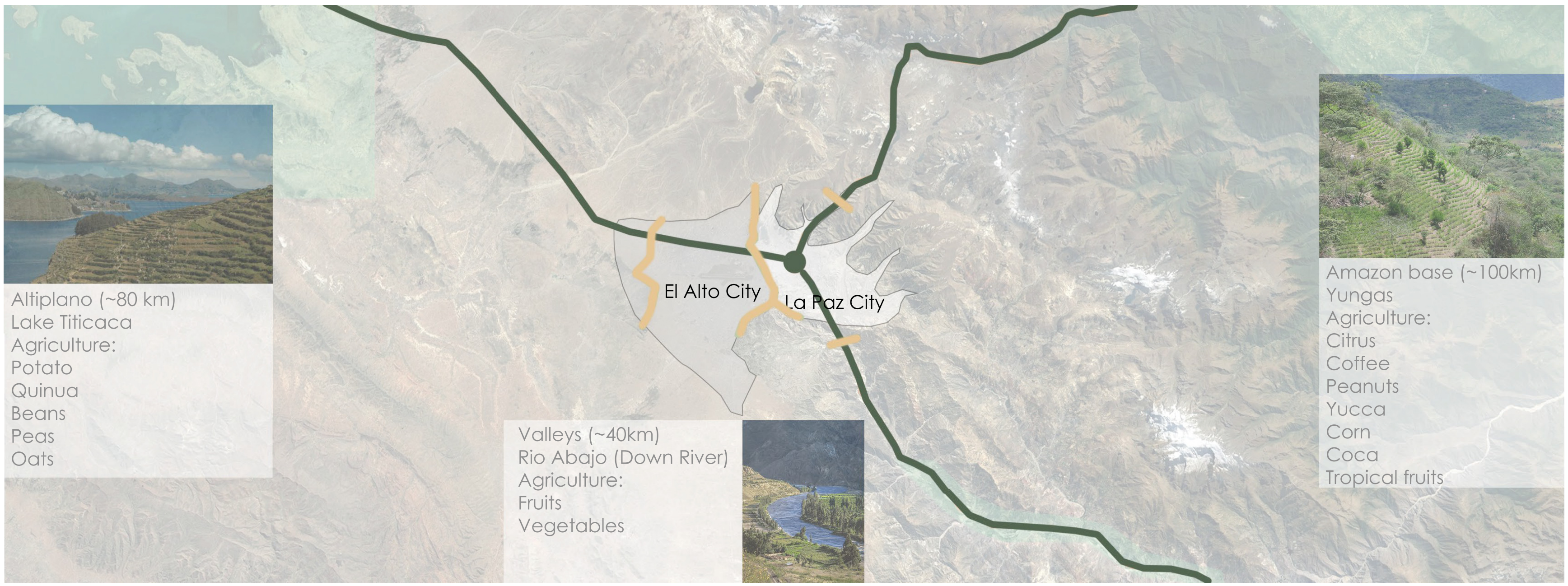

Figure 3 shows the context on how the production in La Paz is distributed with La Paz city and its neighbour city, El Alto, each with its respective connections to the three main rural farmlands highlighted in green. The map also shows the land's production of each of these three main agricultural farms. The strategic places where road blockings occur are highlighted with orange lines. Altiplano photograph by Guillermo Doffo. Valleys photograph by Matthew Straubmuller. Amazon base photograph by Gobierno Municipal de La Asunta. Background map by Google Maps.

Figure 4 show an aerial photograph of El Alto in the plateau and La Paz in a lower altitude. Photograph by Gon Laserna.

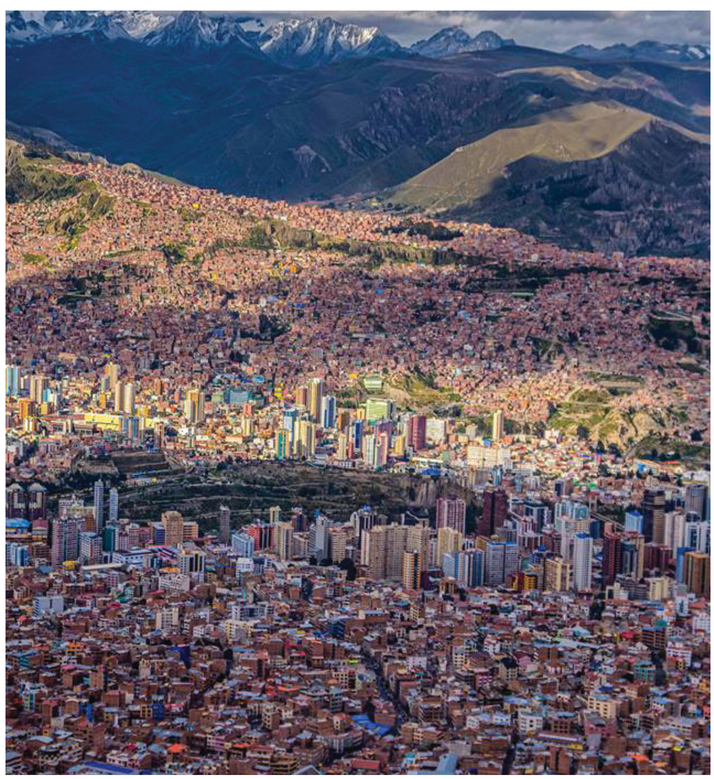

Figure 5 give a visual context of the city. Original photograph by Rafael Segurondo Torrico.

Thesis Question

How can architecture contribute to address the issue of food insecurity in a self-sustaining way in La Paz?

Positioning Ideas

In La Paz, social conflicts lead to road blockings People who organize and participate in the blockings, strategically target the main roads that connect the city with farmlands in the rural areas of the Department. By doing this, they force a dialog with the institution that blockers protest against, frequently demanding a political issue. According to a study of social conflicts in Bolivia, led by Roberto Laserna and Miguel Villarroel, between 1970 and 2008, there were around twelve thousand events of social conflict in Bolivia. From these events, roughly 390 were road blockings, which have been increasing in the past two decades[1] (Figure 5). When these blockings occur, markets have fewer supplies for the public, and thus, the price of the goods increase drastically. In a blocking that happened in 2016, for example, the price of carrots increased by 384%, potatoes by 143%, and strawberries by 250% to name a few.[2] Similarly, in 2017, blockings caused prices of oranges and mandarins to double.[3] Furthermore, as explained in the book "Carrot City: Creating Places for Urban Agriculture", by Mark Georgeolewski, June Komisar, and Joe Nasr: "The separation of cities from food sources is directly linked to many of the most pressing problems in the world today- including climate change, obesity, pollution, security of the energy supply, and global poverty."[4] This means that urban agriculture can bring a solution to many of the problems happening in the world, and more specifically, in La Paz.

1 Roberto Laserna and Miguel Villarroel, *Enero De 1970 - Enero De 2008: 38 Años De Conflictos Sociales En Bolivia* (Cochabamba, CERES, 2008), 16 and 22.

2 "Bloqueo Provoca Alza Y Escasez De Carne De Pollo, Fruta Y Verduras," *Página Siete*, February 04, 2016, https://www.paginasiete.bo/economia/2016/2/4/bloqueo-provoca-alza-escasez-carne-pollo-fruta-verduras-85626.html.

3 "Suben Precios De Productos En Los Mercados Por Las Heladas Y Bloqueos." *Los Tiempos*, July 22, 2017, http://www.lostiempos.com/actualidad/economia/20170722/suben-precios-productos-mercados-heladas-bloqueos.

4 Mark Gorgolewski, June Komisar, and Joe Nasr, *Carrot City: Creating Places for Urban Agriculture* (New York, Monacelli Press, 2011), 13.

Currently, there is one urban farm in La Paz that is implementing events and succeeding to engage the community with urban farming. However, generally, the urban population lacks education in agriculture, which would be vital to address to create urban agriculture that can tackle the issue of food instability. The idea is that this project will act as a pilot project to inform people about urban agriculture, using production of crops, education, and community programs to involve urban agriculture with people. Strategies for this engagement with the public and the project consist of interactions between communities and cultural events on the project, hosting activities that can bring the public into the project.

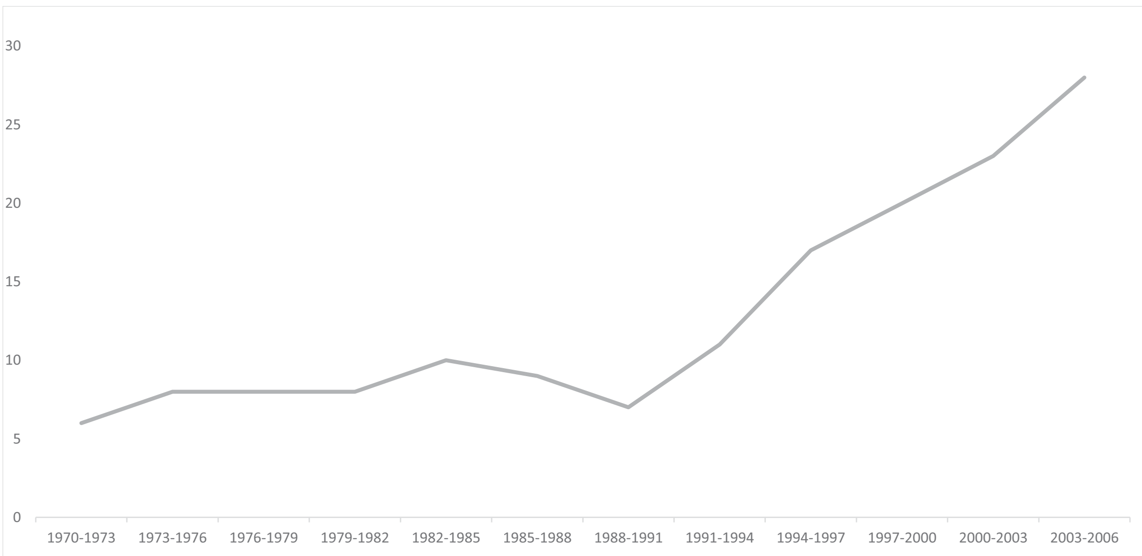

Figure 6 shows the increase of blockings in La Paz from 1970 to 2008.

To investigate the problem of food insecurity, this thesis is focusing on generating knowledge on this alternative food supply that can minimize the issue of food instability, especially when road blockings occur. Moreover, it has been proven that urban agricultural spaces bring numerous advantages to the population. “Carrot City” lists several benefits of urban agriculture. “Apart from enhancing food security and reducing our ecological footprint, urban agriculture can also play a role in greening cities, which benefits water management, air quality and social programs.”[5] La Paz needs to resolve a few of these problems

5 Gorgolewski, Komisar, and Nasr, *Carrot City,* 13.

Figure 7 is a photograph of a blocking that took place between El Alto and the Lake Titicaca. Photograph by Miguel Carrasco and Ángel Illanes, La Razon Newspaper.

that the city faces. Adding urban farming in La Paz can help to bring a solution to these problems.

Expansion

To keep this idea going and for it to work on a larger scale, it is necessary to expand the project in terms of informing people as well as forming a network of urban farms within the city of La Paz. The expansion of this project will occur in five main phases as follows (Figure 7):

-Phase 1: “Plant a seed” with a pilot project that has an integration into the existing market network. (Year 0-3)

-Phase 2: Expansion in empty lots and developing of urban farming. (Year 3-6)

-Phase 3: Create a network of urban farms that integrates into the market network. (Year 6-7)

-Phase 4: Physical connection among developed gardens and further expansion. (Year 7-8)

-Phase 5: Physical connection and expansion to public spaces, creating a Continuous Productive Urban Landscape (CPUL) (Year 8-15)

This project will focus and evolve around phase 1: “Planting a seed”. The basis is that this seed can germinate and activate the expansion. A clear reference is the Middlesbrough Urban Farming Project in the United Kingdom. This project follows the basis of Katrin Bohn and André Viljoen’s book “Continuous Urban Productive Landscapes: Designing Urban Agriculture For Sustainable Cities”. The principle, that their project followed is to identify empty spaces where urban agriculture can be held. Further, develop farming on these sites, and then physically connect them, creating continuous productive landscapes. For the Middlesbrough project, the authors of the book identified eighty locations for productive growth. After recording these spaces, they connected them with major existing streets.[6] (See Figure 8 for a mapping of the city with the identified plots, parks, and streets). To create a similar CPUL in La Paz, it is important to add an extra step at the beginning. The pilot project would be this first step, since there is little knowledge on urban agriculture and it would inform and educate on the matter. The next phases would follow the CPULs principles for the expansion.

Figure 8 is the masterplan for the development of Middlesbrough. Drawings by Katrin Bohn and André Viljoen’s. Diagram from the *Carrot City*.

6 Gorgolewski, Komisar, and Nasr, *Carrot City*, 26 - 27.

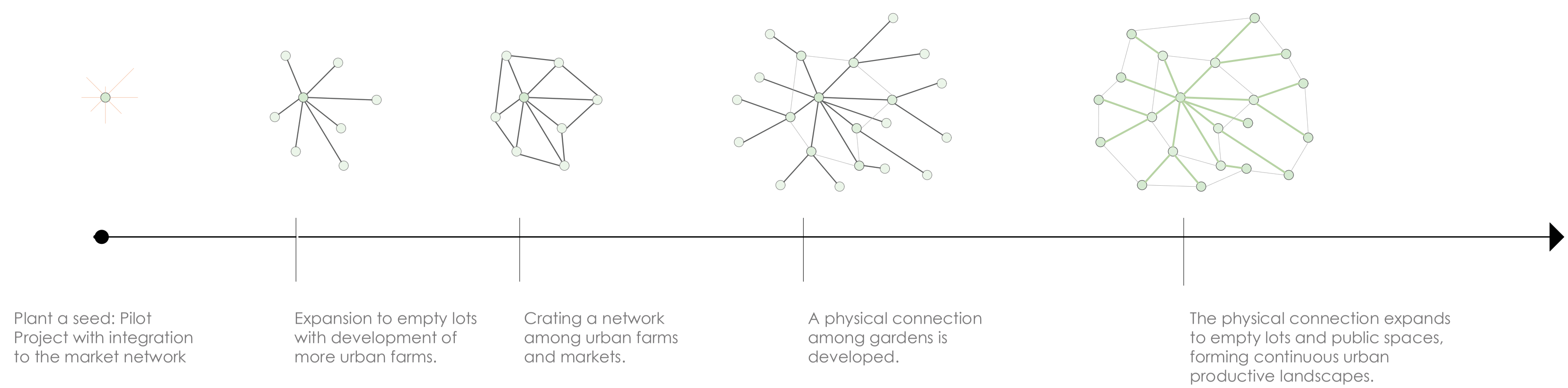

Figure 9 illustrates the five main phases that the expansion will undergo, with an estimated timeline that the expansion would take to convert the city into a continuous productive urban landscape.

CHAPTER 2: SITE

Site Selection

The site selection for this pilot project was based on a study and comparison of several sites around the city. The criteria that each site went through was that the site needs to have a source of natural and clean water for irrigation in order to be self-sufficient. For the expansion of the project, following the steps to develop a CPUL, the site must be located in a green belt, which would facilitate the expansion process. Social and informal housing with proximity to the site the project will facilitate food access to people with low resources. The next criteria is a proximity to main corridors and transportation hubs that will bring public into the project. Moreover, the site should be in an unbuildable land, such as a mountainside, so it has little value for future financial development. Finally, there is a need for a proximity to markets in the city to integrate the project into the existing network of markets.

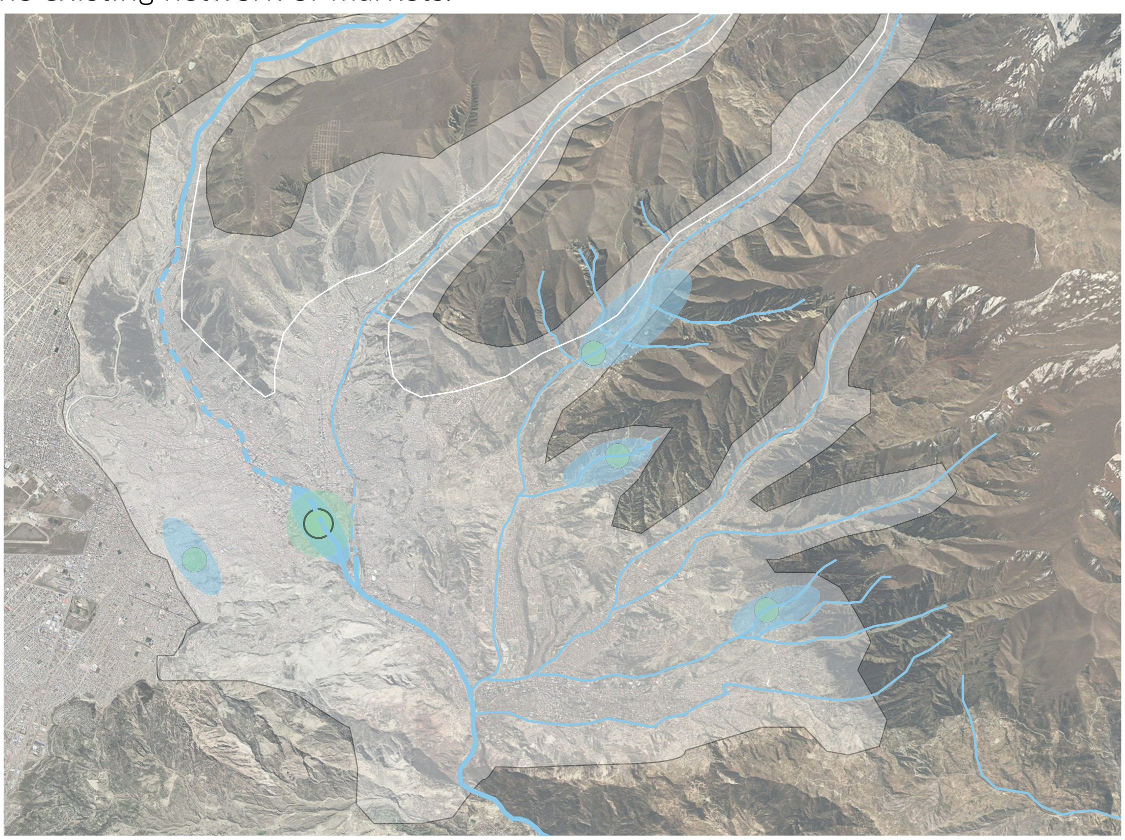

Figure 10 shows the studied sites, with a highlight on the selected site between Av. Arce and Av. Del Poeta. The map also shows the rivers of the city and the most concentration of water springs for natural water. Background map by Google Maps.

Water

The water criterion is extremely important for the project to be self-sustaining, understanding that water needs to be an efficient system in the project. La Paz has an ongoing water scarcity issue due to its poor management, which suggests that the project should not use water from the city supply network. Rather, it is important to look for natural water sources, in order for the project to be self-sufficient. The rivers, which historically, had been the most important water sources in the city are unfortunately severely polluted. The network of rivers in the city had been used as the sewage system of the city. The city and government even enclosed some sections of the rivers to build roads on top of them.

