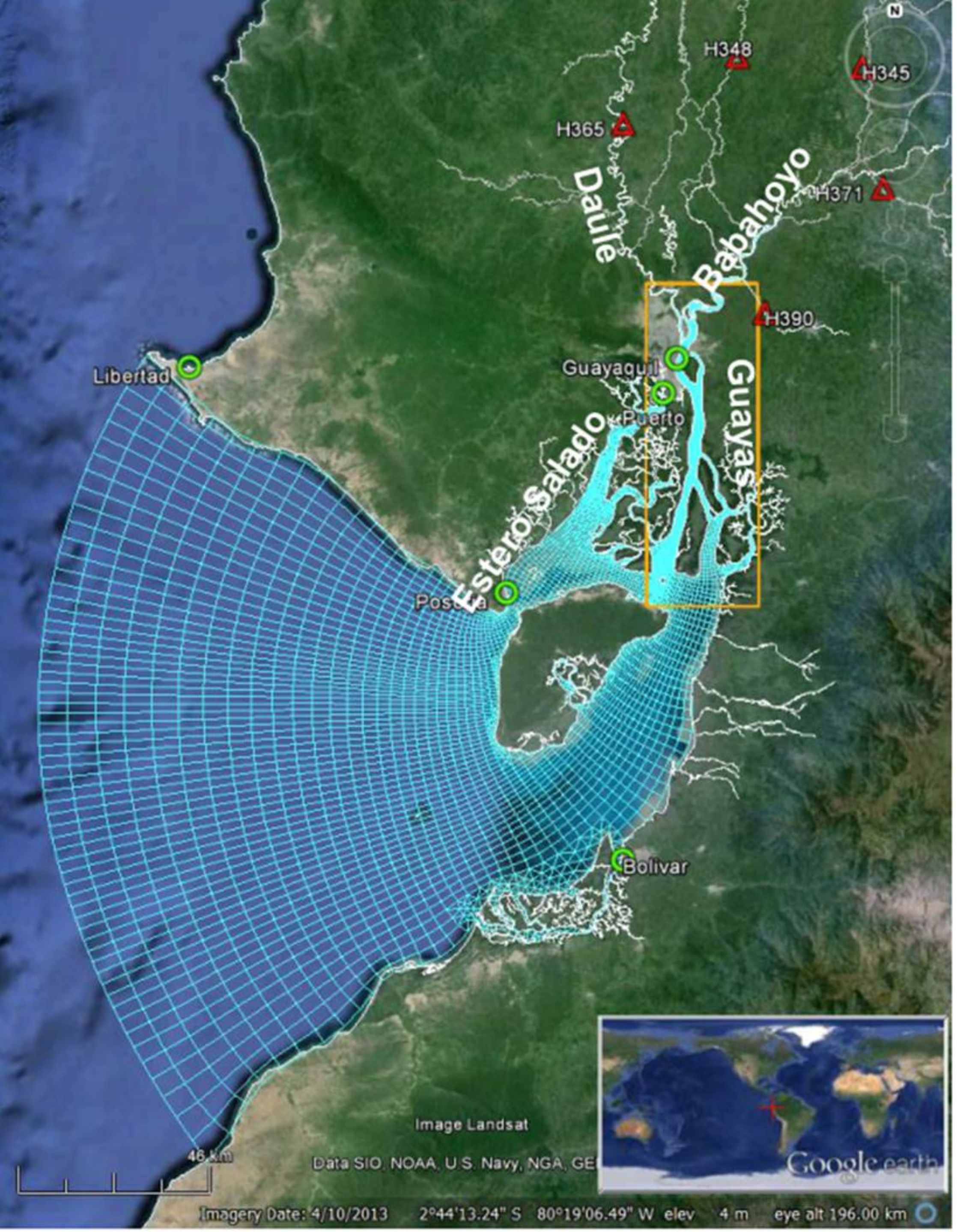


Deltares

Sustainable Urban Water Management – Challenges and Opportunities in mainstreaming Climate Adaptation

Improving Flood Resilience in Guayaquil

Deltares, ESPOL, Rebel Group, Urbanisten, Municipality Guayaquil, Partners voor Water

Ad Jeuken

PARTNERS VOOR WATER
Bundeling van krachten

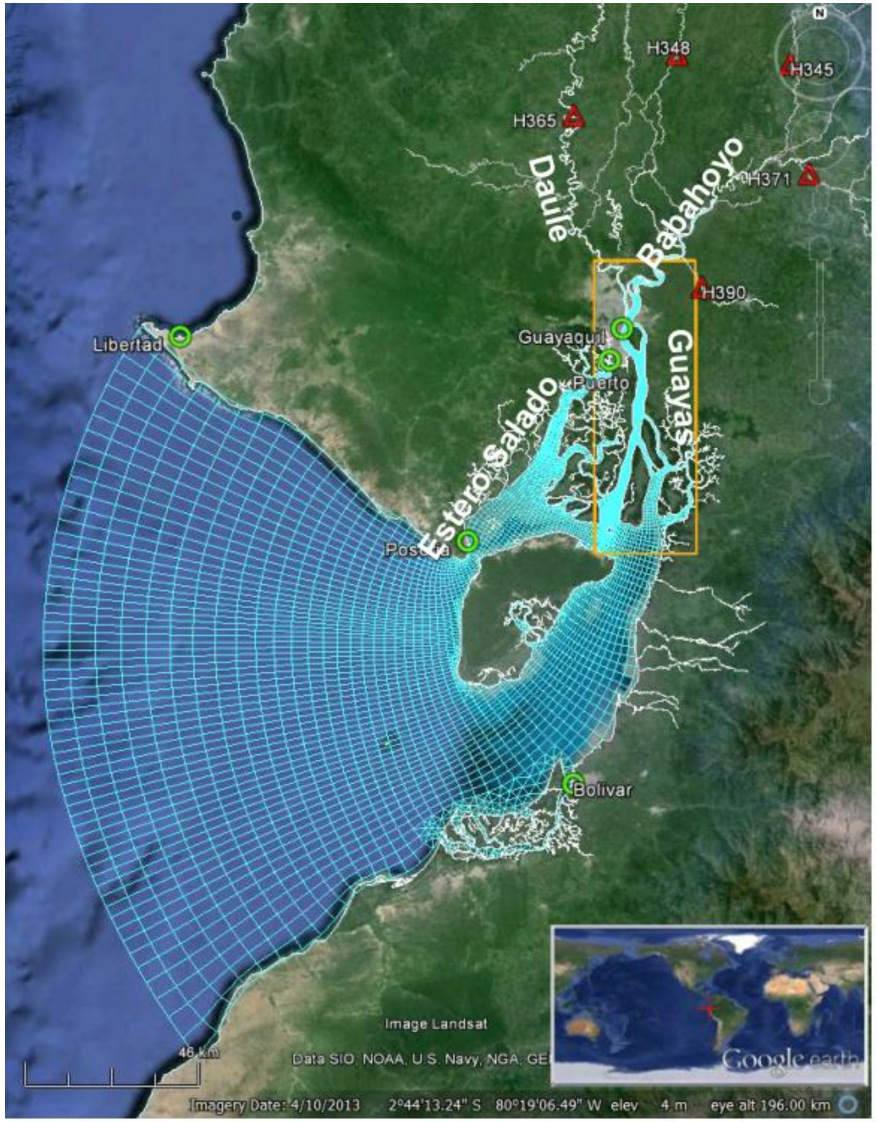
espol Escuela Superior Politécnica del Litoral

DE URBANISTEN

REBEL

5 March 2021

Project location



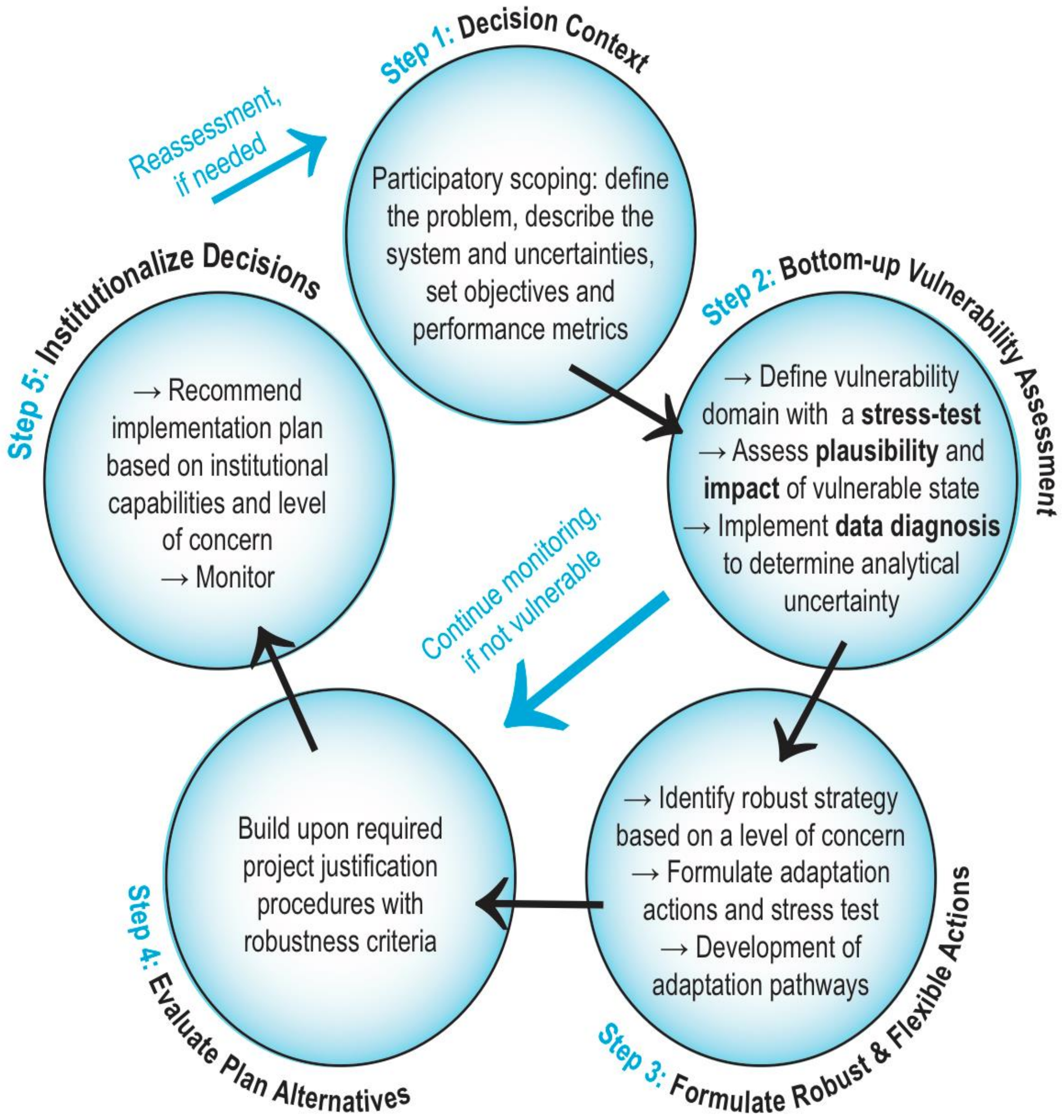
Goal

- Improve resilience to floods in the Delta city of the Guayaquil
- Implementation of innovative tools for urban development and flood management

Unique elements:

- Full scale CRIDA application
- Novel application to tidal and pluvial flooding
- Combining Climate with social and economic vulnerability
- Integration urban design & stakeholder perception

Deltares



Storyline flood vulnerability analysis and strategic response (CRIDA approach)

Step 1) Decision context

- Problem analysis – problem tree and impact indicators
- Selection of performance metrics for stress test

Step 2) Vulnerability and impact analysis (Floods and Socio-economic)

- Selecting drivers and ranges for stress test
- Results of stress test and selecting a strategic approach
- Approach to socio-economic vulnerability and results
- Defining and selecting priority areas for interventions based on impact (combination of flood depth and socio-economic vulnerability)

Step 3) Identification and Selection of interventions

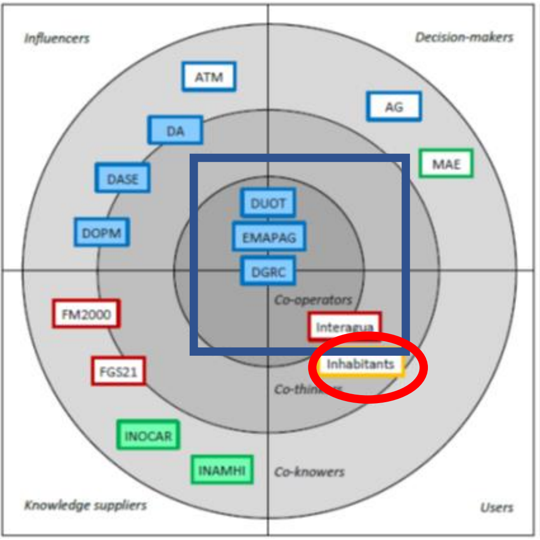
- Selection of interventions for priority areas
- Integrated design of three alternatives for priority areas

