INTEGRATED MITIGATION

Flood Risk mitigation fostering Social Integration

Transitional Territories studio

FRANCISCO MONSALVE

1st mentor: Fransje Hooimeijer

2nd mentor: Taneha Kuzniecow Bacchin

Dedicated to my family.

Msc Thesis - P5 Report

Synergetic Infrastructures

Delft, June 24, 2019

Authors:

Francisco Monsalve Cazorla
(monsalvefrancisco87@gmail.com)

1st mentor: Fransje Hooimeijer

2nd mentor: Taneha Kuzniecow Bacchin

Research Group: Transitional Tarritories
MSc Architecture, Urbanism and Building Sciences
Track Urbanism

Faculty of Architecture and the Built Environment

Delft University of Technology

The Master program and the thesis where sponsored by:
Secretaria Nacional de Educación Superior, Ciencia, Tecnología e Innovación - Ecuador
(SENESCYT)

CONTENTS

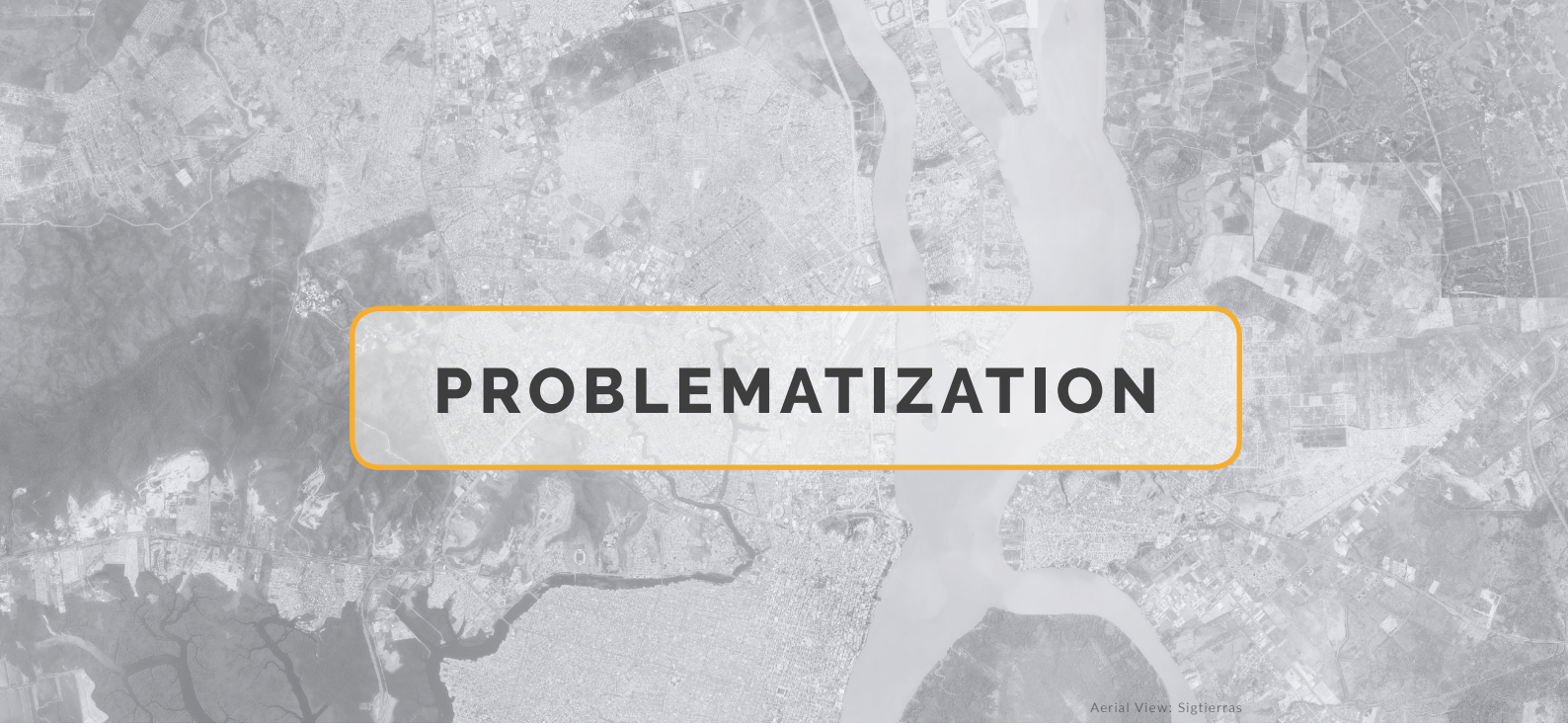
ABSTRACT

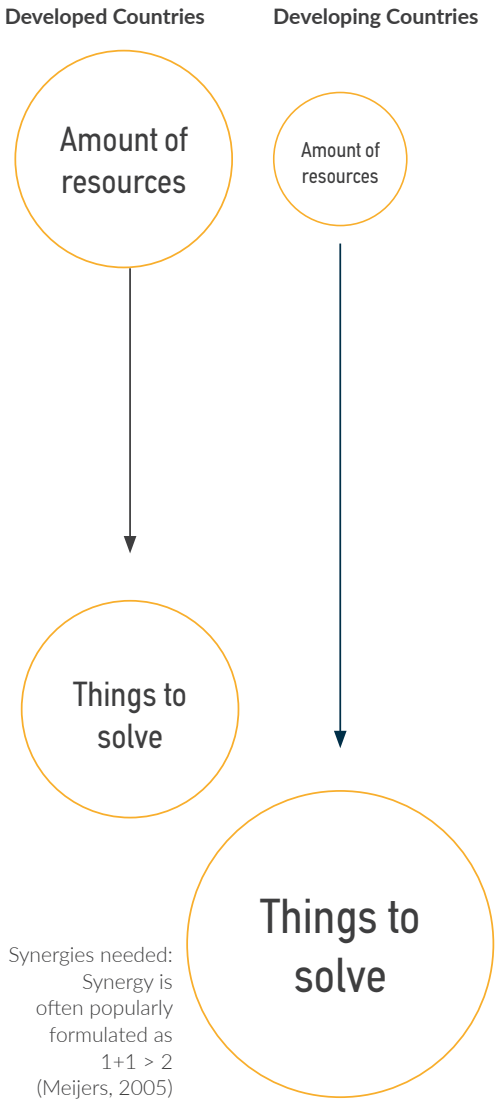
Guayaquil is the 2nd Largest city of Ecuador, located in one of the largest estuary ecosystems of the pacific coast in South-America (Delgado, 2011). Since 1960's the city has gone through a rapid process of urbanization and informal settlements. This has caused severe spatial segregation and a development model that ignores the existing biophysical characteristics of its land and water. With increasing global environmental threats, Guayaquil faces big challenges related to future flooding vulnerability that can eventually have consequences nation-wide. Characteristics of the developing world are also present in Guayaquil, evidencing the need for an approach aiming to solve more than one issue at the time. In this context, Flood Risk and Spatial Segregation are the core problems considered for an integrated strategy. Neighborhoods that show evidence of spatial segregation are better bridged by stablishing a green and blue infrastructure which improves the geometrical configuration of the street network. This enhances the flow of non-locals (according to Legeby people leaving further than 1000m) through the previously fragmented areas. Along this network spaces for mitigating flood risk and fostering social integration are implemented. Schools appear as key elements in the city offering big potential for creating areas for interaction and space for water storage.

Keywords:

Flood risk, Spatial segregation, Open Schools, Infrastructural ecology, Guayaquil, Ecuador.

June 24th
2019





Synergies needed: Synergy is often popularly formulated as 1+1 > 2 (Meijers, 2005)

Problem statement:

Guayaquil is the 2nd Largest city of Ecuador, located in one of the largest estuary ecosystems of the pacific coast in South-America (Delgado, 2011). Hosting the main port of the nation and contributing to the 25% of the national gross domestic product (MG, 2000). The city could be considered as one of the main motors of Ecuador's Economy. However, since 1960's the city has gone through a rapid process of urbanization and informal settlements. This has caused severe spatial segregation and a development model that ignores the existing biophysical characteristics of its land and water. With increasing global environmental threats, Guayaquil faces big challenges related to flooding vulnerability that can eventually have consequences nation-wide. Characteristics of the developing world are also present for Guayaquil, which evidences the need for an infrastructural approach integrated to the existing delta ecosystem and aiming to solve various problems simultaneously.

-Research questions:

-How can a coordinated strategy mitigate flood risk and diminish spatial segregation following the Infrastructural Ecologies paradigm? This is tested in case study of Guayaquil (Ecuador) by conducting a case study with explanatory and exploratory research methods.

Secondary Questions:

-How are water systems influencing to flood risk in Guayaquil?

-What is the current spatial distribution of housing according to socio-economics?

-What steps could be taken in order to mitigate flood risk in Guayaquil?

-What steps could be taken in order to mitigate spatial segregation in Guayaquil?

AIMS

Photo source:
Alexander peña

L1

L2

-How can flood risk mitigating actions improve socio-spatial integration? And vice versa, How can Social integrating actions can improve the mitigation of flood risk?

Context

Even though the majority of green-house gas emission leading to global warming were generated by developed countries, climate change and sea level rise will present the biggest challenges in developing nations.

The accumulation of conflicts in the developing world calls for a rethinking of the problem-solving approaches currently practiced. The main believe of this project is that a flood risk mitigation be strategically structured in such a way that it improves socio spatial integration. Such a synergetic strategy could increase the efficiency of the city's functionality. In order to develop the previous assumption a strategy will be outlined.

Objectives

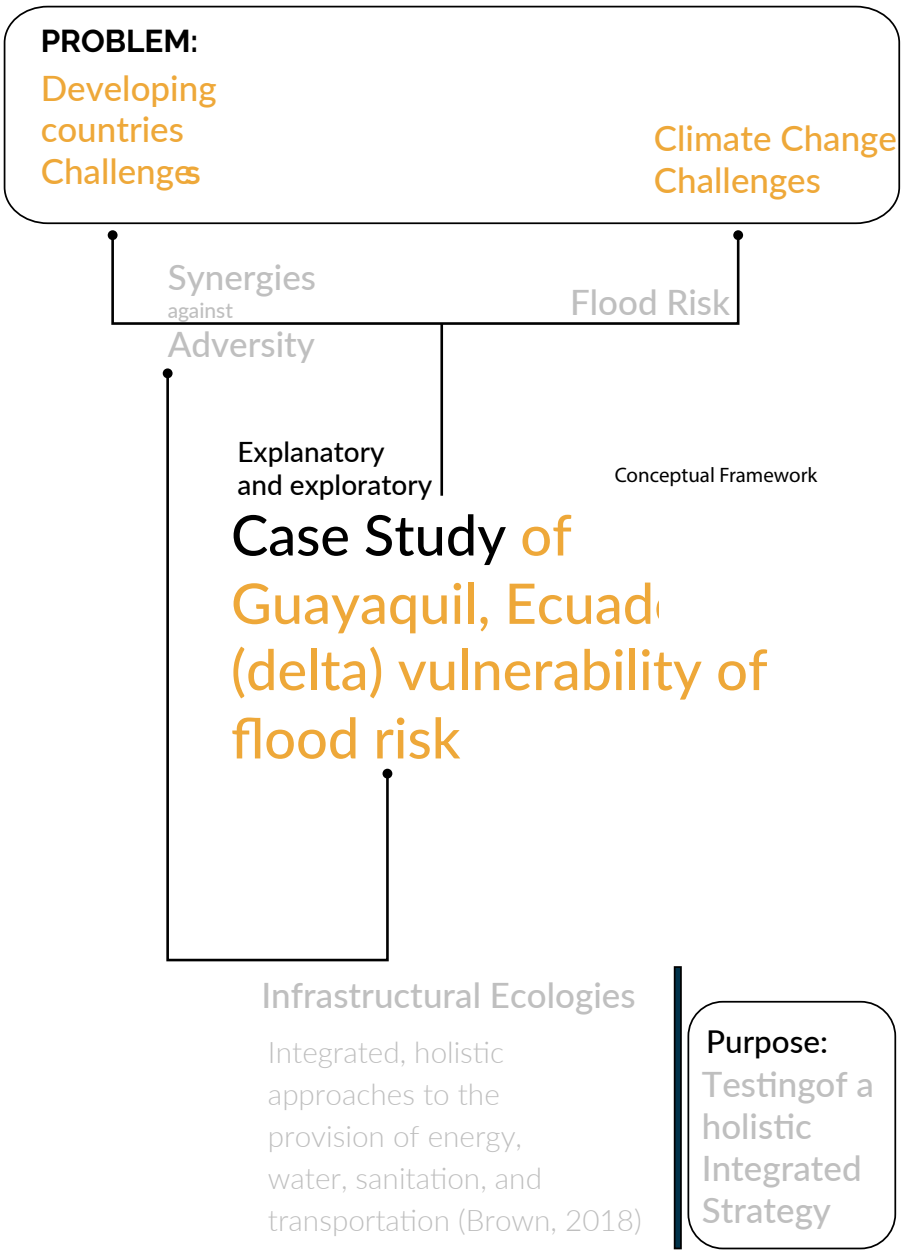
-The strategy should aim to outline concrete actions that can improve more than one problem at the time.

-The analysis should clearly explain the Water systems dynamics in Guayaquil, and possible approaches to mitigate flood-risk

-The analysis should reveal the existing distribution of socio-economic groups their integration status.

Logo 1 by Eucalyp from the Noun Project

motivating challenges



-Products and outcomes

-Analysis of current relation of Guayaquil to its biophysical ecosystem.

-Analysis of biggest factors within water systems contributing to Flood Risk Vulnerability in Guayaquil

-Integrated Strategy under planning paradigm of infrastructural ecologies.

-Visualization of new potential condition.

-Spatial distribution of houses based on Socio-Economic groups.

-Surface water flow in Guayaquil.

Direction of surface water

Drainage segments

-Guidelines for potential spatial intervention.

-Integrated strategy for Flood risk mitigation and Socio spatial integration.

THEORETICAL FRAMEWORK

Image source: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

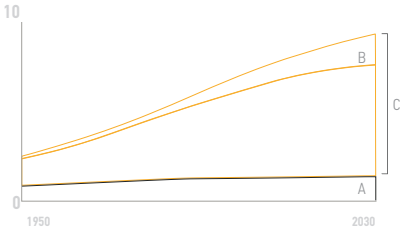
Climate change challenges and the Developing World

Adversity

The variation in weather is continuously increasing, and the question of How Vulnerable are we? arises. Along with the potential frequency increment of extreme weather events, "the vulnerability of Developing Countries to extreme weather events may also increase" (M. Monirul Qader Mirza, 2011).

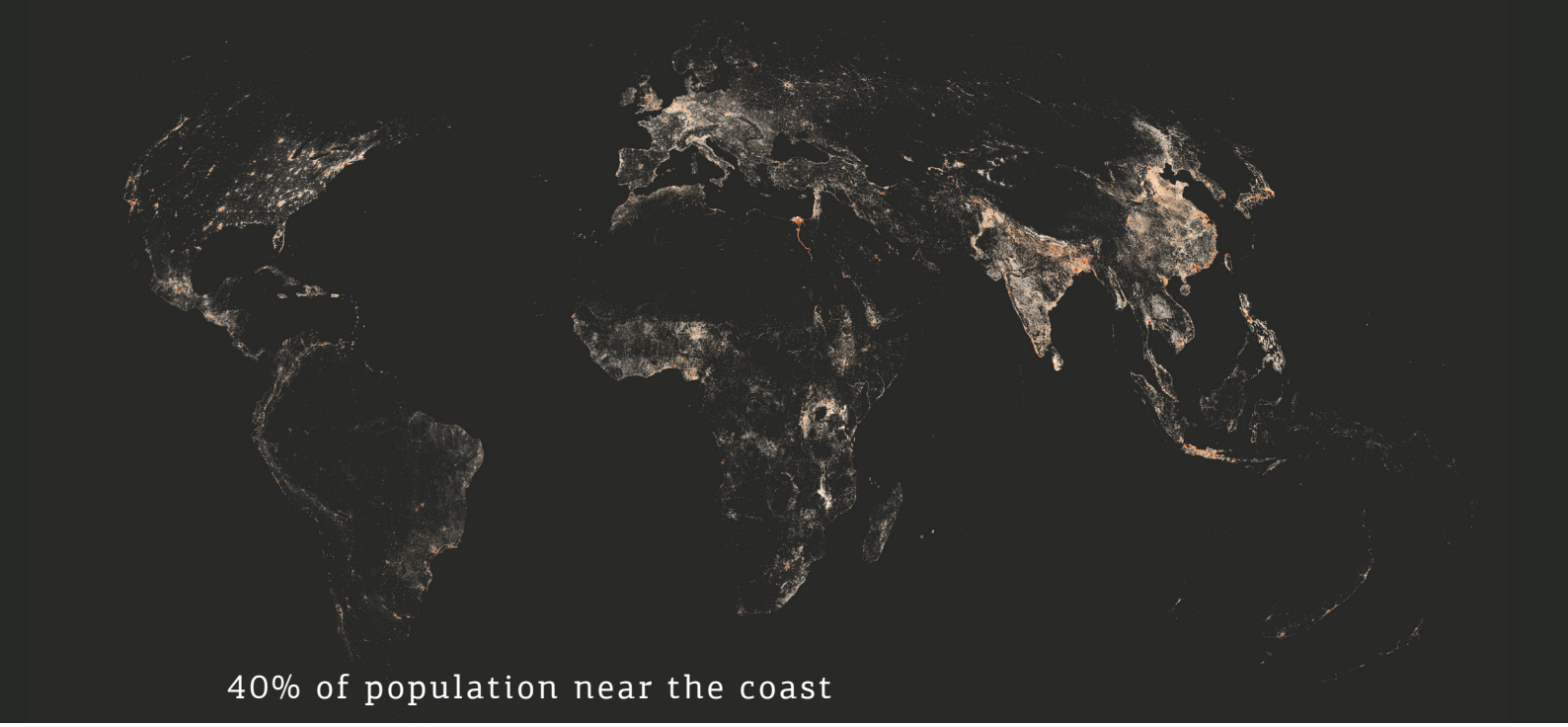
In places where the vulnerability is high, most of the efforts, attention and funding focuses on the stages following major disasters instead of the pre-hazard risk mitigation. (M. Monirul Qader Mirza, 2011). Indicating that the efforts are more focused on taking the smallest impact from the hazard instead of looking for approaches of previous precaution. This may obey to the fact that Developing Countries face complex situations related to "Rapid urbanization; lack of financial, organizational and human capital; and diminishing natural resources" (Brown, 2018). This adversity makes the topic of climate change adaptation to fall down in the list of priorities for the inhabiting populations.

The majority of the Globe's population resides in Developing Countries. According to the Population Reference Bureau, by 2018 the inhabitants of Less Developed and Least developed countries represent the 83% of the globe's population. This mark is likely to increase to 85% by 2030 and to 87% by 2050. (PRB, 2018). An increment in attention about climate change affecting Developed Countries is required, since -based on previous facts- the Ground Zero of Extreme Weather Events affecting sensitive settlements will be in Developing Countries.



A) Developed countries, B) les

PRB. (2012, July 2012). World Population Trends 2012. Retrieved from Population Reference Bureau: https://www.prb.org/world-population/



40% of population near the coast

Visualization: Author. Data source: European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network – CIESIN (2015): GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-ghsl-ghs_pop_gpw4_globe_r2015a

Coastal inhabitation

Furthermore, the threats of Climate change don't only depend on the development level of a nation but in its geographical location. With Climate change, temperatures fluctuation will take place in the ocean a land surface. Meaning that the presence of water will vary. Bringing with it, the extreme cases of flooding or droughts (M. Monirul Qader Mirza, 2011).

Because of sea level rise, coastal areas are especially relevant when we talk about climate change affecting urban settlements. More than 40% of the entire population lives within 100km off the shore, and more than half within 200km (UN Atlas of Oceans, 2002). However, sea level rise will not only affect the inhabiting populations but the infrastructure in which our societies relies for daily operation (ports, airports, transportation stations, etc).

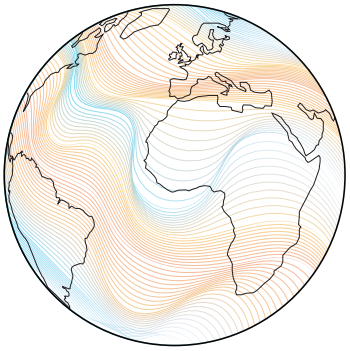
"Products - and therefore money - traditionally flow into countries through their ports. This has set a precedence for populations to naturally migrate towards coastal areas" (UN Atlas of Oceans, 2002). Is not surprising that more than 90% of all the trade is done by shipping (UN, 2017). With these circumstances Flood Risk is one of the biggest threats imposed by climate change.

Flood risk

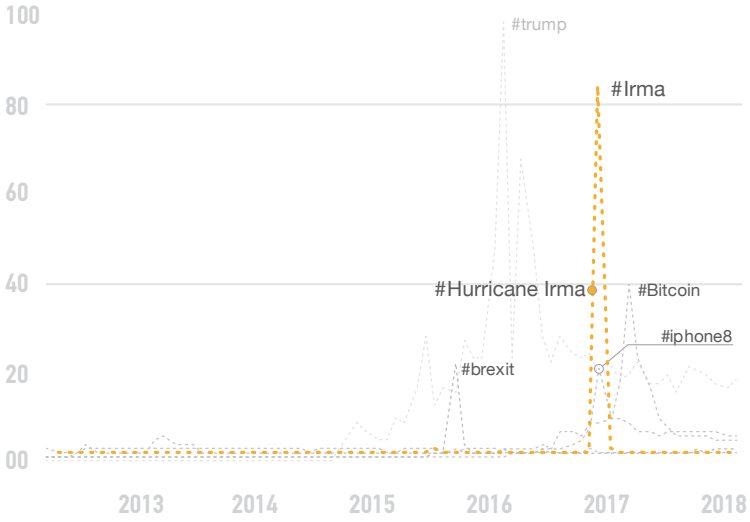
The relation between infrastructure and flooding is particularly interesting, according to Belanger, the concept of Infrastructure as "the collective system of public works that supports a nation's economy… originated during military planning over the past 500 years but gained importance in the US during the great Mississippi flood of 1927" (Bélanger, 2009). Evidencing the long existing link between Flood mitigation and Infrastructure.

Flood risk and extreme weather events are not a problem awaiting around the corner, they are already present, and our concern and fear has been evident. This became especially notorious a year ago, 2017. In 2017 the major global peak search done in the Google search engine was "Hurricane Irma", even surpassing peaks as the one generated by events such as "Brexit" (in 2016) or consumer technology products as "iPhone 8" (2017). The peak of Hurricane Irma was only matched by the highest trend point of the term "Bitcoin" (not a single peak). However, the single term "Irma" showed a peak twice as big as the highest trend point generated by "Bitcoin". This has not been an isolated case, in 2005, a big peak generated by Hurricane Katrina was also spotted. It is undeniable the impact and alarming feeling extreme weather events could have in economy and ultimately in society.

Hurricanes are formed on top of warm water currents, affecting mostly coastal areas. They cause severe damage in settlements and generate heavy rain fall eventually leading to flooding. Hurricanes take place primarily in tropical areas, but this does



Climate Change affecting the whole planet



not mean that the rest of the world does not witness extreme weather events. Actually, warming water temperatures are usually related to the El Niño Southern Oscillation.

El Niño Southern Oscillation (ENSO) is a phenomenon in which the water of the Easter part of the pacific warms and with it generates recurrent precipitation. The phenomenon is popularly known for its influences on tropical climates, and hurricane frequency incrementation in the tropics. It is presumed cyclical but an exact measurement about time or periodicity has not been possible to state. This phenomenon has caused severe flooding in years when it has stricken strongly. One of these years was 1998, and the Latin American coasts of Ecuador and Perú were severely affected.

Flood mitigation, a Referential Strategy

Polder model.

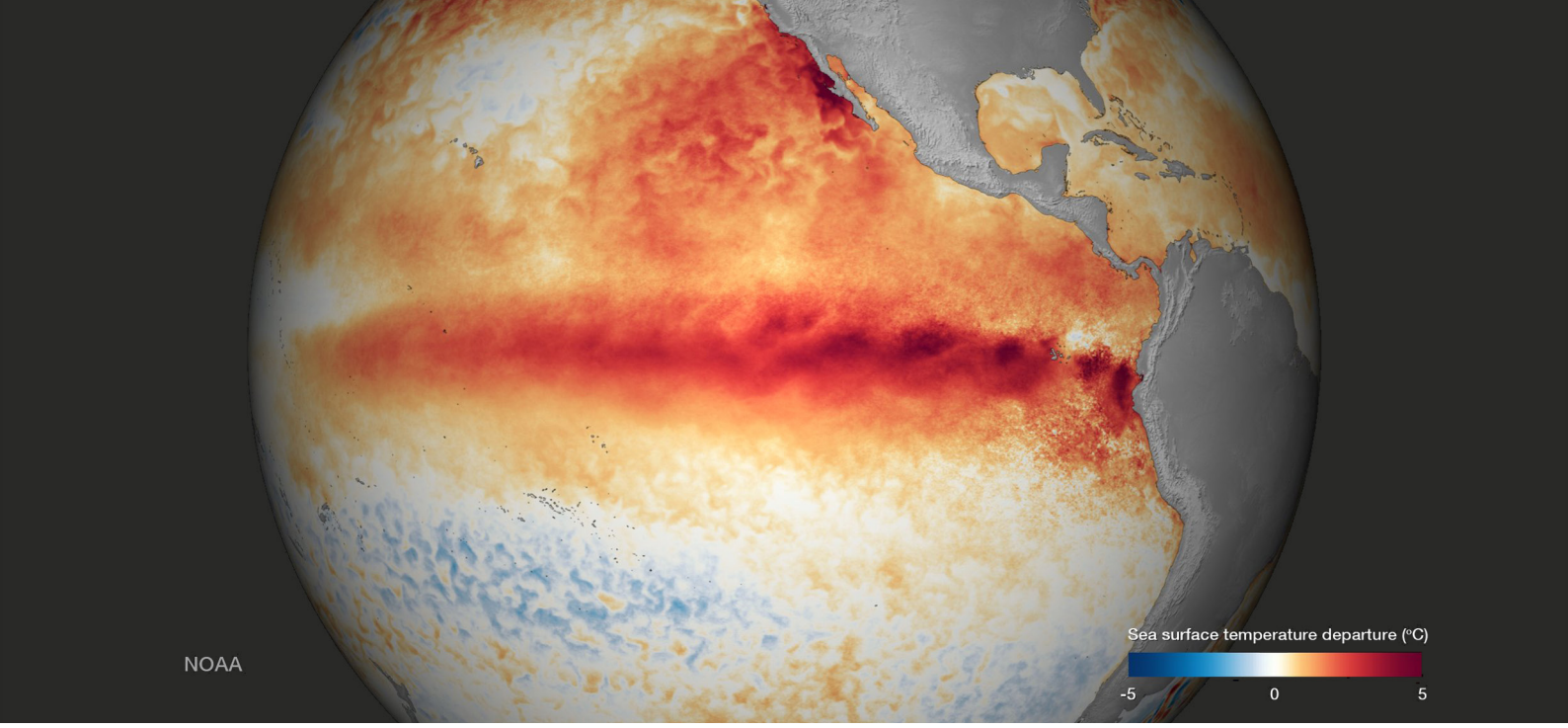
In this context, many countries are seeking to stablish policies and infrastructure in order to deal with flood risk. To do so, taking a look at foreign experiences has become usual. The Netherlands with its long history of dealing with water is a regular referent. Since the 17th Century, the Dutch polder model has been part of Dutch planning (Schreuder, 2001). The polder, - "an area of low-lying land reclaimed from a body of water and protected by dikes against flooding" (Schreuder, 2001) - is the central piece of the Dutch planning tradition. According to Schreuder the polder model is an example of "cooperation between capital, labor, and the state" (Schreuder, 2001). It is a demonstration of the tradition of consensus building among those different sectors in this country. Is important to say that the polder model has deeply influenced on how the role of private and public property is understood. The private property is fully respected, but it is understood that there are cases where the collective benefit stays above the particular one.

Even though, the polder model is a remarkable achievement that enabled human inhabitation and later a fertile land cultivation. Its direct emulation abroad has seemed difficult due to a couple of reasons. One is the contentious relations between public and private sectors in other planning cultures. Another one could be that, the system protects a Densely populated country with a high GDP per Capita which at the end provides the means for a concise and proficient coastal defense for protecting dense presence of population and resources.

The mentioned characteristics of the Polder model make it an important referential method, but a different approach needs to be adapted for developing countries to counterbalance Climate Change challenges.

Infrastructural ecologies paradigm, a Synergetic approach

In order to efficiently use the limited resources possessed by developing countries, synergies are



Visualization & Data source: NOAA, July 2015

needed. “Synergy is often popularly formulated as 1 + 1 > 2, which, however, emphasises well that synergy can be expressed as the rise in performance of a network through efficient and effective interaction” (Meijers, 2005). Synergies generated from the available resources is one of the only options to deal with all the problems at stake.

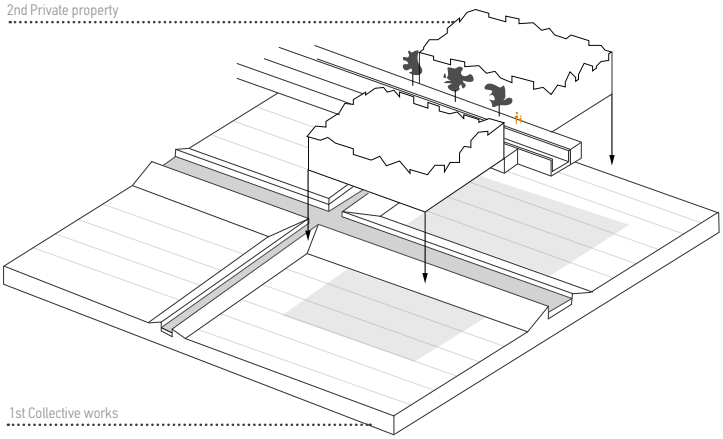
Brown & Stigge have developed and outlined an approach that takes into consideration the current conditions in what is now called the Global South. They suggest an approach for the provision of basic services (water, energy, sanitation, food and transportation) capitalizing on synergies. This approach is developed under the planning paradigm of Infrastructural Ecologies. They suggest that this system capitalizes on the synergies of the flows and contributes to refute the “persistent misconception that economic and environmental values are at odds” (Brown & Stigge, 2017).

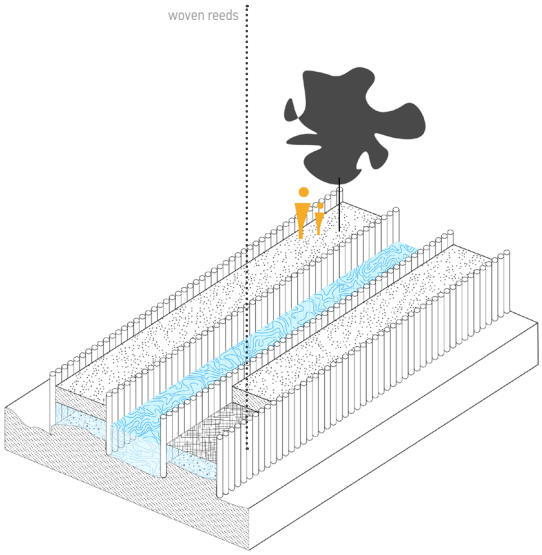
“Even in resource-rich nations, meeting infrastructural needs continues to be a daunting task. The problems are almost unimaginably more severe in developing nations, which face a host of additional difficulties–rapid urbanization; lack of financial, organizational, and human capital; and diminishing natural resources” (Brown & Stigge, 2017)

This paradigm sees an opportunity in the creation of infrastructure and services that benefit one another without diminishing their respective performances; avoiding infrastructure construction that serves for only one porpoise. The better understanding of this potential can change planning practice for good.

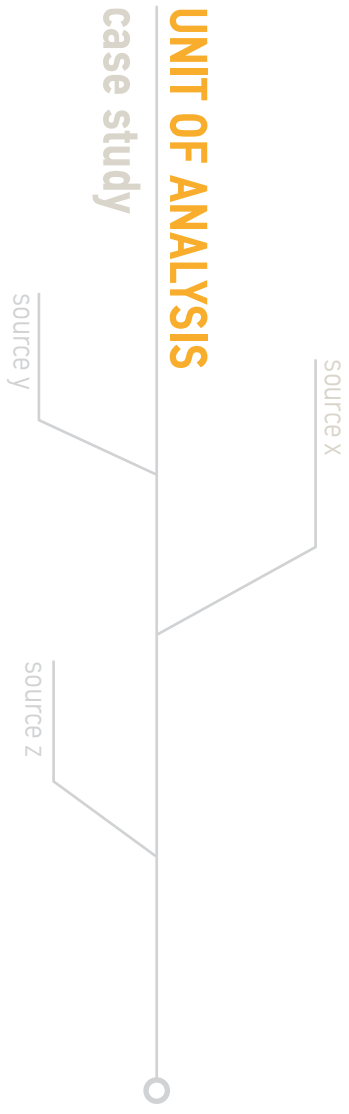
To illustrate their logic, some examples mentioned by Brown & Stigge: The first is Chinampas, an example developed by pre-Columbian civilizations in the valley of México. They consisted on rectangular plots planted in shallow waters, delimitated by wooden stakes. Inside these areas on top of beds bounded by woven reeds mud from the lake bed was placed along with other organic matter (Brown & Stigge, 2017). The chinampas offered agricultural services and expansion of the land. They became a busy area of the settlements and transportation happened through the canals. The approach “allowed two to seven crop yields a year of maize, tomatoes, peppers, moniac, edible greens, and root vegetables, at a scale capable of feeding large urban populations” (Brown & Stigge, 2017). All the nutrients and the created microclimate attracted “fish, turtles, crustaceans and waterfowl” (Brown & Stigge, 2017). Because of the way they were constructed they were most of the year self-irrigating and self-fertilizing. (Brown & Stigge, 2017). Chinampas evidence that more than one objective can be achieved by punctual spatial actions.

Another exciting case outlined in the book shows how infrastructure (in this case telecommunications) with more than one porpoise can be beneficial for users. It is explained under the notion of “Commensalist Association” (Brown & Stigge, 2017). Nowadays, most of the population in the developed world has access





to financial services (putted simply, to credit cards and debit cards), which at the end foster economic growth and streamline the movement of money. What happened in central Africa is that lacking banking services “individuals in several central African nations had improvised ways to use mobile airtime to transmit money simply by transferring mobile minutes to friends or relatives”. Reeling in the clarity and speed of the mobile sector mobile money became a thing and the praxis expanded rapidly in nations inside and outside Africa (Brown & Stigge, 2017). The opportunities behind a simple paradigm switch are enormous; specially for countries where resources are scarce. The proposal developed in this project will be structured under this planning paradigm.



METHODOLOGY

Image source: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

Chapter purpouse

The main aim in the development of the methodology chapter has been to find suitable and data and frameworks capable of containing the needed actions. The project is structured under Case Study Research methods.

The chapter describes the research approach based on Problem Statement, Research Motivation, Research Questions and Products & Outcome. Then the specific approach and methods are explained in 2 phases. An analytical and one (explanatory) and based a prepositive one (exploratory)

Why a case study?

What Type of case study?

The methodology is based on the literature developed by Robert K. Yin in his book Case Study Research: Design and Methods.

Given the fact that the subject of the research is related to current flood risk and possible synergetic opportunities in Guayaquil – Ecuador; The understanding of the context of the project is the central point (environmental, social, spatial). Due to the importance of understanding the context, the methodology of Case study appears as one of the most suitable methods. Since "A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2014). The approach provides the opportunity for analysis based on different data sources, always having the units of analysis as central.

Within the aforementioned method, the type of study may vary. According to Yin, the three principles porpoises can be "Exploratory, Explanatory or Descriptive" (Yin, 2014). To define the subsequent stages, it is important to first define and chose the most suited type.

Given that the systems present in the city are complex and considering that the aim of the first stage is to create a clear understanding of the city, the Explanatory approach suits the purpose. Once this understanding is built the approach needed is different. Therefore, a second phase will follow; Taking the reading of the city from phase 1 as a starting point. Phase 2 will be done under an exploratory conception, and a strategy responding to the problems in Guayaquil will take place.

-RESEARCH APPROACH

A. Explanatory Phase 1/2

In the first stage based on various sources of information an explanatory analysis will be carried out. The objective is to understand which events have influenced Guayaquil to be identified "among

Descriptive study	Explanatory Study	Exploratory Study
Seeks to build a sequence of events in a phenomenon possibly not described above. (Yin, 2014)	According to Yin, this type of study seeks to clarify which are the links that generate or generated the current reality. "The objective of the analyst should be to propose competitive explanations for the same set of events and indicate how such explanations can be applied to other situations" (Yin, 2014). For example, by exploring different sources related to the same phenomenon. As an example, a biography of a person can be done under this method, since it links sources and provides an explanation.	Begins with the intention to find a response related to a hypothesis. The answer may assert or contradict previous assumptions. The exploration must have a proposal and a clear criterion for the evaluation (Yin, 2014). Yin adds that, as in other cases, research methods such as experiments in laboratories are carried out with purely exploratory motives, affirming the relevance of the method

the most vulnerable coastal delta-cities in the world" (Deltares, 2018); In the same way is crucial to clarify the social impacts of this risk.

For this reason, inputs from different sources and formats will be used to create a clear understanding (or explanation) of the conditions influencing vulnerability and vulnerable groups. The study will be classified with topics in-land and topics off-land

The conclusions from this phase will be used as a starting point for the next one.

1. ON LAND

1.1 Environmental Conditions (environment)

-Pluvial: (L) (M) The drainage system has generated flooding problems in cases of heavy rainfall. When this heavy rain fall happens along with high tide, water from the rivers and ocean backwashes into the storm water system (CAF, 2013). This causes the rainfall to not be drained or absorbed. (Molenaar, Pak, de Pous, & van der Werff, 2018). This analysis will aim to spatialize and give a better perspective of the problem.

