Resiliency Design Case Studies in the Developing World

TH504

Friday, June 21, 2018, 10:30 AM – 11:30 AM

1.00 LU HSW GBCI RIBA

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Questions related to specific products and services may be addressed at the conclusion of this presentation.

Speakers List

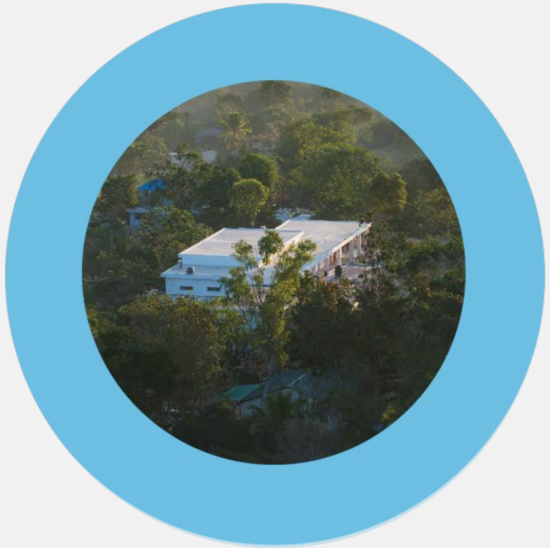
- Ching Hua-Ho, Principal, Payette
- Pedro J. Sifre, Senior Principal, Simpson Gumpertz & Heger
- James Kostaras, Senior Fellow, Institute for International Urban Development
- Alison Laas, AIA, Associate, Payette, International Practice Committee 2018 Chair

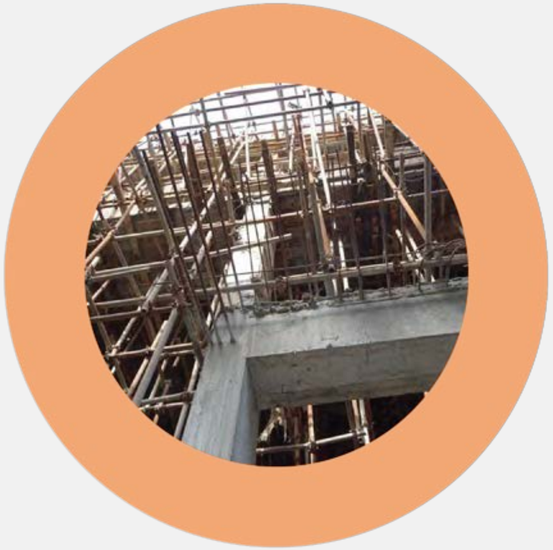
Course / Learning Objectives

- Discover the challenges and opportunities of designing for resiliency in places where resources, infrastructure, and limited technology require unique and creative design solutions.
- Learn the importance of understanding local building practices, availability of construction materials, and infrastructure in delivering a successful resilient project.
- Learn key strategies for engaging larger-scale entities, like municipal governments and communities that are essential to resilient design strategies on international projects.
- Explore how researching local climates, contexts, and design partners are essential to delivering resilient projects in the developing world.

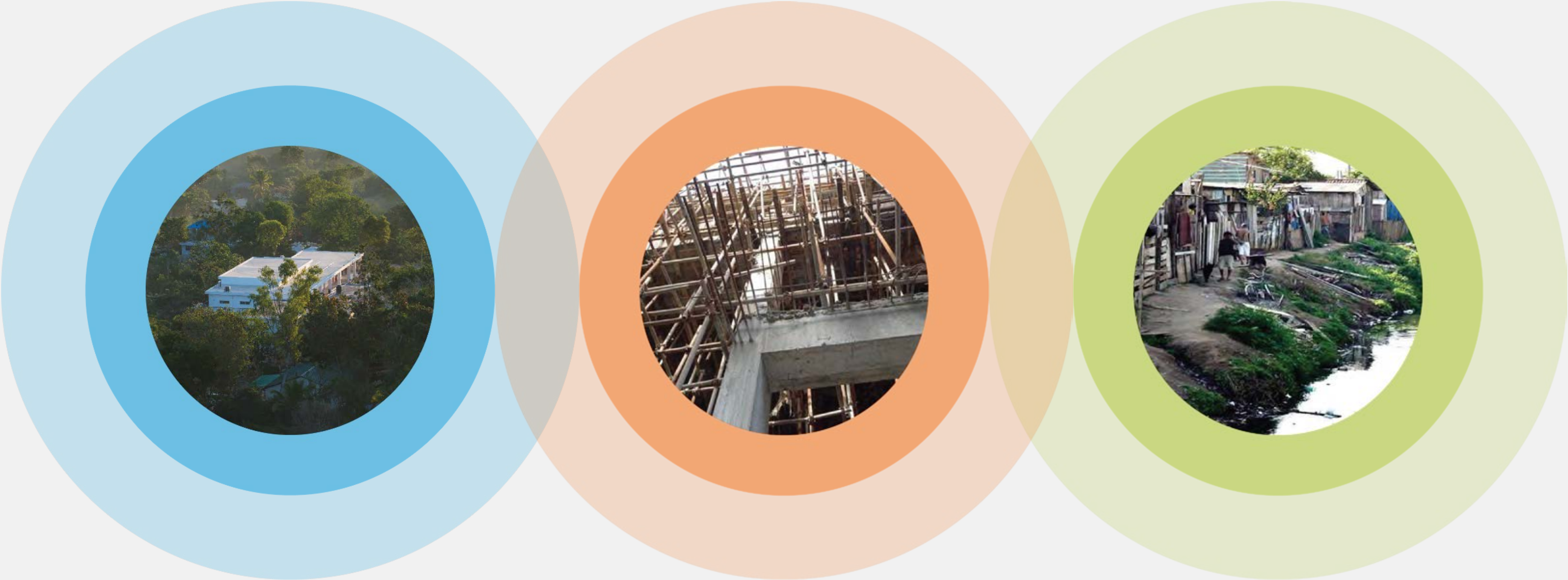
Resiliency

Resiliency





Resiliency



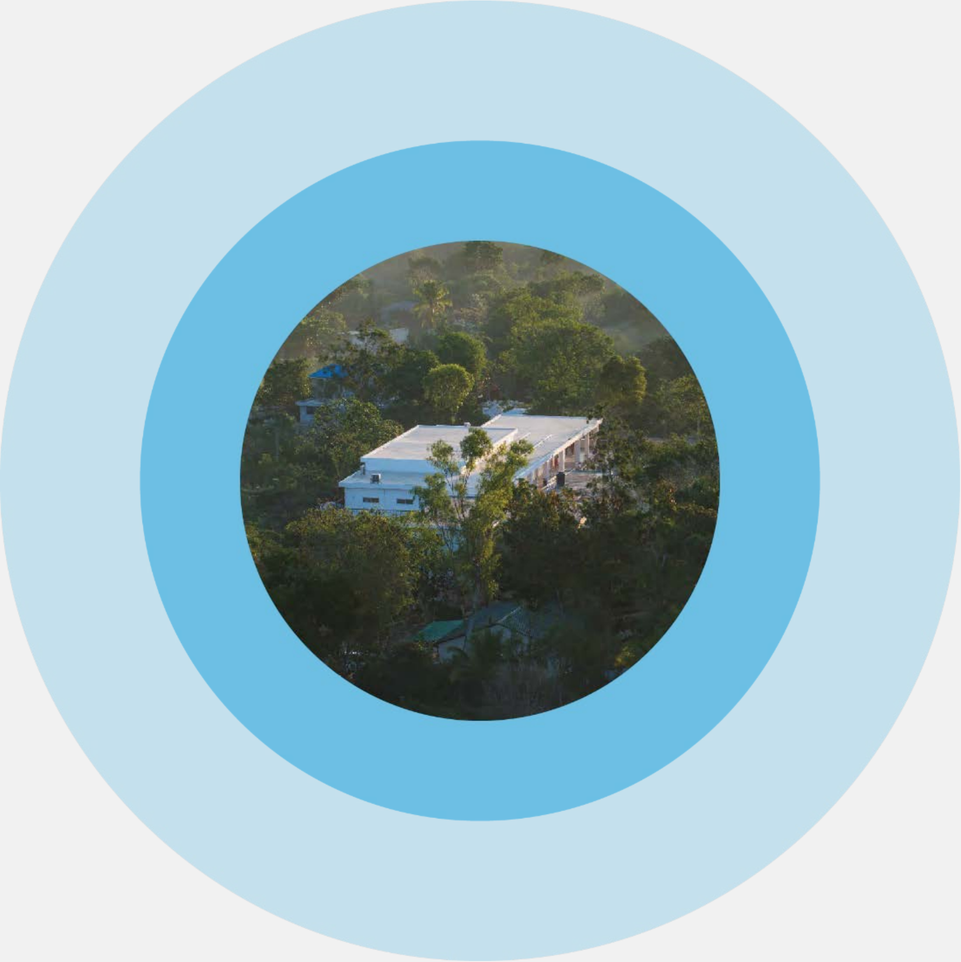
Resiliency

Architecture:
Ching Hua-Ho

Building Systems:
Pedro Sifre

Community + Planning:
James Kostaras

Resiliency: Architecture

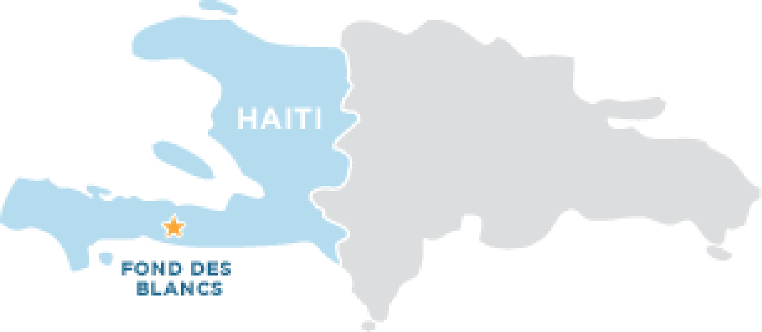


Challenges & Opportunities

Case Study 1

L'Hopital de St. Boniface, A New Maternity Ward
Fond des Blanc Haiti

St. Boniface Haiti Foundation



- **1983**- Started at the poorest parish in Quincy MA -built school and one room clinic in Fond des Blanc
- **1992-built** 20 bed hospital
- **2008**-added 40 more beds
- **2013**-new Spinal Cord Injury Rehab Center (only one in Haiti)
- **2014**-build new maternity addition


St. Boniface Haiti Foundation

Affordable Healthcare

Education & Training

Community Development

Working in Haiti | Realities

- Haiti- earthquakes, hurricanes, absences of government

- Remote locations
  - Absence of transportation
  - Bad or no roads
  - Poor access to resources

- No infrastructure systems
  - Water, electricity, sewage, site drainage
  - new projects have to provide its own system

- Lack of skilled labor-limited skill sets

- Rudimentary construction technology- equipment: no elevators

Enabling Projects

- Site enabling project-increase infrastructure capacity
- Electrical systems upgrades
- Site drainage
- Drilling additional well

Context & Existing Conditions



Context & Existing Conditions

Context & Existing Conditions




Context & Existing Conditions

Project Goals

- Create center of excellence for maternal & neonatal care for Haiti's southern peninsula

- Raise the standards: delivery of care and facilities for future campus growth

- Create a training center for community health and development activities

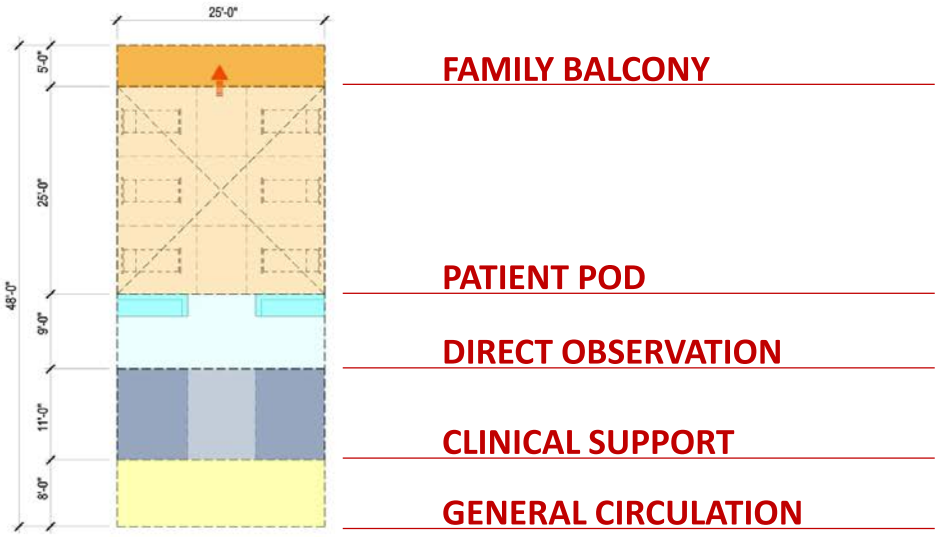




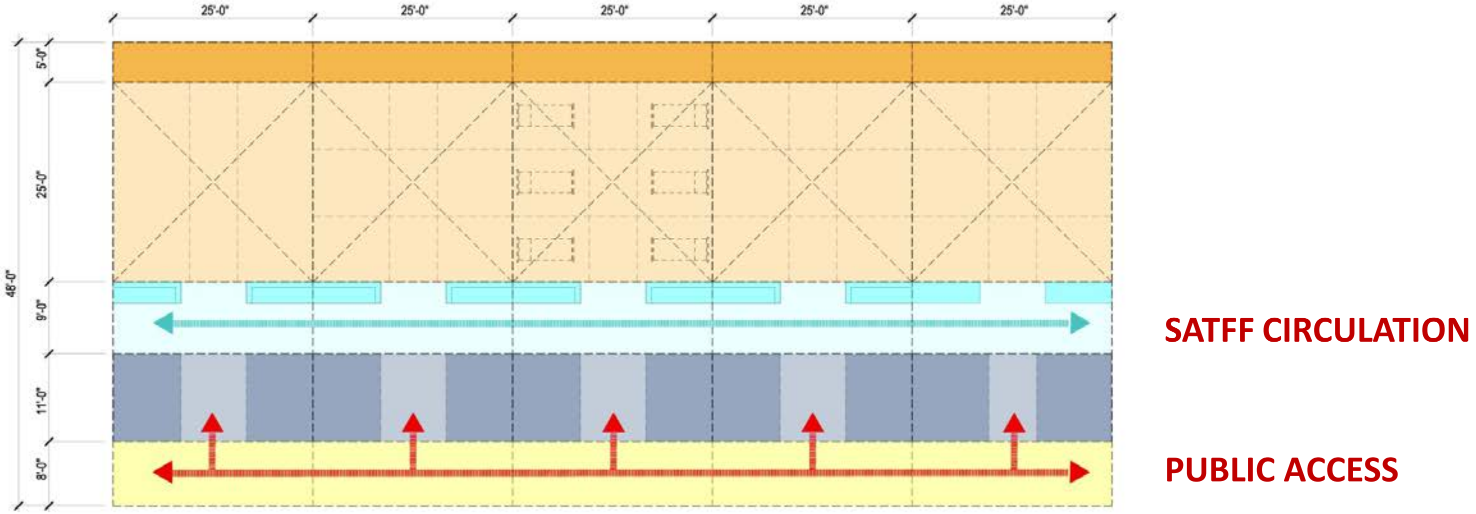
Project Approach

- Maximize local available resources materials, skill sets & technology
- Minimize imports –costly,delays in custom, local transport
- Ease of operations & maintenance: staff training, access to replacement
- Advisors who have delivered successfully in Haiti
- Look for donations

Universal Patient Unit



Universal Patient Unit



Unit Layout


NICU
WORK STATION
PATHOLOGY
WORK STATION
POST PARTUM
WORK STATION
L & D
EXAM
EXAM/ ULTRASOUND/ EKG
TRIAGE
SUB-WAITING
PATIENT/FAMILY WAITING
VITAL/ WEIGHT & HEIGHT
CHECK-IN
ARCHIVE
HOUSE-KEEPING
EXAM
MEDS ROOM
SUPPLY
MEDS ROOM
EQUIPMENT
SOILED UTILITY
MEDS ROOM

Natural Ventilation

Structural Design Challenges

HURRICANE

SEISMIC

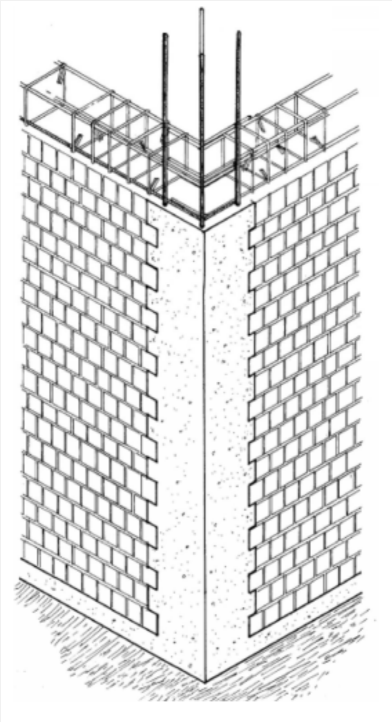
Design Wind
Boston: 110mph
St. Boniface: 145mph

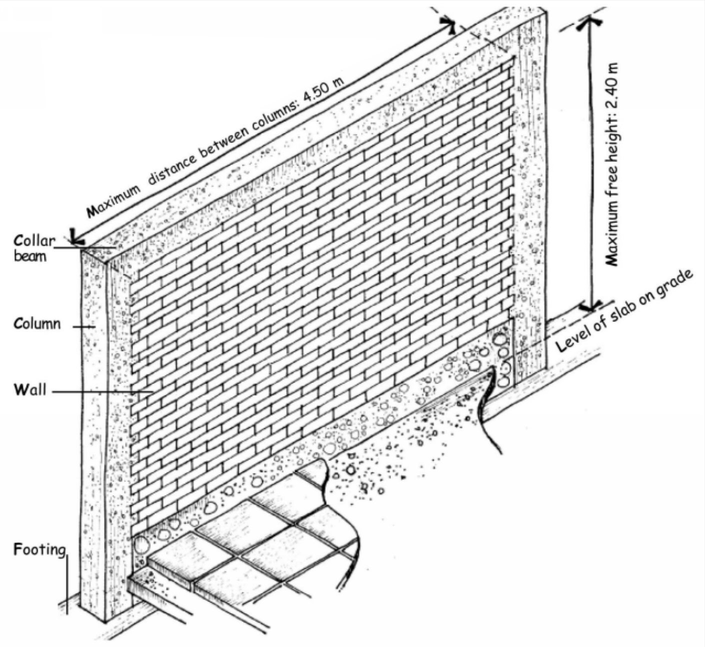
FORCE = +175%

Design Earthquake
Boston: 0.29%g
St. Boniface: 1.22%g

FORCE = +420%

Typical Construction

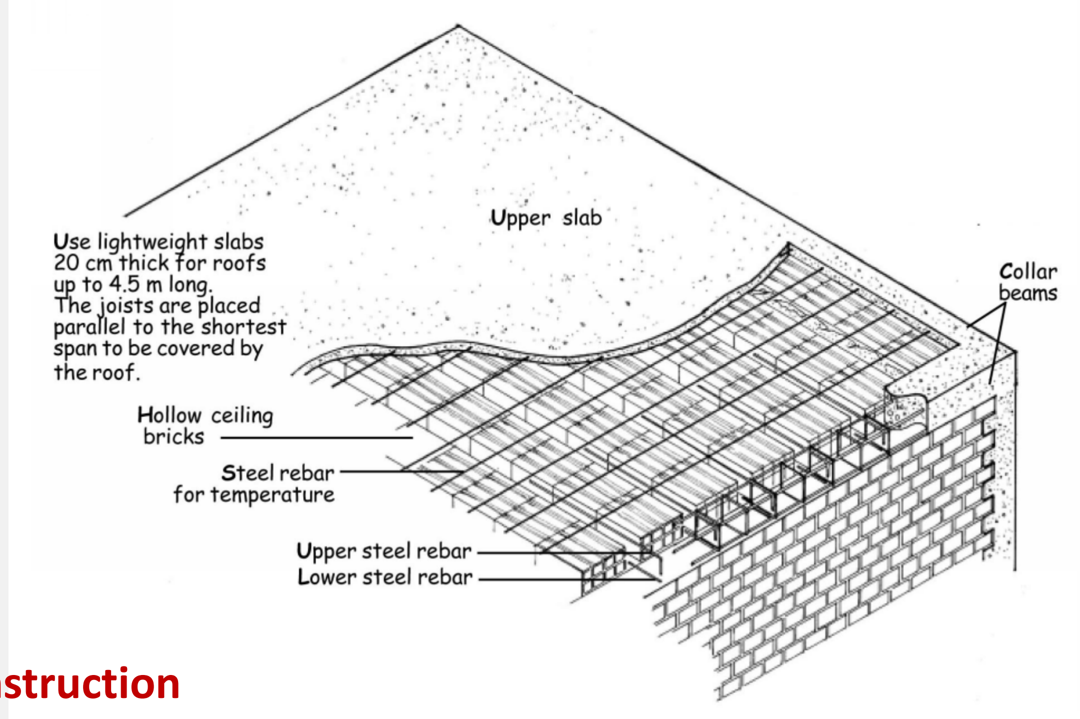




Vertical Construction

- Column Rebar Cage
- CMU Walls
- Infill Concrete Frame

Typical Construction



Horizontal Construction

- ‘Stick Built Formwork’ (no panelized systems)
- Concrete Infill Frame on CMU
- One-way Voided Slab