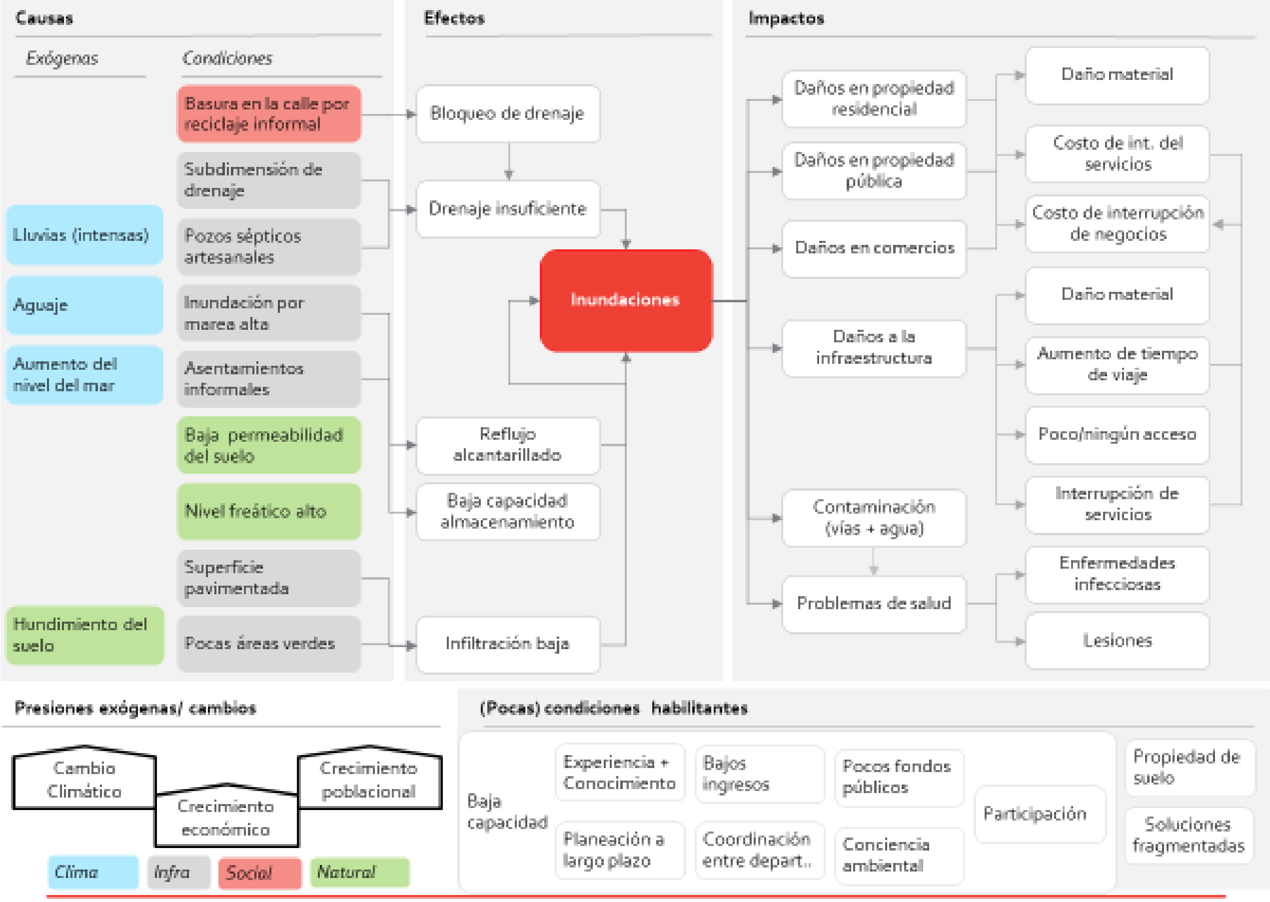
Step 4) Evaluation of plan alternatives

- With attention to ecosystem services of measure, and operational costs

Step 5) Implementation of selected interventions

- With attention to financing opportunies





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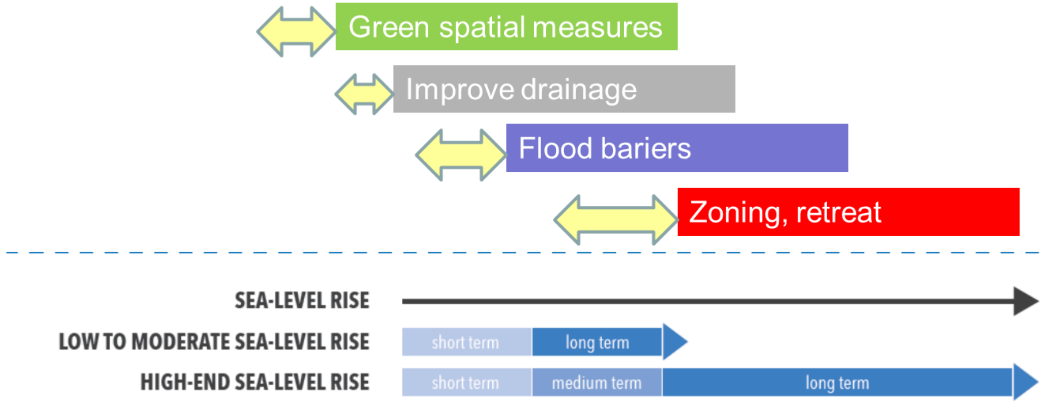
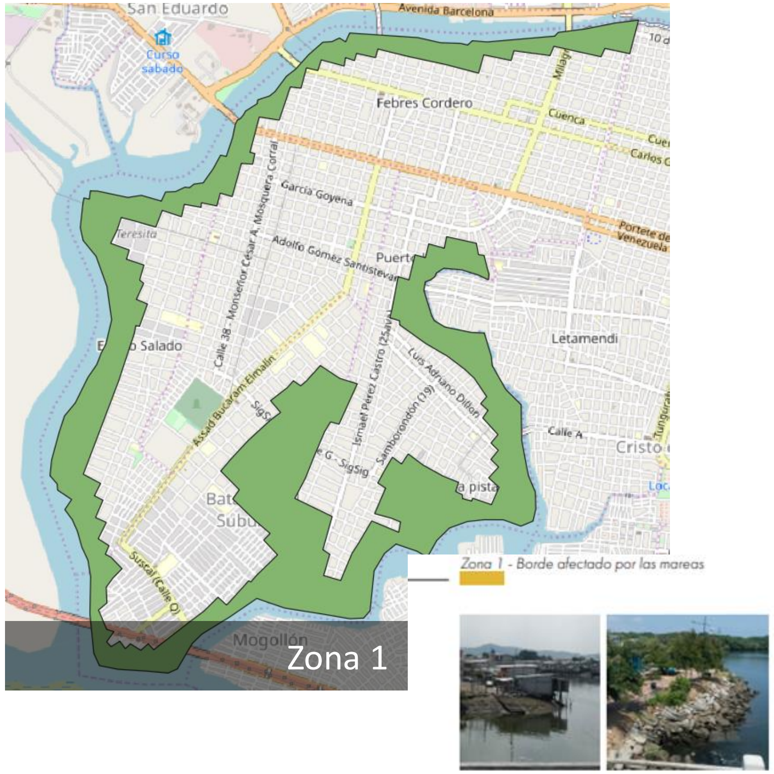


1) Decision context

- Stakeholder analysis
- Problem analysis – problem tree and impact indicators
- Selection of performance metrics for stress test
- Objectives and preferences

Consider three characteristic zones:
1 coastal, 2 commercial, 3 residential



Performance metrics

Are critical depths (0.2,0.4) exceeded over significant large areas, for critical durations?

Water depth on the streets

how deep is the flood?

Model output

Outliers

Drainage time

how long will the flood last?

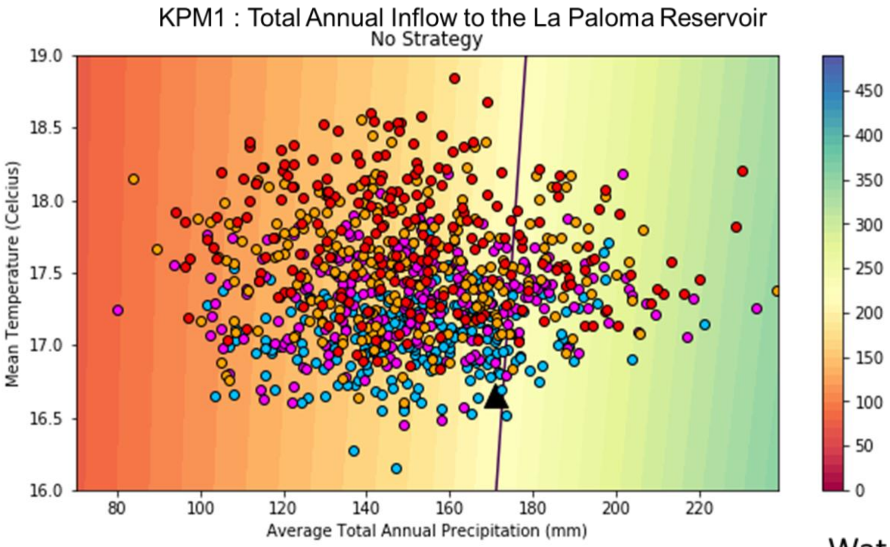
Based on water on streets

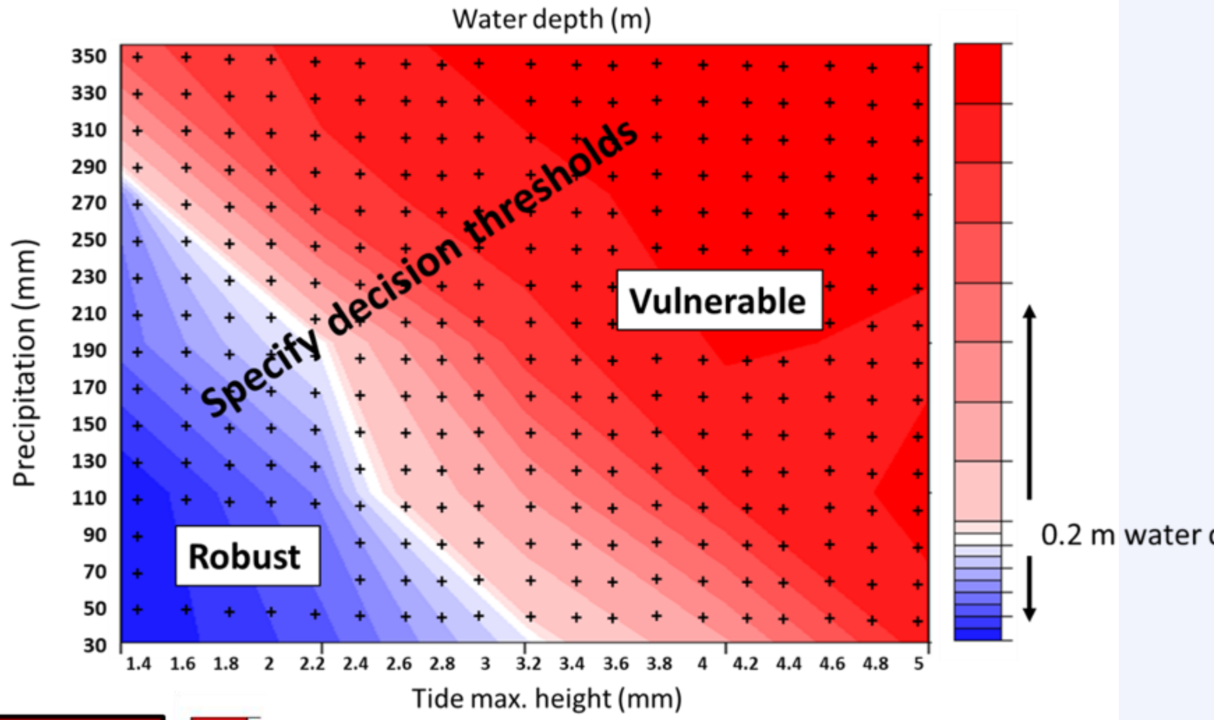
Flood extension

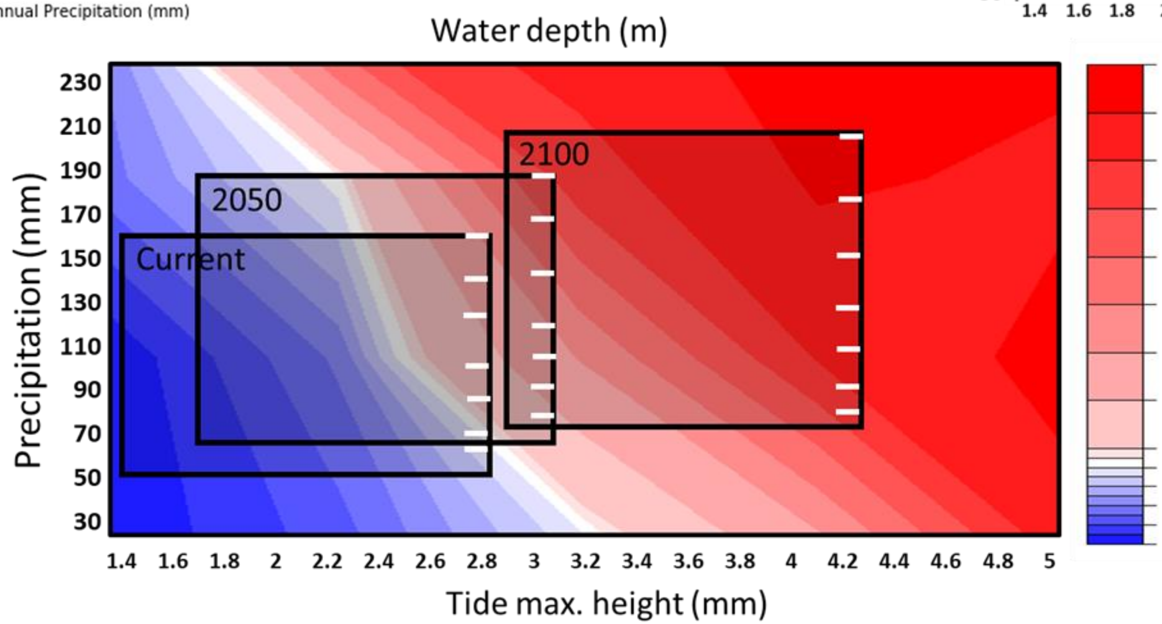
How large area is hit?

