Super Levee Breached: A New Infrastructure For Magangué

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SUPER-LEVÉE_BREACHED

A New Infrastructure for Magangué

THESIS 2014-2015
SYRACUSE UNIVERSITY
NIKOLE CABRERA
CONTENTION

Cities that are extremely prone and vulnerable to flooding require innovative architecture that can provide improved community livelihood and resilience through water-adaptive strategies that are site specific and user-accommodating.

This thesis is an experiment meant to re-imagine fluvial edges as thickened places of habitation. These interventions must exist on land, on the edge, and in the water, acting as a system of infrastructure to spread excess water out, absorb it, and capture it to release it later when necessary.

In order to reconcile the relationship between the built and natural environment, the proposed solution requires the integration of water into the overall design. The outcome is a community that can better withstand flooding, recover quickly, and continue on with their daily lives while maintaining their respectable livelihoods.

The various water-adaptive strategies in this project respond to site by involving both floating and floodgate technology. They are not only site specific by catering to the existing context, but the units also take into account the local practices and characteristics of Colombian culture. In addition, residents are able to manipulate the space inside units to fit their lifestyle. The flexibility of the system allows change, accommodating public and private program as well as reconfigurations that mitigate water, sunlight, and natural ventilation.

In essence, “guided by the latent ecological, social, and economic conditions [of Magangué]... and the positive and vital element of cultural heritage,” this thesis hopes to embody “a living architecture [that evolves as people do] and [expresses their] way of life.”
Within the past two decades, the news is becoming increasingly filled with stories about natural disasters across the globe. The Earth is constantly changing, and therefore so is the climate. The extreme effects of evolving natural phenomena and man-made interventions have led to intense weather and frightening calamities.

In architecture, this is nothing new. With new technologies and a focus on sustainable, eco-friendly building, we are learning to build with climate change in mind.

The most threatening agent to rising cities and the future of architecture is sea level rise. As several metropolises lie along coasts, they remain to be vulnerable to damaging effect of flooding. It’s time to start thinking about the possibilities of building on top of the water and with it, as opposed to away and against it.

The following map depicts a selection of countries that according to the Global Risk Index of 2014 were among those that ranked highest in risk for being victims of natural disasters (1993-2012; except the US). Out of the major natural disasters in the past two decades (1995-2014), the percentages demonstrate which had the largest impact on the population. These countries where flooding is prominent represent the possible locations for testing this thesis.

**Map Key:**
- Storm
- Flood
- Earthquake
- Epidemic
- Extreme Temperature
- Drought
All Statistical Data was retrieved from EM-DAT: The OFDA/CRED International Disaster Database.
In 2010, **1.5 million** people were left **homeless**, over **2.7 million** Colombians were **affected**.

All statistical data was retrieved from EM-DAT: The OFDA/CRED International Disaster Database
Introduction

Colombia is one of the most populated countries in Latin America, coming in third behind Brazil and Mexico. Its coastline stretches over 1,000 miles which is home to several tourist cities and most of its economic infrastructure, including agriculture and cattle ranching. In total, roughly 30% of Colombia’s population is distributed along the coast, 20% in the Caribbean coastal zone and the other 10% in the Pacific.

In addition, “Colombia has one of the highest rainfalls in South America with an annual average of 3,000 mm, compared to the 900 mm global average and 1,600 mm for the rest of Latin America” (Pulitzer Center on Crisis Reporting, 2011).

In 2010 and 2011, Colombia was devastated by the weather phenomenon known as La Niña. Over the course of two years, Colombia suffered from the worst flooding it had seen in decades.

In the Headlines

A Media’s Perspective...
reports on flooding as a result of La Niña in 2010 & 2011.

“Mudslides and floods wreak havoc across Colombia.” ~The Watchers

“Thousands affected by flood in Colombia.” ~SINA.com

“No end in sight for Magdalena flooding?”

“After 11 months Colombia asks, who’ll stop the rain?”~TIME Magazine

“Number of people hit by Colombia’s worst flood in decade continues to rise.” ~Oxfam International

“Floods leave 50,000 homeless in Colombia.” ~CNN

“Flooded in Colombia brings life to a standstill as La Niña continues its wrath.”

“According to Semana magazine the emergency has been compared to the floods caused by Hurricane Katrina in New Orleans, United States, except at a national scale.”

The Center for Global Development ranked Colombia “among the top 20 most vulnerable countries in the world to extreme weather in 2015.”
Home owners are unable to use their kitchen space or electrical appliances. They try to salvage what they can in order to continue on with their daily routines.

Home owners are unable to use their living spaces and their furniture turns into sculptural figures in order to preserve whatever they can from being damaged by the water.

Children are unable to attend school, and desks become window ornaments.

*Images: [Top 2 - Luis Robayo / AFP - Getty Images] A man collects belongings from his flooded house and a woman wades through their flooded home in Cali, department of Valle del Cauca, Colombia, on April 22, 2011. [Bottom - Gianmarco Panucci] Schools are closed and education is brought to a hault due to flooding in La Mojana, 2010.*
Often times, the streets are too flooded to walk around in, so those who are able to, use boats to get to work, even though their homes remain unaccessible.

The people in this town joined to create an elevated walkway using local materials in order to get around.