-Fluvial: River Basins

1.2 Urban Spatial conditions (space)

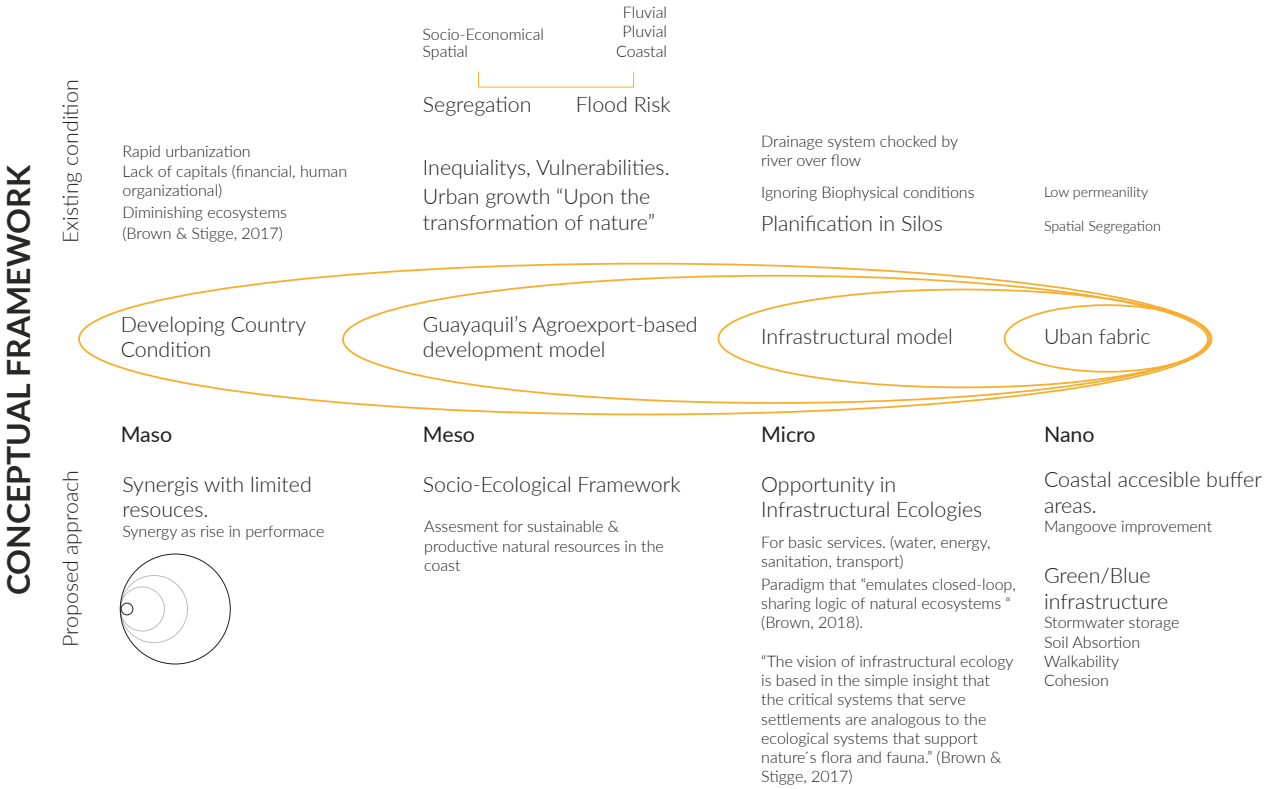
Urbanization: (L) (M) From the 60´s. Guayaquil has gone through a rapid process of urbanization which has created vast informal settlements, leading to a society with problems of social segregation. This expansion has taken over even previous Mangrove forests. This 2 are the main problems present in Guayaquil, social disintegration and a development model ignoring its biophysical condition.

Biophysical condition: (M) The urbanization expand throughout different types of soil, with different stability levels. This different soil types have different draining capacities. Furthermore, there are soil types in the city that should not carry urbanization, due to their delta nature.

Green areas: (L) (M). According to the local municipality the green area per inhabitant in this location is more than 9m2. However according to the methods stablish by the Ecuadorian National Institute of Statistics and Census the city poses 1,13 m^2/ hab; the main difference relies on including and not including preservation areas out of the city. (Compte-Guerrero, 2017) Is important also to analyze the type of vegetation and how it is distributed along the city, since some areas are more prone to flooding than others.

1.3 Socio –Economic conditions and city dynamics (humans)

-Socio, Economic (L) (D) (M): Due to big economic trends, Guayaquil's population has evolved into a heterogenous society. Inequalities among Socio-Economic groups in Guayaquil have been the focus of attention for more than one publication. Erik



Swyngedouw in his research about Policy, nature and the city, uses Guayaquil's case to explore how a central element of ecosystems, such as nature's water, can be "embedded in the political ecology of power" (Swyngedouw, 1995). Here he explores how Agroexport-based economy in Ecuador, deeply influenced Guayaquil´s urbanization and particularly the domestication of water. He adds how, the first Agricultural boom influencing the city occurred on 1860 with Cocoa production; here this economic inflow attracted people from the coast to migrate to Guayaquil (Swyngedouw, 1995). The second boom was Bananas production between 1950 t0 1974, growing the city population from 200.000 inhabitants to 820.00.

Swyngedow describes that the next boom was oil exports. The extraction extended from the amazon directly to Quito, so the country economic hub started changing. Is fair to argue that after Swyngedow's study aqua-culture has also developed as a new agro-export business model.

He argues that in this case "The water issue [urbanization of water] is just a mere illustration of how nature and society become one in the production of a socio-spatial fabric that privileges some and excludes many." (Swyngedouw, 1995). This is perhaps also the logic behind the exploitation of natural sources for exportation.

Steps in the processing of available data: The information in this format is not available (or has proven to be difficult to access, a couple of national organizations have answered unfavorable about possessing related information). Therefore, additional steps of data processing are needed. The most resent official data related to theis porpoise is from the Census of Population and Housing 2010, (CPV2010 - Censo de Población y Vivienda 2010). Additionally, the methods of a survey by the Ecuadorian National Institute of Statistics and Census (INEC, by its initials in Spanish) are used as a reference. The survey is made partially in order to prove a method to determine Socio-Economic Stratification. The mentioned survey asks 25 questions subdivided in 6 group (Housing, Education, Economy, Goods, Technology, Consuming habits), giving different weights to each question, and having a maximum score of 1000 points. The survey is not carried out in the complete city of Guayaquil, but 71% of total sum of the weights in the survey can be found on similar questions in the CPV2010. Under these circumstances, based on the weights of the Socio-Economic Stratification survey and the data available for the entire city an adjustment in the weights is done in the following explained logic.

The total weight per category is maintained in the categories where there are matching questions in the census (which means all of the categories except consumption habits). To do so, the total of the weights is added to see how many points per category are available.

Maintaining the percentages per category of the

survey, the weights of the available questions are adjusted. Since there are no questions related to "Consumption Habits" category; The categories of Goods, and Technology proportionally absorb this 10% (since they are considered the most related ones). Based on these distributions, the new weights are calculated and are proportioned as indicated attached table.

Based in this, different topics can be visualized in a GIS Software generating maps related to the socio-economic distribution along the city. This processing will provide with useful information to analyze the Social Stratification across Guayaquil. Additionally, the methods can be applied to the whole country of Ecuador, since information of the census is available.

As an example, the category of education is mapped in the following map. The Education index represents 2 factos; A) Social Aspirations, B) Economic Capacity, which makes it a good example of the socio-economic inquiry. Higher education became free in Ecuador in 2008; in some years this will change the condition in the map. However, the processed information is the most recent official data. Other socio economy maps will be produced (Housing type, Sanitary services, technology access, Social security) . The addition of them all, will represent the Socio-Economic Stratification.

-Functioning: To have a better picture of the city, the understanding of the functioning of the city is needed. To do so, spatial indicators as Population Density, Centralities, and Land use will be mapped.

2. OFF - LAND

Environmental Conditions (Environment)

Coastal: Hydraulic engineering reports

Fluvial: Hydraulic engineering reports. Analyzed on and Off land, because is a system that crosses these 2 spectrums

The environmental threats affecting Guayaquil´s flood vulnerability have to do with Pluvial, Fluvial and Coastal vulnerability. While Pluvial reasons have to do with absorption and drainage of the urban fabric, Fluvial and Coastal have to do with environmental degradation of mangroves, a entering tidal domination, and processes of sedimentation that take room from the river. For this reason, the technical aspects influencing flooding are learned based on Hydraulic engineering. For both Coastal and Fluvial

Ecological Systems Mangroves (Environment + Humans)

Mangroves are capable of slowing tidal currents up to a 90% (Brown & Stigge, 2017), at the same time they were capable of retaining sediments currently flowing in a landward direction. The current situation is seen a s problematic. The mapping of the current state of one of the islands which was fully covered by a mangrove forest will me mapped. Additionally, potential strategies will be outlined for improving the

Categories	Porcentaje in survey	Total of Weight in Survey	Total of weights in questions available	Porcentage available
Housing	24%	236	204	86%
Education	17%	171	171	100%
Economy	17%	170	170	100%
Goods	16%	163	53	33%
Technology	16%	161	122	76%
Consumption Habits	10%	99	0	0%

current state.

B. Exploratory Phase 2/2

Unit of analysis: Potential areas for implementation of Infrastructural ecologies

The second stage will have an exploratory approach due to the fact that it starts from proposed assumptions and a particular purpose (risk mitigation and social integration). As explained previously, it is necessary to have previously established criteria for "interpreting the findings" (Yin, 2014).

Based on the theory, product of the explanatory phase of the study; A prioritization process will be used to determine potential areas of study. The results from the mapping showing vulnerable groups, and vulnerable areas will be influential. In these areas the paradigm of Infrastructural ecologies unfolds aiming to contribute for flood risk mitigation in Guayaquil, Ecuador. The purpose will be to understand the advantages this type of infrastructures present for the study. The resulting product from the exploration is a Strategy

Strategy

The strategy will depart from a general vision, showing the potentialities that could be generated, not only by solving the problems but by triggering new alternatives for the correct performance of the space (either natural or urban). Under the paradigm of infrastructural Ecologies, the strategy will aim to get imbedded in the local ecosystems. The most remarkable concepts applicable to the case of Guayaquil are Green/Blue Infrastructure, (due to soil absorption, water storage, improved walkability, less heat island effect, fostering of social cohesion) and Mangrove forestation (due to better coastal defense, less sediment accumulation).

The mentioned conceptions should aim on assessing specially the most vulnerable groups. The strategy should aim to foster social integration an at the same time mitigate risk. In this way the necessary activators will be pointed out, either in the form of:

-spatial interventions improving the network configuration of the city to improve processes of co-presence.

-Spatial interventions to deal with surplus water

-Spatial interventions to improve interaction.

. With the integrated strategy set, performance can be deducted. The performance of the integrated strategy will clarify possible guidelines that can be integrated in the understanding and management of Guayaquil.

Criteria of assessment:

In turn, the criteria under which the quality of the Project will be measured will be the 4 tests that "have been used to stablish the quality of any empirical social research" (Yin, 2014). These tests are: Construct Validity, Internal Validity, External validity, Reliability.

Questions	Category	Original Wieghts	Availability in CPV2010	New Weights
Do you buy clothing in shopping centers?	Consumption Habits	6	No	0
Have you read a book in the las 3 months?	Consumption Habits	12	No	0
Does someone privatly posses a car?	Goods	15	No	0
Do you possed washing machine?	Goods	18	No	0
Do you posses a sound systems	Goods	18	No	0
Does de house have a regular phone?	Goods	19	Si	76
Have you used internet last 6 months?	Consumption Habits	26	No	0
Do you have personal E-mail?	Consumption Habits	27	No	0
Do you have social networks?	Consumption Habits	28	No	0
Do you have an oven?	Goods	29	No	0
Do you have a fridge?	Goods	30	No	0
How many rooms with showers?	Housing	32	No	0
Do you poses a Color Tv	Goods	34	Yes	137
Do you poses a Desktop Computer	Technology	35	Yes	60
Type of Water Closet (WC)?	Housing	38	Yes	44
Do you poses Portable computer?	Technology	39	No	0
Are you afilliated with the National Social Security?	Economy	39	Yes	39
How many activated Cellphones exist in the home?	Technology	42	Yes	72
Do you have internet service?	Technology	45	Yes	78
Material of the floor in the house:	Housing	48	Yes	56
Do you poses Health insurance?	Economy	55	Yes	55
Housing type:	Housing	59	Yes	68
Material of the walls in the house:	Housing	59	Yes	68
Ocupation of head of the house:	Economy	76	Yes	76
Educatuin of head of the house:	Education	171	Yes	171

Conclusion:

The analysis, and assessment of the city needs frameworks that help the linking of various information. in this way, a bigger picture can be understood. In the analysis (explanatory) phase, data related to socio-economic and environmental characteristics is gathered and processed; this creates a better background to support the proposal.

The proposal aims to reduce social and environmental vulnerability. This is done by a strategy under the planning paradigm of infrastructural ecologies

Bibliography:

Brown, H., & Stigge, B. (2017). Infraestructural Ecologies. Cambridge.

CAF. (2013). La inundación de Guayaquil en marzo 2013. Guayaquil.

Compte-Guerrero, F. (2017, March 02). Índice verde urbano. Expreso, pp. https://www.expreso.ec/opinion/columnas/indice-verde-urbano-XD1126088.

Delgado, A. (2011). Guayaquil. Cities.

Deltares. (2018, April 12). Deltares. Enabling Delta Life. Retrieved from Guayaquil invests in flood resilience and climate adaptation: https://www.deltares.nl/en/news/guayaquil-invests-flood-resilience-climate-adaptation/

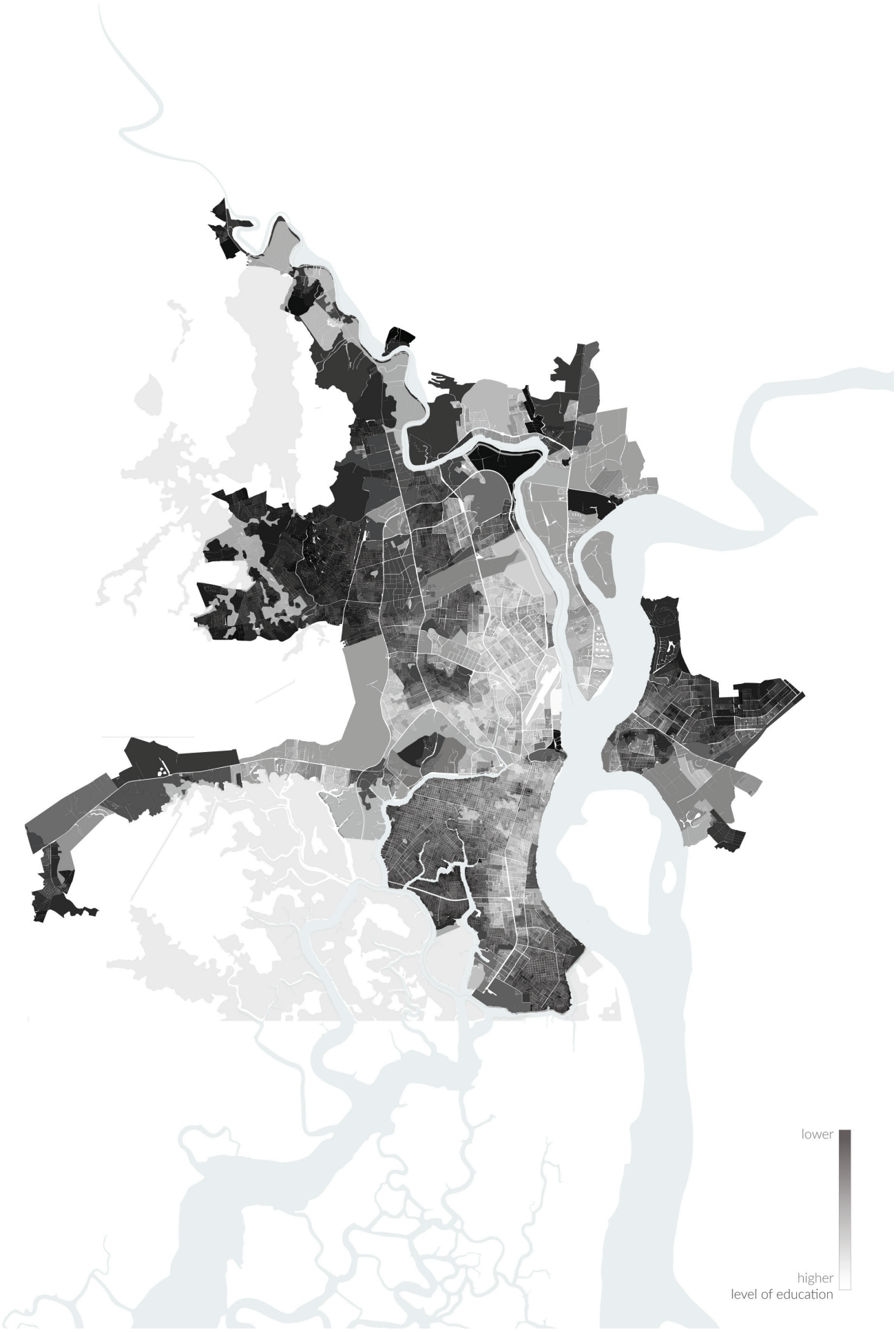
MG. (2000). Municipality of Guayaquil: Informe de Avance de Objetivos de Desarrollo del Milenio en Guayaquil. Guayaquil: UN-Habitat.

Molenaar, F., Pak, T., de Pous, H., & van der Werff, B.-J. (2018). Flood Prevention Guayaquil. Delft: TU Delft Repository.

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science 325, 419-422.

Swyngedouw, E. (1995). Power, nature, and the city. The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador: 1880-1990. Environment and planning, 311-332.

Yin, R. K. (2014). Case Study Research: Design and Methods. Los Angeles: SAGE.


lower
higher
level of education

EXPLANATORY PHASE

The explanatory phase aims to generate an understanding of the current social, spatial, and environmental conditions present in Guayaquil. The unit of analysis is Guayaquil and its vulnerable areas. For this reason, systems from different scales are included. The explanatory phase can be broadly subdivided in 2 topics. 1st Macro water systems (ending in areas prone to flooding) and 2nd Socio economics (ending in the spatial dimension of groups prone to exclusion). The reason for stablishing these 2 areas is because the least privileged groups are at the same time the ones with the biggest exposure to flood risk. The sources of information's and formats of the analysis follow this sequence:

1 Macro water systems

The fluvial, coastal and pluvial systems together interrelate and are key in order to understand the threats faced by Guayaquil.

1 Macro water systems analisis (L)(M)

Fluvial system (with Equadorial seasons wet&dry)
- Catchment area in km^2
- Discharge in m^3

Coastal system (with Equadorial seasons wet&dry)
- Tide fluctiation
- Sedimentation landward flow

Pluvial system
- -Average mm of rain per month
- -Soil absortion
  - Soil type
  - Green area index (deforestation map)

2 3X3X3. Processes increasing flood risk.
- -Infrastructure (Dam building upstream)
- -Ocupation (Growth of informal settlements, decrease of green)
- -Landscape (shrimp farms replacing coastal mangrove buffers)

Resulting seddimentation.
- Dredging as the only implemented measure

3 Result: Areas prone to flooding and causes

4 Socio-Economics - demographics (D) (M)

Level of education map
- Social aspiration
- Economic capacity

Aditional Socio-economic indicators
- Ocupation (job type)
- Housing type
- Social security

Demographics
- City density
- Inhabitation patterns

5 Patterns of occupation

City scale
- Informal settlements
- Infrastructure & Services
- Centralities
- Role of Private property per area
  - Gated comunities.
  - Gated Public space (it exists!)
  - Shopping centers
  - Private comunal centers

6 Result: Areas prone to exclusion

7 Areas of Overlaping vulnerability

Patterns of occupation

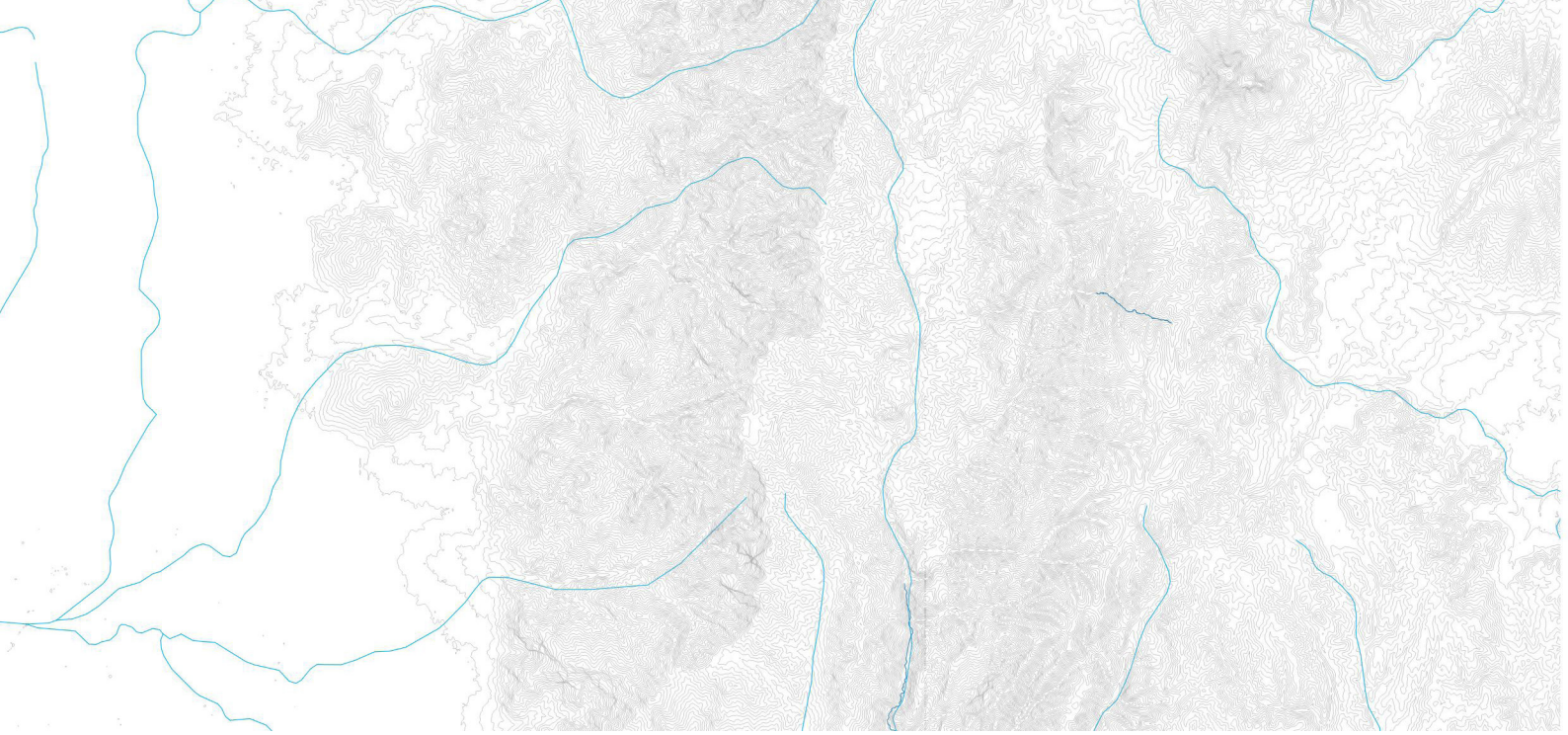
Neighborhood scale
- Spatial Inhabitation
- Spatial Behavior
- Existing Typologies

Exclusion "a situation in which someone or something is not allowed to take part in an activity or to enter a place" (cambridge dictionary)

Private ownership without collective role as a facilitator of exclusion.

8 Proposal The promotion of semi private spaces for the improving of stormwater managment. Semi-private spaces as the vehicle to change the understanding of private ownership. From individual and liberal to Individual and collectivly useful.

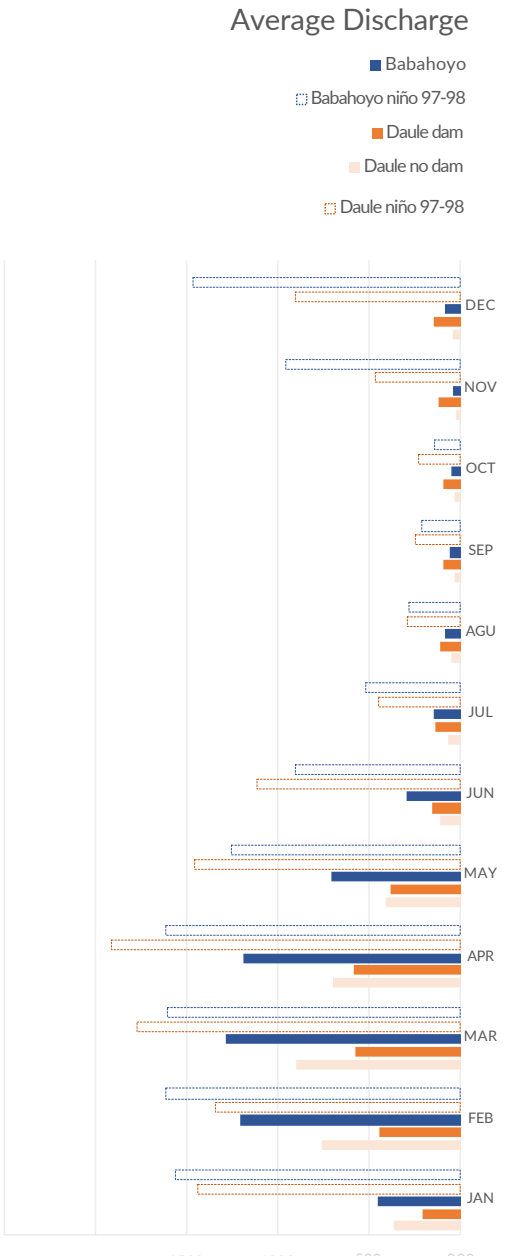
The promotion could be strutured as:
"in areas of active semi-private green infrastructure, the municipality will invest in creating permeable and vital urban space". This can improve flood risk and foster social integration.



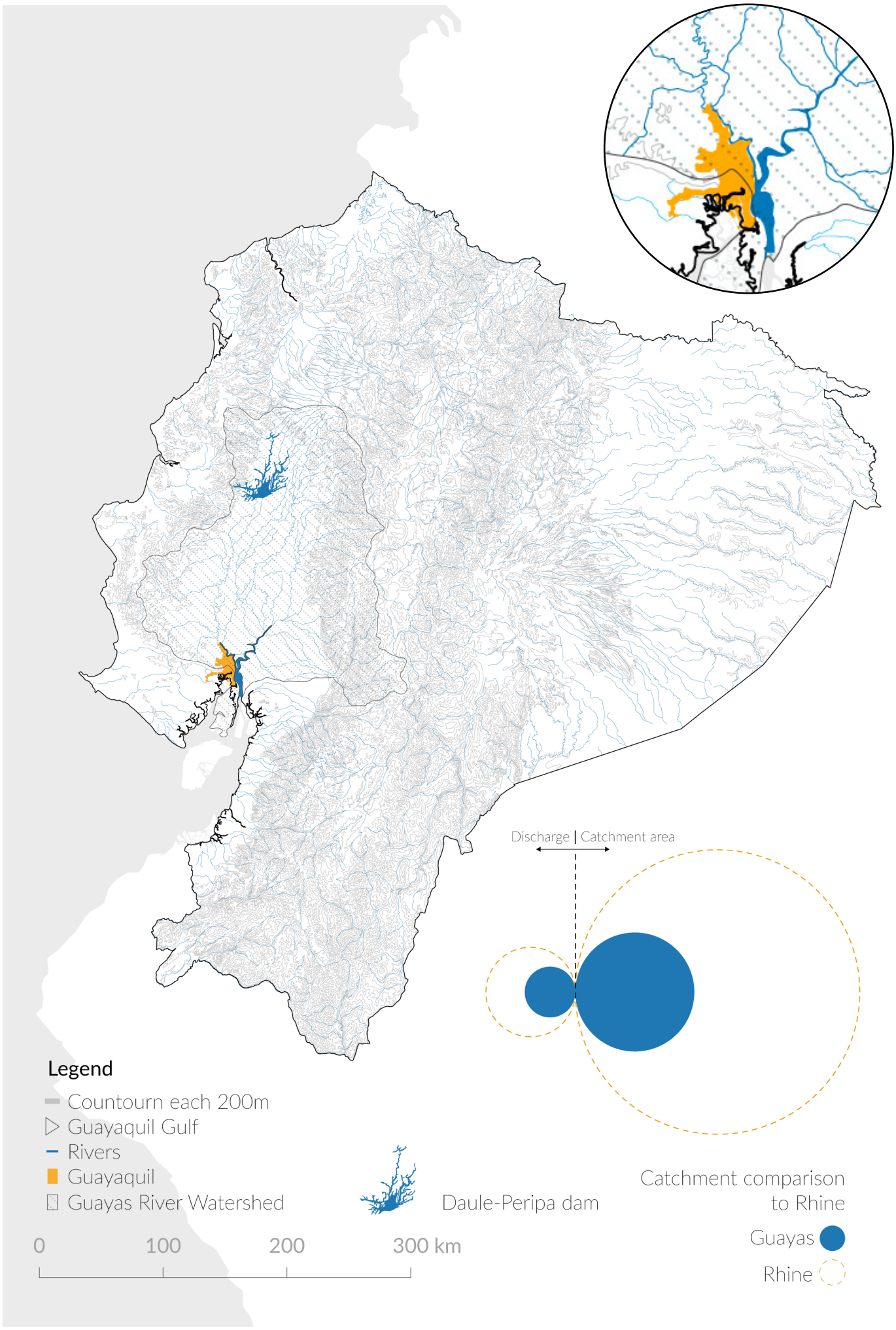
Fluvial System.

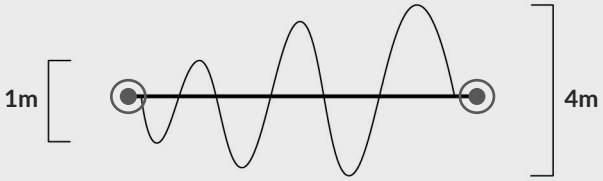
Guayaquil is located in two watersheds. The Guayas river Water shed and what is identified by the Ecuadorian water national secretary (SENAGUA) as the hydrographic unit 15 (SENAGUA, 2009). The Guayas River generates an average annual runoff of 1350m3/s (Twilley, et al., 2001; Reynaud, Witt, Pazmiño, & Gilces, 2018) and an annual average discharge of 30 billion m3 (CELEC, 2013) which is 951,29 m3/s. The catchment area of the Guayas river is 32.800km2, 64% of the drainage basin (Twilley, et al., 2001). To get a better idea, if the Guayas river is compared to the Rhine catchment area and mean annual discharge of 185.000km2 and 2.500 m3/s respectively (Hoffmann, et al., 2007), the Guayas river discharges 38% of the volume of the Rhine from a catchment area 18% its size. This makes the Guayas river basin the biggest one in the west from the Andes and obviously the most important river in Ecuador.

The Guayas river is formed by the Daule River and the Babahoyo River. The temporal dimension of their discharges depends on the Ecuadorian seasons. Due to the country's location in the Equatorial line, the region around Guayaquil poses a tropical Savana Climate, meaning that there is a predominant dry season and a shorter wet season with heavy rainfall. This is reflected on the discharges produced by the rivers close to Guayaquil. On average 90% of annual precipitation falls between the months of December and April and top values happen in February and March (CAF, 2013). The upstream Daule – Peripa dam built on 1988 also plays a role in the discharge dynamics, with a notable decrease in the natural river discharge.



Data Source: Barrera Crespo, P. D. (2016). Delft3D Flexible Mesh modelling of Guayas River and Estuary system in Ecuador. TU delft.


Discharge | Catchment area
Legend
Countourn each 200m
Guayaquil Gulf
Rivers
Guayaquil
Guayas River Watershed
Daule-Peripa dam
Catchment comparison to Rhine
Guayas
Rhine
0
100
200
300 km



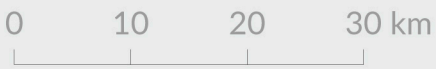
Coastal System.

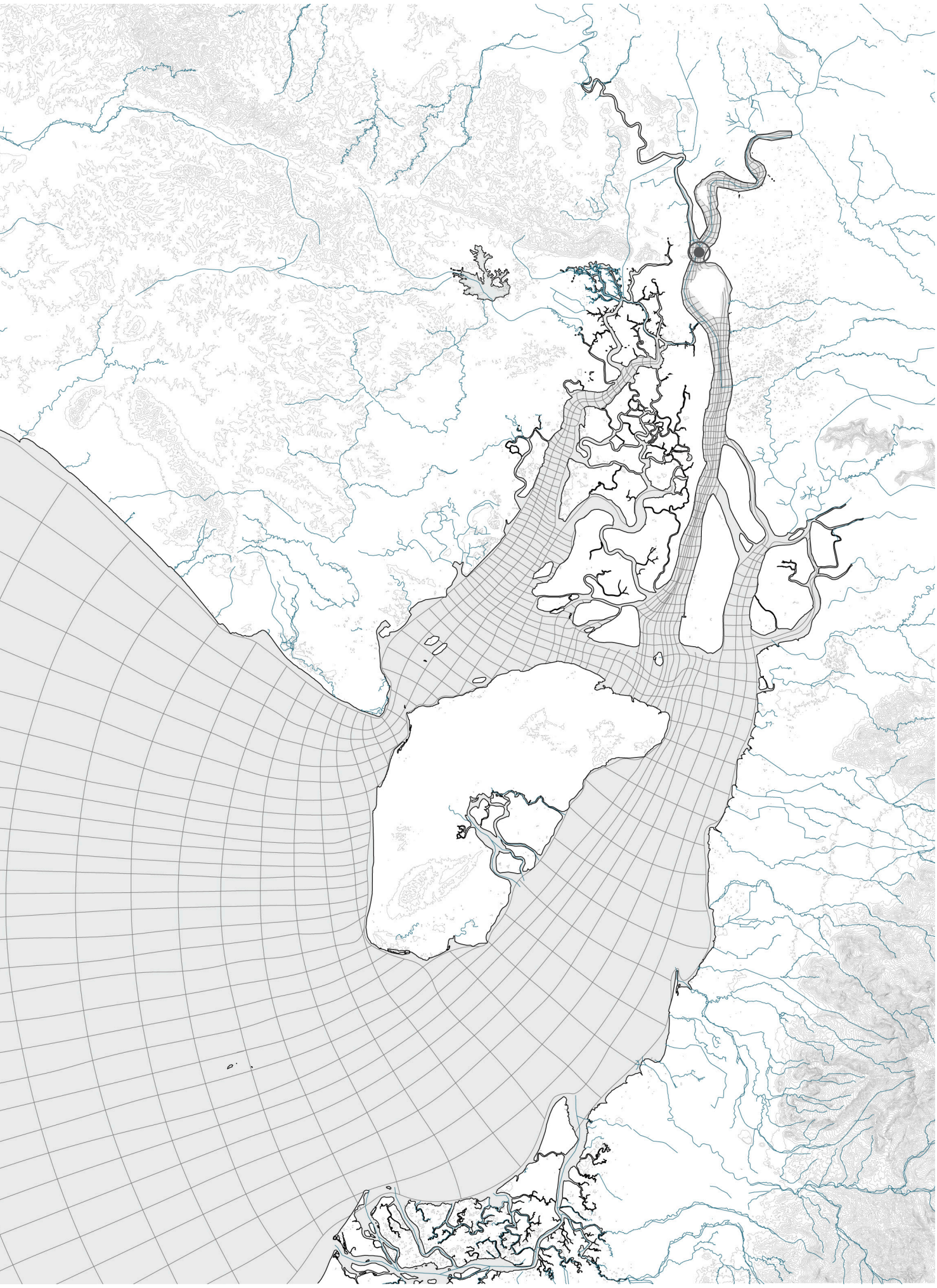
The Guayas river discharge joins the sea by the Guayaquil gulf. This Gulf is the largest tidal system of pacific coast of South America, with a tidal range of over 1m (Reynaud, Witt, Pazmiño, & Gilces, 2018). The tides penetrate deep into rivers and the tidal limits are found 120km and 90km upstream of the Daule and Babahoyo rivers respectively and river bars are still formed. (Dumont, Santana, Soledispa, & King, 2007). The volume of water flowing in the Jambelí Chanel is up to 10 times bigger than its fluvial contributions (Stevenson, 1981; Reynaud, Witt, Pazmiño, & Gilces, 2018). In the jointure area between the Jambelí chanel and the Guayaquil Gulf hollows can be spotted, they reach up to 50m deeper than its surroundings and are aligned with direction of the tides. (Reynaud, Witt, Pazmiño, & Gilces, 2018). Additionally, near this area of the sea bed, tidal ridges reaching up to 20m deep and 20km long appear, these seabed ridges are usual of tidal deltas. (Reynaud, Witt, Pazmiño, & Gilces, 2018)

The Guayas Estuary was originally surrounded by mangroves forests, which evidences how the tides expand inland. (Pozo, Jordán, & Sanfeliu, 2012). The "tidal range increases from 2m in the ocean in front of the Gulf of Guayaquil, to 1.8m at the mouth of the Jambelí Channel, and up to 5m in the Guayas River – and progressively decreases upstream" (Reynaud, Witt, Pazmiño, & Gilces, 2018).

In episodes of high tide, the city drainage systems get backwashed by the incoming water generating problems in the storm water system. (CAF, 2013). In addition, the tidal system shows a predominance of flood tide over ebb tides which means that landward sediment flow take place (Barrera Crespo, et al., 2018). The accumulation of sediments in the Guayas River in front of Guayaquil is a contributing factor for flood risk (Barrera Crespo, et al., 2018). Therefore, is important to picture this dynamic and its potential causes.

Image based on: Barrera Crespo, P. D. (2016). Delft3D Flexible Mesh modelling of Guayas River and Estuary system in Ecuador. TU delft.





