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ADAPTATION

Deltares

Water Adaptation Community Webinar

Integrated Coastal Zone Management for Climate Resilience

29th June 2023, 13:00 CEST



Webinar Knowledge Kit

Knowledge Kit Content

- Background
- **Presentation:** The Geography of Future Water Challenges Bending the Trend
- **Presentation:** OECD Strengthening Climate Resilience in Coastal Areas
- **Presentation:** Ghana Coastal Zone – Resilience for a Sustainable Future
- **Presentation:** Singapore’s Approach Towards Coastal Protection
- **Presentation:** Coastal Resilience Beira, Sundarban and Tacloban
- **Presentation:** Intergrating Coastal Zone Management in Canada
- **Presentation:** Coastal Zone Management of Manhattan New York
- Related Links
- Stay Connected

Background

Chair:

- [Ms. Aoife Fleming](#), Youth Leadership and Education Office, Global Center on Adaptation

Speakers:

- [Mr. Arno Bouwman](#), PBL Netherlands Environmental Assessment Agency
- [Ms. Mikaela Rambali](#), Policy Analyst, OECD
- [Dr. John Kissi](#), Chief Executive of the Ghana Hydrological Services Authority
- [Mr. Chang Chian Wui](#), Coastal Protection Department, Singapore
- [Mr. George Peters](#), Climate Resilience Global Leading Market Director, Royal Haskoning DHV
- [Ms. Joanna Eyquem](#), Managing Director, Intact Center on Climate Adaptation
- [Mr. Matthijs Bouw](#), Architect and Urbanist, One Architecture

Watch the recording [here](#).

- Marine transportation and ocean tourism are trillion-dollar industries. Without climate adaptation measures, damage to infrastructure, losses in crop production, and reduced fishing yields could cause average GDP losses of up to 19.5 percent in the world's deltas similarly, it is estimated that flooding due to climate change could affect 20% of global GDP. As the impacts of climate change continue to intensify, flooding risk will increase, putting infrastructure valued between US\$7.9 and US\$12.7 trillion at risk, as well as the lives of hundreds of millions of people. With 40% of the global population living within 100 km of the coast and 11% living in low-lying coastal areas, the impacts of sea level rise could be felt as soon as 2050. Accelerating adaptation efforts is essential to protect people, landscapes, economies, and even the very existence of some islands and deltaic coasts.
- "Futureproofing Water and Climate Adaptation" is a webinar series focused on adaptation strategy, practices, and financing for deltas, urban deltas, small islands and coastal areas. The series is designed to support the ambition of the International Panel on Deltas and Coastal Areas - to build capacity for effective adaptation planning, governance and finance – through online knowledge sharing and creation. This series of webinars consists of sharing good practices, panel discussions and interactive community dialogues The webinar "Integrated Coastal Zone Management for Climate Resilience" shares the need for and complexity of integrated coastal zone management plans.



