A ROOM FOR WATER

Designing for Flooding. The case of a Medium-Size Mexican City.

This thesis is for my family.
For their infinite support,
encouragement and
love

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Designing for Flooding. The case of a Medium-Size Mexican City.

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00 PREFACE

Floods are the most frequent hazard that affects around 2.3 billion people each year. This natural disaster can occur in every continent and human activity has been contributing to the increasing adverse impacts of flood events. This urban design proposal explores the possibilities of creating a sustainable area that can work alongside floods.

The projects site is located in Morelia, Mexico. The city suffers from floods and every year it affects around 76 neighborhoods located near the river bank. The proposal looks towards the creation of a proof of concept that can be reproduce in different locations along the river to reduce the negative impacts of flooding. The areas should give space for the water and at the same time be developed and offer recreational spaces that can be enjoyed by the cities inhabitants.

There are three main strategies use to achieve these: Re-Naturalize, Re-Build and Re-Connect. The strategies basically create an area that can allow flooding while cleaning water, developing water resilient typologies and creating accessible public spaces for the city.

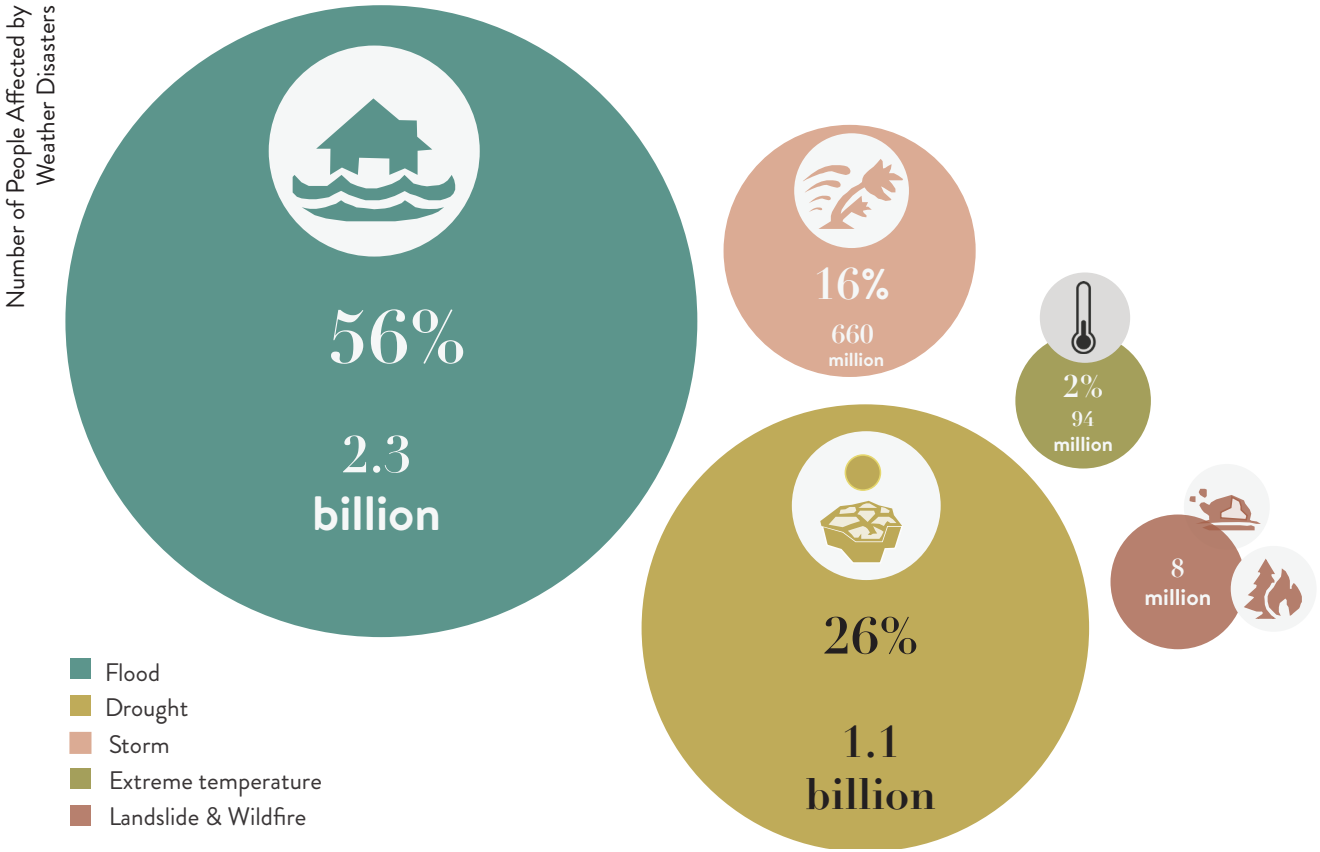
01 INTRODUCTION

ABOUT FLOODS

Water is one of the most valuable natural resources of any country due to the social and economic benefits that brings to the population. Nevertheless, Along with the advantages there are also some “drawbacks” such as floods and droughts. Floods are natural phenomena which cannot be prevented. Temporary or continuous flooding has been common throughout the world for milleniums and they will be here for milleniums to come as well.

While droughts are placed first, as far as human deaths are concerned (about 74,000 deaths reported), floods are the most frequent hazard and cause greater economic losses. Moreover, few countries manges to avoid them, not even those located in desert areas. In Africa, for example, the drought is the most frequent disaster, but the floods and catastrophes related to strong winds occupy the second place (from 1991 to 1995, the floods caused almost half of the total of the economic damages caused by disasters of all kinds).

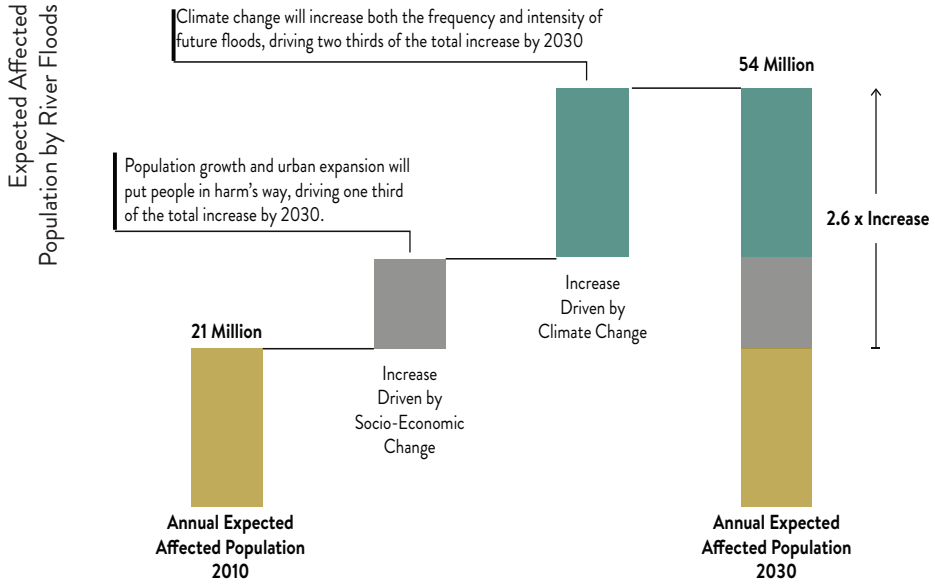
Moreover, human activity has been contributing to the increase of adverse impacts of extreme flood events. According to the EU Floods directive, there are two main reasons on how humans keep affecting flooding. First, by contributing on climate change, which increases the intensity and quantity of rainfall and sea level rising, as well as to the inadequate river management and construction in flood plains which diminishes their capacity of absorbing flood waters. Secondly, the number of people and economic assets located in flood risk zones continues to grow.


Number of People Affected by Weather Disasters
56%
2.3 billion
16%
660 million
2%
94 million
26%
1.1 billion
8 million
Flood
Drought
Storm
Extreme temperature
Landslide & Wildfire

CLIMATE CHANGE ROLE

According to the European Environment Agency (EEA), a further major potential impact of climate change, in combination with land-use changes and water management practices, is the intensification of the hydrological cycle — due to changes in temperature, precipitation, glaciers and snow cover. Large changes in seasonality are also projected, with lower flows in summer and higher flows in winter. Flood events are projected to occur more frequently in many river basins, particularly in winter and spring, although estimates of changes in flood frequency and magnitude remain uncertain.

Climate change drives populations at risk in the developed and developing world alike – there is no clear distinguishing pattern. In Ireland, for example, 2 000 people face flood risks. By 2030, 48 500 more people could face river flood risk, and 87 % of that would be driven by climate change. From the developing world, 715 000 people in Pakistan are at risk today. By 2030, river floods could affect 2 million more people, with climate change driving 70% of that increase.



FLOOD IMPACTS

Floods can have both positive and negative impacts. They can bring welcome relief for people and ecosystems suffering from prolonged drought, but also are estimated to be the most costly natural disaster.

Among the main benefits produced, the following stand out:

• Moisten and fertilize the land. Transports large amounts of organic matter, silt and clays.
• Recharge the aquifers. Especially if the floors are permeable and with little slope.
• Contribute to the survival of the fauna. As a result of the water stored in the lower parts of small gaps.

On the other hand, some of the damage caused by a flood, either by the level reached by the water or by the speeds at which it flows, are the following:

• Loss of human lives
• Loss, in general, of livestock and animals
• Destruction of crops
• Deterioration and destruction of material goods
• Interruption and destruction of communication channels
• Interruption of services (electric, telephone, drinking water and drainage)
• Propagation of diseases

KNOWING THE FLOOD TYPE

Being aware of the types of flooding and their characteristics helps to have a better understanding of how to eleviate a flood area as well as to know the possible factors that provokes it in the firth place. There exist four main different types of flood: Rain Floods, River Floods, Coastal Floods and Lake Floods. As well, floods can be divided by the period of time when they occur, there could be slow floods and flash floods, the last one being the most dangerous.

TYPES OF FLOODING

Rain Floods

They happen when the terrain is saturated and unable to absorb more water, it causes the accumulation of excess rain for hours or days.

River Floods

They are generated when the overflowing water from rivers remains in the ground surface.

Coastal Floods

Occur when mean sea level rises due to the hurricane storm tide and waves, covering large tracks of land.

Lake Floods

Due to the increase of the average in a body of water (wetlands, lakes, lagoons, among others)

Classification according to the time they occur:

Slow Floods

They occur in large areas of low slope; they usually occur within days, giving a chance to evacuate.

Flash Floods

Those that occur within minutes due to heavy rainfalls over a small surface with steep slopes related to mudslides; for this reason, the are considered the most dangerous floods.

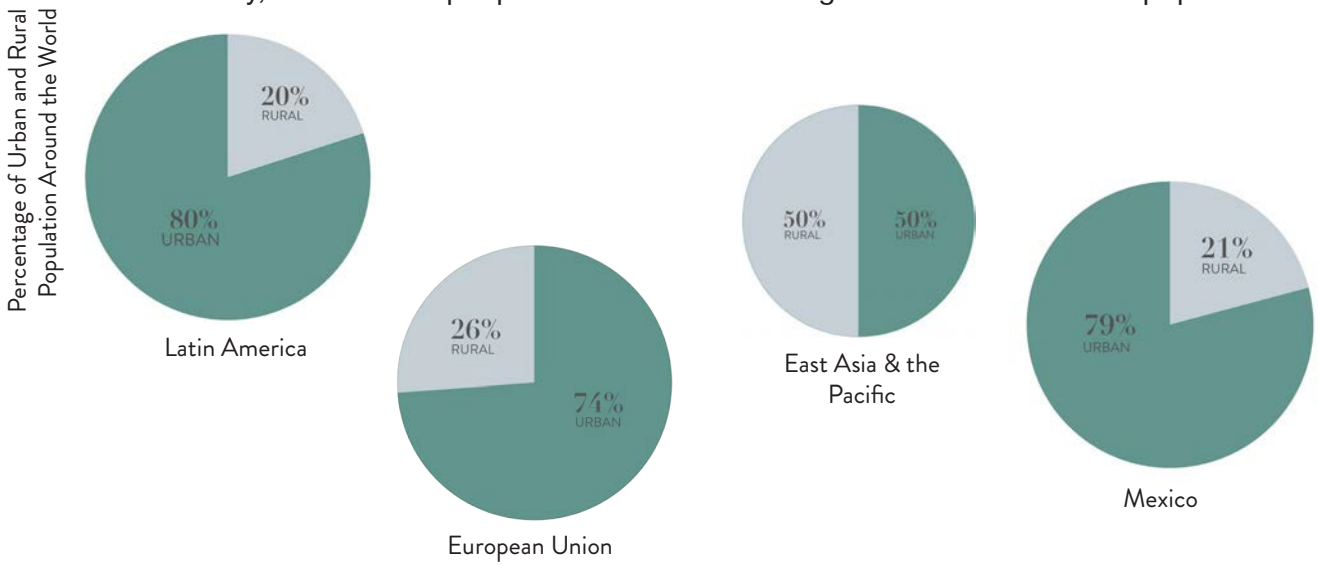
LATIN AMERICA AND THE URBAN DEVELOPMENT

Urban growth in developing countries has been carried out unsustainably with deterioration in the quality of life and the environment. This process is even more significant in Latin America where 80% of the population is urban, making Latin America the world's most urbanized region. (In comparison, the European Union is 74 percent urbanized, and East Asia and the Pacific region, 50%). By 2050, UN-Habitat predicts Latin America's cities will include 90 percent of the region's population.

Today, 260 million people live in the region's 198 large cities (populations of more than 200 000 people) and generate 60 percent of Latin America's GDP. This is more than 1.5 times the contribution expected from large cities in Western Europe.There are 47 cities in Latin America with a population over 1 million inhabitants. Close to 6 megacities (over 10 million inhabitants).

The main problems related to infrastructure and urbanization in developing countries, with special highlights for Latin America are:

1. Large concentration of population in



small areas, with deficiency in the transport system, lack of water supply and sanitation, air and water contamination and floods. These inadequate conditions are the main limitations to its development because they reduce the health conditions and the populations quality of life, besides the negative environmental impact.
2. The uncontrolled city growth by the rural exodus that migrates towards large cities in search of employment.
3. Urbanization is spontaneous and urban planning is only done in the city occupied by population of medium and high income. Without having any development plans, occupation occurs over areas of risk of floods and landslides.

Main problems related to the water infrastructure in the urban environment

• Lack of sewage treatment
• Sanitary runoff networks (many times without treatment), increase the frequent floods and waterproofing
• occupation of the flood plains, with problem of frequent floods
• waterproofing and canalization of urban rivers with increase in flood flow and its frequency; increase in the amount of solid waste and decrease in the quality of rainwater over rivers close to urban areas
• deterioration in water quality due to lack of treatment of effluents.

HIGH DENSITY
DEFICIENT TRANSPORT SYSTEM
LACK OF WATER SUPPLY & SANITATION
AIR & WATER CONTAMINATION
FLOODS

FLOODS IN MEXICO

Due to its geographical conditions, Mexico experiences the assault of a great variety of natural phenomena, among them hydrometeorological hazards, such as tropical cyclones, cold fronts, heavy rains that can cause floods, landslides or other effects of this nature.

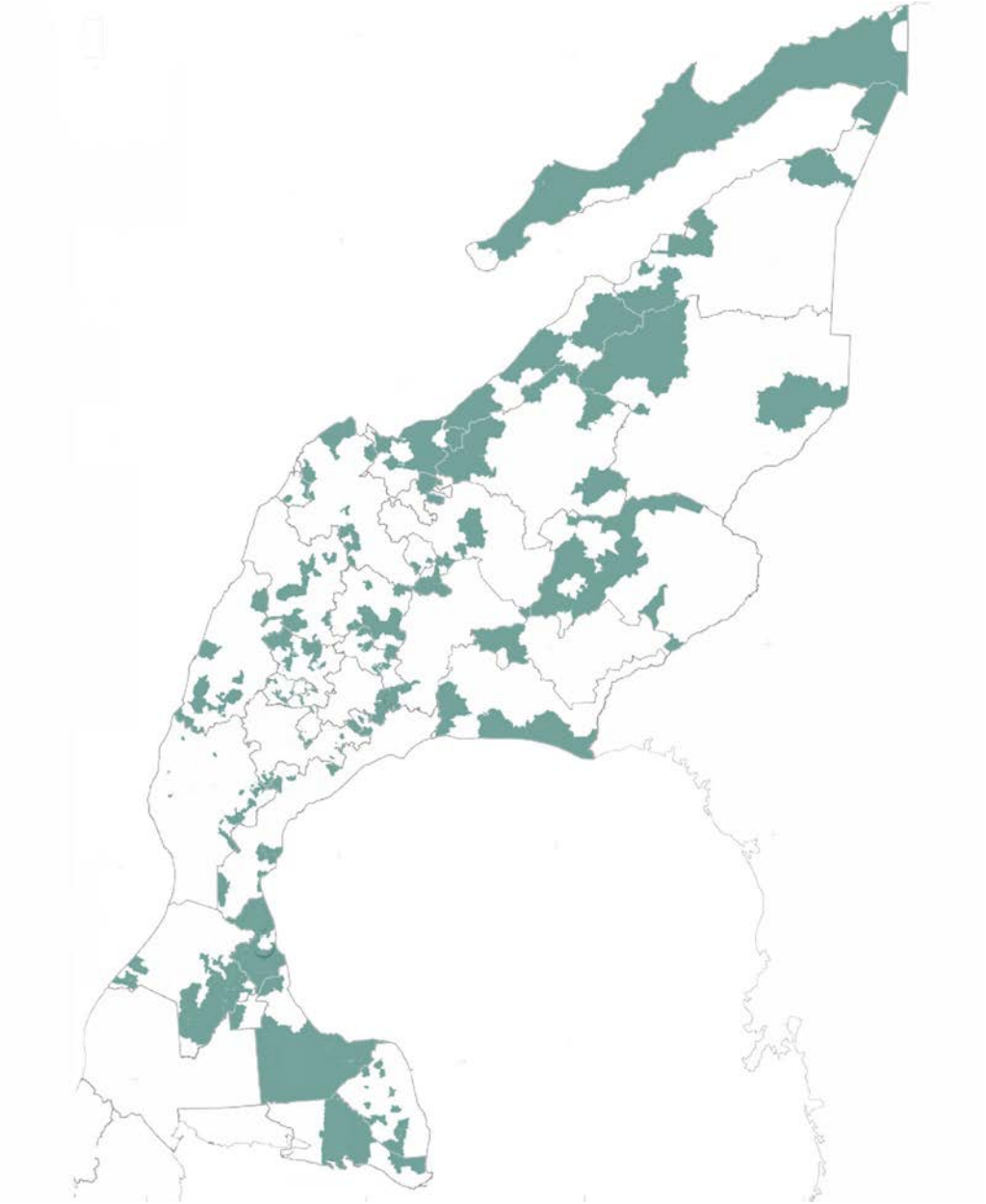
On the other hand, it also faces problems that could be called non-structural, such as: environmental, like deforestation, obstruction or natural deviation of channels, change in the runoff regime, climate change; technical, as the loss of staff's ability to identify, evaluate and determine the risks produced by fluvial currents, avalanches, or flows with a high concentration of sediments; legal, such as land management and administration of flood risks, insurance contracting against natural disasters and the establishment of regulations of more severe construction; and politicals.