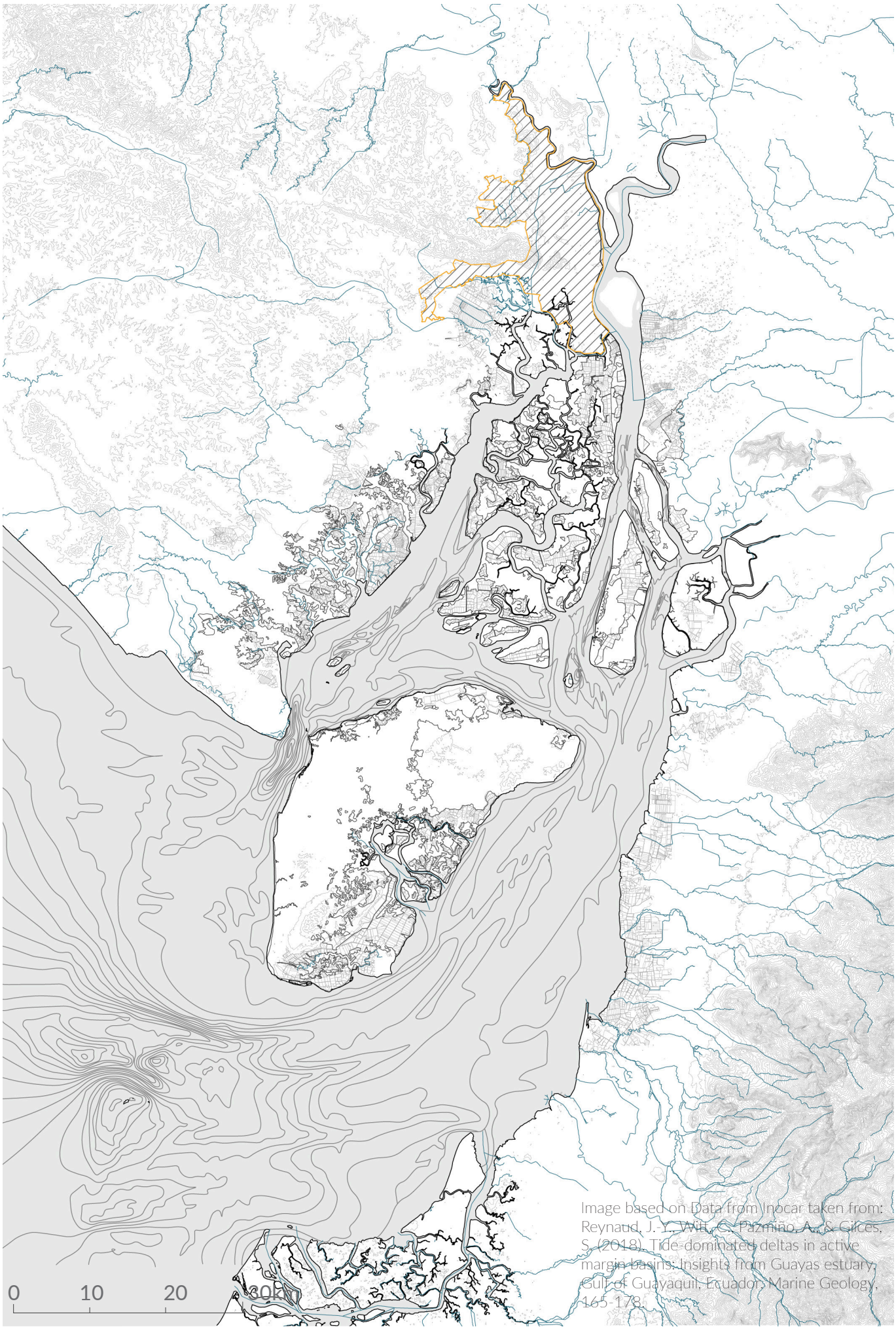
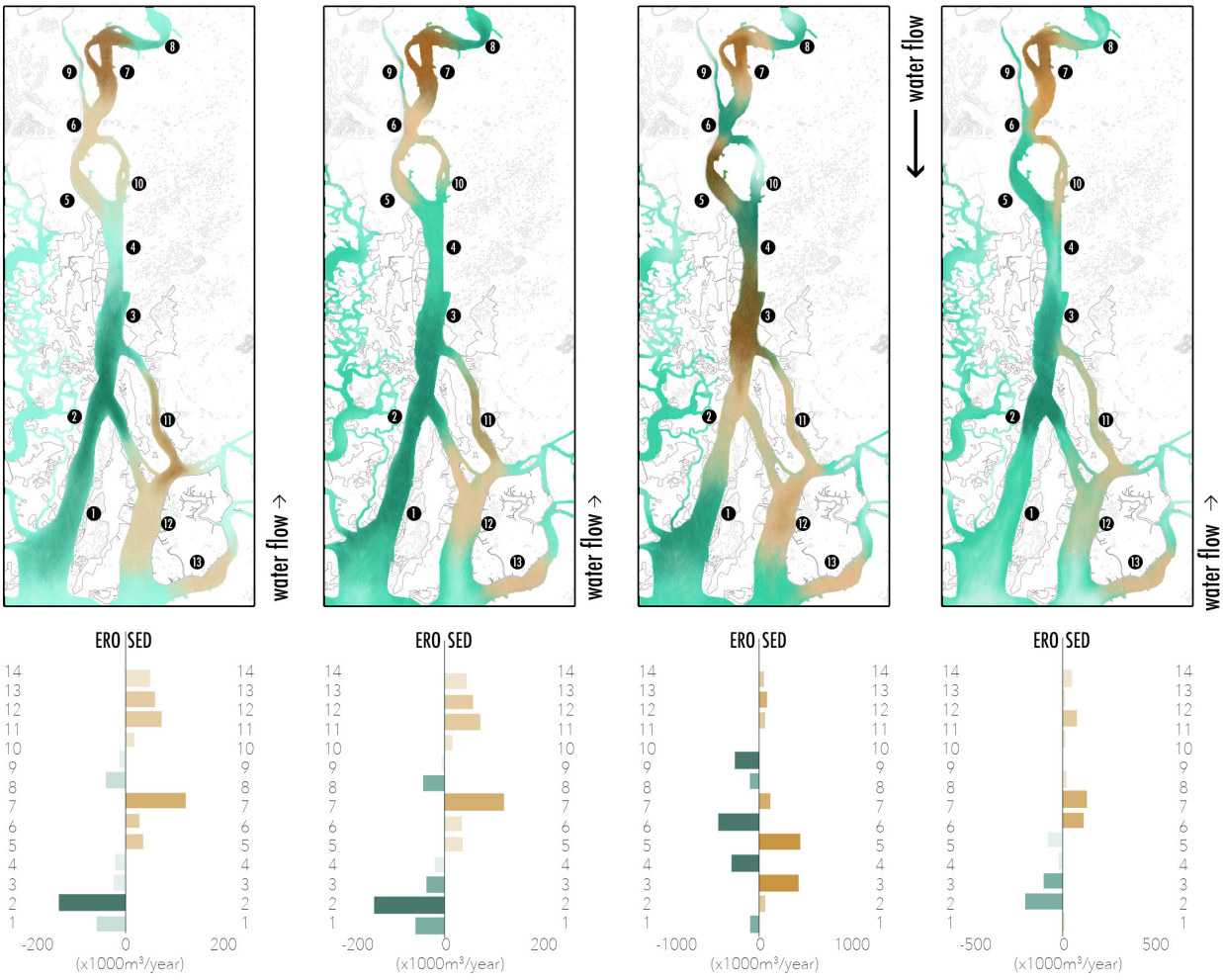


Image based on Data from Inocar taken from: Reynaud, J. Y., Witt, C., Pazmiño, A., & Gilces, S. (2018). Tide-dominated deltas in active margin basins: Insights from Guayas estuary, Gulf of Guayaquil, Ecuador. Marine Geology, 165-178.



Images adapted from simulations in: (Barrera Crespo, et al., 2018)

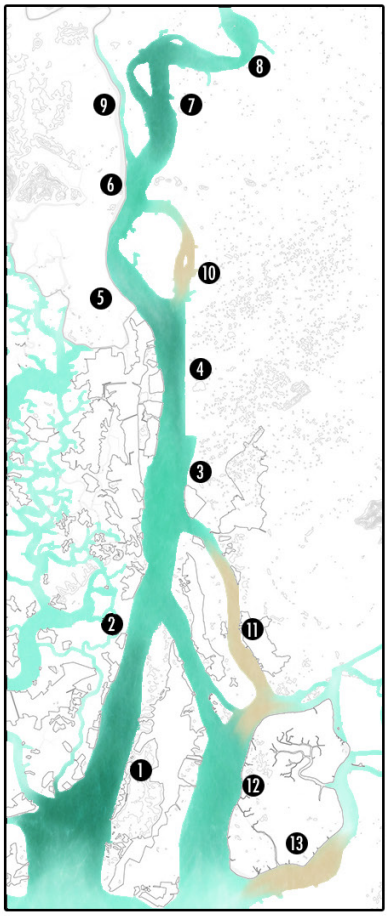
In this sense a specific simulation study about the sedimentation flow of the Guayas river basin is of special relevance. The study simulates the flow of sediments under different scenarios. These scenarios are 1) Current condition, 2) the situation prior to the construction of the Daule-Peripa Dam, 3) the situation prior to the existence of shrimp farming inside the mangrove forests, 4) Deforestation and land-use change in the upper basin 5) The situation of an El Niño season. By comparing these scenarios, the study concludes that the main reasons influencing the sedimentation processes are the Daule-Peripa dam and Shrimp farming.

The shrimp farms occupy area where usual incoming tide encountered space to flow and space for friction (Barrera Crespo, 2016). The reduction of these two factors have influenced a tidal asymmetry which eventually lead to one flow of water dominating the other. In this case the flood tide.

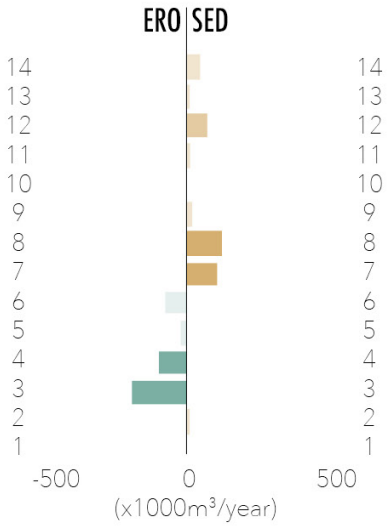
In places as Vietnam, Mangrove forests are seen as a potential line of defense against flood risk. They are capable of slowing the tidal energy up to 90% (Brown & Stigge, 2017)

The mentioned sediment simulation study is:

Barrera Crespo, P. D., Mosselman, E., Giardino, A., Becker, A., Ottevanger, W., Nabi, M., & Arias Hidalgo, M. (2018). Sediment Budget analysis of the Guayas River using a process-based model. Hydrology and Earth System Sciences Discussions.

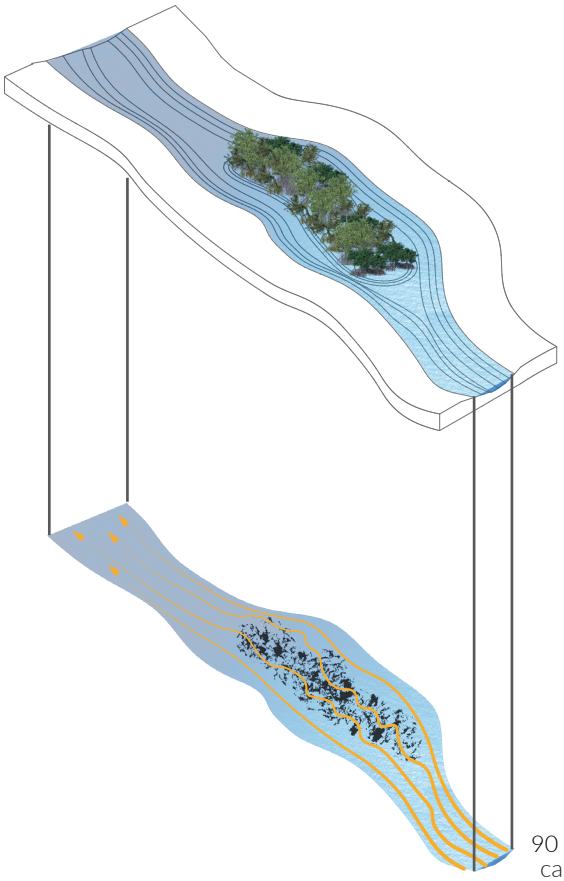


← water flow

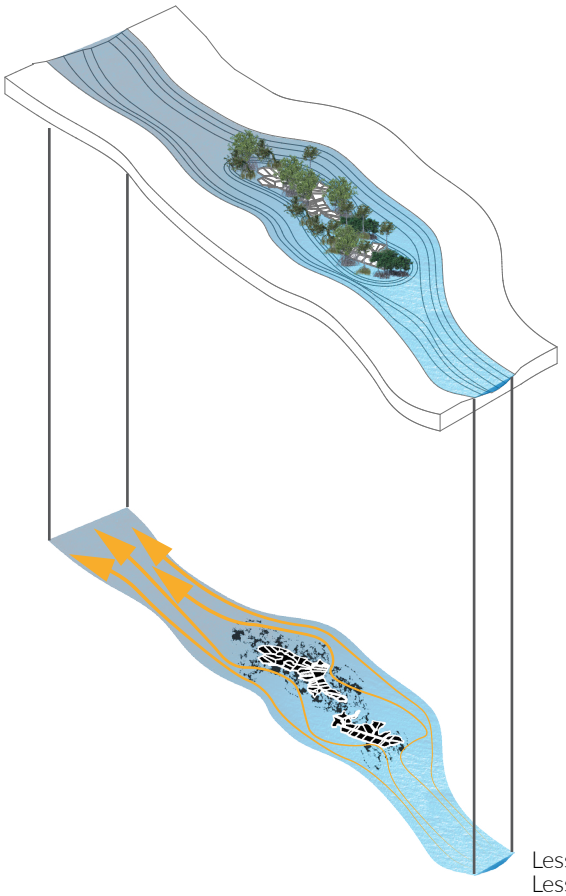


SEDIMENT AN SEA LEVEL PRIOR SHRIMP FARMING AND MANGROVE DEFORESTARION

YEARLY AVERAGE

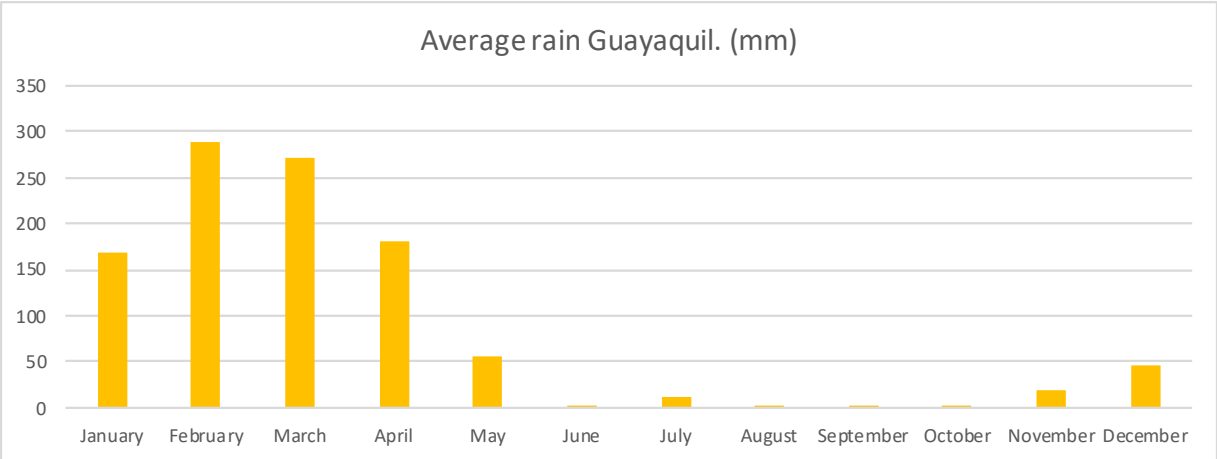


90 % of tidal energy can be reduced



Less friction
Less Space

Image adapted from simulations in:
(Barrera Crespo, et al., 2018)



Source: Inocar

Pluvial systems.

As it was previously mentioned, Guayaquil has a tropical weather with a wet and a dry season. On average 90% of annual precipitation falls between the months of December and April and top values happen in February and March (CAF, 2013). "In March, the wettest month, 280 mm of rain falls on average. In comparison, the annual rainfall in The Netherlands is about 880 mm". (Molenaar, Pak, de Pous, & van der Werff, 2018 (Rijksoverheid, 2018)). This short but abundant rainfall is not coped by the drainage system.

Guayaquil has big challenges related to soil absorption. According to the National Institute of Census and Statistics (INEC), the city poses a green areas index, of 1,13 m2 / person. These scarce green areas are not evenly distributed on the city. Big parts of the city which developed through informal occupation lack green areas. In addition, these informally settlements are set on top of filled space where sea branches preciously existed (Molenaar, Pak, de Pous, & van der Werff, 2018).

Furthermore, the rapid urbanization process has created entire areas covered by asphalt or concrete. The city on average has an index of 90% impermeabilization (CAF, 2017). This urban development model keeps water from getting drained and absorbed, and the same time it enables fast water sliding and accumulation. (CAF, 2013)

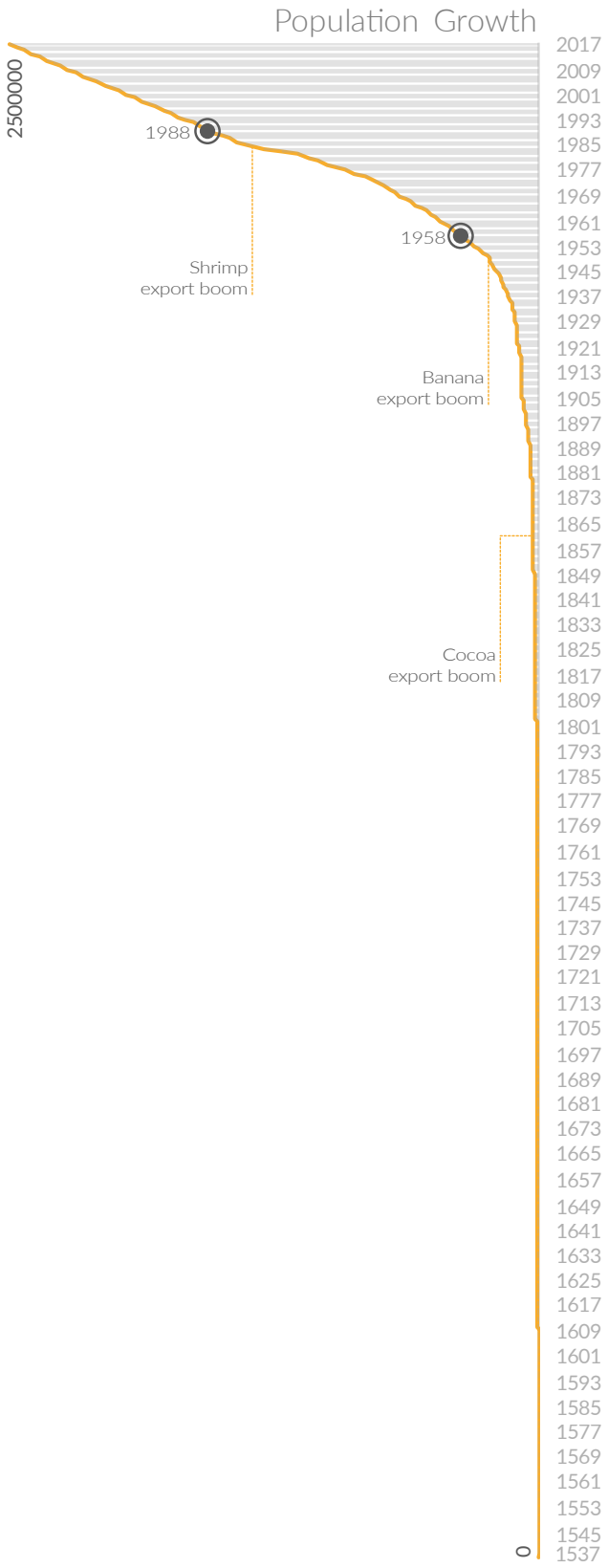
An "El Niño" phenomena (ENSO) brings even a bigger challenge to the city in terms heavy rain fall. Is hard to estimate an exact time periodicity but is estimated to occur between each 2 to 7 years. This phenomenon hits the Ecuadorian coast and Guayaquil's location make it one of the settlements that take the biggest impact from the increase in Rain and River discharge.

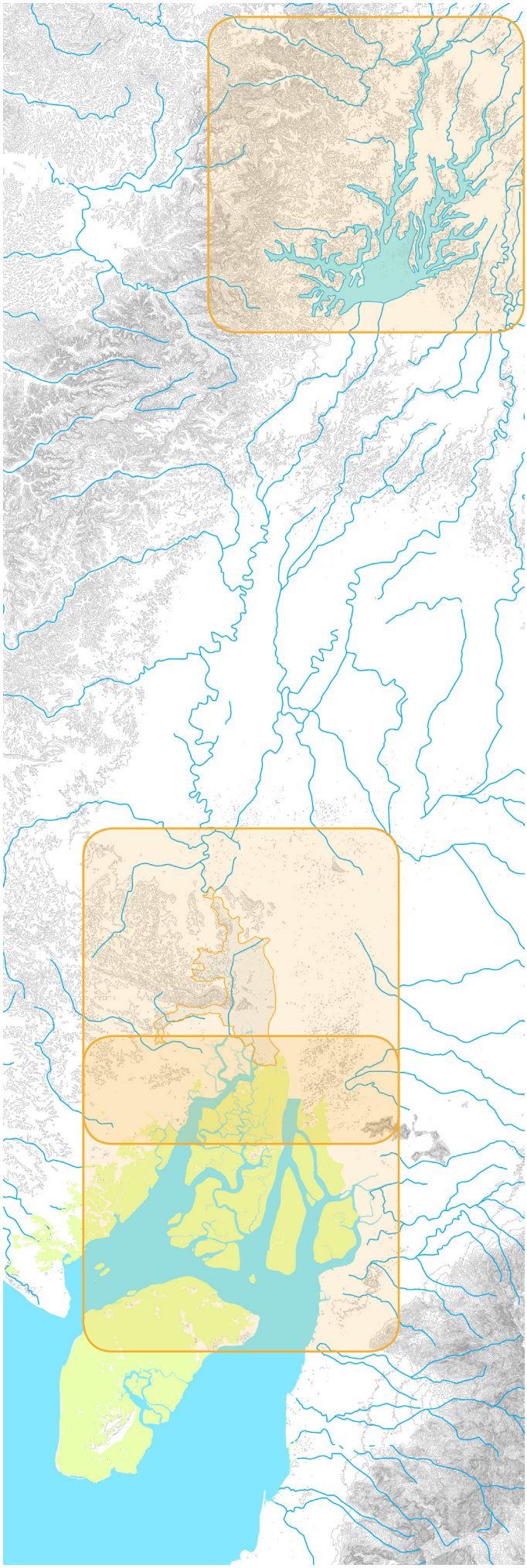
In 1998, a strong ENSO occurred, and areas of Guayaquil were severely affected, The Picture is and image from Isla Trinitaria after the phenomena.

3X3X3 Systems influencing sedimentation and flood risk

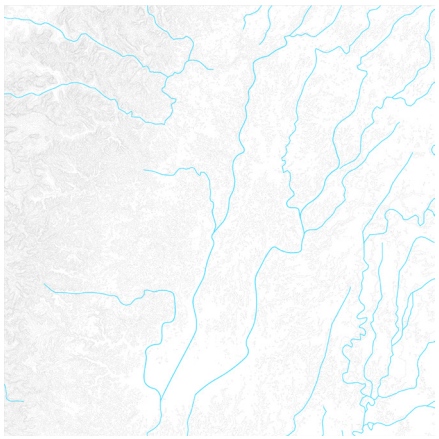
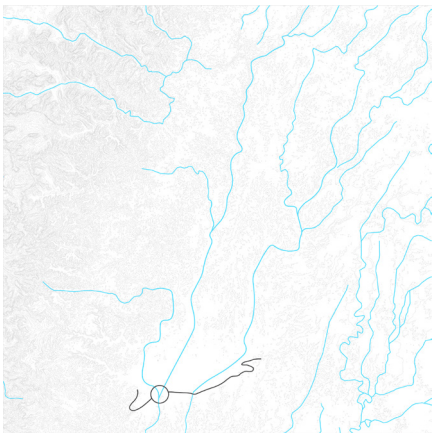
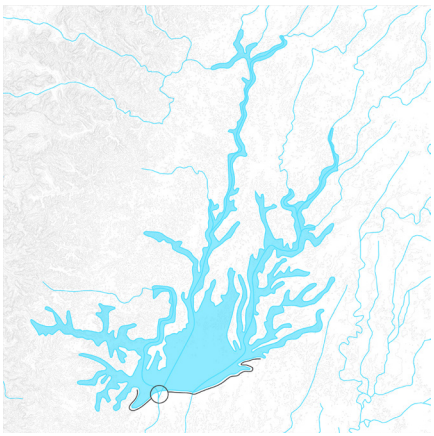
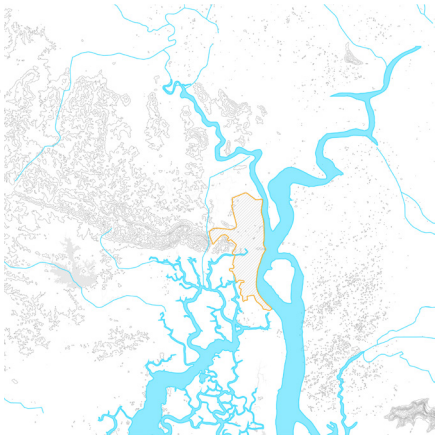
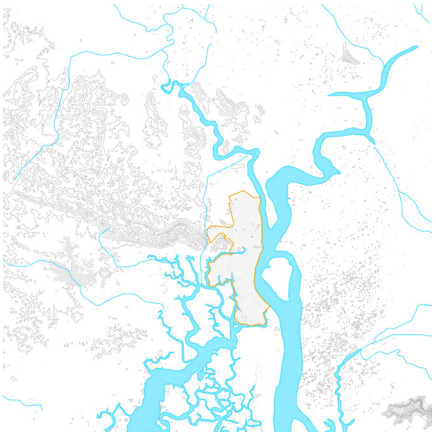
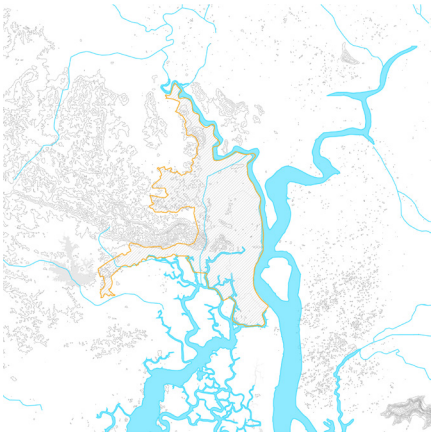
The purpoise of the 3X3X3 matrix is to emphasize on how interconnected the natural systems are, and how an approach to infrastructure without a systems perspective could generate a couple of negative side effects. Additionally, as it has been previously mentioned, in developing countries an approach to infrastructure that aims to have more than one purpose can be one of the only ways to cope with the challenges at stake (Brown & Stigge, 2017).

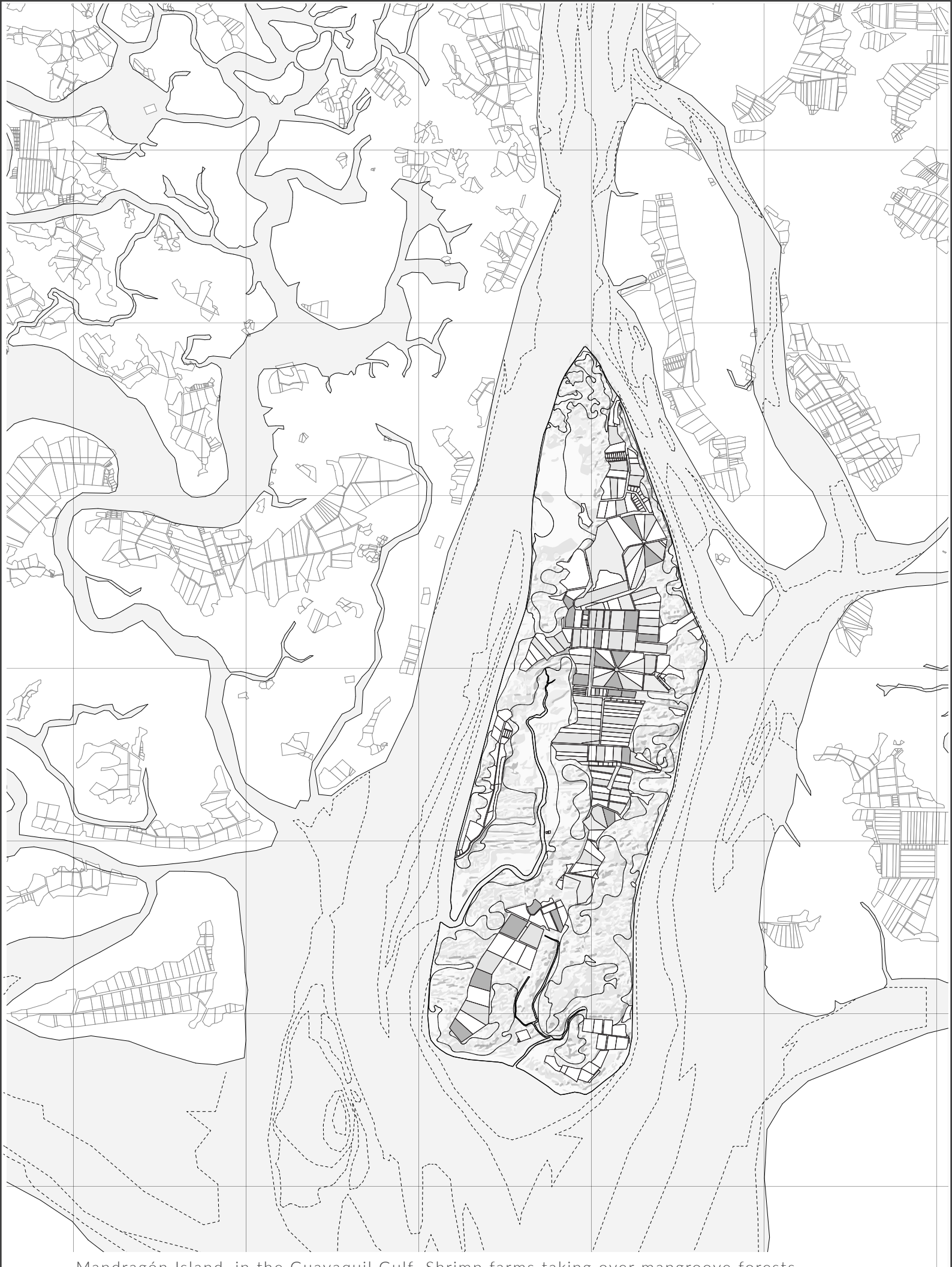
This matrix is based on previous literature. It pictures the Guayaquil region though a time-frame of 60 years. By 2017 the city possessed 2`644.891 inhabitants (INEC, 2017)



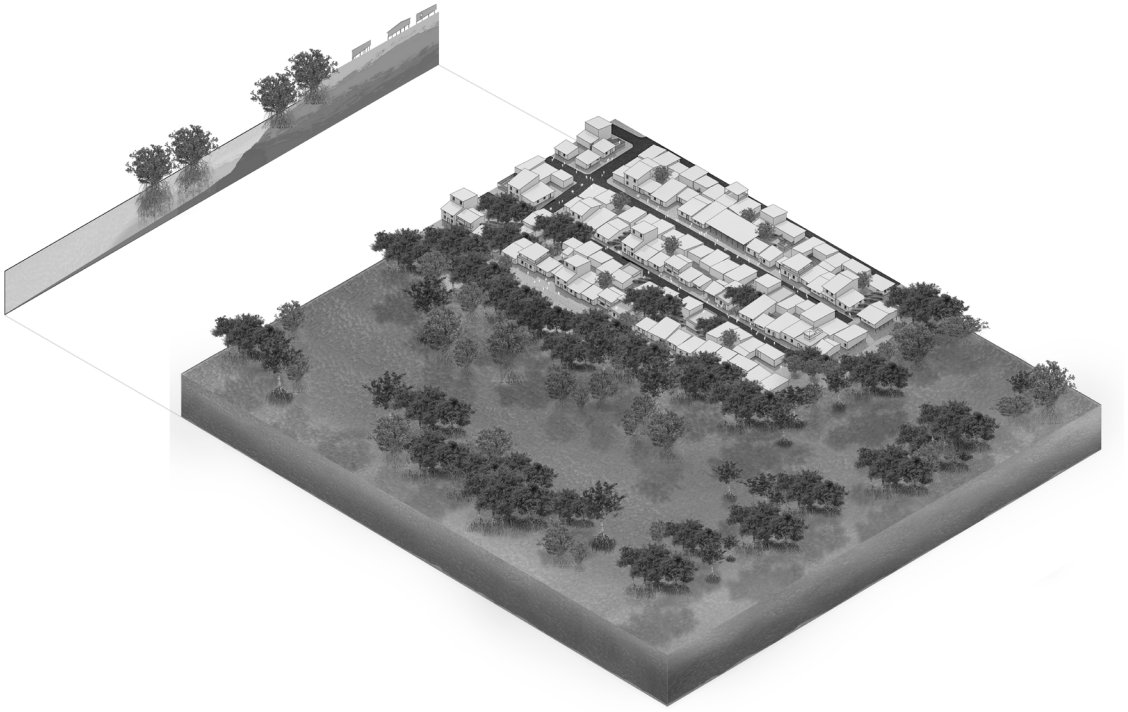


3X3X3 ANALYSIS & CITY GROWTH

	1958	1988	2018
Infrastructure			
	Normal flow of the rivers prior to the building of the Dam	Building of the Daule - Peripa Dam	Water reteined by the Daule - Peripa Dam
Occupation			
	City prior to nature-based agro export booms	City under rapid expansion due to nature based, agro export booms	City today. With informal settlemets
Landdscape			
	Area occupied by mangroves, buffering tidal energy.	After first shrimp export boom	Nowadays condition. Proliferation of shrimp farms



Mandragón Island, in the Guayaquil Gulf. Shrimp farms taking over mangroove forests



Conclusion of Macro Water Systems

The development model of Ecuador into the globalization era seems to have an impact in the ground that can be spotted in the deforestation of mangroves. The proliferation of shrimp farming is another Agro-export business model (following cocoa and banana booms) that puts at risk important ecosystems in exchange of capital flowing into the country. After the reading of the water systems and the current process of sedimentation, it appears as if the current Flood Risk will increase in the future if actions are not taken in order to preserve and reforest the mangrove forests. The Discharge of river Duale appears to be also lowered by the Daule-Peripa Dam (Barrera Crespo, et al., 2018) which also impacts the direction of the sedimentation process. It would appear as if the processes of dredging are not a long-term solution, and therefore, not sustainable in time. Keeping in mind that sewer systems gets backwashed in time of high tide (Molenaar, Pak, de Pous, & van der Werff, 2018) is important to realize that sedimentation processes will only make the situation harder.

Is possible to conclude that Flood risk related to coastal and fluvial systems will increase in the future. For these purposes a mangrove reforestation process reclaiming areas now occupied by shrimp farms is suggested. This will reduce future risk. Furthermore, waterbodies should have a buffer area where no settlement should take place. Such buffers can also become areas for reclaiming mangrove forests. An empirical model is suggested where mangroves are spread into the buffer area and the water body so incoming sedimentation can be retained into the shore and not in area for water flow. This will enable the creation of a natural barrier that can protect the urban are into the future.

This topic of mangrove reforestation could be further understood and improved under the framework of Socio-Ecological Systems. This will give a clear picture of how the current state has come to be, as well as some potential ways for improving it.

Furthermore, the current situation of a heavy rainfall along with a soil with very low absorption, make of Guayaquil a city that currently suffers from flooding on a yearly basis. Flooding impacts areas in the entire city, but it obviously affects people in different ways. There are areas of the city that in the 2010 census reported houses with earth or untreated wood flooring. For cases like these the urgency for attending flood risk varies in even though the problem is long extended in the city.

Ortophoto Source: Sigtierras

Flood Risk in Guayaquil

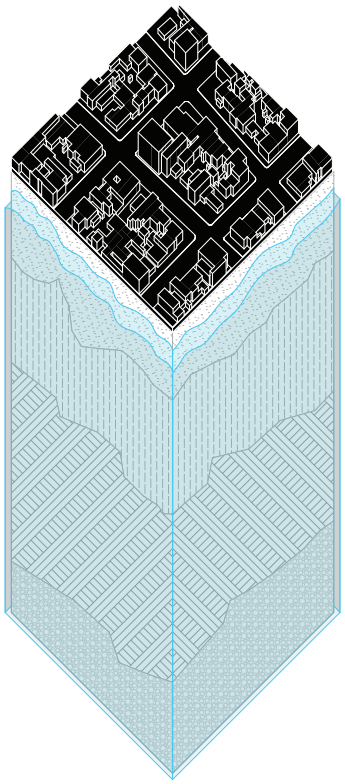
Map based on:
Municipality map_Flood prone areas
Map from Climatecentral.org

The situation In Guayaquil in relation to Flooding is quite problematic. Various sectors of the city are affected by presence of water in the wet seasons. As has been previously mentioned, the city struggles with a good drainage system and has very little absorption capacity. The soil where the city sits has deltaic characteristics which is by itself saturated on water, which equals on low absorption. Furthermore, the city does not have a strong presence of green infrastructure. This ironically presents the perfect storm for flooding to continuously take place.

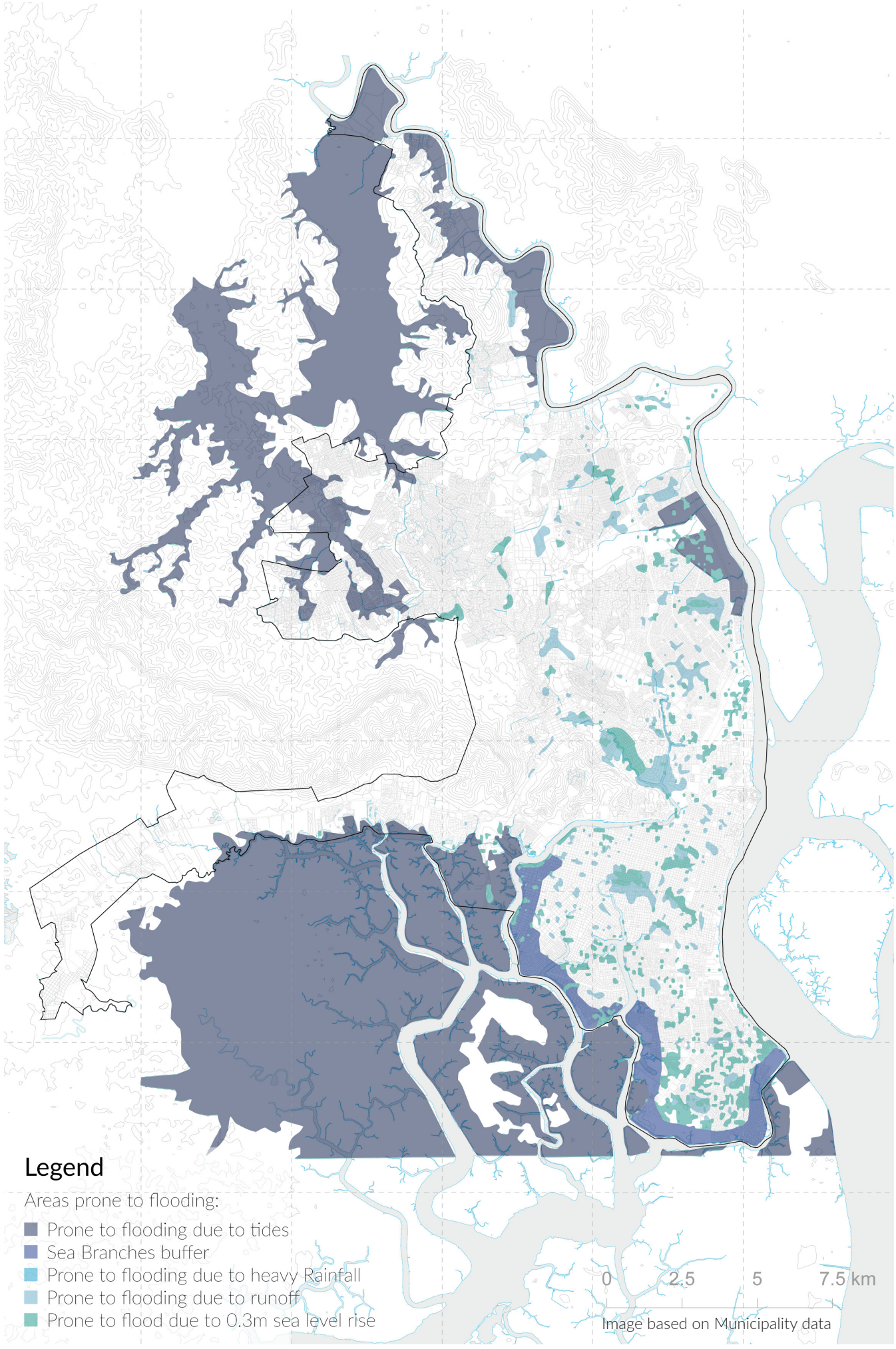
In the municipal map of areas prone to flooding various categories exist. Indicating there are different hydraulic systems causing flooding. Inside the urban limits, the map contains only areas prone to flooding due to heavy rainfall. However, studies suggest that the city faces big threats on the future due to sea level rise.