Sacks full of stones and sand are placed and backed up with dirt to prevent the river from flooding the villages. Nevertheless, the rivers level rises and waves surpass the make-shift barrier.

Images: [Top - Carlos Ortega/EPA] People travel by boat through a flooded street of a town in Colombia, 2010. [Bottom 2 - Gianmarco Panucci] The population makes efforts to continue their daily lives. The Cauca River broke the artificial barriers consisting of a barrage built from inhabitants, and proceeded to inundate the whole area.
Bordered by both the Pacific and Atlantic Oceans, Colombia has subsequently been divided into 5 major geographical/hydrological regions based upon watershed. With over 500 rivers (14,300 km) covering its area, it’s no surprise that when rain increases, the surrounding rivers react resulting in almost immediate flooding. The Pacific Coast specifically is known as one of the wettest regions in the world.

La Majana area is one of the most affected areas, where 7 out of 10 families live below the poverty line. This area is critically at risk because it lies at the intersection of the Magdalena and Cauca rivers, between the Sucre and Bolivar Departments.

Colombia is more infamously known in the news for its ongoing internally armed conflict and drug trafficking, which has resulted in approximately 60% of the population living in poverty and a disturbingly high unemployment rate. Much of the violence has caused displacement of families and has consequently led to a pattern of dense settlement in increasingly vulnerable areas prone to natural disasters (SEI, CGDEI, 2008). Flooding is responsible for the largest natural disaster-induced displacements each year. They are predicted to keep increasing in frequency and intensity rendering the rivers volatile, exacerbating human displacement and poverty.

Just within the period from January 2012 to March 2013, “971,105 people were affected by natural disasters, primarily floods... A total of 137 disaster events were recorded led by flooding at 49...” (GoC, UNGRD).

La Guajira’s northern peninsula is the most vulnerable area along the Caribbean coast and at highest risk in terms of sea level rise, said to be increasing at 20m a year. Potential sea level rise has also put the low-lying coast in jeopardy of permanent flooding, affecting up to 1.4 million people, 29% of households, and 44.8% of the coastal road network (NC-Colombia, 2001).
Comparative Scale

Colombia’s area: 440,831 sq mi
Population Density: 108/sq mi

Department: 32 total; equivalent to the definition of a U.S. “state”.
Municipalities: 1,119 total; equivalent to a “city”.
**Bolivar's area:** 10,030 sq mi  
**Total Est. Population:** 2,229,967 people  
  Capital - Cartagena: 990,179 people  
**Population Density:** 222/sq mi

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**La Mojana Area**  
**Municipality:** Magangué, “River city”  
**Area:** 605 sq mi; Land: 403 / Water: 202  
**Total Est. Population:** Urban Area – 346,988 people; Metropolitan Area – 392,214 people  
  Capital - Magangué City: 198,124 people  
**Population Density:** 215/sq mi
Within the river basins and tributaries there exists over 200 species of fish, half of which are endemic to the site. Unfortunately, increased pollution has put a halt to the fishing industry, as well as place some of the species under threatening conditions.

The drawing to the right explodes the layers of the constructed site, using water to illustrate the site's unique figure-ground condition. Within this area, approximately 40% of the landscape consists of water. The marshes vary in depth and the water changes color based upon the sediment content.

The Magdalena proceeds North, its delta lying in the Caribbean Sea. Along its length are several other communities and townships, however it is very difficult to find information about this impoverished area. After careful research, Magangué city, appropriately nicknamed “river city,” had the most information available and presented itself as a prime area of study due to its proximity to both marshes and the river, and its prevalent flooding vulnerability.
In Colombia, the páramos atop the Andes chain are known as the high-mountain wetlands or high-altitude reserves which feed the watersheds of the Magdalena and Cauca Rivers. The páramos serve as natural buffers for floods during the bimodal season (Months: April/May and Oct./Nov). However, deforestation and mining has led to much of their destruction. Furthermore, glaciers in the area are beginning to melt at an increasing rate generating high volumes of water with extreme downstream force causing torrential floods.

The drawing to the left illustrates how the river bank has meandered and changed over time. In addition, it shows the proliferation of marshes in the humedales (savanna wetlands) where the majority of the population is located, and not in concentrated areas, but sparse confetti like settlements.

With the floods from La Niña in 2010 and 2011, the marshes have expanded claiming more territory. The furthest node to the right is where the Magdalena splits, intersecting with the Cauca at the two other indicated nodes.
In Colombia, the Paramos atop the Andes Chain are known as the high mountain wetlands or high-altitude reserves which feed the watersheds of the Magdalena and Cauca Rivers. The Paramos serve as natural buffers for floods during the bimodal season; however, deforestation and mining has led to much of their destruction. In addition, glaciers in the area are beginning to melt, generating high volumes of water with extreme downstream force causing torrential floods.

Using the Rosgen Stream Identification System (1996-98), environmental engineers are able to identify various stream types and their properties such as cross-section, width-to-depth ratio, water surface slope, and the channel sinuosity. Another source, Wildland Hydrology provides further classification based on the dominant bed material in the case of the Cauca and the Magdalena in within the range of C4-C6.