Based on water on streets

2) Stress Test – using modified decision scaling approach



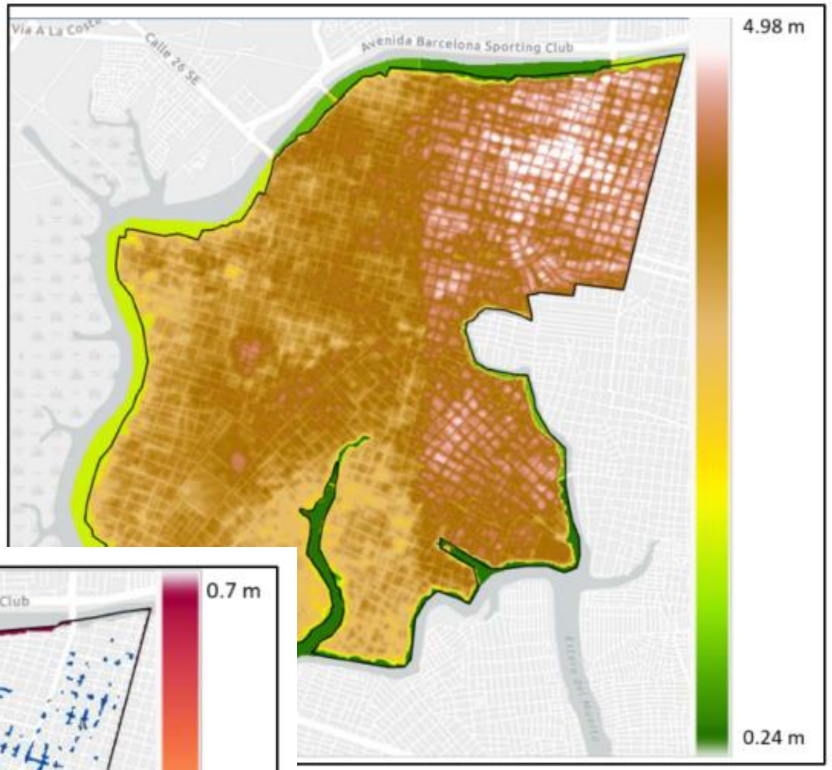


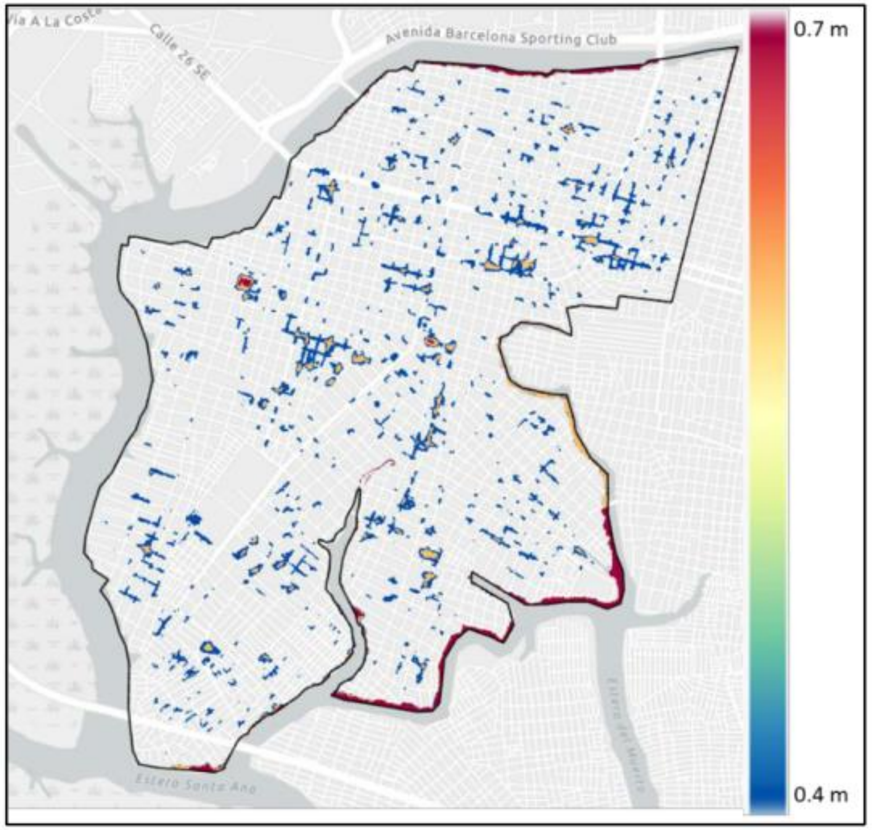


- Event-based
- Plausible shifts based on climate projections and science

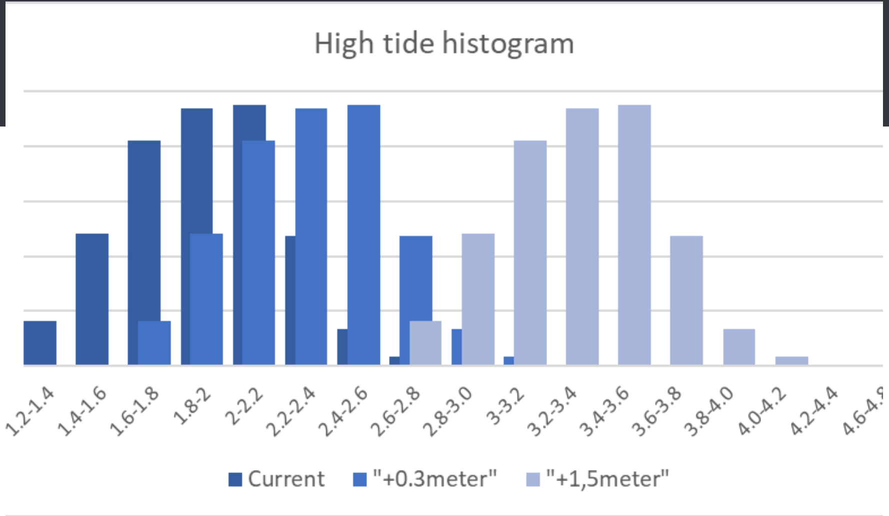
Deltares

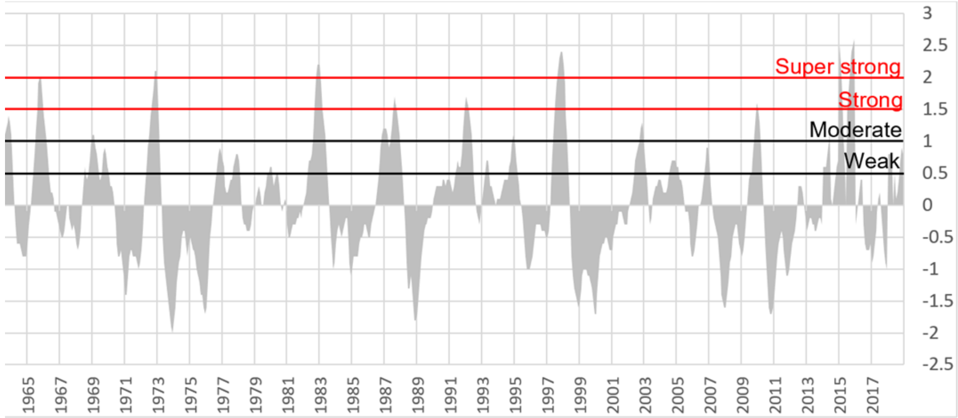
The system model SOBEK1D drainage system model + 2D Dflow

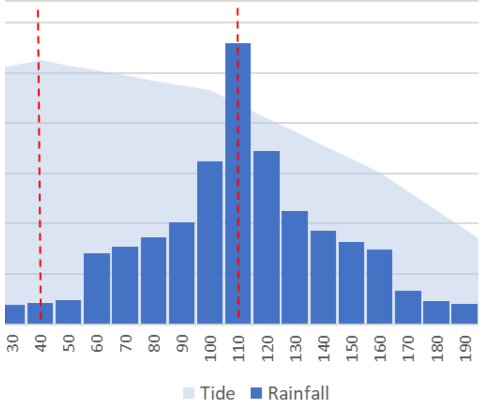


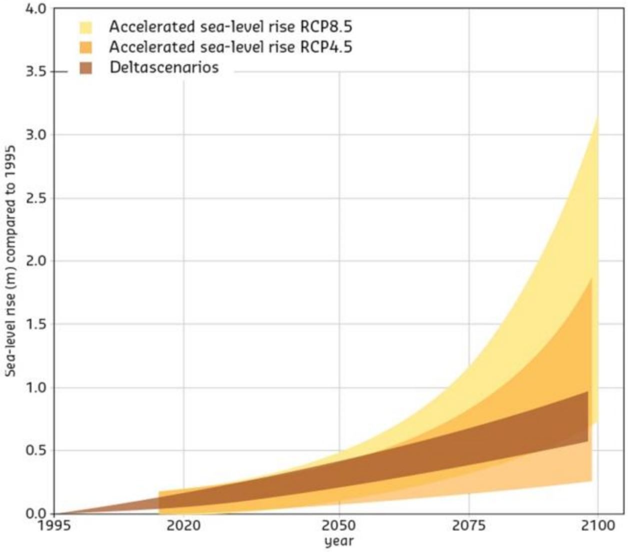


Stress test input

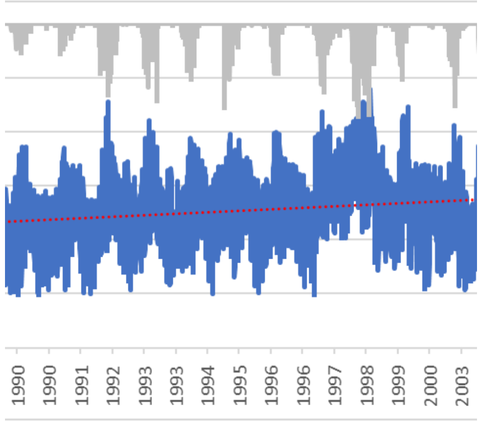








- Rainfall intensity and duration and frequency
- Water level in the estuary depending on Tide, SLR and swelling effect el Nino . Note that el Nino and peak tide are recurring (4-5y, annualy) and SLR is gradually increasing.



Model Runs

Return period	Accumulated precipitation (mm)	Rainfall duration (hour)	Intensity (mm/h)	Simulation period (hour)	Tide (peak [m.a.m.s.l.])
0	0	0	0	24	from 1.4 until 4 increasing 20 cm
TR1	60.9	3.5/5	17.4	24	
TR2	70.7	3.5/5	20.2	24	
TR5	86.3	3.5/5	24.7	24	
TR10	100.3	3.5/5	28.7	24	
TR25	122.3	3.5/5	34.9	24	
TR50	142.2	3.5/5/18	40.6	24	
TR100	165.2	3.5/5/18	47.2	24	

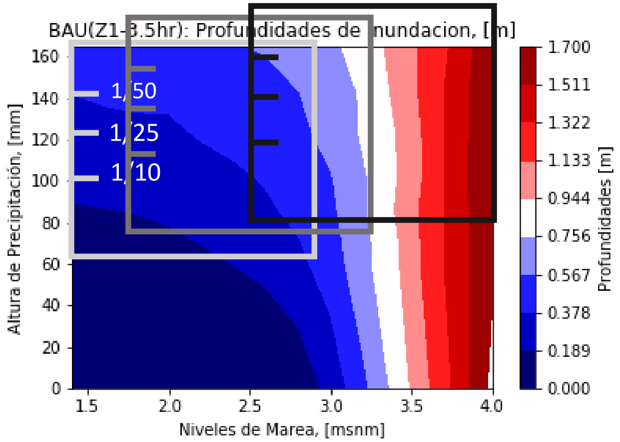
We show stress test plots:

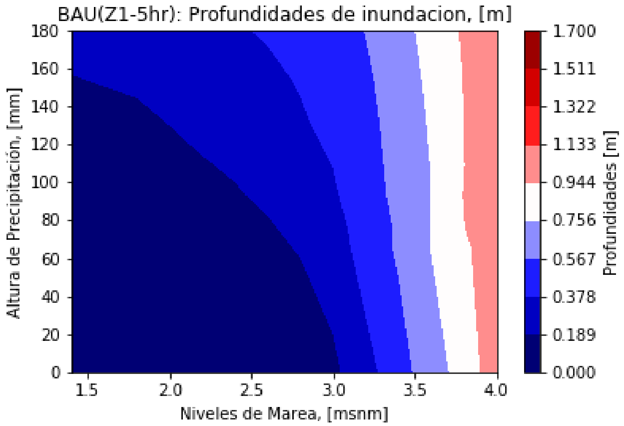
- Flood depth (10 max)
- Area (ha) > 0.2 m (now missing)