Mexico is affected by precipitations originated by different hydrometeorological phenomena. In summer (June - October), the most intense rains are associated with cyclones. On the other hand, during the winter, extratropical storms and polar fronts are the main source of rainfall. These weather conditions cause the rivers to have very irregular water levels.

In the plains of the great rivers of Mexico, practically every year, there are floods caused by their overflow. While in semi-desert areas are less frequent, so the people and government tend to forget, but they can cause serious problems when they present.
From June to November is when majority of floods occurs, while the dry season is from December to May.

It should be noted that disasters, both in number and in their consequences, will increase predictably as a result of climate change. The risk of floodings will increase vulnerability and exposure of comunities, affect environmental resources, infrastructure, economy, social and cultural assets.

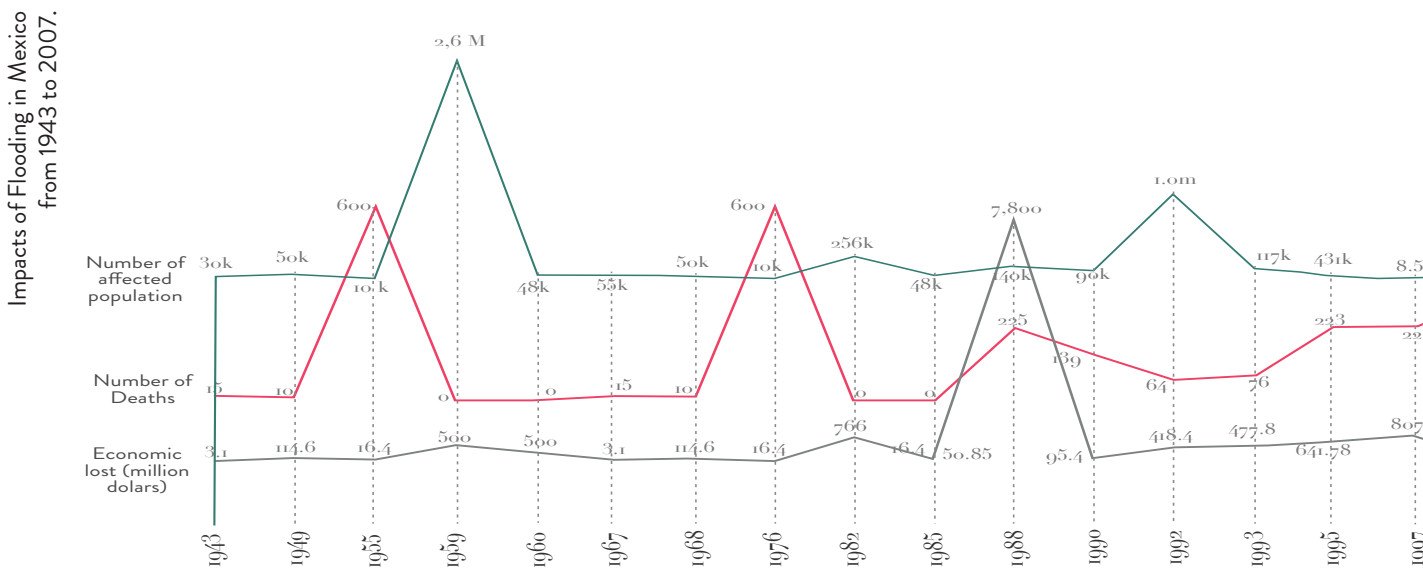
Vulnerability to Climate Change in Mexican Municipalities. INEC (2013), National Institute of Ecology and Climate Change.

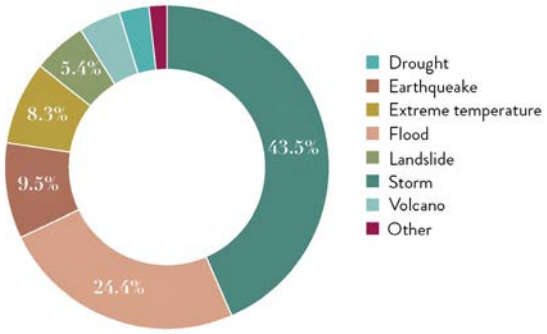


EFFECTS OF FLOODING IN MEXICO

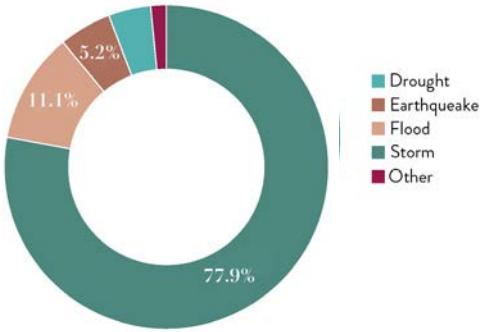
Water related events occupies the first causes of economic loses, deaths and the most frequent hazards among different kinds of natural disasters. Floods and storms represent the 89% of the economical reported looses, while on mortality and frequency represent two thirds of the total loses.

In a 60 years period, from 1943 to 2007, the number of affected population by flooding reached its peak in 2007 with 3,9 million people, wherease the economic loss is calculated to be 7 800 million dollars and during the 60 years there was 3 128 documented deaths.

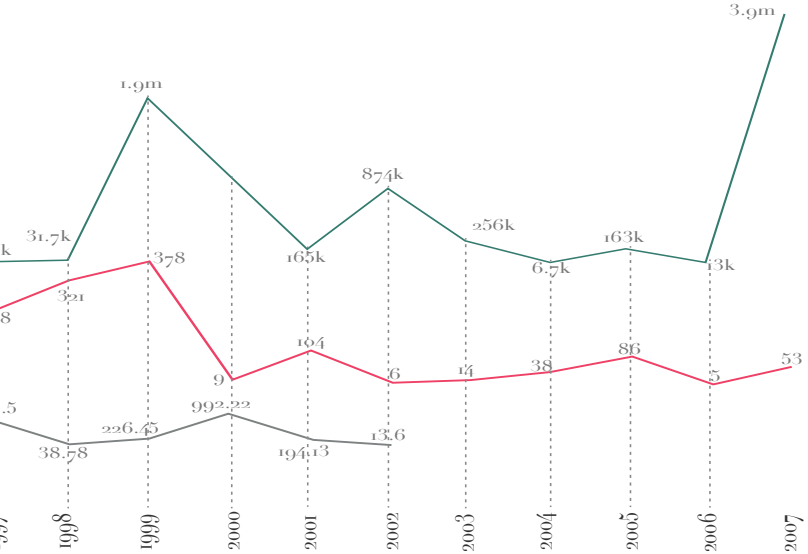


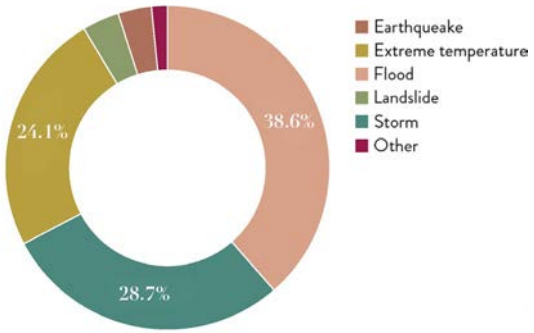


Frequency



Economic Issues





Mortality

02 PROJECT BACKGROUND

MORELIA'S CITY

Morelia is a city, municipality and the capital of the state of Michoacán. Located in west-central Mexico. The city sits in the Guayangareo Valley, formed by a fold of the Trans-Mexican volcanic belt.

Morelia is the most populated and extensive city in the state of Michoacán and the twenty-seventh nationwide, with an area of 78 km^2 and a population of 784,776 inhabitants according to the results of the INEGI Population and Housing Census 2015. Its Metropolitan Area had 911,960 inhabitants in that same year, occupying the 19th place among the largest metropolitan areas of the country. It is also the most important city in the state from the social, political, economic, cultural and educational point of view.

The city center is a UNESCO heritage site. It was built in the 16th century, and is consider a great example of urban planning which combines the ideas of the Spanish Renaissance with the Mesoamerican knowledge. Well-adapted to the slopes of the hill, its streets still follow the original layout. More than 200 historic buildings, all in the region's characteristic pink stone, reflect the town's architectural history, revealing a masterly and eclectic blend of different influnces, from medieval spirit with Renaissance, to Baroque and neoclassical elements. Morelia was the birthplace of several important personalities and has played a major role in the country's history.

The main economic activities of Morelia are services, among which the financial, real estate and tourism stand out, followed by the construction industry, the manufacturing industry and, ultimately, the activities of the primary sector. As part of its active tourist life, the city is home to important annual cultural festivals such as the international festivals of music, organ, cinema and gastronomy.

Morelia.
Ilustrative
Pictures.

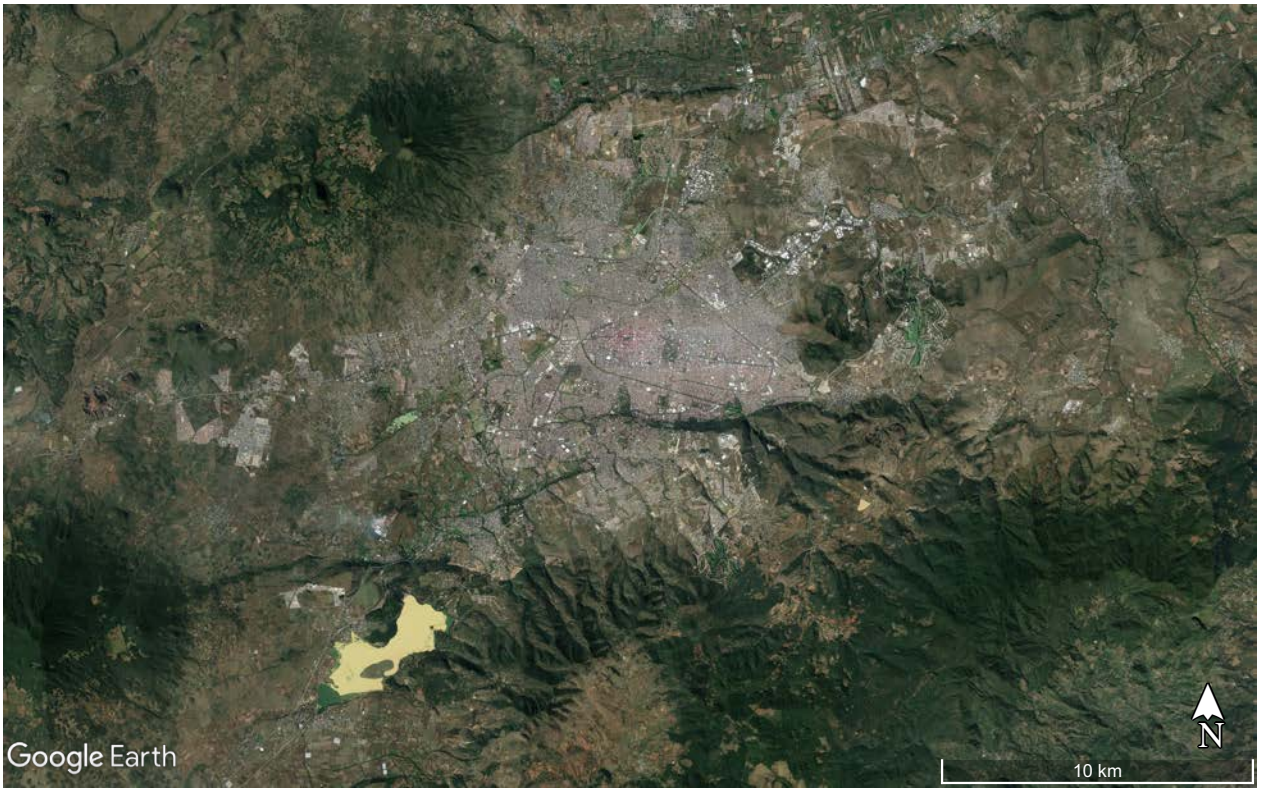
MORELIA IN MEXICO

The city of Morelia is located in central Mexico and it is surrounded by important cities and economic centres. The city is located between the two most important and populated Mexican cities, having Mexico City 301 km away and Guadalajara at 278 km. As well one of the main ports on the west of Mexico is located in the state of Morelia´s three and half hours away.

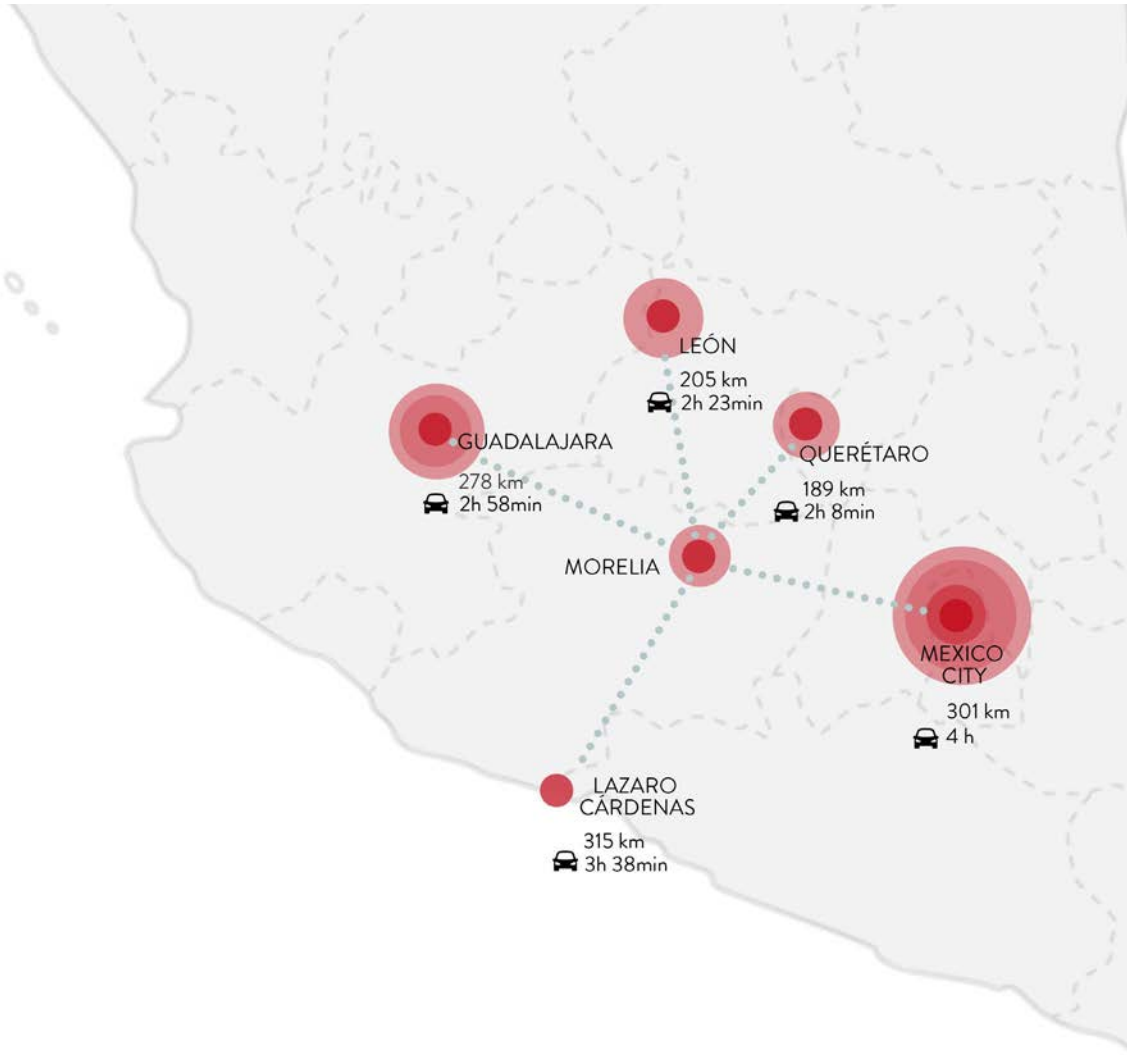
All of this makes Morelia an important touristic hub, and attracts people not only to visit, but to move and live there. It has been considered as a small city that still does not have all the problems that a big city have.

Morelia city is located between the parallels 19 ° 26 ´and 19 ° 52 ´north latitude; the meridians 101 ° 02 ´and 101 ° 31´ of west longitude; altitude between 1 500 and 3 000 m

Morelia's aerial view

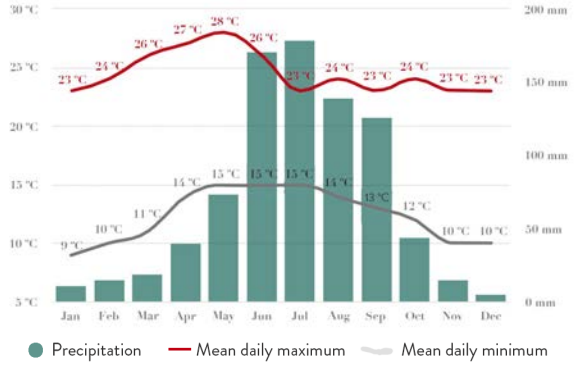


Distances between Morelia and the Main Cities of Central Mexico.

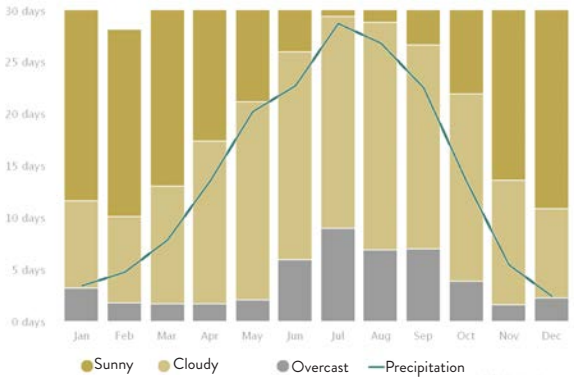


CLIMATE & WEATHER

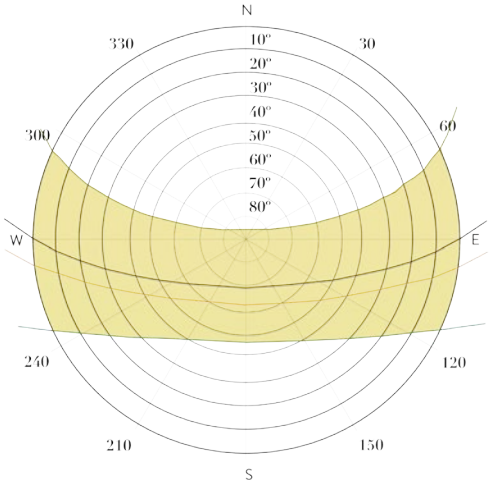
According to the National Institute of Statistics and Geography, the municipality of Morelia has a temperate subhumid climate with rains in summer and medium humidity. The temperature range between 12 to 22 C and the Precipitation between 600 and 1500 mm. However, in the city we find a variation on temperature ranging from 7 to 32 C and a mean temperature of 19, an average humidity of 60% and annual rainfall between 567,6 and 773,5 mm. The prevalent winds come from the southwest and northwest, variable in July and August with intensities of 2.0 to 14.5 km/h.