### Stream Characteristics

<table>
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<td>1.8</td>
<td>1.3</td>
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</tbody>
</table>

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The Momposina Depression is a large alluvial valley of 24,650 sq. km, located between the Caribbean plains and the foothills of the Cordillera Central. This depression comprises the lower reaches of the Momposina Depression, which includes the lower reaches of the rivers San Jorge, Cauca, Cesar, and their confluence with the Magdalena, in the territories of Córdoba, Sucre, Bolivar, Magdalena and Cesar.
The city lies 200 km North of one point where the Cauca and Magdalena Rivers meet. Southwest is a larger marsh that runs along the majority of the city’s length, and there is also a large area of wetlands in the Northeast.

The city lies in a precarious position since it is surrounded by water on almost all sides, when flooding occurs, the population is displaced and forced to move further inland. It increases the distance between the people who live there and where they work.

There is a main road that splits the city in half, towards the North lies the majority of the residential population and as the main road terminates, one reaches the commercial area in which the density increases.

There exists a juxtaposition of parallel and rotated grids within the major residential grids of the city. As the city approaches the river’s edge, the regularized residential grids morph into irregular concentric patterns where the commercial and retail portion of the city is located.

There is one major school ground and other minor significant buildings like doctors, offices, and banks scattered around.

There are few parks and recreational areas spotted within the city, but many need refurbishing and others remain to be abandoned.

There is a plot where farming takes place above the body of water to the left, making it quite vulnerable to flooding and likely to compromise or damage crops.

During the floods of La Niña, the water reached way into the commercial area affecting several businesses and closing the school.

The main method of transportation besides the main road is by water. Their main port lies at the city’s edge which is viable for imports and exports. In addition, their tourism gains profit from boat tours and ferries.
estadio diego de carvajal
punta de piedra
beginning of flood season 2010
travel by boat; tourist ferries

Residential Area
Residential Area
Parallel Grid
Rotated Grid
Commercial Area
Irregular Grid
Significant Buildings
Retail, Health, Institutional + Cultural
Green Spaces

Hydrology

constructed
centro magangué during flooding season
Mean precipitation: 300-2500 mm/yr.
Mean runoff: 457 mm/yr.

1.4 million households affected by floods in Colombia.

The Magdalena River was at its highest level in 40 years.
1.7 million households affected across the country.

In February, heavy rains caused several rivers to overflow their banks leaving thousands with damaged homes.

La Niña affects 75% of population in La Mojana.
2.7 million Colombians were affected by the consequential flooding and landslides of this major storm event.

A total of 684 floods were reported from Sept-Dec 2011. Colombia attains record high precipitation in South America: 3000 mm yearly average (900 mm global; 1600 mm Latin America).

A total of 49 floods were recorded from January 2012 to March 2013, bringing the total to those affected by natural disasters in that time period to just under 1 million people.

Total Precipitation in Magangué and surrounding Bolivar area: 2000-2400 mm
Wettest Quarter: 1000-1200 mm

Prominent Factors:
The city of Magangué is at an altitude of approximately 62 ft (19 m) above sea level.
It’s climate consists of tropical savanna (81%) and monsoon (19%).
It falls into the category of tierra caliente, the tropical lowlands (sea level - 2500 m), coastal plains, and interior basin regions.

CGD predicts extreme weather for this upcoming year. Annual precipitation is also suggested to increase 10-30% within the next couple decades.

2010-2011

2012-2013

2014

2015

CNA predicts ENSO (El Niño/La Niña weather phenomenon) which occurs every 2-7 years will become more frequent, intense, and volatile.

According to CNA, between 2025-2050 hurricane likeliness will be 4 x greater in this area, in addition to a 1-2° C rise in temperature.

Since 1950, glaciers in the páramos (3000-5000 m) have decreased by 50%; in 2050, they are predicted to be completely melted causing watersheds to experience large disturbances as a result of torrential floods.
Mean precipitation: 300-2500 mm/yr.

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Bimodal Flood Season

Precipitation Ratios

April/May: 1:2 - 2.5

Oct./Nov.: 1 - 1.5 : 2 - 2.5

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In addition, sea level rise along the Caribbean Coast is predicted to increase by 1 m. Due to fluvial processes, the river will try to match the new level of the delta, increasing in height, placing more sediment in the riverbed. The new water level of the river can then be estimated to be 1.25 m (roughly 4 ft).

Colombia also happens to lie in the Intertropical Convergence zone, an area encircling the Earth near the equator where NE & SE trade winds cross paths. This results in erratic weather patterns ("stagnant clams and violent thunderstorms") which drastically affect rainfall creating dry and wet seasons marked by severe droughts and intense flooding.

CNA predicts ENSO (El Niño/La Niña weather phenomenon) which occurs every 2-7 years will become more frequent, intense, and volatile.

According to CNA, between 2025-2050 hurricane likeliness will be 4 x greater in this area, in addition to a 1-2° C rise in temperature. Since 1950, glaciers in the páramos (3000-5000 m) have decreased by 50%; in 2050, they are predicted to be completely melted causing watersheds to experience large disturbances as a result of torrential floods.
Families have been displaced several times due to the slow construction of temporary shelters, and those living in them now lack access to clean water and sanitation as a result of neglect from the government.