Case Study 2

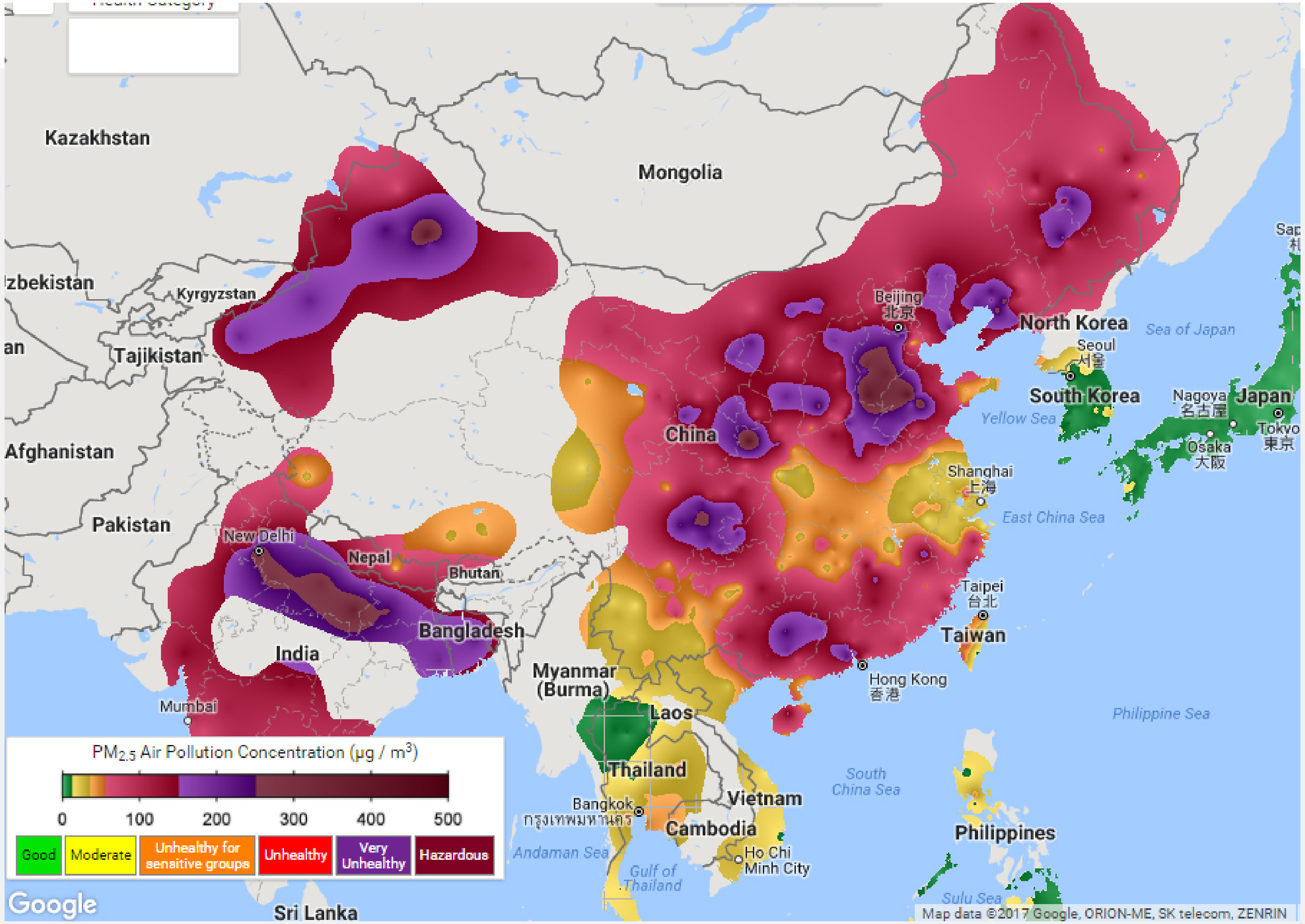
XiangYa Fifth Hospital 2500-Bed Hospital
Changsha Hunan China

Environmental Challenges in China

Air Pollution

Population growth

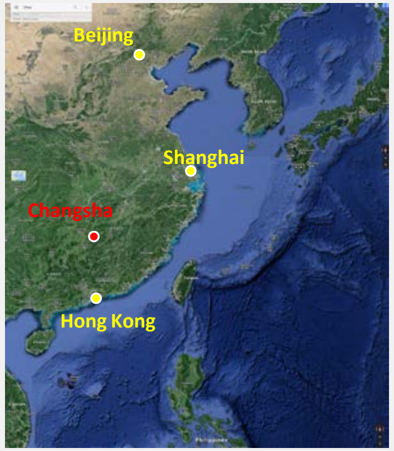
Energy Consumption



City of Changsha

Air Pollution:
Not as bad as Beijing, but worse than Shanghai & Guangzhou

Population: 7.432 M



XiangYa Hospital

Established by Yale-China Association, one of the earliest western hospital in China.

Xiangya 1st Hospital
Xiangya 2nd Hospital
Xiangya 3rd Hospital
Xiangya 5th Hospital
Xiangya Dental Hospital
Xiangya Tumor Hospital

Current: **11,000 Beds**

Expansion: **13,500 Beds**

Size & Volume

Site **155,000 SM**

Floor Areas **60,280,00SM**

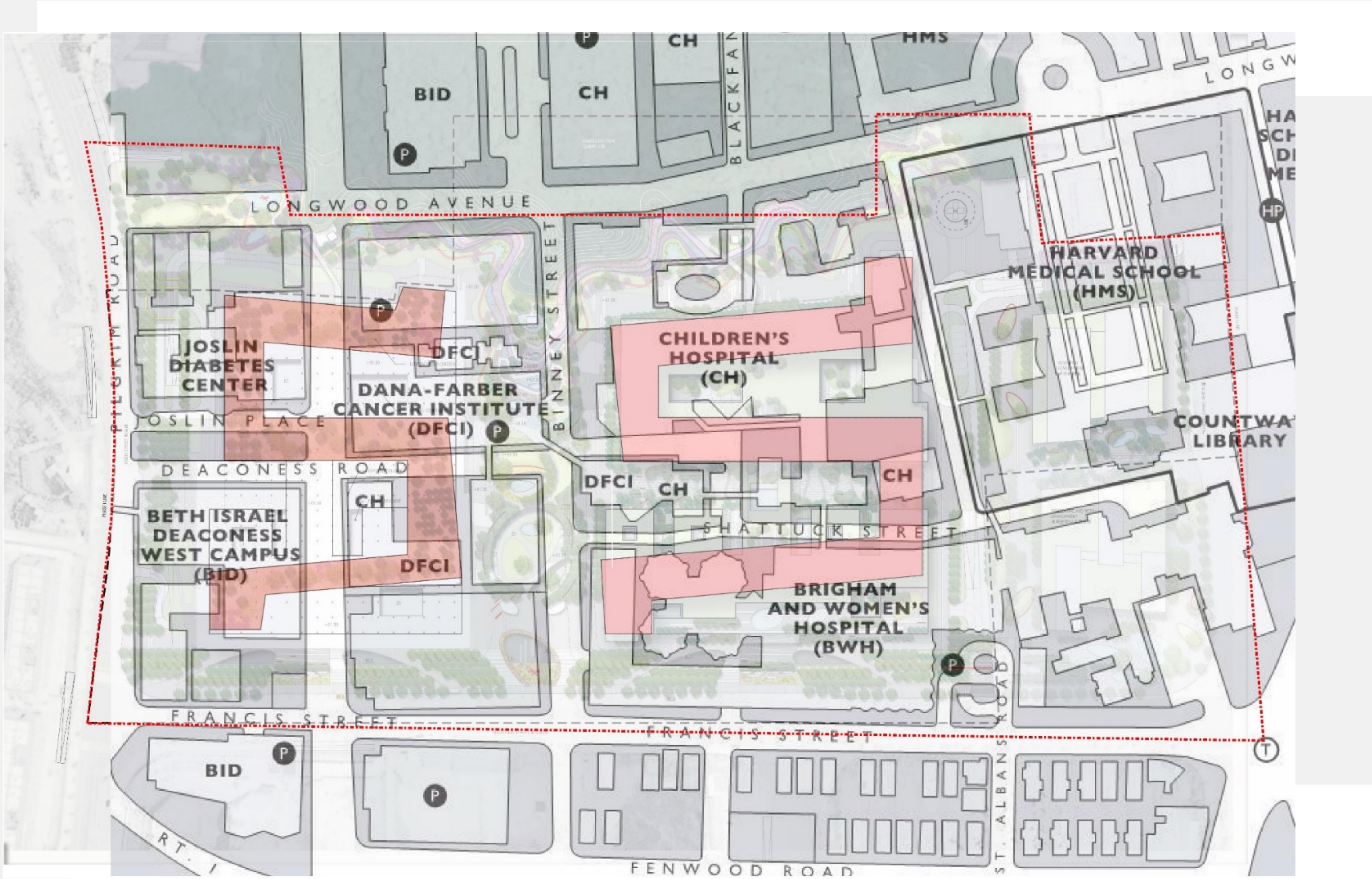
Inpatient **2500 Beds**

Inpatient Visitors **10,000+**

Outpatient Centers **12**

Outpatient Volume **10,000+**

ORs **50**

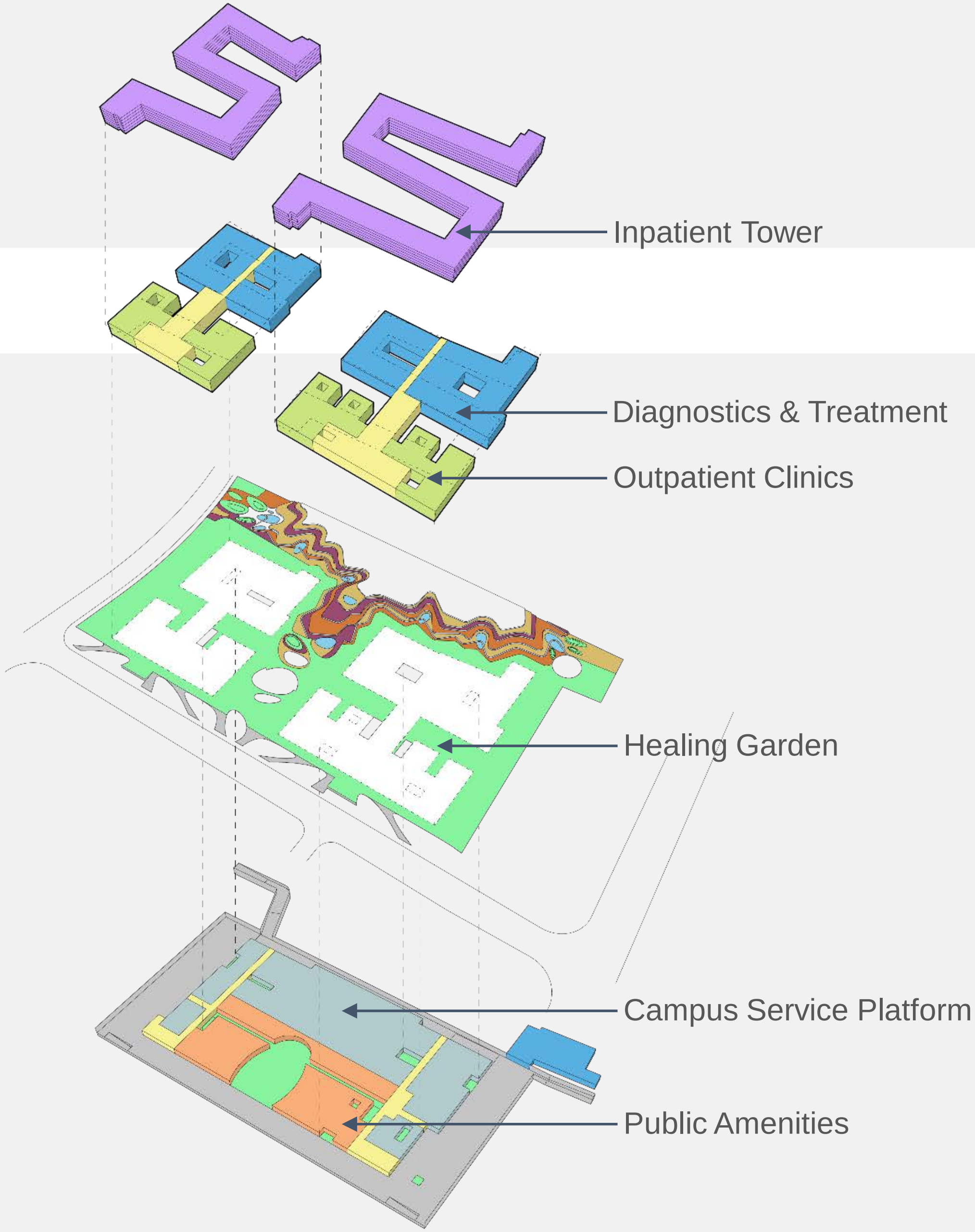


Project Design Guiding Principles

- **An Eco-Hospital in a Garden**
- A patient-Centered Hospital
- A Machine for Healing
- **A High Performance Building**
- A Smart Hospital

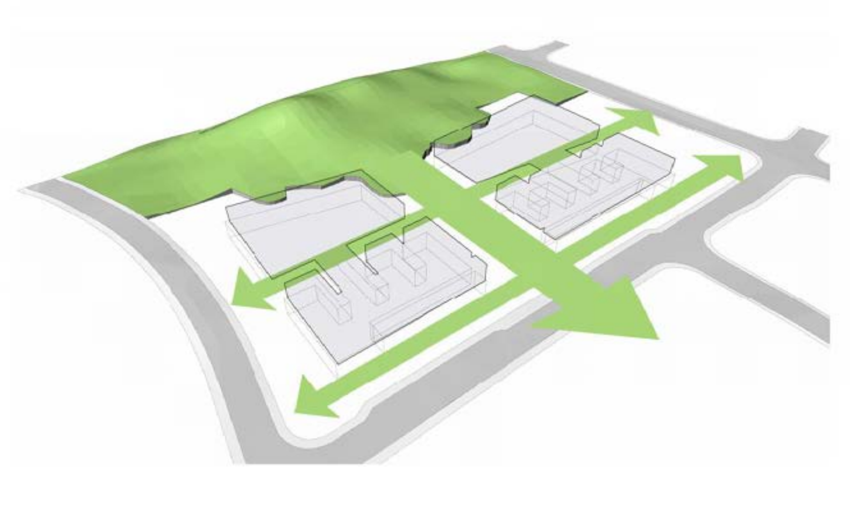
Project Approach

- Integrate Healing Mountain with Healing Park.
- Maximize the Utilization of Natural Resource
  _ Daylight, Rainwater & Solar Energy
- Provide High Efficiency Energy Production
- Reduce Energy Usage
- Design a High-Performance Building Envelope

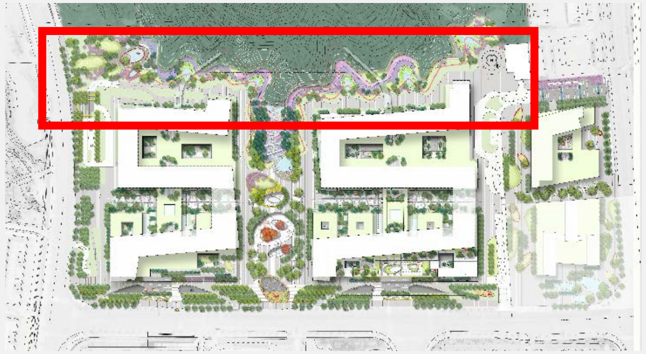


Growing Fresh Air

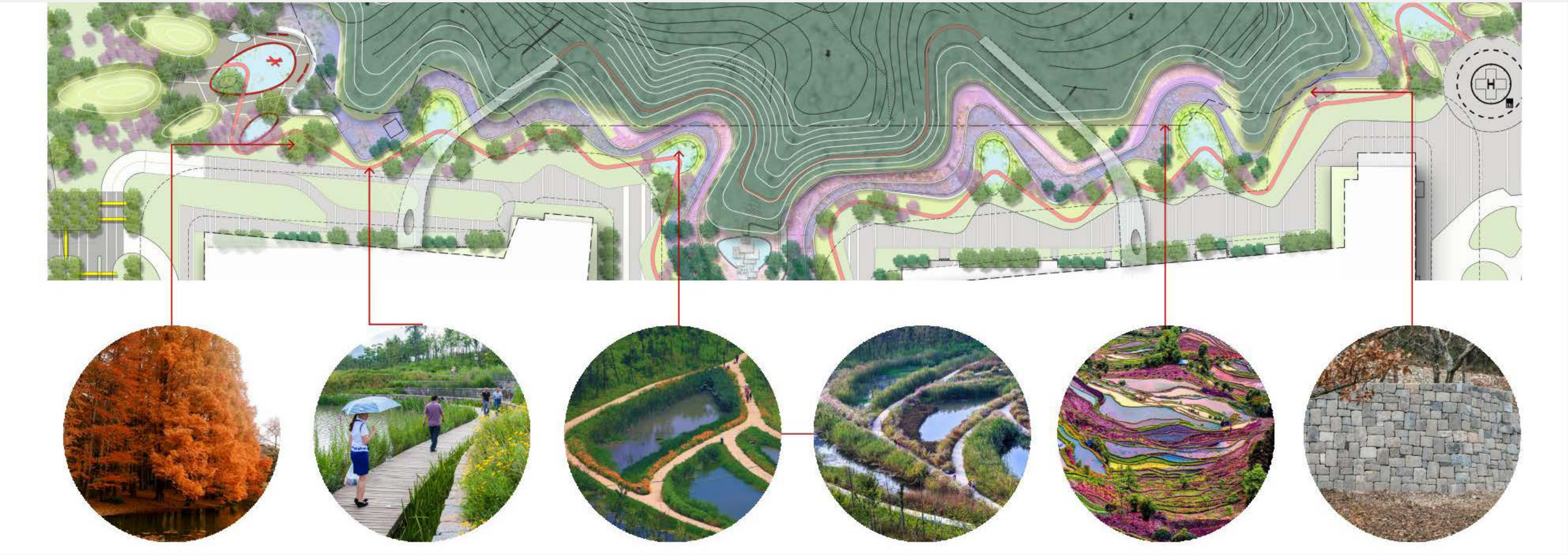
Integrate Healing Mountain with Healing Park.