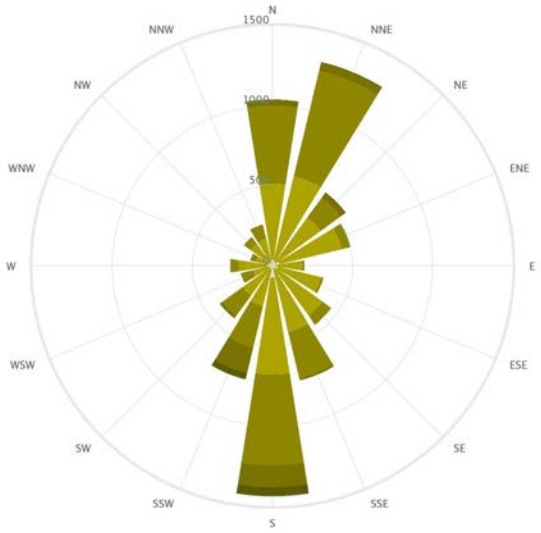
Precipitation and Temperature



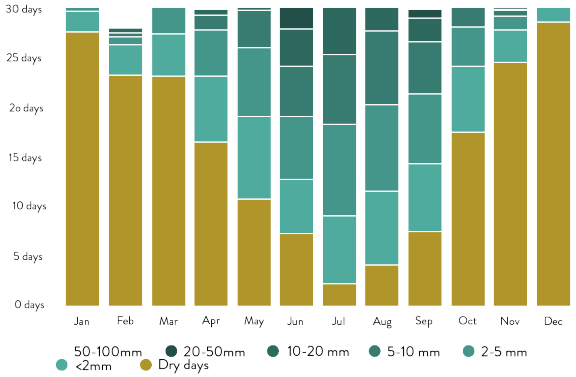
Cloudy, sunny, and precipitation days



Solar Chart



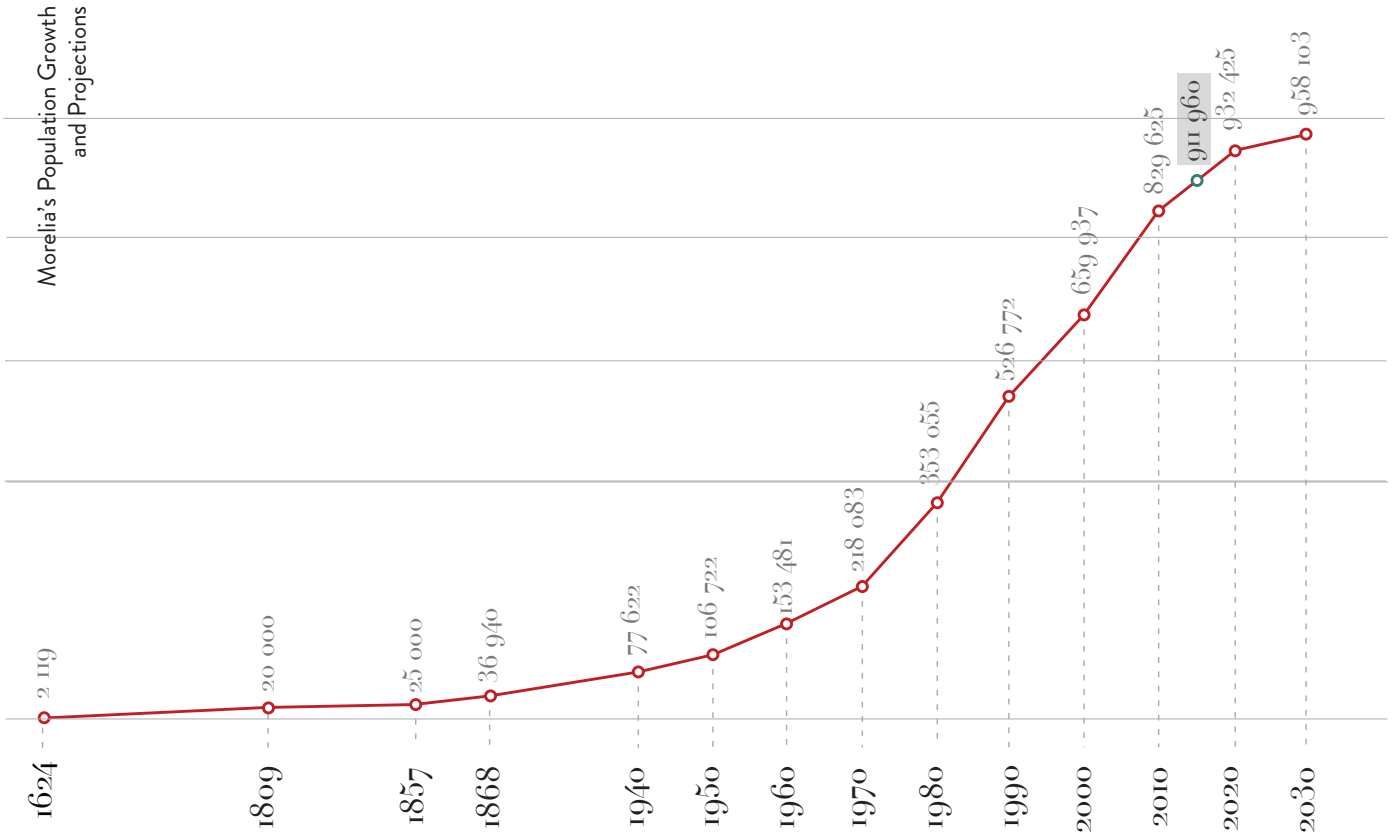
Wind Rose



Precipitation amounts

POPULATION GROWTH

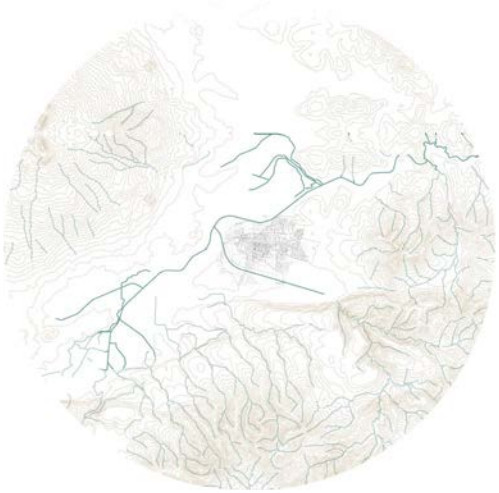
The population of Morelia's city in 2015 was the 784 776 inhabitants, whereas the population of the metropolitan area rises to 911 960. Morelia has experience a big increase in its population from 1980 to 2000, almost doubling the number from 353 055 to 659 937 inhabitants. The expected population for 2030 its estimated to reach 958 108 people.



URBAN DENSITY

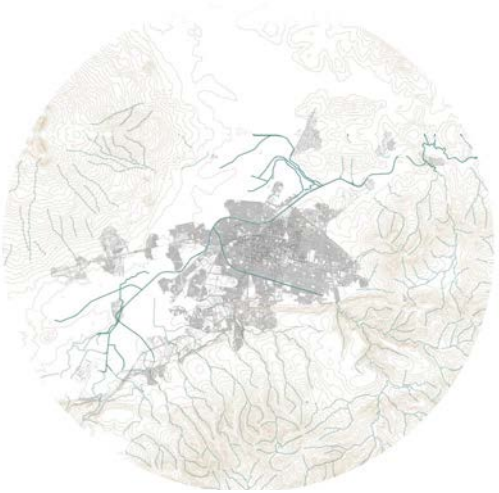
The urban density is 4 219 hab/km2 in the city, putting into comparison with different cities, we see that the density is comparable to Berlin (4 100 hab/km2), even if we are talking about a city with 6 million people with a different housing typology.

MORELIA CITY GROWTH



1940

77 622
inhabitats

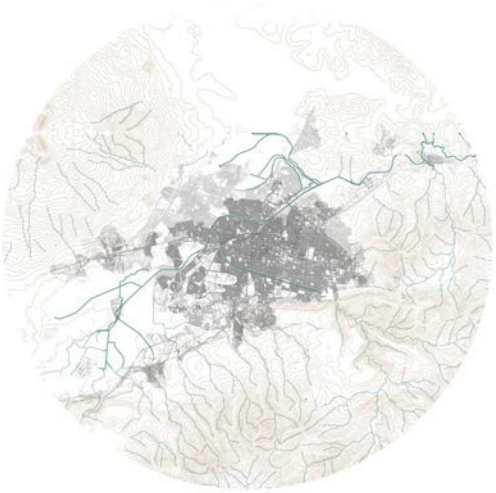


1980

353 055
inhabitats

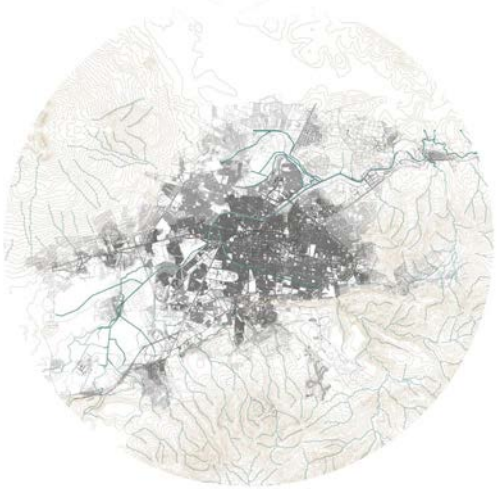
As we said it before, Morelia went through a rapid urbanization, characterized by a lack of planning and suburban sprawl. In the images, we see the evolution of the city and how it sits in the valley and also the hydrological network of the region.

Morelia started near the two main rivers of the city and stood there until the 50's. Thirty years later the city was starting to develop on the sides of the mountain and joining the adjacent municipalities forming the metropolitan area.



2000

659 937
inhabitats

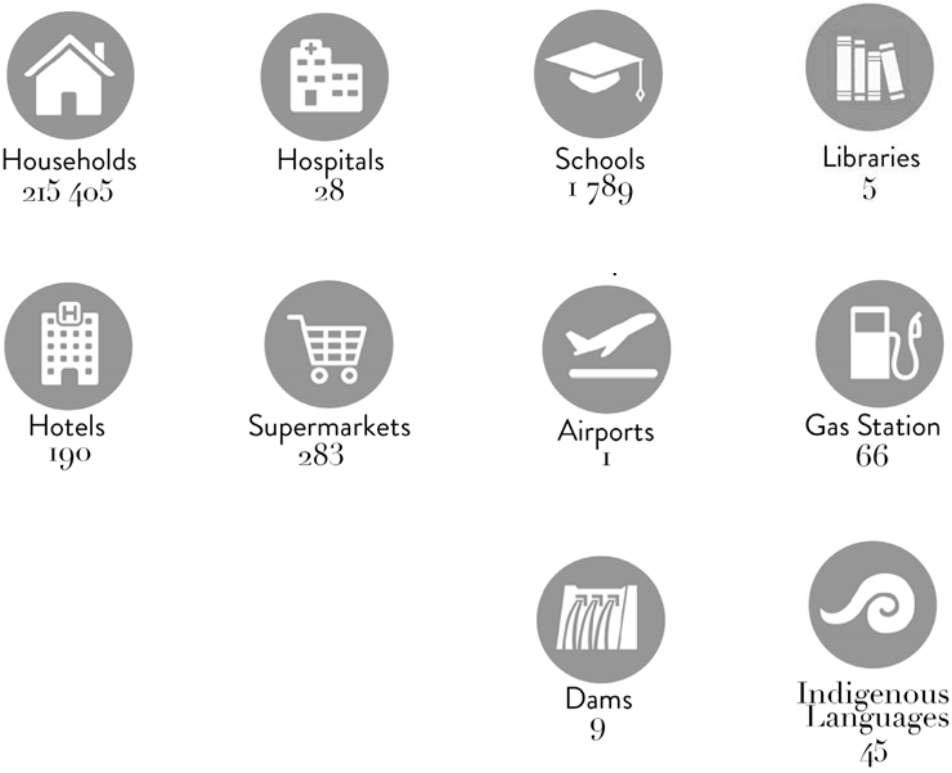


2018

911 960
inhabitats
(in 2015)

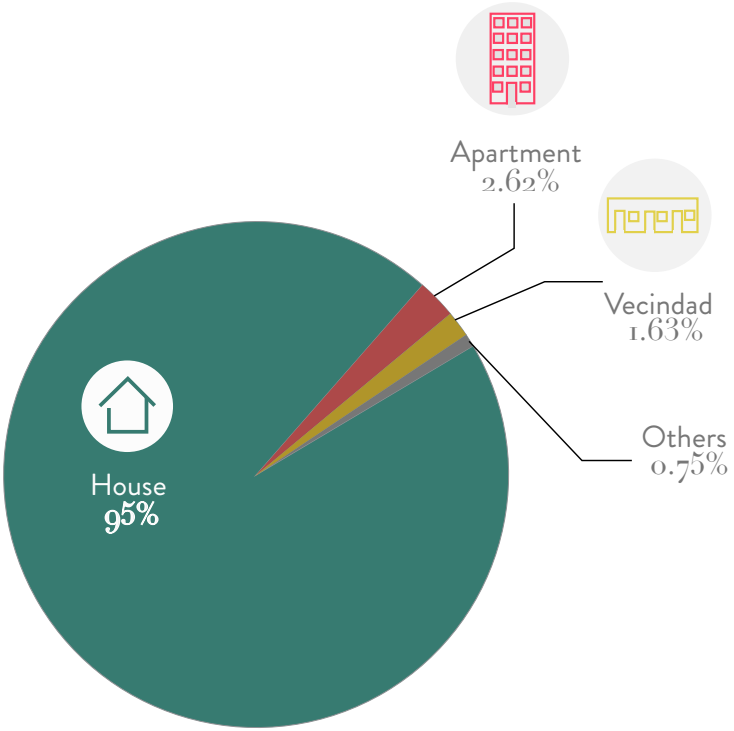
NUMBER OF HOUSEHOLDS AND URBAN FACILITIES

When looking at the facilities in comparison to the number of inhabitants in the city, it is quite shocking to see only five public libraries for 700 thousand inhabitants. Especially considering that the city is a center of education for all the region. Having the possibility to have access to knowledge should be easy for everyone.



HOUSEHOLD TYPOLOGIES

There are 3.6 inhabitants per household on average on the Morelia's city. From these 215 405 households, the grand majority are houses, being a total of 95% of the total. In smaller numbers, we have apartments, with 2.63%; while vecindades and other typologies represent the remaining 2.38%. This situation gives us another insight of the city sprawl and the issues that comes with it.



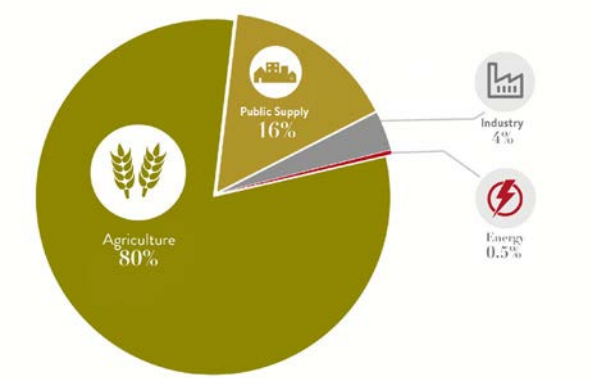
Note: Vecindad is a Latin American term for a building containing several (often low-income oriented) housing units.

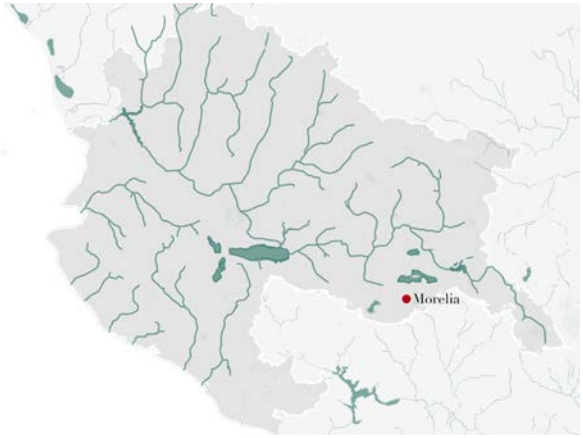
HYDROLOGICAL REGION

There are thirteen hydrological regions in Mexico, Morelia is part of the largest hydrological region, the Lerma-Santiago, which has a territorial expansion 132 916 km2 and normal annual precipitation of 819 mm (data from 1981-2010), with twenty-three hydrological basins.

The majority of the economic activities and cities are concentrated around the region that goes through five states, 30.26% of this region is located in Michoacán.

Most of the water goes for the agricultural industry, with 80%. The remaining 20% goes mostly for public supply, follow by industry and energy. The basin supplies around 24 million inhabitants, and the estimation for 2030 is for 27.5 million people.

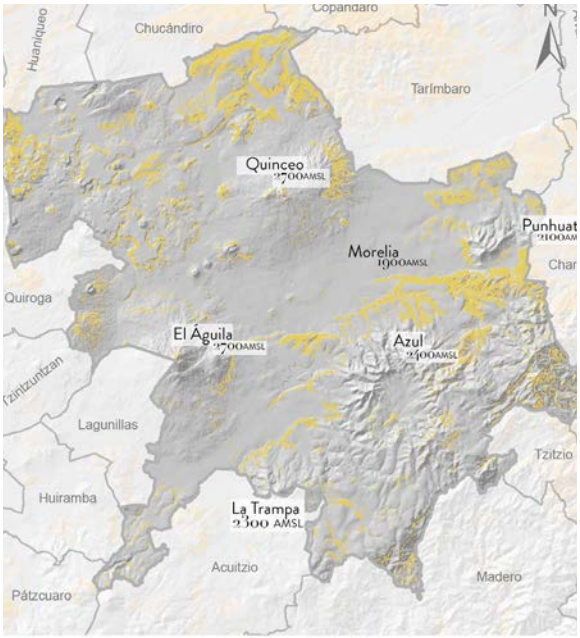




TOPOGRAPHIC REGION

The Trans-Mexican Volcanic Belt or the Trans-Volcanic Belt is a volcanic belt goes across Central-Southern Mexico from the Pacific Ocean to the Gulf of Mexico and it rests on the southern edge of the North American Plate. It is approximately 1 000-kilometer-long, 90–230 km broad structure is an east-west, encompassing an area of approximately 160 000 km^2.