Based on the previously mentioned facts, is possible to say that the city of Guayaquil complex scenarios relating to flooding currently and in the future. Currents challenges are presented by heavy rain fall and high tide, and the future threats will be related with sea level rise and high processes of sedimentation in Guayas river.

Based on simulation webpages from the organization Climate Central (Climate Central, n.d.) is possible to see what are the area which will be most affected by sea level rise. In the case of Guayaquil, the southern part appears to be the most exposed. In such southern case, groups with smaller socio-economic conditions would be affected alongside the city´s port. This could represent a clear threat not only to the city but to the country. This is part of the future threats. The map of areas prone to Flooding has been elaborated by joining 3 sources: a) Municipality map with areas prone to flooding, b) Areas prone to flood due to sea level rise from Climate Central's Risk finder, C) Buffer areas in water margins suggested by this project.

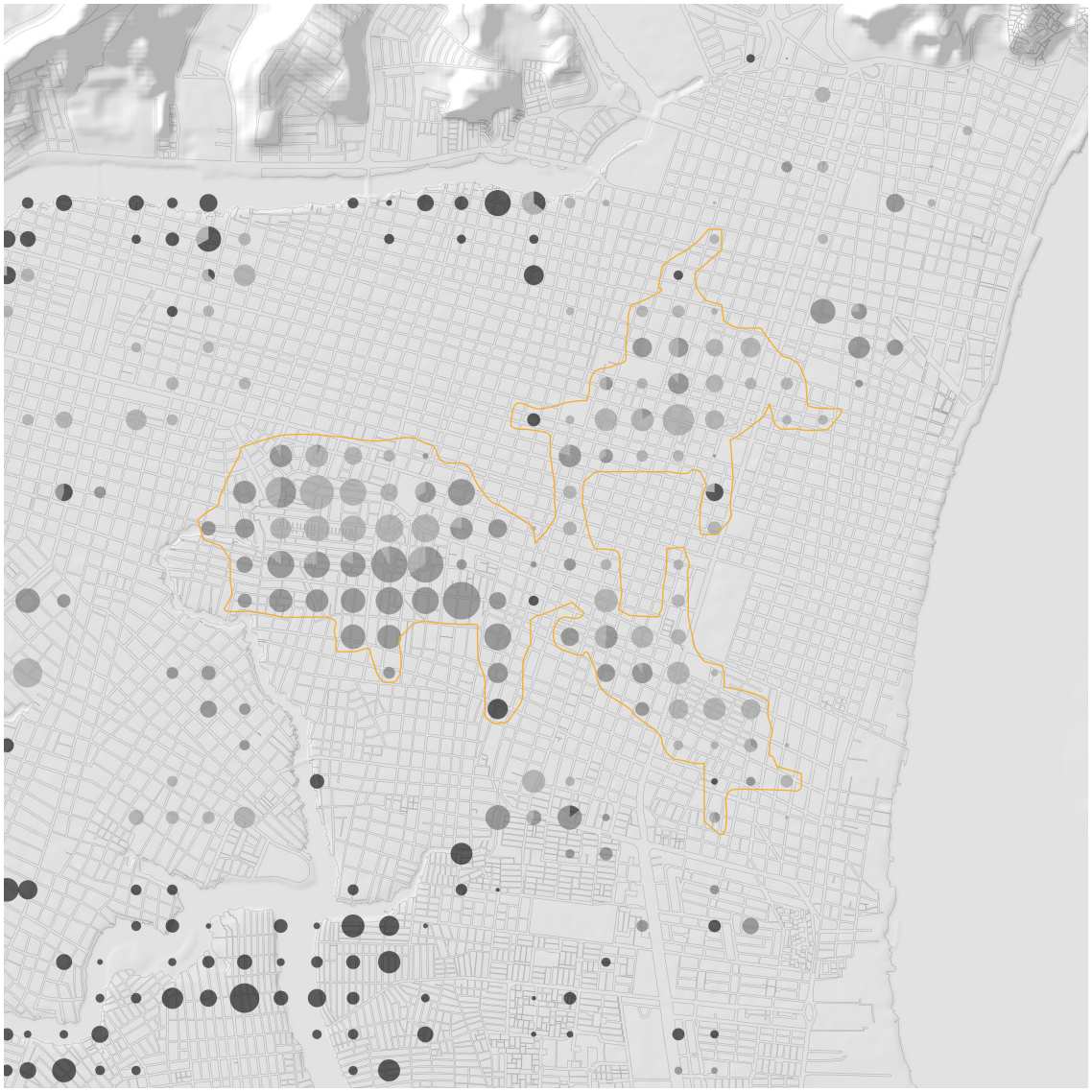


Guayaquil's low absorbing & saturated soil


Legend
Areas prone to flooding:
Prone to flooding due to tides
Sea Branches buffer
Prone to flooding due to heavy Rainfall
Prone to flooding due to runoff
Prone to flood due to 0.3m sea level rise
0
2.5
5
7.5 km
Image based on Municipality data

People affected by type of flood-Risk

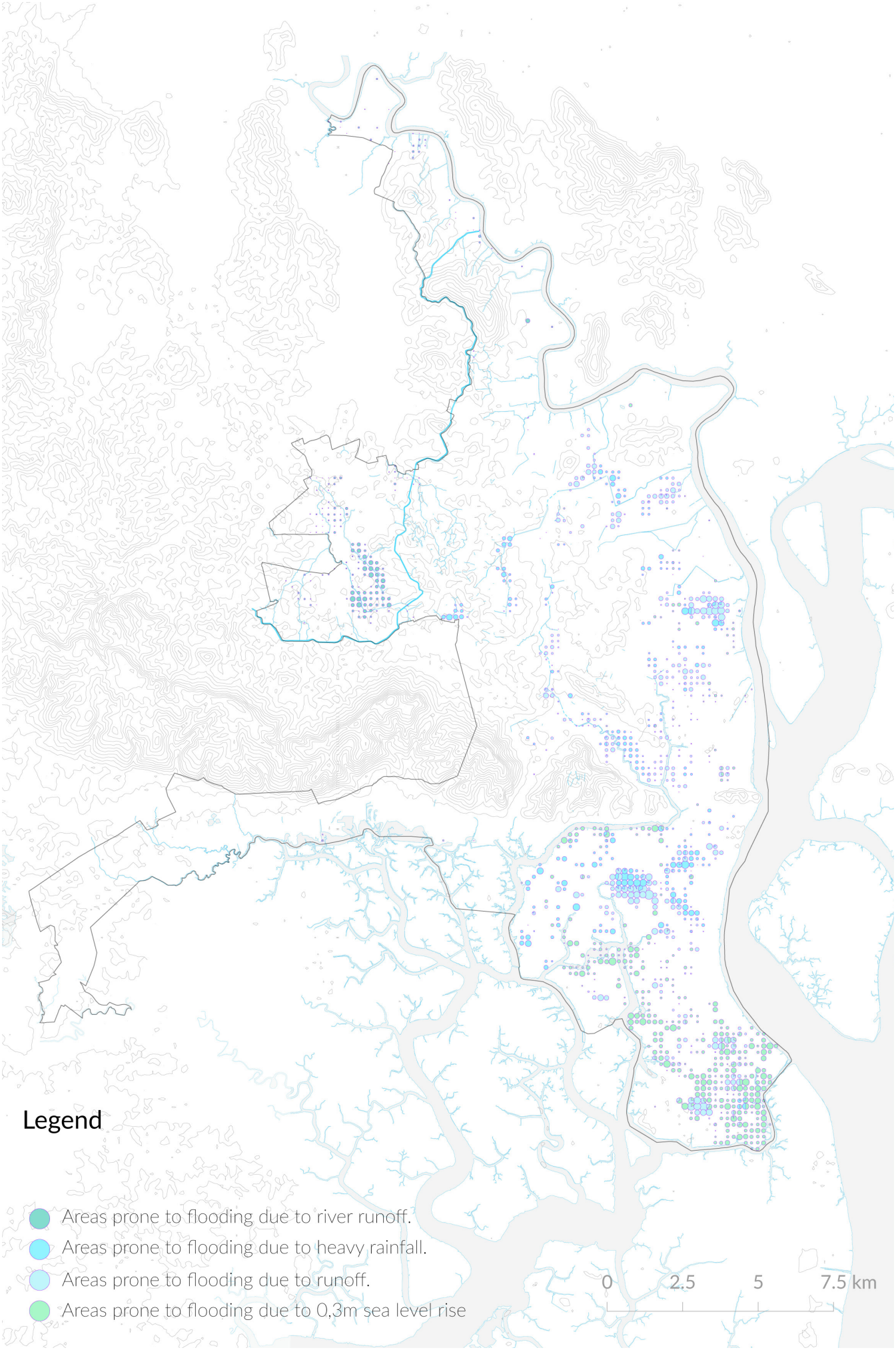
Maps based on:
2010 Ecuadorian Census
Municipality flood prone areas map
Climate central Risk Finder - Sea level rise 0,3m



A map of flood prone areas produces a flat image where is hard to distinguish the possible impact of such a phenomenon. Therefore, it is opportune to consider the impact these potential floods have on society. Is necessary to keep in mind that flooding by itself is not the problem, but the fact that is it takes place in locations where citizens execute daily routines. Is fair to say, that flooding in areas with no settlements is not a source of deep concern. Nevertheless, this is not the case in Guayaquil, where people are constantly exposed to this issue. To measure the magnitude of the impact among all the different areas, the amount people residing in areas prone to flooding was quantified. For this porpoise, a 200m by 200m spatial grid is used. The grid keeps the analysis from being influenced by urban morphology and only the stablished criteria comes into play.

In areas prone to flooding due to heavy rain fall and canal overflow there are 78.110 residing citizens that can be affected in the entire city. In areas prone to flooding owing to water concentration of run off, there are 110.203 residing citizens. In areas with high flood risk due to river overflow there are 19.940. In areas prone to flooding due to sea level rise there are 118.676 residing residents. This adds up to 326.929 potential cases of flooding affecting citizens. Not to say that this is the total number of people affected, since some areas share more than one cause of flooding. The area prone to flooding with most amount of residing citizens appears to be the one discharging in Estero Salado, indicated in here in orange.

The amount of residing citizens is based on the 2010 census.


Legend
Areas prone to flooding due to river runoff.
Areas prone to flooding due to heavy rainfall.
Areas prone to flooding due to runoff.
Areas prone to flooding due to 0,3m sea level rise
0
2.5
5
7.5 km

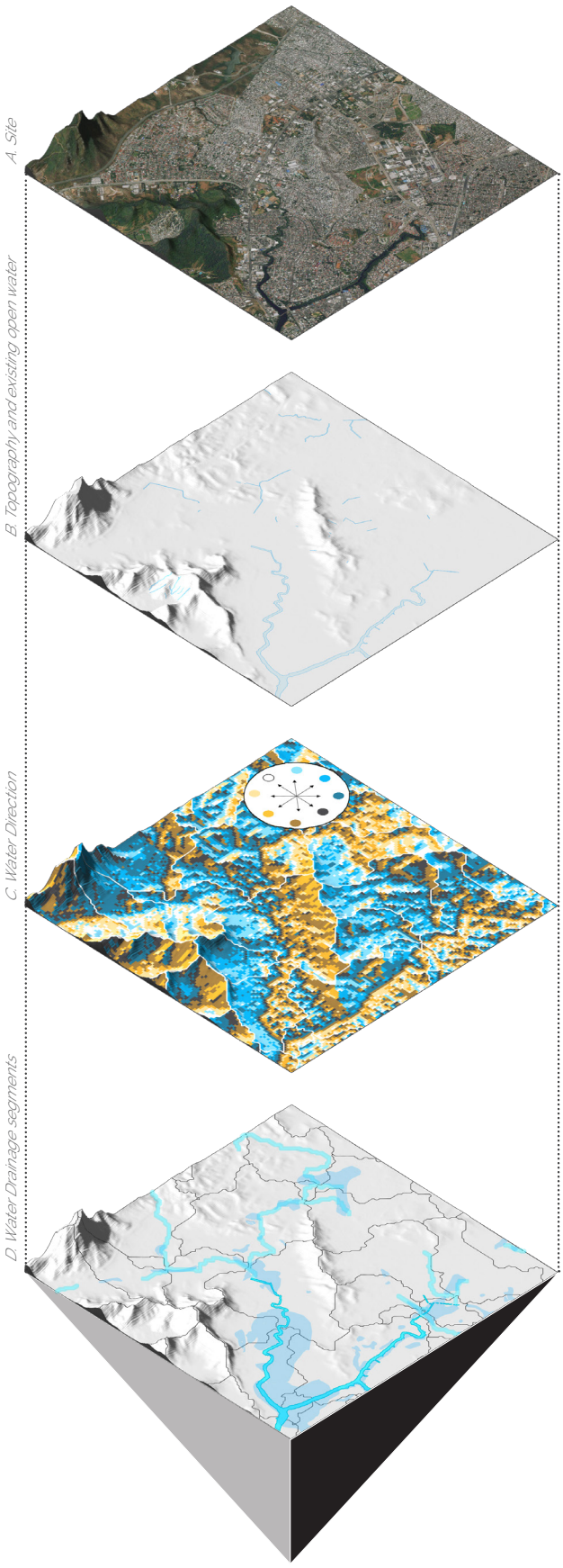
Surface water flow

Map based on:
Senagua watershed subdivision
Ecuadorian DEM provided by Sigtierras

The Surface water flow consist on a GIS calculation based on the Digital Elevation Model (Dem). The model was obtained from the Ecuadorian Agriculture minister under the program Sigtierras. The Dem has a resolution of cells of around 41 by 41 meters. With the Surface water flow analysis is possible to see why water gathers in certain areas. Each color in the map represents a direction. North is represented with Blue, South with orange; East with withe and west with black. The colors in between them represent the direction of 45 degrees between them. This analysis enabled a cross-scalar understanding of water movement. In addition, it enables the obtainment of water drainage segment (where all cell directions point to), most of them discharging to open water.

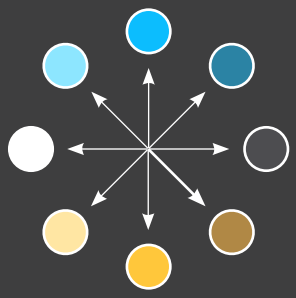
This segments and direction of the waterflow enable a clear reading of the direction of the water flow. In addition is also possible to estipulate the configuration of the watersheds. This is useful for generating strategies of flood mitigation since the structure of water flow can be clearly considered.

The Axonometries illustrate the process. Image A shows the site. In image B is possible to see the configuration of the topography and the disconnected water segments. With this input, the direction is obtained as in image C and the drainage segments as in image D, that seem to have disappeared but that are still where water gathers to flow out.

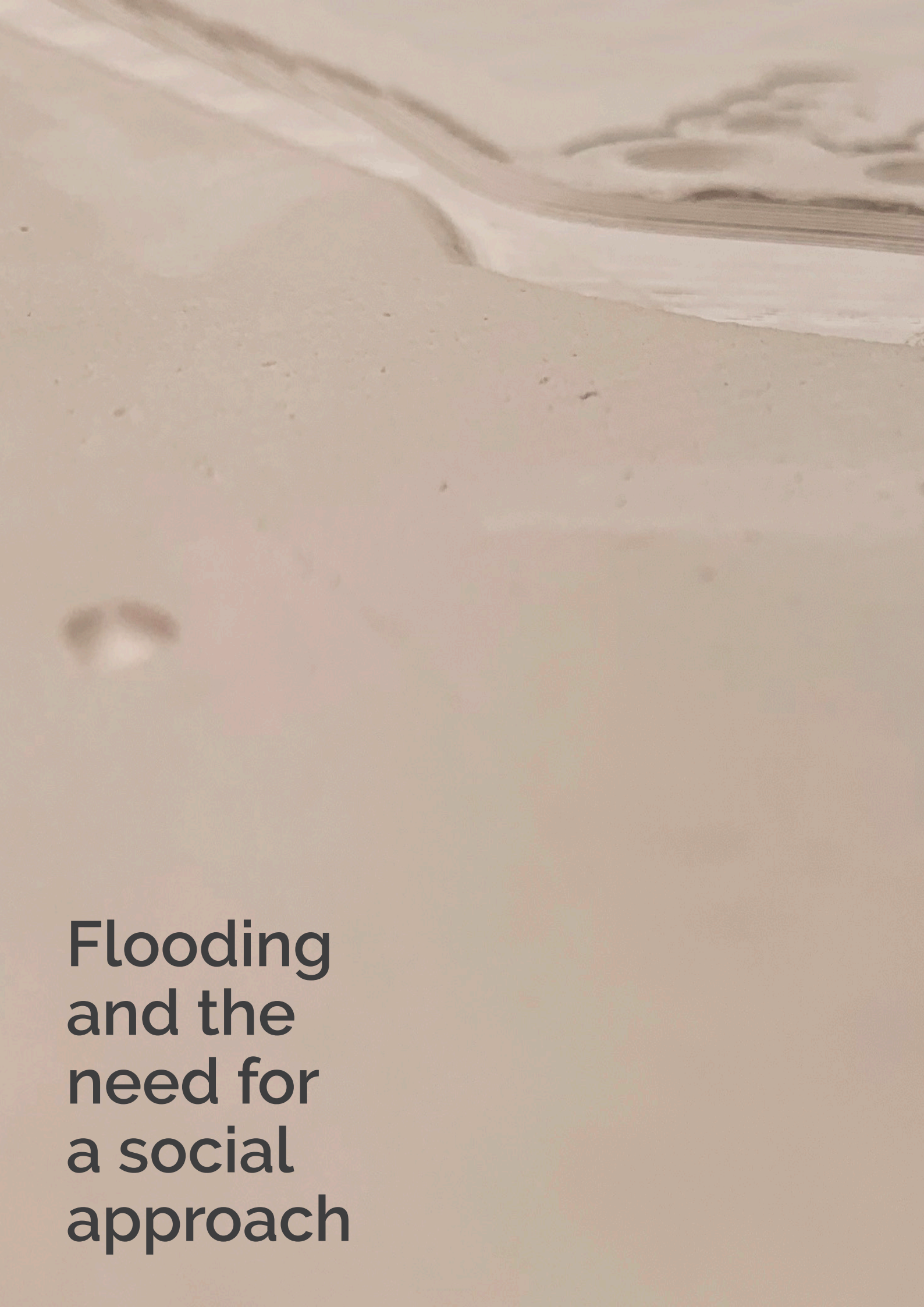


Surface water flow direction

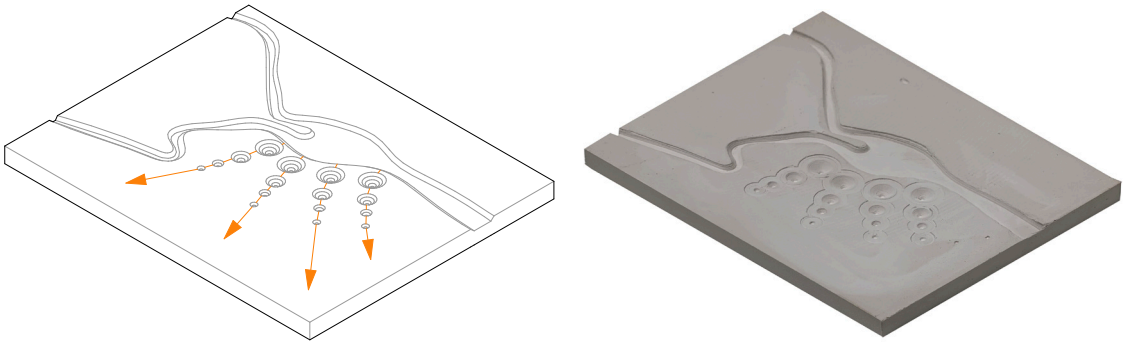
Map based on:
Senagua watershed subdivision
Ecuadorian DEM provided by Sigtierras



Water Drainage segments



Flooding and the need for a social approach



Ilustration of flood risk equal distribution

Flooding and the need for a social approach

With an overview of the conditions and constrains faced by Guayaquil related to the risk of flooding, different questions arise. How to mitigate the risk? How to save resources and execute the best strategy for the context? Is there anything positive from Guayaquil´s current condition? In the middle of this uncertainty, there is an example that sparks hope from all this inconvenience. The case of the Netherlands. More precisely, the process of how this country dealt with its challenging natural conditions and in this process developed what is defined by Han Meyer as a strong "Sense of Nationhood".

There could be critical observations about bringing these 2 totally different cases together (Guayaquil -Netherlands). However, the objective here is not the replication of any particular action developed in one to the other but to reflect on how the dealing with natural conditions has positively impacted Dutch society. This came to be, due to the fact that before any public organization was stablished, Dutch farmers and inhabitants stablished Water Boards in order to coordinate the water level on the polders. This water level needed to be commonly agreed since it was not possible to control it on an individual unit of occupation. This began to develop a tradition of consensus building which can be traced even today in the Dutch culture of planning.

According to Meyer, water management was central in the development of the nation. To dig deeper into the meaning of "Nation", Meyer recalls an 1882 speech from the French historian Ernest Renan entitled What is a Nation?. In this speech Renan explains how a nation is made by its members desire to stay together; based on past experience, history and future prospects (Meyer, 2017).

This reflection is interestingly relevant for the case of Latin America. Latin America is the region in the world with highest income inequality (Roser & Ortiz-Ospina, 2016). This means that within the same continent people have totally different realities. Going further, this could mean that they have not seen or experienced their history (or the one of their previous generations) from the same pair of lenses. If we disintegrate Renan's ideas of nationhood based on past experience, history or future prospects, we could say that Latin American population has a hard time finding collective harmony. At the same time, it witnesses problems affecting all social groups.

In a quick side note, we could analyze almost any Latin America city and witness that within their social structures daily routines vary so much, that their co-existence awareness inside the same system could be rendered almost invisible. There are groups which start their days far away from the central hubs, in self-made houses and need to invest considerable amount of time in public transit to reach workplaces; At the same time, there are groups that have enclosed themselves in particular areas of the city and move from private communities to private transportation to

private facilities.

The social dynamic in Guayaquil is not an exemption. According to Delgado, after the city experienced a rapid process of growth due to inmigration, Guayaquil could be described as "a city without citizenship" (Delgado, 2011). For this reason, various campaigns aimed at creating this sense of collective urbanity. But even after this social identity has been improved, the city still has strong problems related to social segregation. Delgado concludes that measures will have positive impact in the short and medium term but on the long term "A process of social integration by social participation and inclusion in city programmes, ... should be incorporated for connecting the fragmented city" (Delgado, 2011)

This "fragmented" condition and social disassociation can generate unawareness of the different realities experienced by different groups inside interdependent social, economic and environmental systems. One way to harmonize these realities is through improving how groups share common goals.

In societies where, daily lifestyles vary so much among groups, the fact that environmental challenges as flood risk do not distinguish these social distances and hierarchies should be seen as a common line for improvement. Flood prone areas in the case of Guayaquil suffering from the brief and loaded winter rainfalls show a wide range of socioeconomic conditions. If the severity of the risk is understood by the population, this step in the city agenda could not only represent the improvement of some spatial condition but an important step in the city's social timeline. This understanding of flood risk as a threat that does not distinguish social classes does not aim at triggering any class battle, on the contrary it aims to create a cross understanding and cooperation among these networks.

Portraying the urgency of this issue is not an easy task but the severity of the case could be supported by the fact that annually on average almost 1% on the city's GDP is lost due to flooding (Hallegate, Green, Nicholls, & Corfee-Morlot, 2013). This positioned Guayaquil in 2013 as the 3rd city in the world, with the biggest percental losses of GDP (Hallegate, Green, Nicholls, & Corfee-Morlot, 2013).

This fragmented character of Guayaquil´s population, could be analyzed from several angles. There are topics related to income distribution, social distance, power distance, exclusion etc. However, from the spatial point of view this social disintegration could be analyzed from the framing of spatial-segregation.

Spatial Segregation

Spatial segregation could be related to various reasons. According to Lung & Baires, in the developed world within literature and policy, spatial segregation is usually related to ethnical and racial topics; On the other hand, In the developing world it is more closely related to topics of social and economic differentiation (Lungo & Baires, 2001). This means that the segregation in developing countries could follow a hierarchy of privileged and unprivileged; and at the same time, it can create clusters of wealth or poverty. This clusters can also gather people siting close on the power distance scale. In a country like Ecuador that poses a spread power distance metric, the different social groups not only sit apart but have a totally different scenario related to power in society (affecting access to information and people and ultimatly jobs).

In order to grasp the Socio Spatial segregation situation in Guayaquil, topics of socio-economic groups come relevant. According to Conley & Topa, the evidence relating job search to social networks is extensive. "A vast body of research in economics and sociology has shown that at least 50% of all jobs are found through informal channels, such as talking to one's friends, family, neighbors, and social contacts in general" (Conley & Topa, 2002). This indicates that spatial segregation could lead to problems like unemployment, meaning segregated groups do not only face less access to information but also a bigger economic challenge.

The socio-economic analysis done in this study considers topics related to housing, basic services, consumption habits and assets. In Guayaquil, indicators based in the 2010 Ecuadorian census show that sanitary services are not covering the whole city, meaning there are areas without basic services in the North West periphery (such as El Fortín, Prosperina, Pascuales). After rough episodes of the 1990's about water provision, this are matters that need urgent attention. According to the municipality, by now 2019, these topics have been solved, however public institutions in the country are known to have a bias and not always operate with precise facts. Similar spatial configuration show the North West periphery struggles with topics related to materials of housing (walls and floors). A different spatial pattern exists in matters as Education, where not only the north west part appears to have lower values but also the south (Guasmo) and south west areas (Febres Cordero,

Trinitaria, Guasmo oeste). Similar patterns take place with type of Jobs.

The Socio-Economic configuration at city scale shows the center with higher values extending a to the north (Urdesa, Alborada), and to San Borondón (out of city limits) across the Daule River in the east. The socio-economic analysis apart from giving an overview of the city helps verifying if different problems are originated from this social distance. Since in Latin-America various social issues relate to socio economics, it is a useful base map to look for correlations.

Particularly relevant to the project are the location of green spaces and gates. Green Areas represent areas for water infiltration and they also mitigate the Urban Heat Island effect. In Guayaquil the green areas look to be mainly located in areas with higher socio-economic values. The reason for this could be that some areas grew unplanned and with no green infrastructure due to rapid and informal development of the city. However, after they have become part of the city they should go under processes of enough planning and provision.

With data from Open Street Maps, gates could be located geographically; The presence of gated streets, enclosing gated communities are mainly located in residential areas of privileged groups. This evidences a process of exclusion where groups with higher socio-economic conditions cluster together, creating inaccessible areas in the urban fabric. Furthermore, gated communities not only stablish a break in the continuity of the urban form but also a change in the urban pattern where various street segments connect to the context trough only minimal points where gates are located. In other Ecuadorian cities, spatial segregation phenomena are believed to be one of the causes for urban dispersion and lower density (Orellana & Osorio, 2014).

An alarming fact spotted by the author while visiting the city is that there are gated urban parks with only specific spots for entrance during the day, which are closed during the night due to safety issues.

Spatial Analysis.

The topics at stage at this point are space and society; and the concept developed around the theory of The Social Logic of Space (Hiller & Hanson, 1984) can help understand if Guayaquil's social dynamics reflects into how the city is structured. Furthermore, after understanding the configuration of the city, improvements can be suggested.

But why is space relevant in the topic of segregation? What is the influence of space in society? Cities are the agglomeration of people. By agglomerating, people can do more specific tasks, but we need to belong to a system where people do the same; As a consequence, we are all functional, but no one is irreplaceable (Wirth, 2005). These agglomerations and activities generate movement; and this movement takes place in a defined arena. As Gehl has explained,

occupation of people in the public realm takes place in Streets and Squares, for moving or staying respectively (Gehl, 2010). When people occupy and move around spatial networks, they are influenced by the spatial configuration, space is therefore not a neutral base; What influences people is not the materiality, but how the space is socially constructed and linked one another (Hiller & Hanson, 1984). Hiller & Hanson argued that architecture becomes the basic structure that "provides the material precondition for the patterns of movement, encounter and avoidance which are the material realization – as well as sometimes the generator – of social relations" (Hiller & Hanson, 1984). Additionally, it is argued that spatial configuration has an effect on the distribution of amenities, meaning that space could influence how accessible these amenities are among neighborhoods (Legeby, Berhauser Pont, & Marcus, 2015)

By occupying a city with its spatial configuration and moving around it, citizens have the opportunity to coexist, and share presence. By sharing space and public facilities "we have the possibility of gaining insight into other´s people living conditions" (Legeby, 2013). As Legeby suggests co-presence entails bringing social differences together, making them visible, allowing awareness of other realities. Processes of co-presence has an influence on the "exchange of information, knowledge or simply learn and form the unwritten rules of society" (Legeby, 2013). This social process of Co-Presence is needed in cities; it is a substantial way of being reminded that urban life is about differences, not only on activity but on opinion, thought and desire. It is one of the most basic needs of urban life since after all, as putted by Jane Jacobs, a city is a concentration of strangers. Or as defined by others: Urbanity.

The question is what is exactly co-presence and how it can be improved? Co-presence is the situation where people are present in space where they are close enough to see each other. They did not necessarily aim to this setting, but they may be part of it on a daily basis. This process is believed positive for social integration since it enables awareness about other people in society and it is fundamental for further interaction (Legeby, 2013). In the Guayaquil, the Network betweenness analysis show street segments that have higher probability to become part of a shortest routes. When analyzing this characteristic in a low range (500m), is possible to see how some areas of the city are more connected or disconnected at neighborhood scale. This capacity to be part of a route influences the potential presence from people living outside of the area. This presence from what has been denominated as non-locals containing knowledge and information could be crucial for getting a job. (Legeby, Berhauser Pont, & Marcus, 2015). According to Legeby et al. the creation of urban spaces that "give access for non-locals should make for greater diversity of groups in society to share space" (Legeby, Berhauser Pont, & Marcus, 2015).

Is fair to say that Co-presence is not a solution for segregation but is definitely an important step towards integration. If we realize that due to the spatial configuration of the urban weave, there are neighborhoods that won't be able to attract moving people, it is hard to imagine deeper processes of social integration in such neighborhoods. Therefore, co-presence could be understood as an initial dynamic necessary for further social integration.

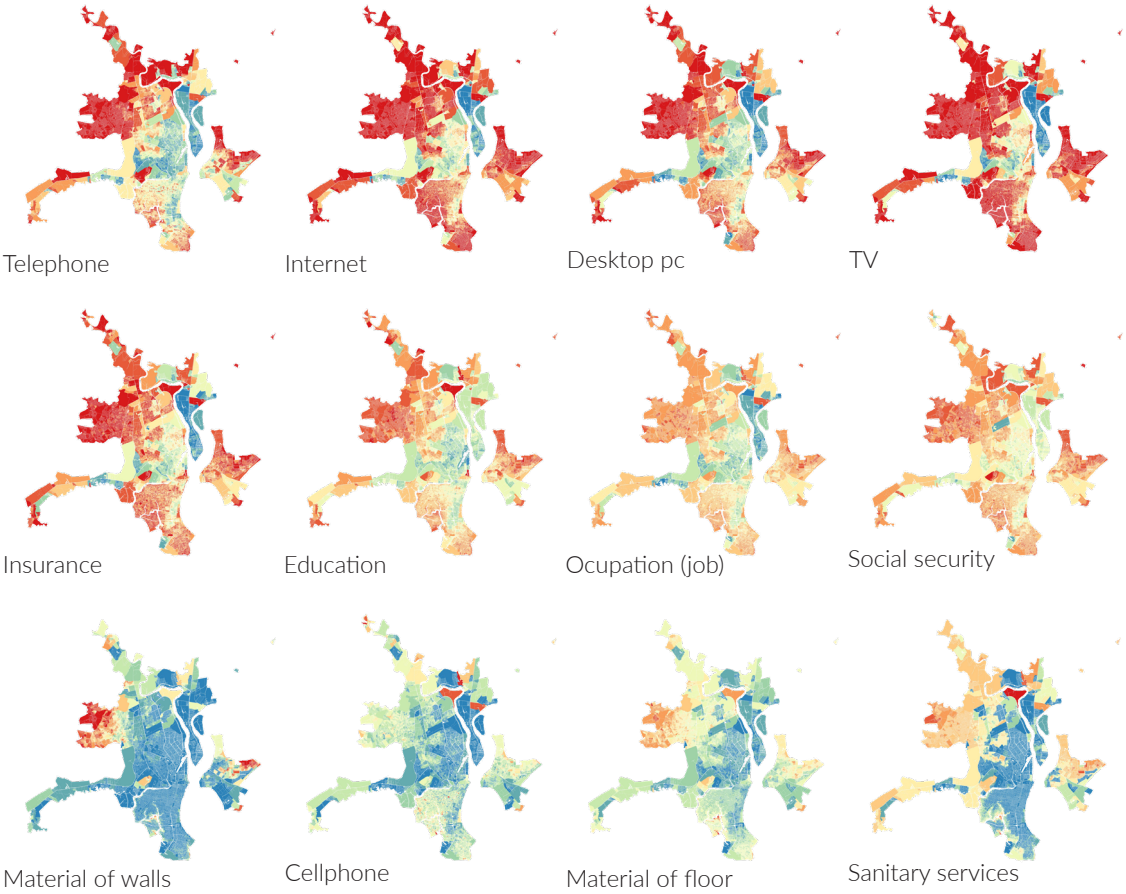
The methodology developed by Hiller & Hanson in The Social logic of space, analyses city configurations based on a couple of ways. Specially relevant for this project are the network integration analysis and network betweenness analysis. In the integration analyses each street is taken as an axis, and each axis in the network is compared to each other axis. With this process it is possible to see which areas are more or less integrated (Hiller & Hanson, 1984). This is done by calculating the number of turns taken from one axis to every other axis, following the shortest path (Hiller & Hanson, 1984). This is done for every component of the street's networks. They developed an additional method for network integration based not on the number or turns but on the degrees turned, this analysis is named Angular Integration. The difference is that the analysis considers the angular deviations a street may have. On the other hand, the network betweenness analyses what streets are more likely to fall into the shortest path routs, meaning these streets are likely to be taken in between the origin and destination for all network routes. For all analyses, Network integration, Angular integration or Network betweenness a distance range has to be stated, in order to see what scale of trips are analyzed.

For conducting this analysis, the Place Syntax Tool developed by KTH, Chalmers & Spacescape was used.

Flooding and the need for a social approach

Socio - Economics Guayaquil

Map based on:
2010 Census of Housing and Population
& Adapted method by Inec



The information related to the socio-economic spatial occupation was done following a method developed by the Ecuadorian National Institute of Statistics and Census. Different weight is given to different characteristics of the population and dwellings. Then, all these are added in sum where the maximun value is 1000 reflecting the socio-economic distribution.

The socio-economic map reflects a city with a center occupied by the more privileged socio-economic groups. North from the center, various gated communities appear occupied by similar clusters. Out from these areas, a gradient can be spotted with the less privileged socio-economic groups in the external areas. The map includes settlements outside the city of Guayaquil. As mentioned before, the settlement of San Borondón appears fully occupied by higher socioeconomic groups in a high number of gated communities. The settlement of Durán (east of Guayas river) shows a occupation by less priviliged groups.

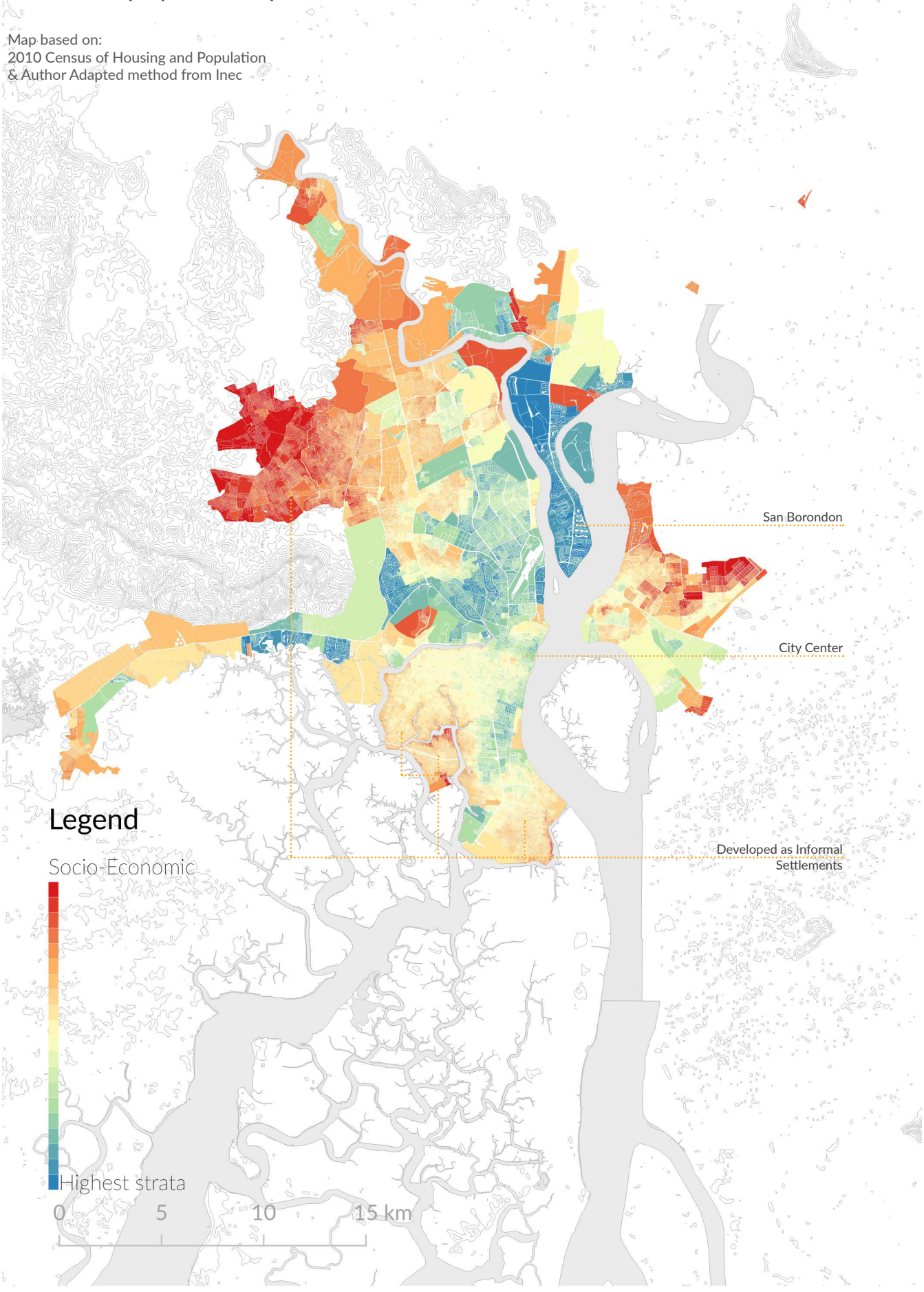
Areas out of the city also show a bigger presence of Dengue reported cases. Dengues is a virus transmitted by a tropical mosquito, which in certain cases can be lethal. The reasons for the spatial distribution of the virus have to do with poor housing, and access to piped water among others (Lippi, et. al, 2018)

The social disintegration of Guayaquil has generated various social problems that eventually affect how the city operates and the sense of insecurity is high.