Securing land to build more permanent homes is also a lengthy process and so these shelters that are designed to last at most 6 months, end up being pushed beyond their limits of use which result in these unhygienic living conditions.

Colombia: Two Years Under Water, Refugees International

Octavio: “Queremos mantenernos aquí porque nosotros nacimos en esta región la queremos mucho y queremos morir aquí.”

The idea of relocation is very difficult for those affected by flooding because they feel a sense of pride and attachment to their villages.

Iraida: “Lo que yo quiero es volver a mi casa con mis hijos y mi familia cuando las casas se secan y que nos ayuden arreglar las casas y que nos sacan esta agua rápido porque se nos van a caer las casas.”

They want help removing the water quickly and help rebuilding not just their homes, but their livelihoods. Waiting for food and supplies for 4 months while their houses remain in terrible conditions is the reality many of these disaster victims face.
In an interview with Bas Smets, the Director of Strategic Planning for the Housing Corporation of Antioquia (one of the departments in La Majana), he states “People never leave their houses and the government offers them little to no help regarding temporary housing or tents. Instead, what people do in times of flooding is adapt their house. Some build a second temporary wooden floor on top of the existing one, or move up to the second floor if they have one, and ‘normal’ living goes on. Streets become waterways in which they transport in boats or other floating devices.” Instead of relocation, it makes sense to adapt, to accommodate the flooding.

In addition, current dikes located along the Cauca River are beginning to fail and the river continues to crest during flooding season. In 2012, the Colombian government “requested the Netherlands to assist in looking for ‘Dutch proof’ solutions to water safety in the country,” La Mojana being the main priority. The asked the Royal Dutch Embassy in Bogota and the Dutch Ministry of Infrastructure and Environment for their expert opinions and recommendations for increased protection against flooding and approaches to living with water. The most architectural note was to “develop a spatial vision or land-use plan for agriculture, nature, housing, etc.” in order to establish levels of vulnerability and frequency of flooding in areas so as to be able to build appropriately within them.

Dutch history is full of prime examples of successfully living with water. In architecture, they have famously produced the “houseboat.” Herman Hertzberger, Attika Architecten, Dura Vermeer, Deltasync, and WaterStudio have all proposed and built several versions and adaptations of water-adaptive and floating architecture. Hertzebger has used the technology of deep-sea oil rigs to inspire a floating house that rests on a ring of hollow steel tubes which allows it to float. The other firms and some engineering companies have recently been working to upgrade the concrete caisson, experimenting with hybrids, trying to make them more light meanwhile maintaining their durability and affordability.

Koen Olthius, of WaterStudio, has used building on water to give “new space to the city” as well as a response to climate change. In his TEDTalk, “Future Cities will Float,” he outlines the 10 “trends” towards floating architecture. In my opinion, the list is not necessarily a trend but what floating cities can afford us: safety, sustainability, scarless developments (no footprint), instant green solutions, private islands, plug’n’plays, expansion of the urban fabric, flexible urban components (moving parts), a new market for temporary events (i.e. Olympics), and most importantly, they can instantly upgrade the life of the poorest. In tandem with my values of site specificity, Olthius asserts that the new building forms should resemble their context as opposed to being “wild and futuristic.” Aquatic architecture should “enhance” the city, not overshadow or neglect it.
CASE STUDIES

Maasbommel
Factor Architekten
This community of 37 houses no longer relies on higher dikes to keep the water out. Instead, while they rest on land, they are designed to rise with the water and float back into place when the water recedes. The hollow concrete foundation is attached to six iron piers, with a larger one placed in between every two homes to keep them in place as they move.

Spin Off Utopian
EAFIT
Produced through a collaboration between students at the University EAFIT in Medellin, Colombia and various organizations including the UNDP, the UNGRD, and the EU, this proposal, of which an actual life size prototype has been built, is meant to be of floating classrooms, but the idea is that the technology can be applied to houses too. The unit rests on the construction of a steel truss platform frame, which placed within it, are bags filled with bottles. It’s a simple, lightweight solution to climate change and flood mitigation.

Watersniphof & Zwanenhof
Herman Hertzberger
This multifamily residence was intended to make a dramatic statement. Its elevated height indicates not just monumentality but serves the purpose of keeping its residents away from flooding all the while offering a unique view of the Veersche area.
Located in a town 4.8 meters under sea level, these eight family homes each consist of timber frames built on concrete caissons. The architect varied each unit slightly through size, color, and shape in order to accommodate the owners’ wishes. They also feature split level design which allows for uninterrupted views, advantageous sunlight, and the reflection of the water into the interior space.

These are durable, low-maintenance homes that allow flexible floorplans in order to maximize comfort. They use radiant floors as the main source of heat, as well as highly insulated materials and include individual water pumps. The barrier along the water’s edge is a bank consisting of large basalt stones.

In this example, the firm used reinforced concrete piles to raise the homes above the water. A unique component of this development includes parking off the main road that extends partially into the water and raised walkways elsewhere to accommodate both vehicular infrastructure and pedestrian traffic.
3 Water Villa’s Regenboogkade
+31 Architects

Although this composition was designed by three different architects, their collaboration produced both variety and cohesion. The houses stand out as individual compositions, meanwhile speaking to each other through materiality and scale.