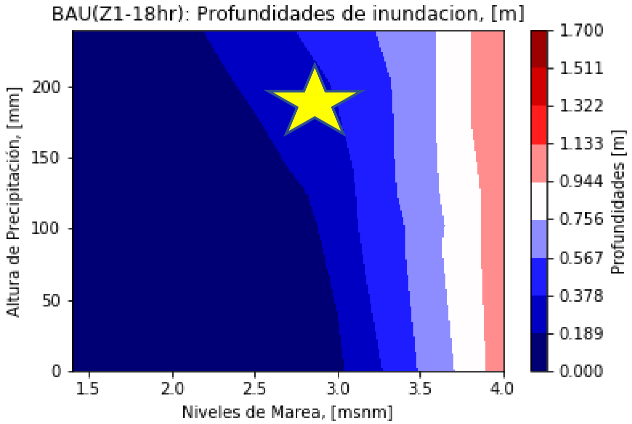
And selected plots of flood area >0.2m against time (illustrating retention)

Zona 1 (reckangles showing shifts due to SLR (+0.3, +1m) and CC (+10%, +20%)

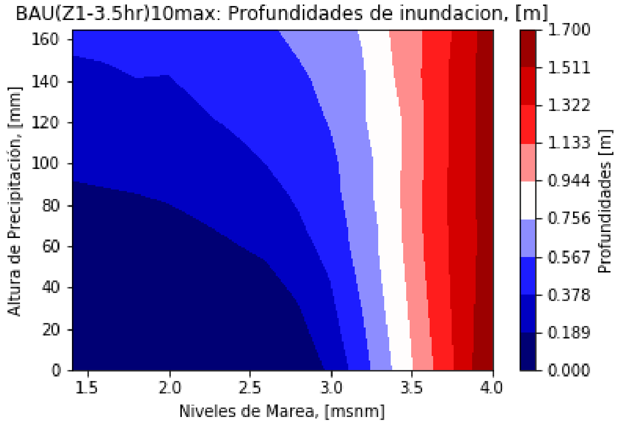
Max

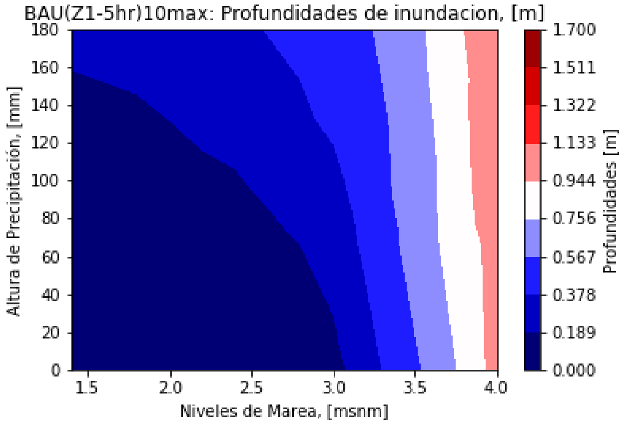


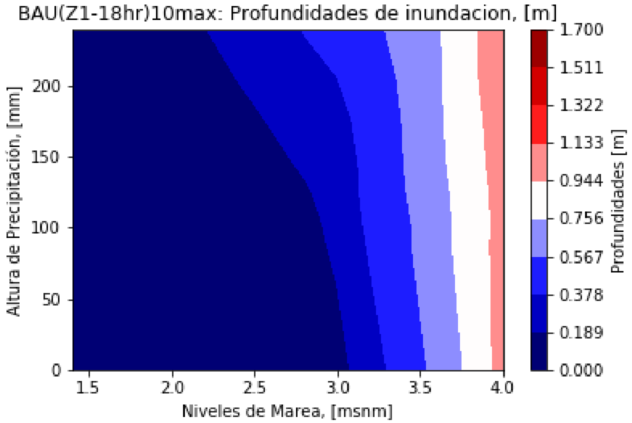




10 Max

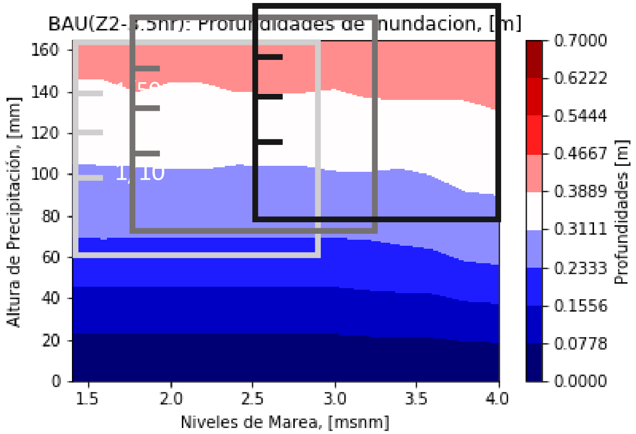


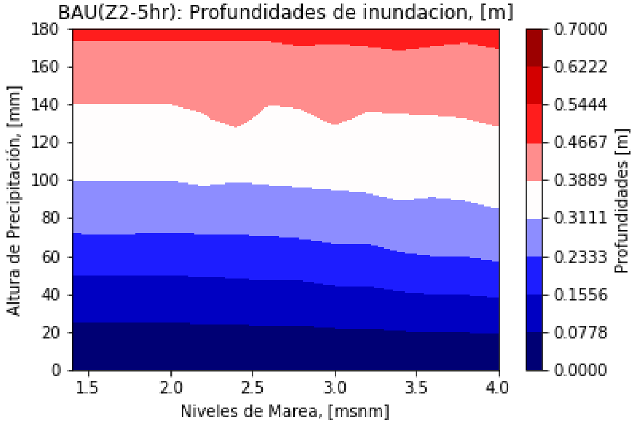


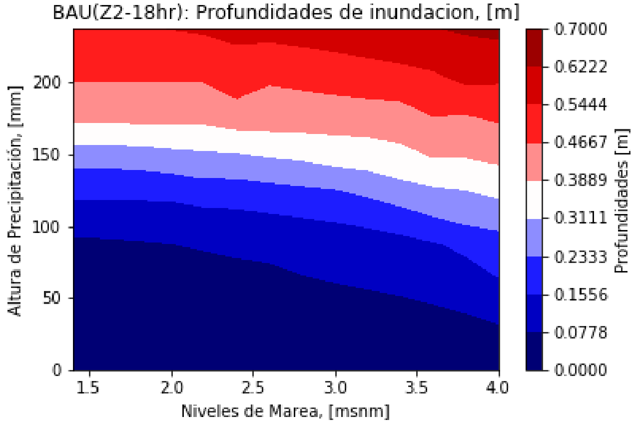


Zona 2

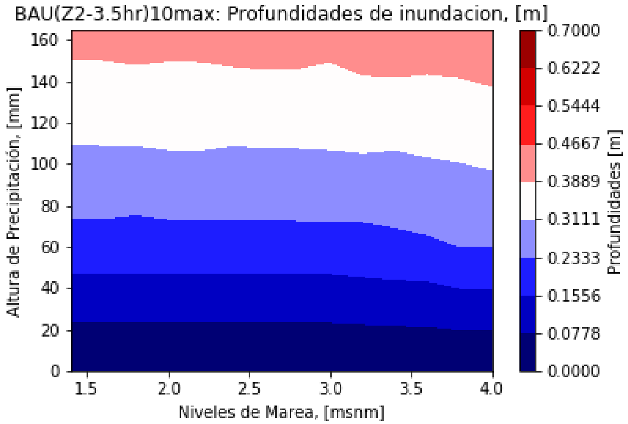
Max

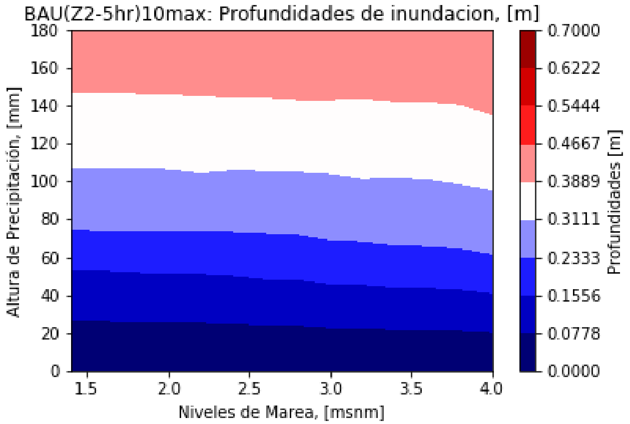


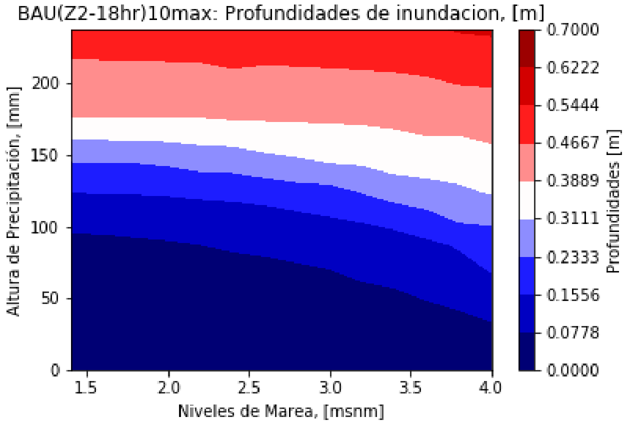




10 Max

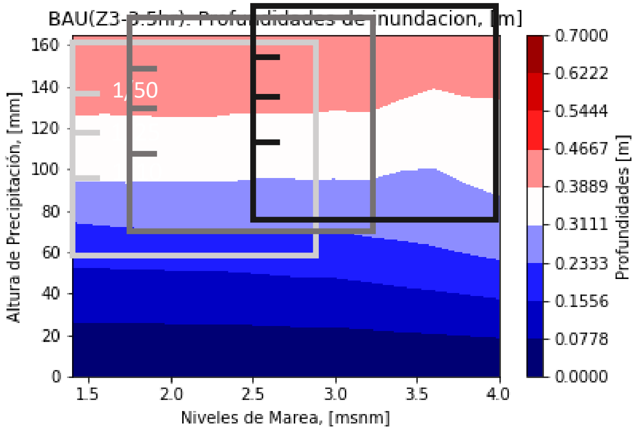


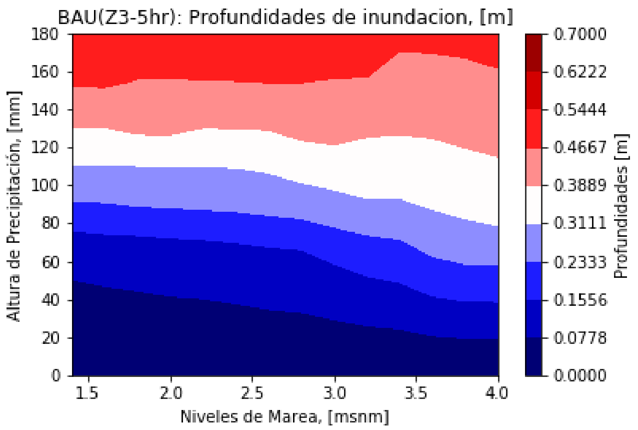


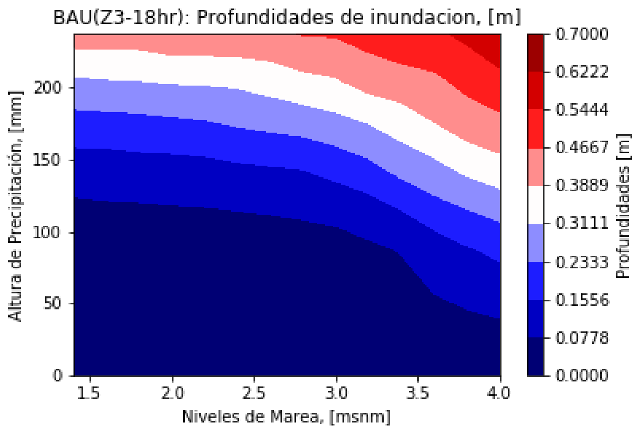


Zona 3

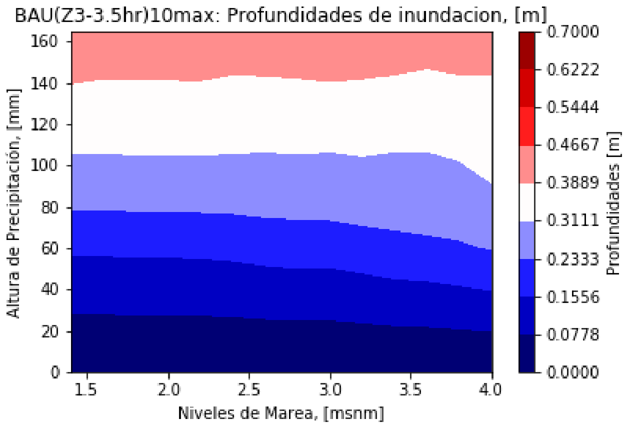
Max

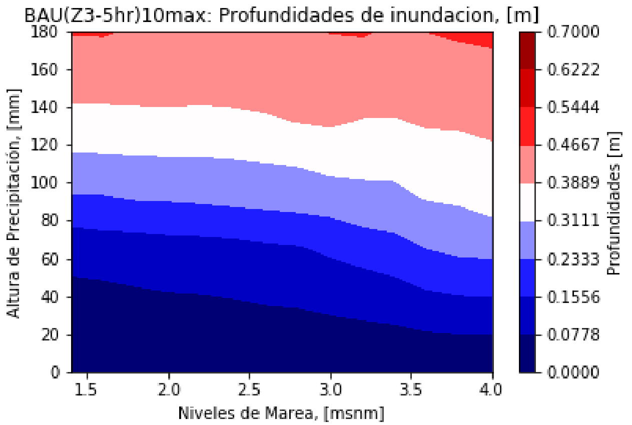


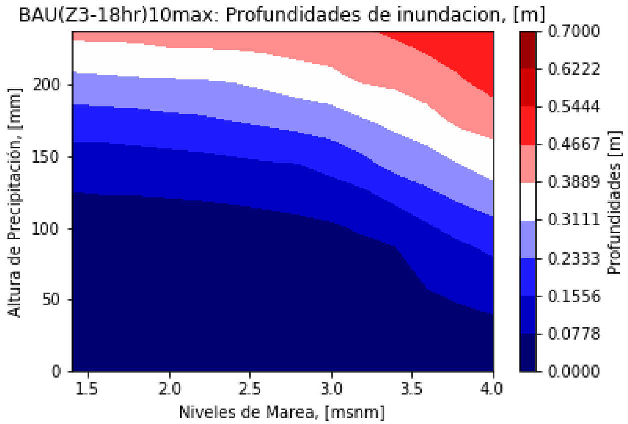




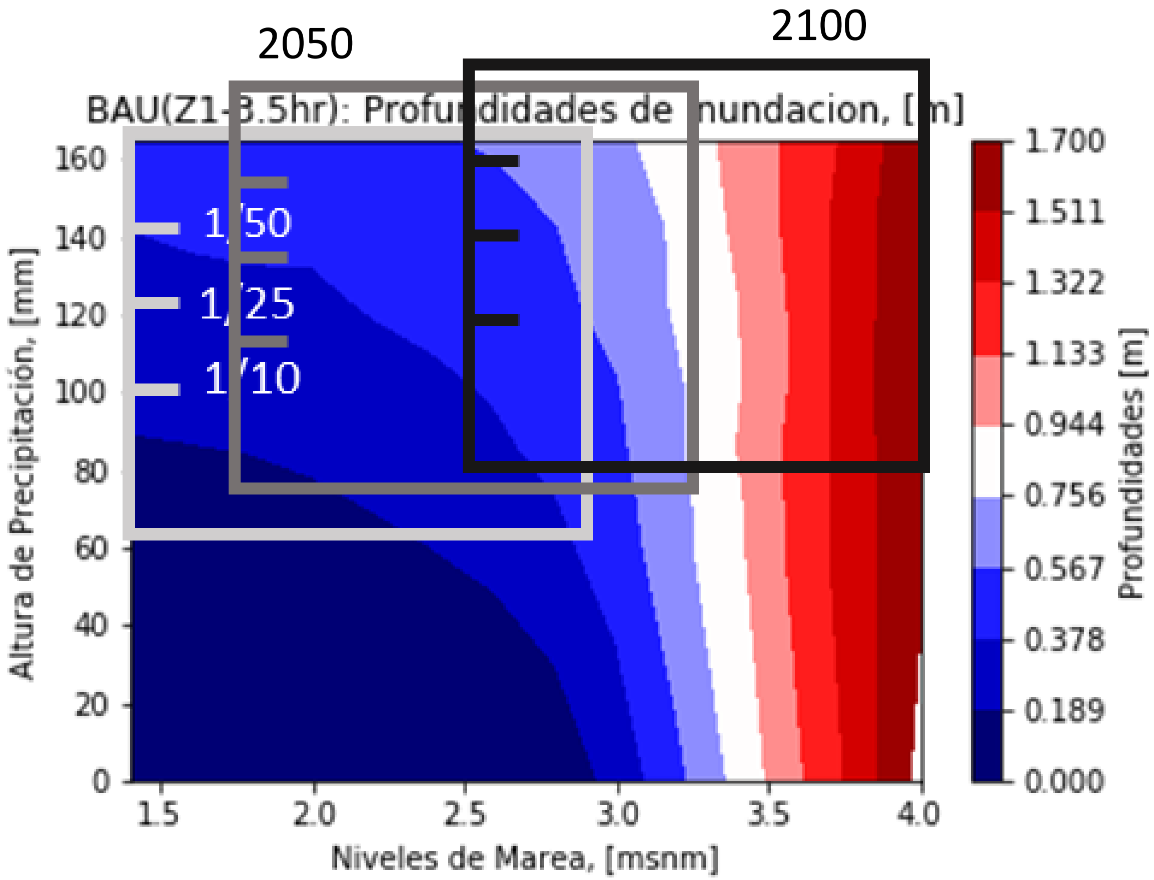
10 Max







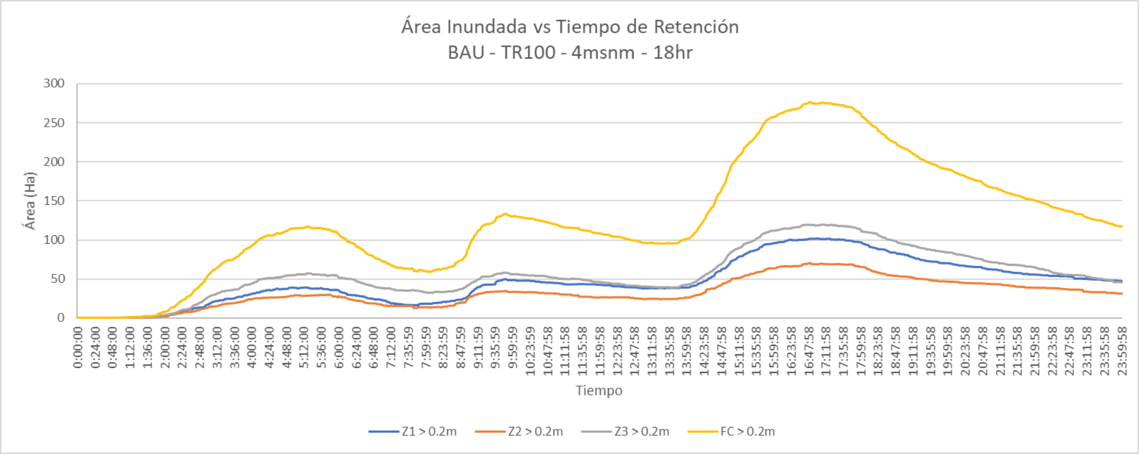
1/25 event now ~ 1/10 event 2050

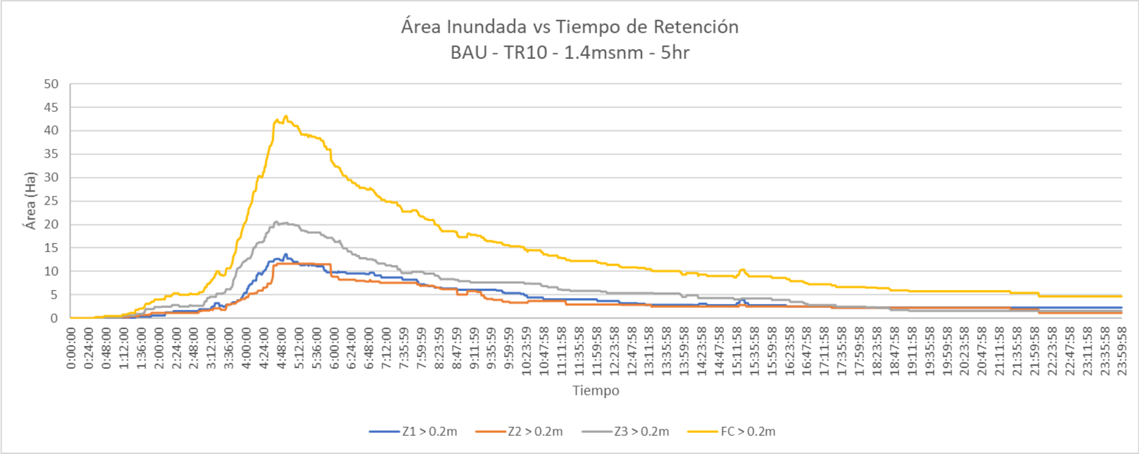


Flood development

4 scenarios are shown:

- TR100, 4m, 18hr, worst case;
- TR50, 3m, 18h, bad nino;
- TR25, 3m, 5h, future design;
- TR10, 2m, 5h, current design





Conclusions

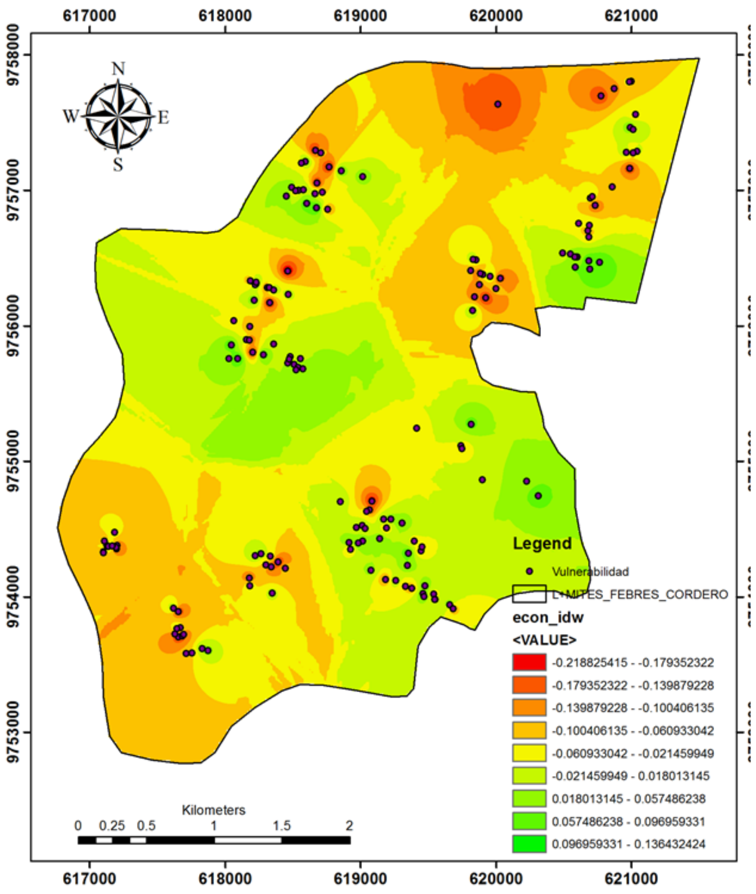
- In general the critical water depths over 0.2 are occuring regularly (between 1/1 and 1/10 years), over 0.4 are occuring less regularly (~1/25y).