In the Trans-Volcanic Belt, we find the highest peaks in Mexico and the youngest volcano in the world (located in Michoacán state); it also forms the southern boundary of the North American tectonic plate that indicates the geological limits between North America and Central America. The mountains are home of many endemic species as well off to the Trans-Mexican Volcanic Belt pine-oak forests, one of the Mesoamerican pine-oak forests sub-ecoregions.



The city of Morelia is located on a valley at 1 900 above mean sea level and it is surrounded by five main elevations: Quinceo (2 700amsl), El Águila (2 700 amsl), La Trampa (2 300 amsl), Azul (2 400 amsl) and Punhuato (2 100 amsl).


Quinceo
Morelia
Lake Pátzcuaro
El Águila
Cointzio Lake

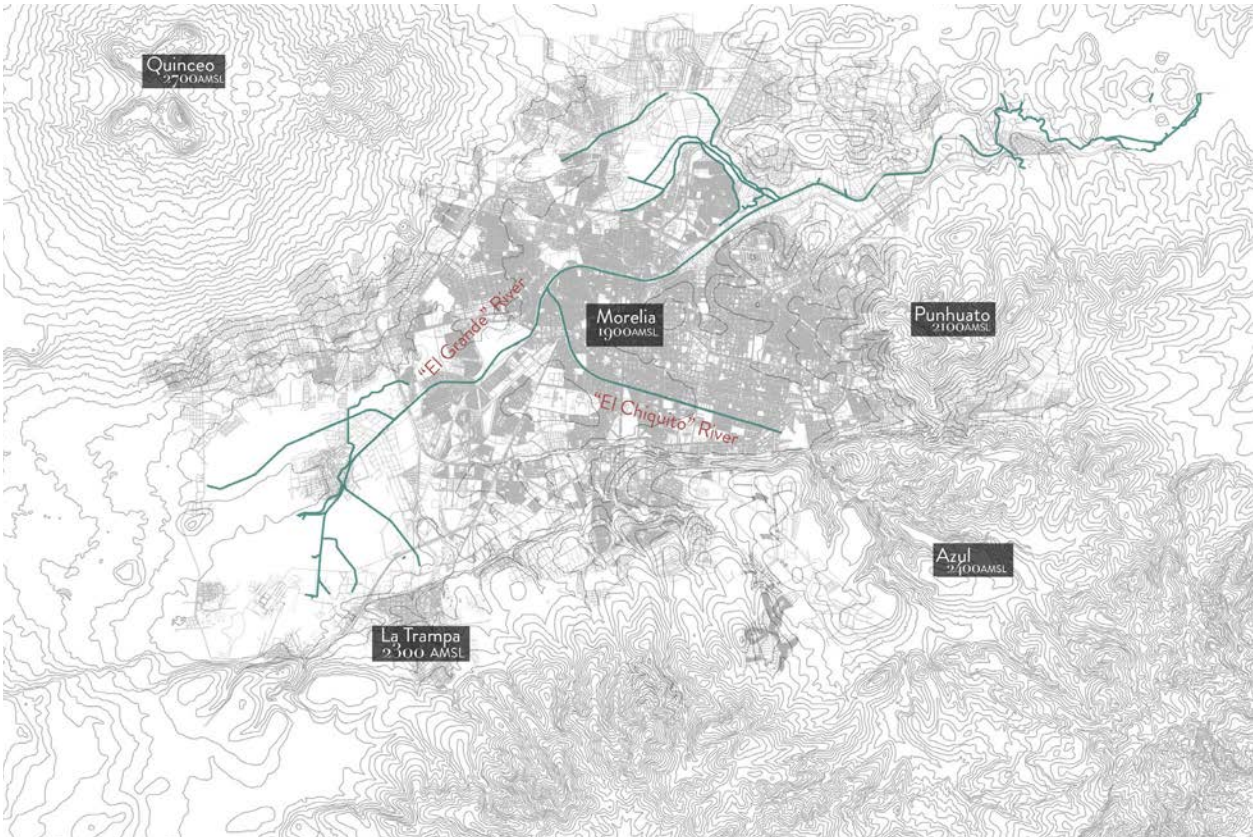
The region is characterized by a rugged topography, and two important lakes: Patzcuaro and Cuitzeo.

Cuitzeo Lake is the second largest freshwater lake in Mexico with 4 026 square kilometers, The three main inflows to the lake are the Viejo de Morelia, Grande de Morelia, and Querendaro rivers. Lake Cuitzeo is of great importance for the region, since it contributes to regulate the climate of the basin; It is also the sustenance and habitat of various aquatic species

The basin of the Lerma River lies to the east and north, and the basin of the Balsas River lies to the south, separated by the mountains of the Trans-Mexican Volcanic Belt. The endorheic basin of Lake Pátzcuaro lies to the west.

About 40% of the basin is agricultural fields, 15% is pasture, 20% is pine-oak forests, and 15% is tropical dry forest.

According to the National Institute of Ecology and Climate Change, the Lake Cuitzeo basin is in a situation of extreme alteration with respect to its functional dynamics. This has to do with various aspects, such as excessive deviation and extraction of water for agricultural and livestock purposes, urban and fertilizer contamination, illegal logging, as well as problems associated with climate change. This has dramatically reduced the lake's extension, increased its salinity and fostered the proliferation of aquatic weeds. The local population has also been affected by some of these aspects and is already suffering from economic, climatic and health problems.



Morelia's Main Elevations, Rivers and Streams.
Contour lines every 50 meters.

The stream bed of the Rio Grande and the Chiquito river where modifications took place at the end of the 1800 and the first half of the 1900. The image shows the original stream and the present one.

FLOODS IN MORELIA

Due to the fact that the city is located in a valley, the runoff created by the impermeable surfaces of the urban fabric, the lack of green permeable spaces in the city and the bad conditions and lack of maintenance of sewage infrastructure and rivers, Morelia gets flooded every year. It is estimated that about 76 neighborhoods suffer from ponding or flooding during the rainy season, and 26 of them present a high risk of flooding.

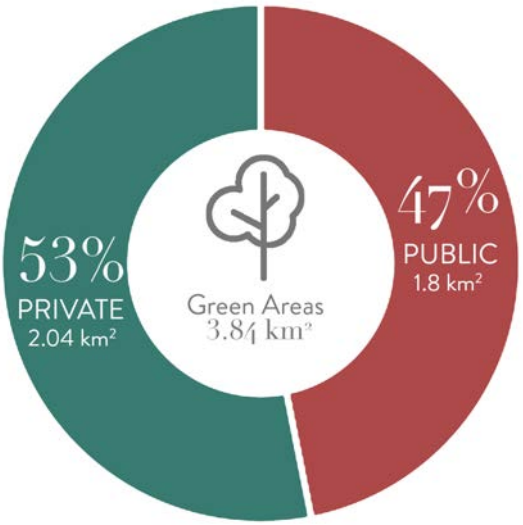
The image shows a prediction of 1 to 100-year event. Where a large amount of the city is flooded more than 2 meters, and the rest of the city also presents lower levels of water. This make us very aware of the level of problem that the city could have and the hundreds of people that can get affected if proper measurements aren't taken.

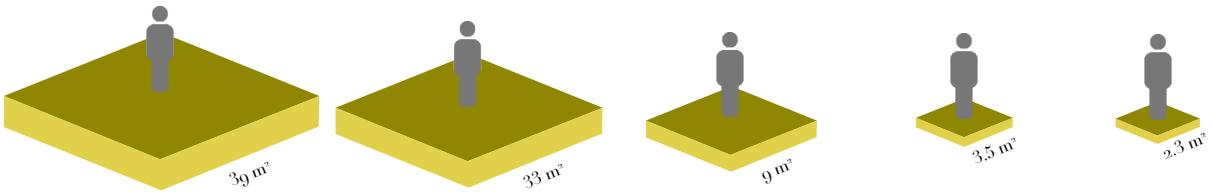
Map of Depths for the city of Morelia, Mich.
corresponding to a return period of Tr = 100 years.

GREEN ACCESIBLE AREAS

With the information from the development plan, we can see that the green areas of Morelia are only 3.84 square kilometers. From these, 47% are public, giving us 1.8 square kilometer of accessible green areas. With these number, we estimate that Morelia has 2.3 square meters of green space per inhabitants.

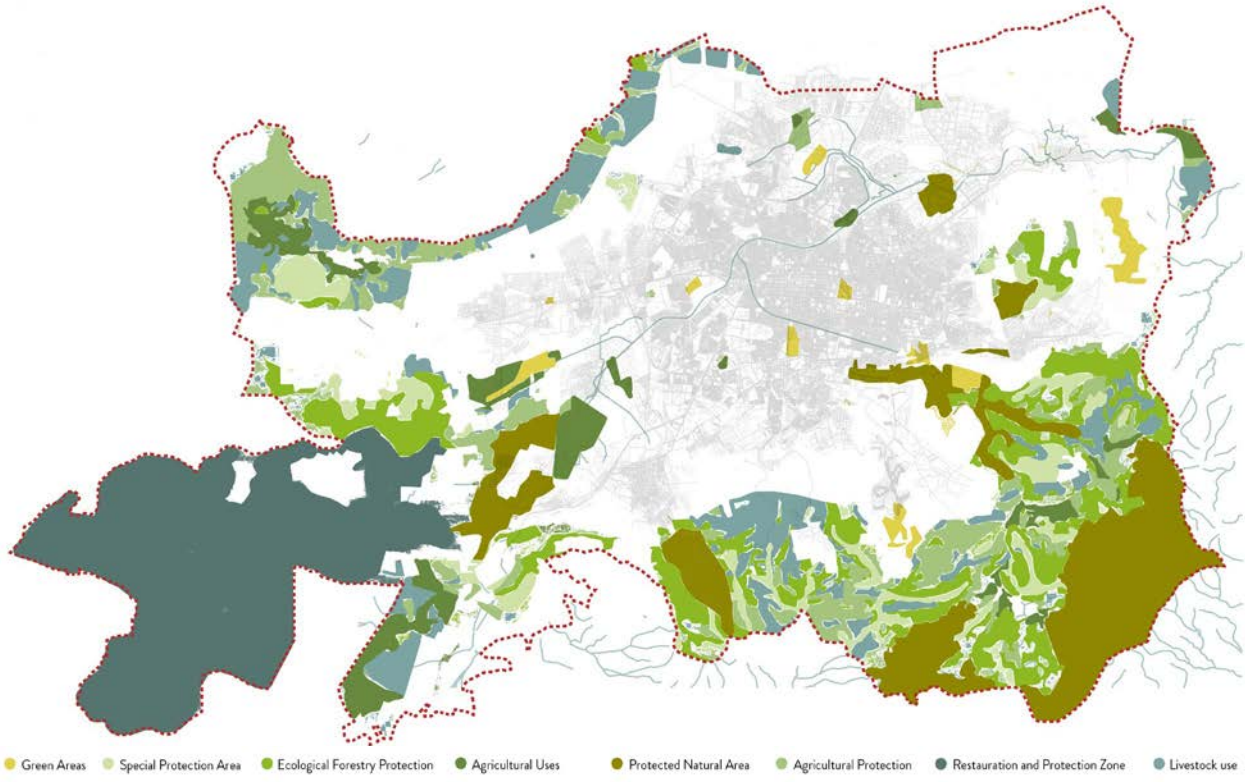
In comparison with cities with a similar density, like Berlin, and the request as a minimum form the WHO (9 square meters per inhabitants) the problem of lack of urban green spaces on the city is quite obvious.





Berlin | Malmö | WHO World Health Organization | Mexico City | Morelia

Moelia's Protected Green Areas



03 REFERENCE PROJECTS

Minghu Wetland Park

Turenscape
Location: Liupanshui, China.
Photos: Turenscape

The objective of the project includes ecological restoration of the river, the upgrading of urban open space system, as well as increasing the value of urban waterfront land. As a result, the landscape along the river was recovered as an ecological infrastructure while helping the ecological need of the region. Turenscape created a series of ecological purification systems along the river that that also work as flood control features. Also, the natural riverbank was revitalized and maximize the self-purification capacity. The project also includes a series of pedestrian and bicycle paths to integrate the urban recreational and ecological space.

Illustrative Photos

Qunli National Urban Wetland

Turenscape
Location: Harbin, China
Photos: Turenscape

Turenscape's strategy is to transform the dying wetland into an urban stormwater park, which will provide multiple ecosystems services for the new community. The design solution was creating a series of ponds and mounds surrounding the former wetland, which would be untouched for natural evolution. This system creates a stormwater filtrating and cleansing buffer zone. Storm water from the new developments is collected and distributed into the wetland after been filtrated and deposit into the ponds. Platforms and viewing towers are set in the ponds and on the mounds to allow visitors have a immediate touch of the nature and have distant views.

Illustrative Photos

Modern and Traditional Elevated Buildings

Location: Chile and Mexico

Of all the risk-reducing building typologies, the elevated building is the most common. Used all over the world and for centuries, the elevated buildings have been evolving and built in materials from masonry or stone, or on posts varying from bamboo to reinforced concrete. The posts must be designed to resist water pressure, weight of flood, water scour and impact from floating debris.
The images show, on the left side, two pictures from the architecture of Chiloé, Chile. Which characteristic architecture is on elevated poles, use on the lakes of the region. In the right side, examples of houses and hotels in Mexico, build on mangrove regions.

Illustrative Photos

Traditional Moria's Houses

Location: Morelia.

Morelia is an excellent example of urban planning which combines the ideas of the Spanish Renaissance with the Mesoamerican experience. Well-adapted to the slopes of hill site, its streets still follow the original layout. The buildings are constructed with the characteristic pink stone, that reflect the town's architectural history, giving an eclectic blend with the medieval spirit with Renaissance, Baroque and neoclassical elements. The typical houses are conformed by a central square patio with the rooms surrounding it, this typology used to be the common way of building houses in central Mexico until the mid-1900.

Illustrative Photos

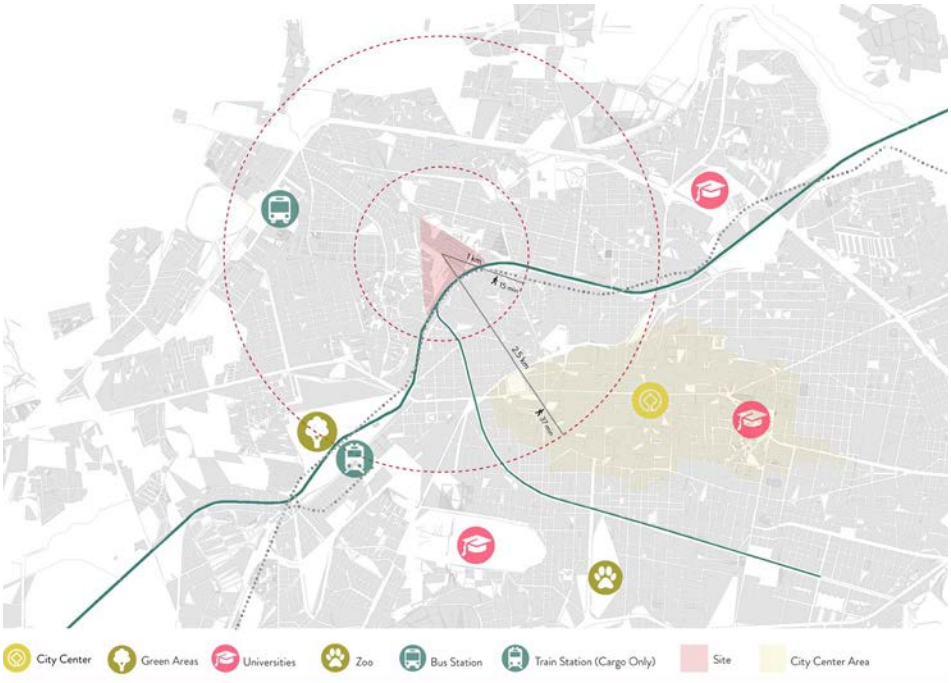
04 SITE OVERVIEW

The choosen site is part of two city neighborhoods, Carlos Salazar and Pedro María Anaya, both of them on the list of the colonies with the highest flood risk and more harmed by annual flooding.

The design site is located 2.5 km to the north of the city center and where the two rivers of the city meet. Transportation nodes are close by, this being the main bus station and the train station, although the last one is only cargo and brings more negative impact on the area due to the lack of security measures, the fact that it creates a barrier to the north of the city and the noise contamination.

In the 2.5 km radius, we also find a neglected park that floods every rain season. The campuses of the university of the state are also somehow close to the river and the site, which could be another factor to take into consideration for the proposal part.

The site in the context of Morelia's City and Close Important Palces.



SITE SIZE AND COMPARISON

The design site is approximately 35 ha and consists of two different neighborhoods that have been developing at different rates and have different levels of built area. The southwest side is around 90% built whereas the northeast side is 30% constructed in a spread way. Due to this fact, is more likely to be able to preserve and adapt some houses from this side.

When comparing the site with cities like Berlin and Malmö we can appreciate the lack of green accessible spaces in our site and how compact the buildings are squeezed together.

Design Site
35 ha

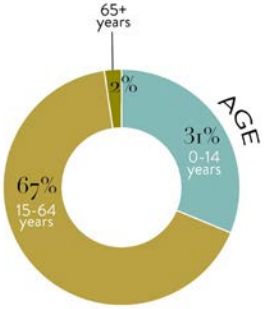
Berlin

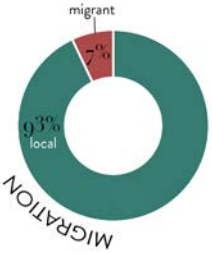
Mexico City

Malmö

SITE'S POPULATION

According to the National Institute of Geology and Statistics, by 2015 the site had 3 273 inhabitants, with almost 90% of them located in the southwest side of the area. In total, there are 824 houses, giving us an average of 3.97 residents per household. The census also shows that 31% percent of the population is between 0 and 14 years-old, which in proportion is quite a large number and must be taking into consideration. Furthermore, only 7% of the population are migrants and the gender quantity is balance.