New Water project: Traverse villas
WaterStudio

These housing units also feature the same concrete base construction, but they form a heterogeneous assembly. They consist of similar configurations, each slightly varied from the next, and keep matching color palettes as well, which remain to be neutral as opposed to a defining characteristic.

Borneo-Sporenburg
West8

While this precedent is not that of floating or water-adaptive architecture, but a reinterpretation of the traditional Dutch canal home, it demonstrates the type of architectural variation that the previous examples of the typology could benefit from. The animated elevation maintains unity through scale and a continuous roofline, but allows the individual to emerge among the collective.
The success of most of these case studies lies in the fact that they respond environmentally to climate change and rising water levels, as well as being specific to the immediate context of the site in which it is placed. “[One approach is] to investigate the existing situation—building, city, or native land—to discover its latent qualities or potential; inherent conditions can motivate the ensuing construction so that the new participates in the existing. This allows both a criticism and a release from the received conditions and, reciprocally, a reverberation of them so that the boundaries between the conditions as received and as renovated become blurred.”

~Carol J. Burns, On Site: Architectural Preoccupations

Furthermore, water-adaptive designs must accommodate the social forces of the site. This refers to the user-desire and the owner’s identity within the community as well as the appropriation of the overall present culture. “This initiative is of great importance to the country due to the large social impact it could have [and environmentally] as a measure of adaptation to climate change [while also] mitigating the risk associated with floods. [It can] provide affected communities permanent solutions that enable them to have a dignified life without leaving their original territory.” Adriana García Grasso Director of ICC.
Buoyant Foundations
The most common foundation found in floating homes consists of a concrete caisson, a hollow reinforced concrete box, that is partially always under water. The space can serve as mechanical storage or occupied as living space, such as a basement. Often these units are kept in position by being connected to land through a walking platform, but in some cases can be kept in place using piles or piers. These same piles can be used with another floating foundation which involves a platform steel frame that is filled with buoyant objects, either large steel pontoons or something as simple as bottles.

Platform + Barrier
One version of dry-proofing homes is simply by raising them on a platform, and another includes a barrier between the habitable space and the water.
Elevated
The default remedy to flooding involves relocation to higher ground. However, this is not exploring the potentials of innovative design within the realm of water-adaptive architecture. Many times, relocation is inconvenient, displacing families and interrupting their lives. Instead of high-dry, the solution must work with the low and wet. This not only applies to elevated ground, but elevated floors. For yet another rather typical solution requires the use of pilotis, lifting the entire home into the air.

Barrier
In some instances, barriers are put in place to allow for outdoor areas during low-tide. When the water rises however, the house can either float or the ground floor can be wet-proofed to allow the water to enter and then proceed to empty out once the tide goes down again.

Floodgate
Complete wet-proofing means that the materials are waterproof, and any electrical outlets or water-sensitive objects are placed above the first floor. This approach can be seen in many of the residences in Venice, Italy.
SUPER-LEVEE STRATEGIES

Rebuilding Levees

Example 1: Everglades, Florida

1. Everglades water can seep through the earthen levee.

2. Increased seepage can lead to "piping"—cavities caused by erosion that are at risk of collapsing, which can cause a breach and flooding.

3. New berms add strength to reduce piping and erosion. Vegetation is removed making maintenance easier.

4. Limestone boulders will moved to the base of the berms to add strength.

There are 670 miles of levees.

Strengthening levees

A 25-foot wide berm will be added to prevent breaches in the levee system.

How berms will help:

Water in the Everglades

Existing levee made of soil, sand, rock and shell

Berm to be made of crushed limestone.

Source: South Florida Water Management District

Andrew Reid STAFF RESEARCH, Cindy Jones-Hulfachor SUN SENTINEL
Example 2: Cedar Rapids, Iowa

Example 3: “SUPER DIKE,” Tokyo, Japan
“New Aqueous City”, MoMA Rising Currents
ERIC BUNGE AND MIMI HOANG, nARCHITECTS
RESILIENCY + SOFT INFRASTRUCTURE

“Water Proving Ground”, MoMA Rising Currents
LTL Architects
SUPER-LEVEE BREACHED
Thesis Statement:

Cities that are extremely prone and vulnerable to flooding require innovative architecture that can provide improved community livelihood and resilience through water-adaptive strategies that are site specific and user-accommodating.

This thesis is an experiment meant to re-imagine fluvial edges as thickened places of habitation. These interventions must exist on land, on the edge, and in the water, acting as a system of infrastructure to spread excess water out, absorb it, and capture it to release it later when necessary.
The system is meant to strategically spread out excess water, capture it to release it later during dry season, and absorb it through not only the landscape forms, but green roofs and performative sidewalks. The housing has been oriented within the range of 30 to 60 degrees of true north in order to maintain its performative qualities that fit within the theme of tropicality and site specificity.

The water projections for the future take into account the fluvial processes of equilibrium. As the sea level in the Caribbean delta is predicted to rise 1 m by the year 2050, the river will undergo a process which will cause its bedrock to rise in order to empty out into the sea. This will in return create sedimentary deposits raising the level of the marsh. My predictions take into account mathematical estimates that reflect an inversely exponential pattern.