Socio-Economic map

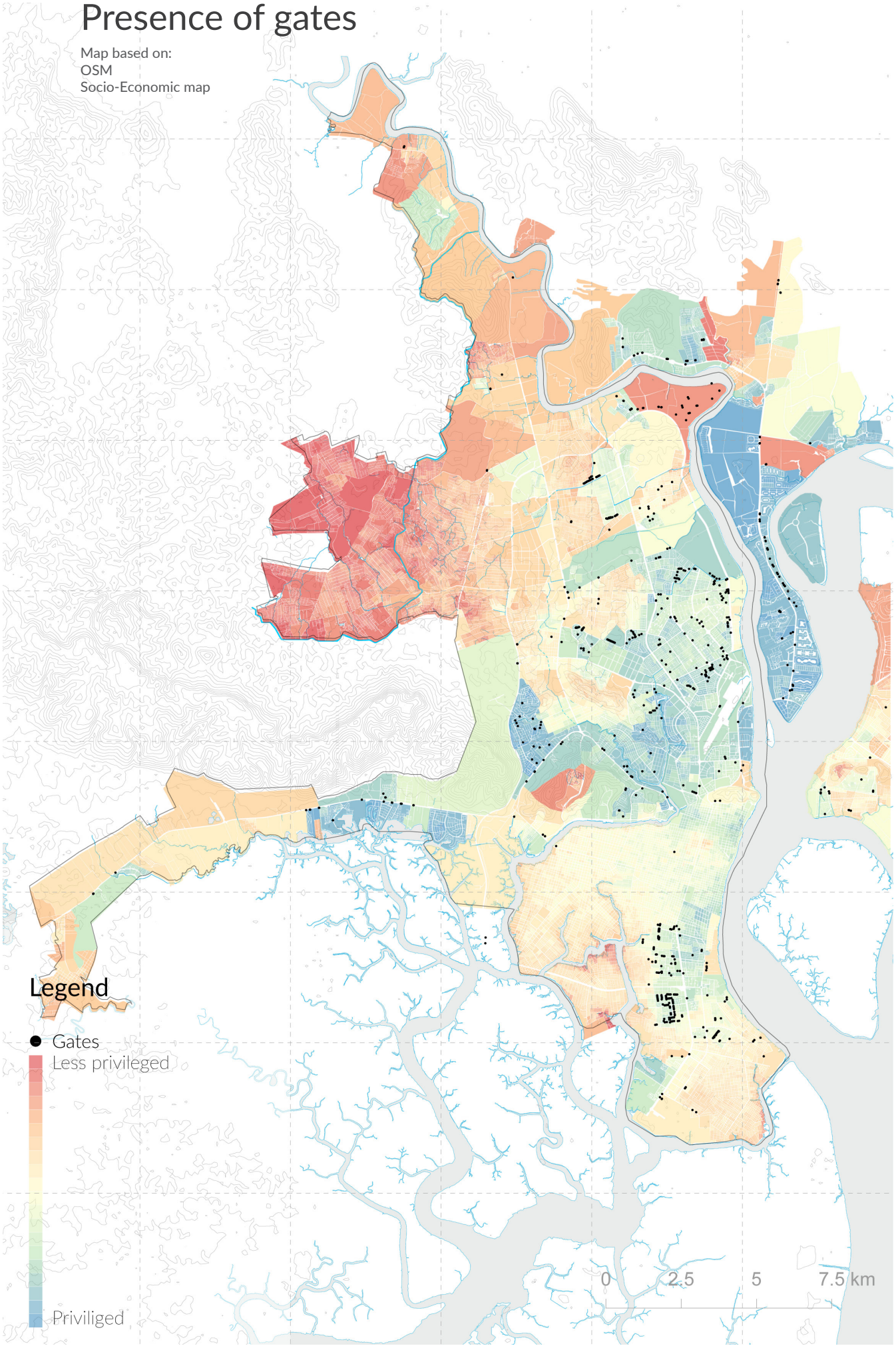
of the Guayaquil Metropolitan Area

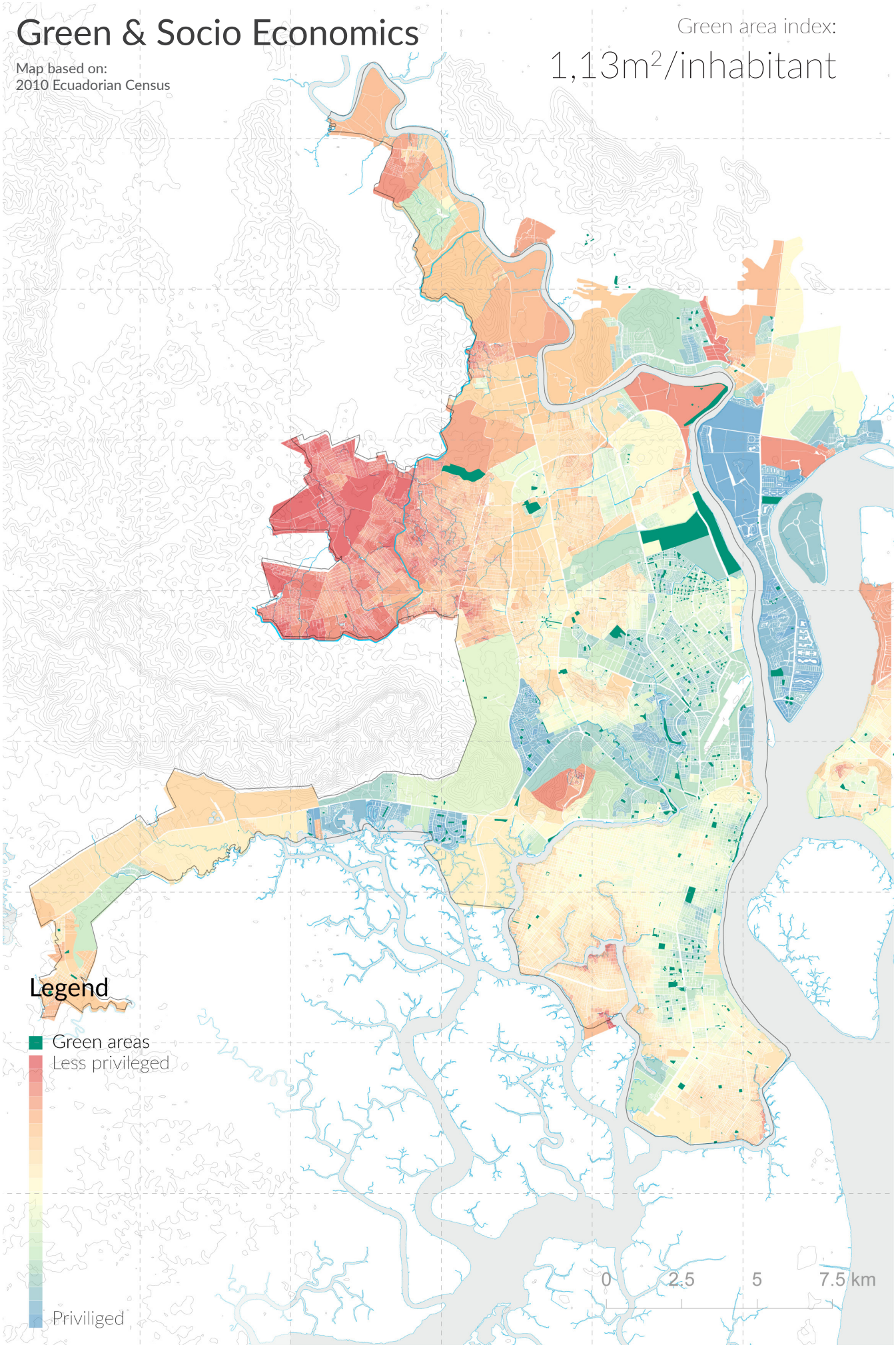
Map based on:
2010 Census of Housing and Population
& Author Adapted method from Inec



Presence of gates

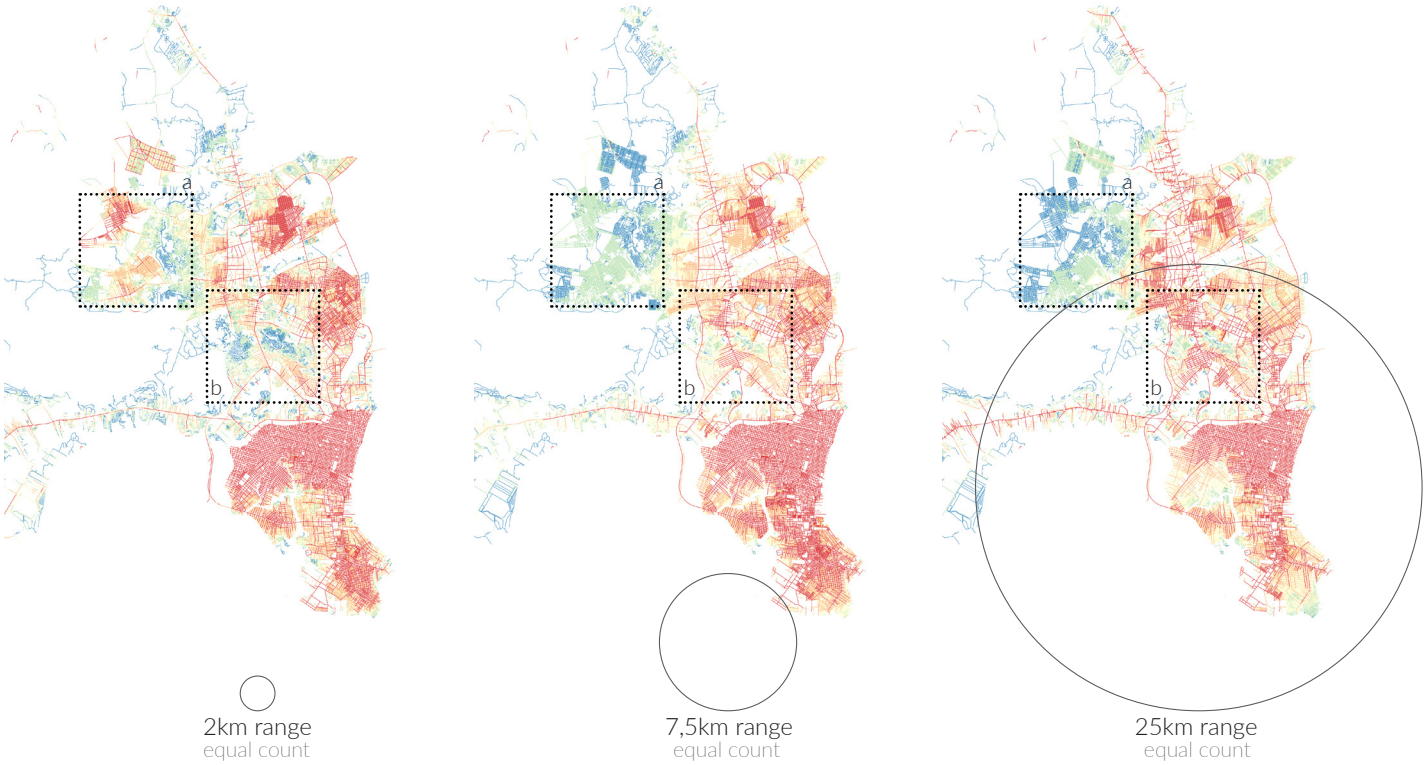
Map based on:
OSM
Socio-Economic map




Green & Socio Economics
Map based on:
2010 Ecuadorian Census
Green area index:
1,13m²/inhabitant
Legend
Green areas
Less privileged
Priviliged
0
2.5
5
7.5 km

Network Integration - Angular

Map developed with:
PTS Tool and Axial map Guayaquil

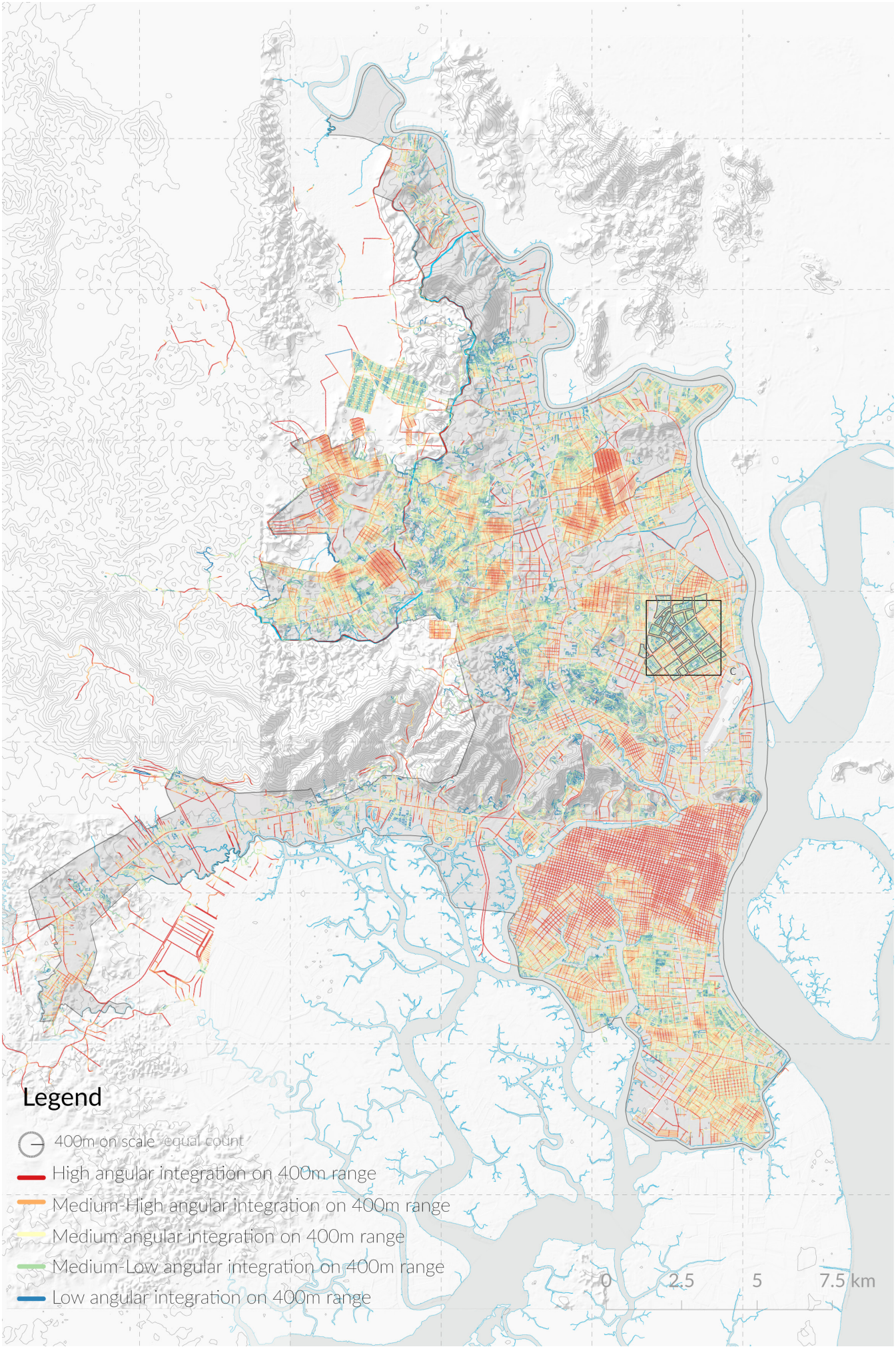


The angular integration analysis consists in the angular distance (sum of degrees turned) each axial street segment has to the rest of the network using the shortest path. For each analysis a Constant trip distance is stablished. This will be the distance determining all the trips analyzed from each street segment. The map is done using the Place Syntax tool.

In the case of Guayaquil various radii are used to stablish a proper understanding of the existing situation. A 2km range aims to illustrate movement happening within the neighborhood scale. The analysis shows a high integration in the CBD as well as in the northern areas (Urdesa, Alborada and Sauces 1-8). The CBD and its immediate surroundings have a regular grid pattern, which makes the Angular deviation minimal and, in this way, enabling a high angular integration. Southern areas look to have a main integrating axis, around where integration dissipates. The North-eastern periphery shows a brake in the integration from the main body of the urban weave, this characteristic takes place as well with ranges of 7,5km and 25km. The area indicated as B also shows disintegration among these 3 scales.

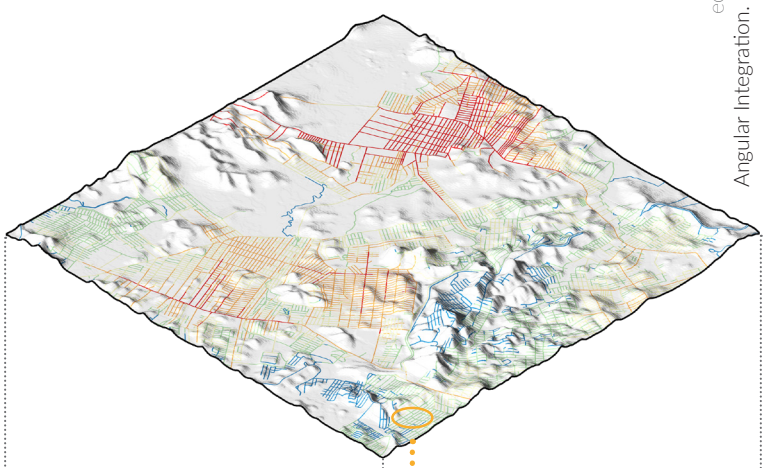
The city seems most angularly integrated at the 7,5km range. This can be a sing of the configuration of the city focused toward this type if trips. Is important to keep in mind that Guayaquil has been a city where car infrastructure seems to be important in the agenda. Several car overpasses spread over the city evidence this.

In a smaller rang of 400m range is possible to see how the northern area north of the CBD also has areas with a lower integration in what could be defined as the residential streets. These areas that present a low network integration present also socioeconomic reasons behind these configurations. They are exact conditions are explored further.

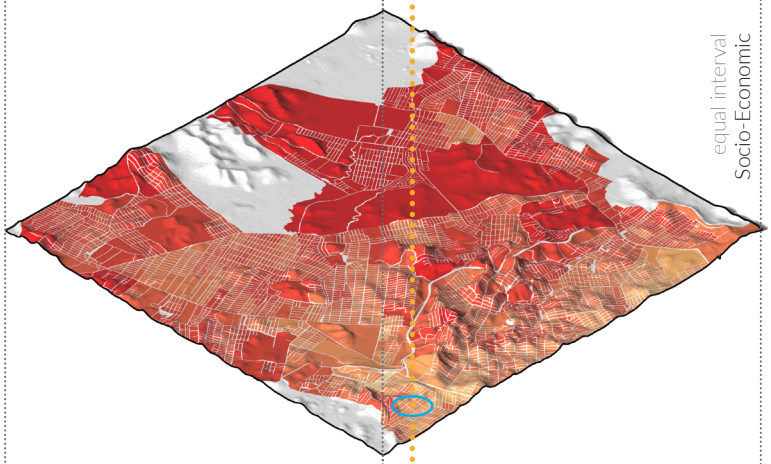

Legend
400m on scale 'equal count'
High angular integration on 400m range
Medium-High angular integration on 400m range
Medium angular integration on 400m range
Medium-Low angular integration on 400m range
Low angular integration on 400m range
0
2.5
5
7.5 km

Network Analysis - zoom A

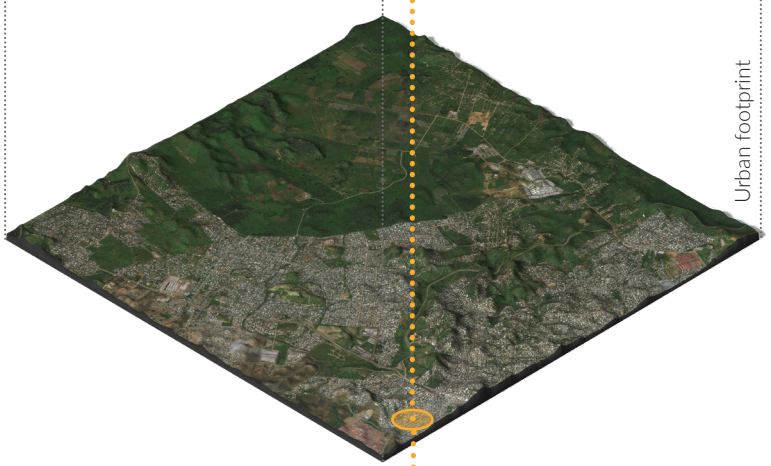
The north west periphery is the area with the hardest situation. According to the socio-economic index, it is the place with the neighborhoods possessing the lowest marks. In Spatial terms, it is an area with a non-flat topography. This has caused a disintegrated network of streets. On the other hand, the steep topography represents a threat due to potential instability of the settlements. It is important to mention that the Ecuadorian coast suffered from a massive earthquake in April 2016 and Guayaquil was one of the cities with human loses.



equal count
Angular Integration. 2km range



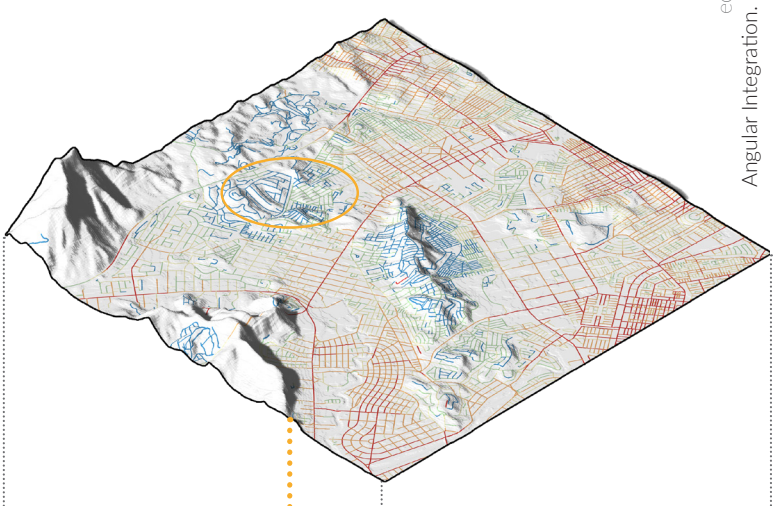
equal interval
Socio-Economic



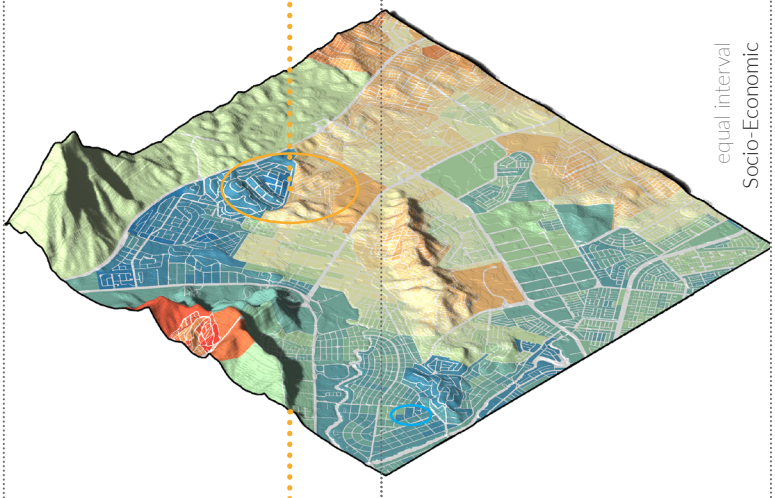
Urban footprint

Network Analysis - zoom B

This area is composed by contrasting neighborhoods. It appears as an area where the socioeconomic conflicts of Guayaquil could be spotted. In the one hand it is primarily composed by privileged groups (Neighborhoods as Urdesa and Los Ceibos). On the other hand, steep topographies appear to be the place where lower groups are able to get some space, they sit in a network not integrated to the context. In the images below an area of drastic change is zoomed in. A wall of a gated community separates 2 neighborhoods. The urban fabric is disintegrated, and the two realities face each other behind a wall.



equal count
Angular Integration. 2km range

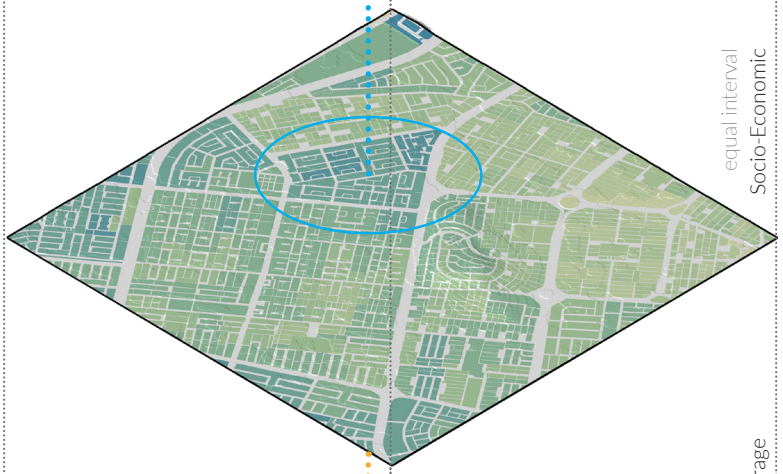


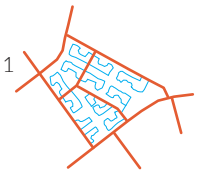
equal interval
Socio-Economic

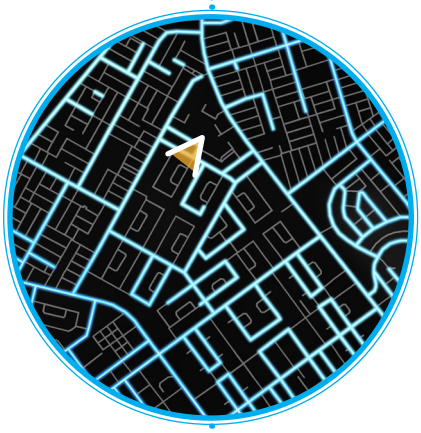
Urban footprint

Network Analisis - zoom C

The analyzed area is composed by neighborhoods of medium, and medium high households. The area shows an interesting network. With a range of 400m, the angular integration map shows a disintegrated network in the smaller scale. Meaning residential streets don't belong to a big urban weave but have more the characteristic of loops around main streets (fig. 1). To access the residential neighborhoods there are several gates. The configuration of gated communities has an impact on integration. Not only because they limit access, but because in order to control entry their configuration aims for minimum contact points with the surrounding street network. The map below shows the Google street view coverage, evidencing the limited access possible in this area.







Network betweenness

Map developed with:
PTS Tool and Axial map Guayaquil

500m range
Equal count

20km range
Equal count
not equal color distribution

Within the Space Syntax theory of Hiller & Manson, architecture agglomeration and collective configuration are argued to have an impact on how people move and therefore potentially be co-present in space. Within Network theory, Betweenness is the property of a line segment to be part of a route, or as described by the Place Syntax Tool Documentation:

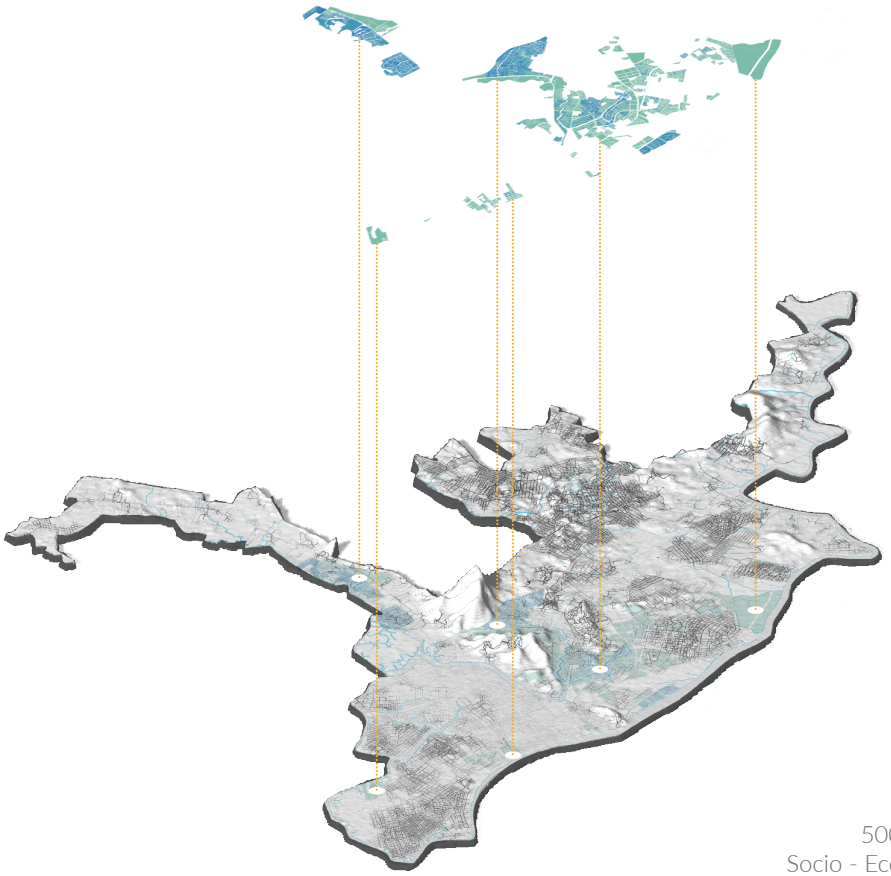
"Network Betweenness calculates how often a line falls on the shortest path between all pairs of lines in a network, or how many shortest paths pass through it. In other words, lines (axial lines or segments) which control and mediate movement and connections between many other lines in the system have a high betweenness value" (KTH, Chalmers, & Spacescape_AB).

For this reason, in the present project network betweenness is seen as the layer of the network showing how movement is likely to happen based on the geometric configuration of the city. In the case of Guayaquil 2 analysis where conducted. At the scale of 500m and at a scale of 20km. In the 20km range map is possible to see the characteristic foreground and background links in the network defines by Hiller (Hiller & Hanson, 1984). On the streets that are likely to take part of local trips are highlighted.

A question raised by Legeby is taken into consideration. "Does a spatial fragmentation inhibit inflow of non-locals?" (Legeby, 2013). Referring to the relation among the network betweenness characteristics in an urban layout at a low range (as 500m), and the presence of people who reside more than 1000m away of X area. In the case of Guayaquil, the map (network betweenness with 500m range) shows a CBD with low network betweenness, this can have a relation with the fact that this area has a regular grid, where trips passing by can have more than one option. The southern areas look evenly integrated. In the north of the CBD the patterns are appear more fragmented, evidencing that at this lower scale neighborhoods are not tightly connected.

For illustrating porpoises, we could say that if there are 2 joint neighborhoods where the network

Conclusion Explanatory pahse



500m range and priviliged
Socio - Economic groups location

betweenness in one is high and in other one low; if we need to take a 500m route where both of them could take us where needed, we are more likely to take the on with highest integration. This will also have an impact on how the two neighborhoods are connected between them.

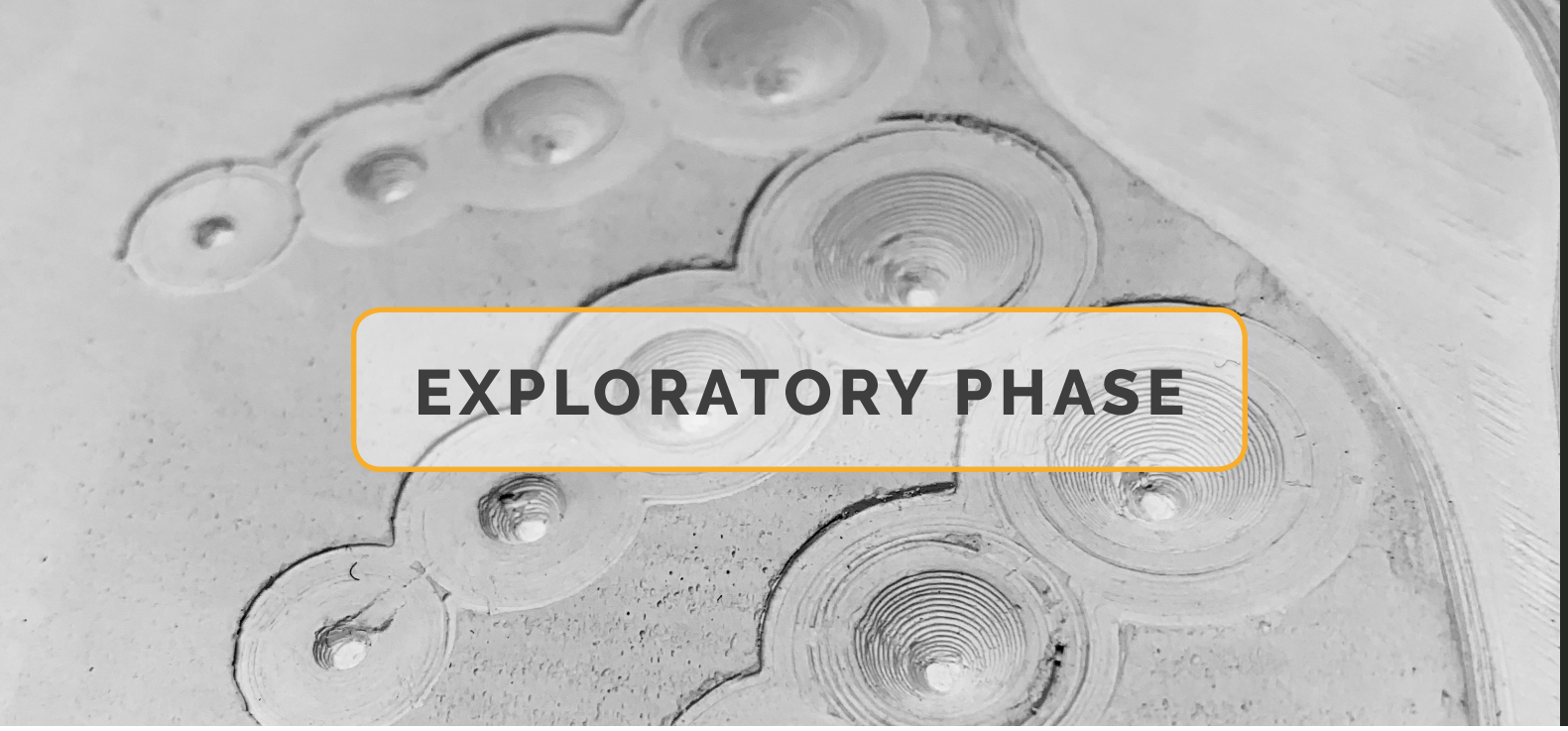
In the case of Guayaquil Neighborhoods in the north of the CBD appear to be fragmented in the network betweenness map of 500m range. When compared with the Socio-Economic map, is possible to see that the higher groups sit in areas that are not heavily integrated to their surroundings. This can be evidence a of case of Segregation of coercion, where higher socioeconomic groups have developed residential enclaves within the city.

Conclusion Explanatory phase

All water systems acting in Guayaquil (Coastal, Fluvial, Pluvial) have an impact on the flood risk of Guayaquil. As manifested by Barrera Crespo, et al., “The picture arises that the sediment balance around Guayaquil is governed by sand import from downstream, owing to the flood-dominant character of the tide, and periodic flushing out of this sand by river floods”. (Barrera Crespo, et al., 2018). Indicating the reason for this could be the deforestation of mangroves and supplanted by shrimp farms. This sedimentation process increases flood risk and will also increase with sea level rise (Barrera Crespo, et al., 2018). Based on various soil test from Molenaar, Pak, de Pous, & van der Werff soil absoption in Guayaquil appears to be low. Indicating that flood mitigation strategies, once increased the area of absobing soil, will need to also increase spaces for water storage.

The area prone to flooding with the biggest amount of residing citizens appears to be the one around the drainage segment discharging in Estero Salado. In the whole city, the total amount of cases of residents being potentially affected by flooding is 326.929. This includes people from all socio-economic groups which opens the door for a strategy that aims to establish a common goal among social groups.

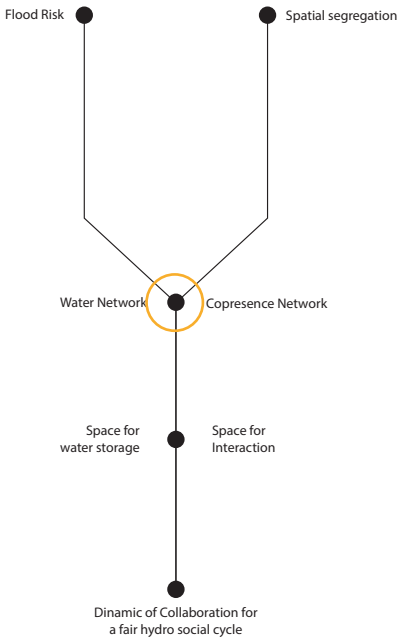
In the social-economic side, the city has a centralized spatial distribution. In addition it shows evidence of residential segregation, both of Coercion and of Choice that is also reflected in the integration of the city from a network betweenness perspective.