There is a way around this situation. The geography and landscape of the city consist of valleys and mountains. The rivers run naturally across valleys and the mountainsides that face these valleys are usually abound with water springs. The amount of water that these water springs produce is significant, however, it is also being wasted. Figure 11 illustrates a diagrammatic section of the city, where the water from water springs emerges to the surface of the mountainside. This water is not collected, finding its way into the polluted river. According to an interview with Edwin Astorga, the Director of the Sanitary Engineering Institute of the San Andres University (Instituto de Ingeniería Sanitaria de la UMSA), the average water flow of water springs is of half a liter per second.[7] Thus, the amount of water is appropriate for irrigation. A study made by the Sanitary Engineering Institute shows a table of the quality of water in water springs in different locations of the city. Figure 12 is an adaption and summary from a water quality report from the Sanitary Engineering Institute, where fifteen water springs around the city had been tested. The adapted table shows the three water springs in and near the site.[8]

7 Edwin Astorga, "Vertientes En La Paz," telephone interview by author, October 18, 2018.

8 Instituto De Ingeniería Sanitaria Y Ambiental - UMSA, "Revista De Ingeniería Sanitaria Y Ambiental," 30.

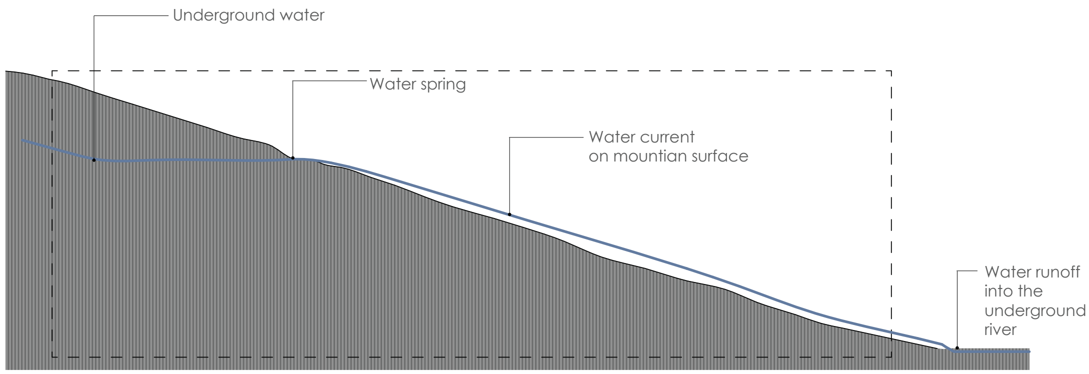

Figure 11 is a schematic section of a mountainside of the city with underground water that flows into the surface in form of water springs.

Analized Parameter	Maximum Requirements by Bolivian standards	Manantial Cementerio Jardin (near site)	Manantial Gruta de Lourdes (on site)	Manantial Parque urbano Central (on site)
True Colour	15	2.5	5	2.5
Turbity	5	0.97	1.33	0.64
Disolved Solids	1000	1302	582	1100
pH(T=25,0C)	6.5 to 9	8.5	8.36	7.64
Conductivity	1500	2151	757	1367
Total Hardness	500	227	263	498
Calcium	200	54.11	56.91	121.04
Magnesium	150	22.36	29.4	47.63
Total Alkalinity	370	528	89	150
Total Iron	0.3	<0.05	<0.05	<0.05
Total Magnesium	0.1	<0.05	<0.05	<0.05
Sodium	200	330	54	6
Sulfate	400	194.62	146.75	261.14
Chloride	250	114.96	38.99	91.97
Nitrate	45	21.96	74.54	140.96
Nitrites	0.1	14.5	10.4	51.2
Coliform Bateria	<1	6.5x10^3	8.5x10^3	3.6x10^3
E. Coli	<1	2.8x10^3	<1	<1

Figure 12 is a table that shows that two of the few water springs on the site have all the values under the Bolivian limit standards. All values must be under the limit for the water to be considered potable. Thus, the water flowing from the water spring on site is suited for irrigation, but not for direct consumption.

Site as an Activator

The surrounding of this selected site acts as an activator for the project to bring the attention of communities into the project, which is essential for the project's expansion. The site is located between a dense commercial main street (Avenida Arce) and main transportation avenue (Avenida del Poeta). The Av. Del Poeta is built on top of the enclosed "Choqueyapu" river on a valley. The mountaintops or plateaus that surround the valley are the neighbourhood of Miraflores and the neighbourhood of San Jorge, the first one being residential and the second one being a mix of residential, institutional and commercial. The site is composed of three lots: one belongs to the cable car station and the two remaining belong to the city. The selected site is surrounded by water springs in the mountainside of the river valley. At the north of the site is part of the Urban Central Park, one of the greenest areas of the city due to natural irrigation from the water springs. As the site is located on the mountainsides, the roughness of the landscape gives the site a peculiar aspect. It extends over 145m, with a height difference of 56m. Significantly, the site's surroundings work as activators of the project. The site lies between the Multicine, a very popular and frequented cinema and food court, and a cable car station. The cable car is the main transportation system of La Paz, connecting several neighbourhoods and La Paz and El Alto together. People frequent this system, using it as a commute to work every day. Just meters away are an engineering faculty of the EMI University, an English school, and a German school. To the south of the site is an important elementary, primary, and high school, and to the north is the biggest state university of the country, the UMSA, which offers a degree in agronomy and agriculture.

This site uses all the selected criteria mentioned previously and the program of the project is developed around this. The water from the spring is used for irrigation; the green belt in the Urban Park facilitates an expansion of the project; communities that live in social and informal housing can get access to food in this project; it is in a central location of the city, which will bring public into the project; it also is located on a mountainside, which suggests that the use of Andean cultivation methods could be implemented in the project.

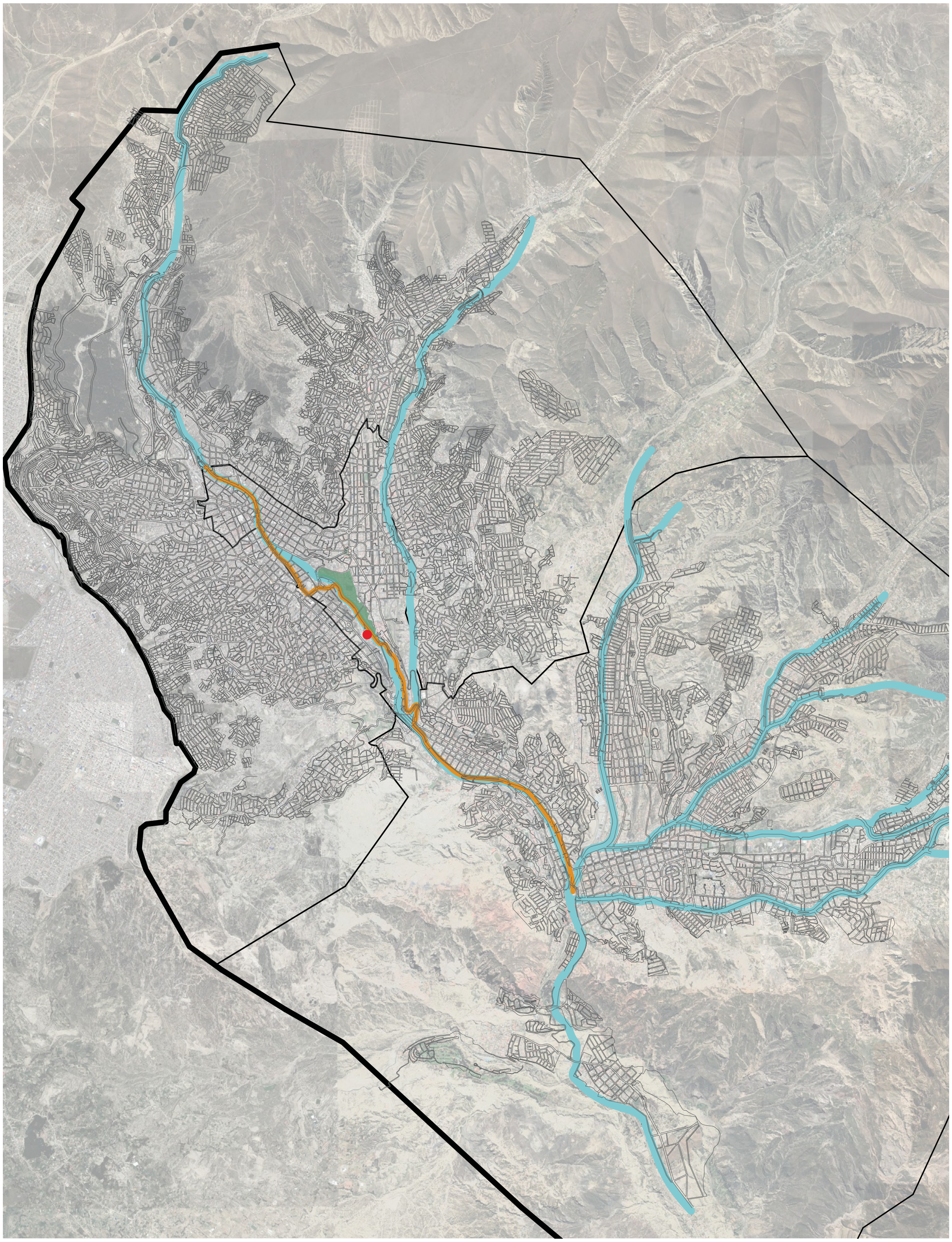

Figure 13 shows a plan of La Paz, with the rivers highlighted in blue, the urban park in green, a major corridor in orange, and the site in red. It is interesting to notice that the city is divided in two: the north and the south, with the site's proximity acting as an important corridor between the two. Background map by Google Maps.

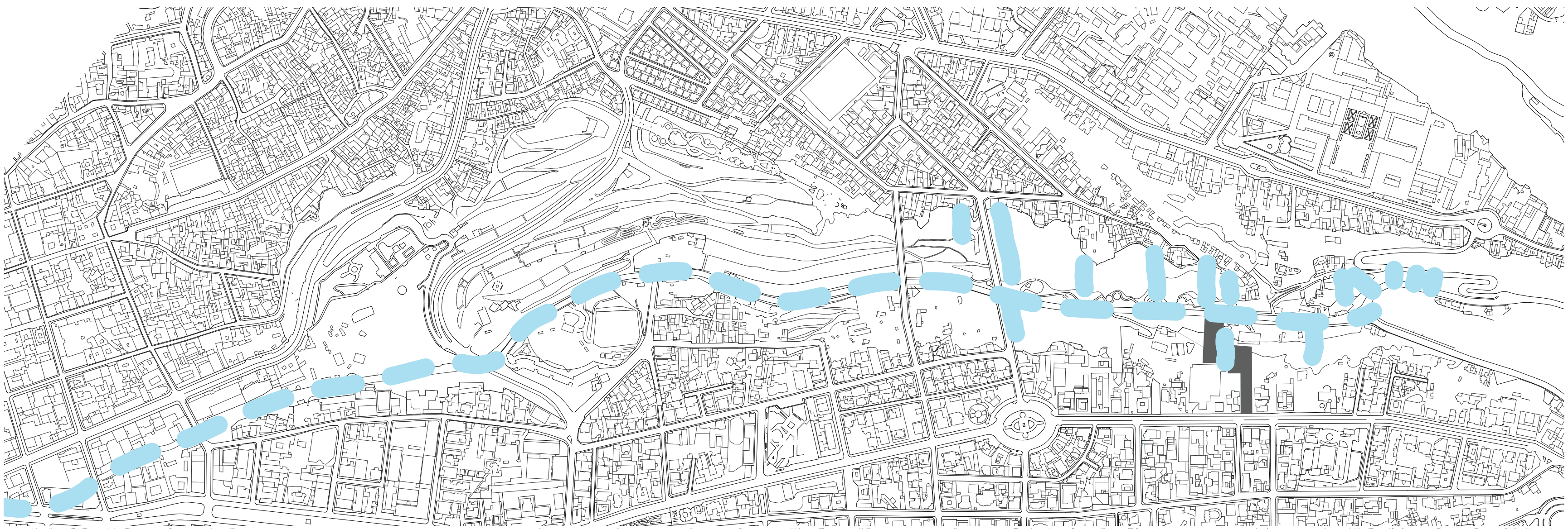

Figure 14 is a map of the site’s surroundings, highlighting the enclosed running river and springs.

Figure 15 is a map of the site's surroundings, highlighting the Urban Park in light green, and recreational green areas in dark green.

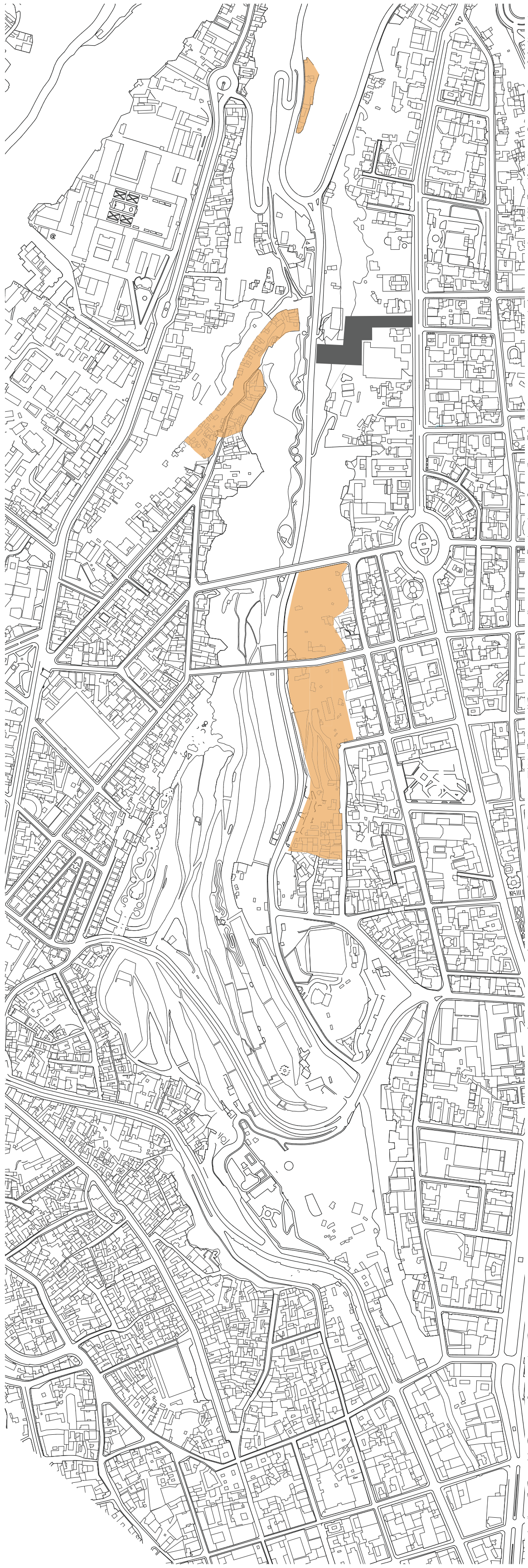

Figure 16 is a map of the site's surroundings, highlighting social and informal housing in orange.

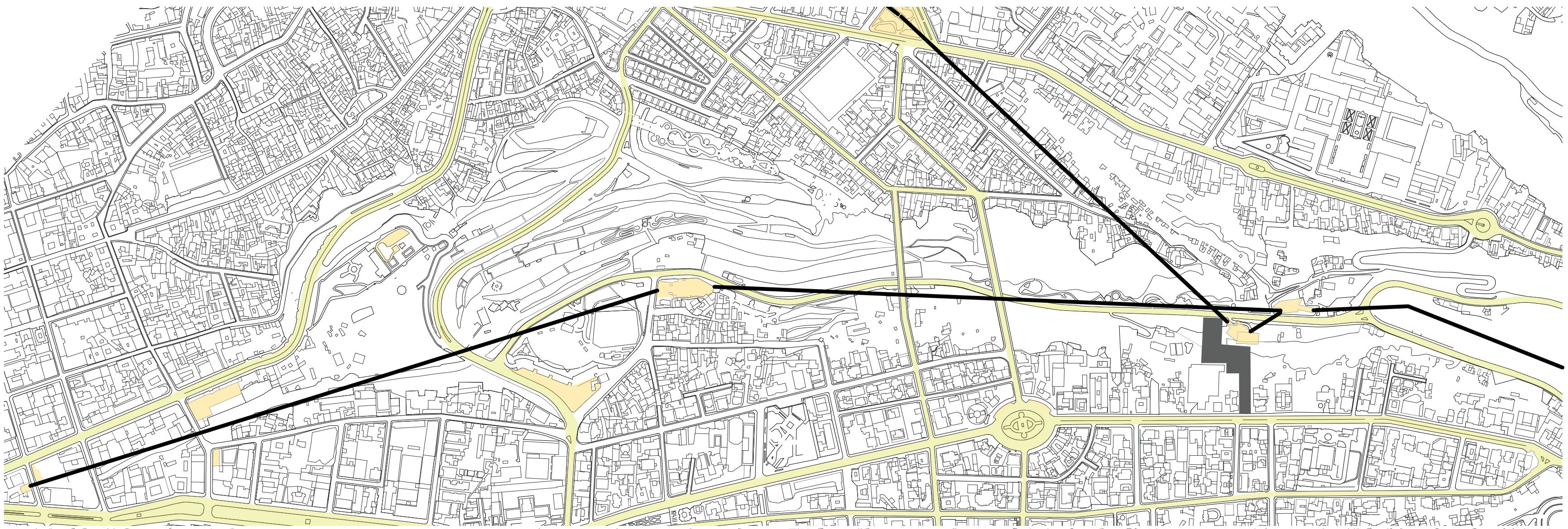

Figure 17 is a map of the site's surroundings, highlighting main corridors and transit hubs in yellow.

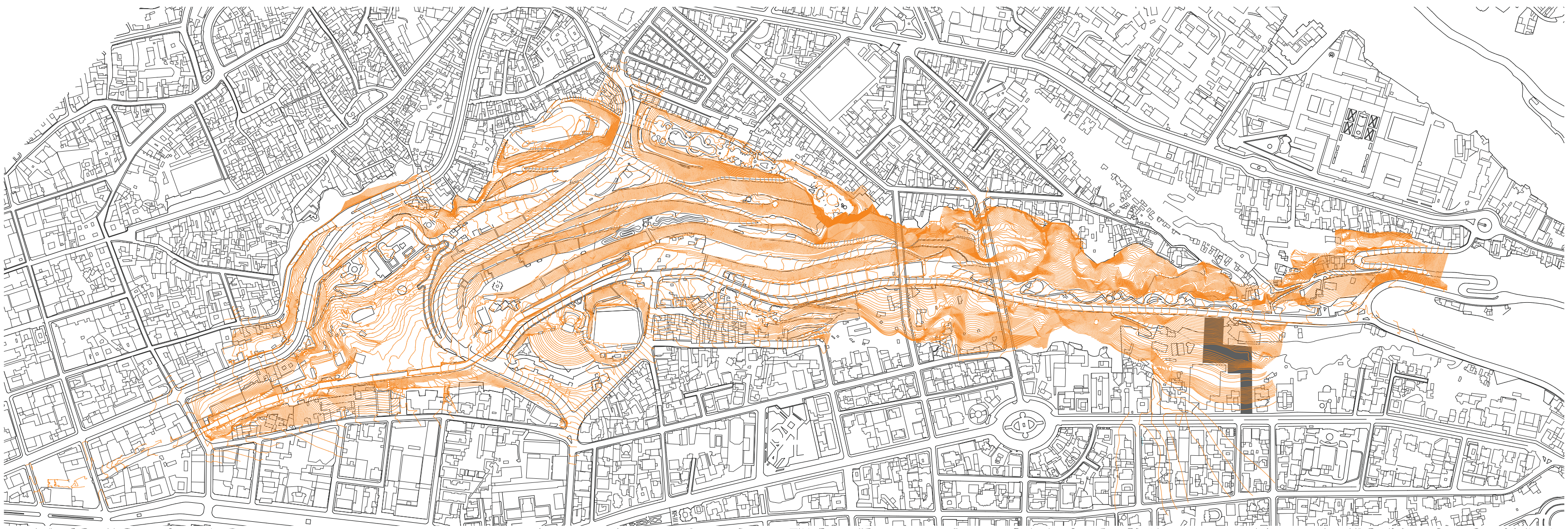

Figure 18 is a map of the site’s surroundings showing the extreme site slope with contour lines representing the slope every meter in the urban park. These areas are particularly difficult to build on.