I utilized a combination of strategies from various precedents including super-levees, resiliency and soft infrastructure, as well as Dutch approaches to housing and flooding.
SUPER-LEVEE  SECTION

design process

imagined section
(with extreme height
differentiation)

typ. levee profile

transitions:
- water behind units
  caters to slope better
- renovated park can
  absorb runoff & collect
  excess in water channel
- consider affects of
  solar orientation on units

typical levee configuration

crest = water depth times 2.5 or 3

vertical and horizontal thickening

existing site section 600'

+60'

+58'

+52'

+49'

600'

high + dry housing

floodgate housing

on the edge

Elevation: +9'

east
North

optional green

space

FIRST FLOOR

SECOND FLOOR

THIRD FLOOR

optional garden

or planter space

FLOATING HOUSING

in the water

Elevation: +6'; +0'

door screens allow

cross ventilation;

“blurring” boundaries

of enclosure

vertical concrete piers

act as louvers in order

to mitigate sunlight

screens mitigate

sunlight & allow

cross ventilation also

absorptive green roof

local materials:

reinforced concrete

+ wood cladding
The housing is not only site specific because of its location on the levee, but also in terms of Magangué and the tropical setting that is Colombia. The first two feature overhangs, louvers, and screens in order to mitigate sunlight and allow for cross-ventilation. They employ local materials such as wood and reinforced concrete. They take advantage of the screens and an abundance of glazing to blur the boundary between inside and outside, another trait commonly found in the history of Latin American modernism and housing in the tropics. In terms of user-accommodation the plans all feature flexible furniture systems to leave program as open and democratic as possible (living space to office/work space to private bedrooms; except for the bathroom and kitchen core), allowing change and adaptation for different family lifestyles.
HIGH + DRY HOUSING on the land

Elevation: +15’

outdoor balcony + overhang provide sunshading

abundant glazing establishes transparency; “blurring” inside + outside

absorptive green roof

door screens allow cross ventilation

local materials: reinforced concrete + wood cladding

vertical concrete piers act as louvers in order to mitigate sunlight
native plants with deep root systems that absorb runoff and pollutants

Gravel, silt clay, bedrock

High + dry housing

Stormwater runoff drainage system

Floating houses, floating island, marsh bed, canal water channel

Perforated pipe connecting to marsh outlet

Gravel, silt clay, bedrock

Main sewage pipe

Earth, ground

Sewerage system

Permeable pavers

Curb and gutter

Canal drainage, submerged garage, underground boat storage

Elevation +4', +8', +12'

Super Levee Section

Typ. levee profile

Idealized levee configuration

Vertical and horizontal thickening

Watershoulder, crest, bermlow-lying land

Existing site section 600'

Elevated entrance into split level section, staircase or ramp attached

Lightweight, water-resistant panels, typ. aluminum laminate, colors may vary

Balcony off kitchen space; also acts as overhang providing shade for glazing

Skylit roof, flip-top access, optional garden or planter space

Door screens allow cross ventilation; "blurring" boundaries of enclosure

Outdoor balcony + overhang provide sunshading

Abundant glazing establishes transparency; "blurring" inside + outside

Screens mitigate sunlight & allow cross ventilation also

Absorptive green roof

Local materials: reinforced concrete + wood cladding

Performative sidewalks

High + dry housing

Underground boat storage

Canal water
**FLOODGATE HOUSING** - on the edge

Elevation: +9’

- Outdoor balcony + overhang provide sunshading
- Absorptive green roof
- Abundant glazing establishes transparency; “blurring” inside + outside
- Local materials: reinforced concrete + wood cladding
- Door screens allow cross ventilation; “blurring” boundaries of enclosure
- Screens mitigate sunlight & allow cross ventilation also
- Elevation: +15’

- Dry housing
- “Blurring” inside + outside
- Abundant glazing

**Second Floor**

- Floating houses
- Optional green space
- Marsh outlet connecting to perforated pipe
- Gravel
- Bedrock

**First Floor**

- Permeable pavers
- Storm-water runoff
- Sewage pipe main
- Earth

- Outdoor balcony + overhang provide sunshading
- Cross ventilation; door screens allow cross ventilation
- East

**Elevation:** +6’; +0’

- Staircase or ramp attached into split level section
- Elevated entrance
- Flip-top access
- Skylit roof

**Third Floor - Roof**

- Floating houses
- Optional garden in the water
- Water-resistant, lightweight panels, typ. aluminum laminate, colors may vary

**SCALE:** 1/4” = 1’0”

**SUPER-LEVEE SECTION**

- Figural gestures
- Transitions:
- Floating docks
- Typ. levee profile
- TYPE I WATER - BUOYANT/FLOATING (+4)
- Idealized levee configuration
- TYPE II EDGE - FLOODGATE/BARRIER (+8)
- Rejects water
- Crest = water depth times 2.5 or 3
- Bermlow-lying land
- Shoulder
- Waters
- +52’ +58’ +60’
- +4’ +8’ +12’
- +49’

- High + dry housing
- Performative sidewalks
- Soccer field
- Underground boat storage
- Floodgate housing
- Excess water storage
- Canal drainage