EXPLORATORY PHASE

The exploratory phase aims to develop a strategy as an answer of the previous analysis. In order to do so, the 2 identified problems are answered from an integrated approach.

Networks of water and Co-presence



After the overview of the current condition of Guayaquil, is fair to say the city has various topics with room for improvement related to Social, Economic and Environmental processes. The strategy conceived in the exploratory phase aims to improve 2 specific problems that relate with Environmental and Socio-Economic challenges. They are punctually framed under Flood Risk & Spatial Segregation. The assumption in this stage is that Flood risk in Guayaquil could be mitigated by an improvement of the water system dynamics and at the same time have a possitive impact in terms of social integration. The mitigation starts by understanding the natural flow of surface water networks. These networks need to be based on the topography of the city into the bigger scale. The Water Basin analysis provided water drainage segments that show the lowest points where water gathers and how it can flow out to water bodies.

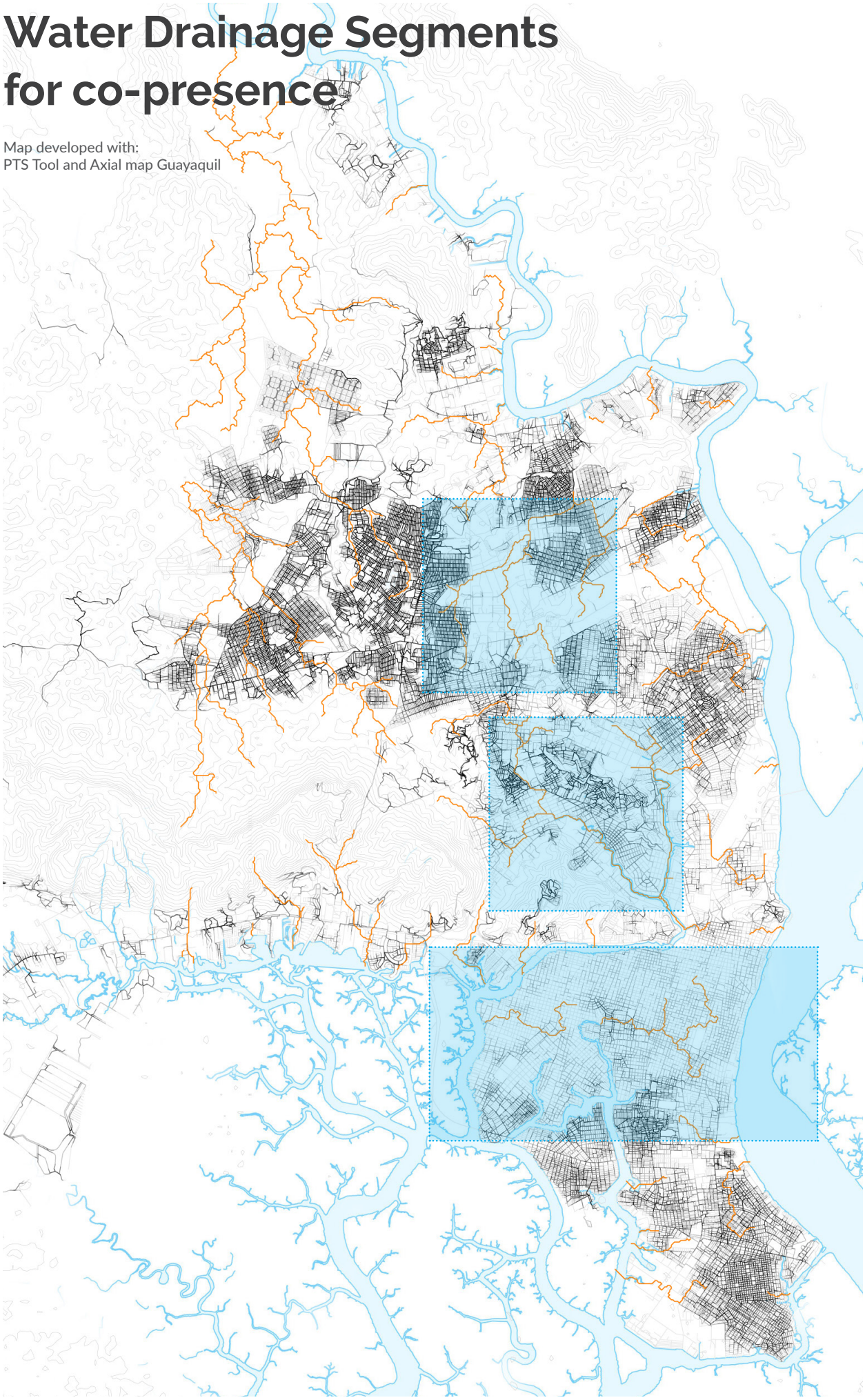
The Drainage segments with the biggest potential from a social point of view are the ones that can help integrating neighborhoods that are not strongly connected. For this reason, the water drainage segments located in areas of low Network Betweenness at a local range (500m) where picked. This created opportunities for creating a water network that also aims at improving neighborhood's connectivity.

According to the analysis conducted in Guayaquil, there is evidence of residential segregation. When neighborhoods develop due to auto-generated enclaves 'segregation of choice' takes places, on the other hand when they are the product of exclusion it is identified as a case of 'segregation of coercion' (Varidy, 2005).

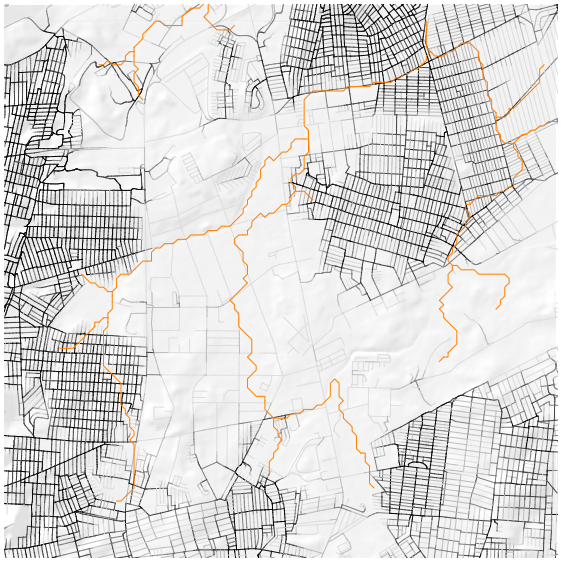
In Guayaquil both cases exist, but the ones fragmenting the city to a bigger degree are enclaves or segregation of choice. Water drainage segments spreading through the whole city represent axis of opportunity that can help to improve accessibility on some enclaved neighborhoods. These segments will be part on the bigger scale on a network of water.

Water Drainage Segments for co-presence

Map developed with:
PTS Tool and Axial map Guayaquil



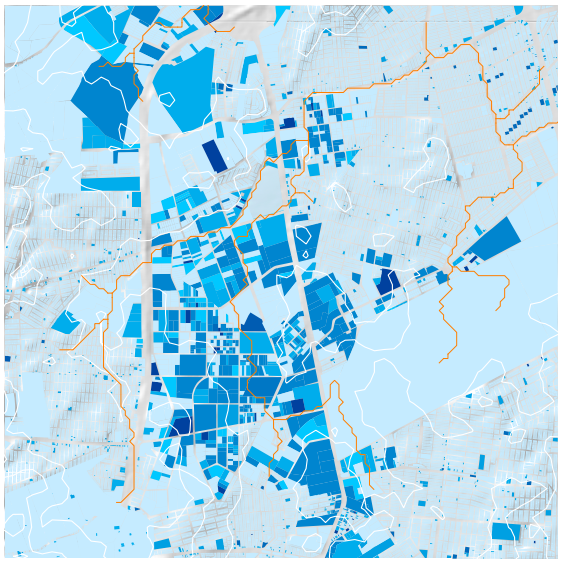
Zoom D



Current state

Map developed with:
PTS Tool and Axial map Guayaquil
Drainage Segments from watershed analysis

Zoom D represents and area where the weave of plots changes. Is possible to see areas with low network betweeneess that fragment this northern area of the city.



Legend

Water Drainage Segments

Land Use

- Retail
- Education
- Storage
- Industry
- Office
- Other
- Park
- Parking
- Health
- Mecanic Shop
- Housing

Functionality

Map developed with:
Land Use Map from Municipality - 2014
Drainage Segments from watershed analysis

The Land Use map shows the industrial use of this zone. This is the main reason for the lack of connectivity between the 2 neighborhoods.

Proposal

Map developed with:
Bing Satellite imagery and Post Processing

The Green and blue infrastructure can become an axis that joins these two areas of the city.

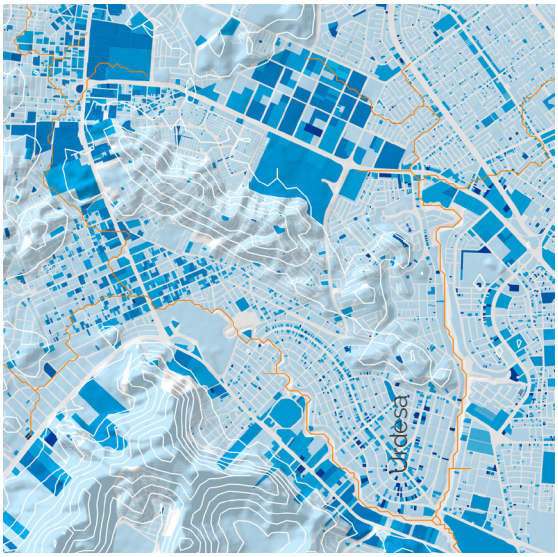
Zoom E

Map developed with:
PTS Tool and Axial map Guayaquil

Current state

Map developed with:
PTS Tool and Axial map Guayaquil
Drainage Segments from watershed analysis

Areas around Sea branches (estero salado) show a low index of betweenness in the 500m range. Additionally, this area is limited in the south by a steep topography where the city finds a limit. The sea branches margins are fragmentated in several plot units. This factor has given the branches a private characteristic. The Water segments appear to be in areas of low betweenness and therefore represent an opportunity for improving the connectivity of the network and at the same time dealing with flooding.



Functionality

Map developed with:
Land Use Map from Municipality - 2014
Drainage Segments from watershed analysis

The area shows a couple of functional corridors. This, as in the previous area represents a factor for a spread network with little presence of links to the surrounding patterns. On the other hand, residential neighborhoods as Urdesa have direct contact with the sea branches.

Legend

Water Drainage Segments

Land Use

- Retail
- Education
- Storage
- Industry
- Office
- Other
- Park
- Parking
- Health
- Mecanic Shop
- Housing

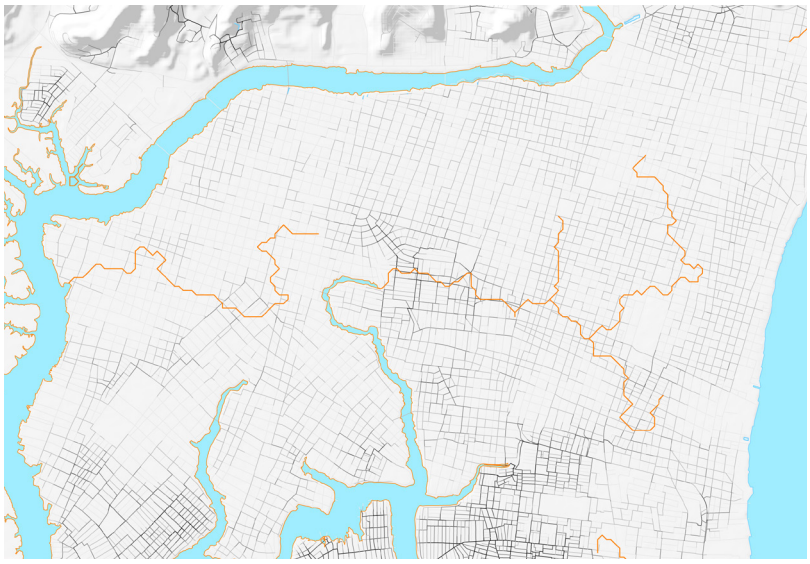
Proposal

Map developed with:
Bing Satellite imagery and Post Processing

The Network of green and blue infrastructure could aim to foster co-presence and eventually integration and collaboration. In order to achieve so, the margins of the sea branches need to become public, in addition to the water drainage segments. As shown in the picture, this could improve the existing network betweenness

Zoom F

Map developed with:
PTS Tool and Axial map Guayaquil



Current state

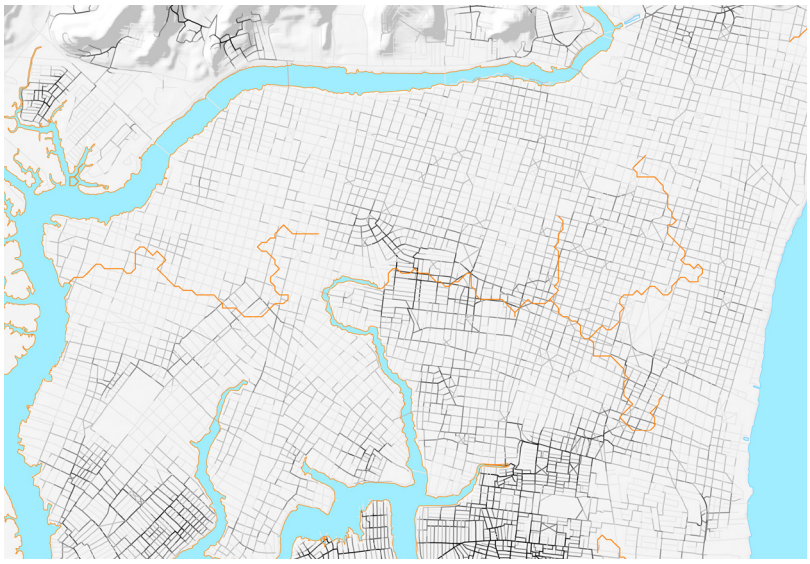
Map developed with:
PTS Tool and Axial map Guayaquil
Drainage Segments from watershed analysis

In a regular grid, the potential shortest paths are evenly distributed. It could be manifested that these urban fabrics have few bottle necks, therefore the street segments have little betweenness score. The variation within the elements of the grid in their betweenness has to do with the variation in size of each block.

Functionality

Map developed with:
Land Use Map from Municipality - 2014
Drainage Segments from watershed analysis

The functionality shows the CBD, and how is defeminated into the residential areas. The Water Drainage Segments cross through the whole spectrum of Socio - Economic Spectrum. This is making the area one of the more interesting zones for implementing the strategic design proposal.



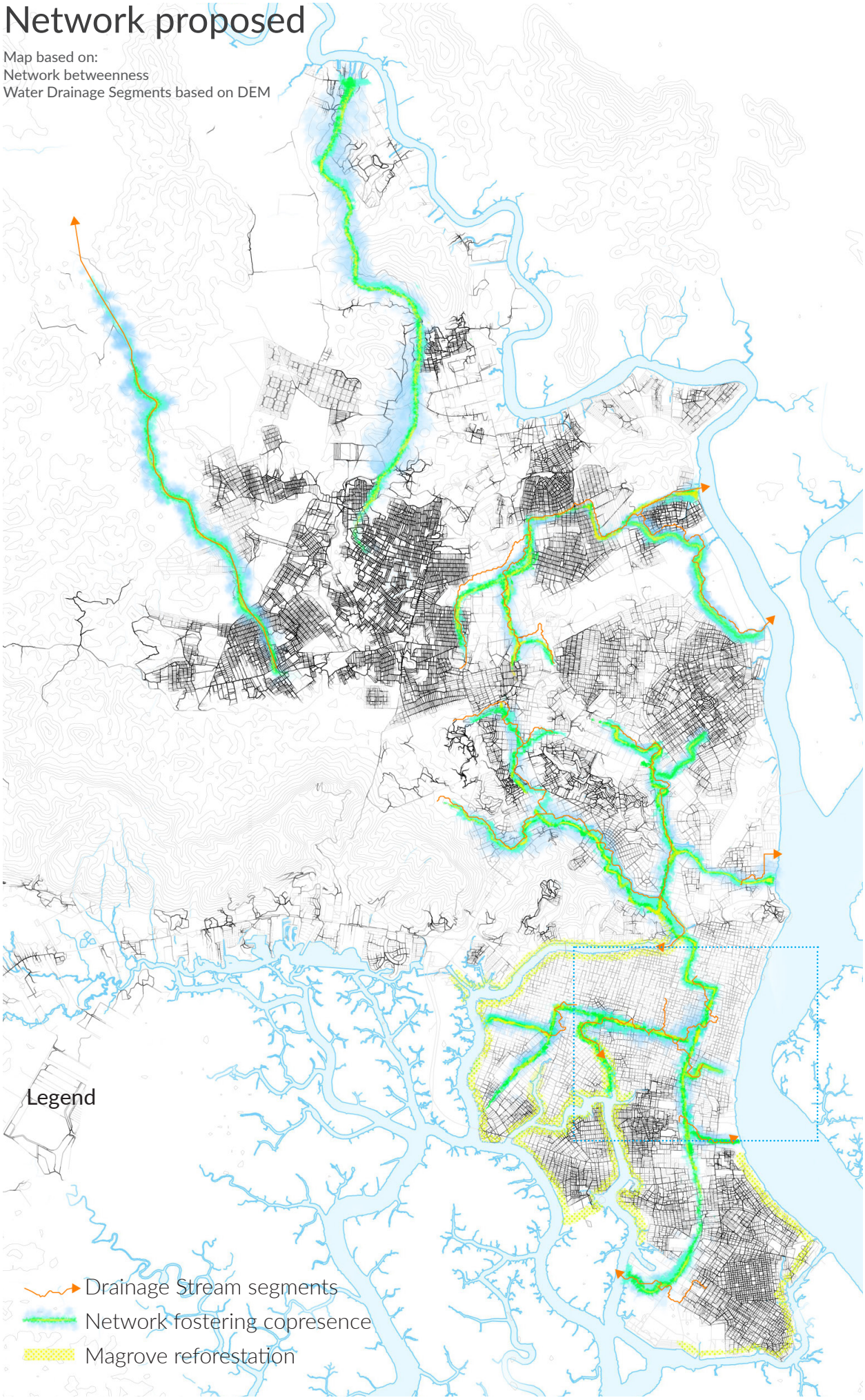
Proposal

Map developed with:
Bing Satellite imagery and Post Processing

The Margins need to be made public as in the previous example. Crossing paths can be created in building with public use. In this regular grid such spacesare schools now possesing an X in their patterns. For example, schools around green and blue infrastructure can become open infrastructure out of education hours. Improving the betweenness in the network and by doing so promoting the circulation of non-locals.

Network proposed

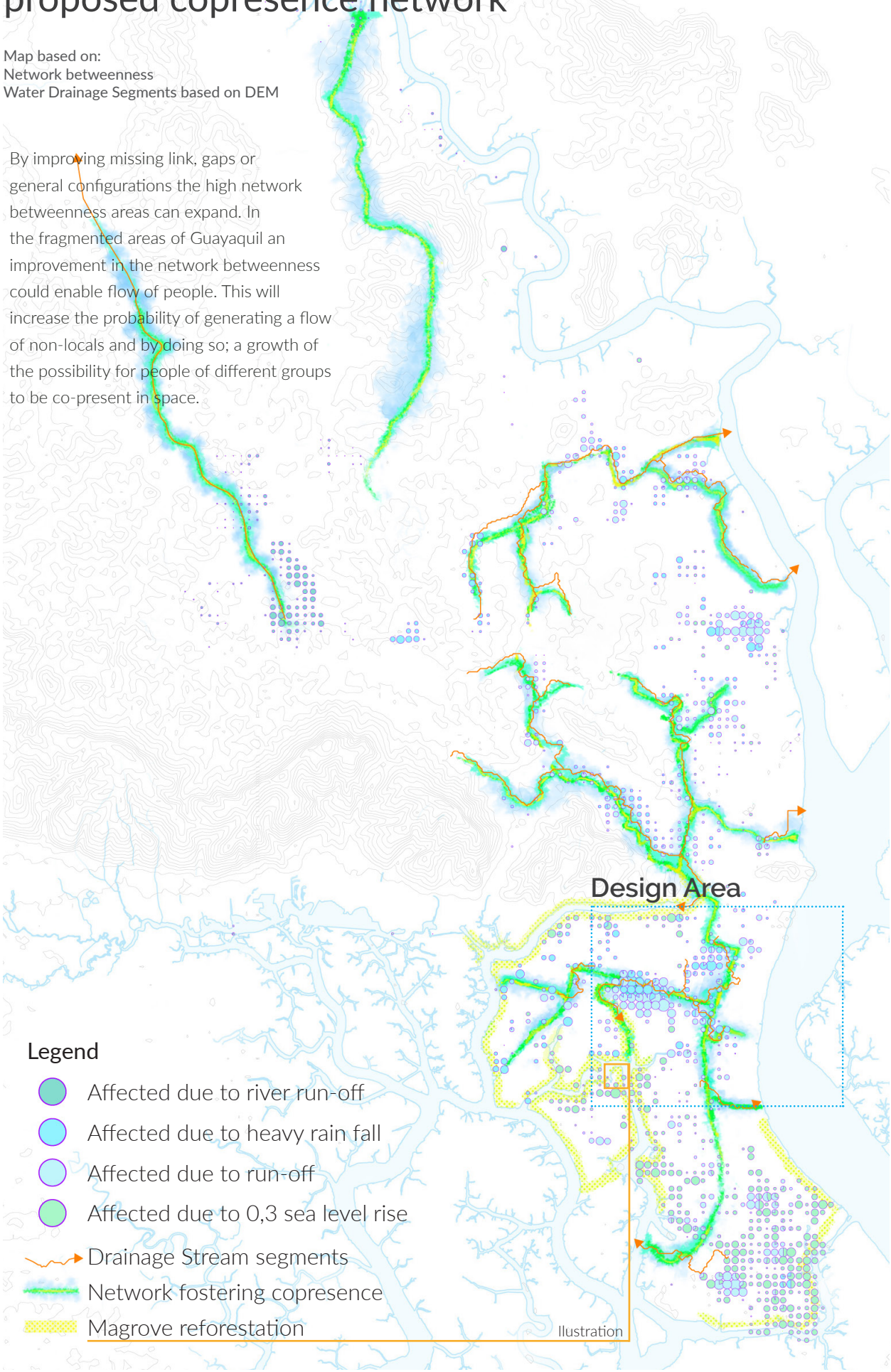
Map based on:
Network betweenness
Water Drainage Segments based on DEM

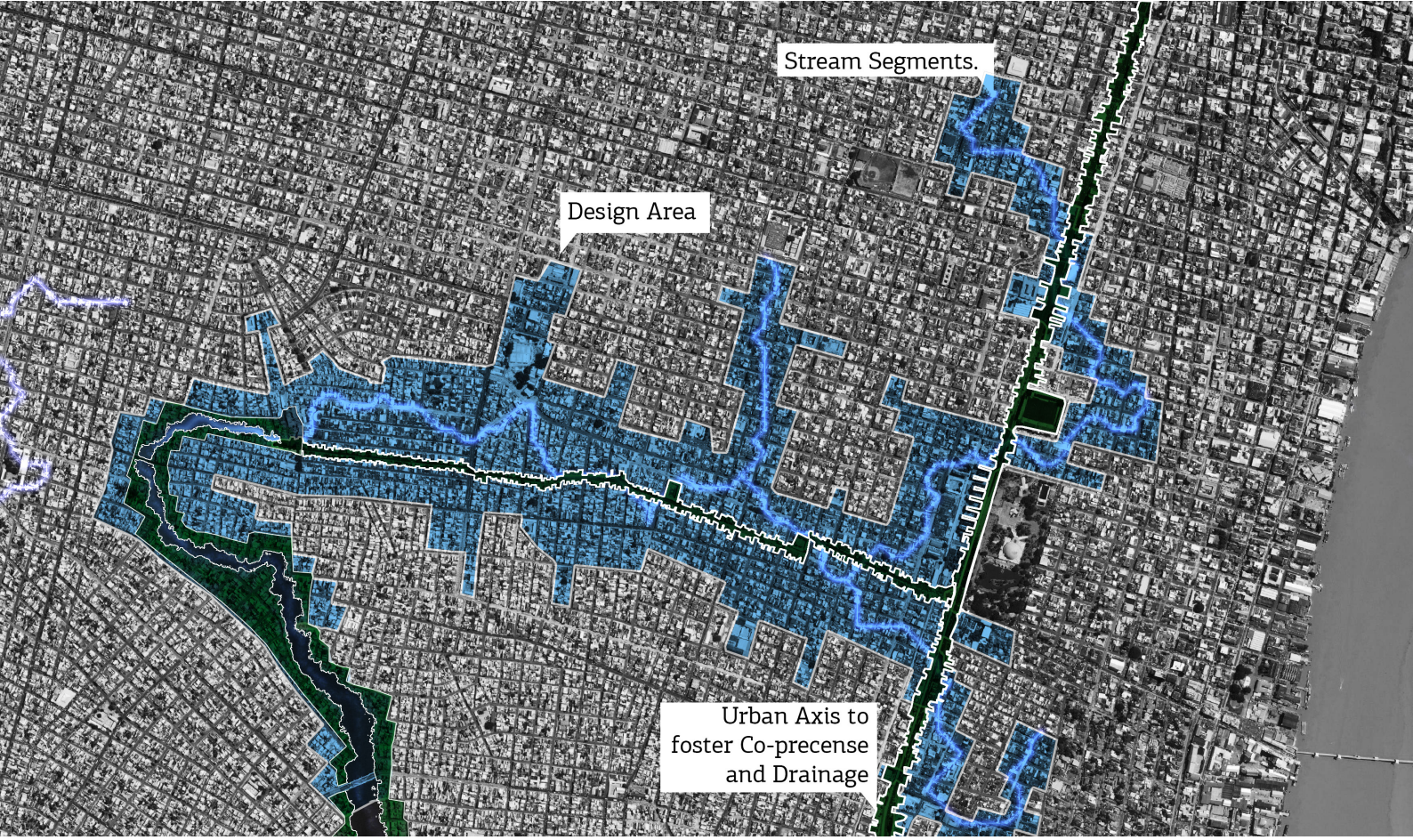


People affected by flooding & proposed copresence network

Map based on:
Network betweenness
Water Drainage Segments based on DEM

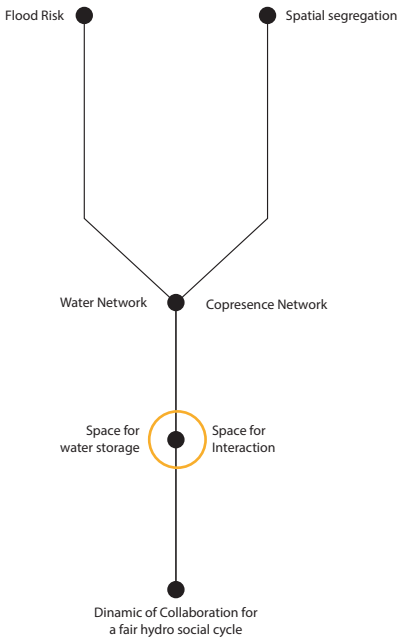
By improving missing link, gaps or general configurations the high network betweenness areas can expand. In the fragmented areas of Guayaquil an improvement in the network betweenness could enable flow of people. This will increase the probability of generating a flow of non-locals and by doing so; a growth of the possibility for people of different groups to be co-present in space.





Strategy Illustration

The area picked for the spatial design illustration is the one with most people affected by flooding in Guayaquil



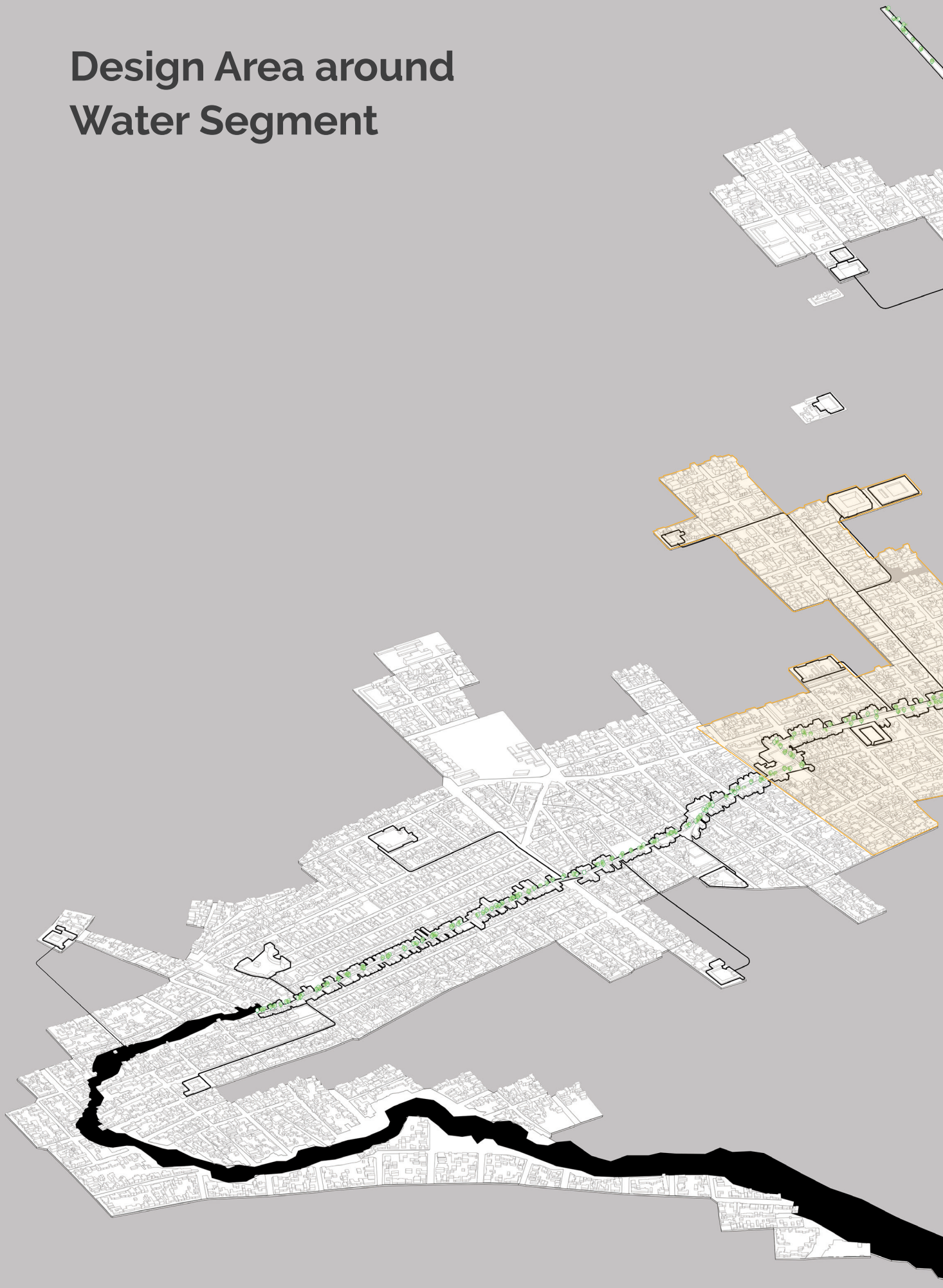
The strategy sits in the previously proposed Green & Blue networks, these networks are based on the existing water draining segments from areas where the network betweenness is low in the 500m range map. By reinforcing and improving the network betweenness among adjoining neighborhoods the presence of non-locals could be enhanced.

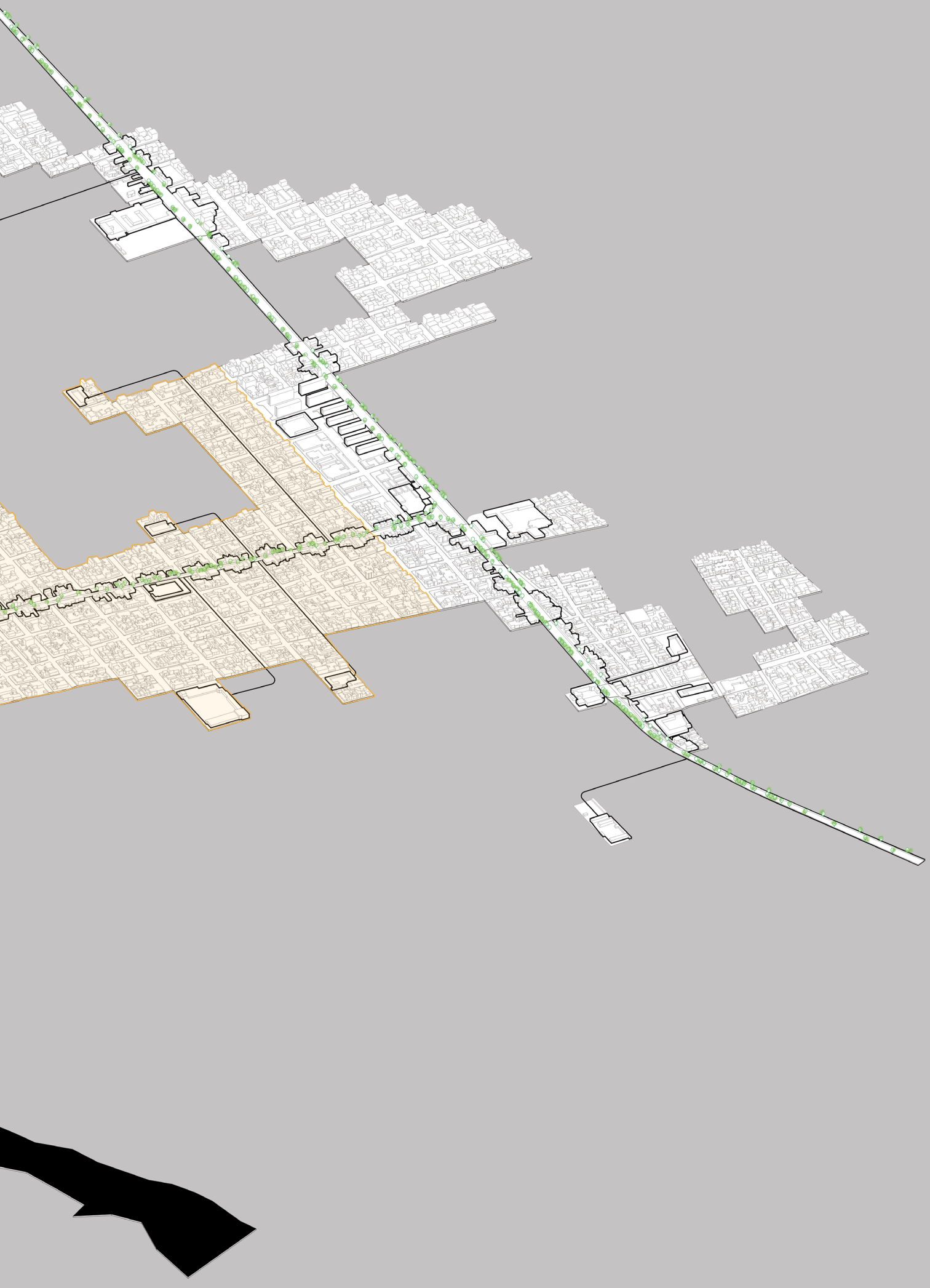
Water infrastructure in Guayaquil needs areas for the storage of surface water. Water storage does not need to necessarily function above ground level. However, in a context as Guayaquil, the construction of sophisticated underground uninhabited spaces does not seem fair when there are urban areas where people live in precarious conditions. For this reason, a piece of water infrastructure should aim at also having a social use and improving social life among different groups.

The research by Ann Legeby on Patterns of Co-presence has clarified what Co-presence represents in fields of sociology, the role it fulfills in the built environment and its active relation to city syntax configuration (Legeby, 2013) .

Referring to Collins, Legeby points out that in Collin's interaction rituals theory, Co-presence is a necessary but not sufficient part guiding to interaction outcomes. In addition, its suggested that in the core of interaction processes participants develop a mutual focus of attention (Collins, 2004). In Addition, based on the theory of Goffman, Legeby cites how Goffman defines a relation between co-presence and interaction, or what Goffman defines as unfocused and focused interaction (Goffman, 1963). Meaning that focused interaction exists when there is a single focus of attention, while an unfocused interaction takes place as a process of nonverbal - communication when people are in

Design Area around Water Segment





immediate presence and they have the possibility to have a glance of others (Goffman, 1963).

There seems to be an agreement among Goffman, Legeby and Collins in relation to how co-presence does not guaranty integration but is definitely a prelaminar step towards interaction. For the present project, this stage proposes spatial activators needed to take forward the 2 central problems of the study (spatial segregation – flood risk). This is done in the local scale by looking into uses that can generate a single focus of attention. In order to promote interaction and integration there needs to be spaces that welcome diverse groups. These spaces can be areas for sports and recreation.

“Playing sport and participating in physical recreation offers important opportunities to enhance health and wellbeing. As well as promoting well-documented health benefits (such as reduced risk of cardiovascular disease), participation can offer a social and political space in which to cultivate cultural diversity and promote social inclusion.” (Cortis, Pooja, & Muir, 2007)

Among Age groups, youth and children are more likely to take part into recreation and physical activities. On the other hand, they can mediate upon their past, present and future reality (Center for multicultural Youth, 2007). This also creates the space for diverse and socio-cultural interactions. In addition, younger groups, have the capacity to involve their older family members into this process. In Places as Europe and Australia sports and recreation have been seen as potential measure for integrating newly arrived refugees.

On these preconditions, Schools are seen as areas with a lot of potential. They can be coupled as center for sport and recreation off education hours, and secondly their spatial typology offers interesting areas for dealing with surplus surface water. Off education hours, schools can become open public spaces where locals, and non-locals passing by could get together, attracted by the possibility of carrying out an activity as a central focus of attention. Schools should become places where people can cross the regular grid present in this area of Guayaquil. If schools enable cross circulation, they can have a positive impact in network betweenness of the area, with all the positive implications of co-presence fostering.

In schools an around them different activities are suggested. All these activators revolve around activities that can become a central point of attention. The suggested activators focus on three categories. Playgrounds (for kids), Gamification (kids and young people), And sports (kids, young, senior).

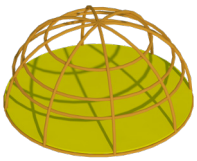
Playgrounds: can happen in and out of the school, with the advantage that temporal uses can take place also within the education institution. As the case of textile playgrounds.

Sport: can also take place inside and outside. The can be team sports of individual. Also, they can be making use of abandoned areas. As could be the case of a parkour park.