Figure 19 is a map of the site's surroundings highlighting the mentioned factors that inform the site's location. Furthermore, three green dots show the location of markets near the Urban Park. A forth location for markets is seemingly missing. The proposed project will have a market component that will close the network of markets near the Urban Park.

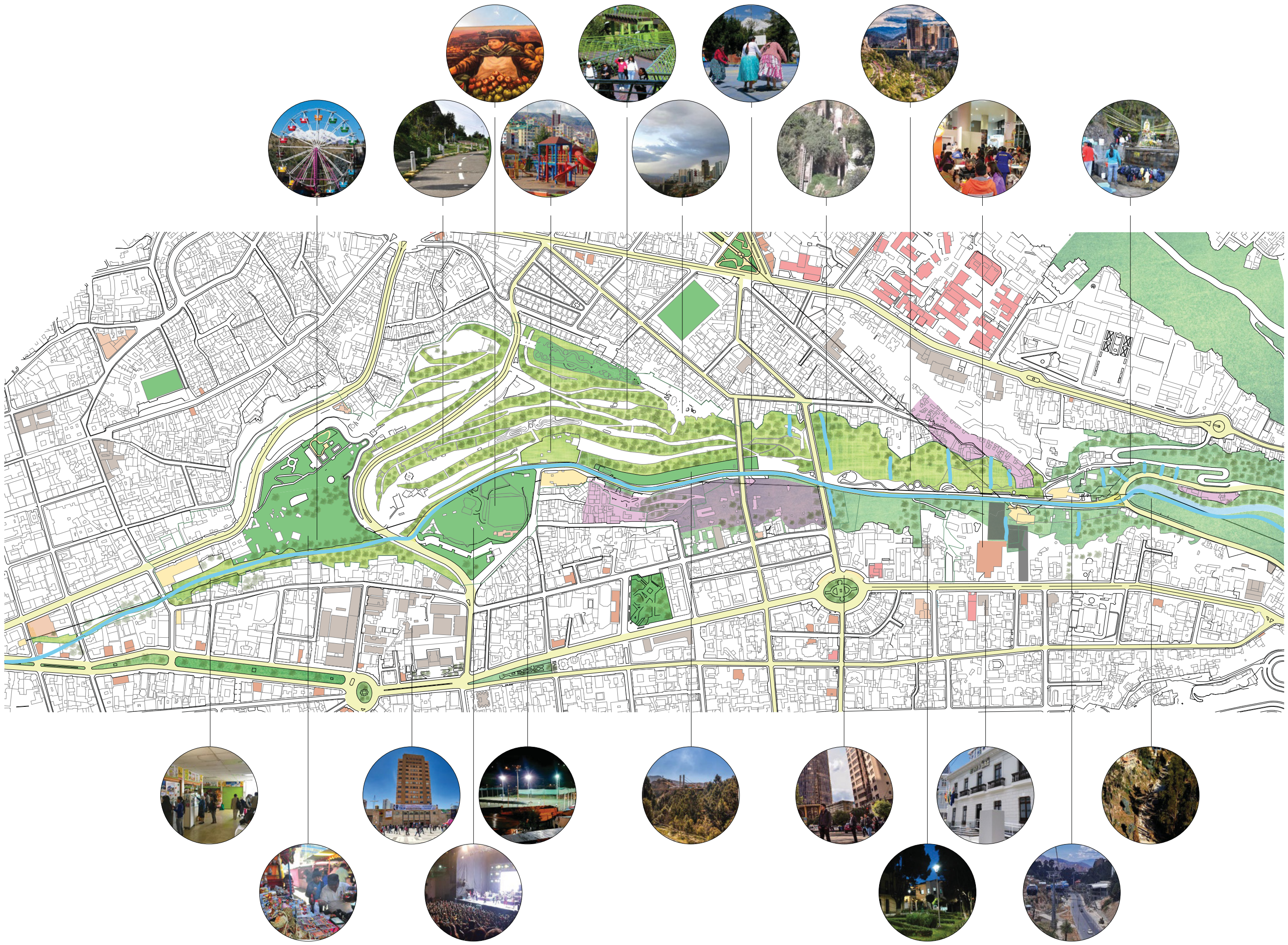

Figure 20 shows the site's surroundings in photographs.

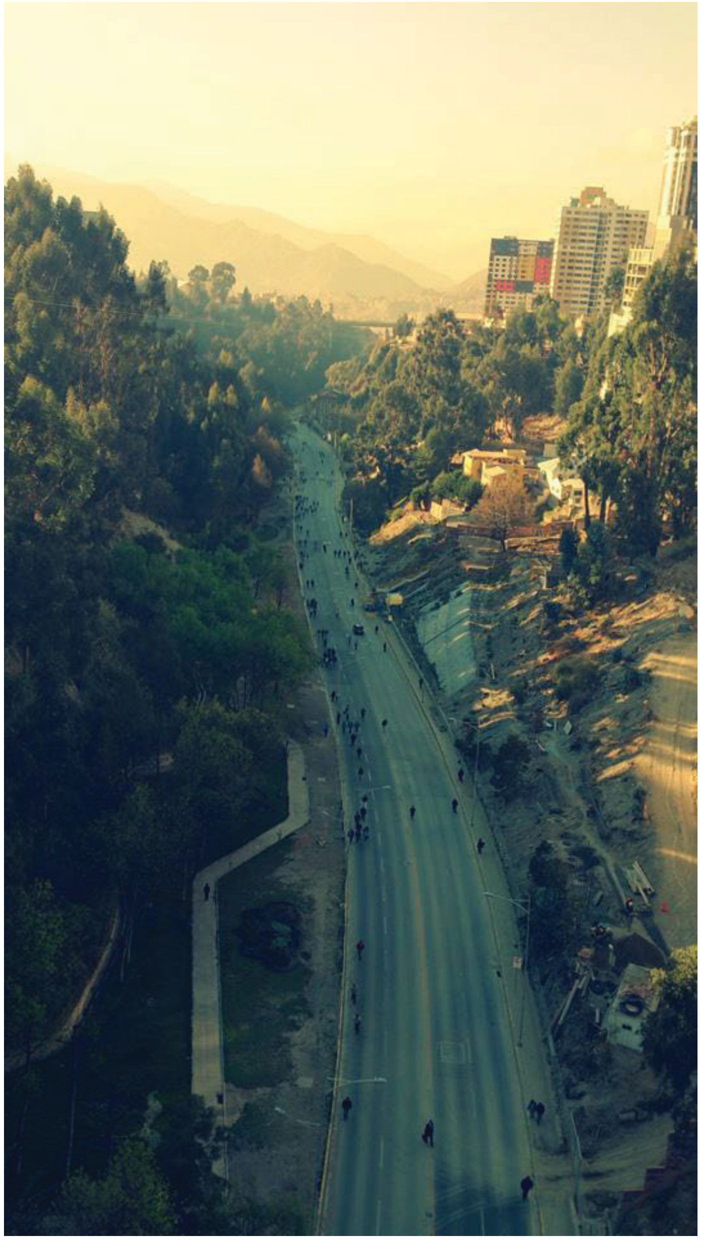

Figure 21 is a photograph taken a day of a blocking in the Av. Del Poeta. The photograph is taken from the Americas Bridge. On the left side is the Urban Park and on the right side is the mountainside of the Av. Arce. The selected site extends between both mountainsides. Photograph by Mariela Carranza.

Figure 22 is a photograph of the Av. Del Poeta with the Americas Bridge and the recently built Twin Bridge on the background. The right side of the image shows the Urban Park. The photograph is populated with the "Mi Teleferico", the main transportation system of the city. Photograph by Susy Kradolfer De Garcia.

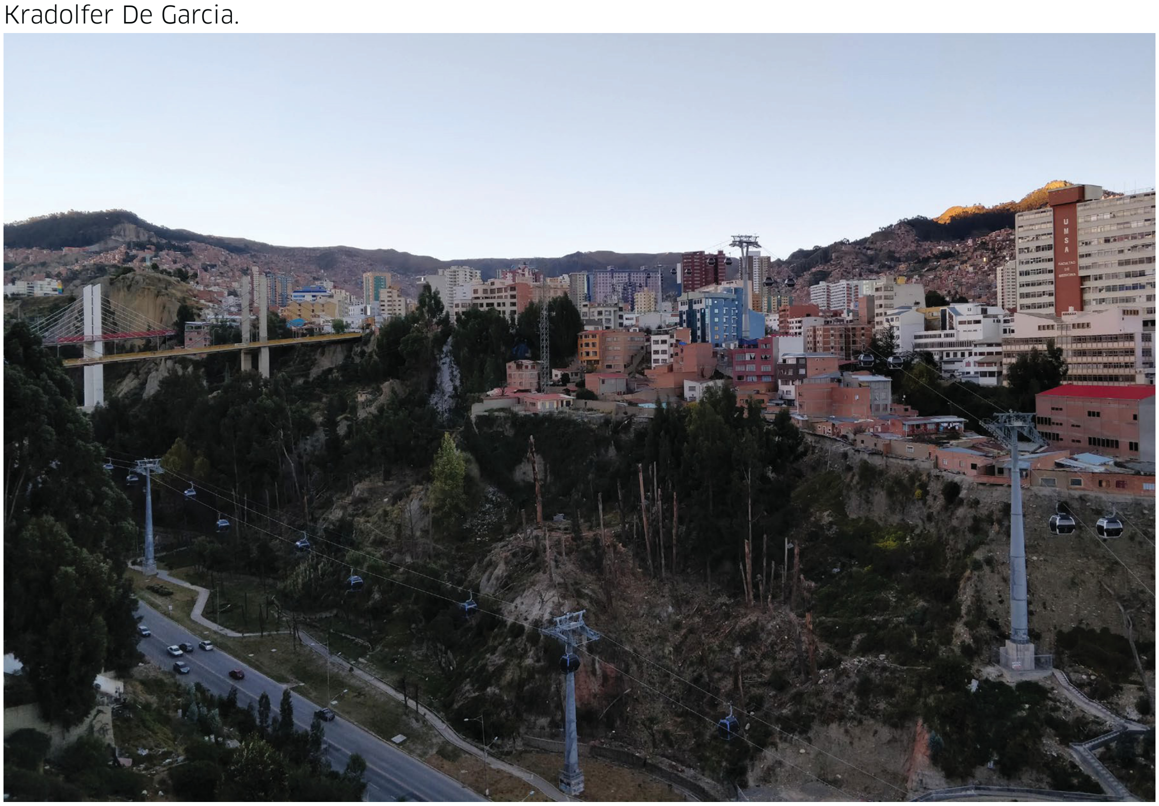

Figure 23 is a photograph taken from the Av. Arce part of the site, looking to Miraflores and the Urban Park.

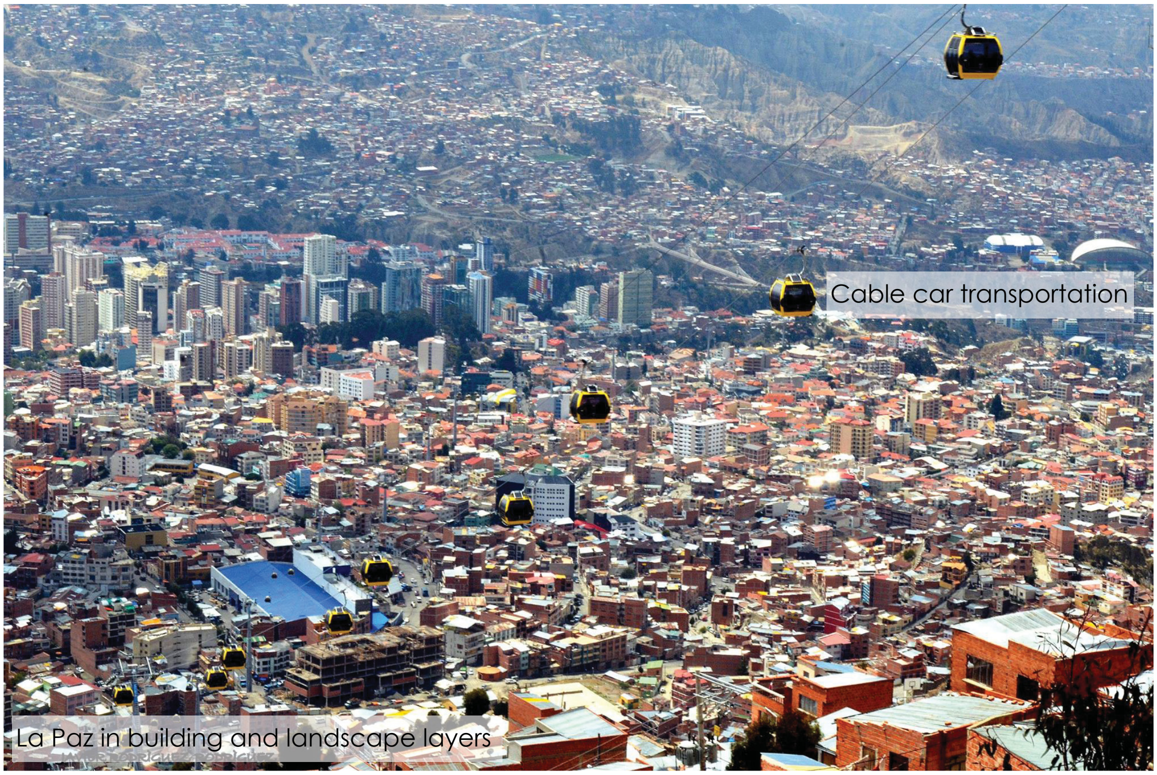

Figure 24 is a photograph taken from a cable car cabin. The site and urban park are located in the mid ground, showing its context in the city. Photograph by Javier Rodriguez Rodriguez.

Figure 25 is a photograph taken from a cable car cabin looking into the site. The photograph also shows the informal housing surrounding the site, as well as the site's landscape.

CHAPTER 3: PROGRAM

Program Intention

The intent of this project is to generate knowledge of urban agriculture that can activate, expand, and tackle the issue of food instability. To achieve this, it is important to bring people into the project, educate them, and produce food for the community. The proposed program focuses on achieving these ideas. The program is separated in these three major components: an education sphere, a community sphere, and a production sphere, all interacting together in the site (Figure 20). The idea is that these spaces interact with each other through the garden and through a water infrastructure, to follow a concept of water and earth interacting together. This idea of the program can be seen as different systems working together in the project, more so like a machine. This can be explained as a system with the three programmatic spheres working together. The idea of this system works as follows: First, the community gets into the project. They, alongside students, are educated on urban agriculture, where they start to experiment with planting. Next, comes the sowing of seeds, harvesting of crops, and the preparing and consumption of them. This part of the system works as a loop since the consumption feeds the community. Part of this system is the networking of ideas, knowledge, and supplies with other urban agriculture gardens and markets in the city. Through all these processes, water is vital, being one of the interacting systems of the project. Although the three programmatic spheres work together as a system, each of them has different components that compose them:

Community

The community sphere will count on strategies to integrate the community into the project. On a big scale of activities, as well as for gaining a sense of community and identity through agriculture. The idea is to bring the agricultural calendar to the site to create events, such as “fiestas” or festivities to the project. These fiestas will be held on site in the most important agricultural days in the Andean culture, which will bring the community together through agriculture. In

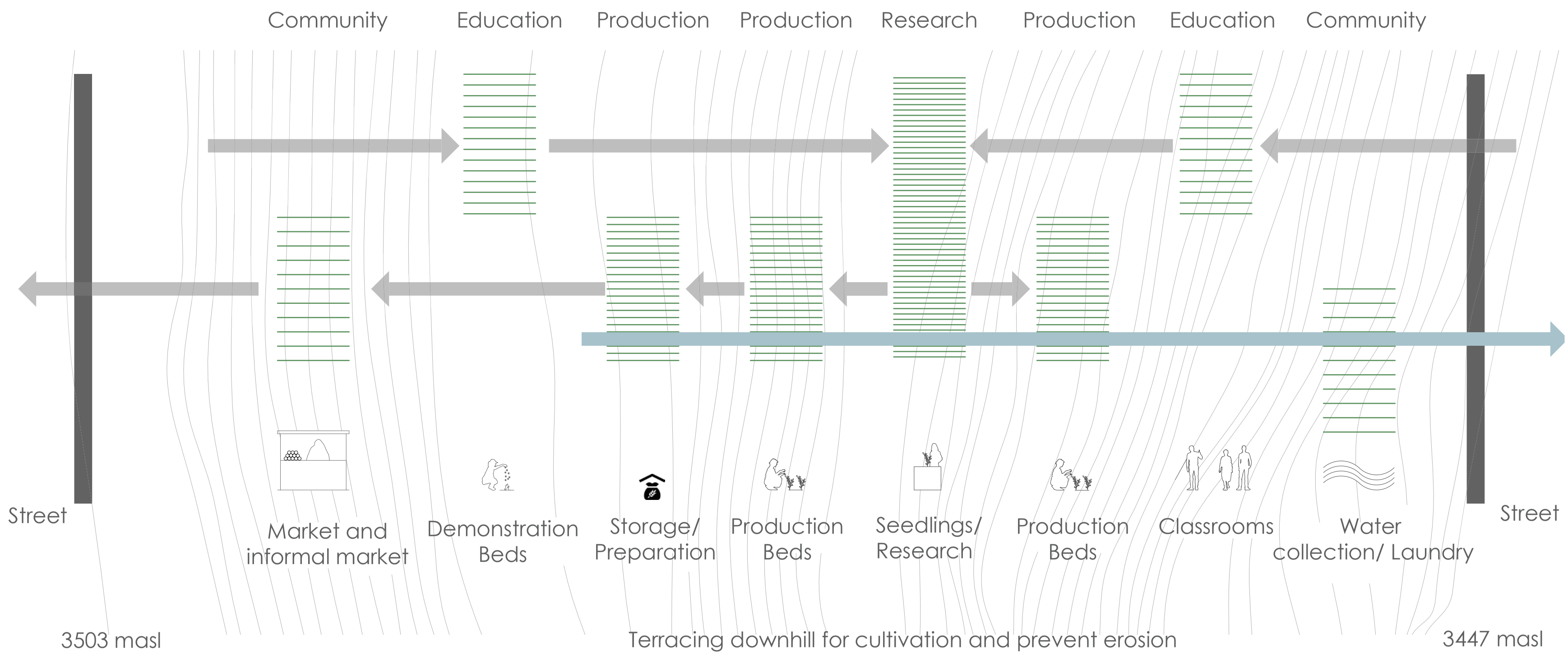

Figure 26 is a diagram of the project's program, showing the three program spheres (comunity, education and production) on top. It also shows the activities held on site for each of these spheres.

the agricultural Andean calendar, each season's peak has an agricultural festivity.