Stormwater Edge Park

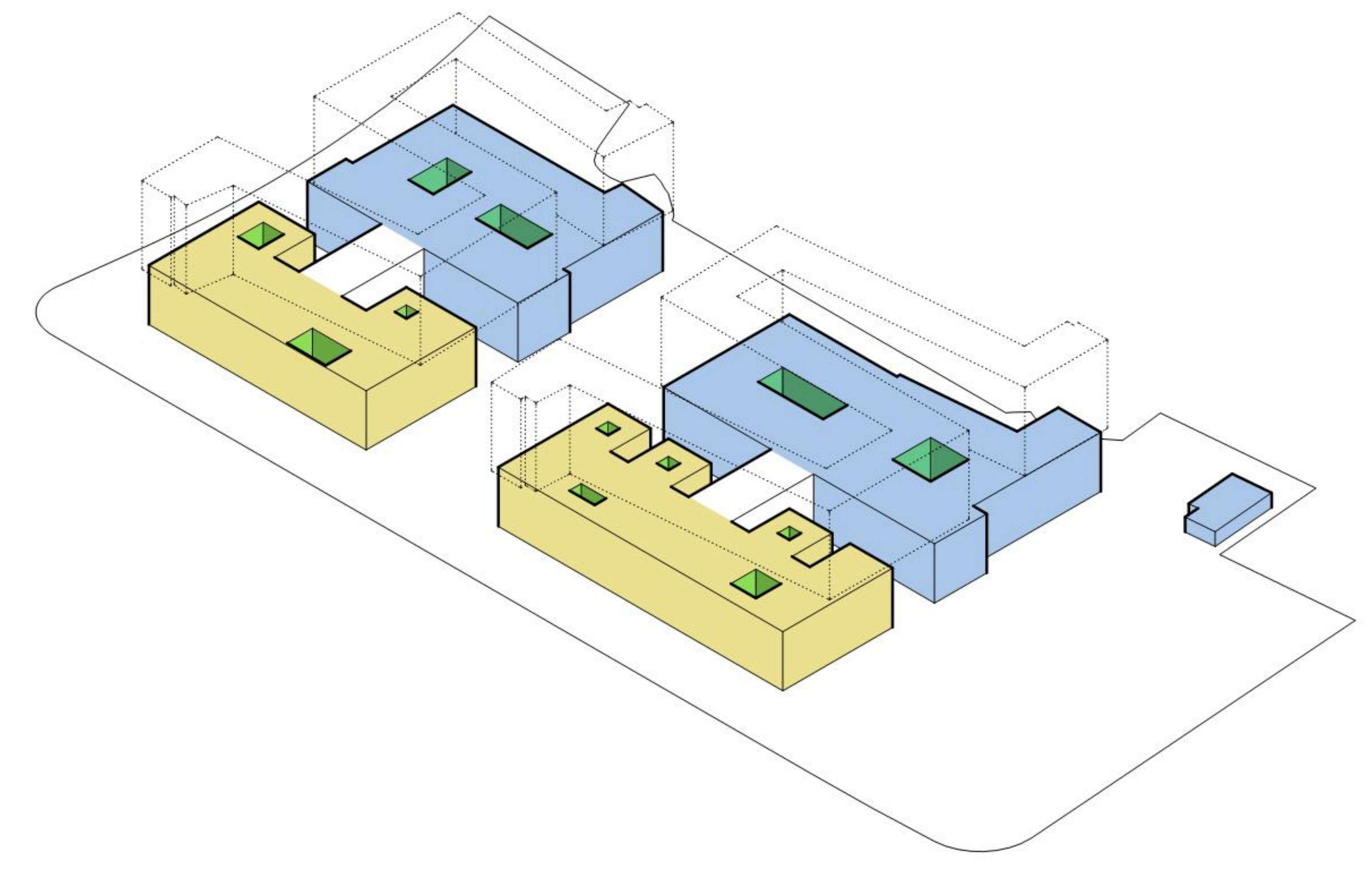


Perform an important ecological function in capturing and retaining the healing water from the mountain.



Natural Daylight & Ventilation

Increase the length of exterior envelopes and maximize numbers of internal courtyards to provide exterior windows to all outpatient exam/treatment, inpatient rooms and staff support.



Natural Daylight & Ventilation

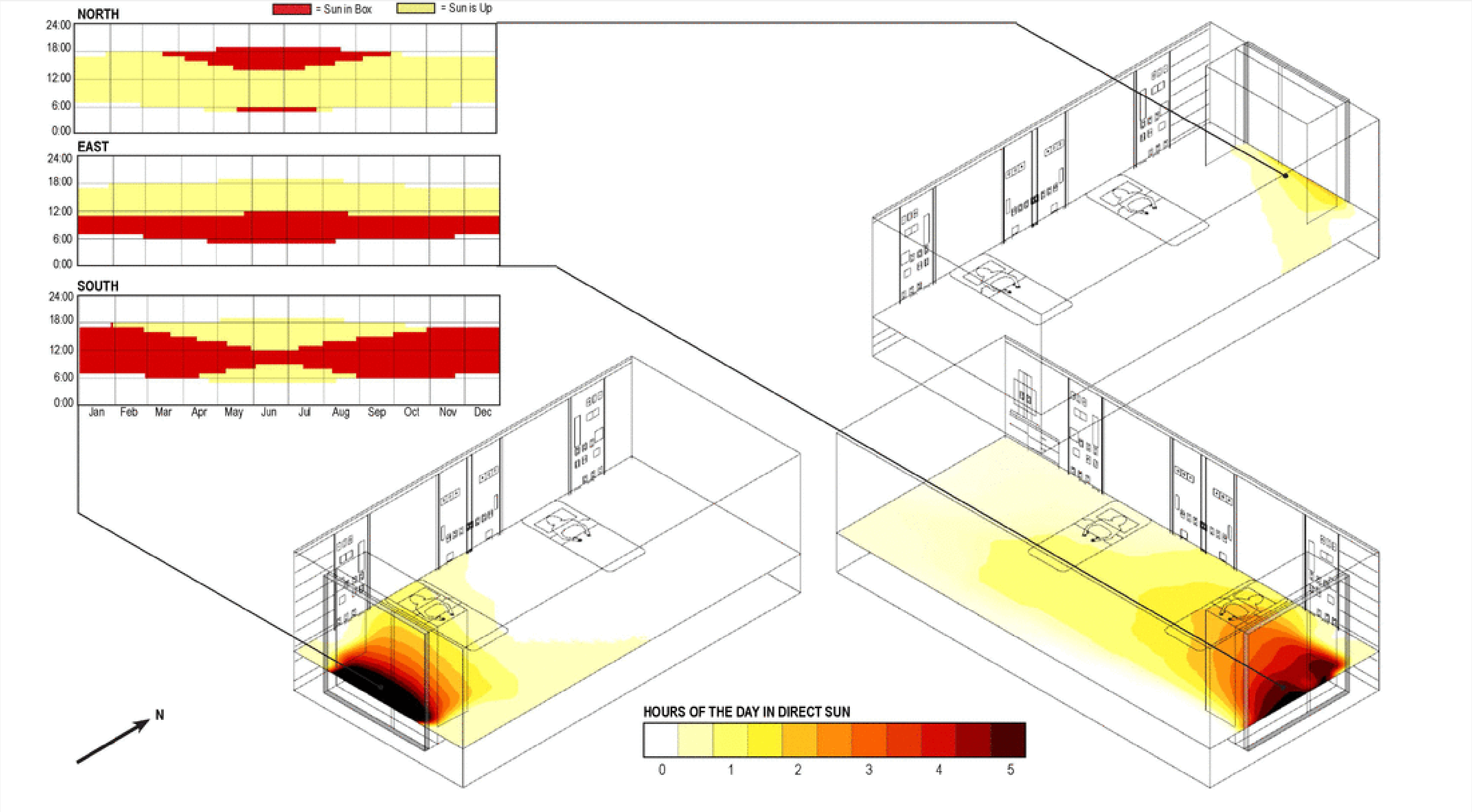
Operable windows in all patient rooms

Inpatient Unit

High Performance Building Envelope

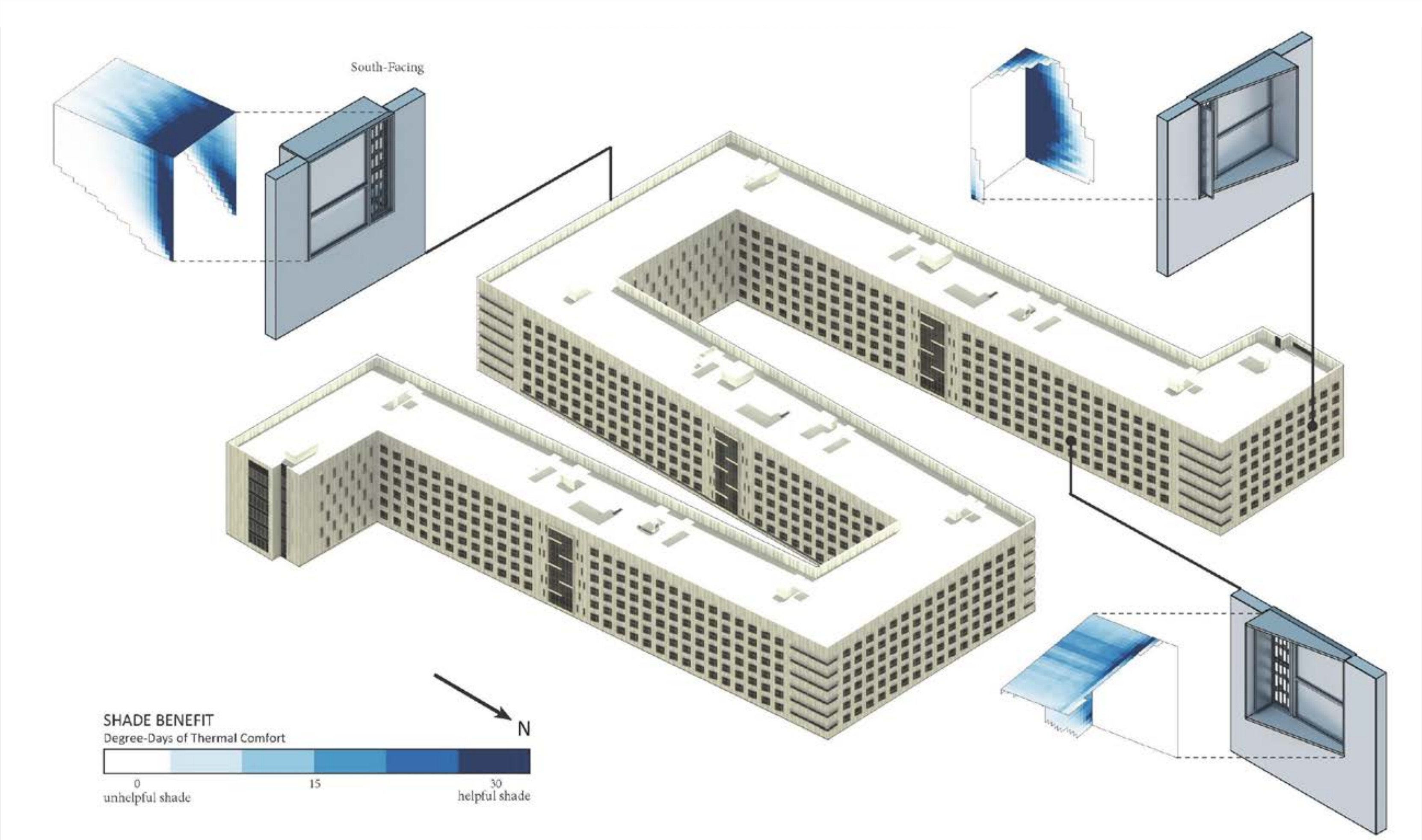
Building Science

Direct Sun Blocked by the Shade



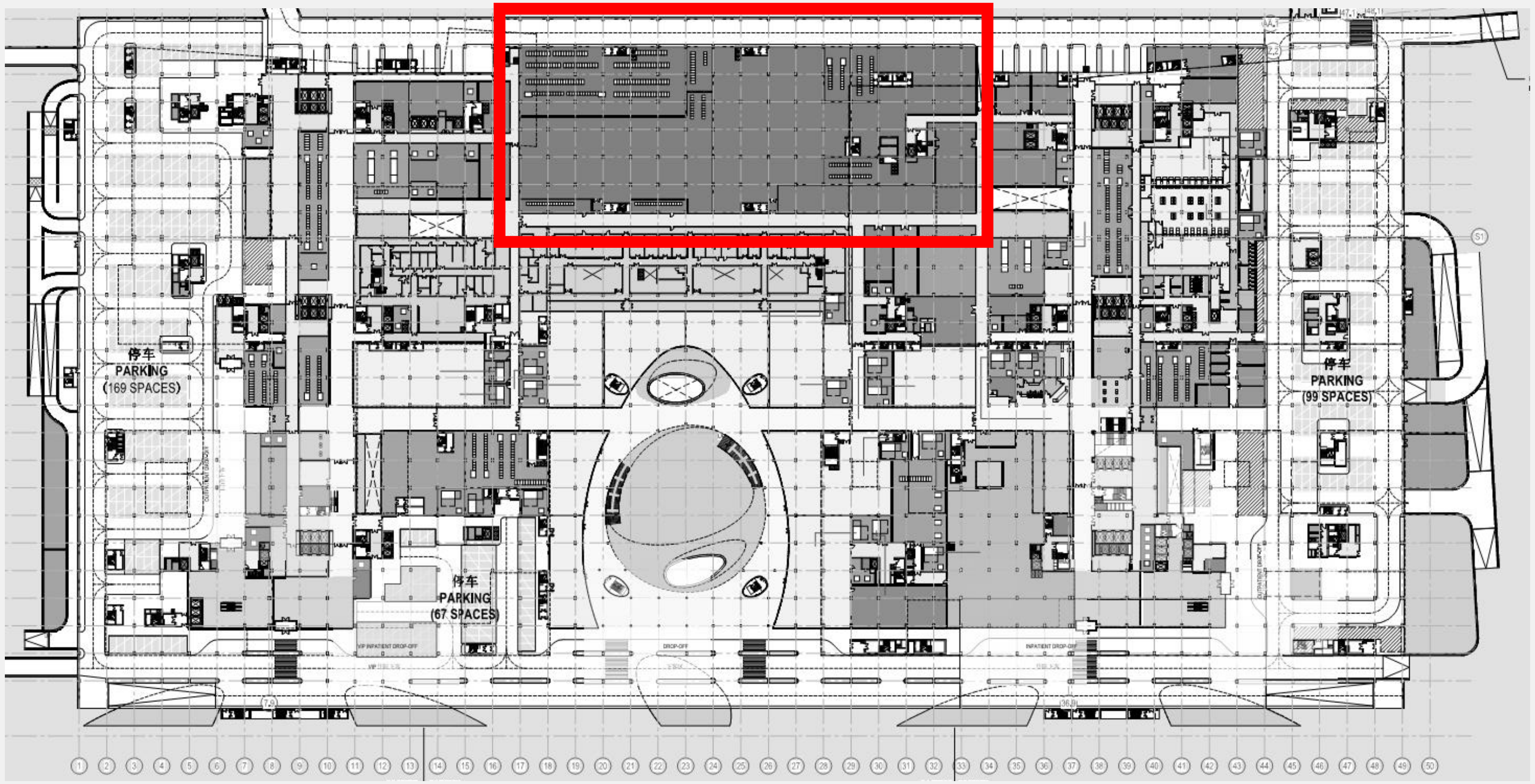
Building Science

Shade Benefit



Trigeneration Power Plant

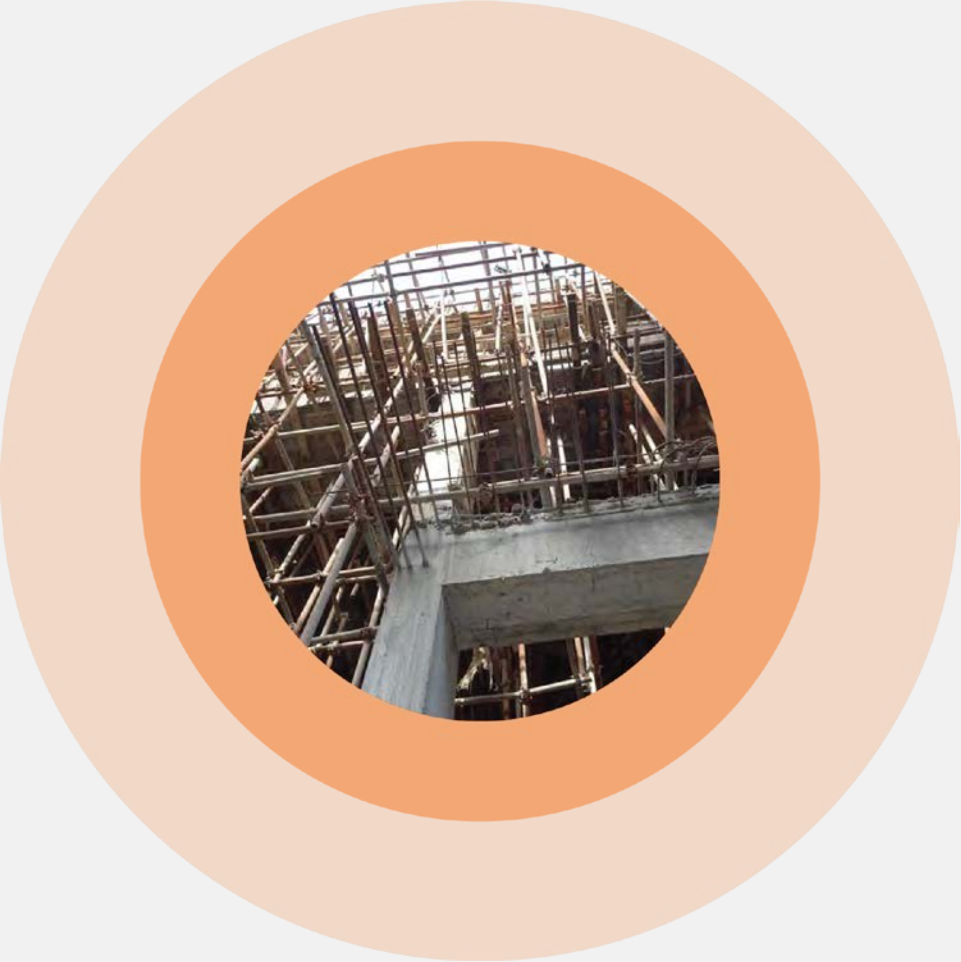
- High efficiency production of electrical and heat
- Reduced fuel and energy coats
- Significant reductions in greenhouse gas emissions



Targeted Completion 2019

Ultimate Goal: “Bring back the Blue Skies”