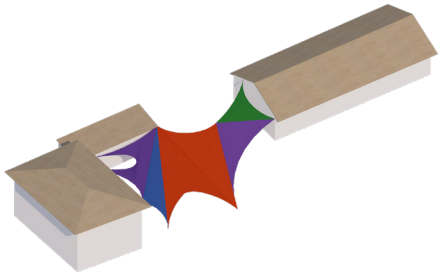
Activators of interaction

Playgrounds

Cube for imagination

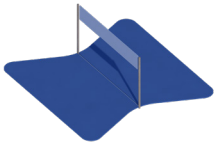


Playground

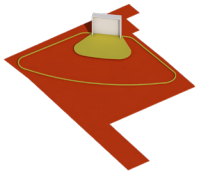


Tensile Textile bed

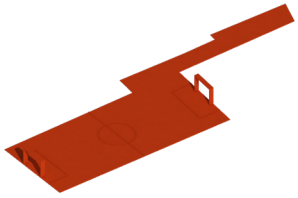
Sports



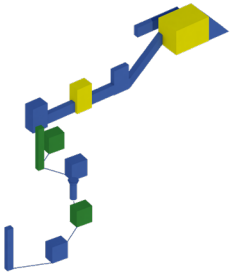
Voleyball Court



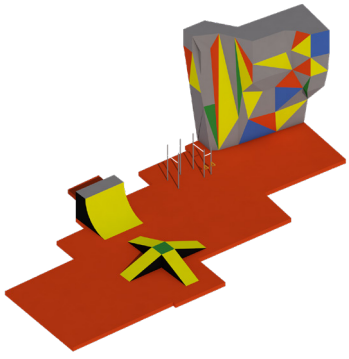
Skore´s Goal keeps



Football

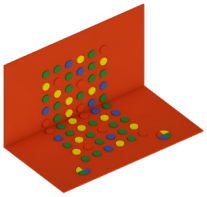


Parkour

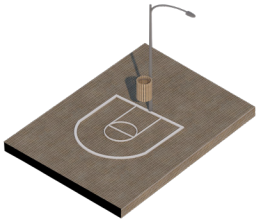


Climbing / Skating

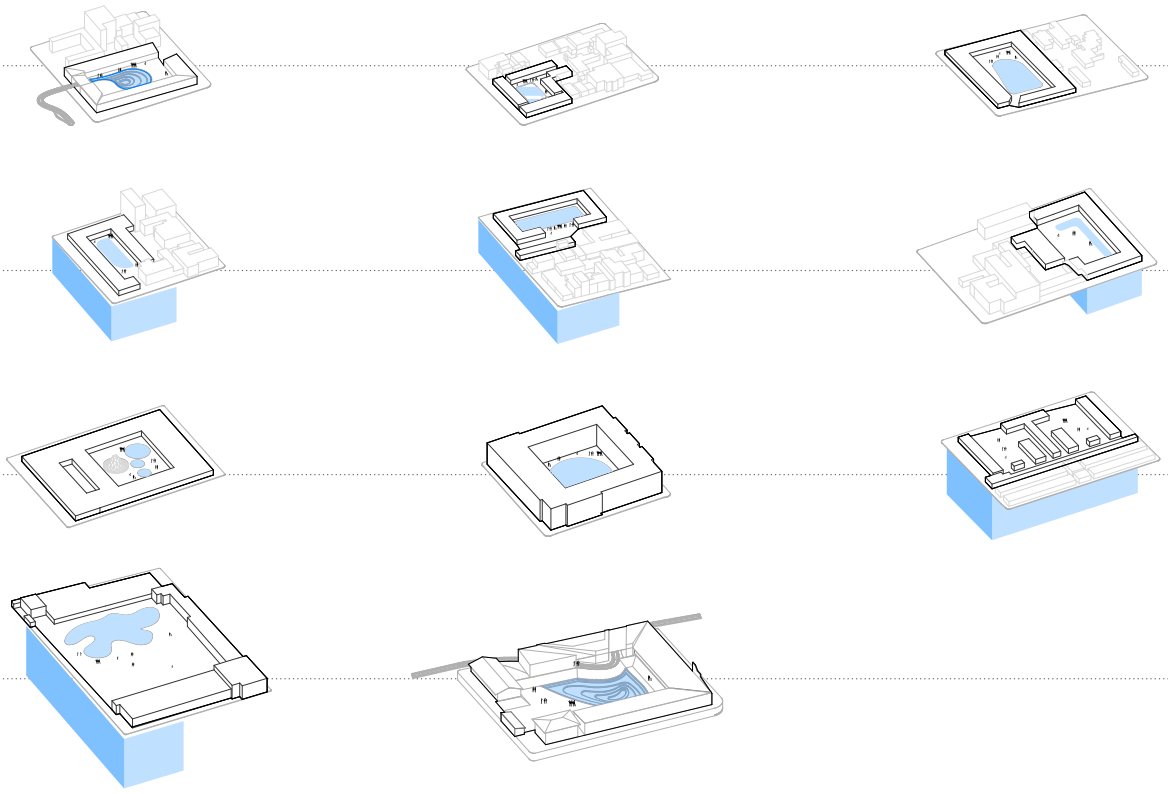
Games



Public Twister



Playfull waste bin



Gamification: Gamification can take place in urban areas, as sidewalks or any kind of public space.

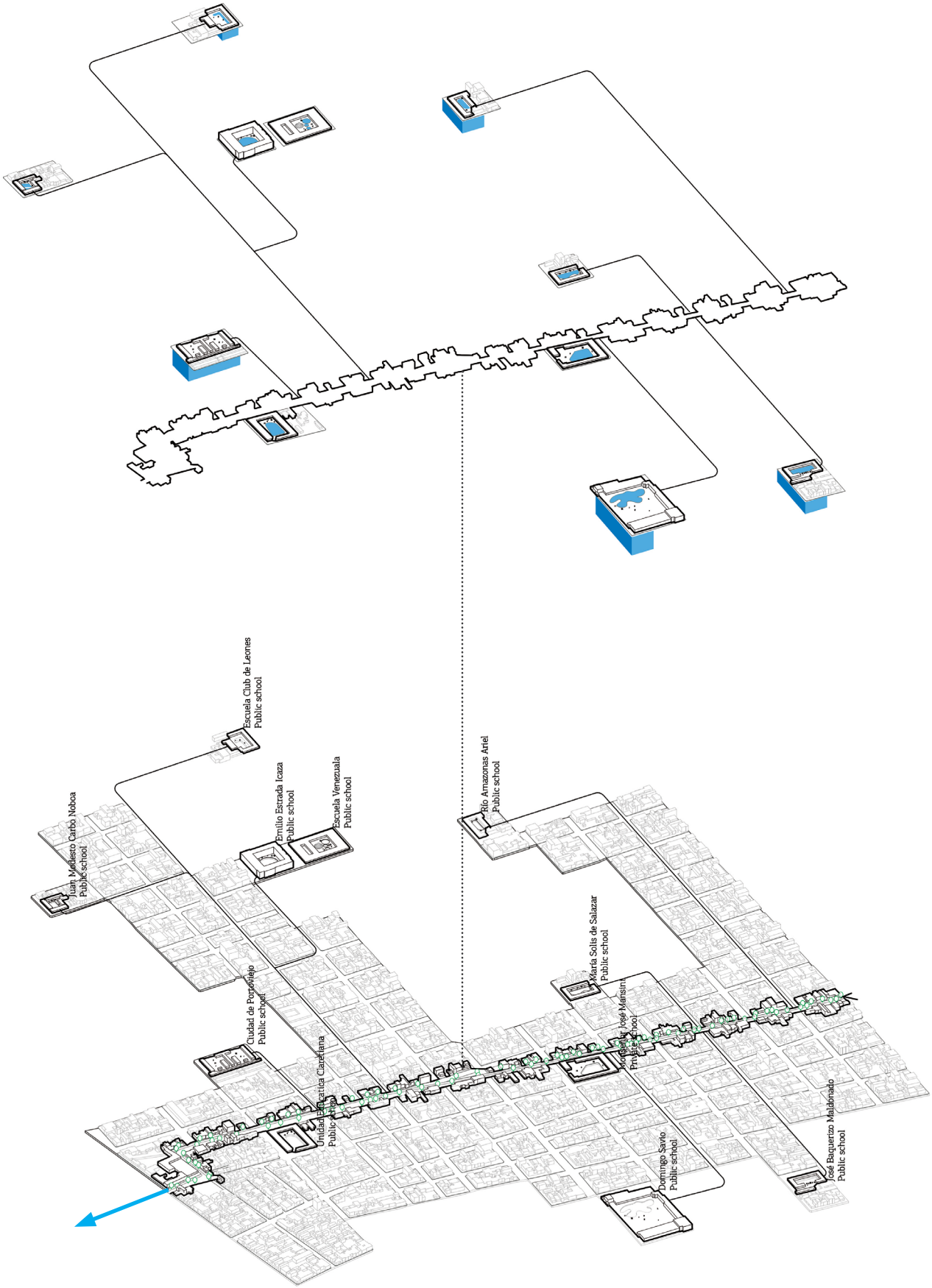
Spaces for water storage

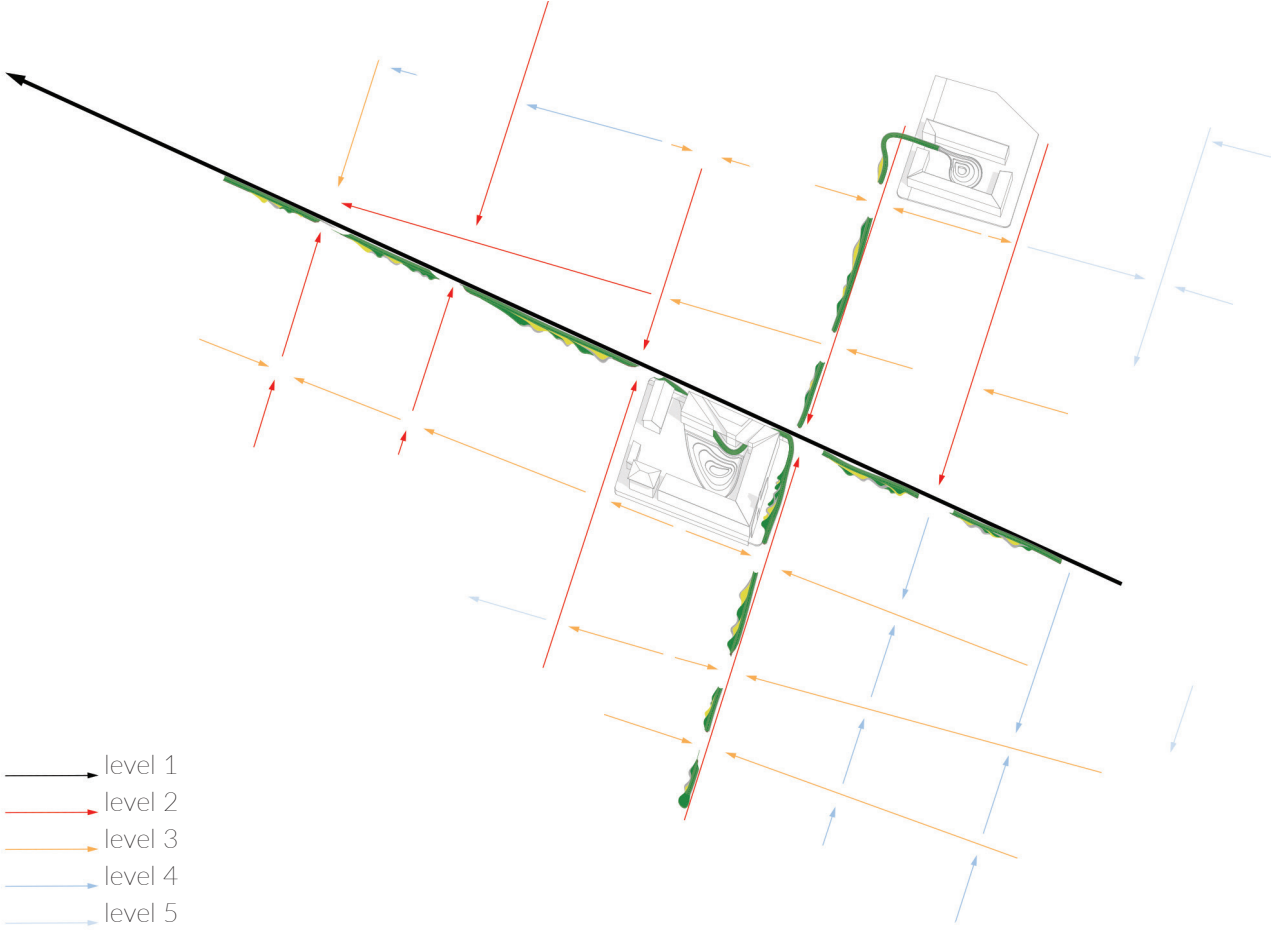
Most Schools have a spatial typology with a central core, where children can play or carry-out outdoors activities. This area within the urban fabric stands out as the only typology with these characteristics. This typology is especially interesting to store open water. If we see a satellite picture of this area, the only open areas are these courtyards, parks, or streets. Other than these spaces, there are only fragmented inner block areas remaining. This is the reason why schools sparked interest as potential spatial typologies. Furthermore, public Schools in Guayaquil are mostly used by the groups belonging to the lower part of the socio-economic index. The current state of schools is not the best and they could require interventions to improve them. The proposal of this projects is for schools to become the central space where water can be gathered and stored and then be further drained to open water bodies. The interventions should generate concavely depressed areas into the courtyards, that can be used for play when they are dry or otherwise be used water storage space.

The Education schedule in Primary and Secondary schools in the Ecuadorian Coast, go usually from the late April to late January. Meaning that schools are empty facilities in February and March. These are 2 of the rainiest months on the year, which is convenient for the purpose of preparing schools as areas for water storage. In this time, they could act as much needed spaces open surface for storage. For this to happen, they need to be immersed in a system of green & blue infrastructure that guides water in and out of them. This Green and blue infrastructure can be a net of bio-swales. Them all can be situated around a green axis that guides water into open water spaces. This can be done by changing the street section of strategically picked streets following the drainage stream segments as much as possible. This will not only improve the capacity to deal with water but also improve the public space linking schools. This bios-wales have to be designed in such a way that they create spaces at a human scale where people can decide to stay.

To test if schools have the capacity to mitigate flood risk, an empirical Method developed in TU-delft is used. It consists on the calculation of how much surplus water flows in the area, depending on the type of space where rain falls into. For this calculation each land uses the storage capacity, and the absorption capacity is considered. The remaining

Illustration of strategy operability





water that has not being absorbed neither stored is considered surplus water. The Surplus water will be either drained by the sewer or dealt with by the blue infrastructure.

To test the capacity of the schools to mitigate flooding, the Intensity Duration Frequency (IDF) rain curves where taken into consideration. The IDF curves used where stablished by Molenaar, Pak, de Pous, & van der Werff. They are as follows:

Intensity (mm/hours)	Duration (hours)					
Return period	1	2	4	8	12	24
2 years	49,9	35,4	21,9	12,5	9	5,1
5 years	58,9	42,8	26,5	15,1	10,9	5,3
10 years	66,2	48,3	29,9	17,1	12,3	7,1
25 years	76,2	55,5	34,4	19,6	14,2	8,2
50 years	84,1	60,9	37,7	21,5	15,7	9,1
100 years	92,3	66,3	41,1	24,1	17,1	9,9

For this case the rains of 2, 10 and 100 years of return periods have been considered; in Durations of 2 and 4 hours, based on the characteristic short and abundant rains of Guayaquil. These return periods generate different volumes of water. Keeping in mind that the schools have a courtyard area of 2500, is possible to see how deep the storage pool needs to be. Based on these calculations the cases of 100-year return periods would require more than the equivalent of 2 stories deep. Therefore, these scenarios seem too complex to be considered for a change in the entire urban fabric. The case of a 2-hour rain of a 10-year return period is considered the next most adverse scenario where the capacity of the schools could be tested. Based on the proposed designs, the schools alone have the capacity to store 8.147 m3. The calculation is made with the proposal in place. This shows that there needs to be improvements in matters of permeable surfaces in order to cope with the rain; since under these conditions the surplus water will be 5.787 m3 per hour which is obviously more than the school's capacities. Therefore, other changes in the watershed are needed in order to mitigate flooding under the 2-hour rain with a 10-year return period. Therefore, new calculations were made, suggesting an improvement on roads and sidewalks as well as creating greener areas. The calculations are made under a method developed by: Frans van de Ven, Fransje Hooimeijer, Kristel Aalbers (2018).

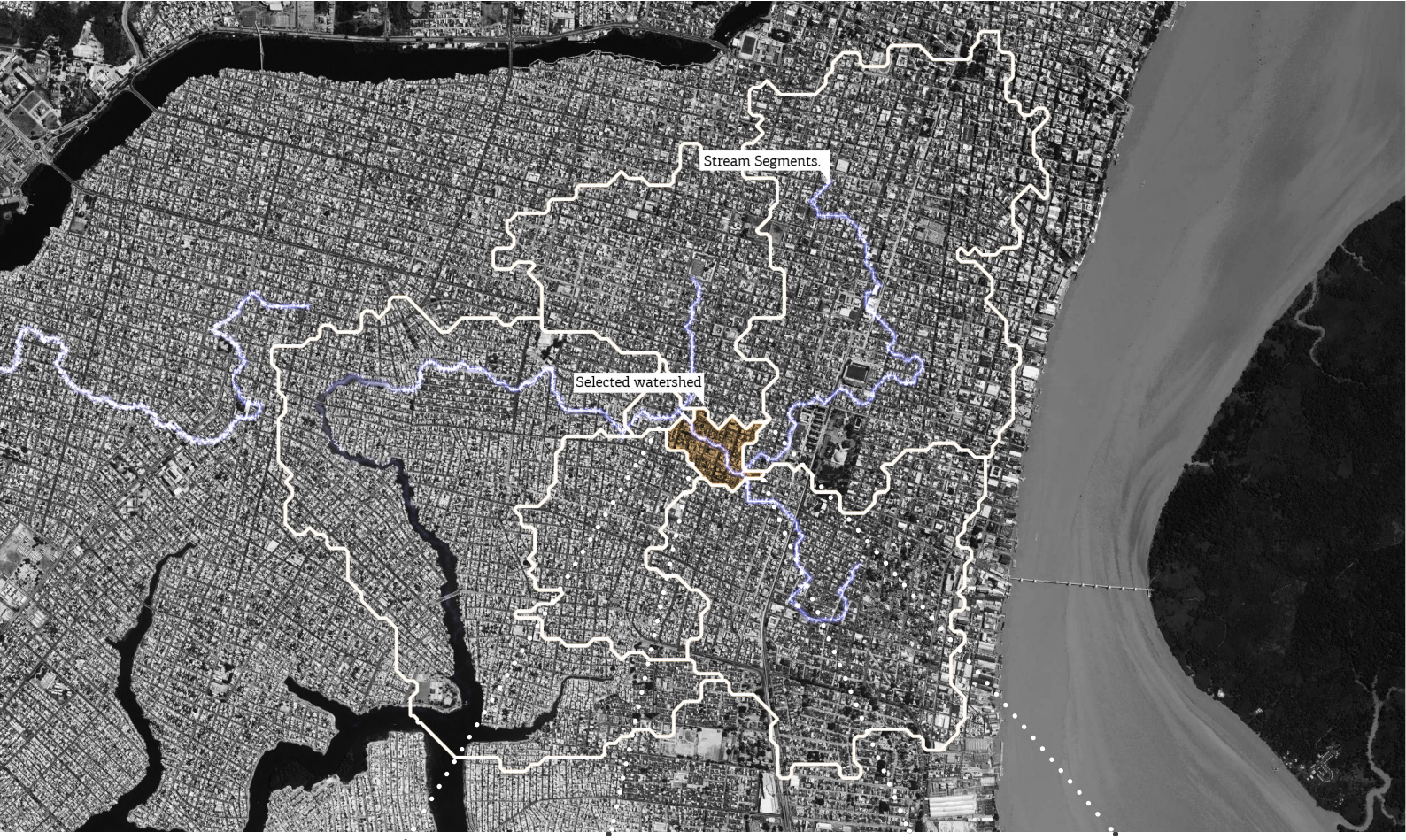
In the Surface Water Calculation table the case A and B refer to:

a) When The areas of the bio-swales, schools, and a change is suggested in the road asphalt (porous asphalt).

b) When 30% of Areas occupied by Roofs, Roads and Sidewalks have been equitably turned into unpaved surfaces.

Under the case B Is possible o see that the m3 of surplus water are equal to 4112,16 which is consider as a capacity that schools could deal with with a drepression of 3,29m.

The table for calculating the surplus water for each



Areas	
Zone Category	Net Area
Garden open soil_Private	2.930,90
Garden tiled	6.125,15
Lawn - Public	1.706,26
Roads	46.881,15
Roofs_Sloping	77.939,83
Schools_open air	2.269,30
Sidewalks	22.686,87
	160.539,46 m²

	Areas in Case A	Adjustement	Porcentaje of unpaved	Adjusted surfce	Improved areas. Case B	Incoming water	Surplus water
Garden open soil (private)	2.930,90	1	42%	2.930,90	24.935,02	82,29	82,29
public							
Surface water	-						
Rain garden, infiltration field	-						
Lawn, green belt, shrub (public)	1.706,26	1	24%	1.706,26	14.516,23	47,90	47,90
Playground, footpath	-						
Vegetated swales	2.373,09	1	34%	2.373,09	20.189,38	369,47	369,47
PAVED			Porcentaje of total		Rested area		
private							
Roofs – sloping	77.939,83	0,7	48%	54.557,88	54.557,88	2580,59	2580,59
Roofs – flat, tar	-						
Green roofs – extensive	-						
Green roofs – intensive	-						
Garden tiled	8.394,45	0		-	-	0,00	0,00
public							
Roads, car parks – asphalt	-		0%				
Roads, car parks – porous asphalt	46.881,15	0,7		32.816,81	32.816,81	567,73	567,73
Roads, car parks – brick	-						
Roads, car parks – porous pavement	-						
Sidewalk, terraces –tiles	22.632,10	0,7	14%	15.842,47	15.842,47	464,18	464,18
	162.857,78			**110.227,41**	**162.857,78**	**m3 water Storage Hight**	**4112,16** 3,29

Surface water Calculation Table, Bases on method from: van de Ven, Hooimeijer, Aalbers (2018).

case of rain are attached as appendix.

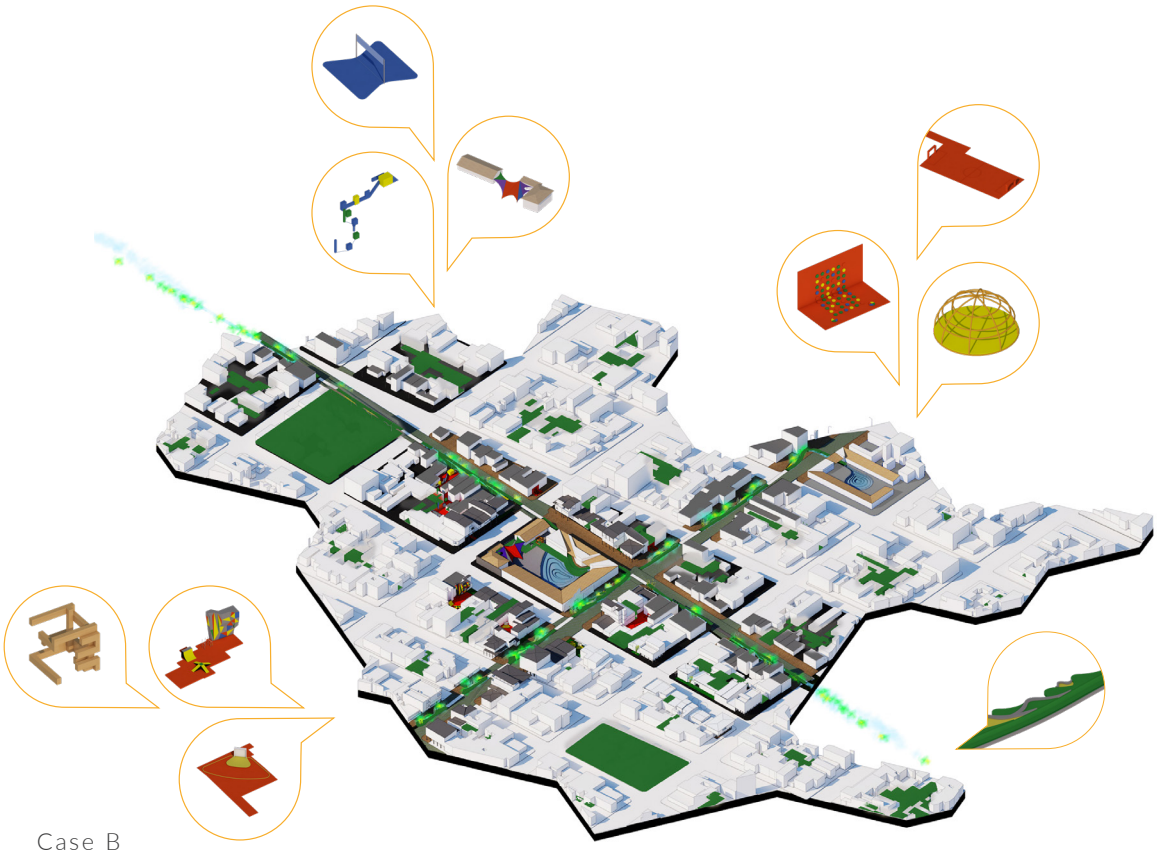
Uses of stored water

The modern conception of water's hydrological cycle, abstract's it from most sorts of backgrounds, subtracting any type of trail about social, cultural and political relations and dealing with it as a single molecular components of H2O (Schmidt, 2014) (Swyngedouw E. , 2006). Within this problematic, the hydro social cycle aims at linking water with its social and political role in societies. In a world with increasing population growth an increasing rates of water consumption, the scarcity of water won't have an even impact in society. Water will follow power hierarchies and will be scarce at first in the groups of the most vulnerable people. In a city as Guayaquil this needs to be considered in order to remember that the relation between water and its social role has to be permanently sought-after and defended.

This is necessary specially considering that Guayaquil has a history of unjust water distribution. Erik Swyngedouw in his book Social Power and the Urbanization of Water evidences how the provision of water can be closely linked to social power structures. As an evidence for this book he describes the case of Guayaquil and how since the 60's, less privileged groups did not have access to public water. According to Henriquez and Timmeren "In 2002, over 600,000 of Guayaqquil's 2.3 million residences depended on tanqueros [water tanks] for their daily water needs. In the early 1990s, private vendors would buy water from municipal sourced for €0.7/m3 (1993 prices) and sell it to poor urban residents for €4.17 - €7.50/m3, a 30,000 percent mark-up for water of an inferior quality compared to households in the richer parts of town which were connected to the municipal system." (Henriquez Laurence, 2017). Even though, currently water is apparently distributed to more than 90% of the households, past episodes of Guayaquil's history have shown that in time of scarcity there is a direct affection to the lower socioeconomic groups.

Keeping this in mind is important to ensure stored water can have positive impact in society. This is considered for the new proposal within the school. After water is stored in open air it can be drained by the Green & Blue infrastructure or stored at designated tanks in the schools. The capacity to store non-drinkable water aims at making schools public building that maintain a permanent fair cycle of water and society. Even if they are not providing all the water needed they can become areas of the city that fulfill a role of maintaining the rights for water.

The water stored in schools can focus on enhancing community services as urban agriculture, the gardening of semi-private green areas and public parks, provision of water to activities as firefighting,



Case B

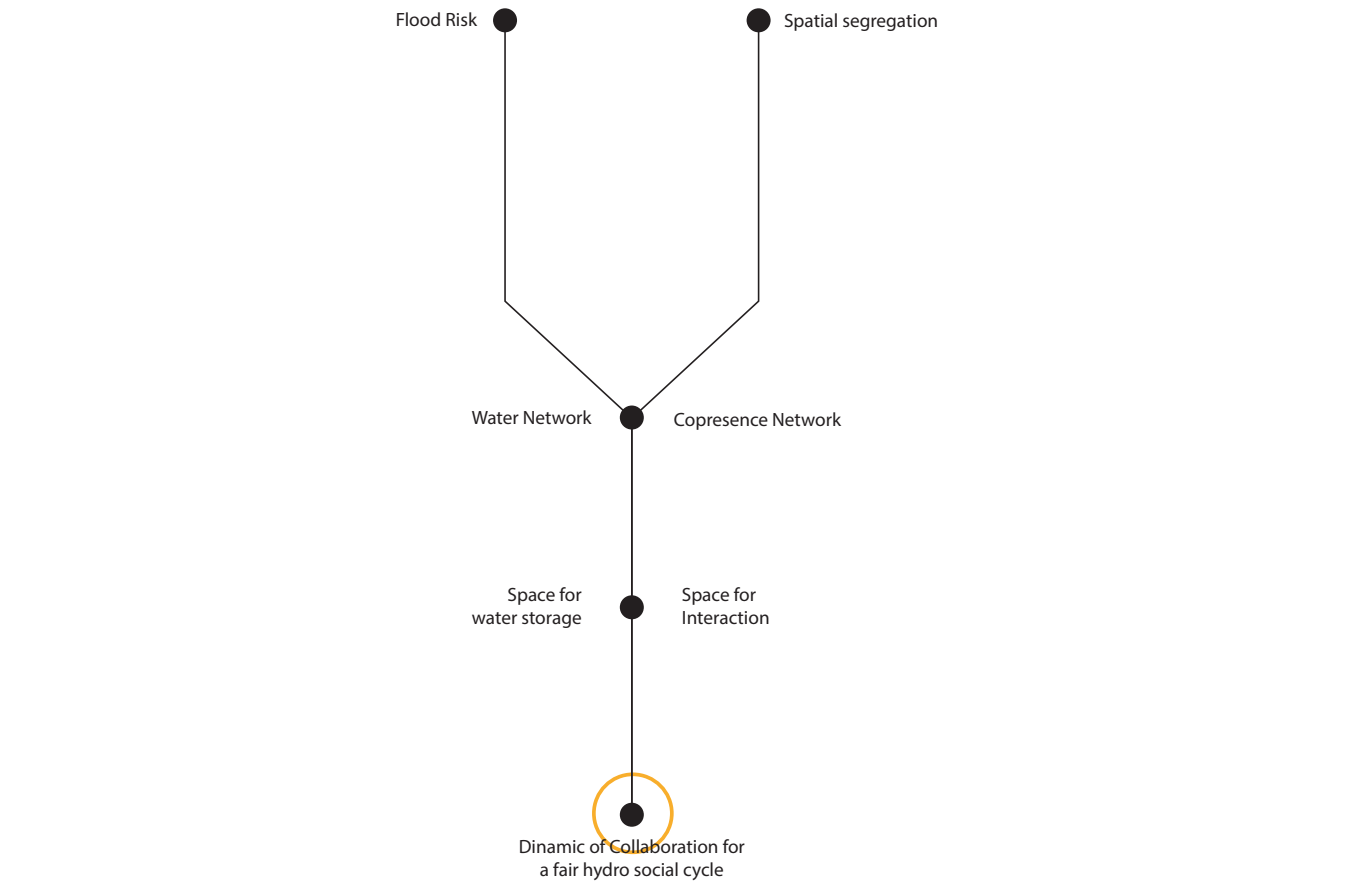
or even for cooling. These activities fulfill the task of creating the opportunity for cooperation. Cooperation around water issues is a key point because it is the final step not only towards a mitigation of flood risk but also towards a strategy if integration. In a process of cooperation people have the possibility to generate common goals can be the first step towards creating a narrative of a more hormonic society.

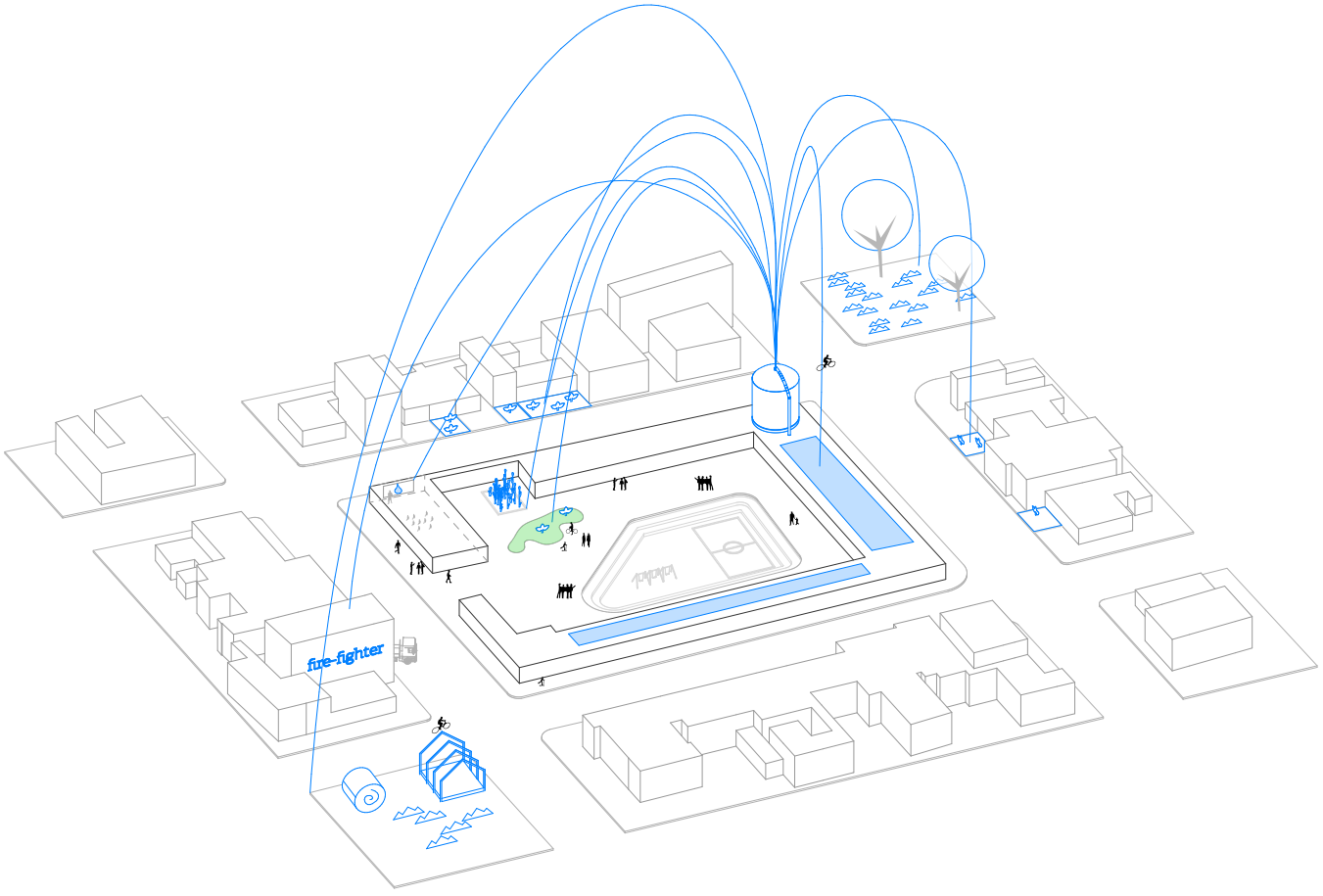
Conclusion:

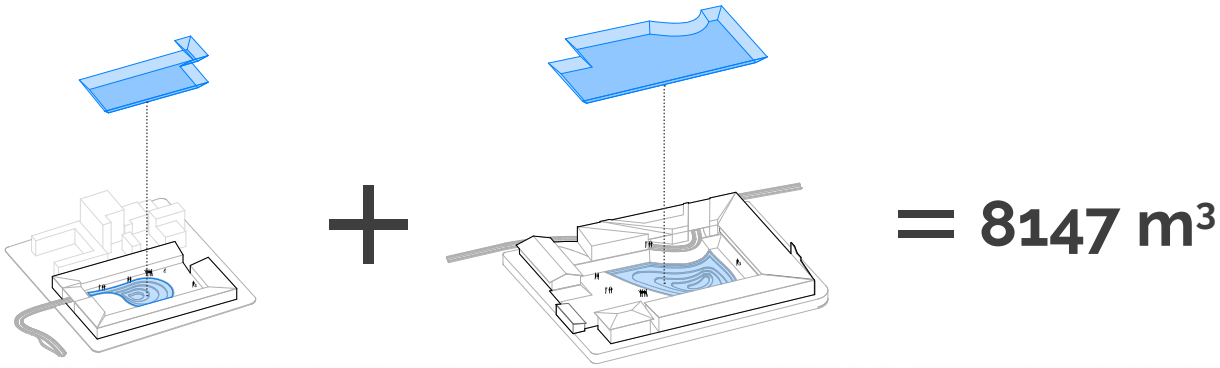
The exploratory phase proposes 3 steps in order to deal with Flood Risk and Spatial Segregation. In some respects, these 2 topics have shown potential to be interlinked; However, the link is not always smooth to stablish. In this context is important to bear in mind that the reason behind the combination of these problems still is a real characteristic of Latin America. The resources are limited, and the challenges are ever increasing so the synergies have to be embraced and put forward. In this sense the strategy aims at defining steps that can be linked as much as possible.

The first step is the establishment of networks. Networks for water as much as for co-presence influence develops the macro scale. It consists on the implantation of a Green and Blue infrastructure in areas where the network betweenness could be improved. The Green & Blue infrastructure aim at improving the network betweenness at a lower scale and by doing so increment the flow of non-locals. This step improves the Betweenness in some areas more than in others.

The second step consists on generating spaces around schools for interaction as much as for storage. The Schools have the potential to create areas for water storage. Furthermore, the storage capacity of schools will be needed in times of the year where there is no school, making schools a convenient space for dealing with surplus water. In the respect to Interaction, the paces in schools and around them aim at creating a central focus of attention around where interaction between locals and non-locals can take place. As a third step, schools can become central in the objective of maintaining a fair hydro-social cycle. This could be achieved if schools generate areas for maintaining water and providing it to the surrounding community. The described proposed route tries to consider the exposed problems from a broad range of perspectives. The improvement of network betweenness seems as the biggest assumption in the study that needs to be further tested.


Flood Risk
Spatial segregation
Water Network
Copresence Network
Space for
water storage
Space for
Interaction
Dinamic of Collaboration for
a fair hydro social cycle


fire-fighter


= 8147 m³

REFLECTION

The project has shown interesting alternatives into how to deal with problems in the developing world. Taking the planning paradigm of infrastructural ecologies as a starting point has proven to be an effective tool. The proposal aims to be potentially executed in a context where the strength of local institutions is not abundant. The project aims to create a strategy for mitigating flood risk and mitigating spatial segregation at once. Personally, I believe one of the strongest points from the outlined strategy is that it has a low political cost. It aims to improve the conditions around these two problems, in spaces of schools, without affecting citizens; and creating interesting spaces for children.