The festivities are celebrated as follows: Starting with "The day of the dead" on November 2nd. Around this date, the rainy season starts, and the belief says that the spirits of the people that passed away will bring rain with them. With rain begins the agricultural cycle with sowing. This date is followed up with Carnival, which comes in summer's peak. The specific date changes every year accordingly to the Lunar calendar but is held around February 3rd. Carnival together lasts 4 days, in which there are distinct types of celebrations. The last day of these celebrations ends on a Tuesday that is called Martes de Ch'alla This "Martes de Challa" is dedicated to ask for abundance. In this festivity, farmers move across the agricultural lands thanking the Pachamama or Mother Earth by decorating the plants with confetti, balloons, and candy, as well as spraying beer, alcohol, and wine through the land. The word Ch'alla comes from the Aymara language, which translates to pouring or throwing.[9] The next festivity is held on May 3rd, usually around Easter Week. This is a Catholic celebration called "Cruz de Mayo". This festivity comes with processions and dances to celebrate the start of the harvesting season. The last festivity is on August 2nd, in the middle of the winter and the peak of the driest season. In this festivity, people make offerings to the Pachamama. The project will host these four major events to bring the community through identity and agriculture (Figure 22). These festivities will happen all around the project in form of processions, from one end to the other end of the project.. In a day-to-day use of the garden, community members will also have demonstration beds and a kitchen, where they can learn the first steps in the process of food. Moreover, community members can also gain an entrepreneurial experience by learning the value of food retailing in the market. Finally, the use of therapeutic growing beds on the site would bring special opportunities for community members to gather together alongside growing plants.

9 Laisee Orosco, *Costumbres Y Tradiciones De Los Aymaras Y De La Cultura Andina En La Zona Del Altiplano De La Paz* (La Paz: Fundación Cultural Quipus, 2008), 3.

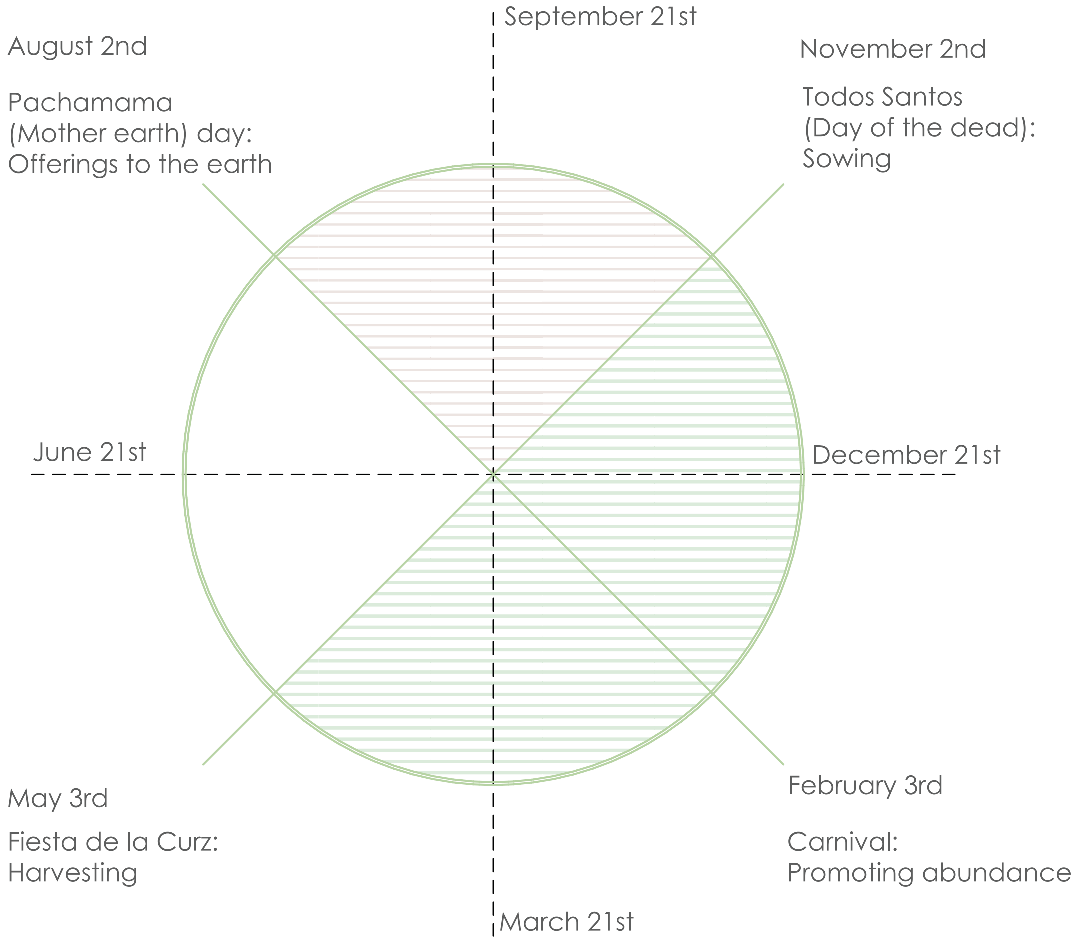

Figure 27 is an illustrated calendar of the described festivities.

Education

The education sphere is where the “seed” is planted. The idea is that community members gain knowledge of urban agriculture through the mentioned activities that engage the public with agriculture, as well as classes that are provided on site. Here is also where the importance of proximity to schools and universities play a big role. The strategy to engage students from schools with urban agriculture is similar to the one implemented in Cuba. Cuba is well known for fostering urban agriculture. During the 90s the embargo from the United

Figure 28 is a vignette of the Day of the Dead celebrated on site.

Figure 29 is a vignette of the Ch’alla celebrated on site.

Figure 30 is a vignette of the Fiesta de la Cruz celebrated on site.

Figure 31 is a vignette of the Pachamama day celebrated on site.

States prevented gas to be delivered to Cuba. This forced citizens to grow crops in the city since food transportation became an issue. Nowadays, urban agriculture is still predominant in the country, and schools in Cuba have programs where students engage with agriculture from a young age.[10] The idea of developing programs with schools to involve students with agriculture is similar to the one existing in Cuba, where students learn the theory behind agriculture in the city, as well as gaining practical knowledge and experience inside this urban farm. The proximity to the UMSA University can provide agronomy and agriculture students experiment with agriculture on a production scale. This can be a perfect site where students engage with agriculture in practice, with education growing beds and use their knowledge in the subject to help the community with agriculture in the city. Community members will be encouraged to come into the site to learn about agriculture in the city by having demonstration gardens, as well as cultivating on site with community production beds. Finally, this sphere also has a research component, where students and professionals in the area experiment with different crops to expand the production on a city level. The education sphere will be composed of experimentation beds, classrooms, and labs.

Production

The production sphere will have preparation area and production beds, which will be spread through different methods of cultivation and microclimates. A further explanation of these methods will be developed in Chapter 4. The production sphere is the final step in the system, generating the product for the community on the site, as well as for networking.

10 Sinan Koont, S*ustainable urban agriculture in Cuba* (Gainsville, FL: University Press of Florida, 2011), 85.

CHAPTER 4: DESIGN FRAMEWORK

Zoning

Having the site and program already explained, the following step is to develop a zoning study. For this project, where three programmatic spheres (education, community, and production) work together as a system, it is important to generate spaces for cross-programming, as well as identify the best physical spaces on site for each program. The spaces where these programs coexist could be referred to as "hot spots" or anchors, where architectural features get together to form spaces with a dense programmatic feature. These mentioned "hot spots" will be driven by infrastructure and will have different sets of thresholds throughout the garden. Spaces to take under consideration are: the relationship of the street to the market, market to preparation, production beds to preparation, among others. The development of these anchors will be described in the following chapter.

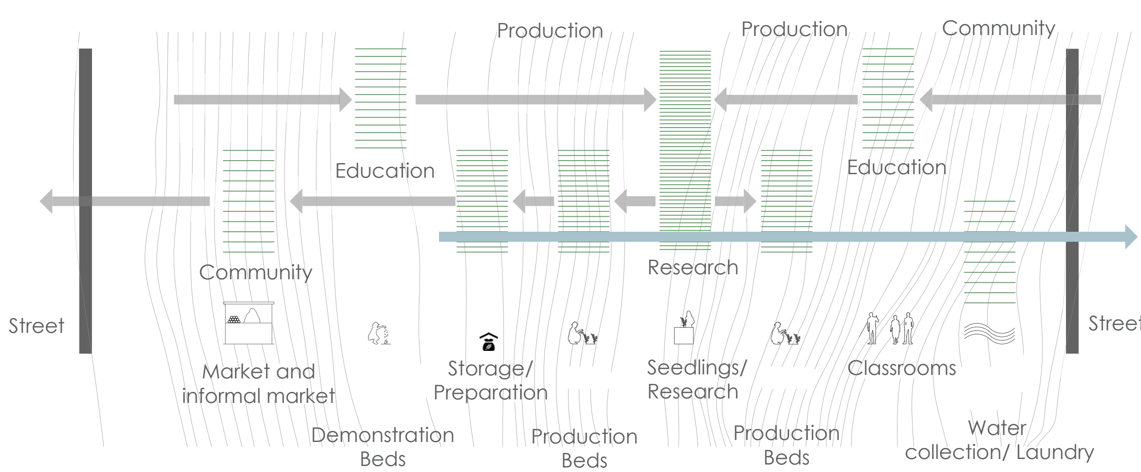

Figure 32 is a the program diagram showing the zoning of the program on the site, with community spaces closest to the street, education in a second tier, and research in a third tire, with production surrounding various spaces. Everything cultivated and the water not used for irrigation goes back to the community.

Cultivation Methods

There is a big variety of crops that are produced near the city that people consume in La Paz. As this is a pilot project, the aim is to produce a diverse range of crops. The crops that are produced in the agricultural lands near the city of La Paz are: in the high plateaus, near the Lake Titicaca: potatoes, quinoa, braid beans, oca, peas, barley, and oats, among others. In the valleys, near the La Paz river: fruits and vegetables. In the Yungas or Amazon mountains: citrus, coffee, peanuts, yuca, corn, coca, and tropical fruits.[11] To create microclimates for the diverse types of crops, there is a need for different types of structures with different materials, as well as different cultivation methods for them. The climate of La Paz is mountainous, with an average temperature of 13°C. To create microclimates similar to the Yungas, in the Amazon mountains, there is a need for greenhouses that elevate the temperature. Moreover, to increase the sense of identity, as well as productive cultivation methods, it is important to study the traditional cultivation methods of the Andes. On the one hand, there is the terracing, which is a system that has several functions. “Terraces modify microclimate, including soil moisture, wind patterns, and temperature.”[12] They can also control the water for irrigation through canals, although some terraces do not require irrigation.[13] The stone from the retaining walls from the terracing absorb the heat from the sun and radiates it back into the atmosphere at nights, keeping the surface of the terrace warmer. These retaining walls also prevent erosion. See Chapter 5 for the implemented techniques. On the other hand, there is the raised fields system. The raised fields have several functions for agriculture as well. Canals built between the raised beds provide the plants with water and nutrients. The water in these canals also absorb the heat of the sun and radiates it back into the atmosphere at nights, keeping the plants warmer and preventing night frosting.[14] These systems are present near the Titikaka lake and produce potatoes the most.[15]

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11 “Agricultura Del Departamento De La Paz,” *Gobierno Autónomo Departamental De La Paz*, May 16, 2004. http://www.gobernacionlapaz.gob.bo/agricultura/.

12 André Viljoen, Katrin Bohn, and Joe Howe, *Continuous Productive Urban Landscapes: Designing Urban Agriculture for Sustainable Cities* (London, Elsevier, 2009), 183.

13 Ibid., 182.

14 Ibid., 269.

15 Ibid., 270.

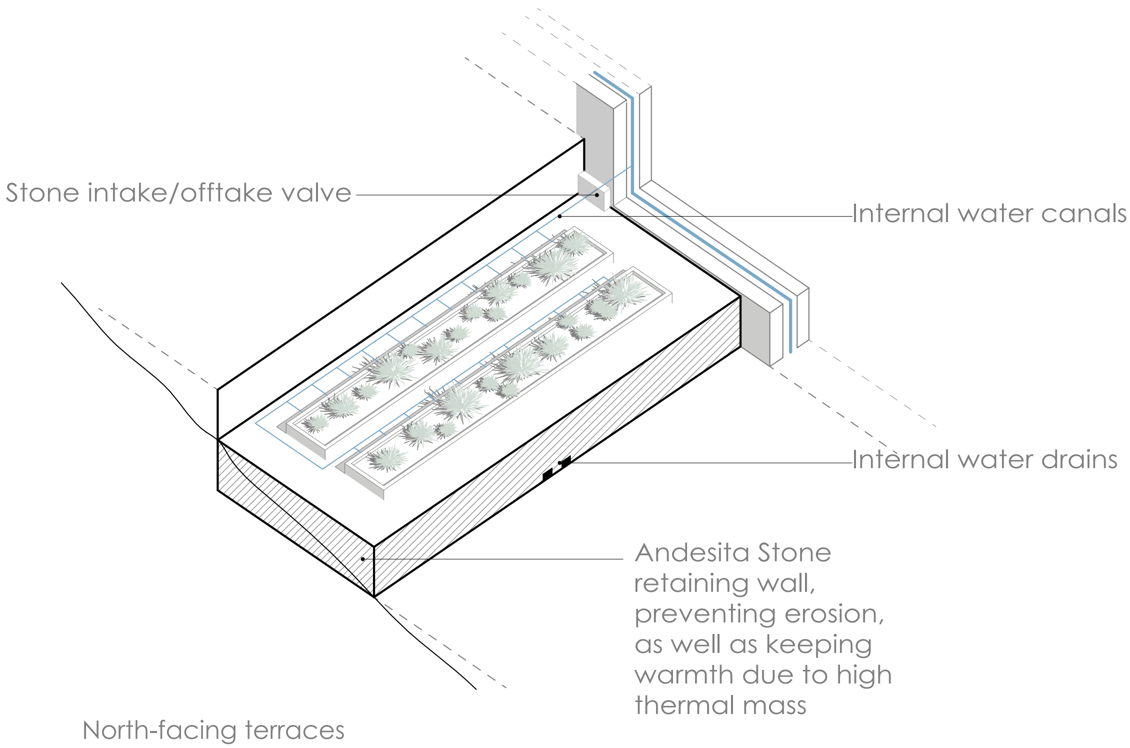


Figure 33 illustrates how the terracing system works.

Figure 34 is a photograph of the terracing systems in Yungas in the Amazon Mountains, called Wachu Wachu by locals. Photograph by the Municipal Government of La Asunta.

Figure 35 is a photograph of the terracing systems in the Isla del Sol (Sun Island) in the Titikaka Lake. Photograph by Guillermo Doffo.

Figure 36 is a photograph of the terracing system in Machu Picchu, an Inca city. The agriculture in terracing form was part of the heart of this ancient Andean city. Photograph by Travel Up Adventure.

Figure 37 is a photograph of the water canals in Tipon, an ancient Inka city near Cuzco in Peru. Photograph by South Adventure Peru Tours.

Figure 38 is another photograph of the canal systems in Tipon. Photograph by Machupicchu Latin America Tours.

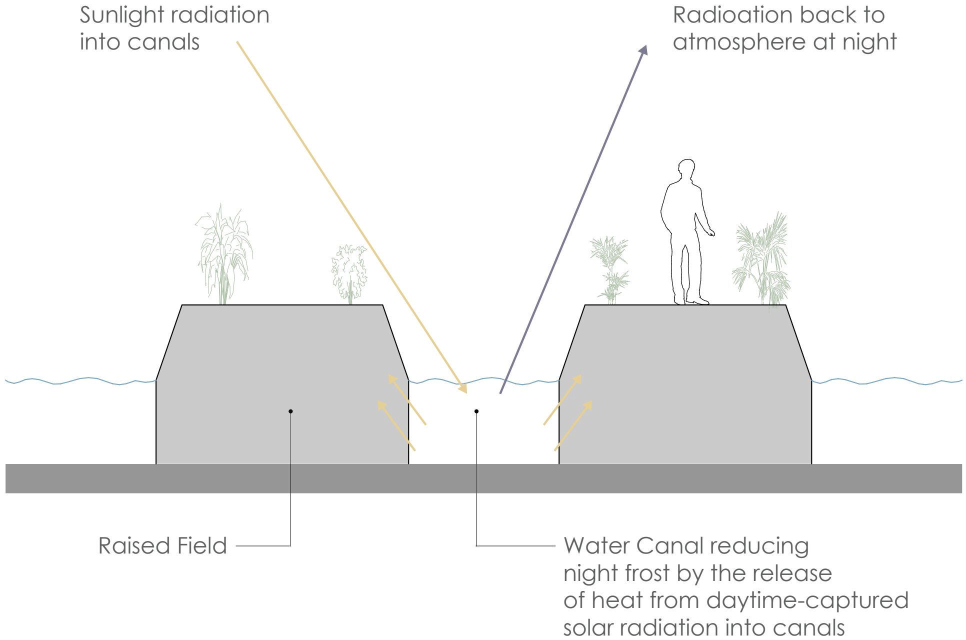


Figure 39 illustrates how the raised fields work.

Figure 40 is a photograph of the raised fields near Tiwanaku. Photograph by Irrigaciondelperu.

Figure 41 is a photograph of the ruins of the city of Tiwanaku. Photograph by Pavel Špindler.

Figure 42 is an aerial view showing the raised fields on the right of the image, and the ruins of Tiwanaku on the left. Photograph by Google Maps.

The classification of the crops that are going to be cultivated in this project can fit in different groups by families of crops by the standards of the Instituto Interamericano de Cooperación para la Agricultura (IICA) or Institute of Interamerican Cooperation for Agriculture from group 1 to 10, [16] with the addition of groups 11 to 13. [17] [18] [19]

	CROPS	TEMPERATURE	FROST ACCEPTANCE	OPTIMAL SEASON	BENEFITS
GROUP 1	onions, garlic, asparagus	13°C – 24 °C	YES	Fall - Winter	Garlic keeps parasites from fongus away
GROUP 2	lettuce, artichoke	15 °C – 18 °C	Yes	All year	Lettuce keeps flees away
GROUP 3	yucca	18 °C – 30 °C	No	Spring - Summer	
GROUP 4	Broccoli, cauliflower, cabbage, radish	15 °C – 18 °C	Yes	Spring - Summer	
GROUP 5	cantaloupe, cucumber, watermelon	18 °C – 30 °C	No	Spring - Summer	Cucumber atracts bees
GROUP 6	beans, broad beans, peas	15 °C – 30 °C	No	All year	
GROUP 7	chard, beets, spinach	15 °C – 18 °C	Yes	Fall - Winter	Spinach keeps parasites from fongus away
GROUP 8	strawberry	15 °C – 18 °C	No		
GROUP 9	pepper, tomato, potato, eggplant	15 °C – 18 °C	Yes, except popato	Spring - Summer	Tomato keeps flees away and atracts bees
GROUP 10	celery, carrots, parsley, cilantro	15 °C – 18 °C	Yes, except carrots	All year	Parsley avoids fongus
GROUP 11	corn, rice, oats, wheat	10 °C – 13 °C	No	Spring - Summer	
GROUP 12	coca	18 °C – 21 °C	No		
GROUP 13	coffee	18 °C – 21 °C	No		

The table (Figure 43) informs the ideal condition and benefits for the crops in the mentioned groups. This will inform where each specific crop should be cultivated.

Materials

To select the material palette for the project, it was important to look at the material culture of buildings in Bolivia to tie the idea of giving the project the identity of the country. Building with earth and stone has been the predominant methods of building in the Andes. Stone has been commonly used in different civilizations in the Andes. Tiwanaku and the Incas, for example, used stone as the main material to build the temples and cities. It was predominantly used also for the terracing retaining walls in the Inca civilization. Two types of stone will be used in the project. The first one is called Comanche stone. (Figure 44) This stone is found in abundance throughout rivers in La Paz, and will be used for building

16 Natalia Curcio and Ana Sartori, "Guía De Formación En Buenas Prácticas Agrícolas Para Hortalizas," *Instituto Interamericano De Cooperación Para La Agricultura*, 2016, http://www.iica.int/es/publications/gu%C3%ADa-de-formaci%C3%B3n-en-buenas-pr%C3%A1cticas-agr%C3%ADcolas-para-hortalizas-un-maravilloso-viaje.