Resiliency: Building Systems



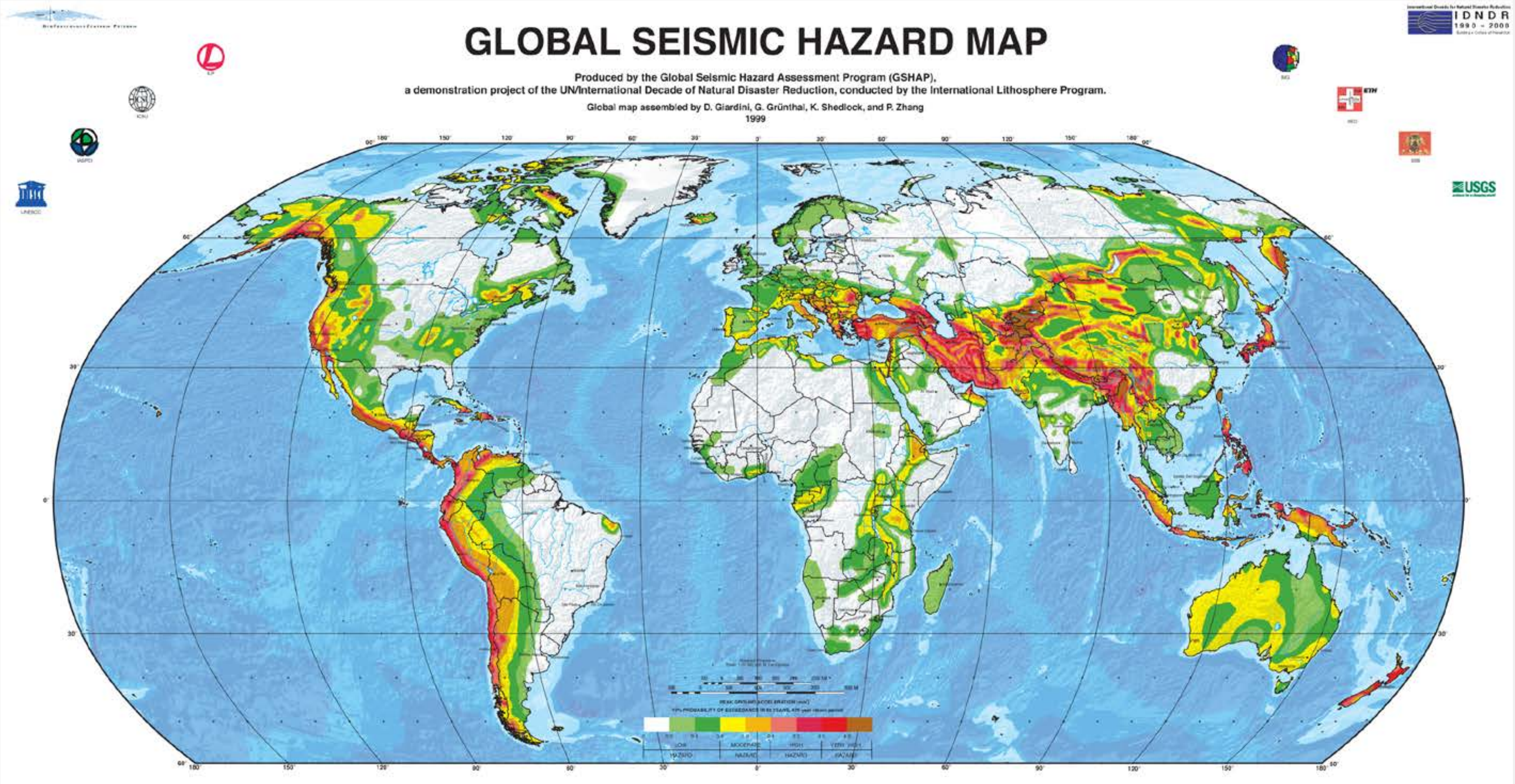
Problem:

Prevalent use of unreinforced masonry partitions.

Unreinforced masonry is fragile.

Masonry is heavy and brittle → heavier buildings.

Seismic Risk – Developing World



The Global Seismic Hazard Assessment Program (GSHAP) was launched in 1992 by the International Lithosphere Program (ILP) with the support of the International Council of Scientific Unions (ICSU), and endorsed as a demonstration program in the framework of the United Nations International Decade for Natural Disaster Reduction (UN/IDNDR). The GSHAP project terminated in 1999. All GSHAP products and maps are available freely and are not covered by copyright, provided that the source is cited.

Intensity vs Fragility

Modified Mercalli Intensity Scale: Measure of intensity of ground shaking.

1906 San Francisco, CA:	**MMI VIII - XI**
1994 Northridge, CA :	**MMI IX**
2011 Mineral, VA :	**MMI V – VII**
2016 Central Italy Swarm:	**MMI VI – IX**

Range: V to XI

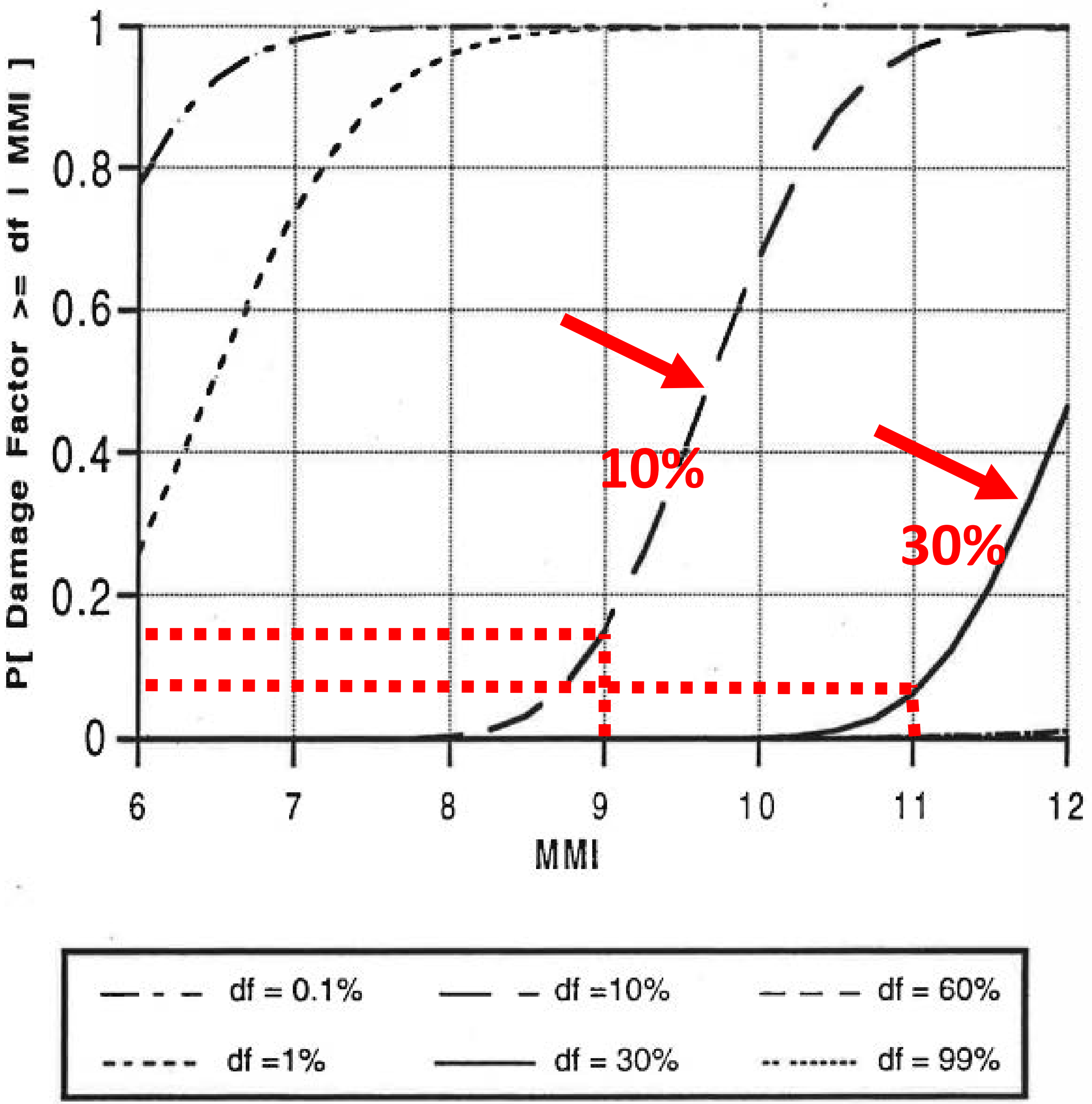
Fragility

- **Opposite of robustness.**

- **Given an overload, what is the expected damage in the real world?**

Fragility

Generic Steel Frame

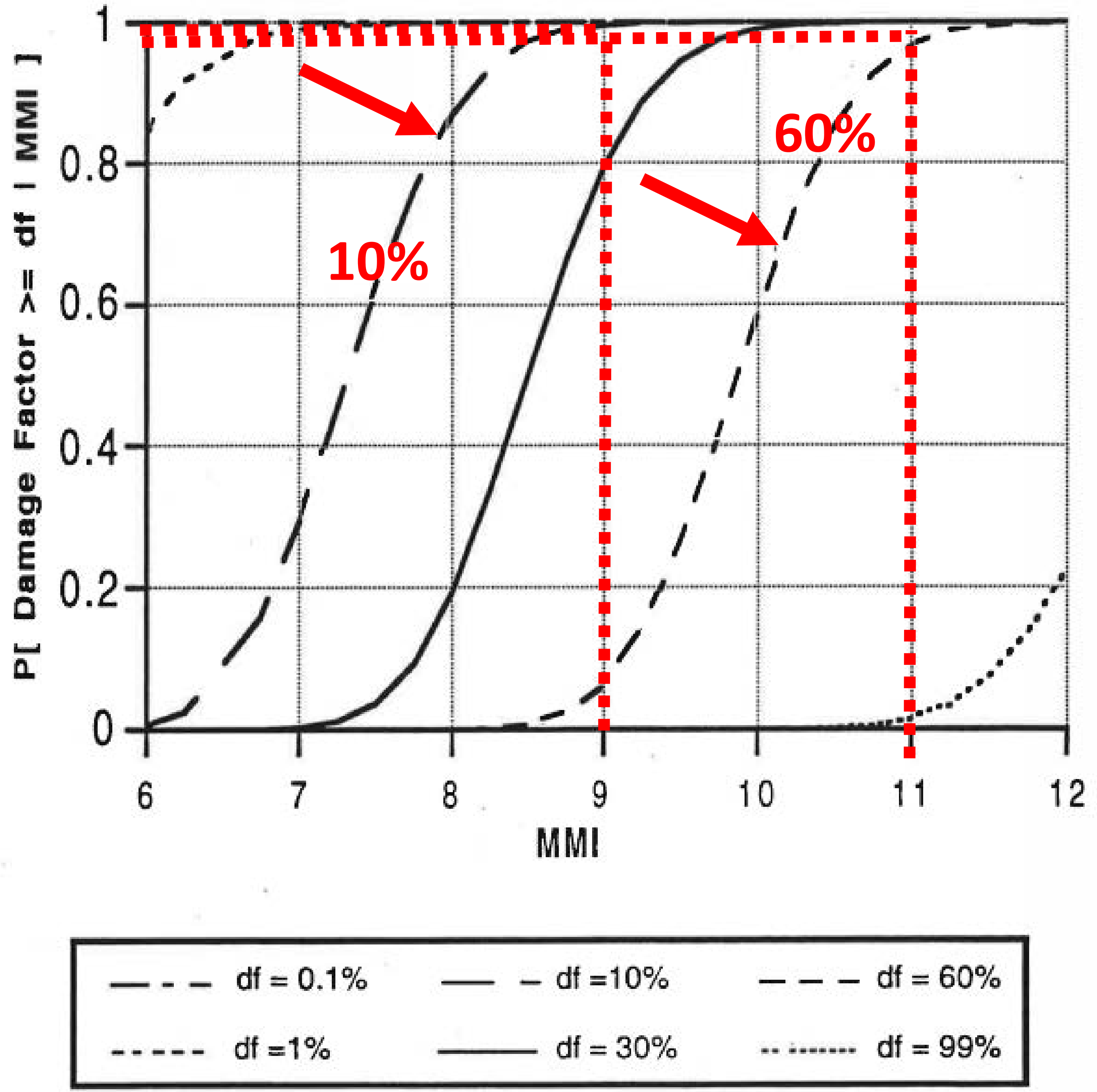


T. Anagnos, C. Rojahn and A.S. Kiremidjian, NCEER-ATC Joint Study on Fragility of Buildings, Tech.Rep. NCEER-95-0003, Jan. 20, 1995

Fragility

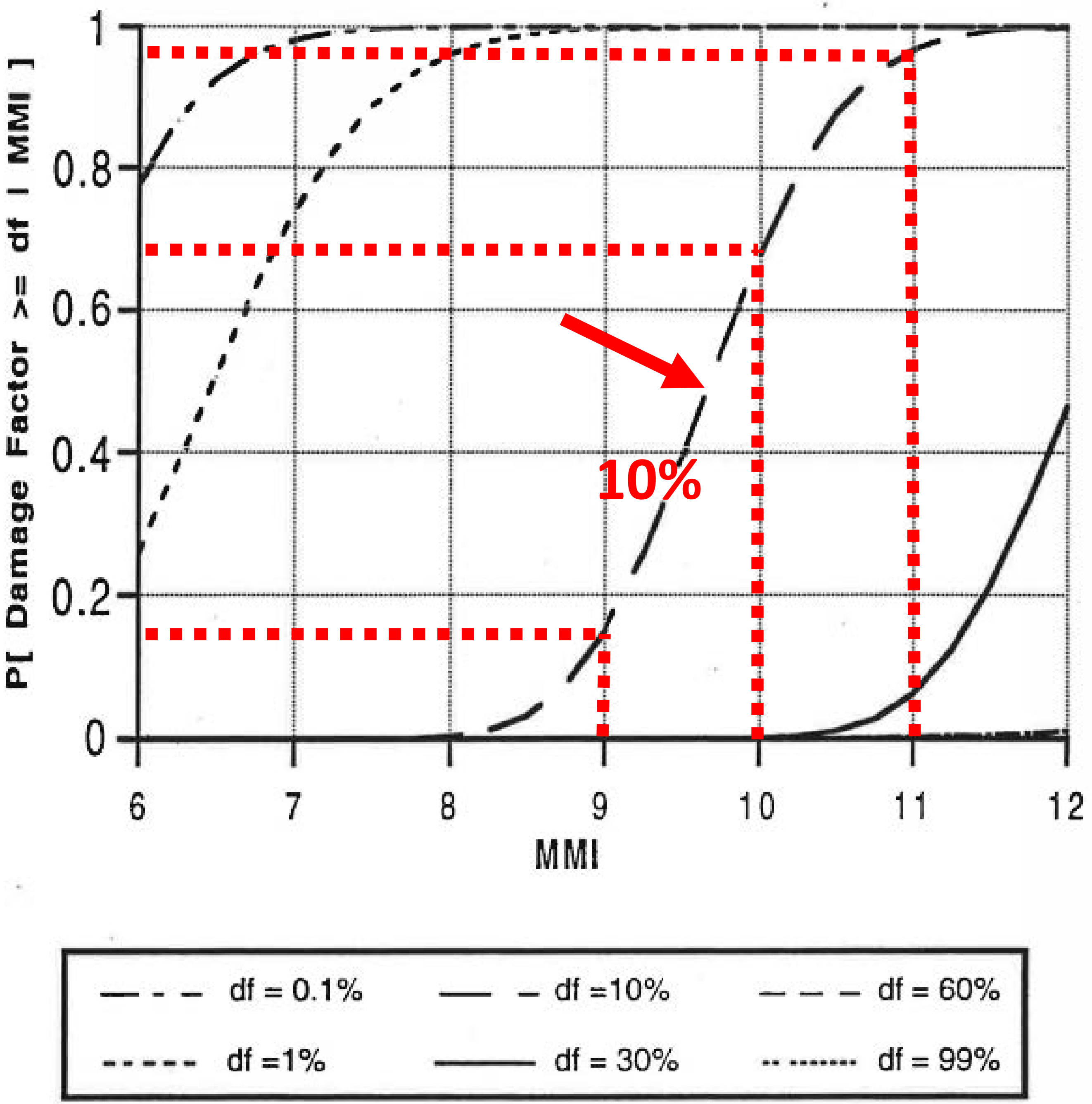
Masonry Wall

T. Anagnos, C. Rojahn and A.S. Kiremidjian, NCEER-ATC Joint Study on Fragility of Buildings, Tech.Rep. NCEER-95-0003, Jan. 20, 1995



Fragility

Generic Steel Frame



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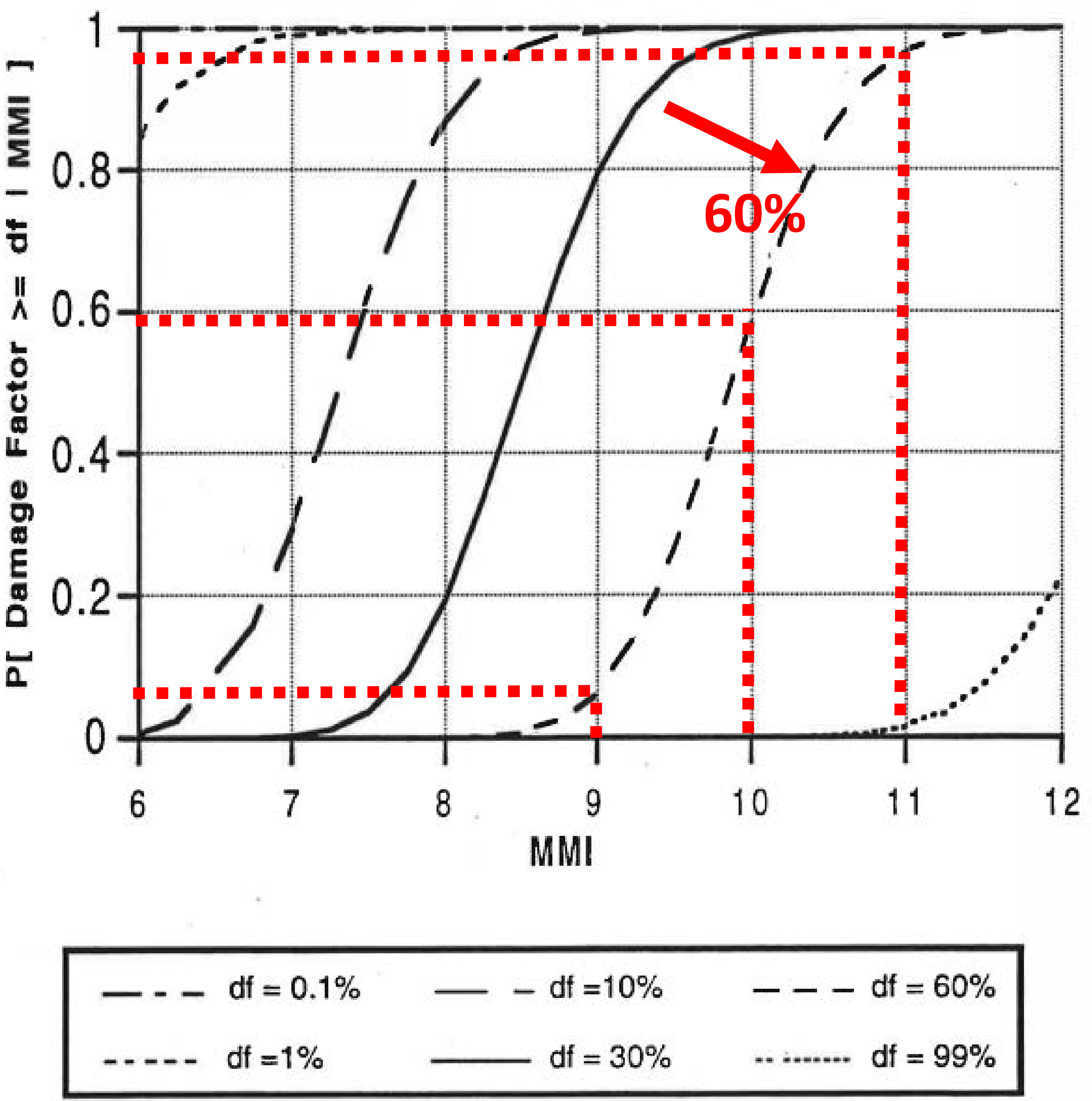
Fragility