PBL Netherlands Environmental
Assessment Agency

THE GEOGRAPHY OF FUTURE WATER CHALLENGES

BENDING THE TREND



PBL Netherlands Environmental
Assessment Agency

webinar Integrated Coastal Zone Management

The Geography of Future Water Challenges

BENDING THE TREND

29 June 2023

Willem Ligtoet

Arno Bouwman

PBL Netherlands Environmental Assessment Agency



From challenges to solutions

Part 1 Setting the scene

Part 2 Exploring future pathways

River basins

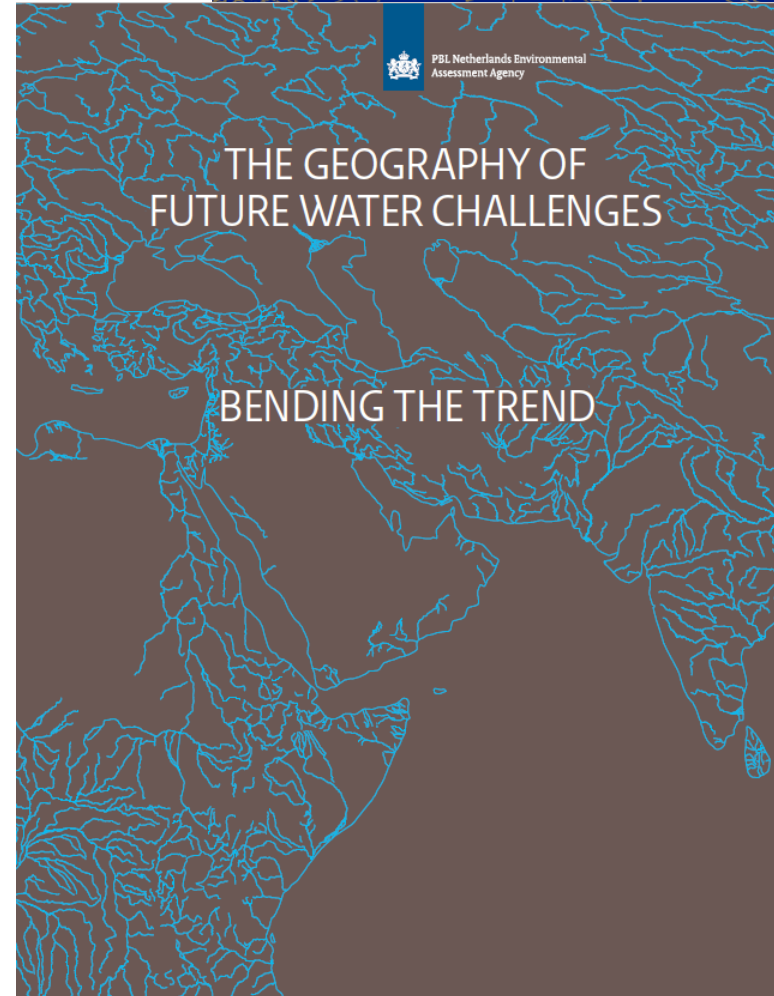
Deltas and Coasts

Drylands

Cities

Part 3 The global picture

Part 4 The way forward



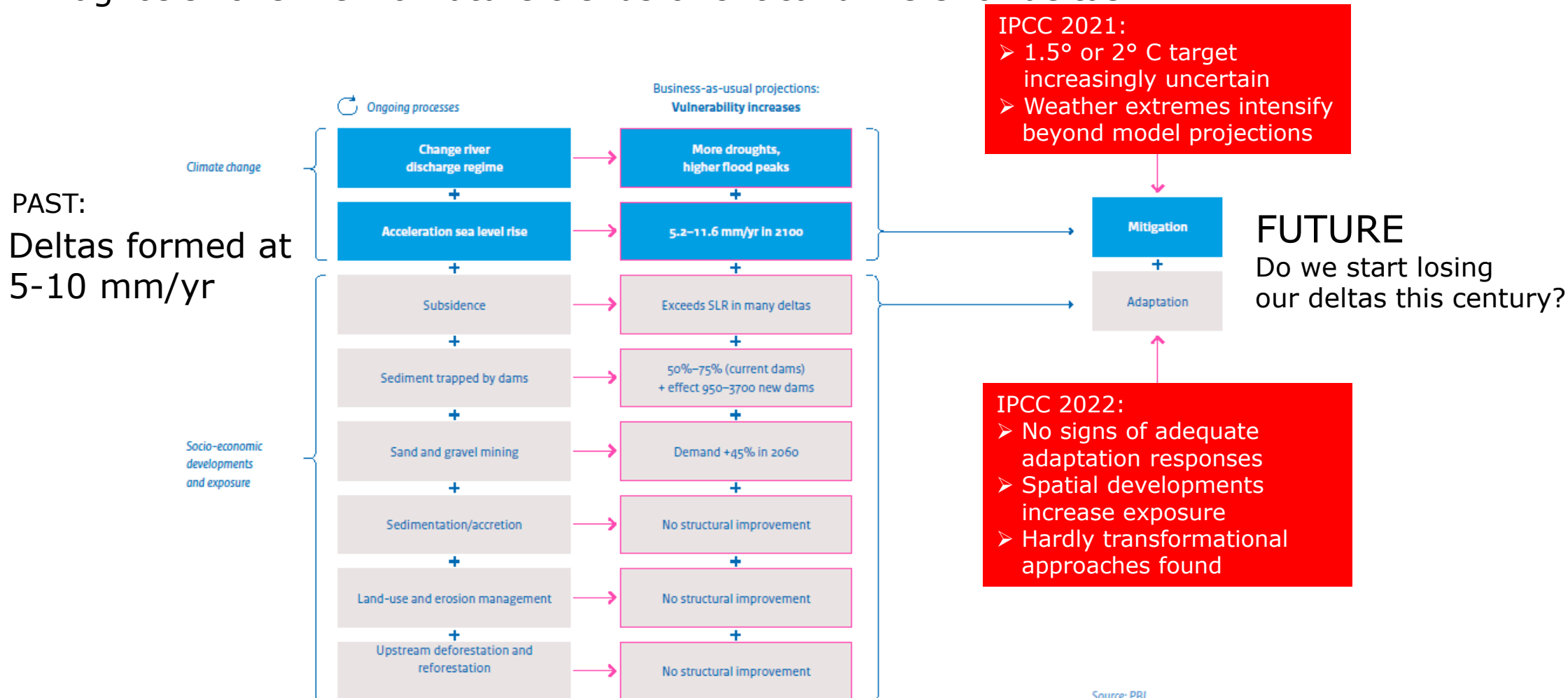
Deltares



De Waterwerkers

Today: all signs for deltas are on red

Diagnosis: overview of future trends of critical drivers for deltas



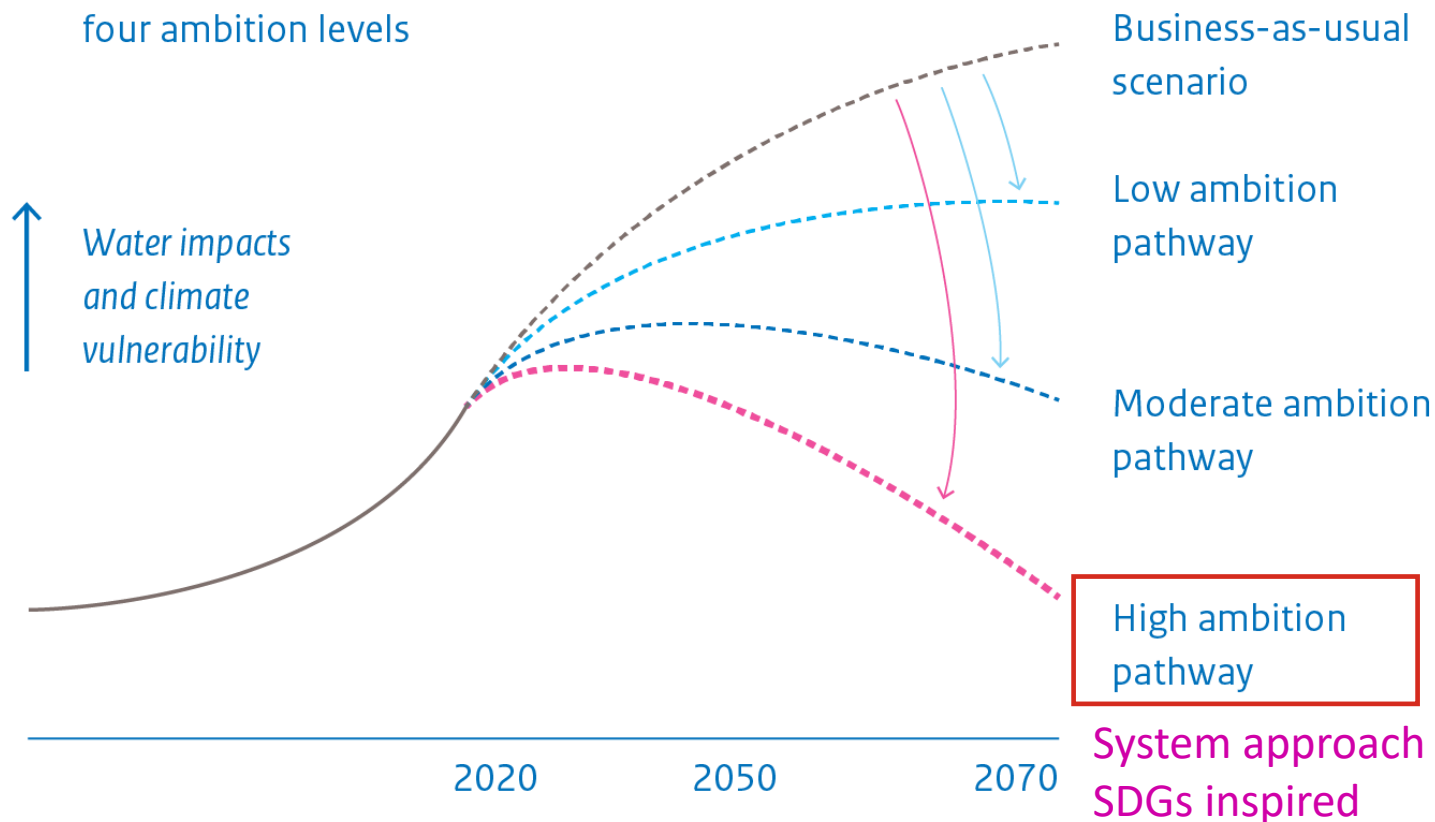


Bending the trend: exploration of future pathways of solutions

SSP2/RCP6.0

Bending the trend

Exploring solutions with four ambition levels



Source: PBL

Eight main water themes

- Water use and crop production
- Water pollution, sanitation and wastewater treatment
- Flooding from sea and rivers
- Hydropower
- Subsidence
- Ecological quality
- Water, displacement and conflict
- Water and climate resilient urban development



Our starting point: system approach based on four hotspot landscapes

River basins

- Upstream dams
- Sediment flows and mining
- Upstream water use
- Upstream water pollution
- Melting glaciers