178 Ministerio De Desarrollo E Inclusión Social, "Biohuertos Familiares Para La Producción De Hortalizas." December 2014, http://www.paccperu.org.pe/publicaciones/pdf/128.pdf.

19 Ministerio De Agricultura, Ganadería Y Alimentos, "Una Propuesta Para La Alimentación Saludable Y Sustentable," accessed March 20, 2019, http://magya.cba.gov.ar/upload/ManualGranja.pdf.

20 Juan Carlos Alcazar Ocampo, "Manual Básico "Producción De Hortalizas". March 2010. http://www.innovacion.gob.sv/inventa/attachments/article/2593/MANUAL_HORTALIZAS_PESA_CHIAPAS_2010.pdf.

the canals. The second type of stone is called Andesita stone. This stone is found in the city's mountains and will be used to build the terraces.

Earth has been used as a cheap and easy material to build with in the cold climate of the high plateaus. Several towns are built with earth and hay in this climate. Besides being a material that people are familiarized with, building with earth significantly decrease the costs of constructions. Further, earth has exceptional building properties, such as having the "ability to balance indoor humidity like no other building material."[20] Earth also stores heat, saves energy and reduces environmental pollution, saves material transportation costs, it absolves pollutants, and preserves timber and other organic materials.[21] The methodology of implementing earth will be building with rammed earth. This type of building method allows for layers to form and tell a story of how the structure has been built. The concept of building with rammed earth is a metaphor to the layers observed in the city. Figure 47 shows a picture of the city expressed in different layers. Figure 46 is an image of a test of rammed earth construction by the author (See Appendix 1 to see the process of this study). La Paz is surrounded by mountains that have different earth composition, which gives different colors to the mountains. This brings the exciting possibility of using different compositions of earth to create layers of different colors in the rammed earth. By using different colors, the rammed earth used in the project can be a representation of the layers that the city shows. The outcome could be similar to the Chulpas (ancient Andean constructions), which are buildings that use only soil to give color to the facades. (Figure 45). The materials selected will bring contrast in the palette and in the project. They will also create an interesting contrast with each other, and connections between these will occur in the previously mentioned "hot spots". On the one hand, since the stone is found in the river, it will drive water through the site. Further, a hydraulic irrigation system will be integrated into these walls. On the other hand, earth will emerge

20 Gernot Minke, *Building with Earth: Design and Technology of a Sustainable Architecture* (Basel: Birkhäuser, 2013), 15.

21 Ibid., 14.

from the landscape to form spaces in the project, driving people through the site. Another reason to contrast these two materials is that water cannot touch rammed earth, since it is not good for the material. A "wish image" (Figure 38) expresses the idea of the materials integrated on the site with the program. This concept will be further developed in Chapter 5: Design.

Figure 44 is a photograph of a Comanche stone pile. Photograph by Piedra Comanche Bolivia.

Figure 45 shows the construction of the Chulpas, with soil that colours the building. Photograph by Tierradevientos.

Figure 46 is a photograph of the outcome of the rammed earth experiment.

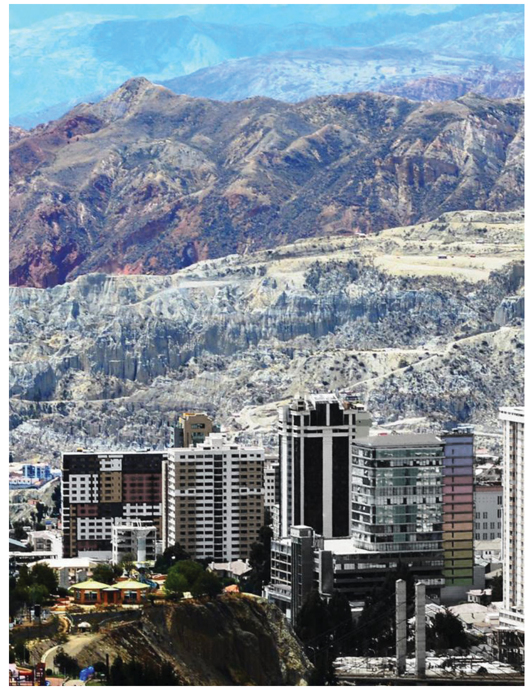


Figure 47 is a photograph of La Paz, with buildings in the mid ground and the mountains that surround the city in the background. Photograph by Adalid Corini.

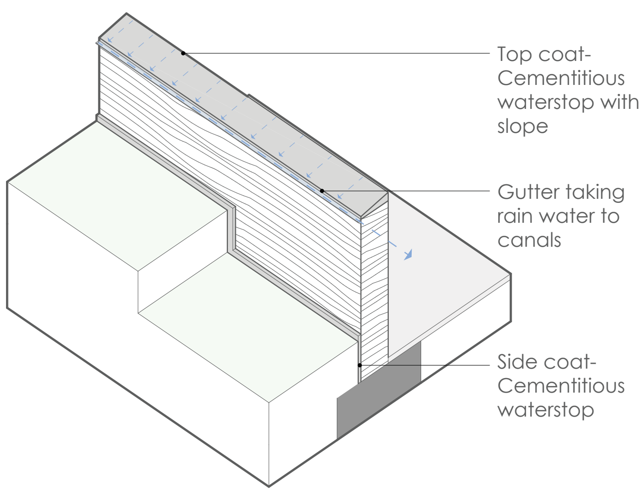


Figure 48 is a diagram showing the implementation of rammed earth wall into the project.

Figure 49 is the “wish image”. The program mentioned in the previous chapter is interacting with the design principles as the material and the cultivation methods through the site.

Figure 50 is a zoom into the wish image, showing the project's interaction with the street and accommodating community program into the project.

Figure 51 is a zoom into the wish image, showing production, education, and water collection in the project.

Case Studies

Rammed earth is a material that has been used for hundreds of years all around the world. Furthermore, there are many modern projects that use this material as well. Two examples of the use of rammed earth in modern architecture are the Nk'Mip Desert Cultural Centre by DIALOG in Osoyoos, BC, Canada, and The School of Visual Arts of Oaxaca by Taller de Arquitectura - Mauricio Rocha in Oaxaca, Mexico. These two projects are perfect case studies of the material use for the proposed project. The Nk'Mip Desert Cultural Centre as a contrast in the materiality between rammed earth walls and concrete walls. The architects use the rammed earth walls to "create a layered view of the desert rising up in the middle ground, receding to the riparian landscape adjacent, and the mountains in the distance."[22] A similar strategy can be used in this project, using the rammed earth walls in a way that they can blend into the landscape. The School of Visual Arts uses concrete, as well as stone for the material palette. In the case of this project, the rammed earth walls are the principal component for almost all the exterior partitions with concrete foundations and wall bases. The use of the stone is usually seen in retaining walls that play with the slopes in the site and to form terraces.[23] The play with the different materials and the contrast that they bring is fascinating. The proposed project can use similar methods for contrasting the materials and playing with sloping and creating terraces.

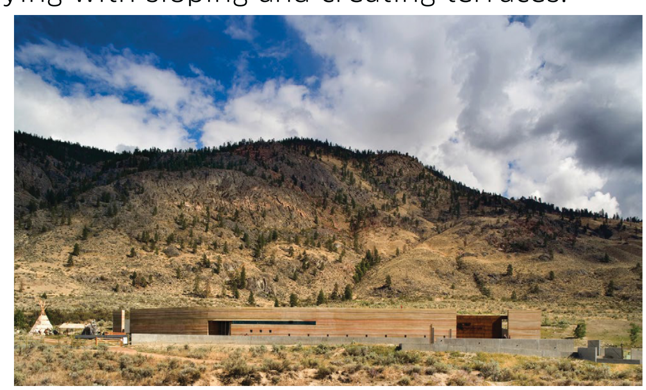


Figure 52 is a photograph of the NK'Mip Desert Cultural Centre. It shows the expression of rammed earth with the blending into the landscape of Osoyoos. Photograph by Nic Lehoux Photography.

22 "Nk'Mip Desert Cultural Centre / DIALOG," *ArchDaily*, May 23, 2014, https://www.archdaily.com/508294/nk-mip-desert-cultural-centre-dialog.

23 "The School of Visual Arts of Oaxaca / Taller De Arquitectura - Mauricio Rocha," *ArchDaily*, July 29, 2011, https://www.archdaily.com/154485/the-school-of-visual-arts-of-oaxaca-taller-de-arquitectura-mauricio-rocha.

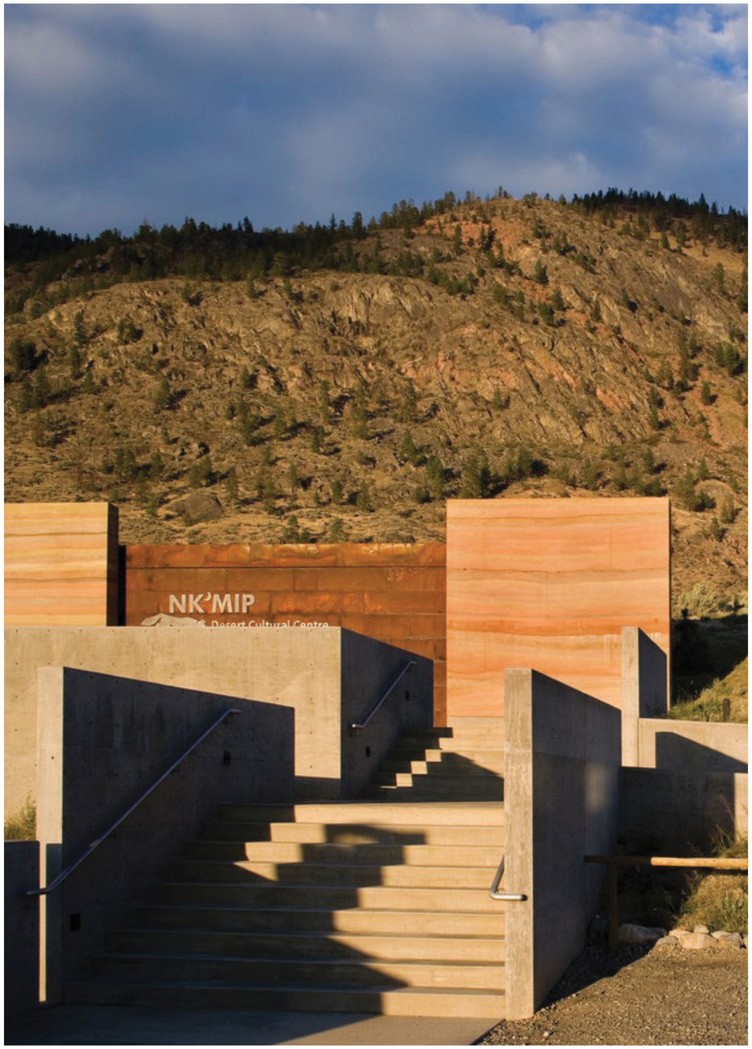


Figure 53 shows the contrast created with materiality: The rammed earth and concrete structures. Photograph by Nic Lehoux Photography.

Figure 54 shows the layers used for the rammed earth in this project. Photograph by Nic Lehoux Photography.

Figure 55 shows the School of Visual Arts. The image shows a contrast between rammed earth and stone walls. Photograph by Luis Gordoa and Rafael Carrillo.

Figure 56 is a photographs of the School of Visual Arts. The image shows a contrast between rammed earth and stone walls. Photograph by Luis Gordoa and Rafael Carrillo.

Projects of architecturally designed urban farms are present all over the world. There are some case studies, that can give some directions for developing this project. Value Farm, by Thomas Chung, and located in Shekou, China is one of them. This project uses cultural events to integrate the community with agriculture. The concept of the design follows the rooftop condition typologies; thus, it creates the concept that cultivating on a rooftop would be similar to doing it in the urban farm, similar to having a "test ground". Furthermore, the garden offers an "alternative and healthy taste, while addressing food safety and accessibility, urban sustainability and self-sufficiency."[24]

Figure 57 shows the an aerial view of Value Farm, showing communities circulating through the garden. Photograph by Value Farm.

Value Farm has a similar vision that the pilot project in La Paz has. Informing the public, having cultural events to engage communities with agriculture, and addressing food accessibility are among the similarities that these two projects have. Value Farm also can inform the pilot project on how spaces are created following this vision.

24 "Value Farm / Thomas Chung," *ArchDaily*, February 17, 2014, https://www.archdaily.com/477405/value-farm-thomas-chung.

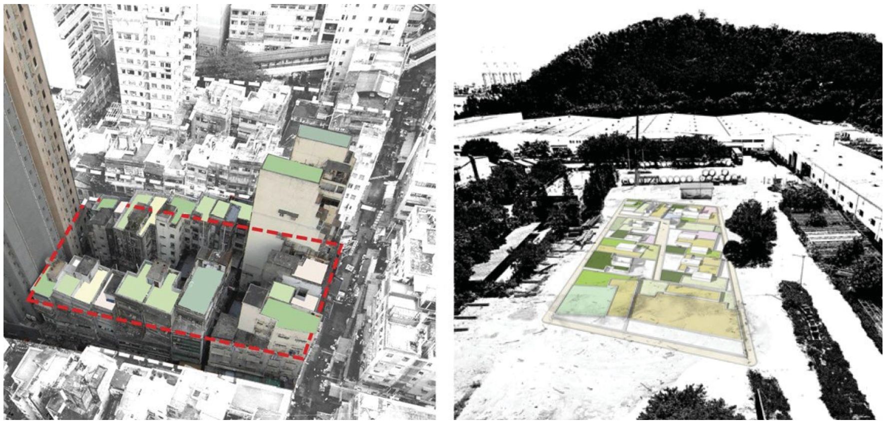


Figure 58 is a compilation of the concept drawings that graphically shows the ideas that shaped the project. Diagrams by Thomas Chung.

Figure 59 is a photograph of community engaging with agriculture in Value Farm. Photograph by Value Farm.

CHAPTER 5: DESIGN

The project follows a concept to allow free circulation from one street to the other street on the site. This responds as a metaphor of lifting the barriers formed by blockings in the country, as well as allowing people to be connected to growing food and water.

Terraces

Terraces are built responding to the site's slope, adapting to the landscape, seeming as if they were part of the mountainside. The material used to build them is Andesita stone, a similar stone used in the pre-Inca civilization of Tiwanaku. The way these are built is shaping them so one rock slides into another, similar to a jigsaw puzzle. Terraces are oriented to the north, providing plants the most sunlight, as well as radiating heat into the stone that stores the heat and releases it at night. The height of them varies to adjust the slope, although most are 1.50m high. These terraces are part of the path system that takes people from one to the other end of the site. Stairs that are also built with Andesita stone and are built as part of the terraces. These move people from one terrace to the other. These are not placed stairs, but rather, they are part of the terracing system, with their sides wrapped around the terrace. Terraces are also the platforms for planting beds. These are distributed throughout the site, responding to the programmatic needs. These are planted following Figure 43 in Chapter 4, using distinct types of plant combinations to repel plagues and insects that might cause harm to the plants. Every bed is 1.20m wide and their length varies depending on the terrace they sit on. They are constructed with recycled roof tiles that hold soil 0.20m above the ground level. Spaces for organic compost are set in different locations, allowing proximity from compost piles to planting beds. Figure 60 shows the distribution and orientation of planting bed on the terracing system.

Material Implementation

Among terraces and planting beds, rammed earth walls emerge from the ground, creating enclosed and exposed spaces. These walls drive people through

Figure 60 is a diagrammatic roof plan, showing the interior of the enclosed spaces in plan view cut at 1.20m the site and provide enclosed spaces for community members, as well as indoor spaces for growing (Figure 61). The layers of rammed earth, show the story of how the wall was built, showing the colors of the city's landscape.

Typologies

Two architectural typologies emerge from these walls. The first one shows a monolithic structure and spaces that emerge from the ground. The quality of space makes people feel connected to the ground when in these spaces. These are wrapped by the terraces and earth, with one open end that exposes the city to the interior space. The big opening looks at the north and illuminates the spaces the rammed earth walls enclose (Figure 62). The spaces that follow this typology are the formal market, the storage, and the classrooms. The market, besides having the north-oriented opening, also has a skylight, that allows communication between the formal market at the bottom, and the informal market in its accessible roof that is connected to the street. The storage takes advantage of the coolness of the ground to store food. Ventilation openings are oriented to the south-east and south-west, allowing air to pass through the interior space, keeping it colder than the outside. Finally, the classrooms count with skylights that communicate them with a plaza built on its accessible roof.

The second architectural typology that the rammed earth walls enclose reflect a contrast of materiality. On top of the monolithic earth walls, a much lighter structure is erected. Tajibo wood members arise from the earth walls, creating a light structure for a much lighter polycarbonate envelope. The translucency of this material allows sunlight to penetrate it and create interior spaces for food growing. Greenhouses in the project use this method of construction. They receive light and heat from the sun through the polycarbonate roof and walls and create a greenhouse effect that allows plants with different climate needs to grow on site. Further, the thickness and high thermal value of the wrapping rammed earth walls, stores the heat from the sun during the night. One façade of the greenhouses opens completely to the north and to the city. This façade is built with a curtain wall system, that opens a communication from the interior of the greenhouses to the exterior gardens (Figure 63).

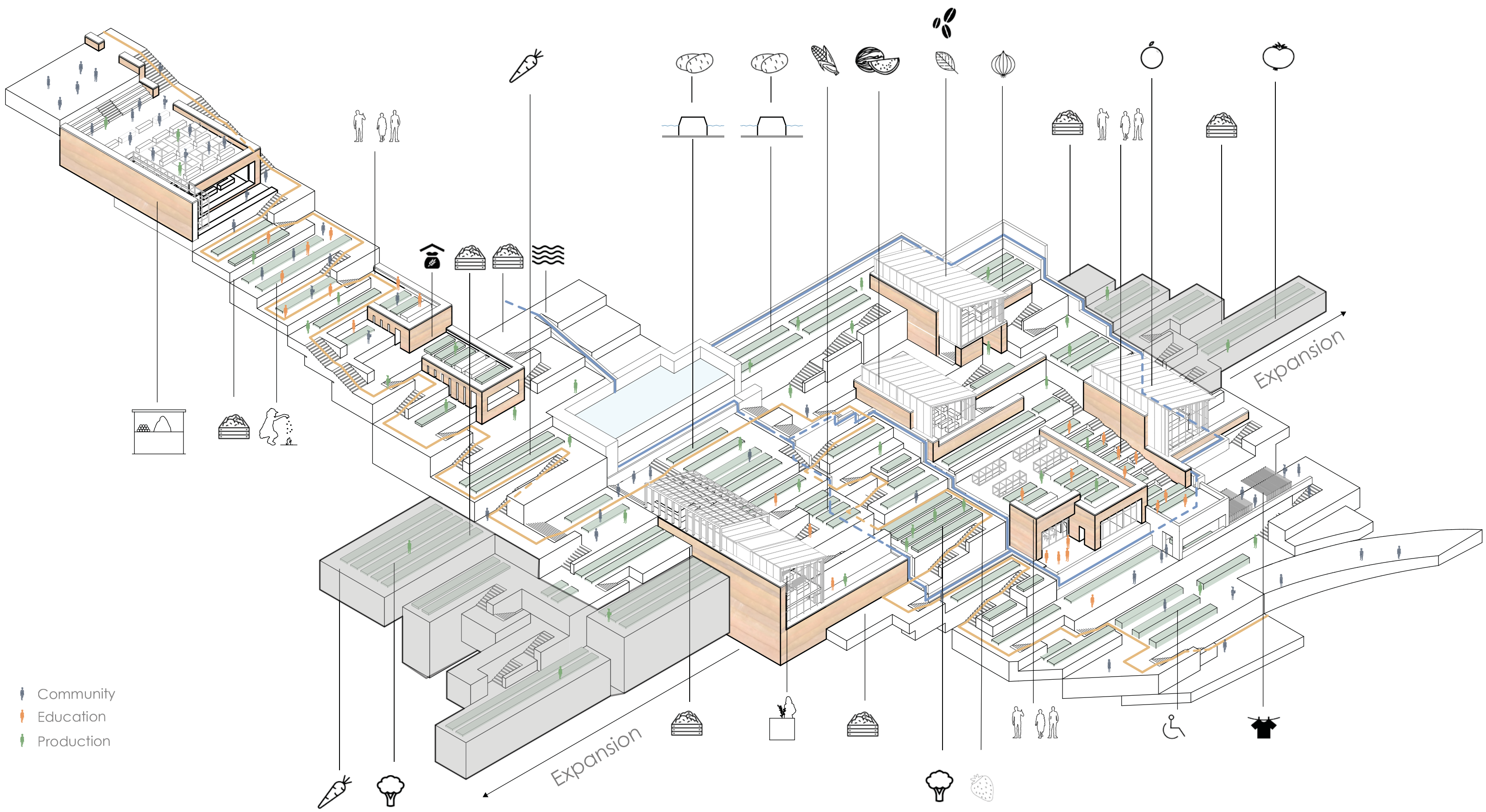


Figure 61 is an isometric view of the project, showing the orientation and location of the spaces, with the systems going through it.
Blue line: water circulation system on the stone canals. Yellow line: people's circulation through the project from one end to the other. Green people: production. Blue people: community. Orange people: students and education staff. Orange surfaces: rammed earth walls. Icons show the location of different spaces of the project. Grayed terraces show the future expansion of the project.