Masonry Wall



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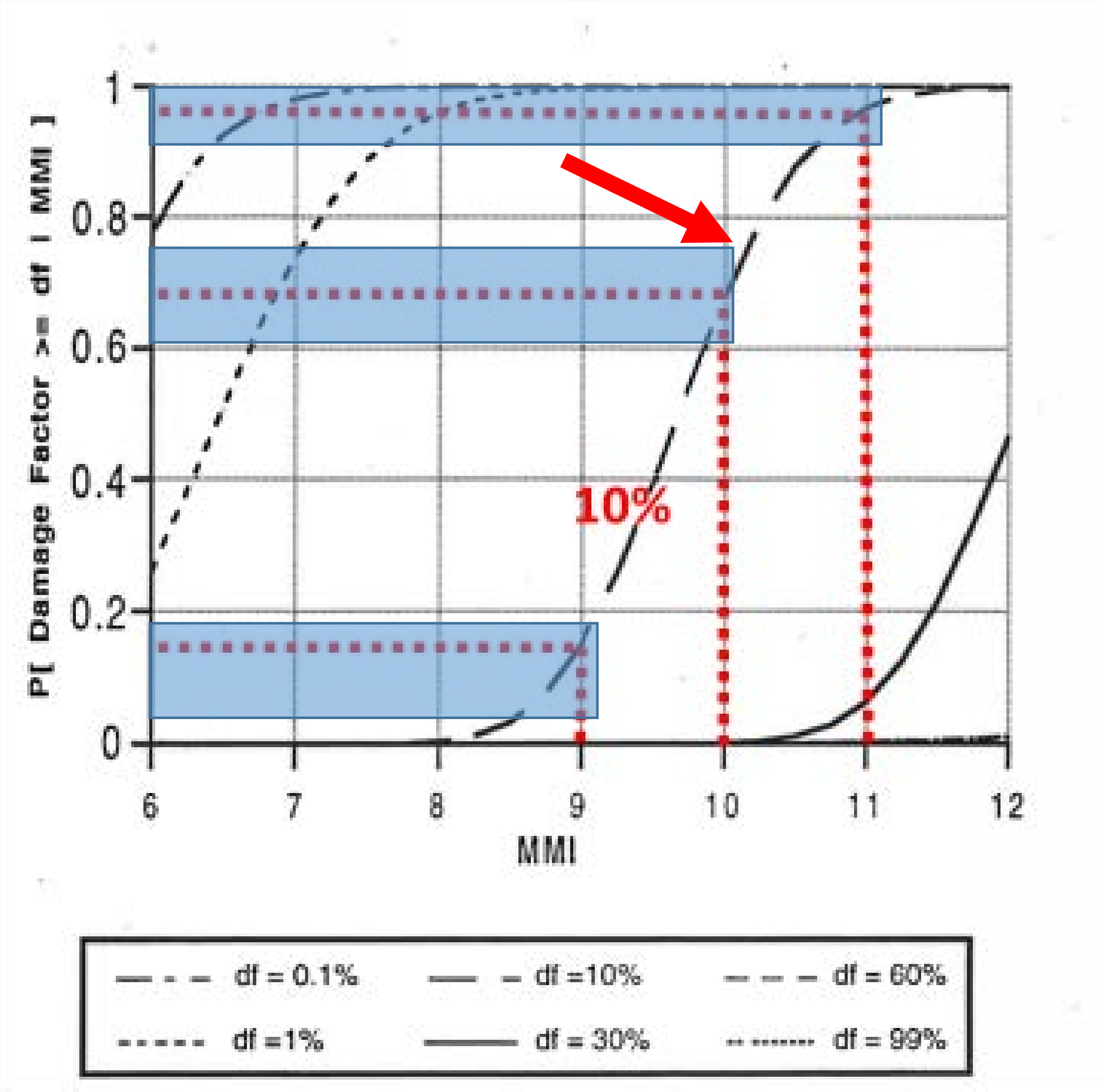
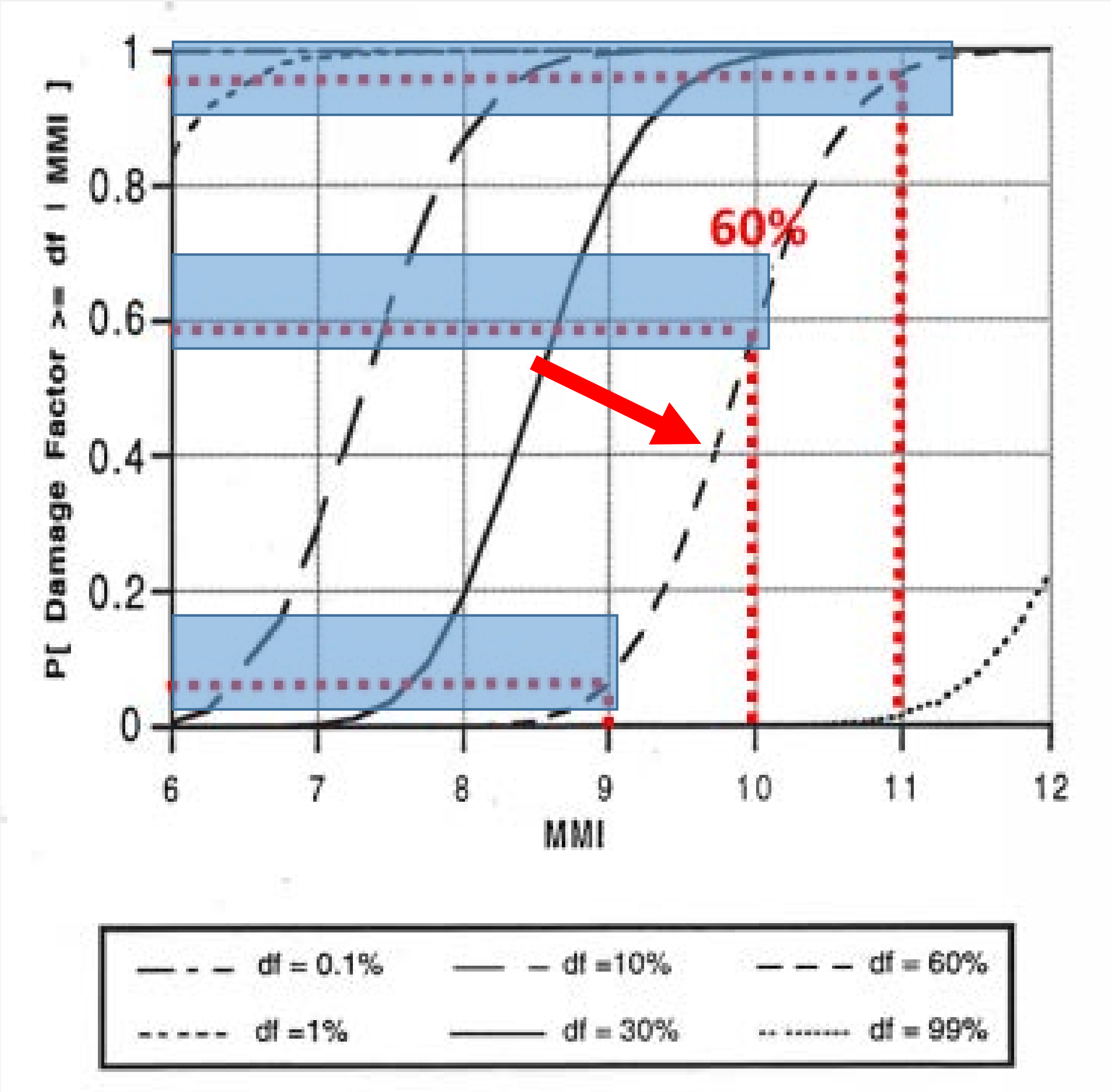


Steel



Masonry

60% ?   - 2016 Central Italy EQ Swarm

2016 Central Italy Swarm EERI Learning from Earthquakes Galley: Somatti
http://www.eqclearinghouse.org/map/photos/f5482d4b-777e-474c-a75c-0bfb91a0da9b.jpg

2016 Central Italy Swarm EERI Learning from Earthquakes Galley: Pescara del Tronto
http://www.eqclearinghouse.org/map/photos/0ad6be29-1c86-4083-8ca1-97e9fe9eb8af.jpg

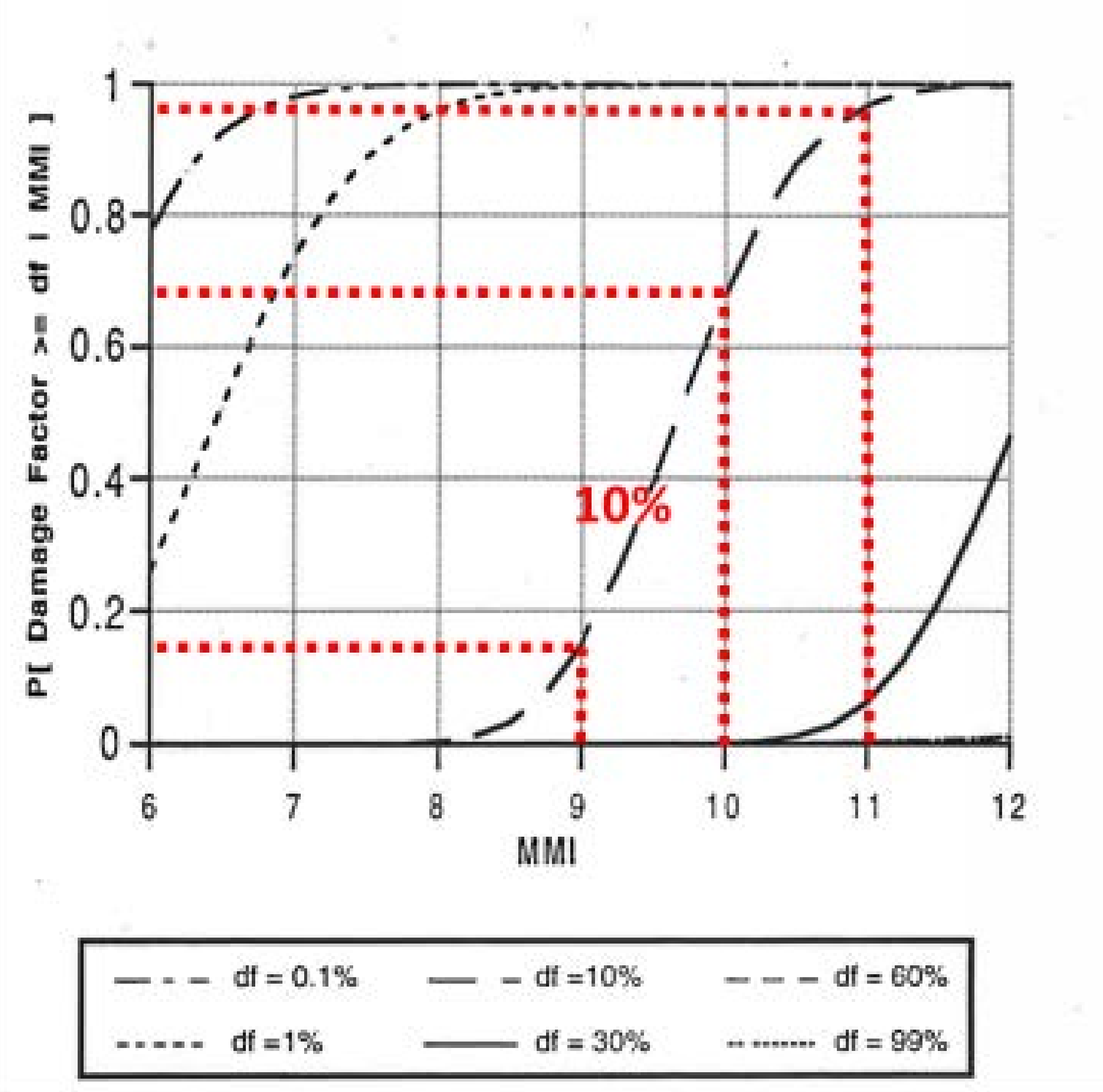
2011 Mineral, VA
Louisa County HS

MMI = V to VII

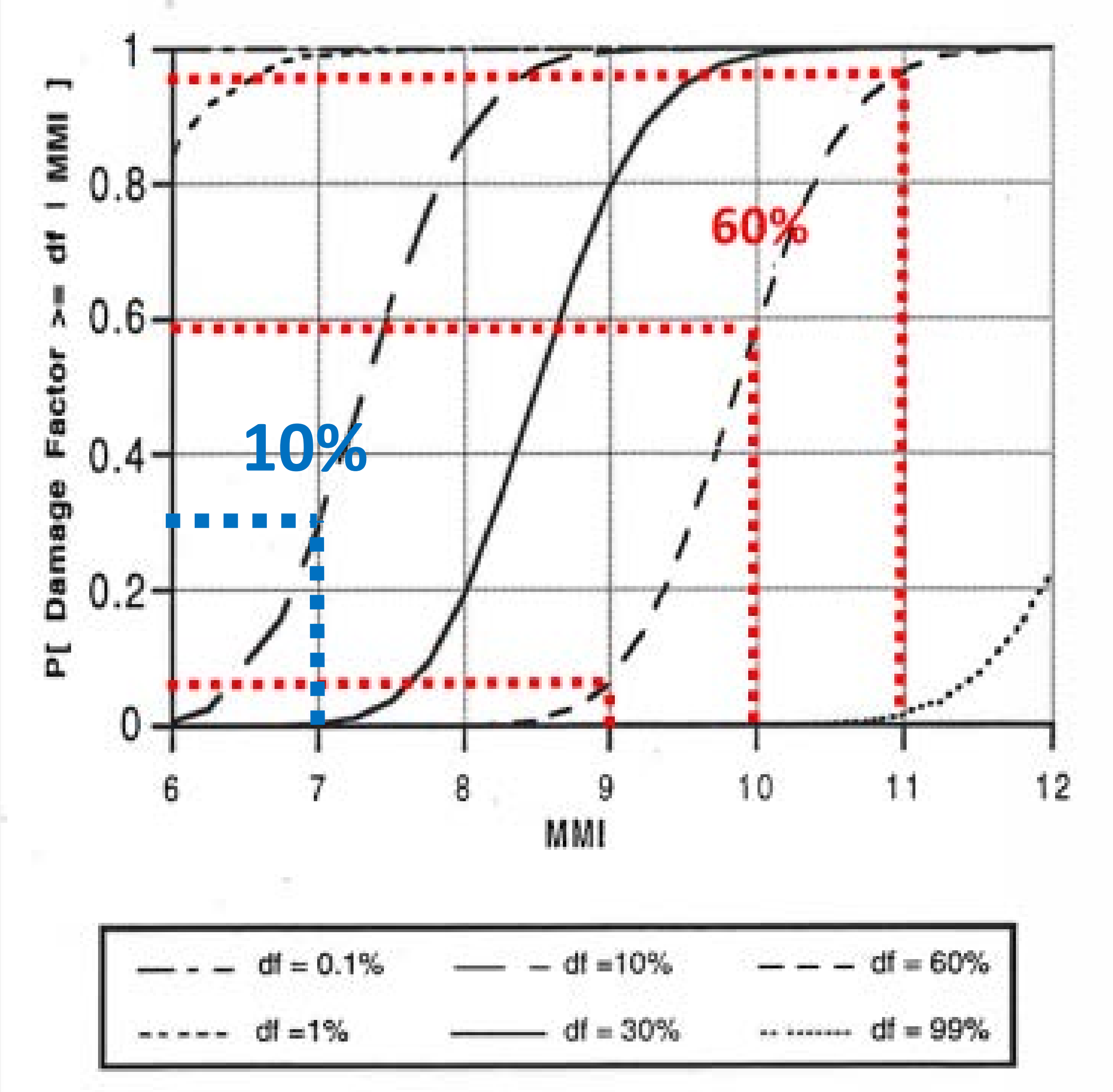
2011 Mineral, VA EERI Learning from Earthquakes Gallery: http://www.eqclearinghouse.org/2011-08-23-virginia/files/2011/09/SAM_8444.jpg

2011 Mineral, VA EERI Learning from Earthquakes Galley: http://www.eqclearinghouse.org/2011-08-23-virginia/files/2011/09/SAM_8494.jpg

2011 Mineral, VA EERI Learning from Earthquakes Galley:http://www.eqclearinghouse.org/20
08-23-virginia/files/2011/09/SAM_8483.jpg



Steel



Masonry

2011 Mineral, VA
Louisa County HS

MMI = VI to VII

2011 Mineral, VA EERI Learning from Earthquakes Gallery: http://www.eqclearinghouse.org/2011-08-23-virginia/files/2011/09/SAM_8444.jpg

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2011 Mineral, VA EERI Learning from Earthquakes Galley:http://www.eqclearinghouse.org/20
08-23-virginia/files/2011/09/SAM_8483.jpg

Photo: https://www.usatoday.com/story/news/nation/2012/11/06/earthquake-virginia-east-coast-geological-survey/1686693/

Secondary Hazards: Blocked Egress Paths

Central Bank Building. Managua Nicaragua, 1972 – FEMA E-74 Reducing the Risks of Nonstructural Earthquake Damage – A Practical Guide, Jan. 2011

Secondary Hazards: Rupture of Plumbing, Electrical, and Fire Protection Lines

Photos: SGH

Impact on Design

Masonry Partitions Are:

Heavier → Heavier Frame

Photos: SGH

Design codes require stiffer framing for masonry partitions:

General Live Load Deflection ≤ SPAN/360

Deflections that affect masonry ≤ SPAN/480

……33 % stiffer

Masonry Partitions Are:

Brittle → Stiffer Floors → Heavier Slabs → Heavier Frame

Photo: SGH

Masonry Partitions are:

Heavier → Higher Seismic Loads → Heavier LLRS (e.g. shear walls)