Drylands



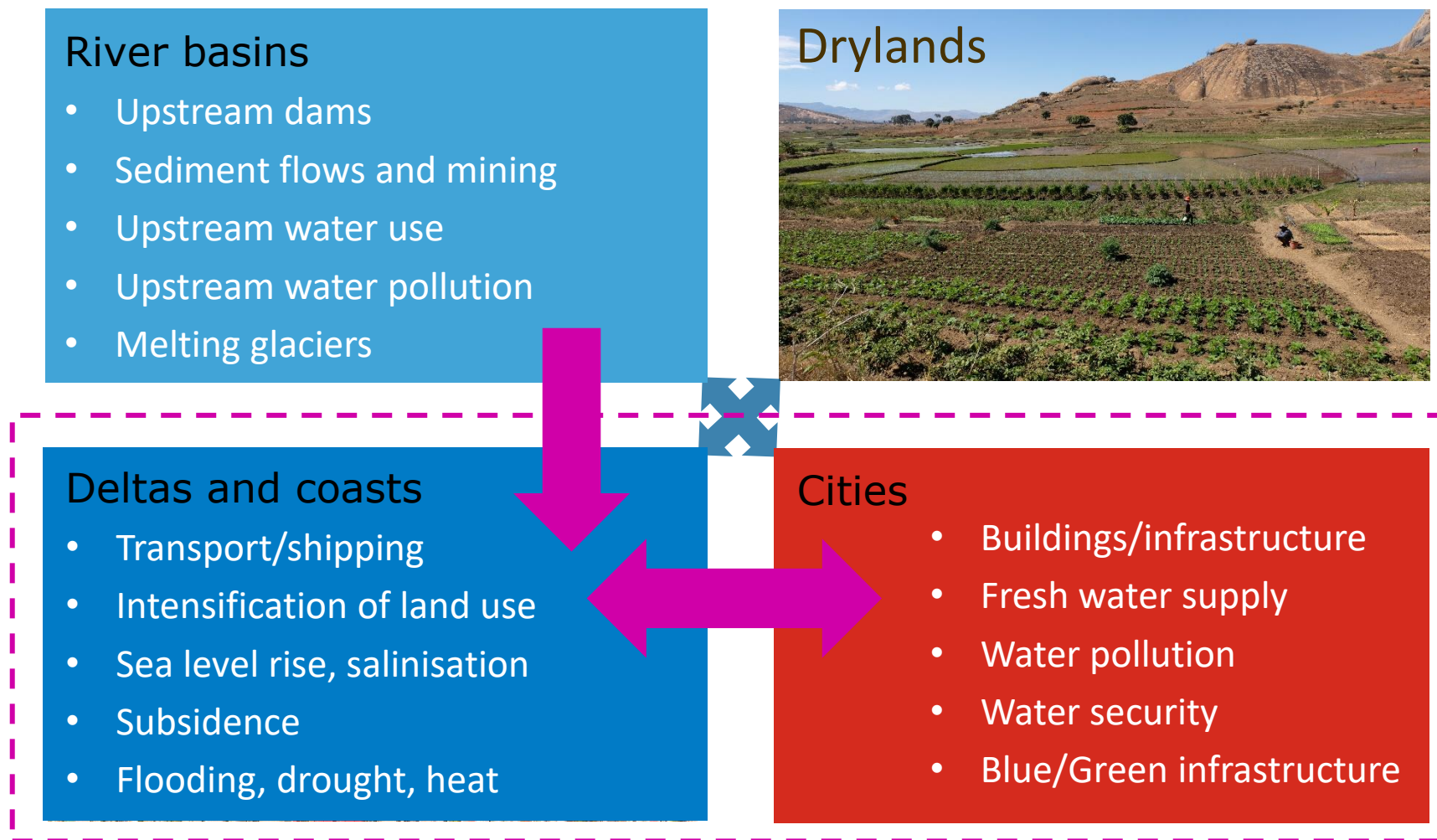
Deltas and coasts

- Transport/shipping
- Intensification of land use
- Sea level rise, salinisation
- Subsidence
- Flooding, drought, heat

Cities

- Buildings/infrastructure
- Fresh water supply
- Water pollution
- Water security
- Blue/Green infrastructure

Long-term sustainability of deltas and coasts requires a coherent and adaptive long-term strategy, also addressing upstream challenges.