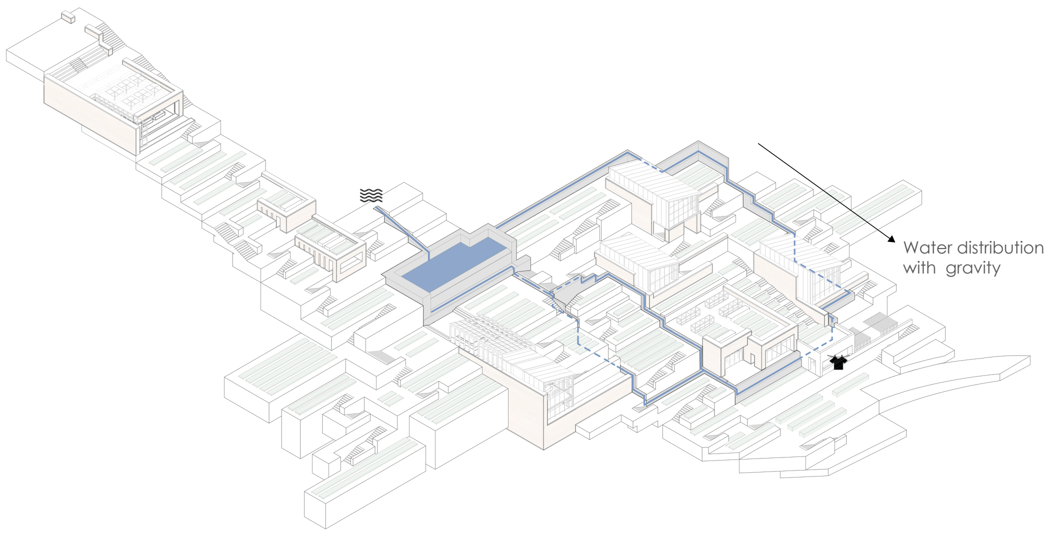


Figure 62 shows the isometric diagram with the water system running through the project.

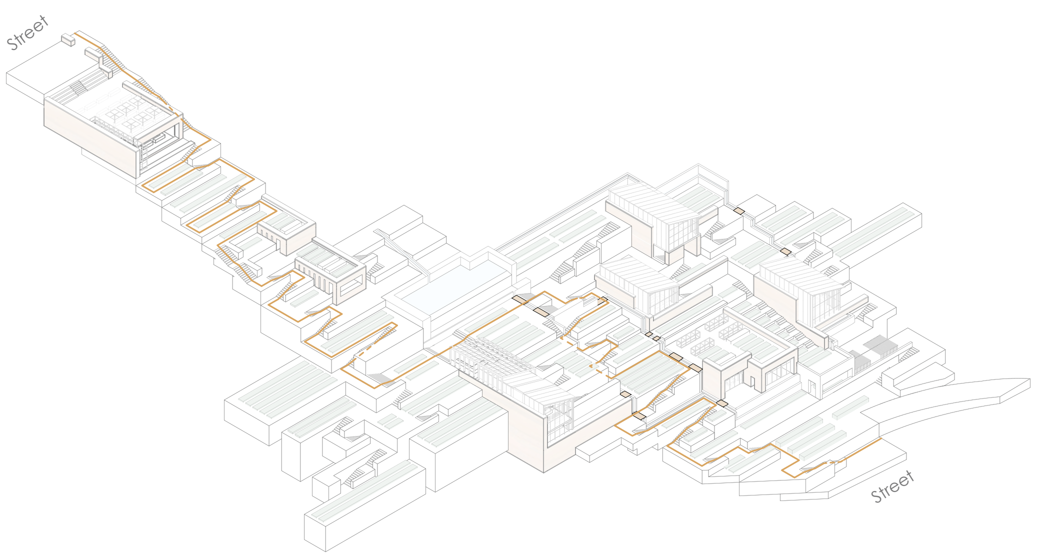


Figure 63 shows the isometric diagram with the path system connecting both streets that project faces.

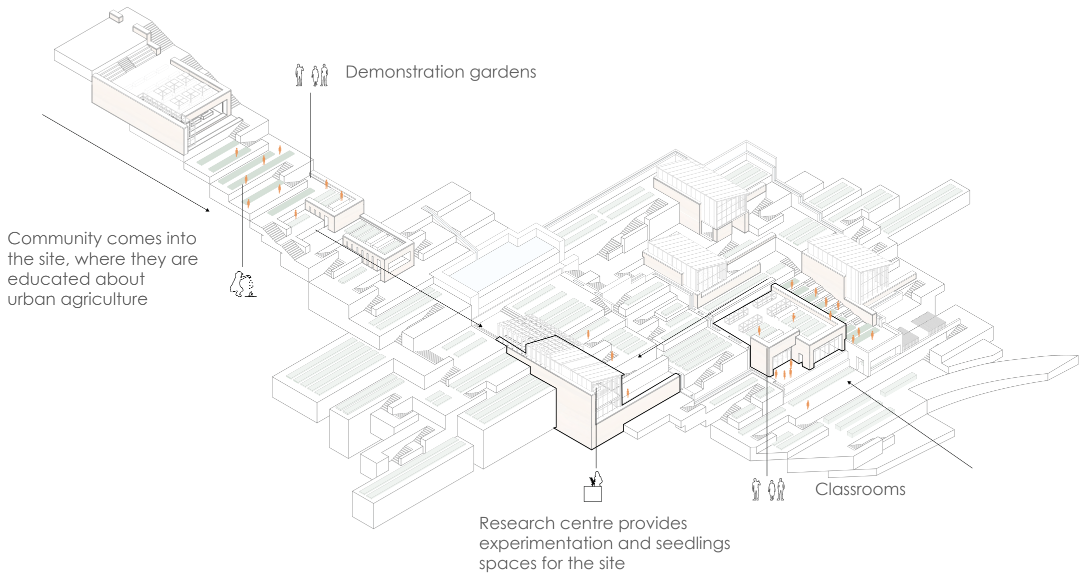


Figure 64 shows the isometric diagram with the education component. This system works as follows: community members come into the project. They learn about urban agriculture on the site, with demonstration gardens, experimentation gardens, and classrooms. They use the research centre for researching crops and growing seedlings.

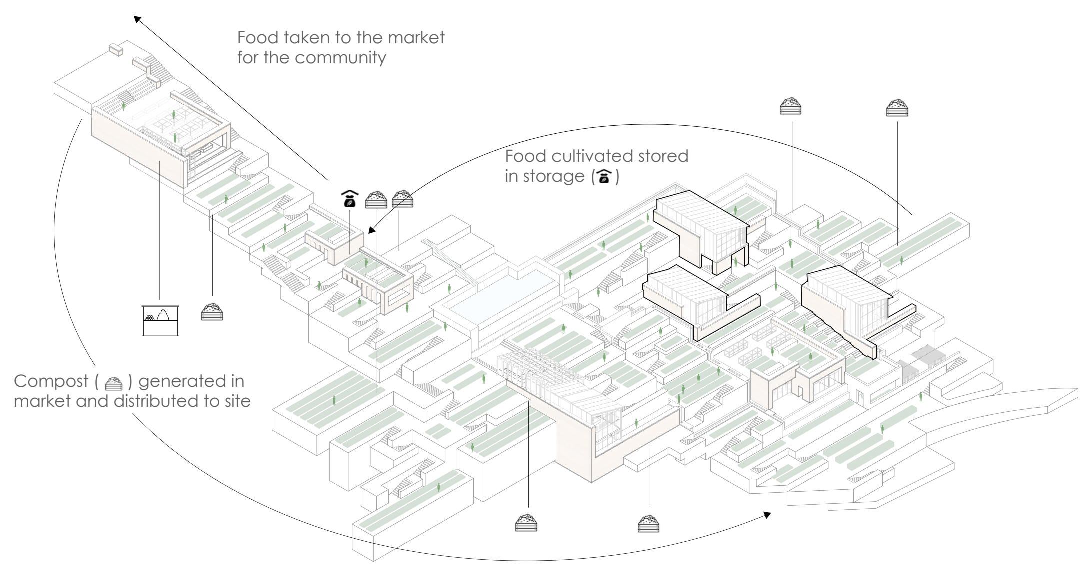


Figure 65 shows the production on site. This diagram can be seen as a continuation of Figure 64 The research centre provides seedlings and knowledge to the rest of the site. Production then occurs as a loop. The market produces compost, which is distributed to through the project and used for the plants. The crops cultivated are taken to the storage, and the to the market for the community.

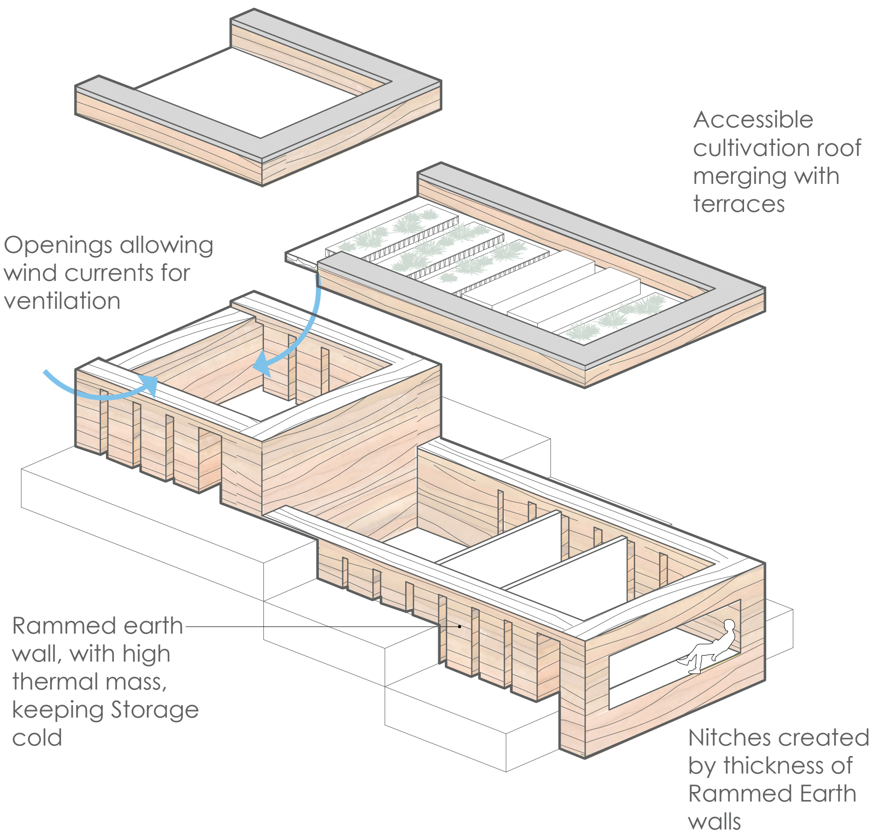


Figure 66 is an isometric diagram of a greenhouse showing the first architecture language.

Systems

In the centre of the site lies the water spring. A water tank that captures its water is built around it. Starting at this tank, Comanche stone walls drive the water throughout the site (Figure 62). These canals and tank are built with the same method as the terraces. However, they are built with the Comanche stone, found in the city's rivers. These let water flow smoothly through the canal's surfaces. The canals also get runoff water from rain captured by the enclosed

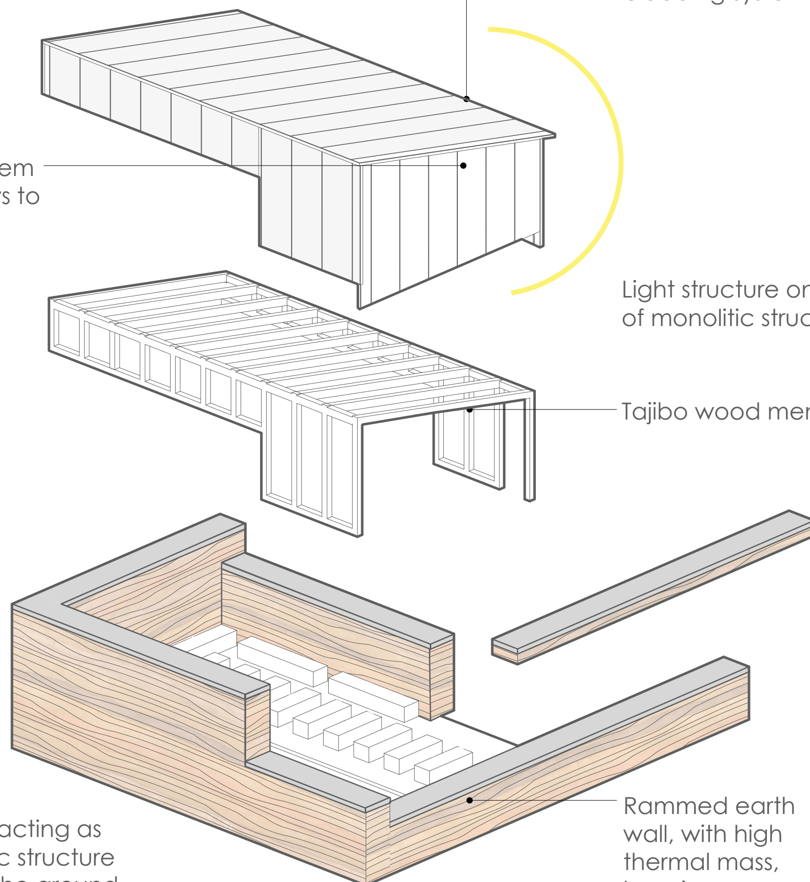


Figure 67 is an isometric diagram of the storage, showing the second architecture language.

spaces and taken into the canals through gutters. The planting beds benefit from the spring and rainwater driven by the canals. When the canals meet each terrace, a stone valve can be opened or closed to let water into the terraces and planting beds. The water in the canals run from the tank to the lower end of the site and is driven by gravity. The water that is not used by the plants ends up in a tank at the lowest level of the project. An interior space for the tank is also built with Comanche stone. The water from the canals flows into the low-

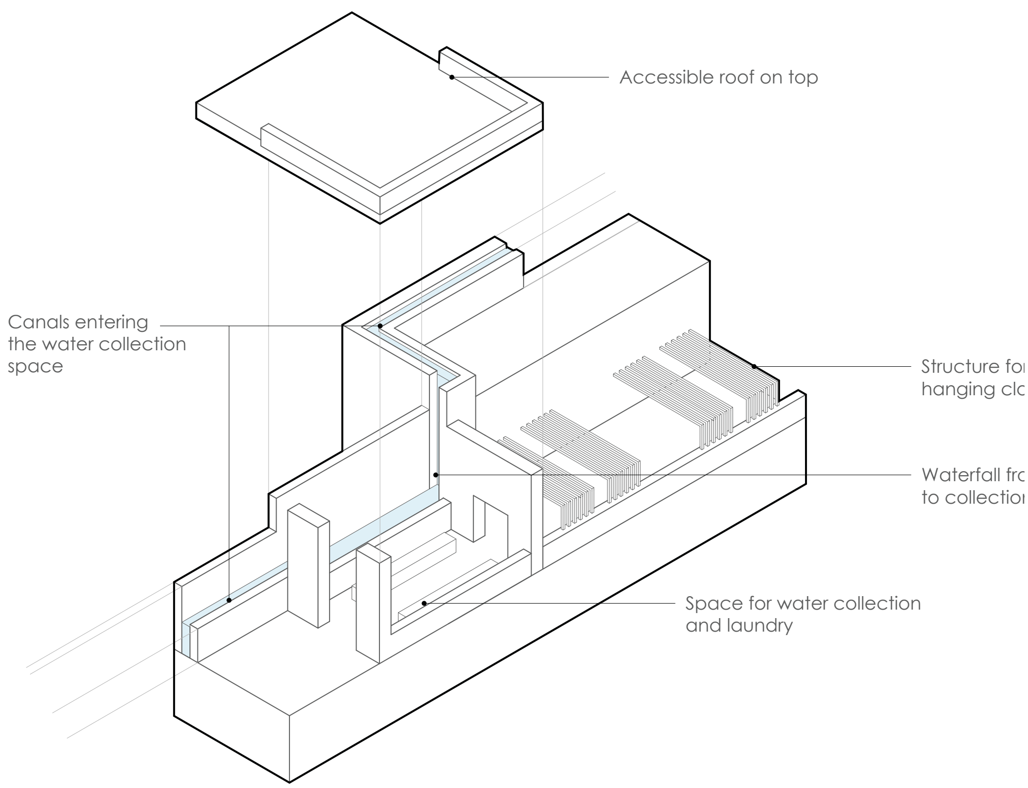


Figure 68 is an isometric diagram of the water collection and laundry space.

end tank as waterfalls. Inside this space is a place for the community. People can come into this space and collect the water from this tank. The space also counts with benches and ribbed texture stone pieces for community members to do their laundry. The water from the spring and rain is suitable for irrigation and activities such as laundry. Outside this space, a trellis is erected. This allows people to hang the clothes to dry (Figure 68).

The canal system interacts with the path system, and the rammed earth walls, all among the terraces, creating harmony among systems that interact with each other (Figure 63). Canals cross through the path system, creating small bridges that cross the waterways. They integrate with the terraces to provide the necessary irrigation. Further, canals run closely with rammed earth walls to collect the runoff water from the spaces they enclose. Although they run closely, they never touch each other to protect the rammed earth walls from being in contact with water. The integration of systems that work together harmonically provides any user and visitor of the project the possibility to experience the trajectory that food goes through in the growing phase, engaging people with what they eat. This harmony of systems provides the experience for people to engage with food, water, vernacular materials, and historical cultivation methods of the Andes; all at the same time.

In a central location of the site, near the water collection tank and the research centre lies a space for people to interact, a central plaza. This space counts with a shading structure wrapped with indigenous plants that need the least maintenance. The purpose of the space is to engage people doing different activities on site with each other. From this central space, one can observe the terraces in higher and lower levels with the planting beds, the raised fields, the water falling from the tank into the canals, and spaces formed with rammed earth walls. A small canal is dug on the plaza, where water comes in. The space also serves as a central space in the agricultural festivities that take place as a procession, stopping in the plaza as part of it. Once again, users engage with nature and identity in this space (Figure 73).