- Precipitation is the dominant driver in all three zones at regular tidal levels.
- With increasing sea levels zone 1 experiences most sea influence, turning into dominance from 3m (Coastal inundation)
- In a worse case situation, with prolonged precipitation over 18 hours and 4m sea level we can sea a clear ‘accumulation’ of the flood because the drainage system cannot empty. Under more regular conditions flood durations is short.
- Climate change will need slightly higher design standards for whole system (not only drainage). >RT10 and >2m SL
- Drainage system has still a decent capacity to prevent high level and prolonged flooding ->so project hypothesis still holds
- **BUT** there is strong need for improved basic information on Drainage System layout and functioning (e.g. flood monitoring) and DEM. Continuous improvement of system model and understanding

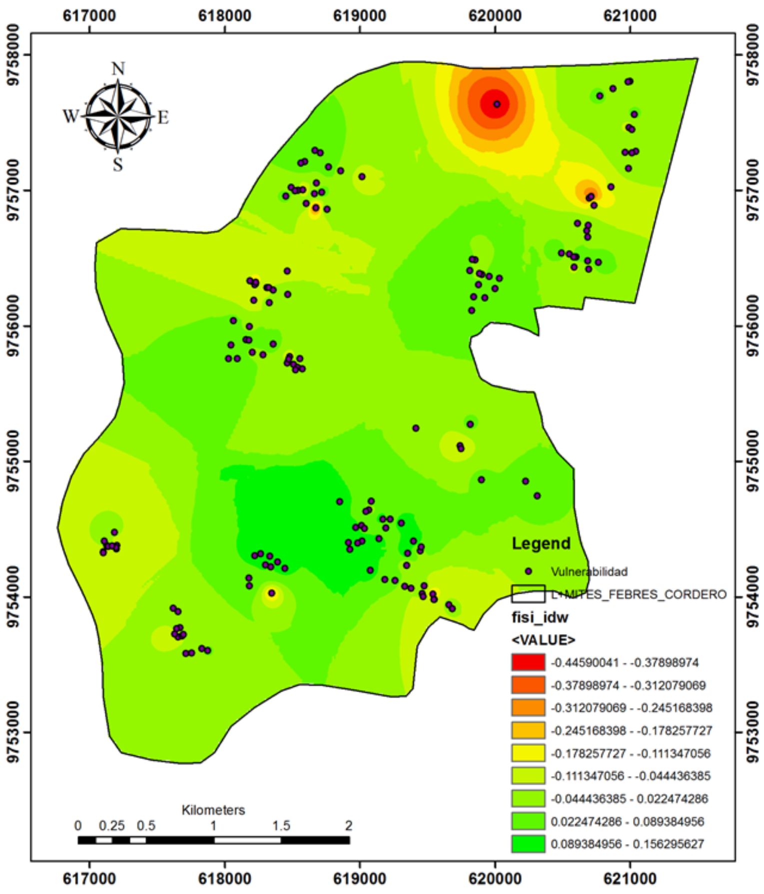
Sub-escenarios BAU	Periodo de retorno [año], P [mm]	Duración de lluvia [horas]	Marea (nivel de agua) [msnm]
A.1	1año, 60.9mm	3.5	1.4
A.2	1año, 60.9mm	3.5	2.0
A.3	1año, 60.9mm	3.5	4.0
B.1	10años, 108.5mm	5	1.4
B.2	10años, 108.5mm	5	2.0
B.3	10años, 108.5mm	5	4.0
C.1	50años, 204.6mm	18	2.0
C.2	50años, 204.6mm	18	3.0
C.3	50años, 204.6mm	18	4.0
D.1	100 años, 237.7mm	18	1.4
D.2	100 años, 237.7mm	18	2.0
D.3	100 años, 237.7mm	18	4.0