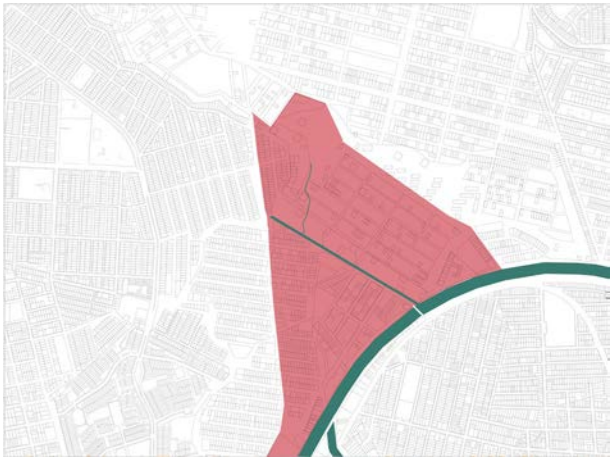


SITE'S CHARACTERISTICS

As establish before, the site is located next to the El Grande river and it also has some small channels going through the site, from the mountains to the river. Most of them have been canalized into pipes. The zone has mainly one use, which is housing, and only a couple of main streets have commercial uses as well. As for the transportation, there are three routes that connect the site one north to south, and two that goes east to west.

There are twenty schools in the nearby area, mainly primary schools, then kindergartens and secondary schools. We also found ten churches from different religions in the surroundings as well as five sport spaces. Green areas are scattered and small in comparison with the density of the zone.

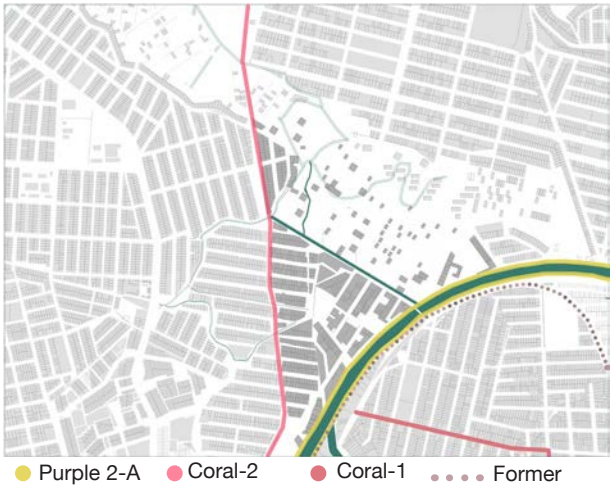
Facilities and Green Spaces in the Area



The Site in Context

River and the Existent and Former Channels

Functions



Transportation Routes

The site used to have a lot of streams, produced by the pendent from Quinceo mountain in direction to a main channel that flows into the Grande River. These small streams have been put into pipes and now days there is just one stream and a main channel left in natural form.

Talking about the site's functions, we could say that the housing use is the most prominent, whereas commercial and mix use is mainly focus on some main streets, and most of them are usually small business owned from the inhabitants of the zone.

As for public transportation routes, there are three busses routes that goes through the site or nearby it, connecting the site to the city center, the northeast, northwest and southwest of the city.

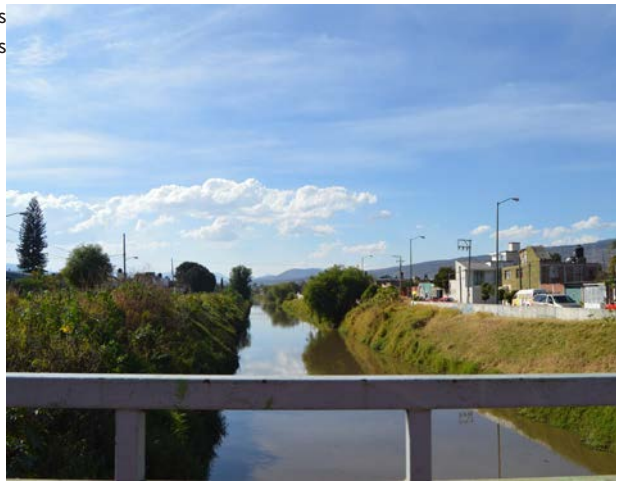
There are 76 neighborhoods in Morelia with flood risks, from those, 26 have a high risk of flooding and the design site is considered among the top ten most affected districts by these phenomena.

Carlos Salazar neighborhood was founded in 1989 in a swamp area and it started as an irregular settlement. For centuries, this part of the city was use for seasonal farming and pasture due to the proximity of the river, the fertile soil and the well irrigated land. Now, due to the flooding issues that the site has, the land is devalued, nobody can sell, no one wants to buy, and the population is stuck with their houses and the only measures taken for protection are soil sacks and walls along the river.

Other improvised preventive measures are taken by the inhabitants of the site, such as moving some furniture to second floors while putting bricks under the heavier things, such as fridges, beds or cupboards. They also have tried to build their houses between 30 cm to 1 meter above the street level to avoid as much as possible the water into their homes.

According to the Research Center of Environmental Geography, after the 80's there are flaws in the urban development plans regarding the expansion of the city limit, which hasn't been possible of stop and they will continue like this for the next 20 years. The lacking of urban planning in the city is the major factor that contributes to the site's flooding. First, because the government allowed to build on a swamp area next to a river. And Secondly, due to the building area on the slope of the mountain that increase the runoff right into the site.

Site's surroundings



Connectios to the site. Bridges.

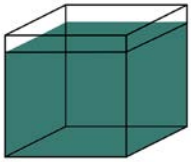
Preventive flood measures

SITE'S FLOODS

Every year during rainy season the site gets flooded, that usually goes from Jun to September. Usually, the water levels go from 50 to 120 cm and these flooding events occurs on an average of 4 times per year. Moreover, the time that takes for the water to vent can oscillate between several hours and a couple of days. Also, it is roughly estimated, that during these events, the site's area and surroundings are handling around 1.4 million cubic meters of water.

The reasons why the area floods are both about its geographical location and human activity. First, as mention before, the site is located in the junction of two rivers and at a mountain slope, as a result, the area used to be a wetland. Secondly, due to lack of city planning, not only they allowed the development of a wetland with risk of flooding, the city has also keep developing north in to the maintain slope, creating more runoff cause by the amount of impermeable surface, this las fact is why the water levels during flooding keeps increasing. Coupled with these, the sewage systems, rivers and channels lacks maintenance, making it more difficult for the water to flow.

When talking about the living conditions, we can say that the population can get stuck in their houses and be exposed to dirty water, putting their health in risk; there are also damages to furniture, cars and building structure generating economic losses. They live with the constant fear of rain and have to be aware and prepare every season. All of these, creates a negative impact in their quality of life, that could have been avoid just by taking water into consideration when developing.



1 400 000 m^3

SITE'S ESTIMATED WATER VOLUME DURING ANNUAL FLOODING

Site's pictures during flood events

Site's pictures during flood events

Model 1:10 000
Showing the relationship between the mountain, the river and the site

Site's pictures during flood events

Return period of Tr = 100 years.

Yearly Probabillity of Flooding

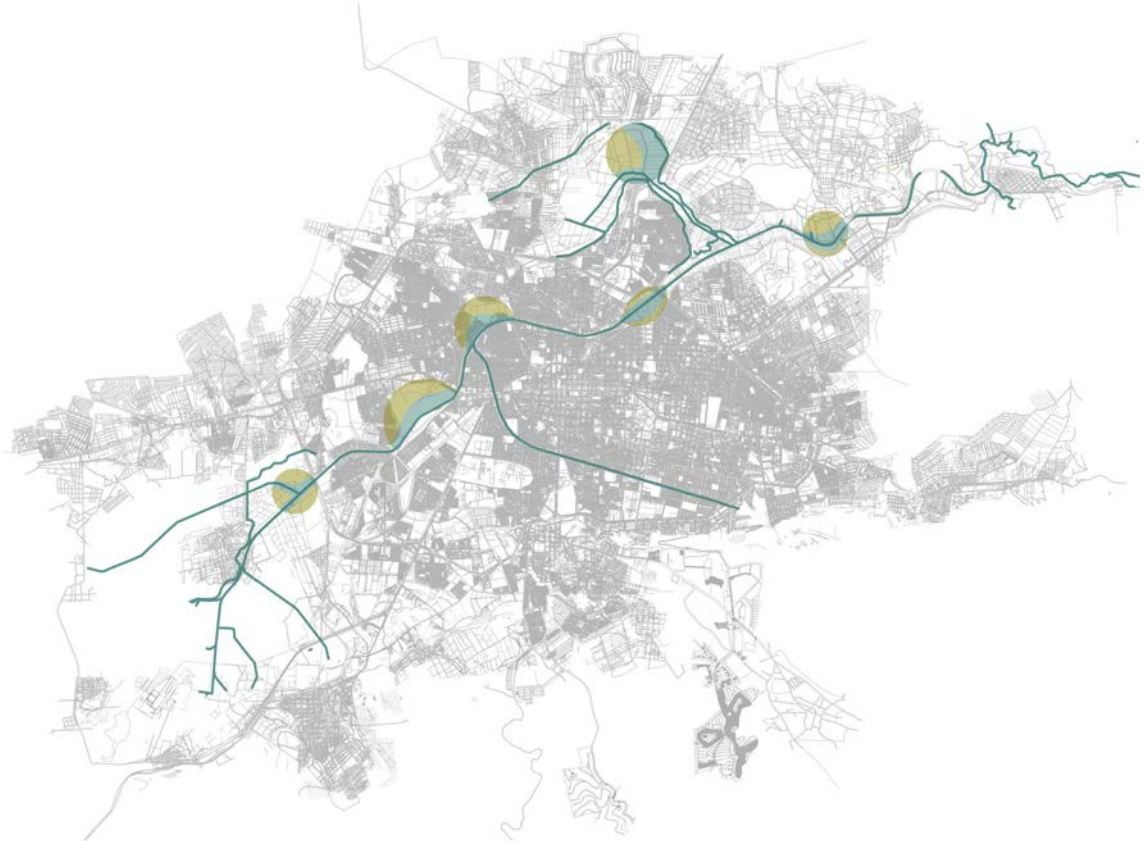
Very High Risk Probability

High Risk Probability

05 DESIGN STRATEGIES

VISION

The vision for the city is to create flooding resilient areas along the river on the most vulnerable places or/and adequate places, that will work as ecological buffers and tha can be linked between each other to create a green network to be used by the citizens as green accessible areas. This project explores the possibilities of how these areas can be developed keeping water, people and green areas in mind.

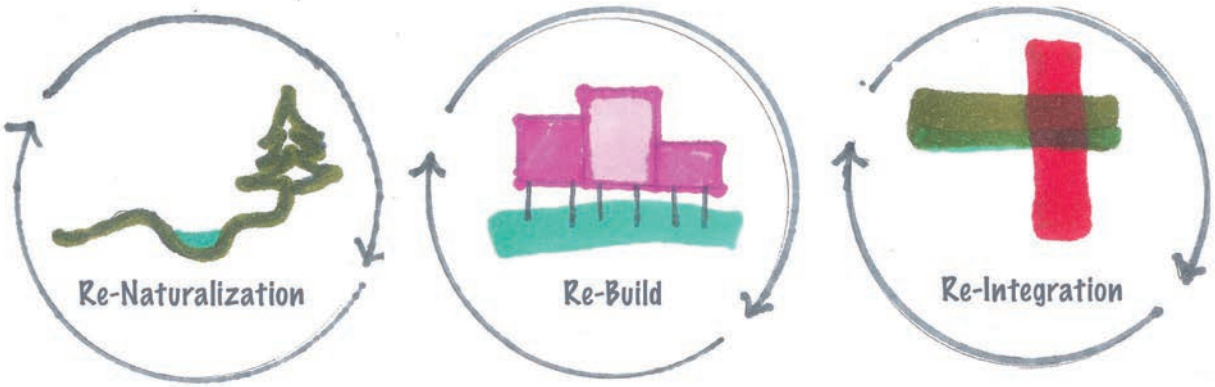


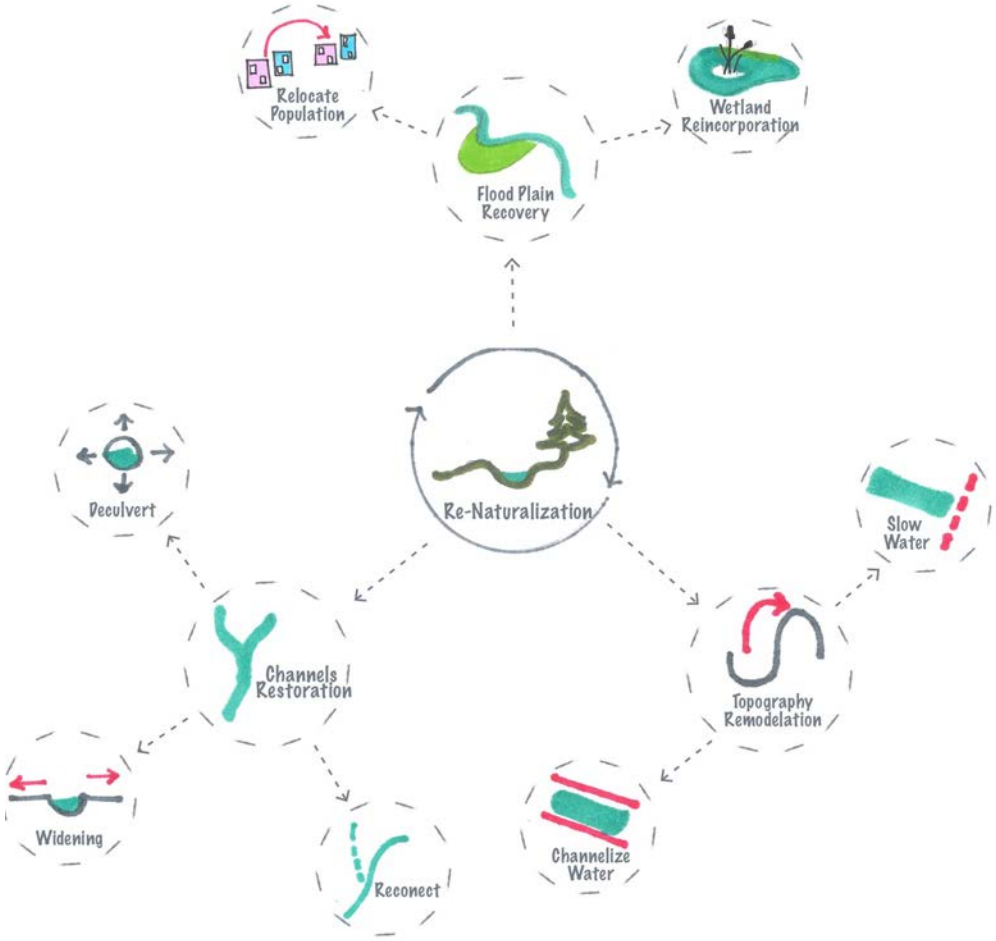
STRATEGIES, TOOLBOX & DESIGN ELEMENTS

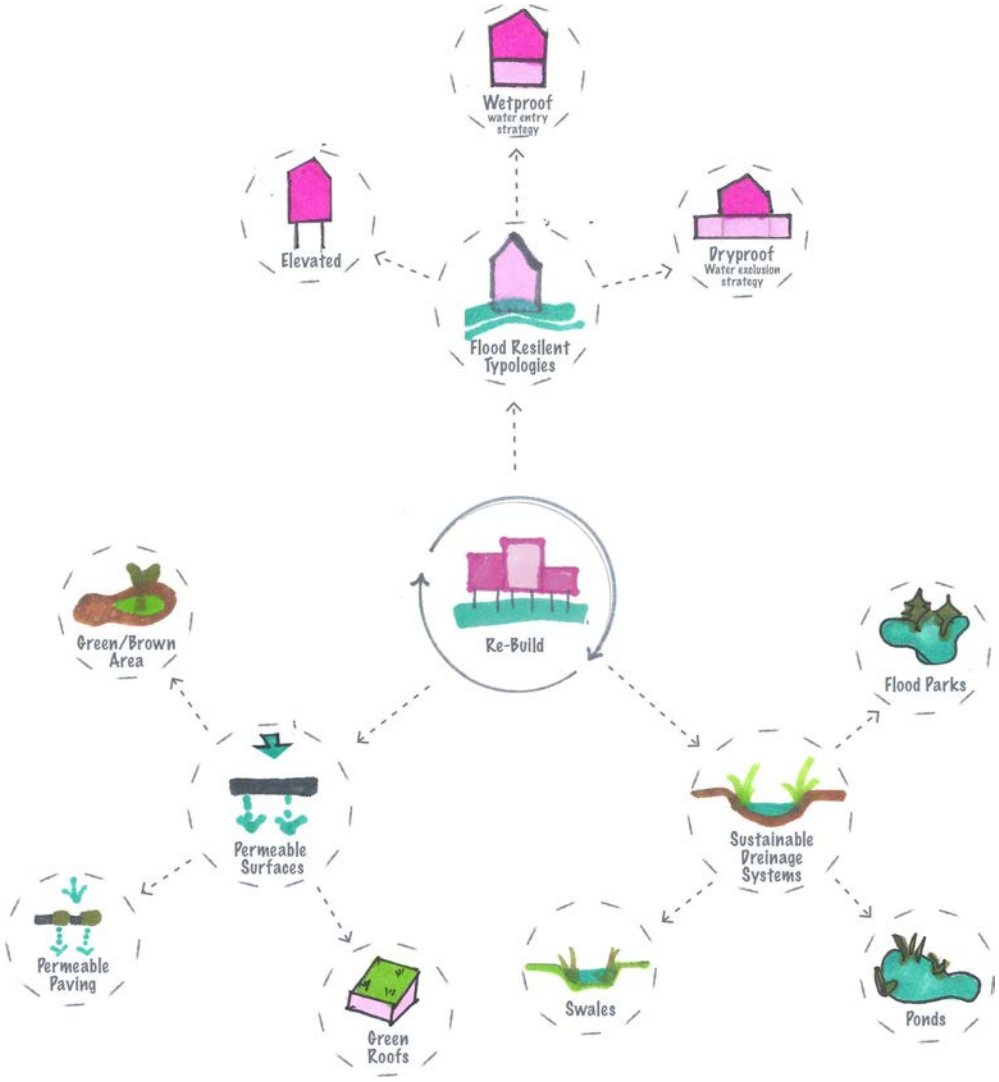
The objective is to generate an area where water is no longer excluded, if not, an essential part on the sites identity, the nature and ecological aspects should be restored and used as a green area. Adequate urban development should be possible and feasible under the right typologies. The links to the rest of the city have to be reassured and the north side of the city reactivated. Sustaining these ideals are the three main strategies: Re-Naturalize, Re-Build and Re-Integrate.

Re-Naturalization

This strategy stands for the idea of restore the natural character of the place and it is mainly focus in the area near to the river. It has three main tool box basics: Flood Palin Recovery, Channels Restoration and Topography Remodeling. The first one focus on Relocating Population and Wetland Reincorporation as design elements. Channels Restoration is about Deculvert, Widening and Reconnect the existent and former channels of the site. And finally, the last toolbox element is centered on channelizing and slowing water on the site by playing with the topography.