The following sections and vignettes show the trajectory from one end to the other end of the site. Inhabited spaces show people's interaction with them. The sections also show the way that the project interacts with the sloped landscape and with the streets that the project faces.

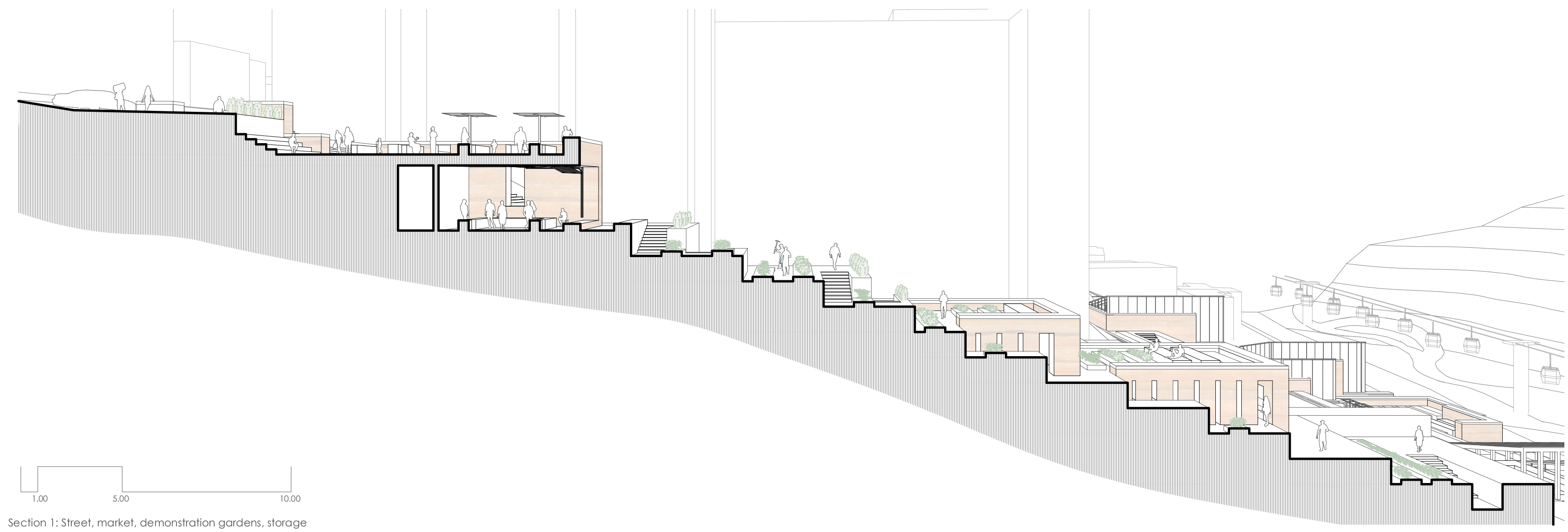


Figure 69 is a long section perspective (see plan for reference), showing the activities on site. This section shows the project's interaction with the street, the formal and informal market, the demonstration garden and the storage.

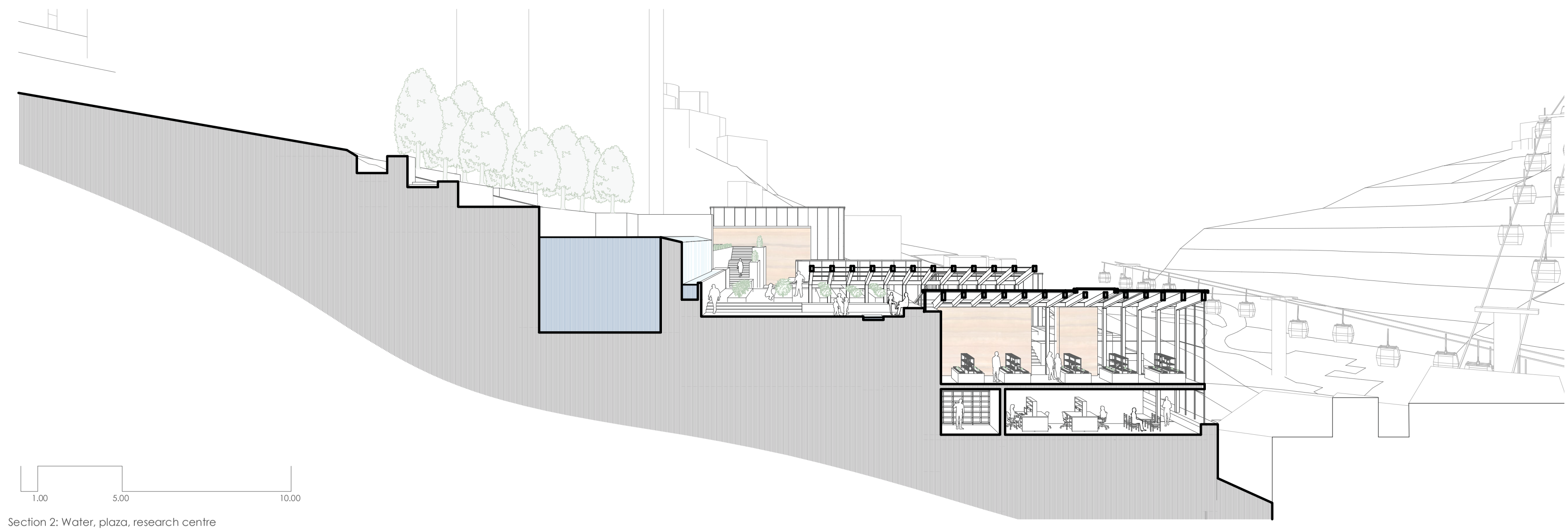


Figure 70 is a long section perspective (see plan for reference), showing the activities on site. This section shows the water spring surrounded by trees that get its water, the central plaza with a water fountain that moves water from the tank to the canals, and the research centre. The second level of the research centre allows northern light through polycarbonate envelope to grow seedlings for the project.

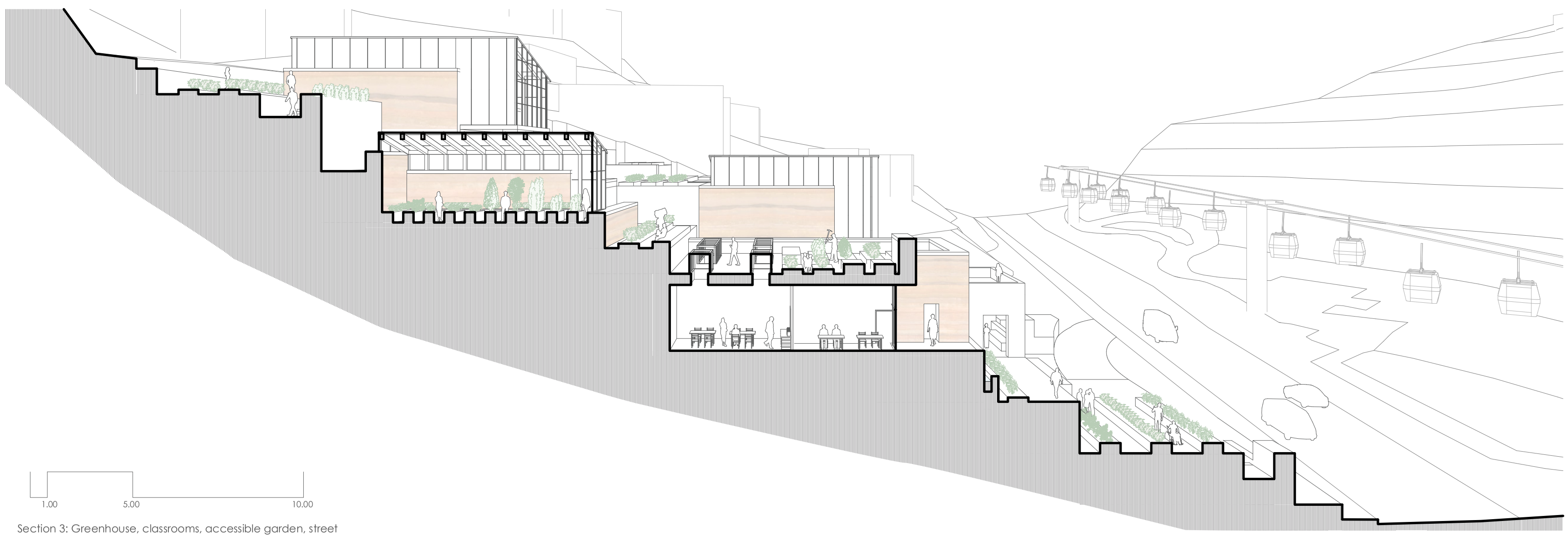


Figure 71 is a long section perspective (see plan for reference), showing the activities on site. This section shows a greenhouse's interior, the classrooms with an accessible roof and the project's interaction with the street.

Figure 72 is vignette of the project showing water and a central plaza.

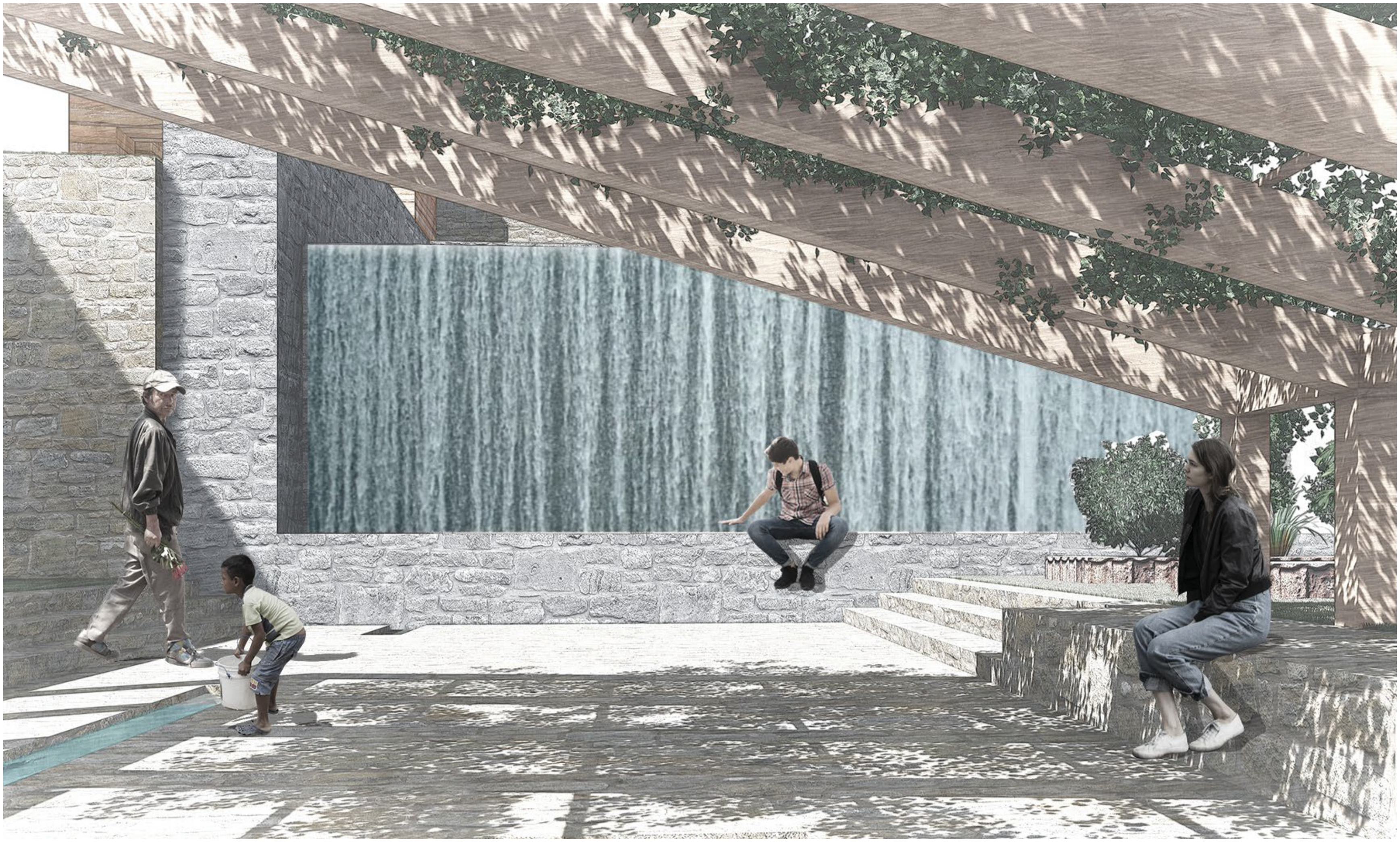


Figure 73 is a vignette of the informal market.

Figure 74 is a vignette of the gardens, showing production activities on the foreground, as well as the greenhouses in the mid ground.

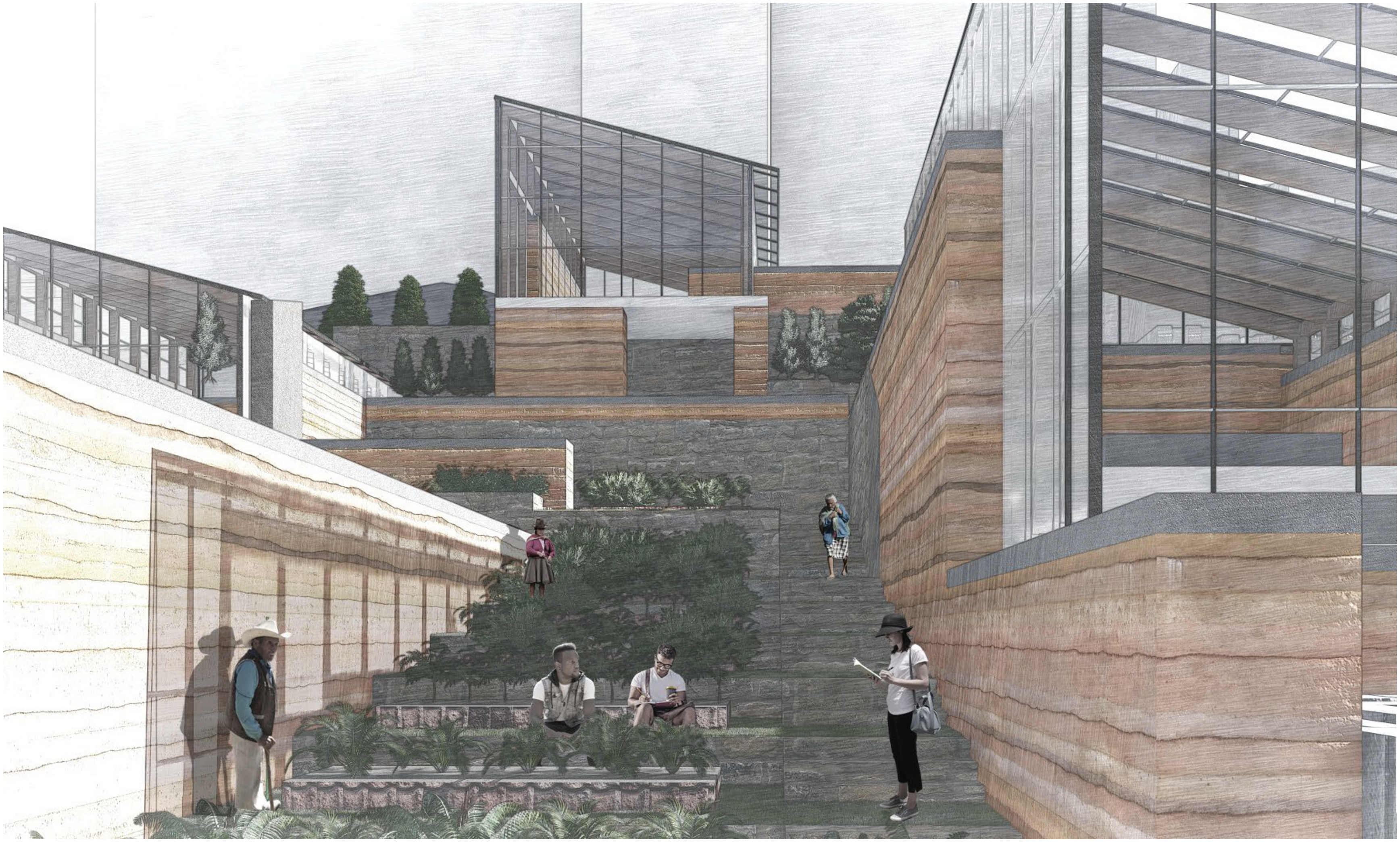


Figure 75 is a vignette of the gardens showing education activities and production.

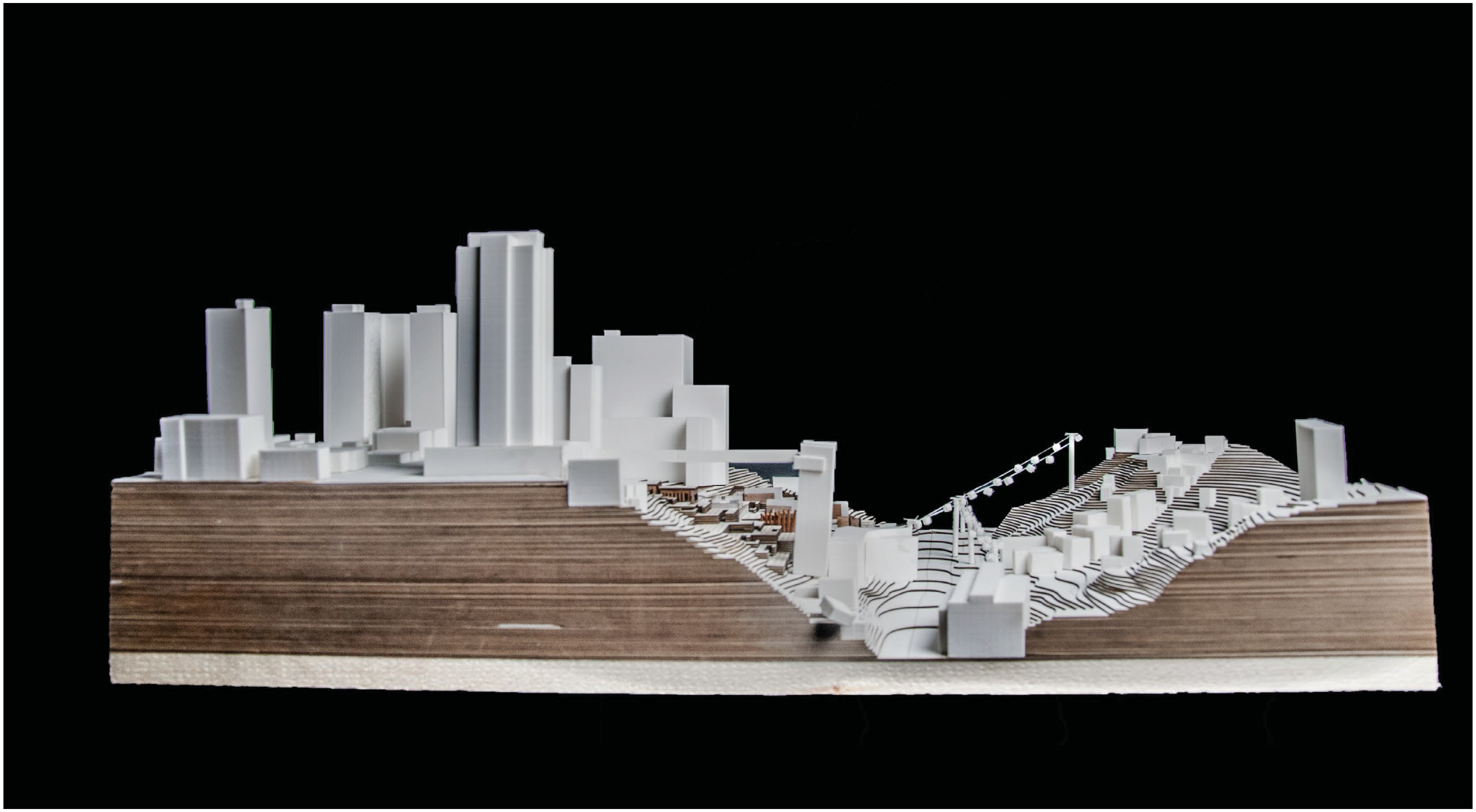


Figure 76 is a side picture of the project's model. The picture shows the 56m of height difference between the mountaintop and the valley. It shows the landscape of La Paz composed by mountaintop, mountainside and valley.