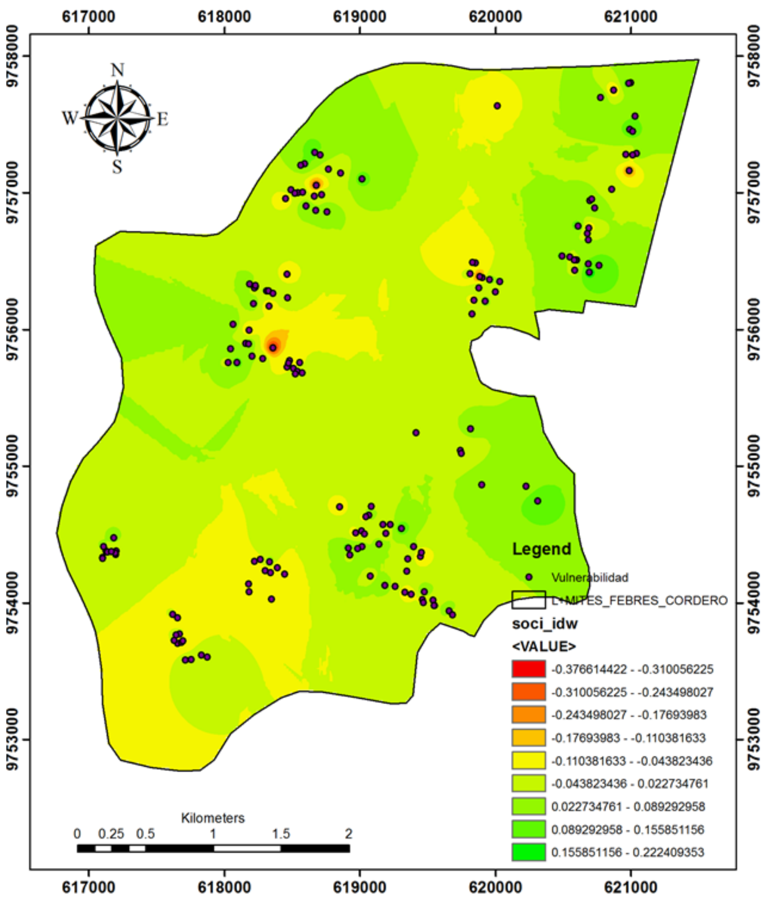
Selection of 2D maps for impact analysis and design

- D1 Baseline
- B2 Interagua
- C2 Bad Nino
- D.3 Worst case + extreme SLR

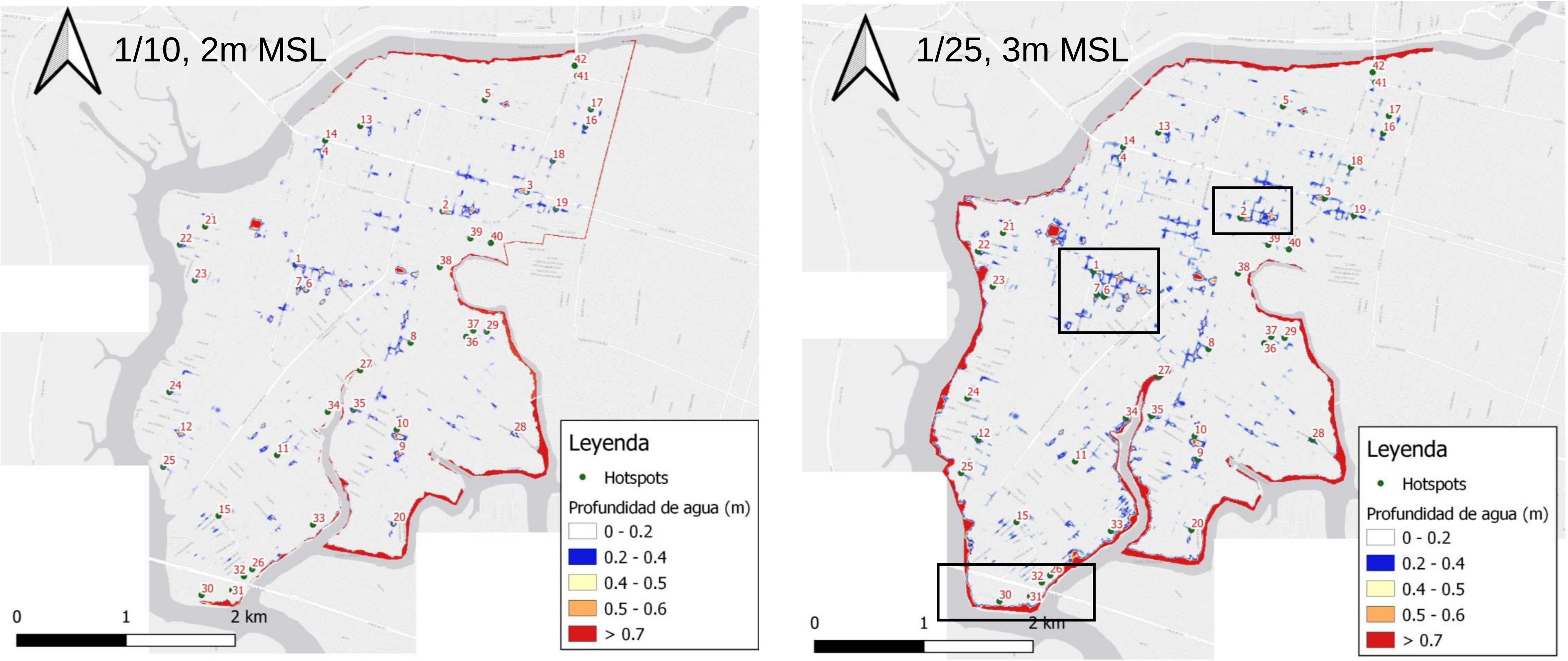
Physical, Economic and Social vulnerability based on questionaires





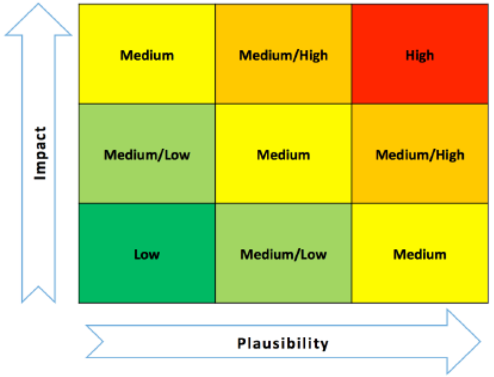


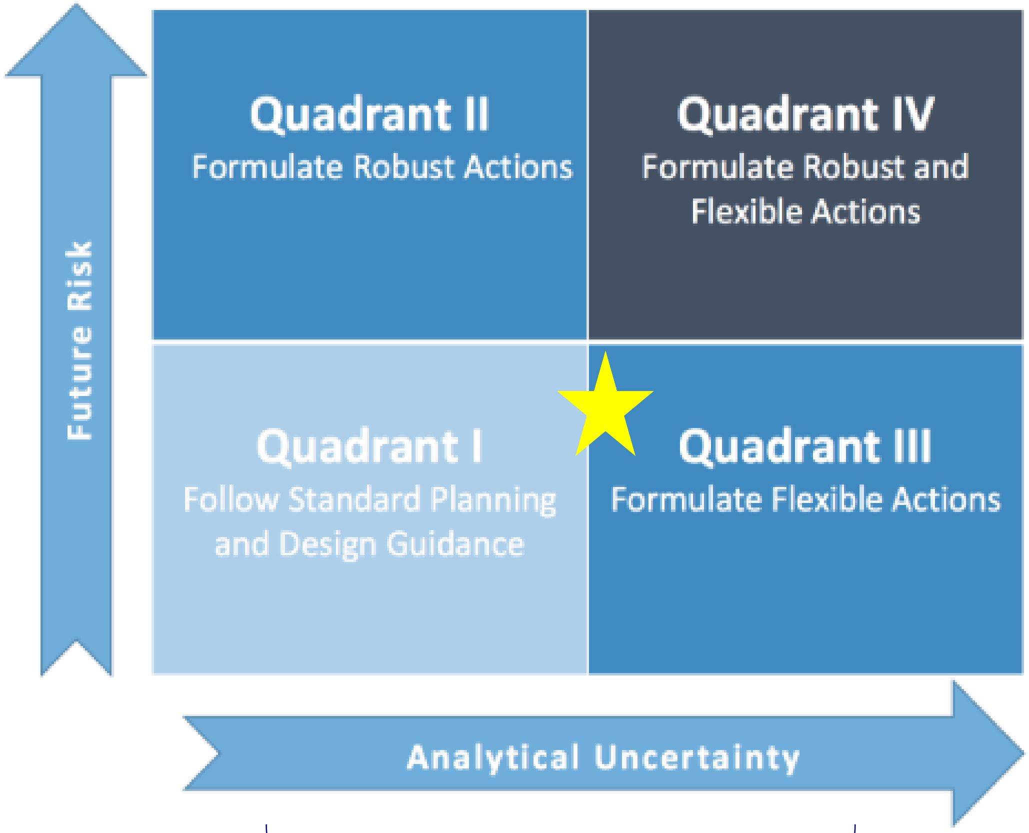
Hot spot selection



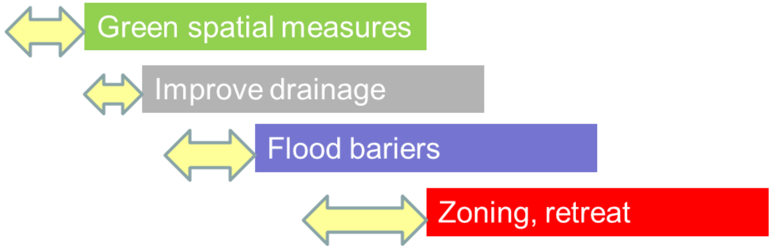
Step 2: The Bottom-Up Vulnerability Assessment