**Canal Water Channel**

- Marsh bed
- Floating houses
- Canal water channel
- High + dry housing
- Performative sidewalks
- Soccer field
- Underground boat storage
- Floodgate housing
- Excess water storage
- Canal drainage

**SCALE:** 1/4” = 1’0”

**SUPER-LEVEE SECTION**

- Figural gestures
- Transitions:
- Floating docks
- Typ. levee profile
- TYPE I WATER - BUOYANT/FLOATING (+4)
- Idealized levee configuration
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- Shoulder
- Waters
- +52’ +58’ +60’
- +4’ +8’ +12’
- +49’

- High + dry housing
- Performative sidewalks
- Soccer field
- Underground boat storage
- Floodgate housing
- Excess water storage
- Canal drainage

**Canal Water Channel**

- Marsh bed
- Floating houses
- Canal water channel
- High + dry housing
- Performative sidewalks
- Soccer field
- Underground boat storage
- Floodgate housing
- Excess water storage
- Canal drainage
Native plants with deep root systems that absorb runoff and pollutants.

- **Main Sewage Pipe**: Gravel, permeable pavers, storm-water runoff drainage.
- **Curb and Gutter**: Floating island, marsh bed, canal water channel.
- **Water Storage Vestibule System**: Floating docks, underwater boat storage, floodgate housing, excess water storage, canal drainage.

**Elevation Details**:
- **+4’**: Bedrock, silt clay, earth.
- **+8’**: Bedrock, silt clay, earth.
- **+12’**: Bedrock, silt clay, earth.
- **+15’**: Bedrock, silt clay, earth.

**Design Process**:
- **Super-Levee Section**
  - **Scale**: 1/4” = 1’0”
  - **Type III Land - High + Dry (+12)**:
    - Rejects water
  - **Type II Edge - Floodgate/BARRIER (+8)**:
    - Accepts water
  - **Type I Water - Buoyant/Float (+4)**
    - Above water

**Imagined Section**
- **With Extreme Height Differentiation**
- **Transitions**:
  - Water behind units
  - Renovated park can absorb runoff & collect excess in water channel
  - Consider affects of solar orientation on units

**Vertical and Horizontal Thickening**
- **Watershoulder**
- **Crest**
- **Berm**
- **Low-lying land**
- **600’**

**Existing Site Section 600’**
- **+49’**
- **+52’**
- **+58’**
- **+60’**

**Crest = Water Depth Times 2.5 or 3**

**Idealized Levee Configuration**
- **Vertical Concrete Piers**
  - Act as louvers to mitigate sunlight
- **Absorptive Green Roof**

**Local Materials**:
- **Reinforced Concrete + Wood Cladding**

**Door Screens**
- **Allow Cross Ventilation**
- **“Blurring” Boundaries of Enclosure**

**Outdoor Balcony + Overhang**
- **Provide Sunshading**
- **Abundant Glazing**
  - Establishes Transparency
  - “Blurring” Inside + Outside

**Vertical Concrete Piers**
- **Act as Louvers**
  - To Mitigate Sunlight & Allow Cross Ventilation

**Absorptive Green Roof**

**Exterior Space**
- **Option for Garden or Planter Space**

**Flipping Top Access**
- **Optional Garden or Planter Space**

**Balcony Off Kitchen**
- **Space Acts as Overhang Providing Shade for Glazing Underneath**

**Skylit Roof**
- **Flip-Top Access**
- **Optional Garden or Planter Space**

**Lightweight, Water-Resistant Panels**, typ. aluminum laminate, colors may vary.
FLOATING HOUSING in the water
Elevation: +6'; +0'

- skylit roof
- flip-top access
- elevated entrance into split level section
- staircase or ramp attached
- optional garden or planter space
- balcony off kitchen space; also acts as overhang providing shade for glazing underneath
- lightweight, water-resistant panels, typ. aluminum laminate, colors may vary
- existing site section 600'
- idealized levee configuration
- accepts water
- rejects water
- crest = water depth times 2.5 or 3
- bermlow-lying land
- crest
- +52'
- +58'
- +60'
- +4'
- +8'
- +12'
- +49'
- above water
- TYPE I WATER - BUOYANT/FLOATING (+4)
- TYPE III LAND - HIGH + DRY (+12)
- renovated park can cater to slope better
- vertical and horizontal thickening
- transitions:
- solar orientation on units
- water behind units
- figural gestures
- scale: 1/4" = 1'0"

Elevation: +15'

- door screens allow cross ventilation; "blurring" inside + outside establishes transparency;
- abundant glazing
- local materials: reinforced concrete + wood cladding

Elevation: +49'

- open performance sidewalks
- vertical concrete piers act as louvers in order to mitigate sunlight
- absorptive green roof
- native plants with deep root systems that absorb runoff and pollutants
- curb and gutter
- marsh outlet
- perforated pipe

SECOND FLOOR
- bedrock
- earth
- silt clay
- drainage
- storm-water runoff
- sewage pipe

THIRD FLOOR
- bedrock
- earth
- silt clay
- sunshading
- door screens allow cross ventilation; establishes transparency;
- abundant glazing
- local materials: reinforced concrete + wood cladding