Relocate Population
Flood Plain Recovery
Wetland Reincorporation
Re-Naturalization
Deculvert
Slow Water
Channels / Restoration
Topography Remodelation
Widening
Reconect
Channelize Water


Wetproof
water entry strategy
Elevated
Dryproof
Water exclusion strategy
Flood Resilient Typologies
Re-Build
Green/Brown Area
Flood Parks
Permeable Surfaces
Sustainable Dreinage Systems
Permeable Paving
Green Roofs
Swales
Ponds

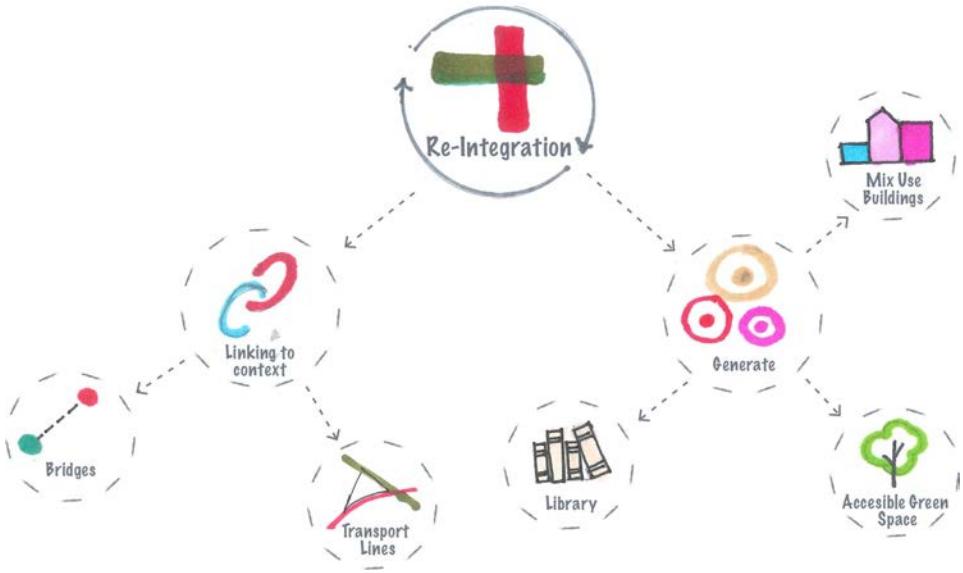
Re-Build

Given the fact that the majority of the population should be relocated to more higher lands, this to keep the inhabitants safer and to give space for water, the Re-Build strategy talks about how to densify and construct the site again following a toolbox that will make it possible to live with water. This toolbox is from Flood Resilient Typologies, Permeable Surfaces and Sustainable Drainage Systems. The design elements for the flood typologies are: Elevated, Wetproof (water entry strategy) and Dryproof (water exclusion strategy), these typologies would be used according to how close are they from the main flooding area and if the construction is new or existent. The second toolbox component has Green/ Brown areas, Permeable Paving and Green Roofs as main design elements. And Finally, a system for cleaning rain and grey water would be implemented and use Swales, Ponds and Flood Parks as design elements.

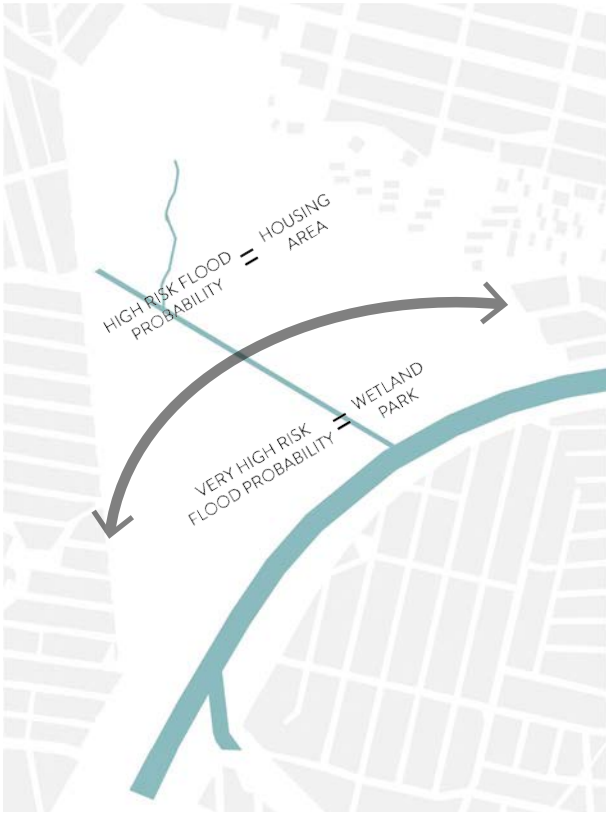
Re-Integration

Re- Integration is about improving the connections from the site to the rest of the city and create spaces and functions that attracts people to visit the site. The two toolbox elements are: Link to Context and Generate. The first one has the constructions of new bridges and the creation of more transportation bus lines as design elements. While the second one, has as objectives to build a new public Library, create Accessible Green Spaces and have a variety on functions on the site.

Some factor to take into consideration are of course, the water. The usual levels reached during flood events would determine the end of the wetland and the beginning of the housing development. With these, it is also important to try to achieve as much permeable soils as possible, in this case, 2/3 of all the 35 hectares should be designated for park area, while the remaining hectares for the new development.



Design Considerations

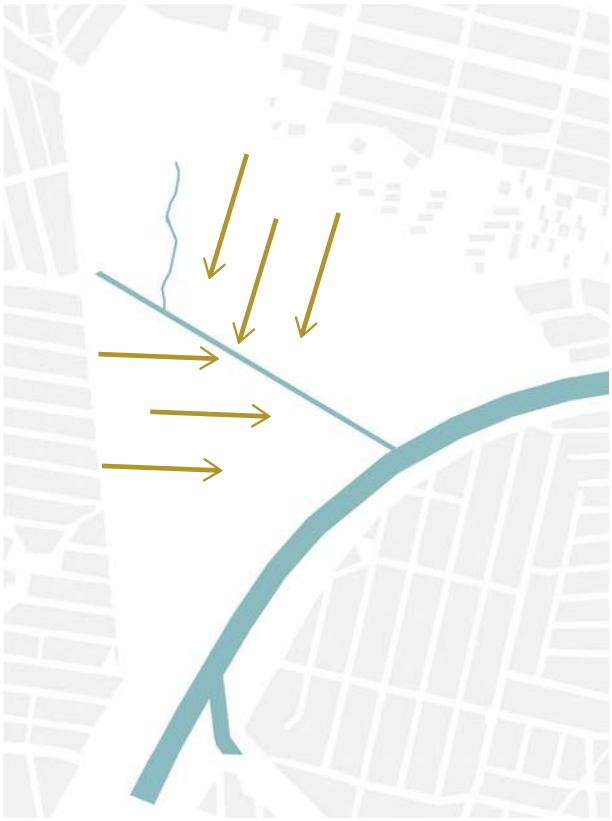


Housing & Wetland Park Location

Housing & Park Proportion

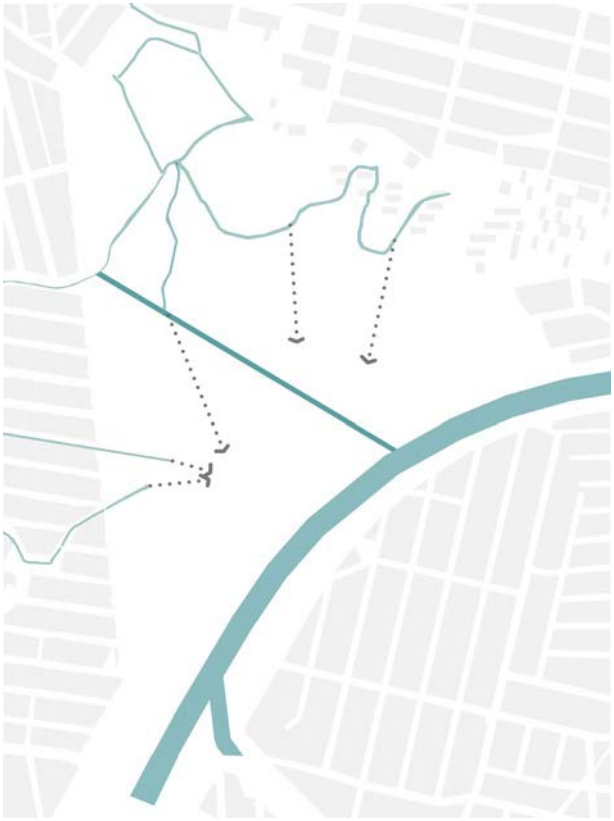
Some factor to take into consideration are of course, the water. The usual levels reached during flood events would determine the end of the wetland and the beginning of the housing development. With these, it is also important to try to achieve as much permeable soils as possible, in this case, 2/3 of all the 35 hectares should be designated for park area, while the remaining hectares for the new development.

Building Direction - Allowing Water Flow



The building directions would be oriented so the water from the streams and swales can flow without problem into the park.

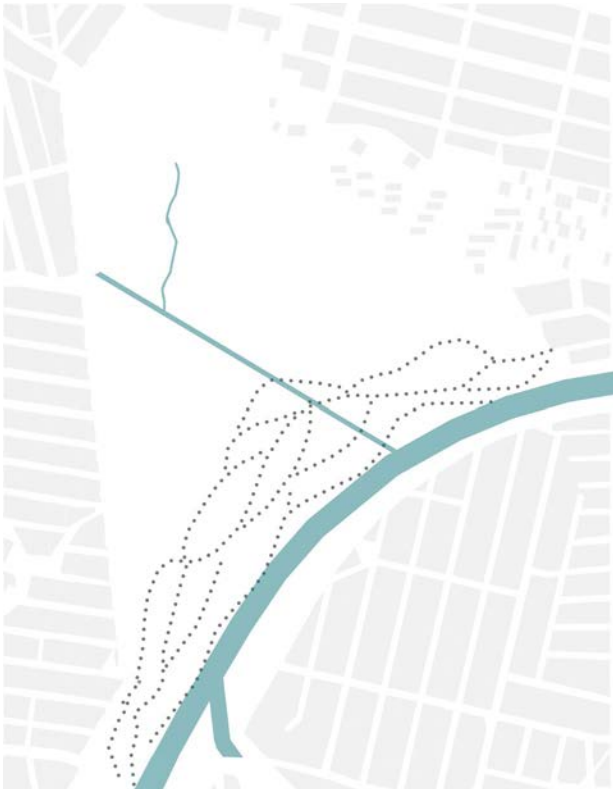
Bringing Up Former Streams



The former site streams would be de-culverted, widened and connected to the new water system, as stablished before on the strategies.

Organic Shape Ponds

First Wetland Sketches



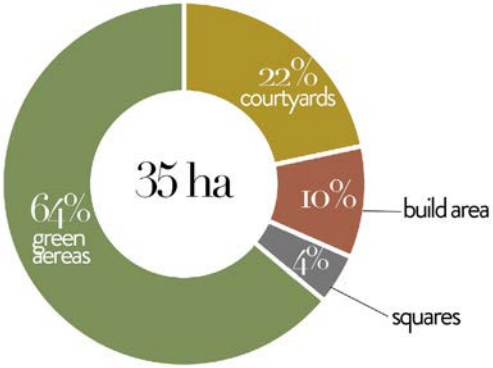
The design for the wetlands is both inspired by the Minghu Wetland Park in China and the concept of “Ojo de Agua” (, which is a Mexican way of refereeing to *Springs*. As some of the streams are born from springs, it works as a nice concept that can be used to create organic edges where the water can flow and move in a natural way.

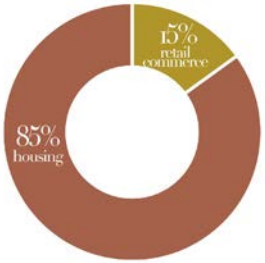
06 DESIGN PROJECT

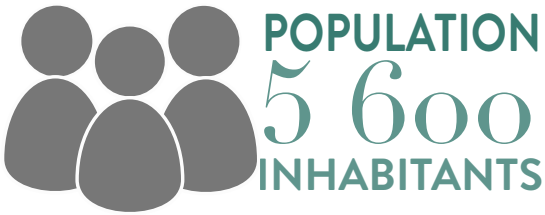
The design proposal tries to create a balance between nature, people and water. From the 35 hectares, 64% are designated for public green areas and 22% for courtyards, which gave us 30 hectares of permeable and semi-permeable surfaces, while 3.5 hectares are occupied by build structures. These measurements, should reduce the water runoff and increase the water infiltration and cleaning, while giving the people a space for recreation.

One of the project main objectives is the inhabitant's relocation to higher lands, and while doing so, creating more housing and retail opportunities. There would be 1 610 units, 15% would be destined for commercial and business purposes, while the remaining 85% is for housing. In other words, there would be 1 368 units for housing that could accommodate an average of 5 600 inhabitants.

During flood events, the wetland ponds would take 25% of the water volume, and around 10% of the whole area. They also would help for water retention and infiltration. The wetland park would change during the year according to the amount of water, but it would be design to be accessible is all scenarios.







MASTER PLAN

In order to create more space for water, the width of the river would be increased and some topographic elements added to guide the water and expand the park area. The wetland park, it's mainly conformed by big ponds to retain water. This park would be accessible during all year, during dry times, there are paths on the ground to wonder around the area; whereas, during flood events, the wetlands would be still accessible by using the elevated paths. A public library would be located on the southwest part of the park, connected to a main road and visible from the other side of the river.

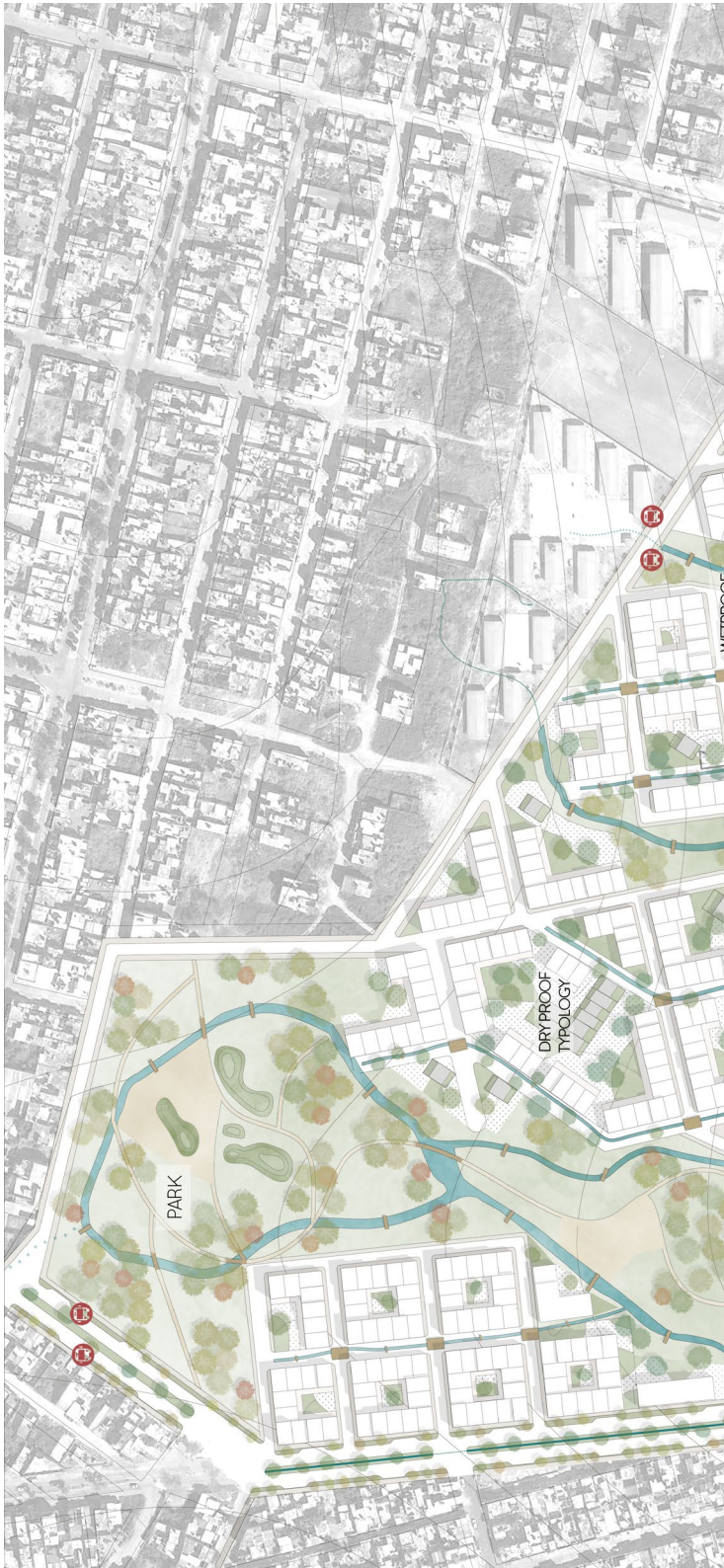
Elevated buildings would be located on the wetland limits and connected to the main kind of housing typologies, which is designed to allow water entry on the first floor. Some of the existent buildings would be mixed with these typologies and would be protected from floods by a water exclusion typology. Swales would collect the rain and grey water from the houses and streets that eventually would lead to the main channel or the wetland park.

On the surroundings, there are four new official bus stops on the main access to the site. Some buildings would be also remove from the riverside in order to create buffer areas to protect the existent houses. The cargo train would be rerouted giving space for a green corridor.

Masterplan


PARK
DRYPROOF TYPOLOGY
WETPROOF TYPOLOGY
WETPROOF TYPOLOGY
section C
ELEVATED TYPOLOGY
WETLAND PARK
LIBRARY

Masterplan.
Original Scale
1:1000




WETPROOF TYPOLOGY
section B
WETPROOF TYPOLOGY
section C
ELEVATED TYPOLOGY
WETLAND PARK
section A
LIBRARY

FUNCTIONAL DIAGRAMS

When referring to retail and commercial units, most of them are located on the first floor and facing the main park streets. On upper floors, it is mostly housing with some exceptions. As to parking concerns, there are some buildings on higher lands where some cars could be parked.

The number of floors would range from one to eight floors, being most of them between three or four levels in order to keep a good human scale.