Photos: SGH

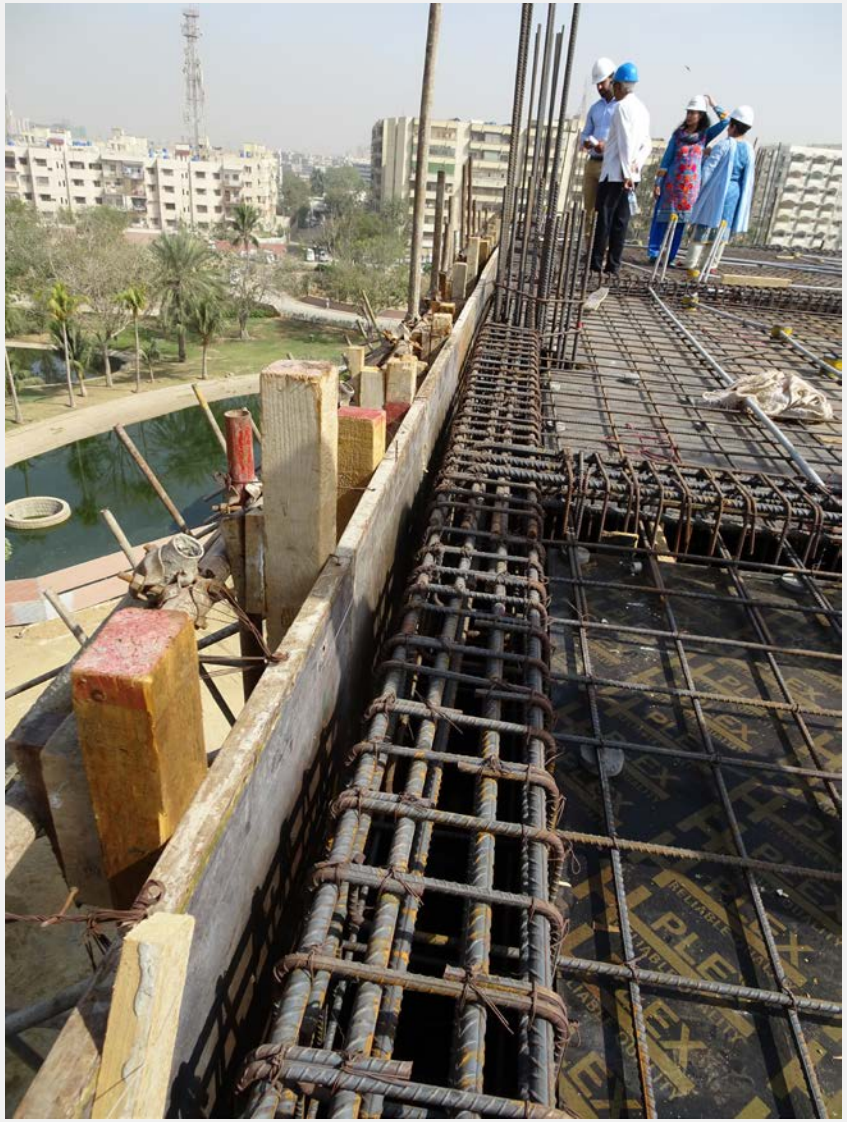
Heavier Foundations

Photos: SGH

Heavier/More Falsework

Photos: SGH

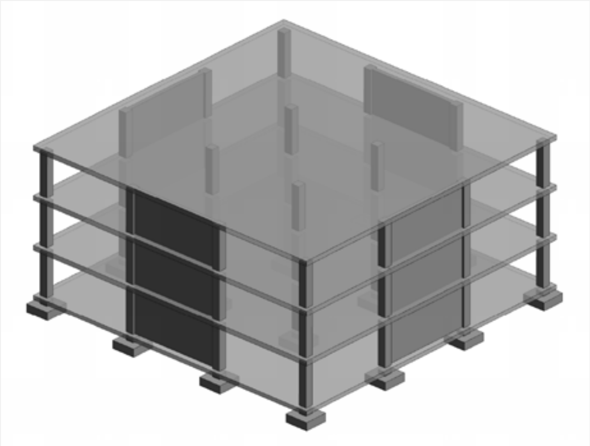
Heavier Reinforcement

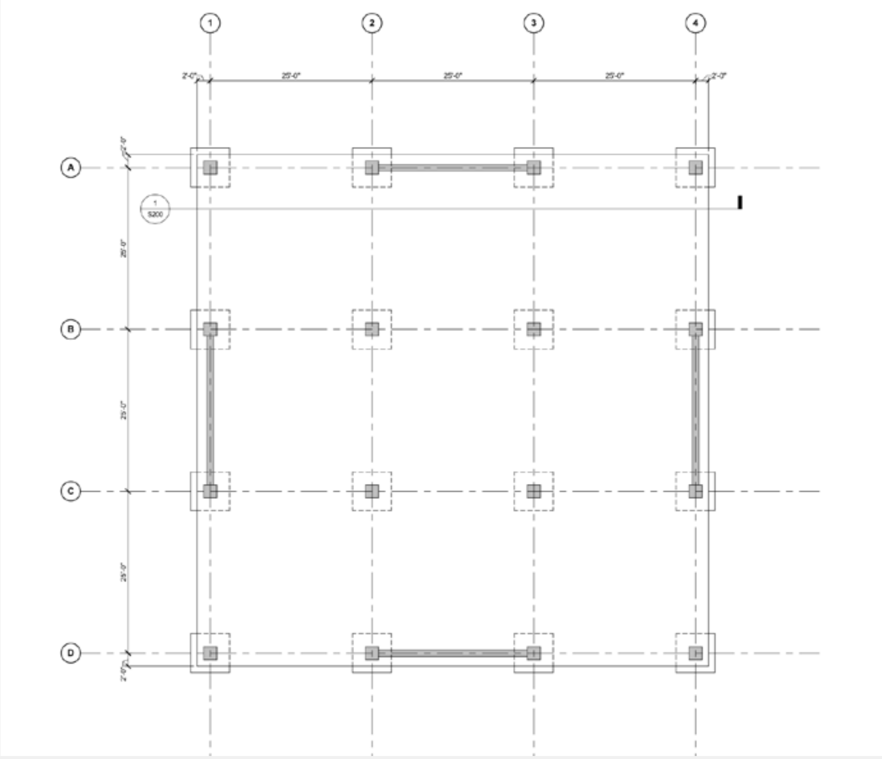


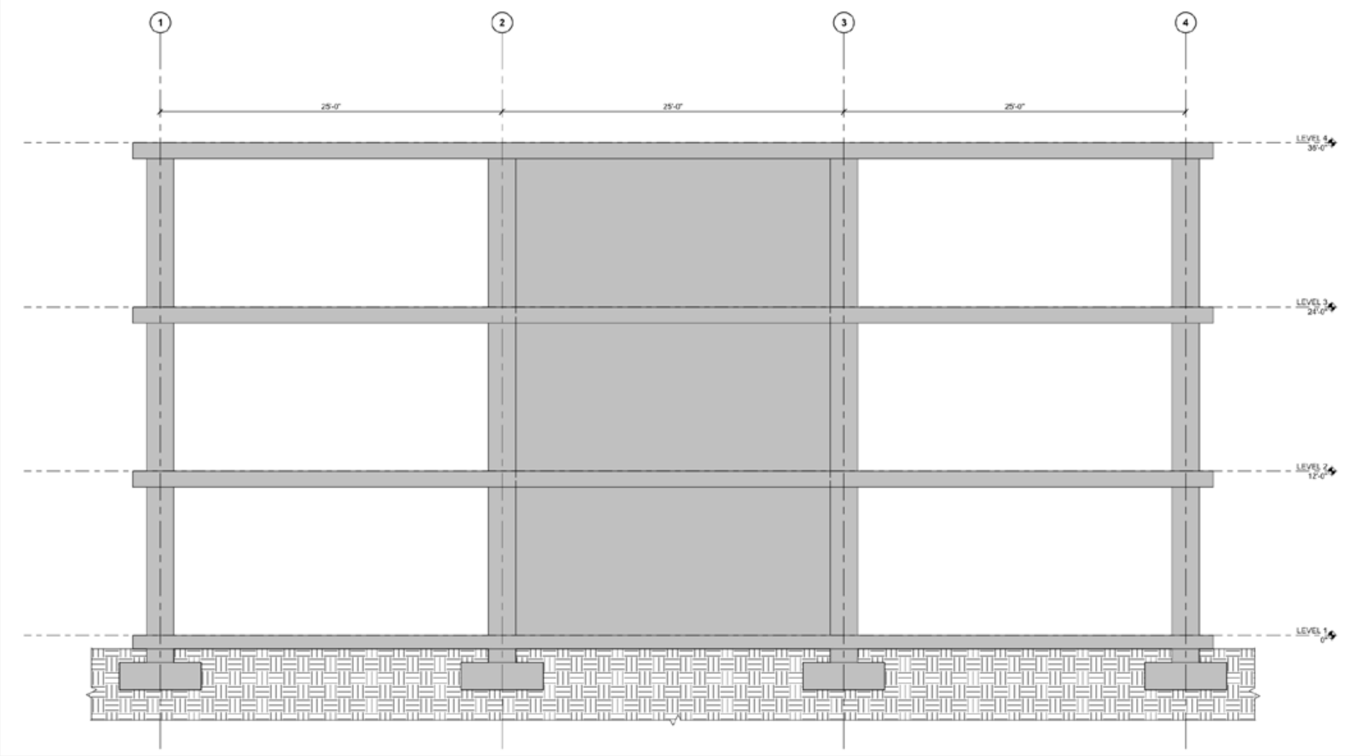
Photos: SGH

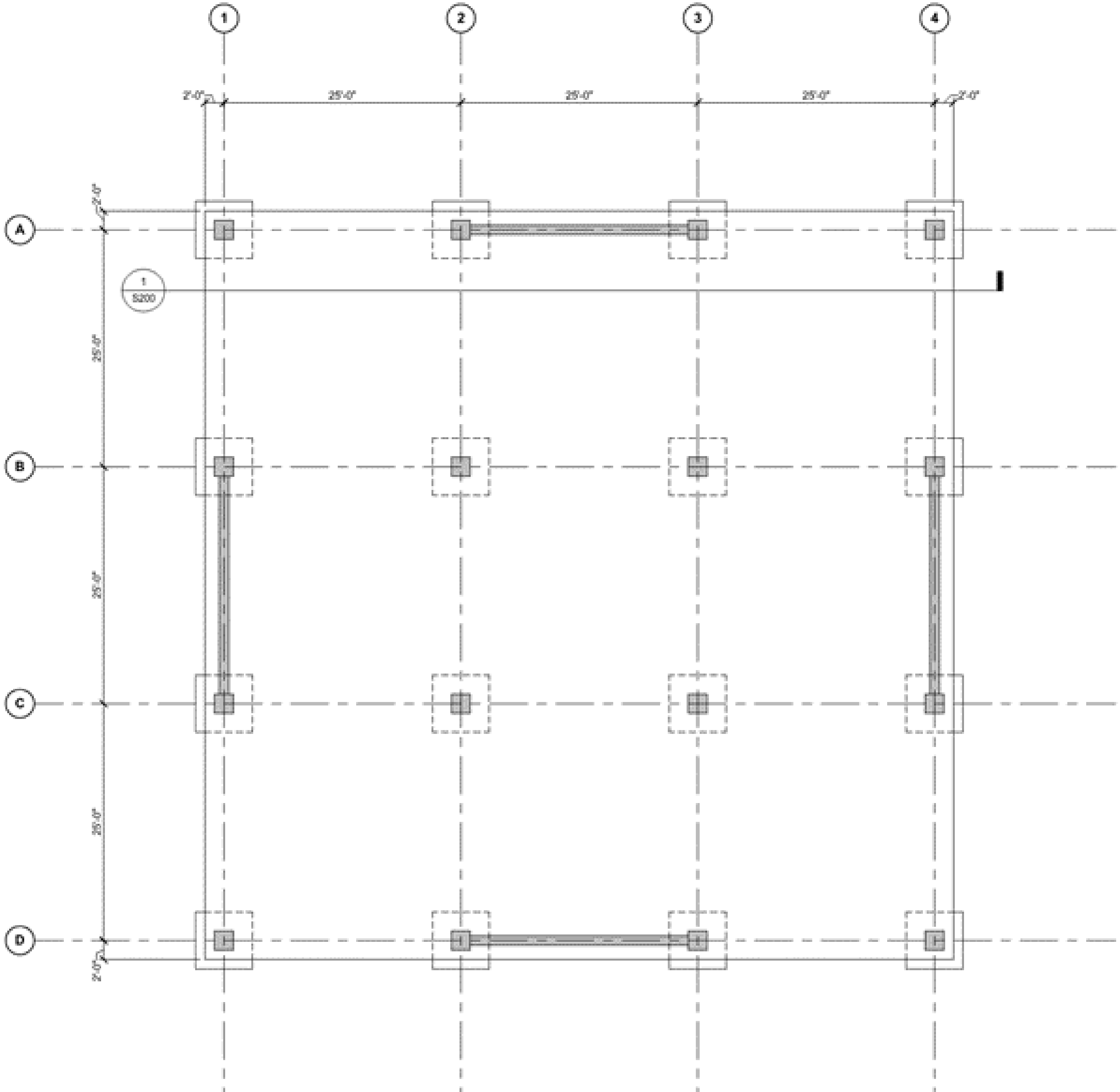
Impact on Building Design – Case Study

- Building A: Masonry Partitions, Masonry Exterior Wall
- Building B: Gypsum and Steel Partitions



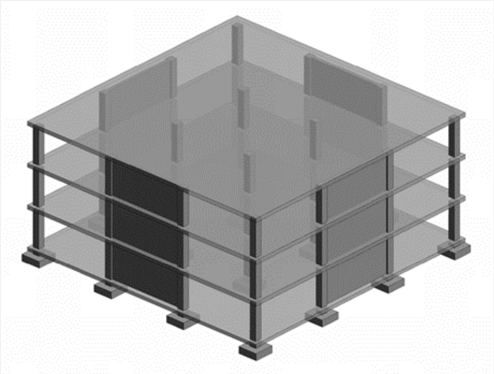





1
2
3
4
2'-0"
25'-0"
25'-0"
25'-0"
2'-0"
A
B
C
D
1
S200

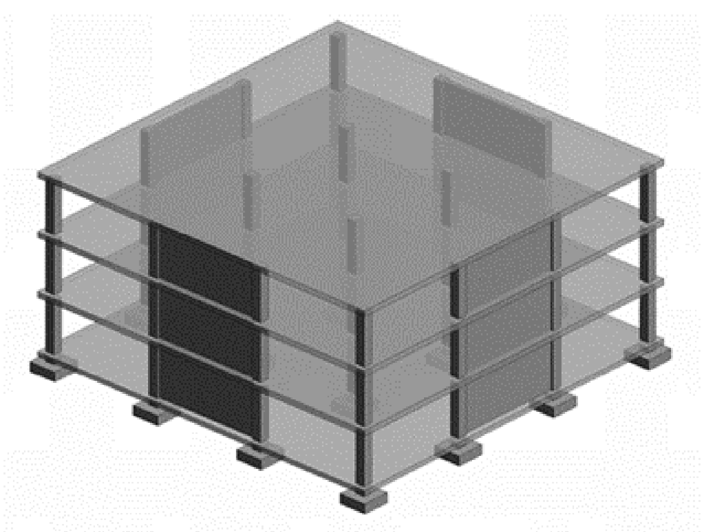
Impact on Building Design – Case Study

Parameter	A – Masonry Partitions	B – Steel/Gypsum Partitions
Slab Thickness	15 in.	12 in.
Slab Reinforcement	# 8@ 12 EW T&B	#7@12 EW T&B
Column Size	18 in. x 18 in.	18 in. x 18 in.
Column Reinforcement – per stack	723 lb	583 lb
Typical Footing Size	12.5’ x 12.5’ x 2’-8”	11’ x 11’ x 2’-4”
Typical Footing Reinforcement	24 #6 EW	18 #6 EW
Shear Wall Thickness	12”	10”
Shear Wall Reinforcement	#4 @12 EW EF	#4@16 EW EF



Impact on Building Design – Case Study

Parameter	A – Masonry Partitions	B – Steel/Gypsum Partitions	Delta
Concrete Volume	1,050 CY	850 CY	200 CY - 23%
Steel Tonnage	115 Tons	90 Tons	25 Tons – 28%






Photos: SGH

Kilns - Energy and Labor Intensive

Photo: http://www.ccacoalition.org/en/news/pakistan-moves-toward-environmentally-friendly-and-cost-effective-brick-kilns

Waste

Photos: SGH

Plaster-on-Steel – Lighter but still brittle…

Photo: SGH

Gypsum-on-Steel Stud …some applications in developing countries...

Photos: SGH

Steel-Gypsum Not a Cure-All

par

FEMA E-74 Reducing the Risks of Nonstructural Earthquake Damage – A Practical Guide, Jan. 2011

Conclusions:

Current practice perpetuates fragile systems.

Can make better use of resources and embodied energy by using lighter partitions.

Chicken and Egg Problem:

Market Requires Demand

Demand Requires Supply Chain, Familiarity – Design, and Familiarity + Skills in Construction

USAID? NGOs? Bill & Melinda?

Resiliency: Community + Planning

Financing Urban Resiliency & Green Infrastructure through Land Value Capture

James G. Kostaras
Senior Fellow
Institute for International Urban Development

Financing urban resiliency: a critical challenge

The World Bank: urban climate adaptation will cost $80- 100 billion per year.

Land value capture.

Need for Technical and Institutional Capacity in Municipal Government.

Land Value Capture

Effective tool for municipal governments to finance infrastructure & public transit.

Latin America: experience implementing innovative land value capture.

Testing ground for climate adaptation finance strategies based using land value capture.

Concept of Land Value Capture: urban public transit

A model for financing resilient design?

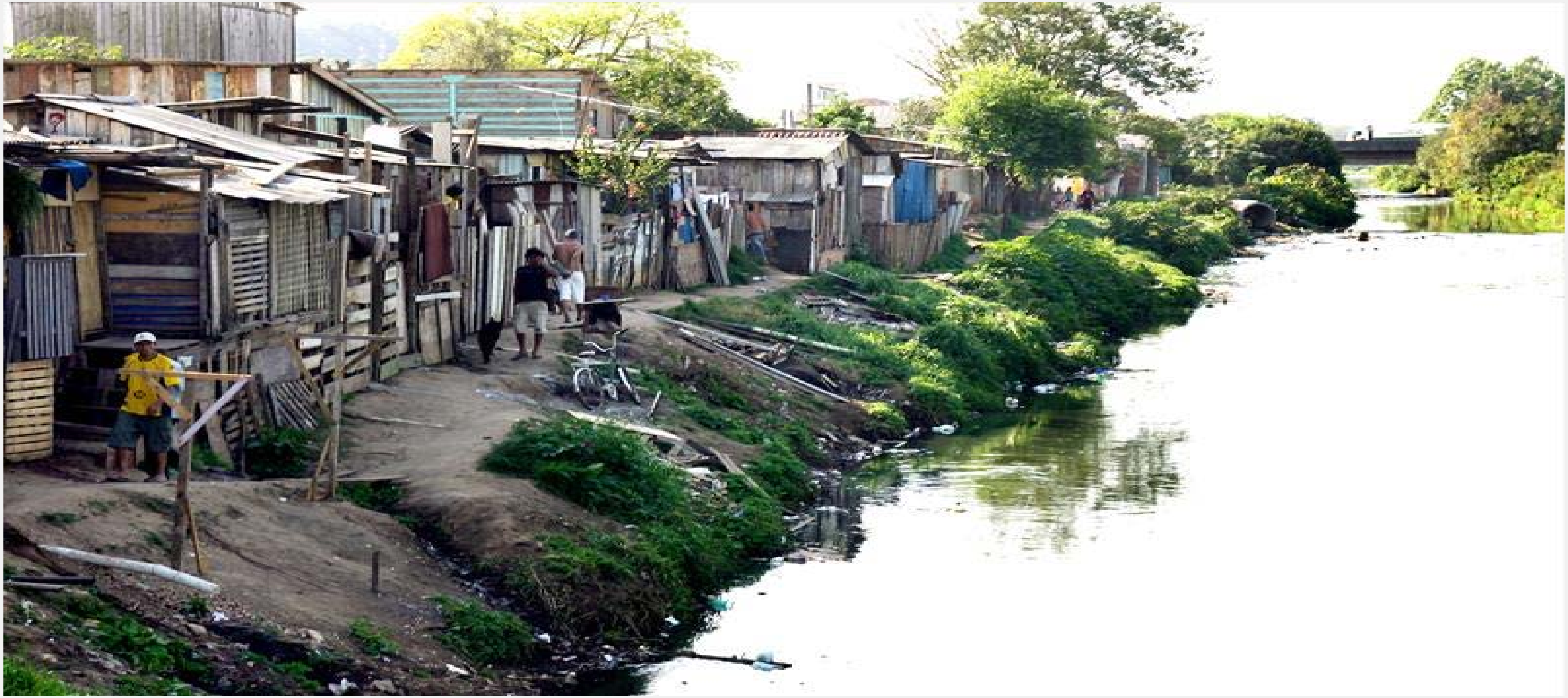
Curitiba, Brazil: example of land value capture to finance urban transit

Concept of Land Value Capture to finance Resiliency

Hypothetical example of the use of betterment contributions, modeled on Tax Increment Financing in the US

Using Land Value Capture to Finance Green Resilient Infrastructure & Urban Climate Adaptation.