The method used for analyzing the city and spotting the first areas of intervention had been diverse. Data processing and spatial analysis has been one of the most demanding steps in the way. The city of Guayaquil does not possess ample data available for the generation of the narrative/strategy. This lack of information has been understood and the project aims to provide enough insights for future research in the topic. Every analysis has been executed for the entire city.

The data processing and spatial analysis efforts have been the following:

A) The generation of socio-economic spatial data. The method used has been adapted from a method developed by the Ecuadorian institute of census and statistics. By using the methods and the national census available, data was weighted and added in order to obtain a socioeconomic mark per block. This approach has proven novel and interesting, since it could be applied all urban settlements in the country; at the same time, it provides valuable information about how the city is socially structured.

B) Using a grid of 200m by 200m based on the one used by Salvador Rueda and his team for Barcelona it was possible to determine the area of

intervention. The grid has proven effective for spotting spatial patterns and at the same time spotting thing happening in the smaller scales. Based in this grid the amount of people affected by flooding was obtained, and the areas in need of more urgent measured became evident. This analysis shows spatial patterns without being restricted by spatial morphology.

C) With the digital elevation model of the city, the direction of the flow of the water was generated. In the same way, the drainage streams where water gathers were also stablished which clarifies how the water moves inside the urban area.

D) Again, making use of the Digital Elevation Model developed by Sigtierras, a map of the direction of the water was elaborated, the map illustrates cells of 41,2m x 41,2m that show in which direction the water is likely to flow due to the topographic characteristics. This map is useful for designing green and blue infrastructure.

Those analysis could be understood as products by themselves. These four processes had enabled a clear reading of the city that influenced the design stage. In the design stage, schools had been chosen as potential spaces of action. Schools have an opportune spatial configuration, most of them have a central open space. For a strategy that aims to touch upon flood risk and spatial segregation 2 things are important; Potential groups for interaction and activities where this interaction can take place. Schools meet both criteria. Schools have open spaces where activities can take place and its most active users are children which is consider a human group with high capabilities for integration.

View in the situation of the city

Dealing with the flood risk situation in Guayaquil, has taken me to the ground level of the daily operation of this urban area. In Guayaquil, any situation seems to be influenced in a bigger or lesser degree by conflicts coming from the social dynamics. Conflicts of safety, segregation, exclusion, are tangible issues emerging daily.

Since Guayaquil possesses an important portion of commercial oriented businesses, the competence over the flow of money seems not to be equally beneficial for all. In addition, close to Guayaquil various agro-export business have their fields; bringing also this income to selected groups inside the city. It is hard to understand whether the socio-economic inequality in Ecuador (as may be in Latin America) has to do with a centralized distribution of the wealth, or with the single fact that the economic production is basically limited. Or perhaps both situations.

The central reason for doing this project as a master thesis is the fact that a change in the collective narrative is needed in order to start dealing with the core problem of Guayaquil's social disintegration. Social Disintegration represents a big problem because it becomes visible in many stages of planning and development. For example, several parks in Guayaquil possess big fences. Due to the feeling of insecurity during night time.

In the case of Guayaquil is clear to see how the objectification of the car has had an impact in space. The Car has become a sign of status; and therefore, space for cars is demanded everywhere. The city counts with several overpasses which hurt the urban livability where they settle. In relation to flood risk, this desire for the car has brought vast areas with impermeable pavement. If we have in mind that Guayaquil's weak soil absorbing capacity, demands bigger areas for filtering water; is not hard to see how vast impermeable pavements don't fit in the picture.

Summing it up, it looks as if Guayaquileños have a collective understanding of their spatial characteristics that does not have into account the natural conditions where the city sits. The desire for a modern city has put the real urban problems in the background and an alien development model in the foreground. This desire for modernity, is also driven by a socio-economic status, where lower classes are implicitly seen as part of the problem. I believe the core goal to achieve in Guayaquil (and in Latins America perhaps) is a shift into how the society understands its socio-economic groups and the social and power distance between them. It is not a problem of class struggle but one of unnecessary class distance that becomes apparent in cases of spatial segregation. This new narrative needs common goals shared by all social groups, one of them could be flood mitigation.


UNIDAD EDUCATIVA
JOSE MANSINI
Corn-Corn

BIBLIOGRAPHY

Barrera Crespo, P. D. (2016). Delft3D Flexible Mesh modelling of Guayas River and Estuary system in Ecuador. TU delft.

Barrera Crespo, P. D., Mosselman, E., Giardino, A., Becker, A., Ottevanger, W., Nabi, M., & Arias Hidalgo, M. (2018). Sediment Budget analysis of the Guayas River using a process.based model. Hydrology and Earth System Sciences Discussions.

Bélanger, P. (2017). Landscape as infraestructure. New York: Routledge.

Brown, H. (2018). Infrastructural Ecology: Embedding Resilience in Public Works. Sage: Public works managment & policy, 1-13.

Brown, H., & Stigge, B. (2017). Infraestructural Ecologies. Cambridge.

CAF. (2013). La inundación de Guayaquil en marzo 2013. Guayaquil.

CAF. (2017). Diagnóstico y proyección de vulnerabilidades frente a la variabilidad y cambio climático en la ciudad de Guayaquil.

CELEC. (2013). 25 años de la presa Daule-Peripa. Guayaquil: Eco Comunicaciones.

Center for multicultural Youth. (2007). Playing for the future: The Role of Sport and Recreation in Supporting Refugee Young People to 'Settle Well' in Australia. Melbourbe: CMY.

Climate Central. (n.d.). Surging Seas. Retrieved from Sea level - Climate central: https://ss2.climatecentral.org/#12/-2.2122/-79.9056?show=satellite&projections=0-K14_RCP85-SLR&level=1&unit=feet&pois=hide

Collins, R. (2004). Interaction Ritual Chains. New Jersey: Princeton University Press.

Compte-Guerrero, F. (2017, March 02). Índice verde urbano. Expreso, pp. https://www.expreso.ec/opinion/columnas/indice-verde-urbano-XD1126088.

Conley, T. G., & Topa, G. (2002). Socio-Economic distance and spatial patterns in unemployment. Journal of Applied Econometrics.

Cortis, N., Pooja, S., & Muir, K. (2007). Participation in sport and recreation by culturally and linguistically diverse women. Social Policy Research Centre - University of New South Wales.

Delgado, A. (2011). Guayaquil. Cities.

Deltares. (2018, April 12). Deltares. Enabling Delta Life. Retrieved from Guayaquil invests in flood resilience and climate adaptation: https://www.deltares.nl/en/news/guayaquil-invests-flood-resilience-climate-adaptation/

Dumont, J., Santana, E., Soledispa, B., & King, A. (2007). El Islote El Palmar, resultado de una evolucion a largo plazo de la distribucion del drenaje entre los Ríos Daule y Babahoyo en la Cuenca del Guayas.

acta Oceanografica Del Pacifico 14, 169-179.

Gehl, J. (2010). Cities for people. Washington DC: Island Press.

Goffman, E. (1963). Behavior in Public Places. New York: Free press.

Hallegate, S., Green, C., Nicholls, R. J., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. Nature clamate change, 802-806.

Henriquez, L., & Van Timmeren, A. (2017). Under Pressure: Wayer and thr city. Delft: TU Delft & AMS Institute.

Hiller, B., & Hanson, J. (1984). The Social Logic of Space. New York: Cambridge University Press.

Hoffmann, T., Erkens, G., K.M., C., Houben, P., Seidel, J., & Dikau, R. (2007). Holocene floodplain sediment storage and hillslope erosion within the Rhine catchment. The Holocene, 105-118.

INEC. (2017, October 6). Guayaquil en Cifras. Retrieved from Instituto Nacional de Estadística y censos: http://www.ecuadorencifras.gob.ec/guayaquil-en-cifras/

KTH, S. O., Chalmers, S. o., & Spacescape_AB. (n.d.). Place Syntax Tool. PTS Documentation.

Legeby, A. (2013). Patterns of co-presence. Stockholm, Sweden: KTH Architecture and the Built Environment.

Legeby, A., Berhauser Pont, M., & Marcus, L. (2015). Streets for co-presence? Mapping potentials. Proceedings of the 10th international Space Syntax Symposium.

Lippi, C. A., Stewart-Ibarra, A. M., Muñoz, Á. G., Borbor-Cordova, M. J., Mejía, R., Rivero, K., . . . Ryan, S. J. (2018). The Social And Spatial Ecology of Dengue Presence and Burden an Outbreak in Guayaquil, Ecuador, 2012. Environmental Research and Public Health.

Lungo, M., & Baires, S. (2001). Socio-Spatial Segregation and Urban Land Regulation in Latin American Cities. Lincoln Institute of Land Policy. Lincoln Institute.

M. Monirul Qader Mirza. (2011). Climate change and extreme weather events: can developing countries adapt? Climate Policy, 233-248.

Meijers, E. (2005). Polycentric Urban Regions and the Quest for Synergy: Is a Network of Cities More than the Sum of the Part?s. Urban Studies, 765-781.

Meyer, H. (2017). The state of the delta. Rotterdam: Vantilt Publishers.

MG. (2000). Municipality of Guayaquil: Informe de Avance de Objetivos de Desarrollo del Milenio en Guayaquil. Guayaquil: UN-Habitat.

Molenaar, F., Pak, T., de Pous, H., & van der Werff, B.-J. (2018). Flood Prevention Guayaquil. Delft: TU Delft Repository.

Orellana, D., & Osorio, P. (2014). Segregación socio-espacial urbana en Cuenca, Ecuador. Revista de Análisis Estadístico, 27-38.

Pozo, W., Jordán, M., & Sanfeliu, T. (2012). Delimitation of the Coastal Transition Zone un the Gulf of Guayaquil, Ecuador. Journal of Geography and Geology 4, 1-9.

PRB. (2018). World population data sheet - Population Reference Bureau. Washington, D.C.: PRB.

Reynaud, J.-Y., Witt, C., Pazmiño, A., & Gilces, S. (2018). Tide-dominated deltas in active margin basins: Insights from Guayas estuary, Gulf of Guayaquil, Ecuador. Marine Geology, 165-178.

Rijksoverheid. (2018, April 25). Jaarlijkse hoeveelheid neerslag in Nederland. Retrieved from Compendium voor de Leefomgeving: http://www.clo.nl/indicatoren/ nl0508-jaarlijkse-hoeveelheid-neerslag-in-nederland

Roser, M., & Ortiz-Ospina, E. (2016, October). Income Inequality. Retrieved from Our World in Data: https://ourworldindata.org/income-inequality

Schmidt, J. J. (2014). Historicizing the hydrosocial cycle. Water Alternitives.

Schreuder, Y. (2001). The Polder Model in Dutch Economic and Environmental Planning. Bulletin of Science, Technology & Society, Vol. 21, No. 4, 237-245.

SENAGUA. (2009). Delimitación y codificación de Unidades Hidrográficas del Ecuador. Quito.

Stevenson, M. R. (1981). Seasonal variations in the Gulf of Guayaqui, a tropical estuary. Boletín Científico y Técnico 4, Instituto Nacional de Pesca, Ecuador, 1-133.

Swyngedouw, E. (1995). Power, nature, and the city.

The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador: 1880-1990. Environment and planning, 311-332.

Swyngedouw, E. (2006). Circulations and metabolisms: (hybrid) natures and (cyborg) cities. Science and Culture.

Twilley, R. R., Cárdenas, W., Rivera-Monroy, V., Espinoza, J., Suescum, R., Armijos, M. M., & L., S. (2001). The Gulf of Guayaquil and the Guayas River Estuary, Ecuador. Ecological Studies Vol. 144.

UN. (2017). Facsheet - The Ocean Conference. The Ocean Conference. New York.

UN Atlas of Oceans. (2002). Human Settlements on the Coast. Retrieved from Oceans Atlas: http://www.oceansatlas.org/subtopic/en/c/114/

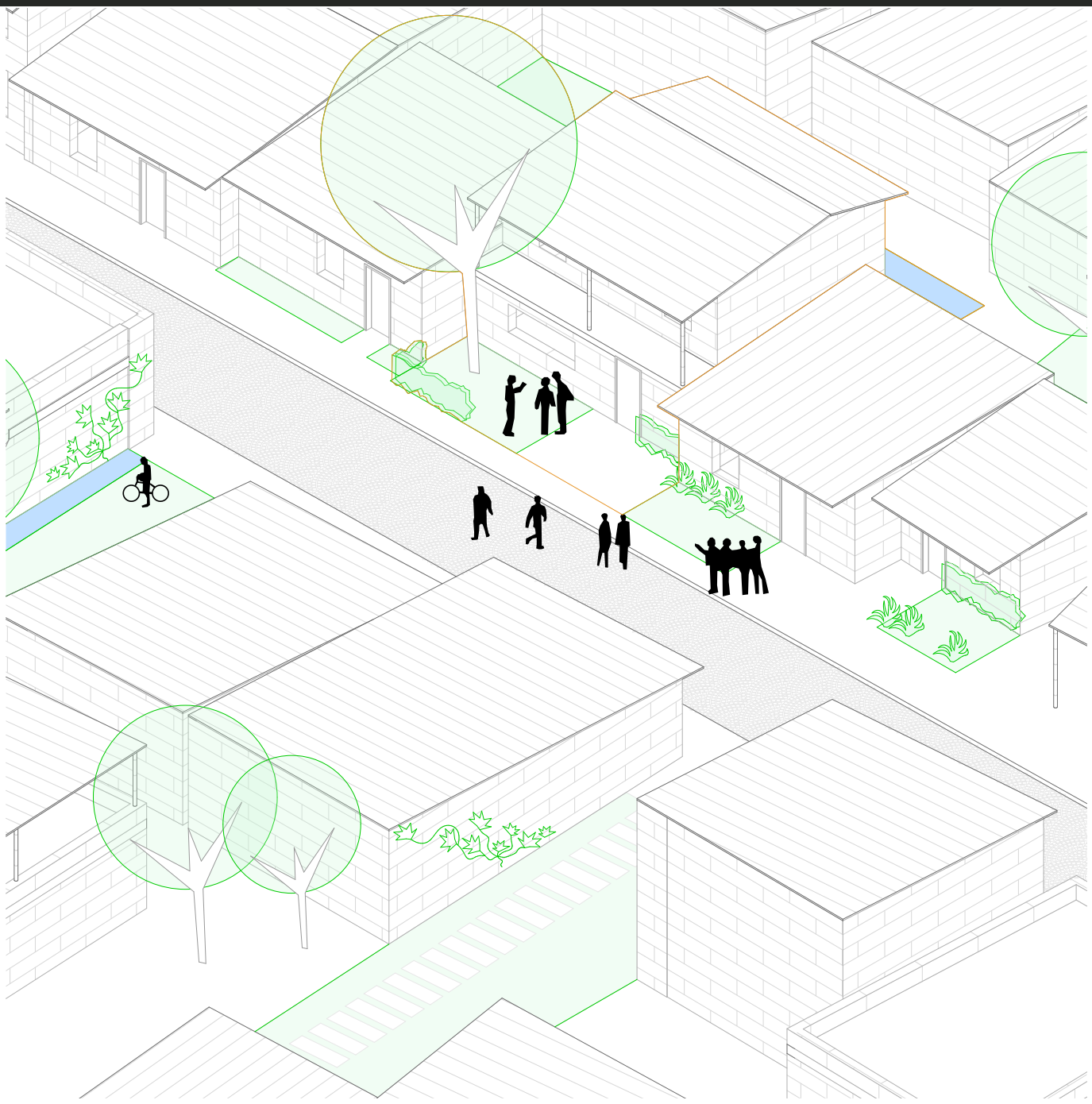
Van de Ven, F., Hooijmeijer, F., & Aalbers, K. (2018). BK3TE4 ST water flow calculation sheet.

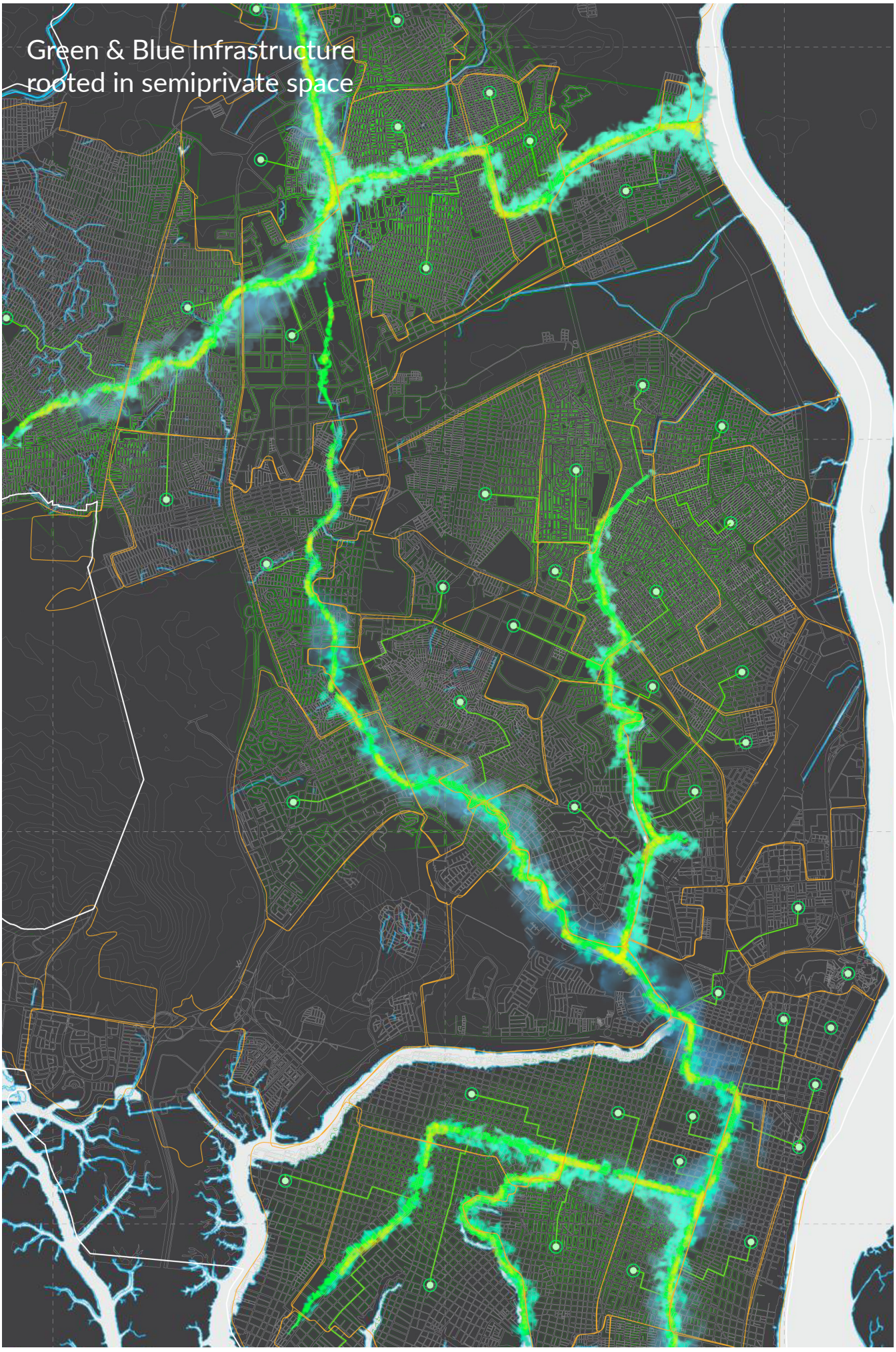
Varidy, D. P. (2005). Desegregating the city. Ghettos, Enclaves, and Inequality. Albany: State University of New York Press.

Wirth, L. (2005 [1938]). Urbanis as a way of life. In J. Lin, & C. Mele, The Urban Sociology Reader. New York: Routledge.

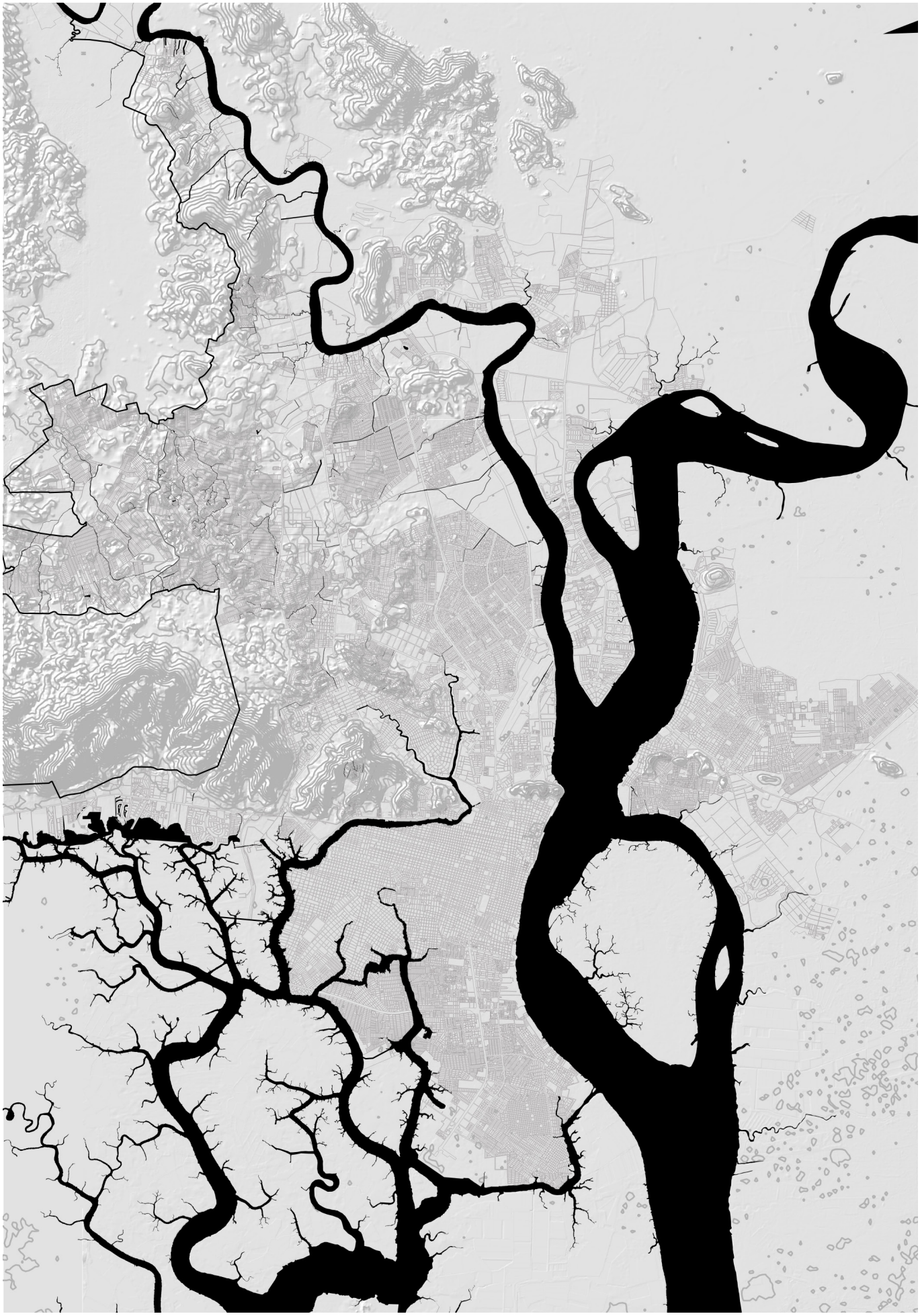
Yin, R. K. (2014). Case Study Research: Design and Methods. Los Angeles: SAGE.

APPENDIX

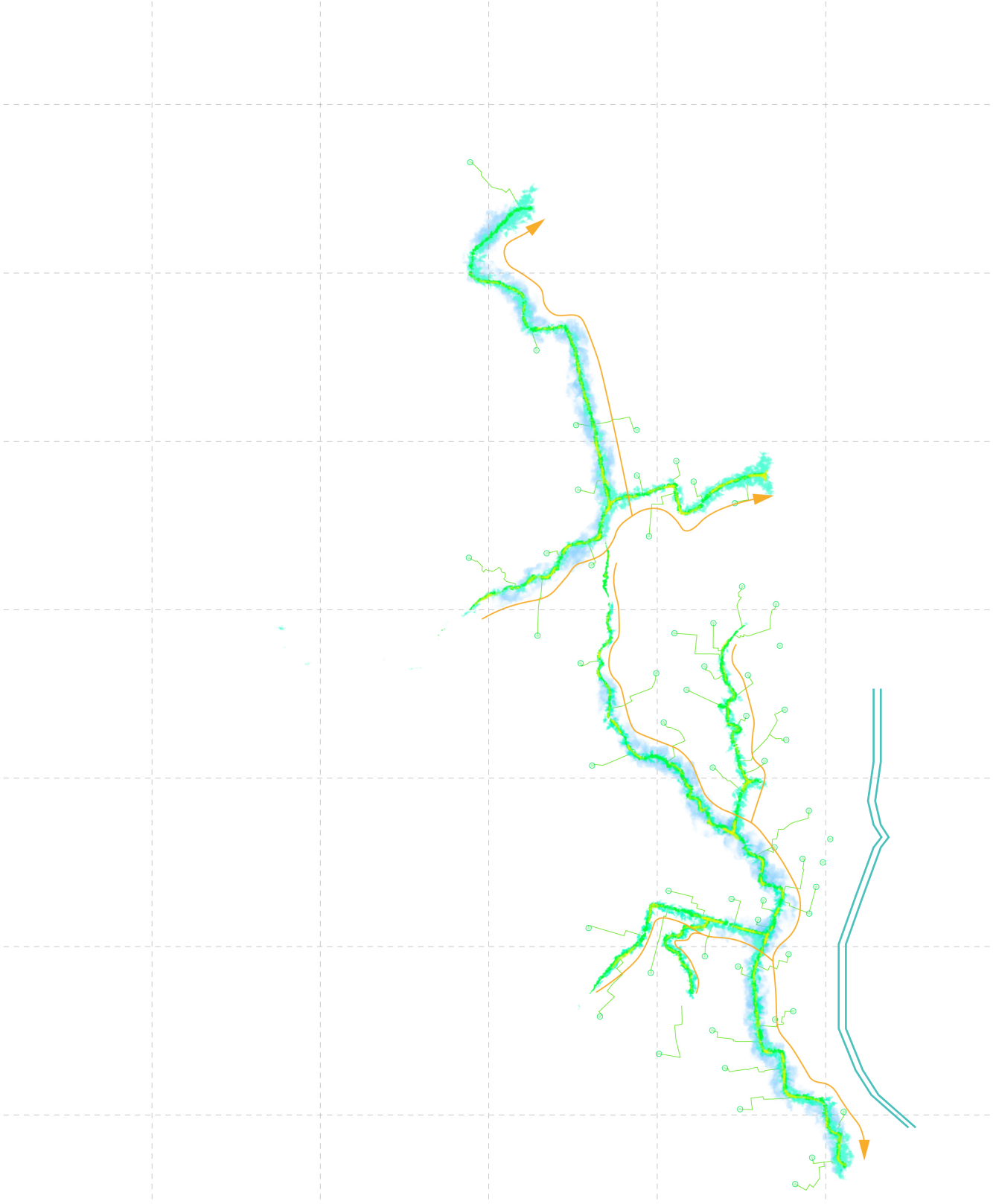



Green & Blue Infrastructure
rooted in semiprivate space

Hillshade



Flow of water in green network



Legend

Green & Blue Infrastructure

Double row of mangrove for sediment catchment

Flow Direction

0 2.5 5 7.5 km

Pattern Analysis

Project, Signature Drawing:

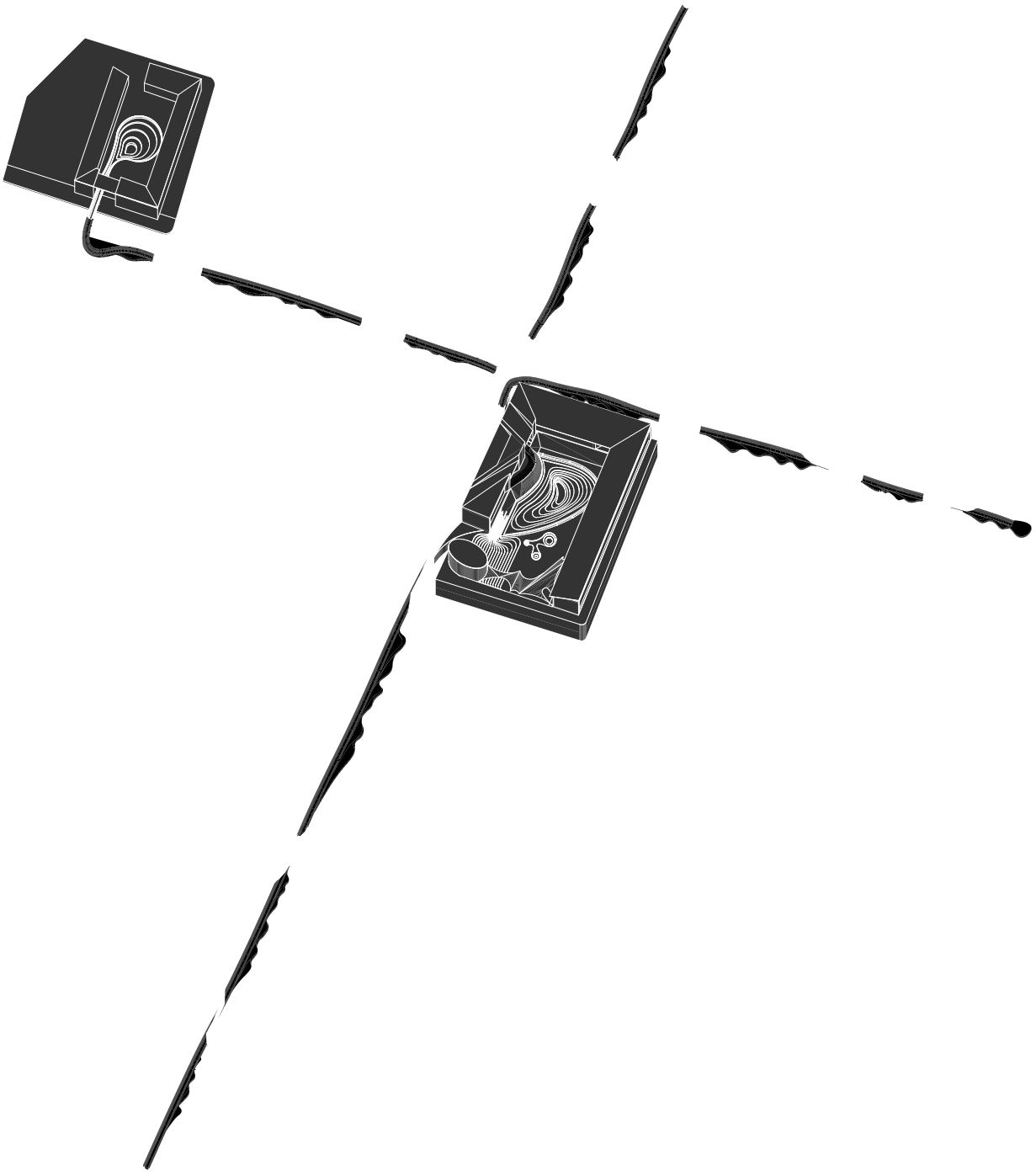
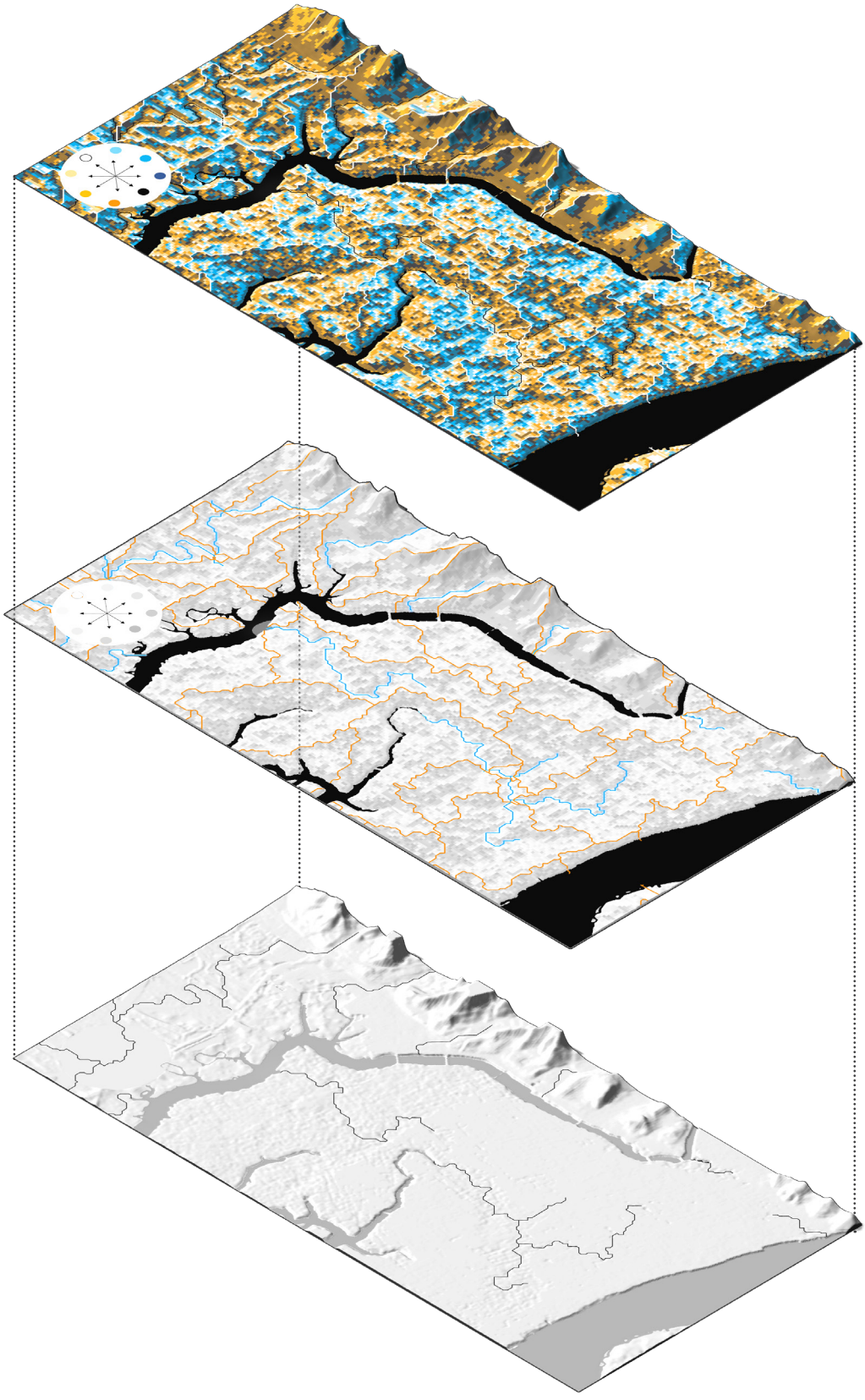
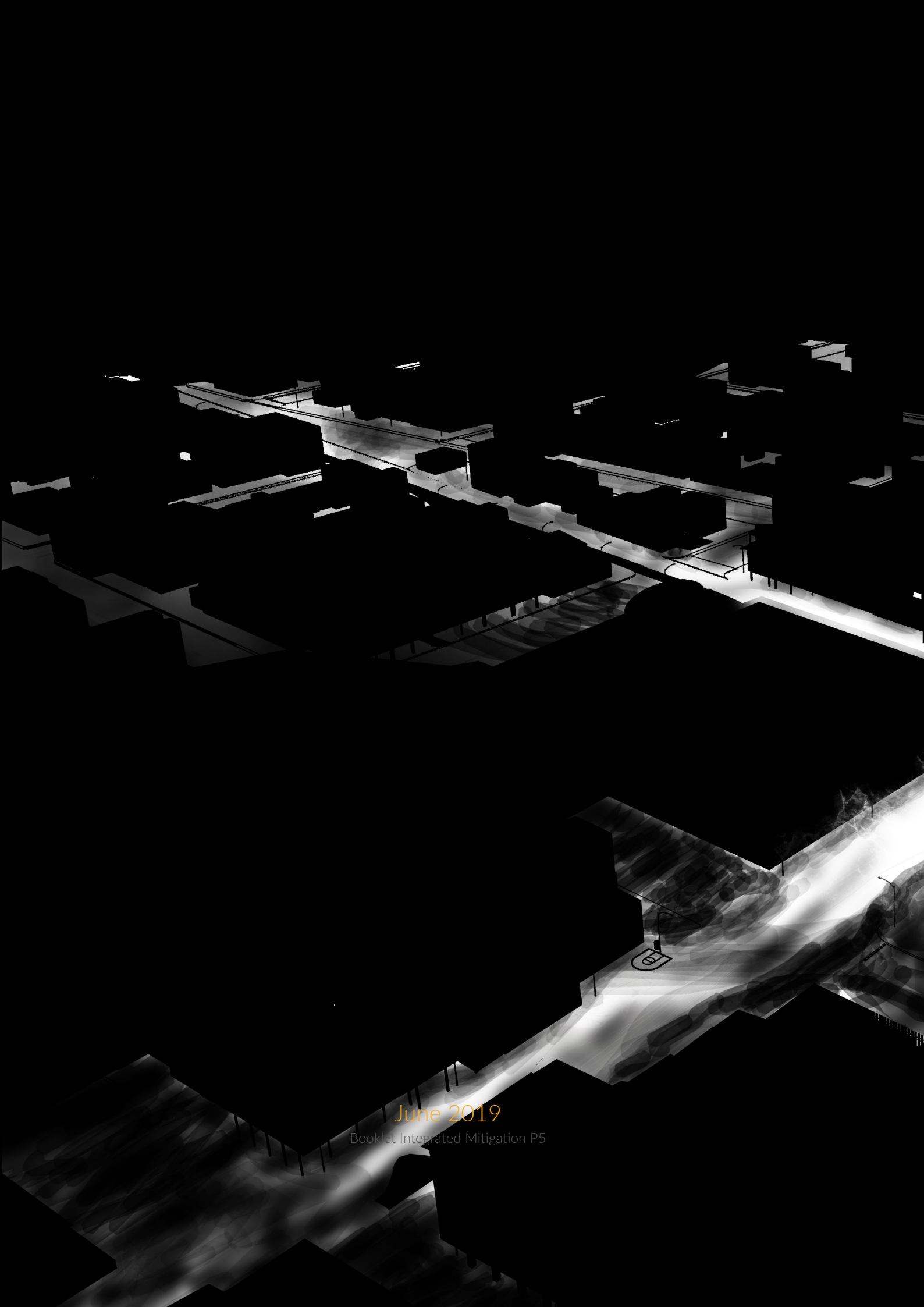


Illustration of water basin analysis - Sector Febres Cordero:



Aqua-Culture Over Mangrove Forests



June 2019

Booklet Integrated Mitigation P5