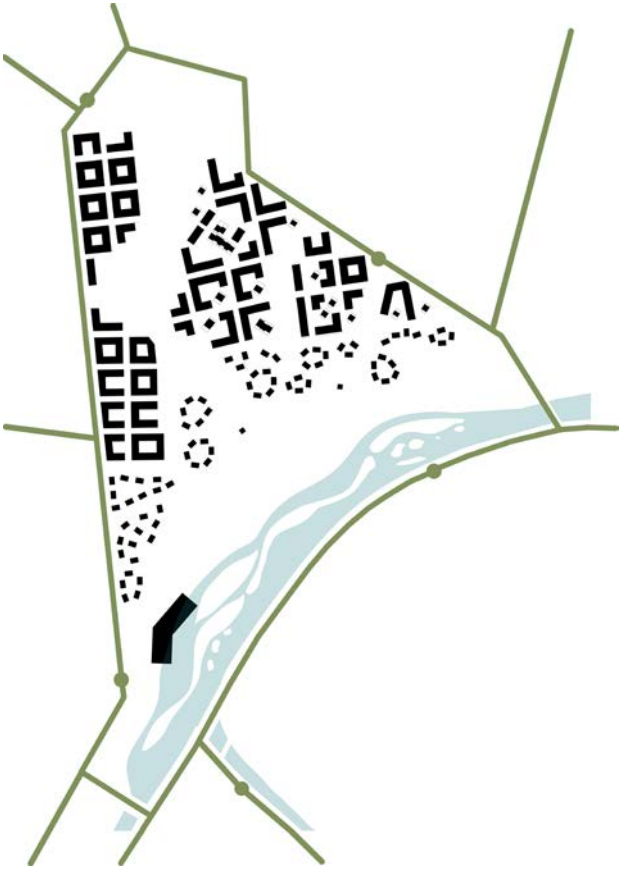
Car movement in the housing area would be restricted to some streets, whereas the public transportation is improved by creating official bus stops that will link to rest of the city, specially the city center and the city bus station. As part of the overall strategy, green corridors would be created along the rivers and linked into the city center.

Housing
Retail & Commerce
Librabry
Parking

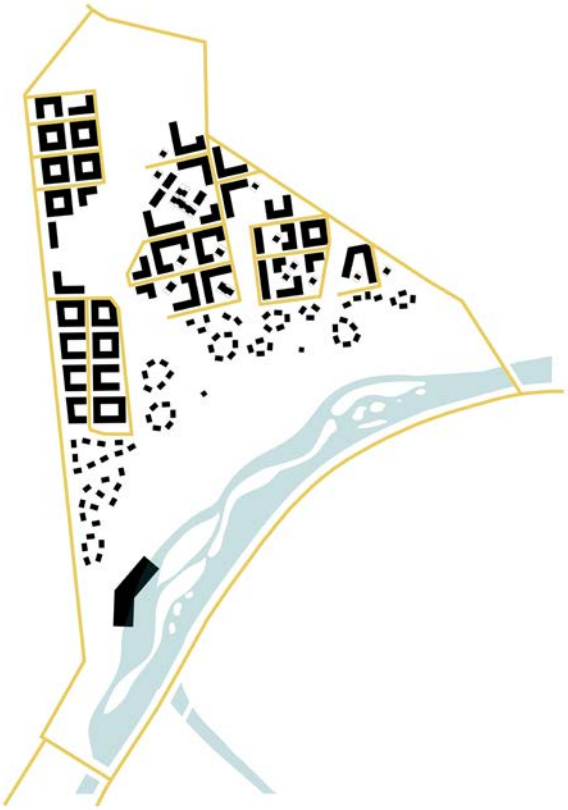
Ground Floor

Housing
Reatil & Commerce
Librabry

Upper Floors



Public Transportion. Bus Lines and Stops.



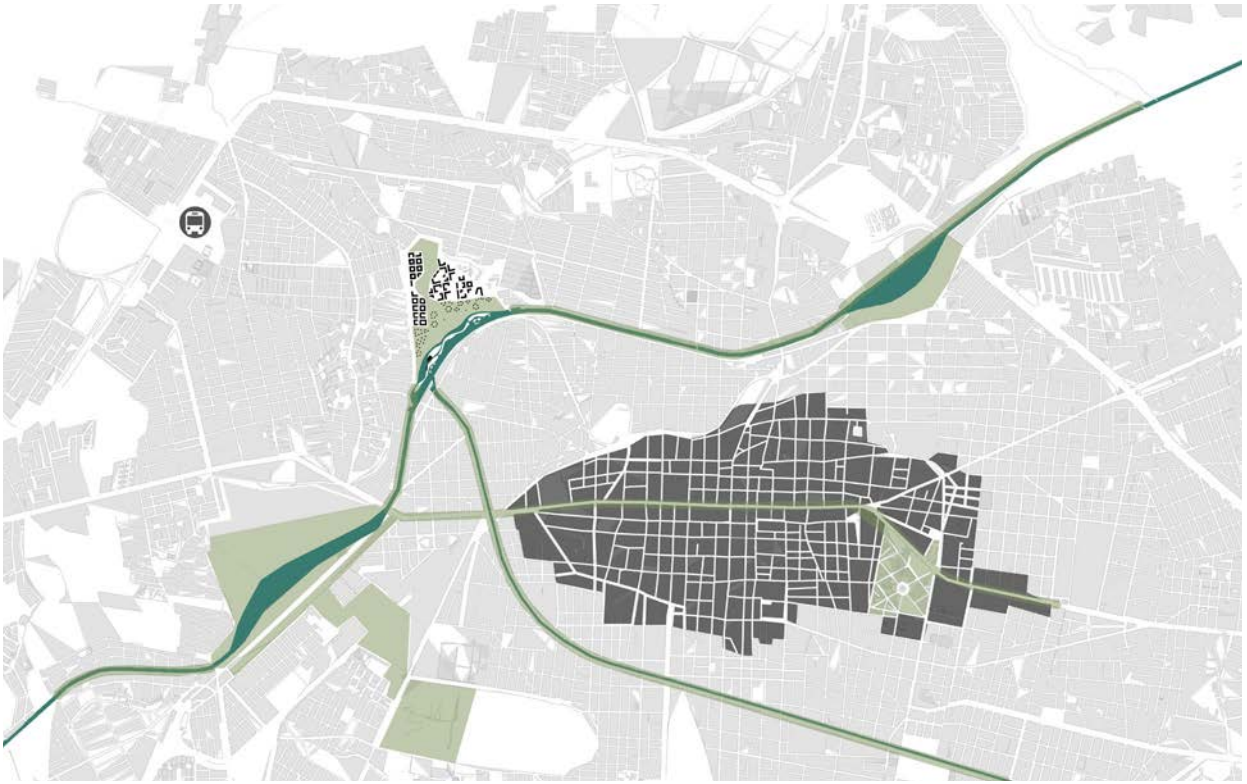
Car Circulation.

1-2 Floors 3-4 floors 5-6 floors 7-8 floors

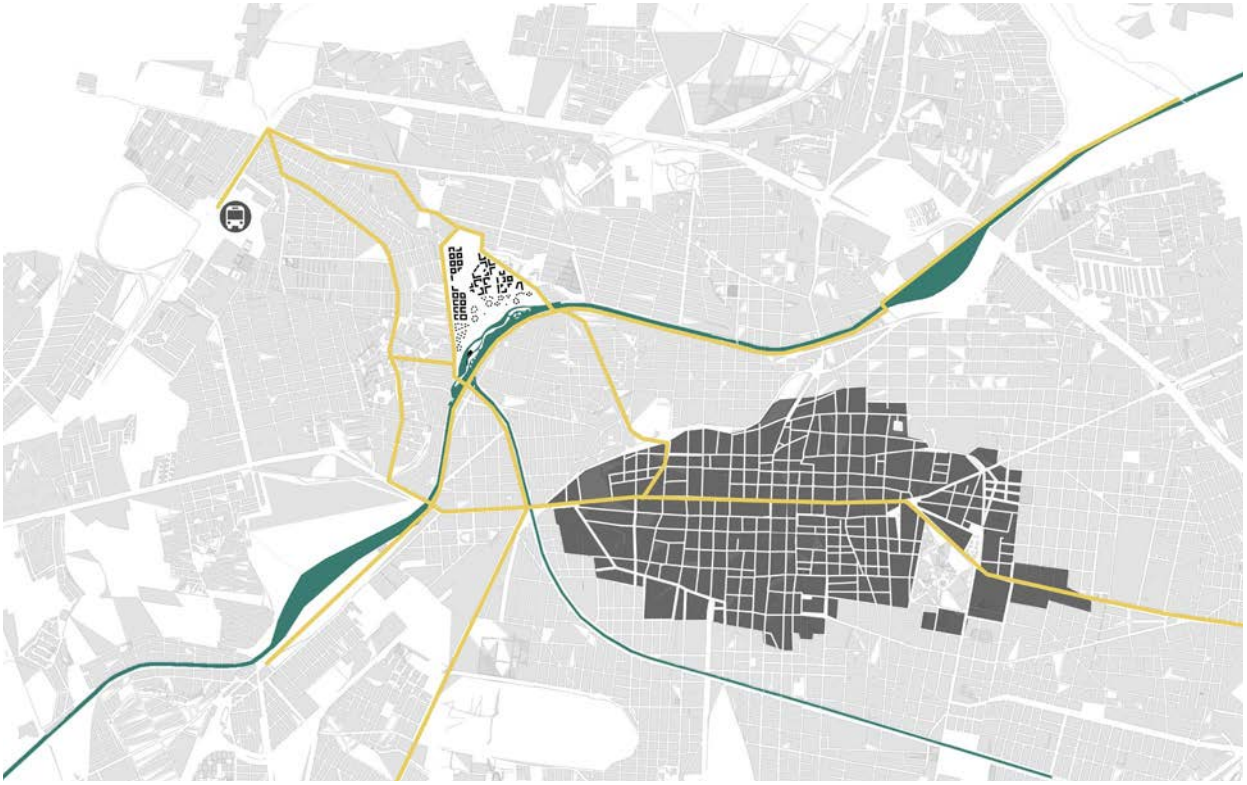
Building Hights

New Existing

New and Existent Developments

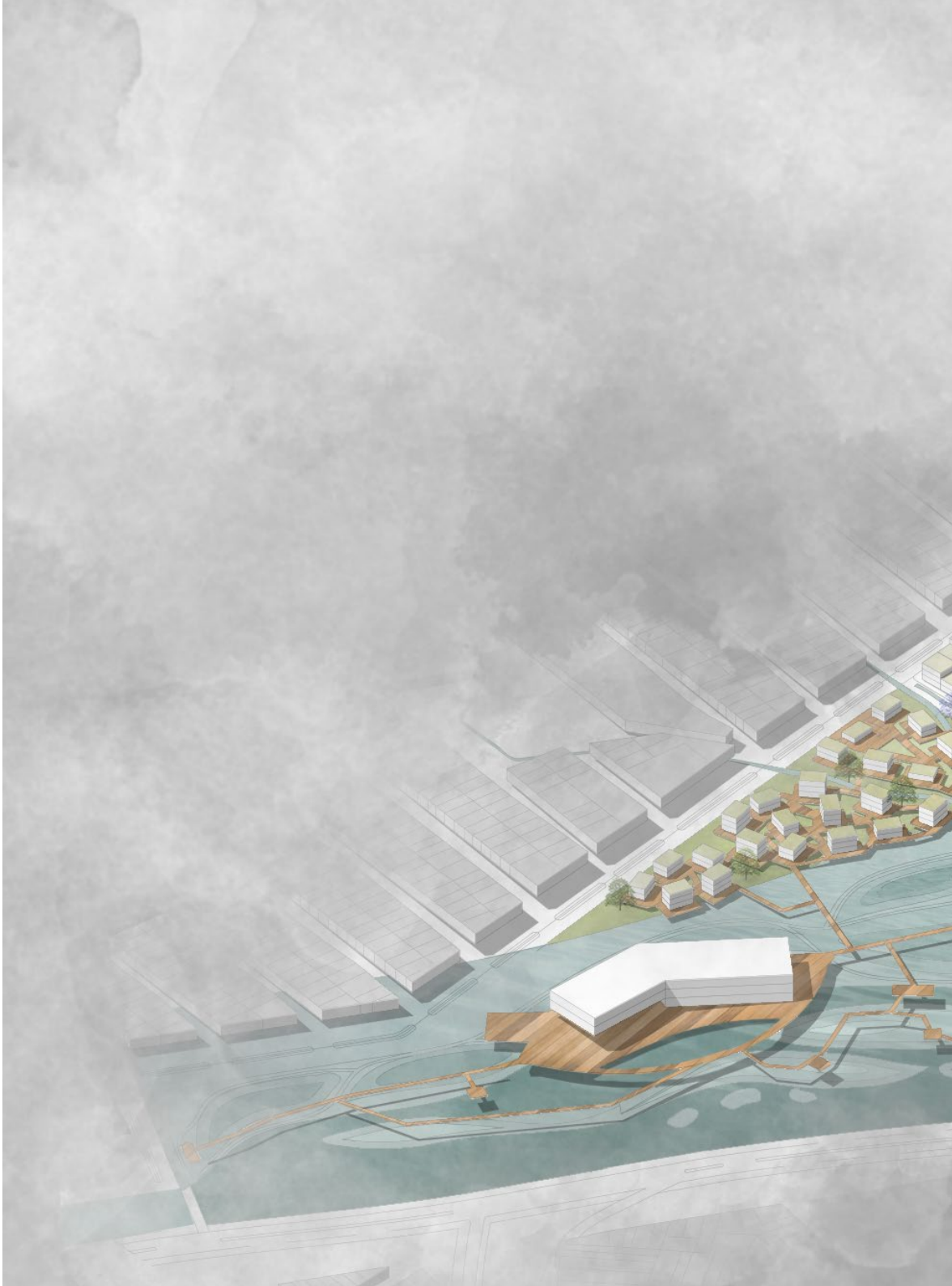


Green Connections



Public Transportation. Bus.

Site's
Bird-Eye view during a
yearly flood event.

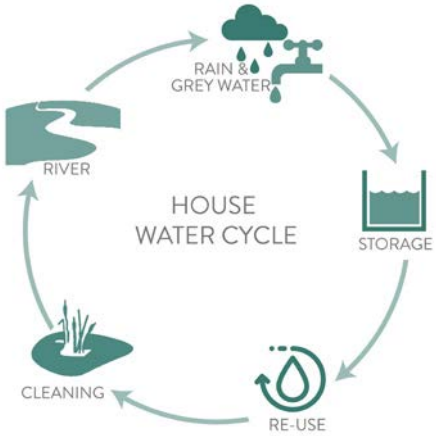


WATER MANAGMENT

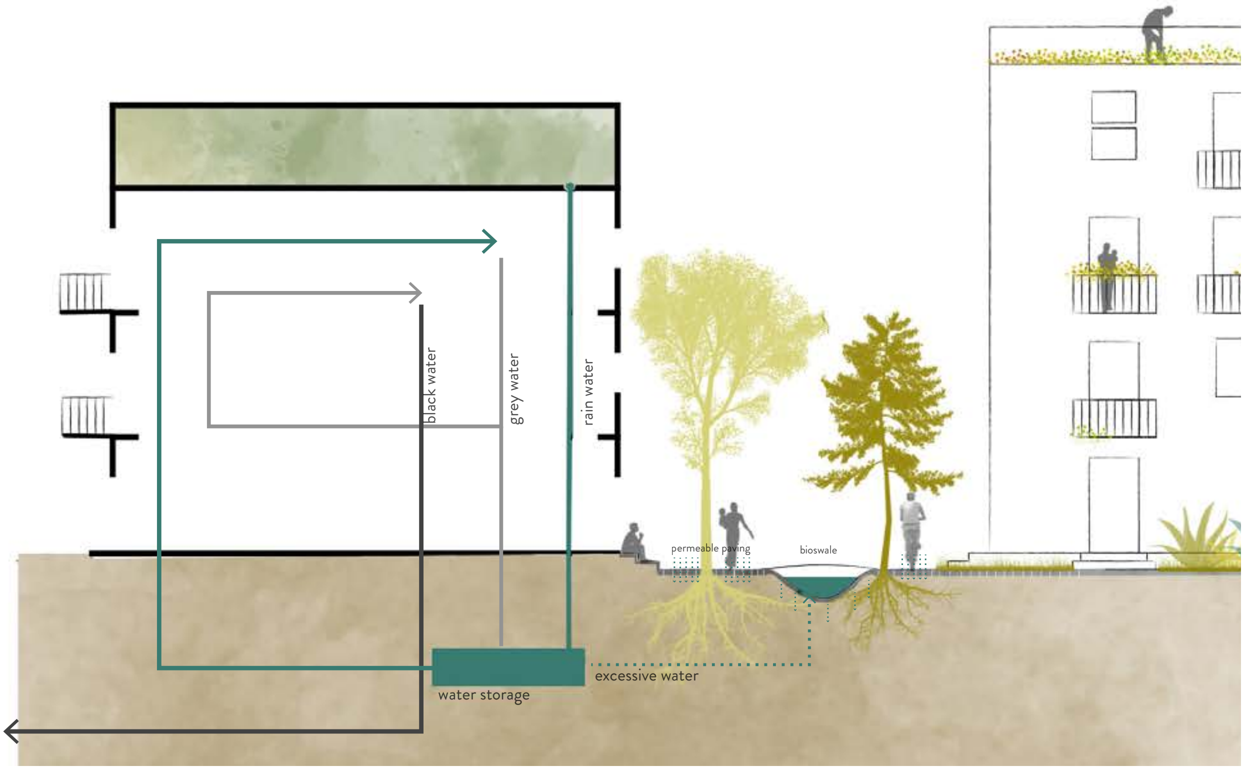
There is a water cycle proposal for the whole site, that covers from the house water cycle to the neighborhood water cycle. It also takes into consideration the management during different periods of the year, from dry season to extreme flood events.

As stated on the strategies, most of these is achieve by topography modification, channels restoration, wetland reincorporation, sustainable drainage systems and implementing permeable surfaces.