- Curtiba, Brazil
- Cartegena, Colombia
- Cali, Colombia

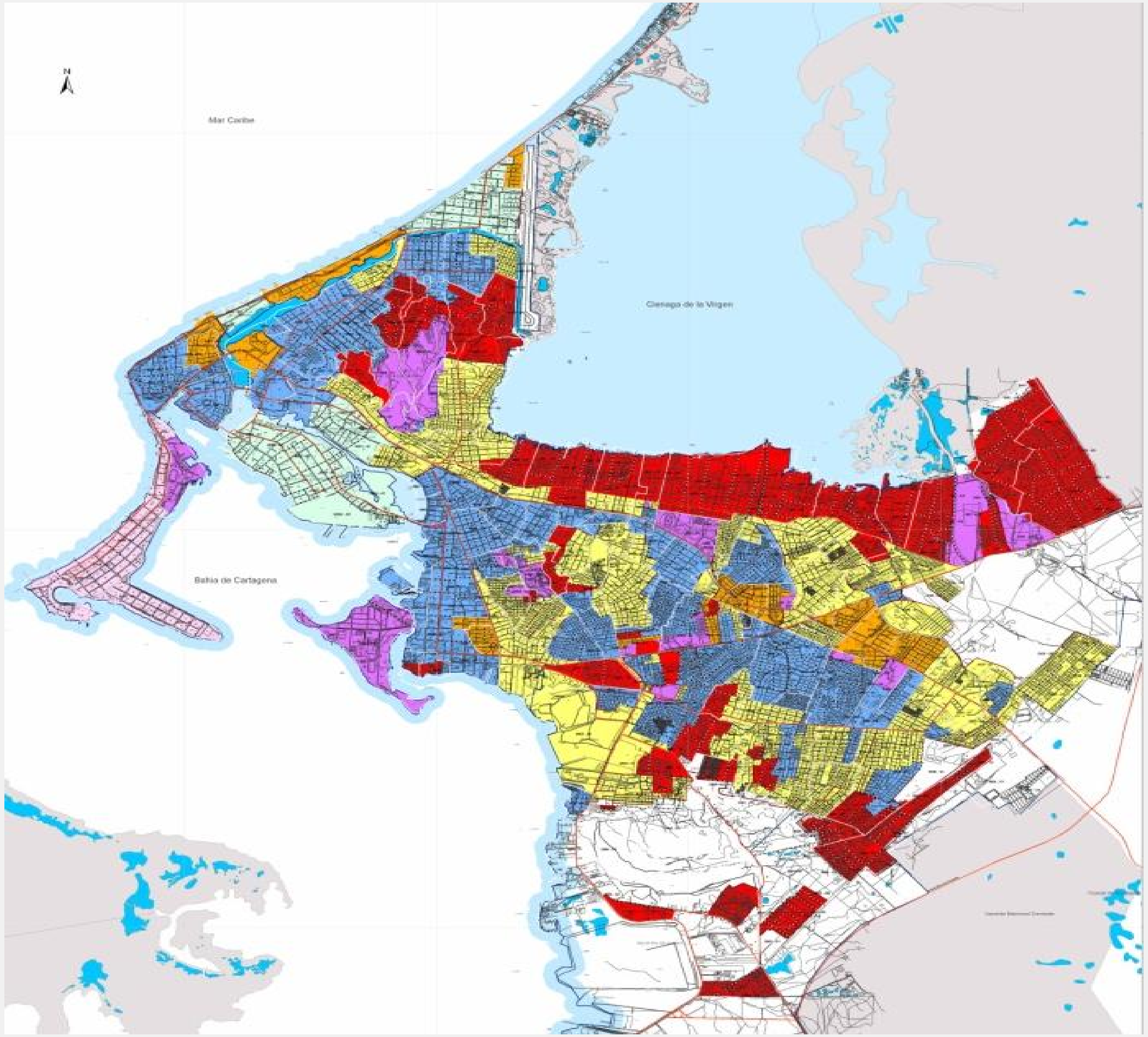


Curitiba TDR Flood Protection Program

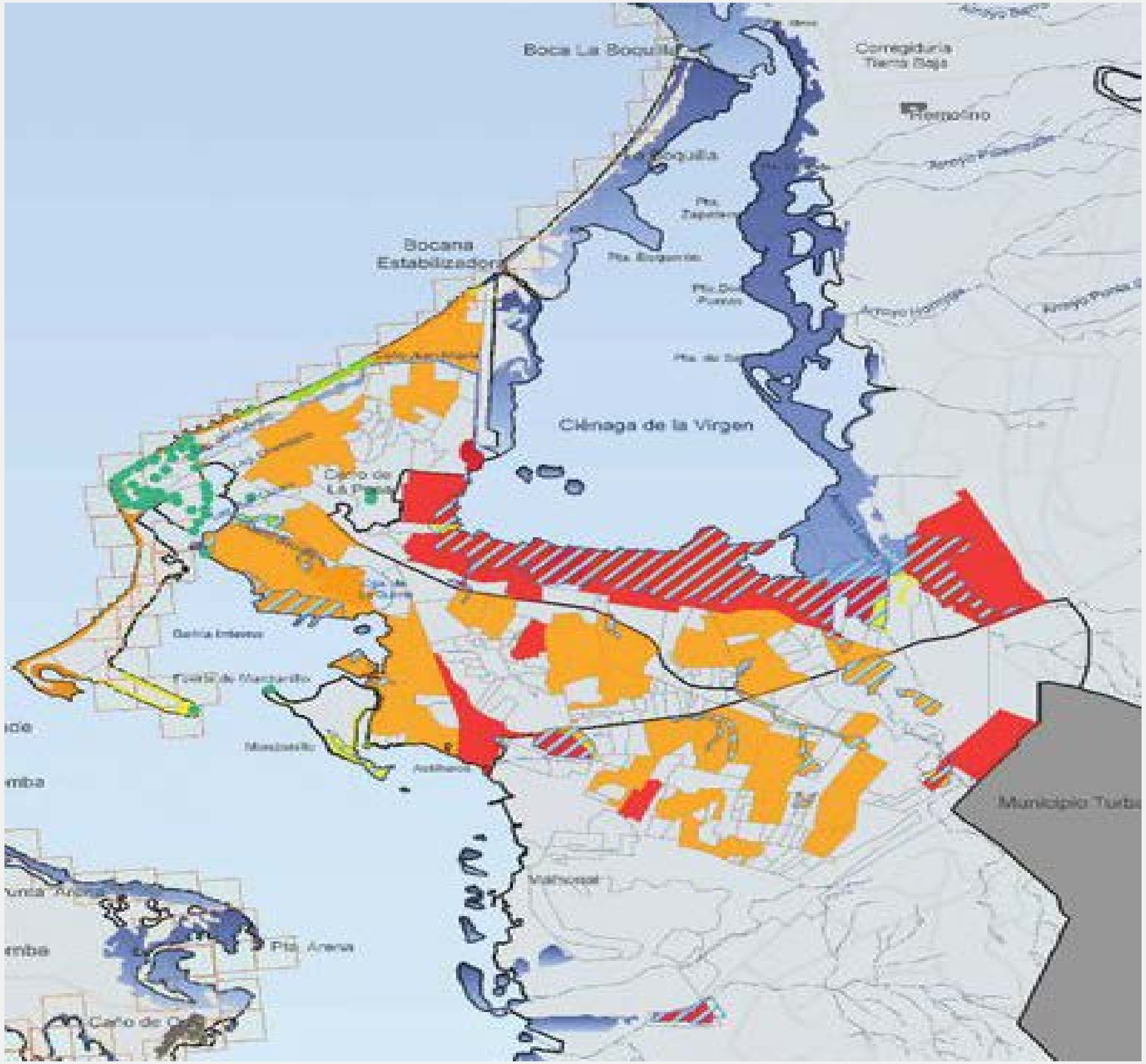
Curitiba TDR Flood Protection Program

Cartagena, Colombia

Cartagena: average income 2004



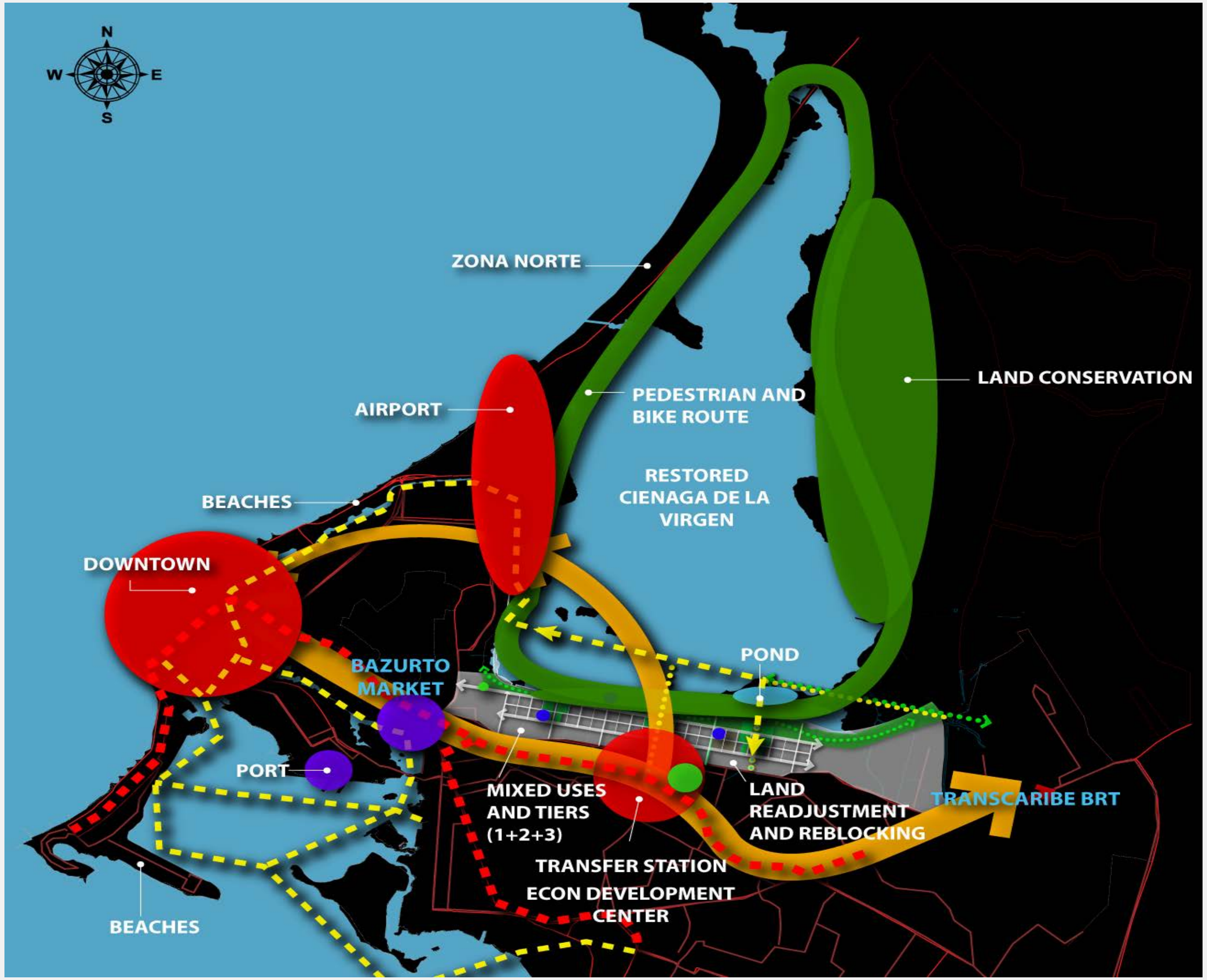
Source: Secretaria de Planeacion Distrital



Cartagena: Vulnerability to climate change 2019

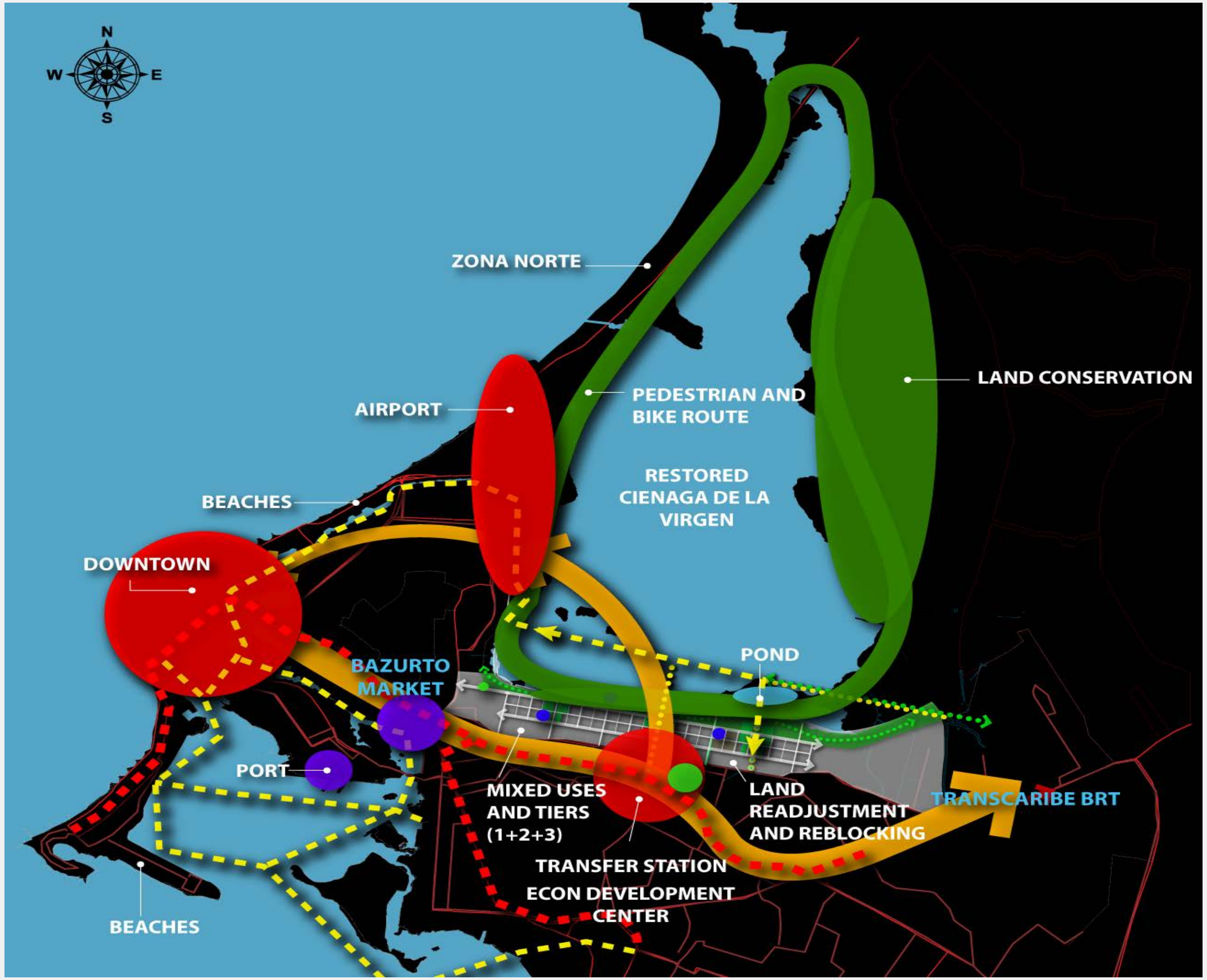
VULNERABILITY INDEX (Exposure and Income)

- High
- Medium
- Low
- Flooding Risk



Cartagena: Development Strategy

- Inclusive Zoning
- Upgrading and retrofitting infrastructure
- Capitalizing on increasing land values
- Land re-adjustment
- Attention to social scale of projects
- Economic Development of emerging strategic nodes
- Returning very low land to water
- Transfer Development Rights: adding green buffer around lagoon
- Mixed income housing
- Local transport



Cartagena: Development Strategy

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Calí, Colombia

Photo credit: Luis Robayo/AFP

Photo credit: Luis Robayo/AFP

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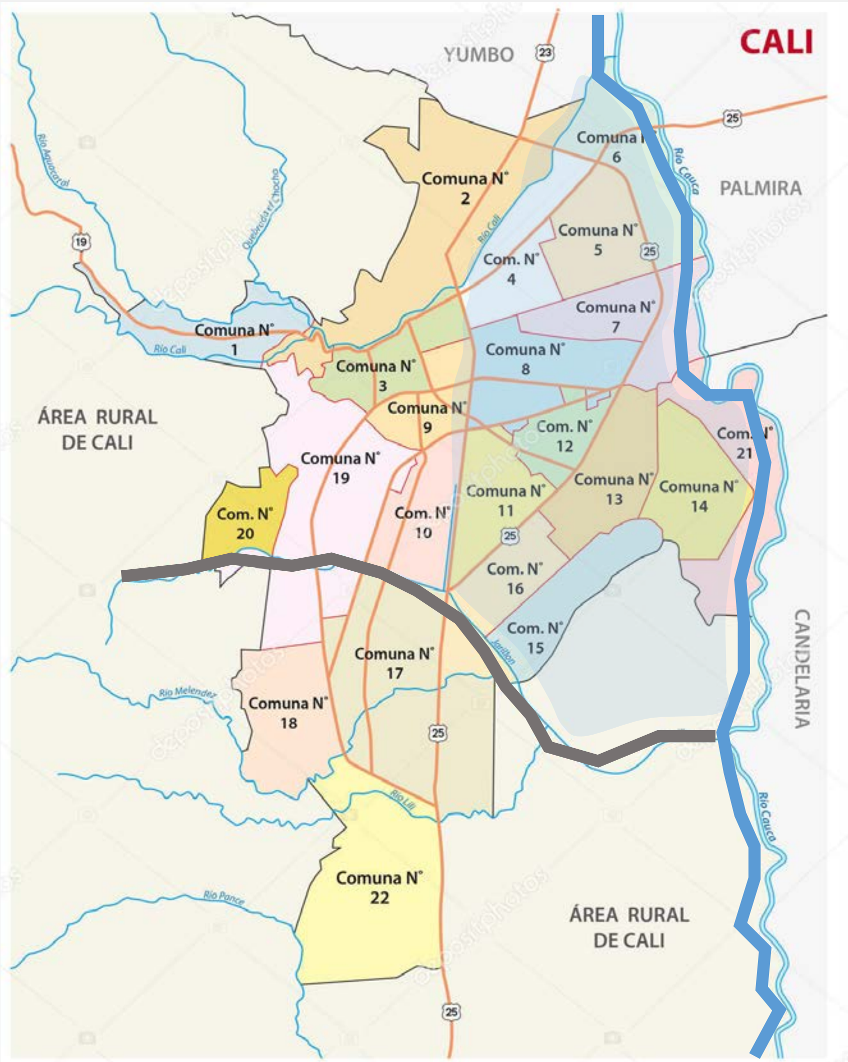
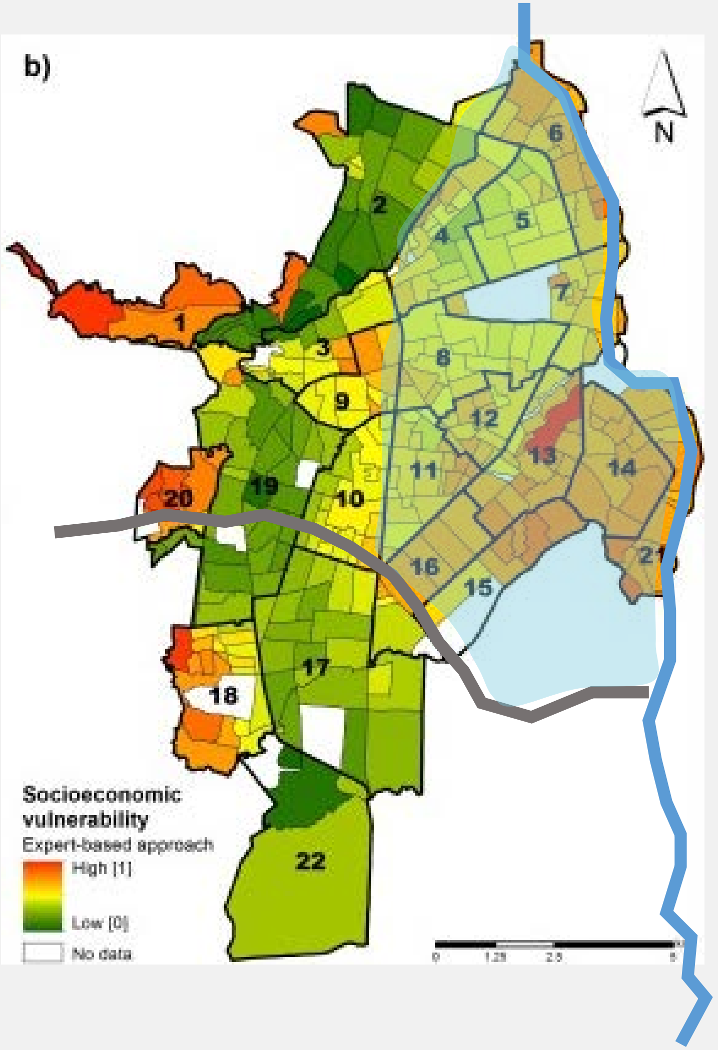