FIRST FLOOR
- vestibule system
- water storage
- permeable pavers
- gravel
- drainage
- storm-water runoff
- sewage pipe

SECOND FLOOR
- bedrock
- earth
- silt clay
- drainage
- culvert system
- canal water channel
- water storage
- excess water storage
- underground boat storage
- floodgate housing
- excess in water channel
- absorb runoff & collect
- caters to slope better

FIRST FLOOR
- bedrock
- silt clay
- earth
- drainage
- culvert
- canal water channel
- water storage
- excess in water storage
- underground boat storage
- floodgate housing
- excess in water channel
- absorb runoff & collect
- caters to slope better

FLOATING ISLAND
- east
- north
- Elevation: +6'; +0'
- marsh bed
- or planter space
- optional garden
- vertical and horizontal thickening

SUPER-LEVEE SECTION
- transitions:
- balcony off kitchen space; also acts as overhang providing shade for glazing underneath
- skylit roof
- flip-top access

CROSS SECTION
- ground level
- Elevation: +15'
- +49'
- +12'
- +8'
- +4'
Magangué, Colombia

thickened levee as habitation + larger breaches (canals) = optimal movement of water across floodplain
As mentioned previously, the designed system is a demonstrative portion of a larger edge condition that requires a re-working of the masterplan with larger canals and levees that move more water across the floodplain and down the Carribean delta.
**Design Study**
The following models were produced as an investigation into possible housing block compositions. They were meant to explore and engage the research done through the previous case studies.

**Repetition**
The first iteration employed the repetition of the unit, proceeding with an A-B-A pattern.

**Shear**
The second iteration introduces a shifting of the units in order to create more opportunities for sunlight and cross ventilation.

**Non-Repetition**
The third iteration increases the amount of variation between the units. While the units maintain the same scale, their configuration, height, and orientation change in order to produce a more varied result.

**Moving Forward**
The next step would be to begin to see how the site and culture can begin to influence the design. In addition, by creating clustering and links between them, the infrastructure can begin to take on different roles such as circulation paths and recreational areas.
PAST SPECULATIONS ON SITE

INTERVENTION SITE #2
SECTIONAL STUDIES

Different techniques & heights can create variety.

Elevated floating walkways can connect homes.

Restrooms can be built within for recreation.

Village can act as a barrier to further inland homes.

Can be arranged closely together to increase density.

Or apart to allow for the introduction of public spaces.

Can vary in section, allowing for light & air to penetrate.

* How can massing begin to take on site & cultural specificity?

Natural forces: water, wind, sun.

Traditional materials, aesthetic, function, purpose.
APPENDIXES

DISASTER RELIEF
“Temporary settlements often become long term homes for disaster victims; their living conditions remain dense, cramped, and unhygienic; they fail to encourage community life.”
~ACSA Archive 100 – I am a Second Responder

CURRENT EFFORTS
While organizations like FEMA and OCHA are indispensible when it comes to disaster relief, their efforts are producing unfortunate consequences. Their temporary solutions have become permanent across the globe, and so it’s time that the design of these universal shelters do the same, so that the villages can prosper, grow, and essentially begin again, as opposed to remaining helpless victims.

organized community flooded

organized FEMA community for displaced people

unorganized community flooded

UNDAC & other NGOs establish tent cities for displaced people
Haiti Earthquake 2010: Three years later, 400,000 still live in the temporary housing tents. (UNDP)

Typhoon Haiyan 2013: Tents are erected as temporary shelters for residents whose houses were flattened by super Typhoon Haiyan in Tacloban city, Leyte province, Philippines. (USAID)

India & Pakistan 2010: Tent city set up by the Red Cross for the thousands of citizens of Leh displaced by the devastating flash floods.

TENTS ACROSS THE GLOBE

NGO Shelter in a Box has already begun to set up tent cities in Magangué, however helpful, to the victims of the disaster this is not the ideal solution.
Shortcomings
The problem isn’t a lack of organizations, interest, or funding; it is a lack of coordination, distribution, and knowledge. The following is a system with great aspirations but fails to adequately address the situation.

PART I: Humanitarian Response- A public-private initiative – Colombia Humanitaria – was established to administer aid to flood (& landslide) victims; it faces “significant challenges: distributing emergency assistance in a timely and effective manner. Contractual delays, bureaucratic obstacles, corruption, poor coordination, lack of government access to large areas of the country, and incomplete information meant that thousands received little to no assistance... Most vulnerable sectors of society who were hardest hit yet often received the least amount of aid, including victims of Colombia’s decades-long, internal armed conflict, and poor communities living in remote areas or on flood-prone, marginal lands; poverty, disenfranchisement, and lack of safety nets have made it far more difficult for them to recover or seek redress.”

PART II: Rehabilitation and Reconstruction- managed by the Adaptation Fund – has the advantage of providing an opportunity for the government to evaluate disaster risk before initiating reconstruction.

“Disaster recovery activities are often an opportunity to integrate improved disaster resilience into communities and build back better.”
~UNDP (United Nations Development Program)

Efforts should fully engage the community in the process of “design[ing] and construct[ing] suitable and culturally-appropriate housing. They should feel included and given adequate consideration. The new locations must provide access to basic services, education, markets, livelihoods, and employment.” ~Refugees International