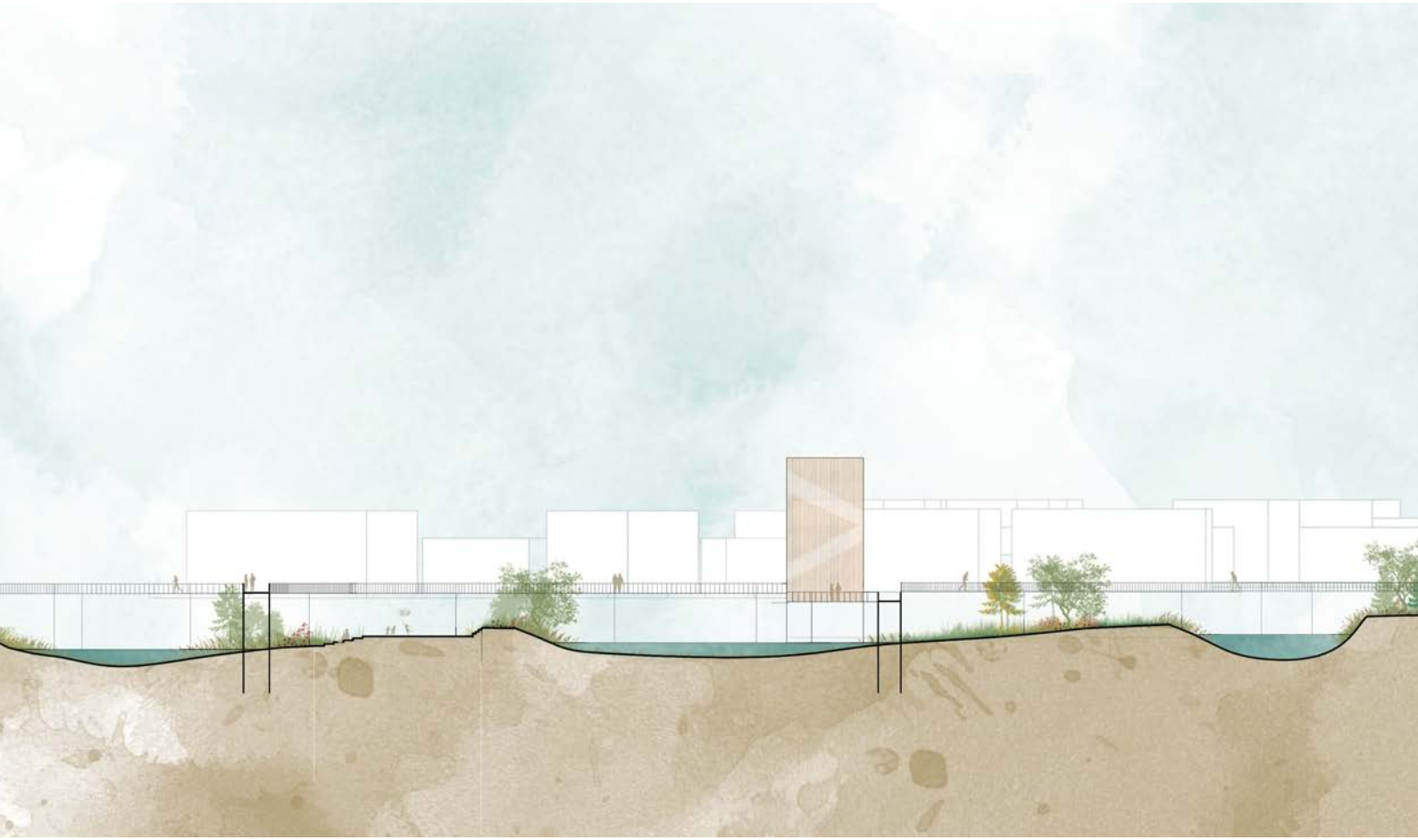
The water management starts in the housing development, where grey and rain water can be resorted and reuse in the house and/or send into the swales and later and later on into the ponds where it can be cleaned, so after wards it can infiltrate into the ground or flow into the river.



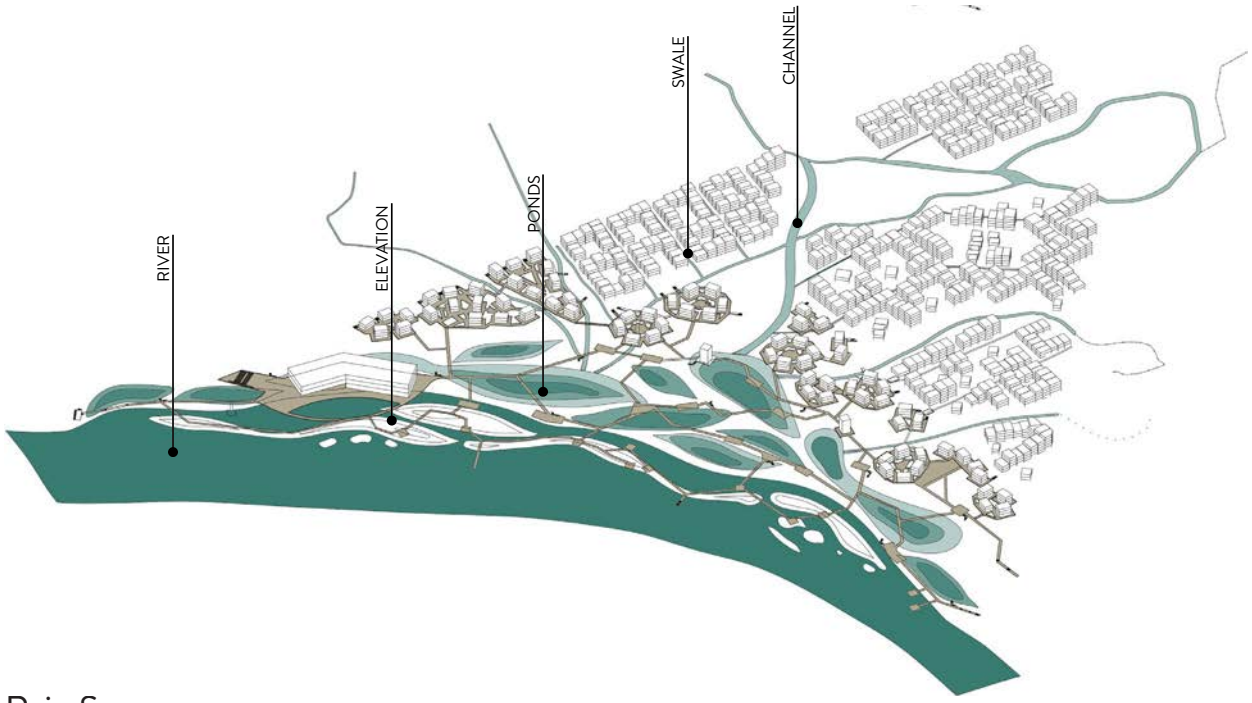
House Water Cycle Section
Original Scale 1:200



Section A. Wetland Park.
Original Scale 1:500



SEASONAL WATER MANAGMENT



Rain Season

Dry Season

Yearly Flood

1 in 100 years Flood Event

Wetland Park
Visualization During
Rainy Season

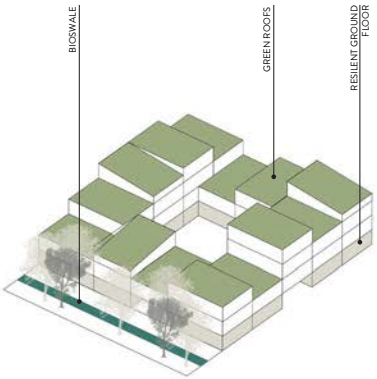
HOUSING TYPOLOGIES

As it was said before, there are three different resilient housing typologies: Wet-proof, elevated and dry-proof. The first two, would be new buildings whereas the last one is a strategy adapted into existent buildings.

Most of the buildings, 72%, are wet-proof typologies, they preserve the structural integrity of the building by allowing the water into the building, this is achieved by building with resilient building materials and making some changes regarding the electricity and sewage build up. The elevated buildings are near areas more prompt to flooding and are raised above the predicted flood level, they are 24% of the housing typologies. Lastly, the dry-proof typology are the existent buildings that, because of their characteristics and location can be saved, they are surrounded by open space and a wall made of impermeable material in order to protect the building.

All they typologies are connected and linked besides the difference between them. The new typologies are designed to have a small courtyard or patio in the middle, this based on the city center traditional architecture, this can vary specially is there are existent buildings in the zone. However, the overall idea is to create a cozy semiprivate space for the residents. Houses would also have the possibility of having green roofs and solar panels.

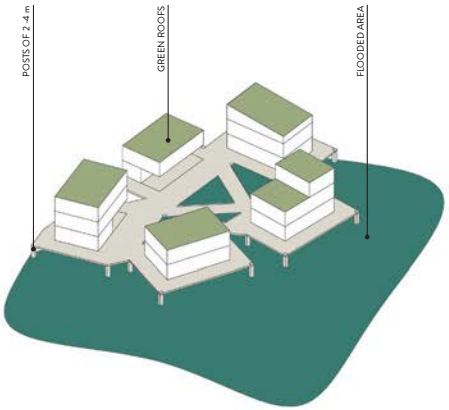
There would be three types of streets in the site, the first kind are the main streets, that already exists on the sites but they would be modified to be more pedestrian and bike friendly. The second type are inside the site and are shared streets. Finally, the third kind are pedestrian only and they are the ones with swales.



WETPROOF
WATER ENTRY STRATEGY

FLOORS 2-6
PERCENTAGE 72%
FUNCTIONS

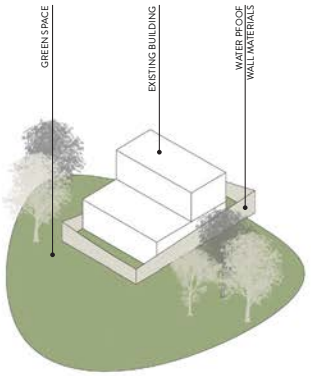
Wet-proofing buildings seeks to preserve the structural integrity of the building by preventing the build-up of water pressure and using resielnt building materials.



ELEVATED

FLOORS 2-4
PERCENTAGE 24 %
FUNCTIONS

The elevated buildings are raised above the predicted flood level by using structural posts.

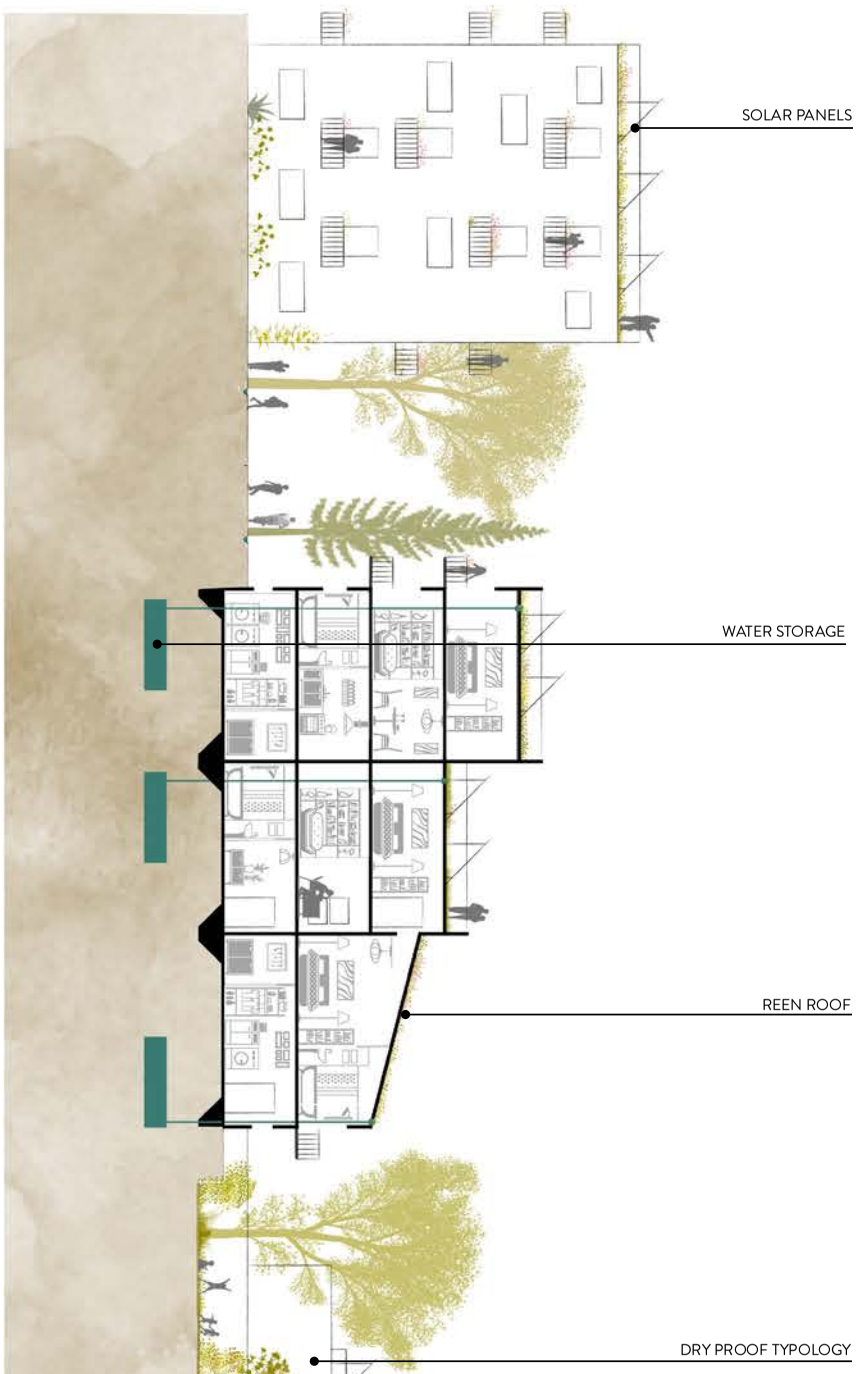


DRYPROOF
WATER EXCLUSION STRATEGY

FLOORS 1-2
PERCENTAGE 4%
FUNCTIONS

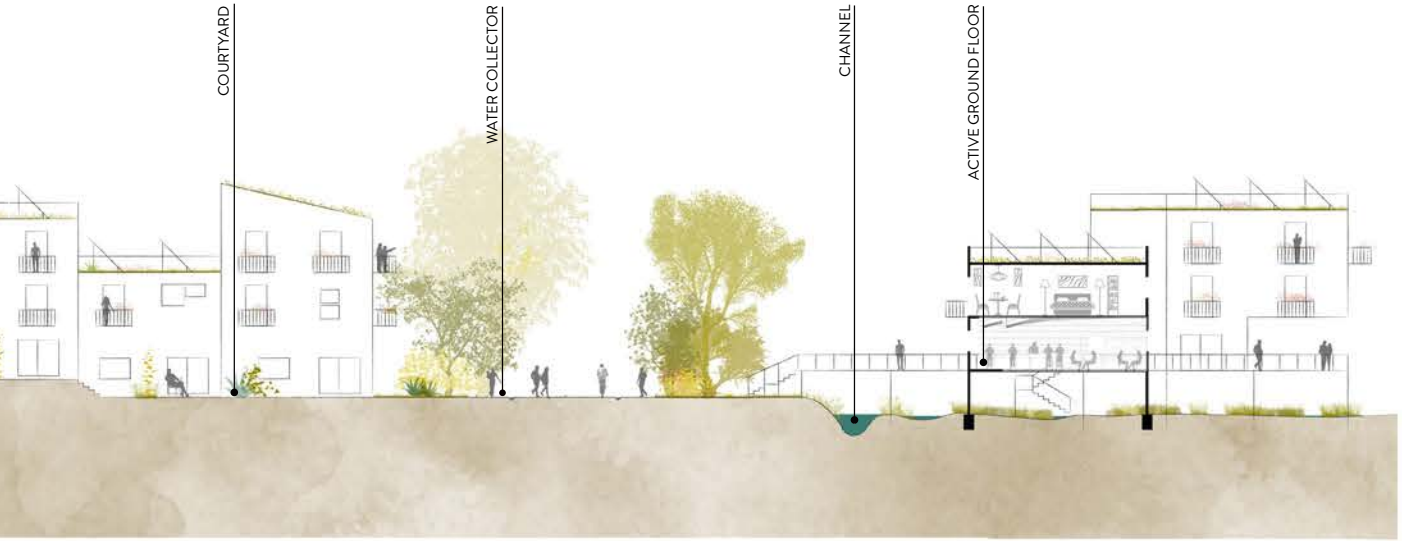
Dry -proofing is a measure to make a building resistent to flood damage by taking the building out of comtact with flood waters. It's use for existing buildings.

Section B. Typologies.
Original Scale 1:200




WETPROOF TYPOLOGY
ELEVATED TYPOLOGY

Section C and Detail Plan.
Typologies. Original Scale 1:200


COURTYARD
WATER COLLECTOR
CHANNEL
ACTIVE GROUND FLOOR


PARK
AN PATH
CHANNEL
ACTIVE GROUND FLOOR
TYPOLOGY
ELEVATED TYPOLOGY

Wetproof and Dryproof
Typologies. Visualization.

Phasing

PHASE 1

BUILD NORTEAST AREA

RELOCATE POPULATION

TRAIN TRACKS RECONFIGURATION

DEMOLISH MORE AFFECTED AREA

PHASE 2

DEMOLISH NORTHWEST AREA

BUILD NORTHWEST AREA

BUILD NORTH PARK

STREETS RECONFIGURATION

PHASE 3

MODIFY TOPOGRAPHY

BUILD WEATHLAND PARK

PHASE 4

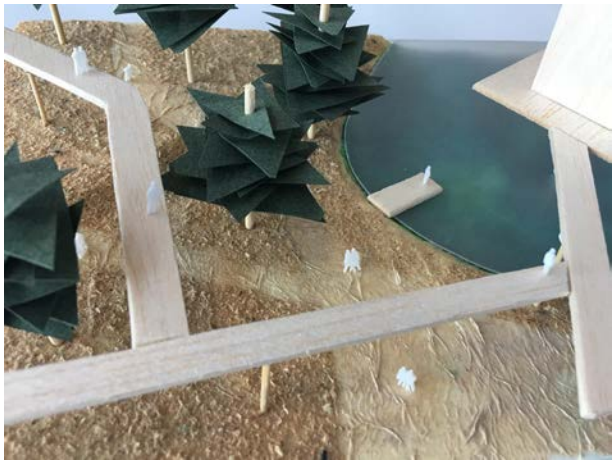
BUILD LIBRARY

BUILD ELEVATED STRUCTURES

Elevated Typologie.
Visualization.

Site model
1:2000

Wetland model 1:200



07 DISCUSSION

As it was said on the introduction, floods are hazards that affects all continents and all kind of countries regarding of their economy or progress. This projects leaves me with the reflection on the importance of urban planning and consequences to build so close to water bodies without having this important factor into consideration.

Also, it brought me awareness on the need for experiment and build for water in an inclusive way, instead of hiding problems or try to solve them in “traditional” ways that need a lot of investment and maintenance that a developing country can’t afford. Instead we should turn this disadvantages into strengths, we should look at nature (again) and learn from it, we should be humble and acknowledge that water, as nature, will always find its way.

The project tries to tackle flooding problematics and turn them into opportunities with a sustainable approach, relying on mimicking nature to achieve a solution. Having as my pillars the parks, housing and the vision for the city; I would have liked to go into deeper in some aspects, such as the fauna and flora, the building materials and to have a more detail strategy on how to connect the city to the vision.

Lastly, the project could have been seen as a very bold proposal for a country like Mexico, and it can be questioned whether or not it would be feasible for being a developing country. On this, is worthy to say that it is better to plan bold, either they project can go through or it can be seen as an inspiration that can trigger other more “down-to-earth” proposal. At the end, what is looked for is to bring a better quality of life for the people that lives in these conditions, while at the same time, making a room for water.

08 PROJECT RESOURCES

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A ROOM FOR WATER

Designing for Flooding. The case of a Medium-Size Mexican City.

Master Thesis Report
Sustainable Urban Design
School of Architecture, Lund University
May 2018

Author: Margarita Rodríguez
Supervisor: Louise Löverstierne
Examiner: Peter Siöström

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