Figure 77 is a top picture of the project's model. The picture shows the project's response to the landscape of the mountainside.

Figure 78 is a side picture of the project’s model. The picture shows the landscape of La Paz, as well as how the project is located between neighbours and in the landscape.

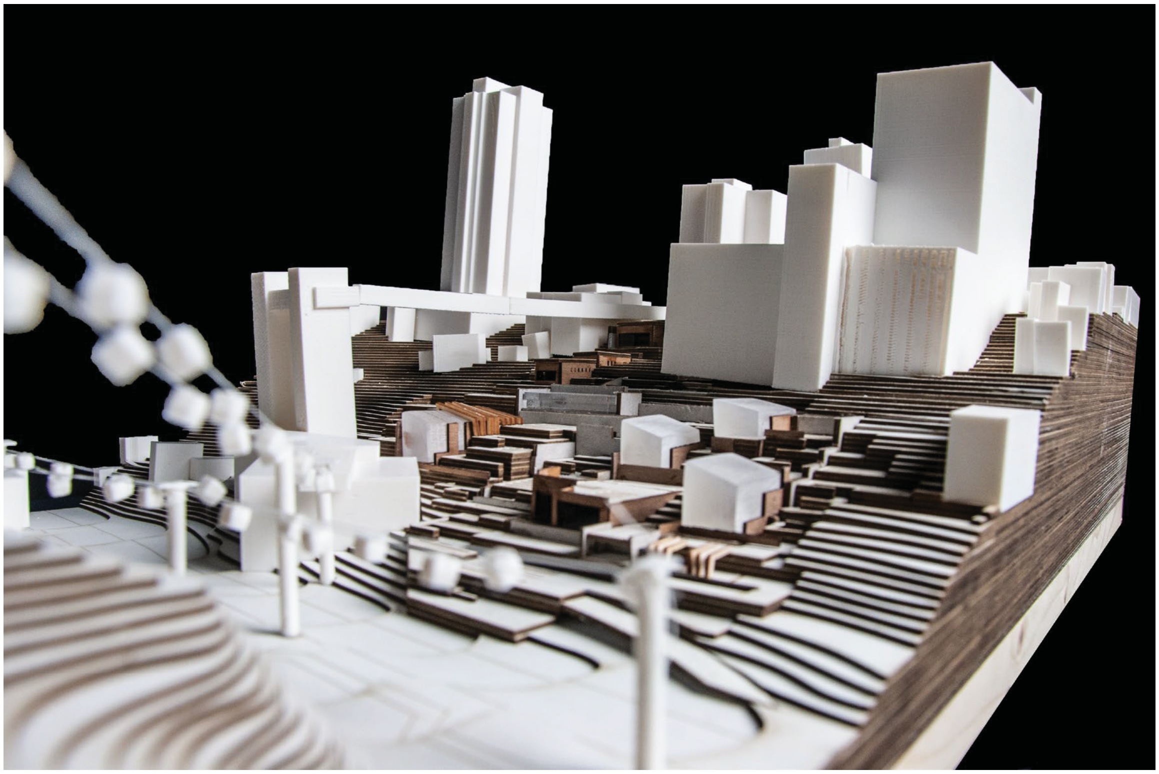


Figure 79 is a photograph of the model. The photograph is taken from a mountainside, looking into the project.

Figure 80 is a photograph of the model. The photograph hows the integration of terraces into the landscape, as well as the project’s spaces relationship with each other and with the terraces.

Figure 81 is a complete view of the project in a straight-on view from a cable car cabin.

CHAPTER 6: CONCLUSION

What Comes Next

> Continuous Productive Urban Landscapes (CPULs) will be open landscapes productive in economical and sociological and environmental terms. They will be placed within an urban-scale landscape concept offering the host city a variety of lifestyle advantages and few, if any, unsustainable drawbacks.[25]
>
> Very importantly, they [CPULs] will exist alongside a wide range of open urban space types, complimenting their designation and design and adding a new sustainable component to the city.[26]

Contemplating the principle of developing CPULs alongside open urban spaces, the location of the pilot project is key. The site is located in the Urban Public Park of La Paz. This park extends several kilometers, starting at this point, and ending in a market near the main Plaza of the city. This brings an enormous opportunity for developing CPULs in the city. The diagram, created by Viljoen, Bohn, and Howe (Figure 73), states that the third phase is "inserting productive urban landscapes"[27], which is starting with this pilot project. By expanding alongside the Urban Public Park, and by identifying more continuous landscapes in the city, where urban farms can be located, gives La Paz the opportunity to become a productive green city.

It is important to mention again that this project is a catalyzer to create an expansion of itself by growing knowledge in urban agriculture to La Paz. The intention is not that all of the other agricultural gardens will have the same program. Rather, the intention is that the following phases of the expansion learn valuable aspect from the pilot project that can be used in specific sites. The image below (Figure 50), shows the previously shown site selection map. The methodology for developing an urban farm will be site-driven, which will inform the program. For example, site #2 is beside a campus of the UMSA University, but it is only frequented by university students. This would inform that the education component that focuses on university students' education would be the catalyst

25 Viljoen, Bohn, and Howe, *Continuous Productive Urban Landscapes*, 11.

26 Ibid., 11.

27 Ibid., 13.

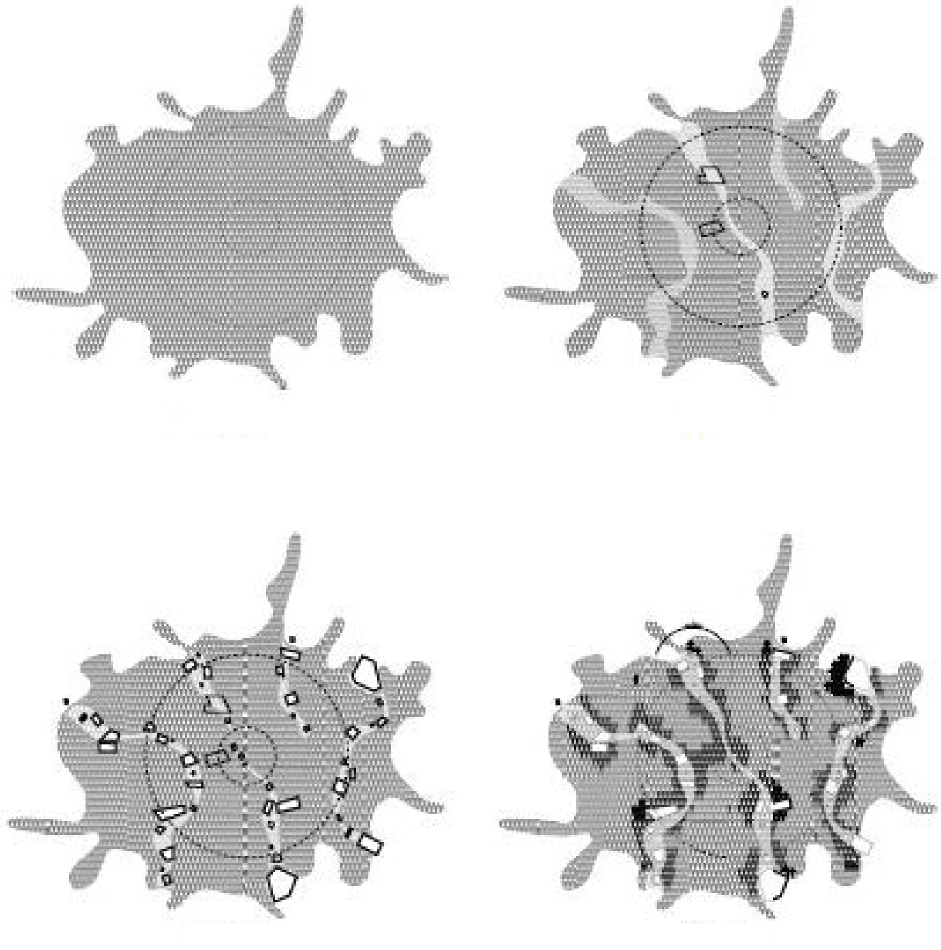


Figure 82 is a drawing by Katrin Bohn and André Viljoen which explains four steps for any city to become a continuous urban productive landscape: 1: Find an established city with no continuous productive urban landscapes. 2: Identify continuous landscapes. 3: Insert productive urban landscapes. 4: Feed the city. Diagrams by by Katrin Bohn and André Viljoen.

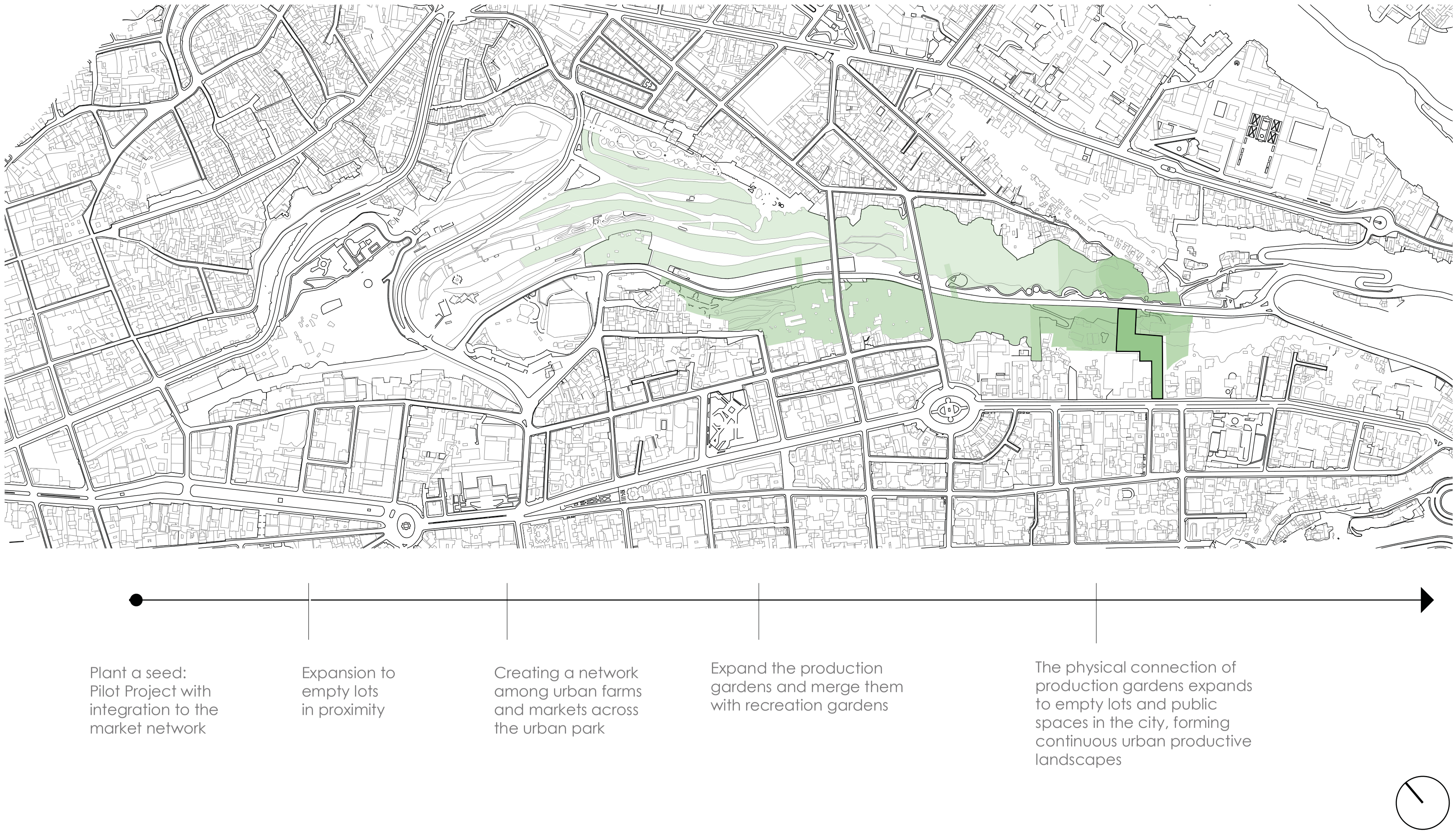


Figure 83 is a basemap showing the project expansion thought the urban park.

for this site to grow and expand. Differently from this site #2, site #3 would be extremely community driven, since it is located in a housing neighbourhood, next to a laundry garden. Hence, educating and engaging community members with urban agriculture would be the catalyst for this site to expand.

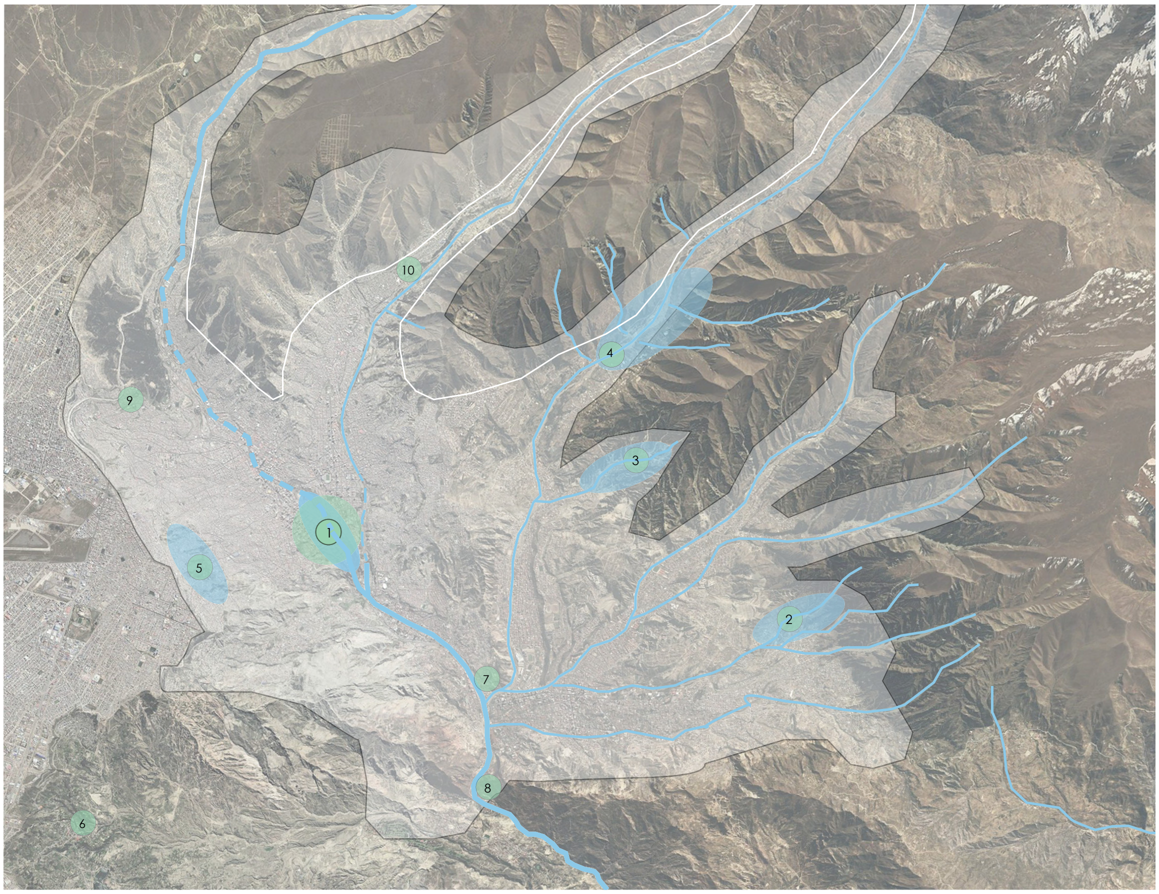


Figure 84 is a map of the city with identified sites that have the potential to be major urban agricultural centres in La Paz. Background map by Google Maps.

Introducing this pilot project to La Paz can expand the knowledge on urban agriculture in the city, as well as expanding itself through the city. By doing this, the Urban Park alone would feed 1.100 people in La Paz. Further development of agriculture gardens in the mentioned areas would feed around 10.000 people in La Paz. Furthermore, culture will be a major aspect of these gardens, which will bring a sense of identity to the people. These gardens will lift a barrier between people and food, creating cultivated, cultural, self-sustaining landscapes in La Paz.

APPENDIX

Rammed Earth Test

To understand the construction of rammed earth, I developed a series of studies with the material. The first step was to identify the components of the material. The soil is composed mainly of clay, lime, sand, and gravel. To find out the ratio of these in the soil, I made a “jar test”. The test consists of filling 50% of a jar with the soil and the other 50% with water. The next step is to shake the jar, mixing the water with the soil. After two days of leaving the mixture rest, the soil settles into layers: the gravel and sand stratify on the bottom, the next layer is the lime and clay, and then the water with organic residues. (Figure #) An ideal percentage of clay is 25%. After figuring out the composition of the soil, I studied the best ratio of soil to cement to water. In this case, the cement is used as a binder for the soil. In some cases, hay is used for the same purpose. (Figure #) The study consisted of ten different mixtures to understand what the best composition is. The ratio that worked the best was: 6 units of soil, 2 units of sand, and 2 units of cement. The water was added gently, massaging the soil and feeling the mixture’s composition. The composition must not be liquid, but solid, but soft enough so one can easily massage it.

To give the mixture the colors of the soil that can be naturally found in La Paz, I used spices to dye the mixture. The used spices are paprika, cinnamon, curry powder, mustard, ginger, cumin, and coriander. For this test, I prepared seven layers with the same composition but using different spices (the ratio of spices to mixture varied from layer to layer). I poured the earth, layer by layer in a previously built formwork (15cm by 15 cm). After pouring each layer, I used a wooden board attached to a 4”x2” piece of wood. After pouring each layer, I rammed the earth, waited for two hours and proceeded to pour the next layer.


1. Jar test.

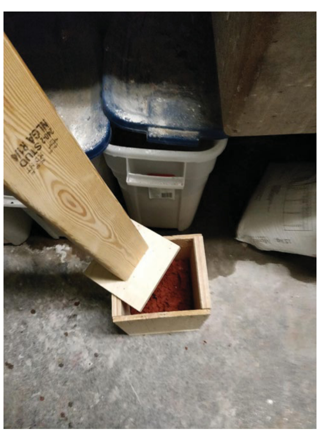

2. Composition study process.


3. Composition study result: different ratios and colors.


4. Composition study result: different ratios and colors.


5. Mixing for the final test.


6. Pouring the mixture into the wooden form work.


7. Ramming the mixture.


8. Result of the rammed earth experiment and studies


9. Result of the rammed earth experiment and studies

Figure 85 shows a series of photographs illustrating the rammed earth process.

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