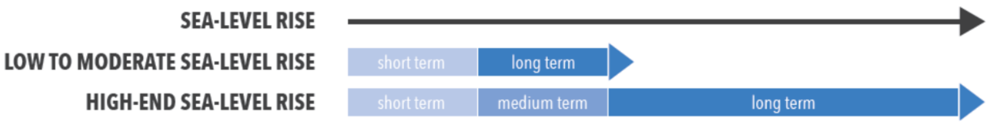
A function of Impact and Plausibility



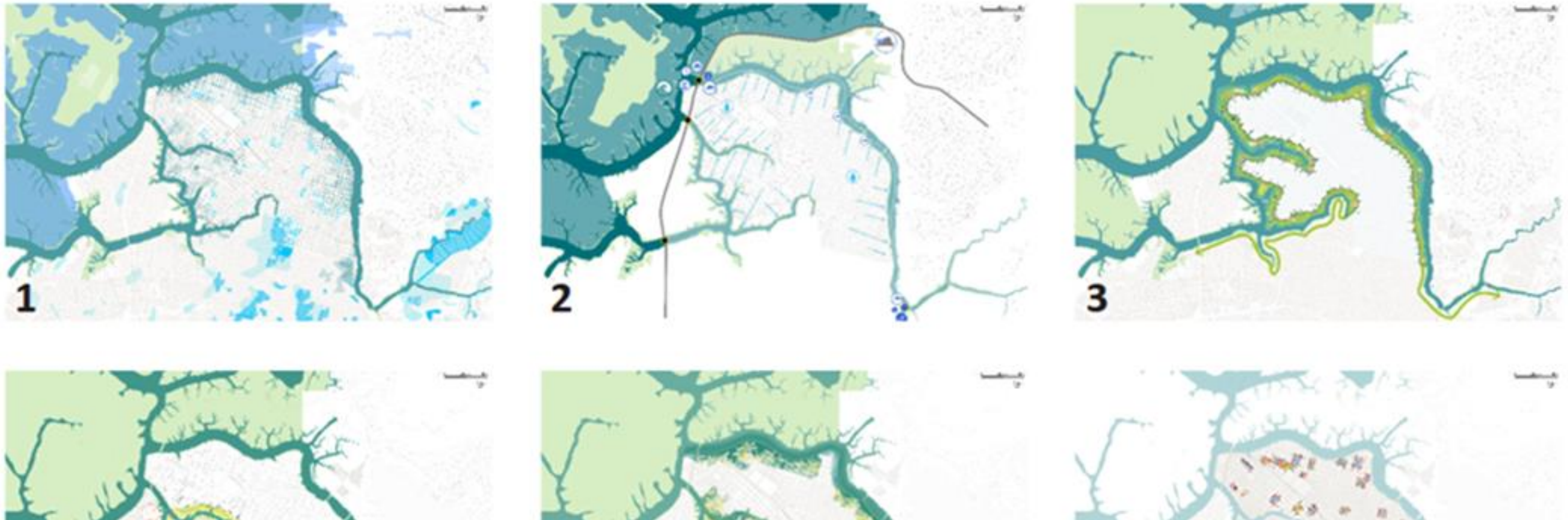


Based on the confidence in data and model

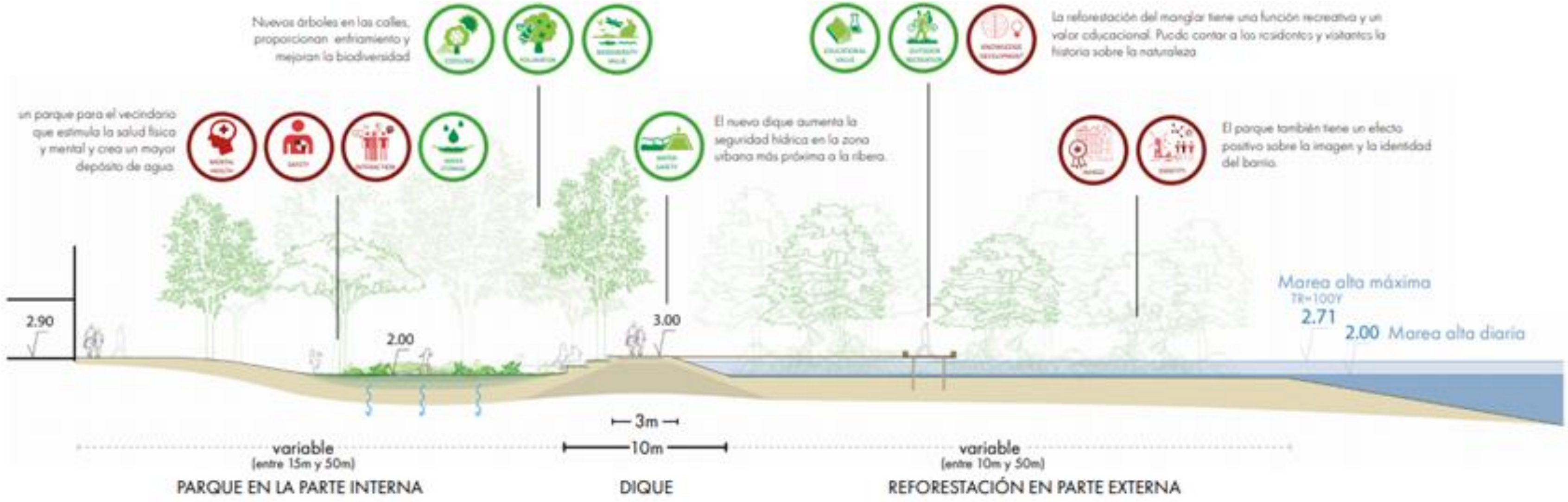




3) Formulate plan alternatives



Designing solutions for hot spots



DE URBANISTEN

BLUE GREEN EDGE PARK - *restoring the indigenous landscape and making places for the neighborhood*

3 Alternatives for zone 3

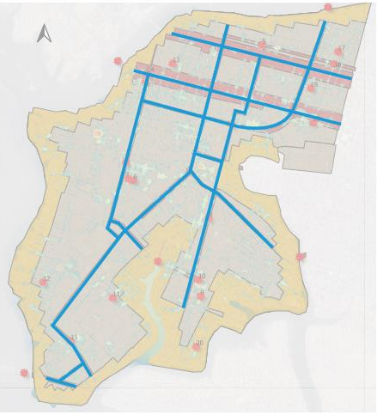
Estra

Esta estrat
ancho de
la calle tra
atractiva. I
esto a cab
han de mo
centro de
una peque
divisoria).
contendrá
bioswale p
agradable
rutas peat

En esta est
el aparcar
principal. (
puede red
concentra
manzanas

Añadir árbol

Visión de conjunto: Capacidad de almacenaje potencial de agua - *extrapolación a todas las calles comerciales principales*



LONGITUD TOTAL DE LAS CALLES COMERCIALES PRINCIPALES

22.670m

Longitud total de las calles comerciales principales en Febres Cordero

ESTRATEGIA 1
CALLE PERMEABLE

por metro cuadrado:

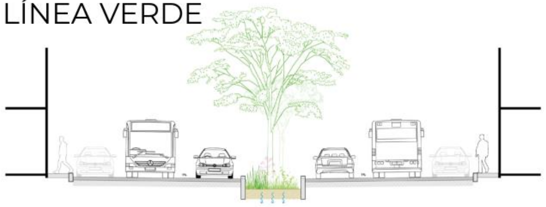
Almacenaje de agua bajo la carretera — **1.9 m³**

Pavimiento permeable + zona central — **5 m²**

Capacidad total de almacenaje de agua en todas las calles comerciales — **43.070 m³**

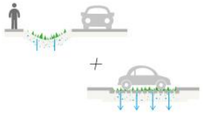
Superficie permeable total en todas las calles comerciales — **113.350 m³**

ESTRATEGIA 2
LÍNEA VERDE



por metro cuadrado:

Bioswale (linear) — **1.775 m³**



Pavimiento permeable + Bioswale (linear) — **5.35 m²**

Capacidad total de almacenaje de agua en todas las calles comerciales — **40.240 m³**

Superficie permeable total en todas las calles comerciales — **121.285 m³**

ESTRATEGIA 3
CALLE TRANSITABLE

por metro cuadrado:

Bioswale (linear) — **2.5 m³**

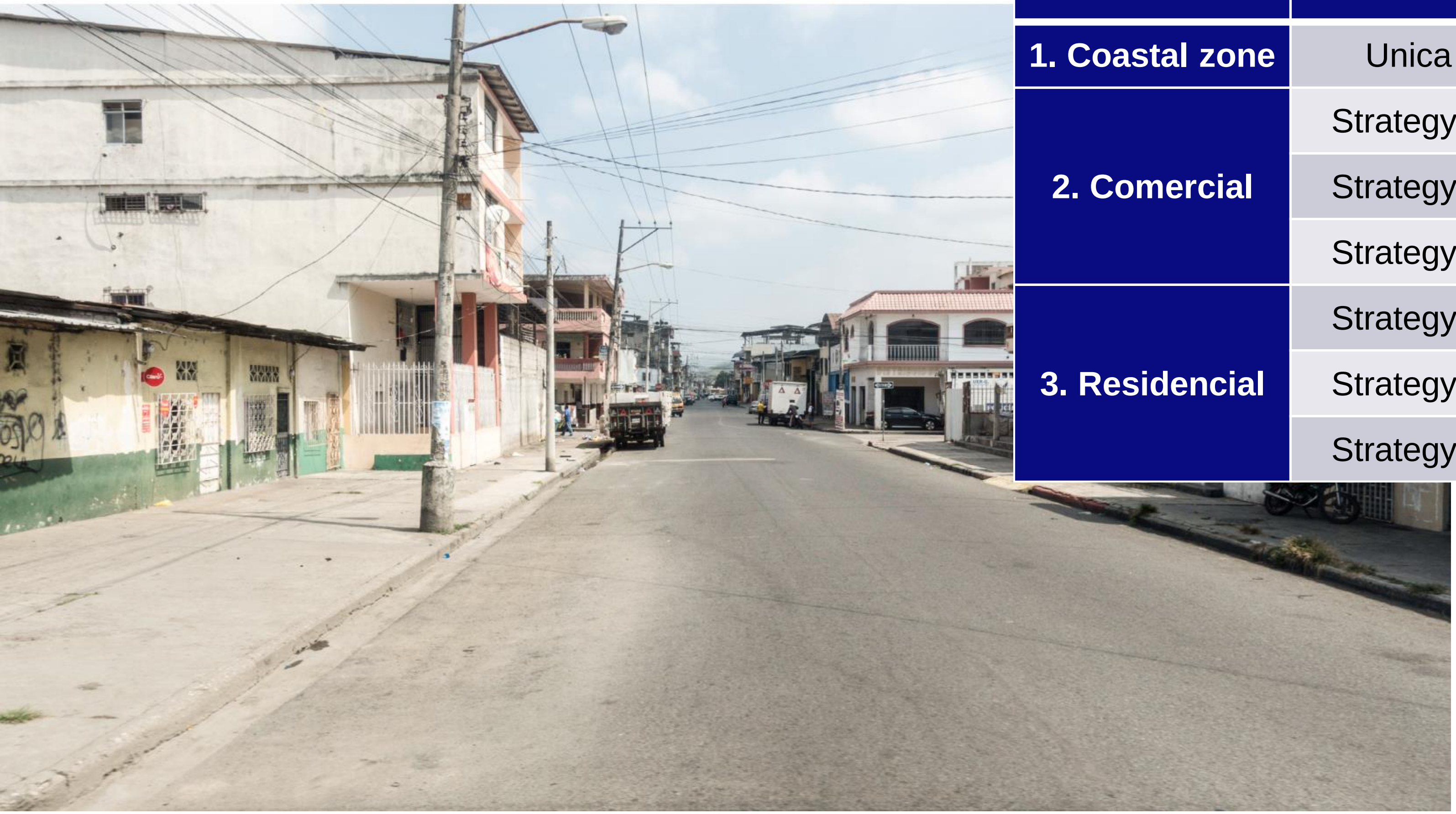
Bioswale (linear) — **5 m²**

Capacidad total de almacenaje de agua en todas las calles comerciales — **56.675 m³**

Superficie permeable total en todas las calles comerciales — **113.350 m³**

3 Alternatives for zone 2

Step 4) Evaluation of plan alternatives: Effectiveness



Zone	Strategy	Reduction of flood extension	Reduction of drainage time	Reduction of water depth
1. Coastal zone	Unica	8%	40%	20%
2. Comercial	Strategy 1	68%	0%	10%
	Strategy 2	70%	0%	16%
	Strategy 3	66%	71%	40%
3. Residencial	Strategy 1	24%	0%	11%
	Strategy 2	35%	0%	19%
	Strategy 3	57%	90%	47%

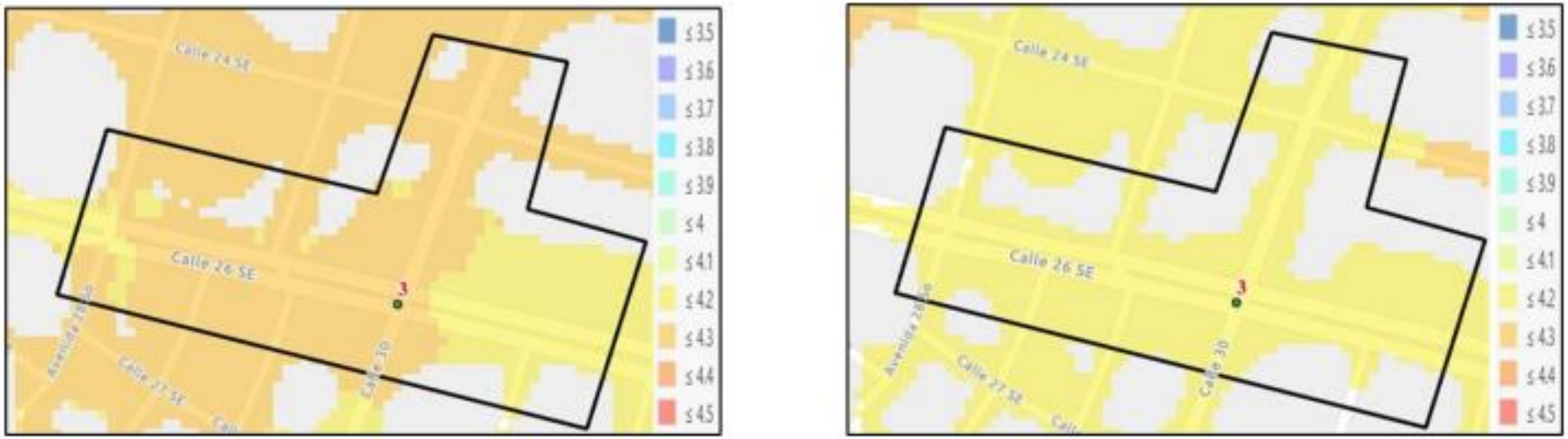


Imagen 73. Comparación de área inundada y niveles de inundación para la Zona 2. Izquierda: BAU TR10; derecha: Solución B TR 10.