CALI
YUMBO
PALMIRA
CANDELARIA
ÁREA RURAL DE CALI
ÁREA RURAL DE CALI
Comuna N° 1
Comuna N° 2
Comuna N° 3
Com. N° 4
Comuna N° 5
Comuna N° 6
Comuna N° 7
Comuna N° 8
Comuna N° 9
Com. N° 10
Comuna N° 11
Com. N° 12
Comuna N° 13
Comuna N° 14
Com. N° 15
Com. N° 16
Comuna N° 17
Comuna N° 18
Comuna N° 19
Com. N° 20
Com. N° 21
Comuna N° 22
Río Cauca
Río Cali
Río Meléndez
Río Pance
Río Lili


b)
N
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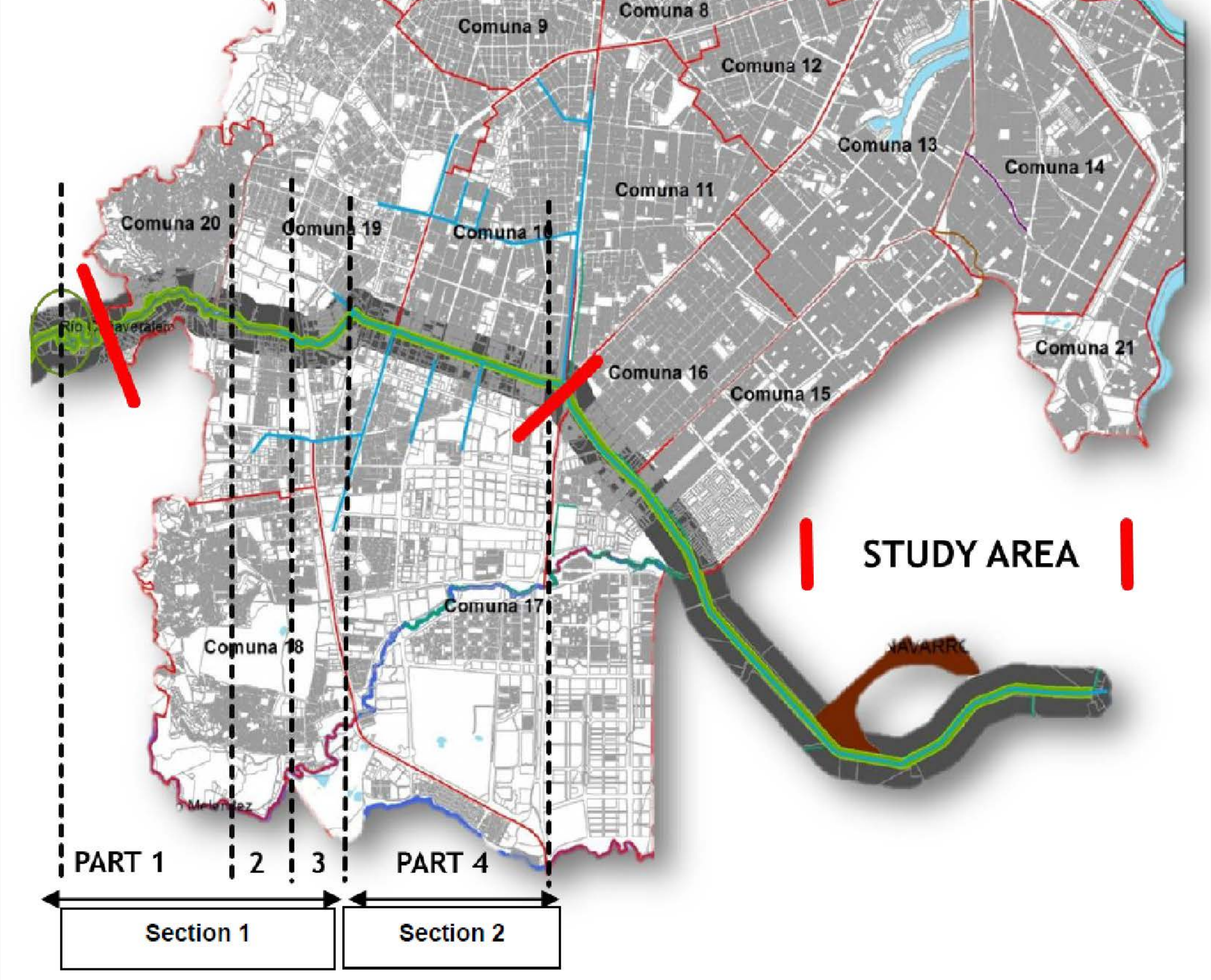
22
Socioeconomic vulnerability
Expert-based approach
High [1]
Low [0]
No data


Michael Tompsett


Comuna 8
Comuna 9
Comuna 12
Comuna 13
Comuna 14
Comuna 11
Comuna 20
Comuna 19
Comuna 16
Comuna 15
Comuna 21
STUDY AREA
Comuna 17
Comuna 18
PART 1
2
3
PART 4
Section 1
Section 2

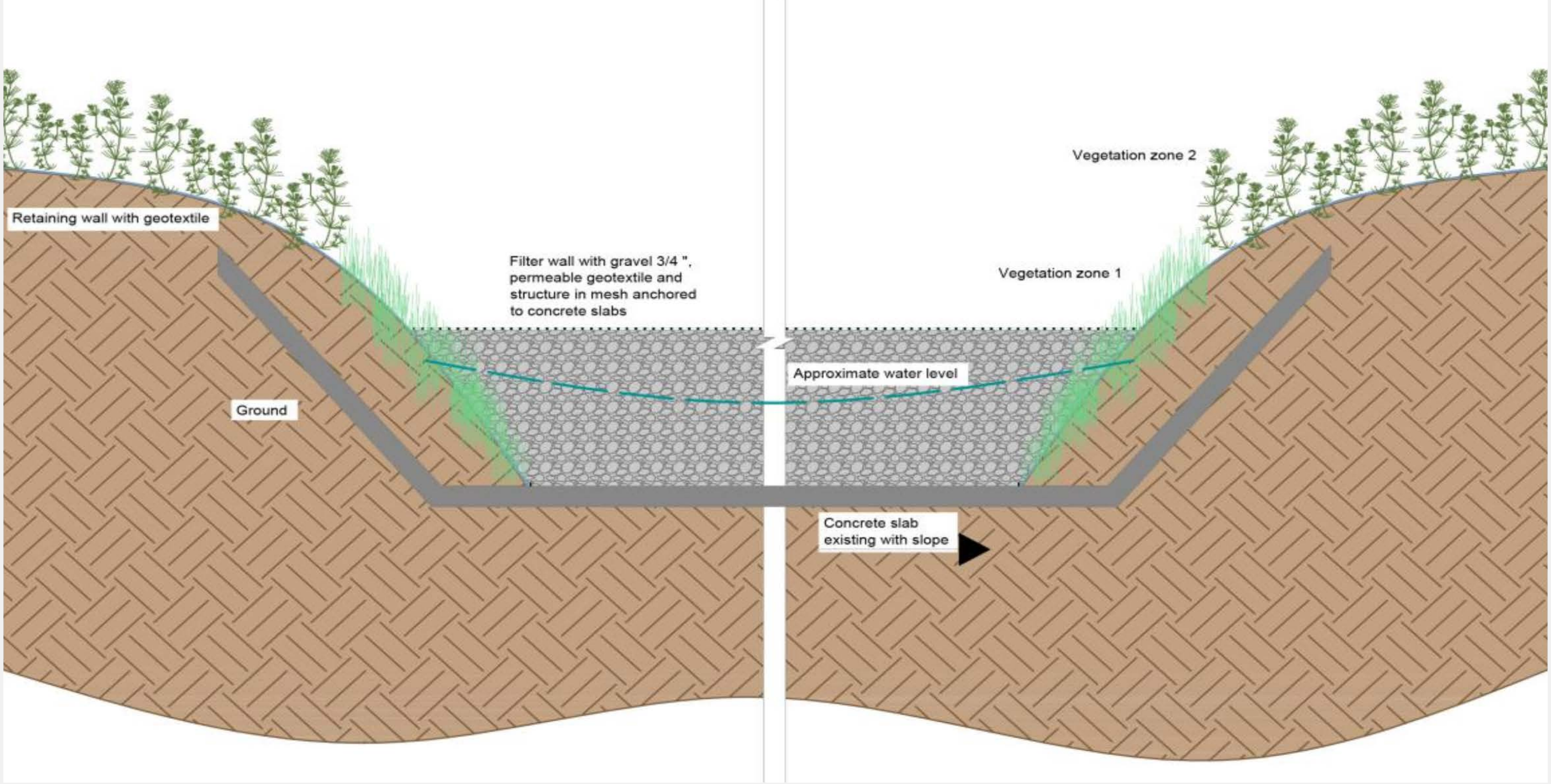


Image 19, Detailed intervention in the canal area combining gray and green infrastructure

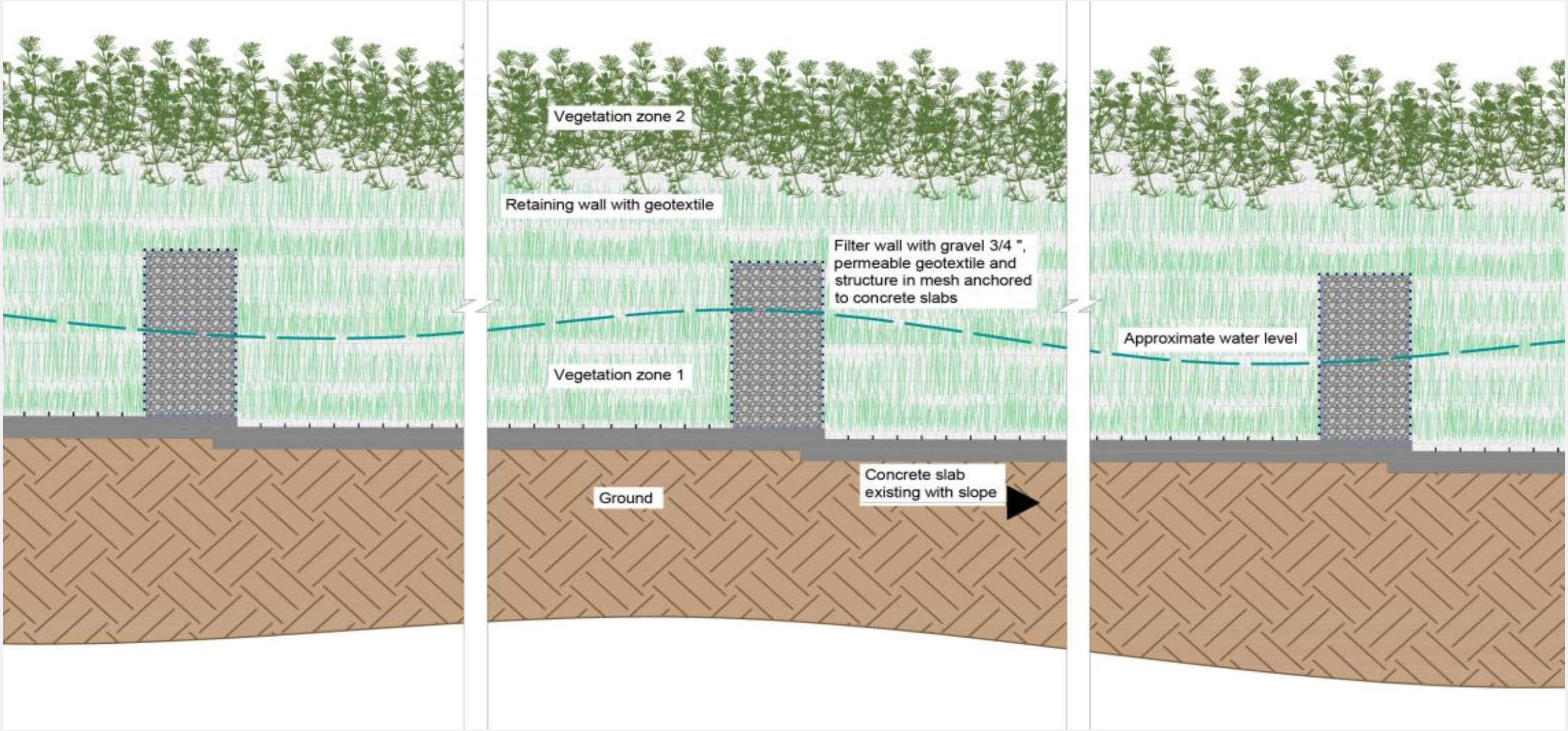
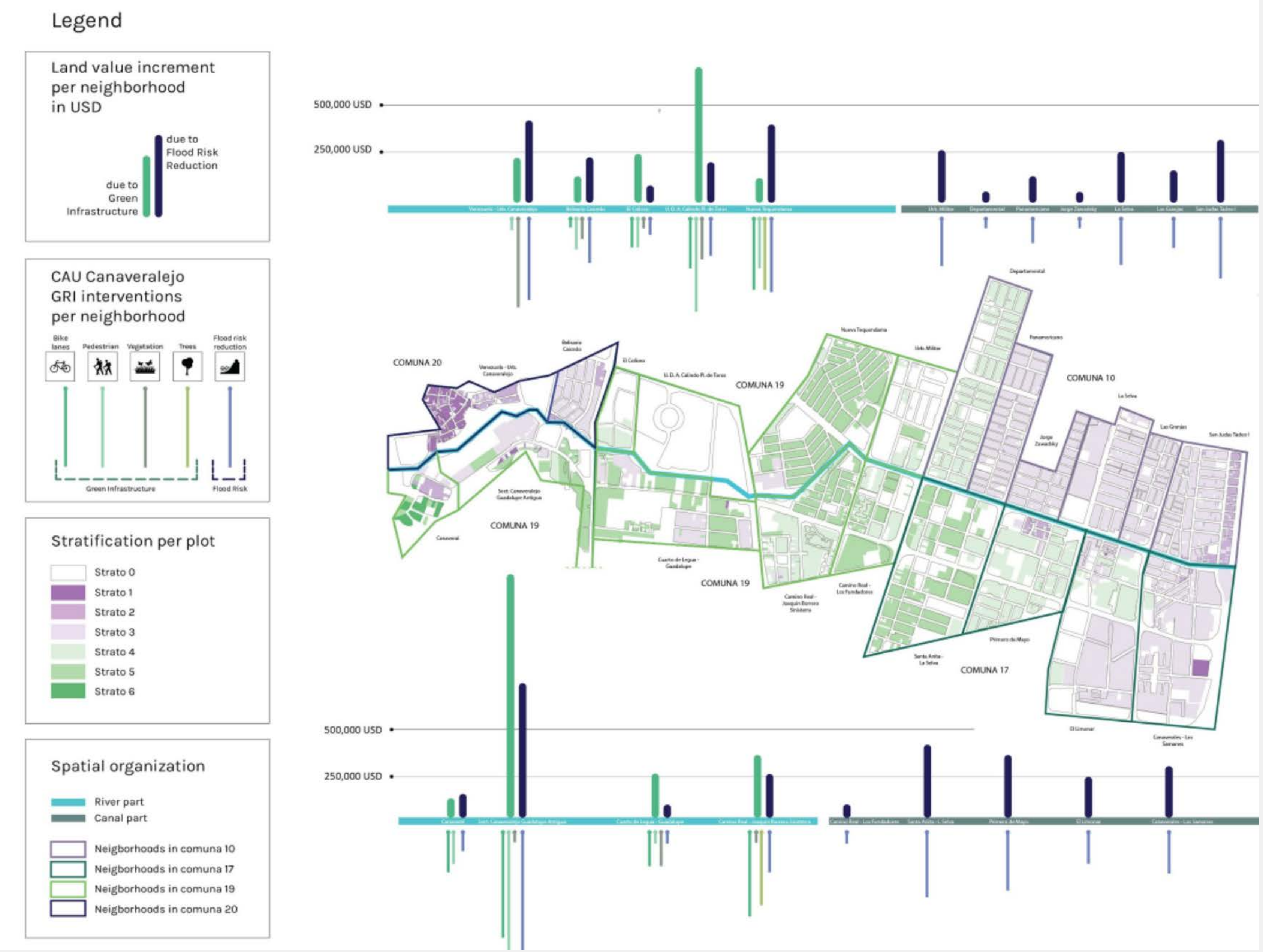


Image 20, Detailed intervention in the canal area adding green infrastructure strategies to the existing project

Image 4: CAU Canaveralejo design (river part, zones 1-3 in image 3 above)

Image 5: CAU Canaveralejo design (case study area's river part, zone 4 in image 3 above)


Legend
Land value increment per neighborhood in USD
due to Flood Risk Reduction
due to Green Infrastructure
CAU Canaveralejo GRI interventions per neighborhood
Bike lanes
Pedestrian
Vegetation
Trees
Flood risk reduction
Green Infrastructure
Flood Risk
Stratification per plot
Strato 0
Strato 1
Strato 2
Strato 3
Strato 4
Strato 5
Strato 6
Spatial organization
River part
Canal part
Neigborhoods in comuna 10
Neigborhoods in comuna 17
Neigborhoods in comuna 19
Neigborhoods in comuna 20
500,000 USD
250,000 USD
COMUNA 20
COMUNA 19
COMUNA 19
COMUNA 19
COMUNA 10
COMUNA 17
500,000 USD
250,000 USD

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Thank you!