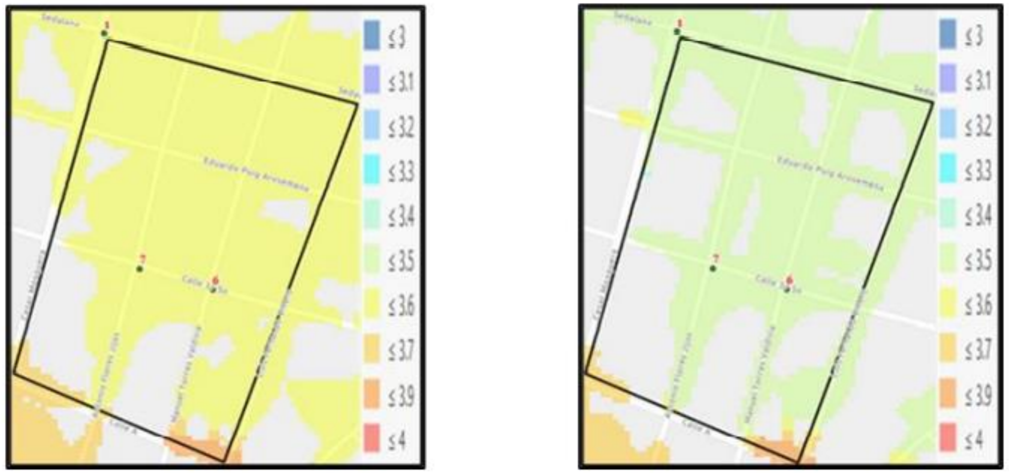


Imagen 72: Comparación de área inundada y niveles de inundación para la Zona 3. Izquierda: BAU TR10; derecha: Solución B TR 10.

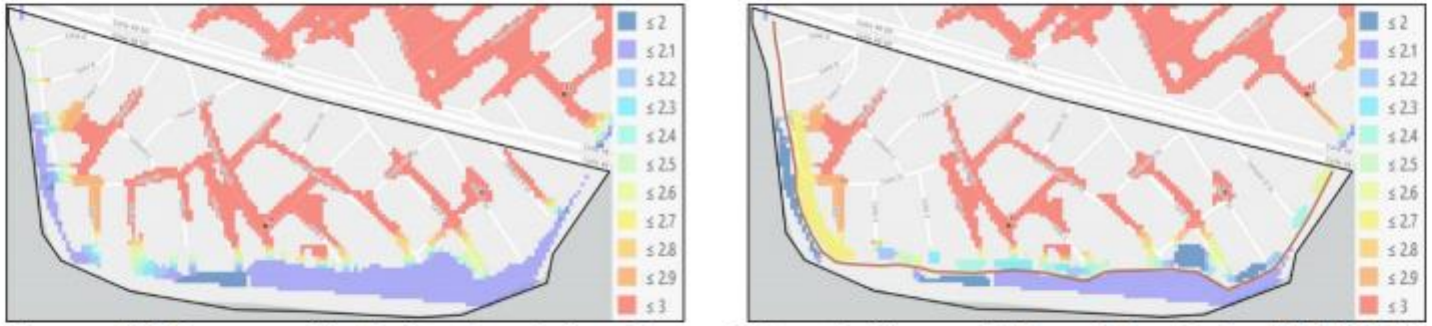
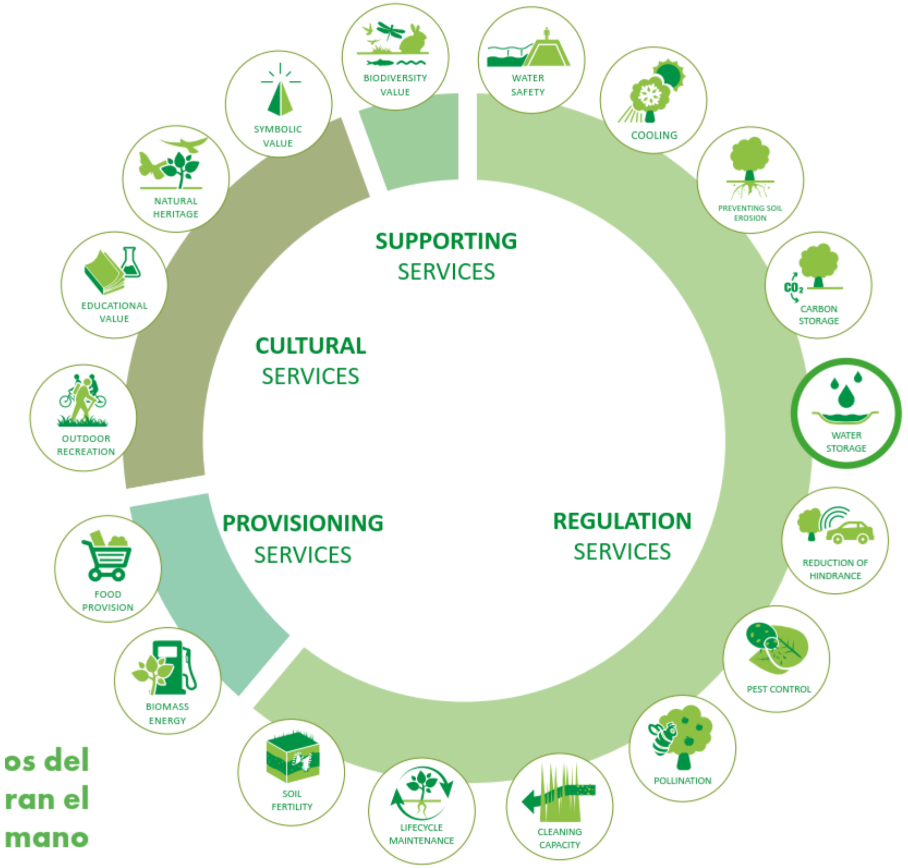


Imagen 74. Comparación de área inundada y niveles de inundación para la Zona 1. Izquierda: BAU TR10; solución de Zona 1 TR10, línea roja representa barrera vegetal

Costs and benefits

	Zona 1	Zona 2			Zona 3		
	Parque natural	Carretera permeable	Línea verde	Calle transitable	Per-meable	Verde	Reclamo
Espacio público reclamado	**		*	**	0	0	1.855 m²
Imago y identificación	**		*	***	*	**	***
Bienestar (mental, físico, social)	**	*	*	**		*	***
Seguridad	*		*	**			
Valor educacional	*						
Valor comercial				*			
Árboles	**		**	***	185	450	500
Áreas bioswales	**	*	**	*	0	4.238 m²	6.930 m²
Pavimento permeable		*	*	*	7.777 m²	3.540 m²	2.623 m²
Cooling (refrescar)	**	*	**	***	*	**	***
Polinización y biodiversidad	**	*	**	***	*	**	***
Capacidad de almacenamiento	**	*	*	**		*	**
Agua limpia	**		**	**		*	**



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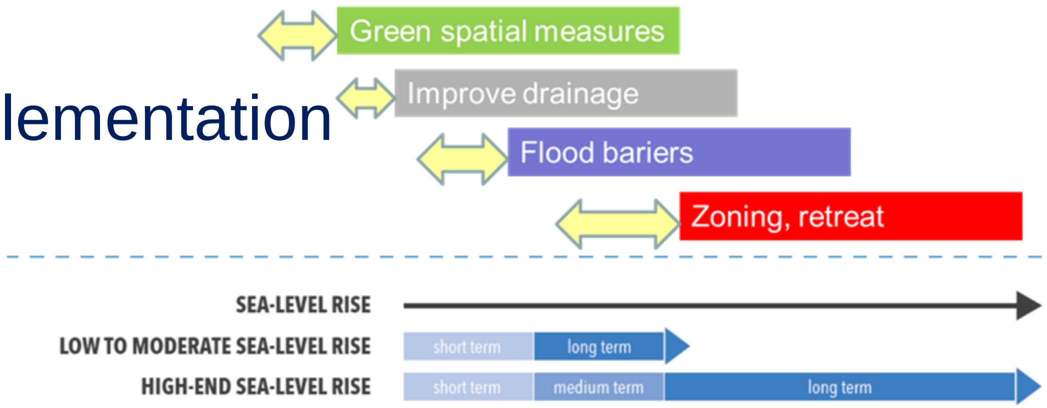
Lessons learnt and way forward

- CRIDA has potential for urban application
- Need to include preferences from citizens and business at an early stage
- This also provides an opportunity for additional data collection
- Need to include all relevant departments for spatial planning, transport, parks, risk management etc.
- Green solutions proposed fit in an integrated view of solutions in space and time
- Analysis and monitoring should be well integrated in the urban WASH management
- Project provided a good basis for implementation
- And upscaling



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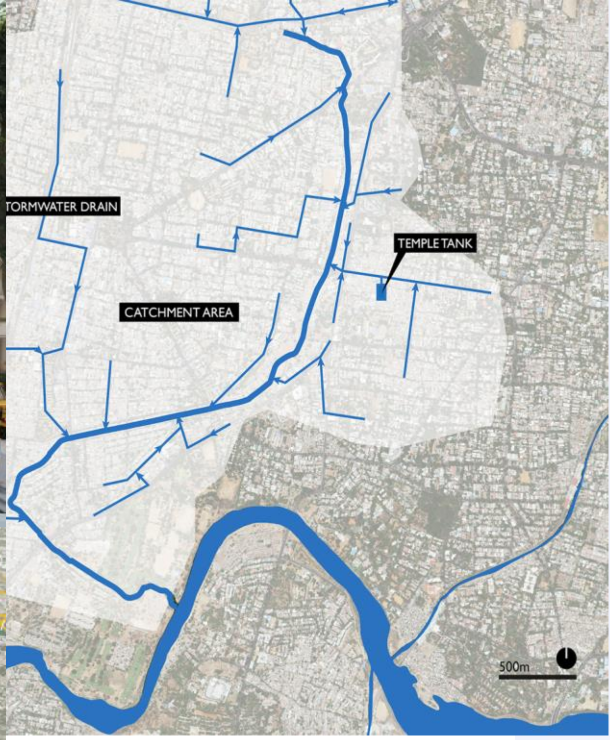
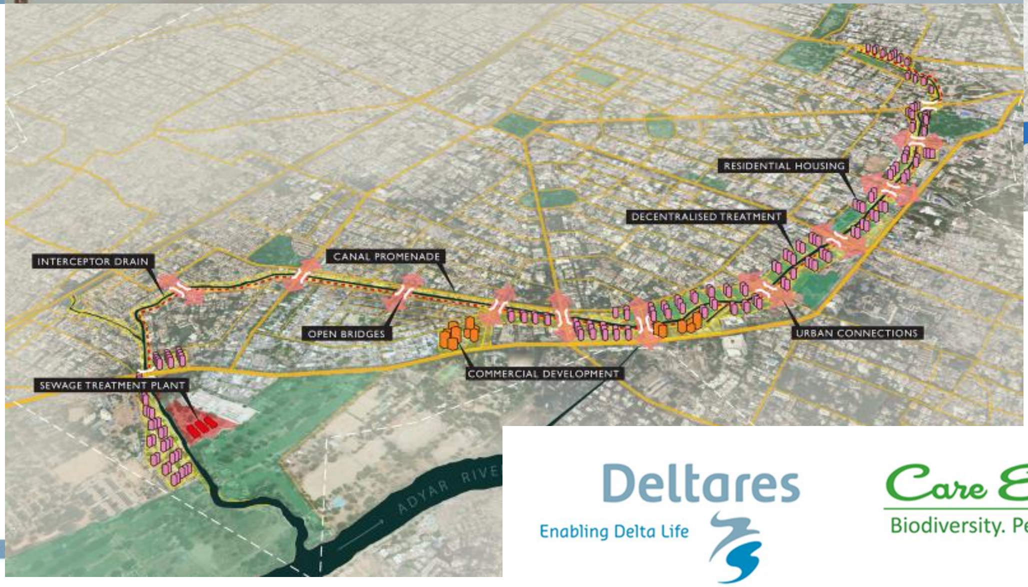
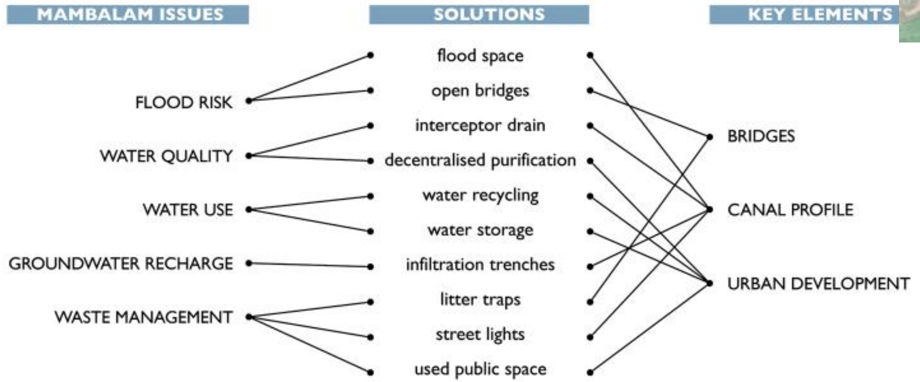
WATER AS LEVERAGE PROPOSAL CHENNAI- APRIL 2019

RISE சென்னை

RISING WATERS, RAISING FUTURES







Deltares Enabling Delta Life

Care Earth Trust Biodiversity. People. Conservation

BNTHMCRWL BENTHEM CROUWEL ARCHITECTS

Indian Institute of Technology Madras

KIT Karlsruher Institut für Technologie

ARCADIS

WAGGONNER & BALL

IGCS INDO-GERMAN Centre for SUSTAINABILITY

VanderSat

periurban initiative

Thanks for listening

Contact details:

Ad.Jeuken@deltares.nl

Links to shown software:

https://publicwiki.deltares.nl/display/AP/Adaptation+Pathways

https://www.deltares.nl/en/software/adaptation-support-tool-ast/

https://www.deltares.nl/en/software/module/d-flow-flexible-mesh/

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