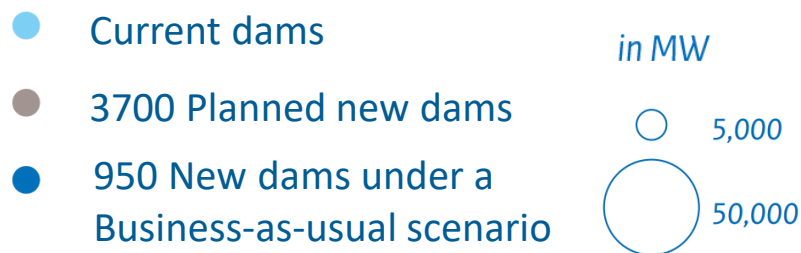
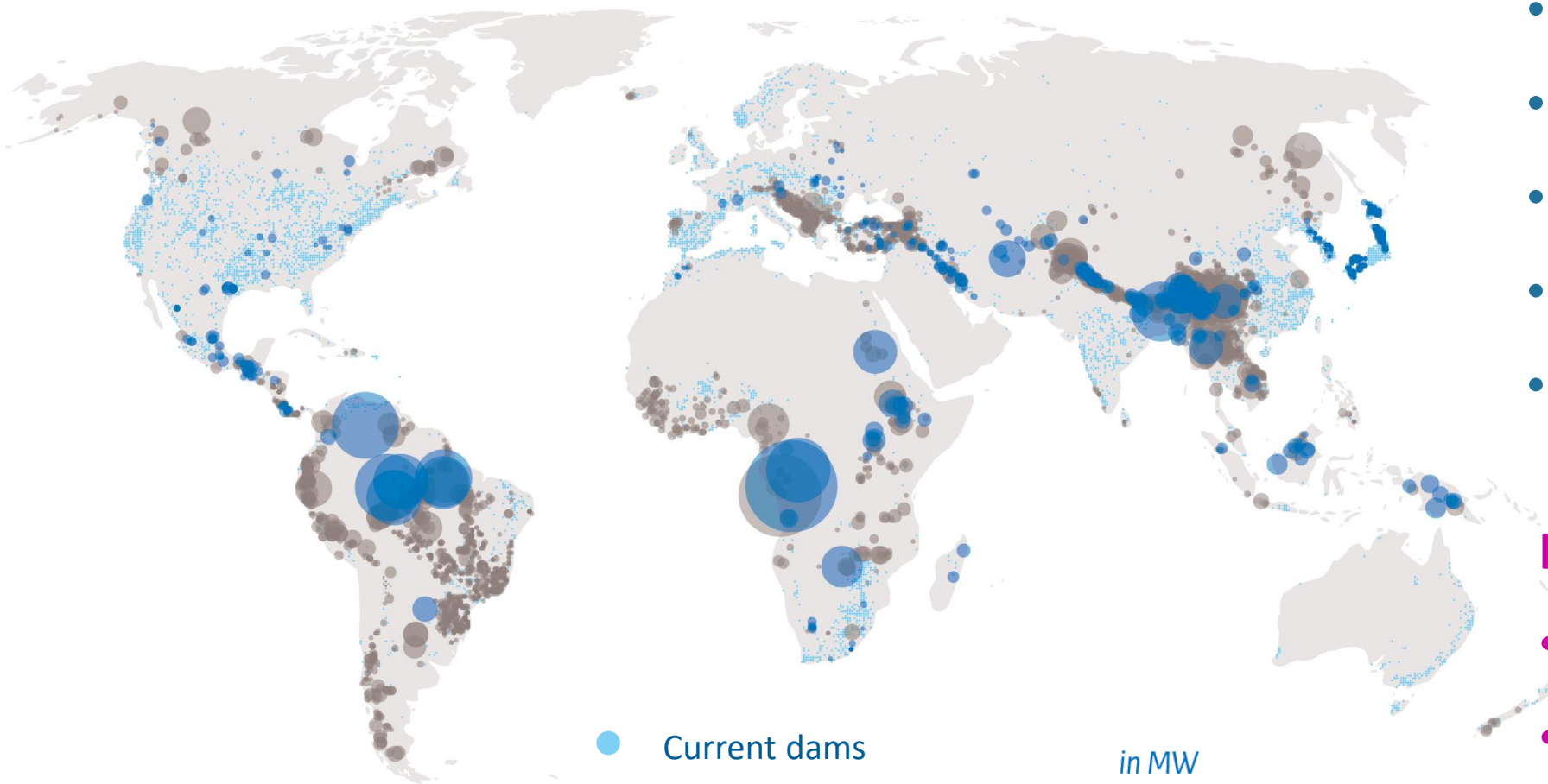




Deltas and Coasts: upstream many more dams likely to be built

Negative implications for:

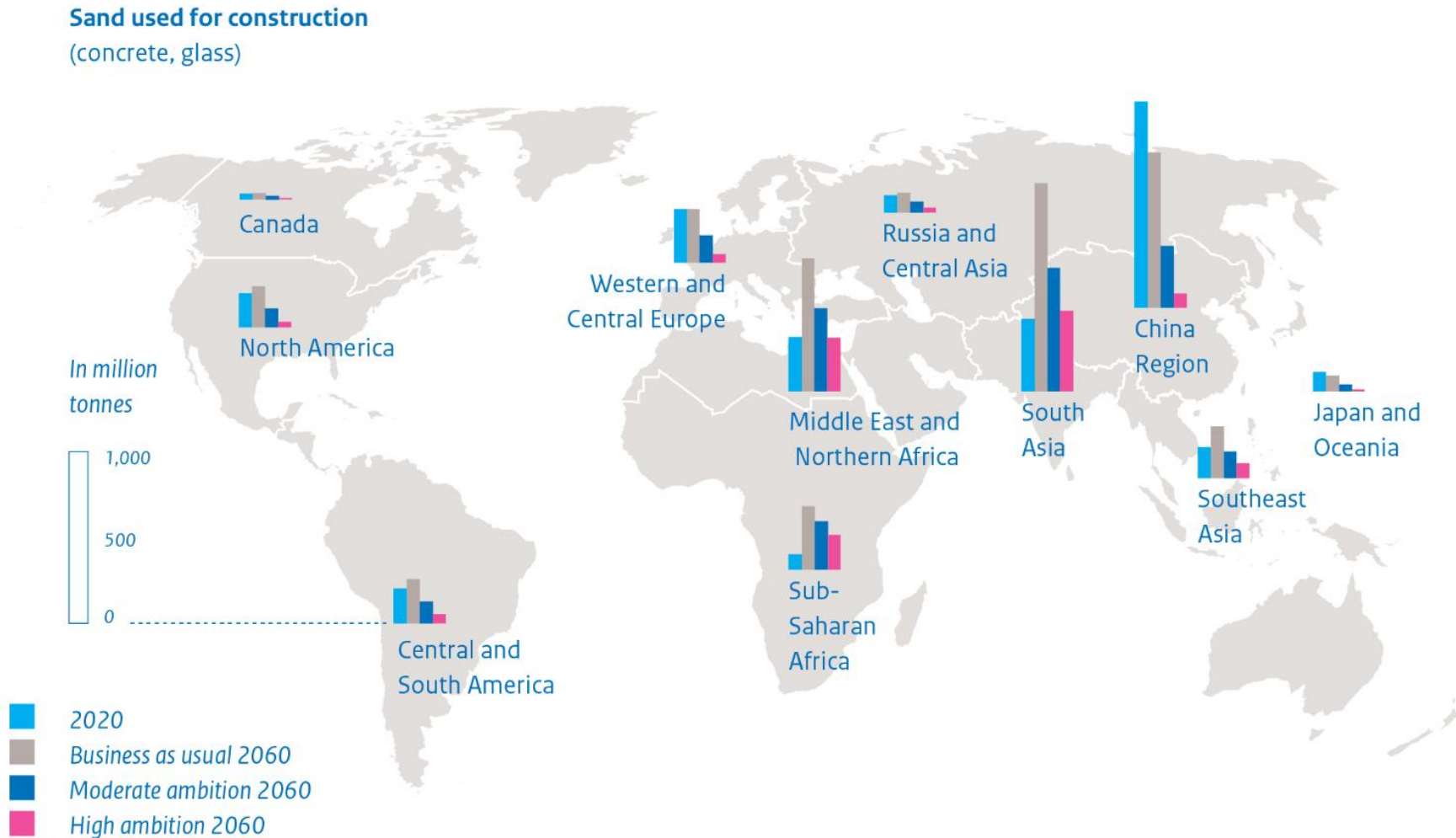
- water dynamics
- sediment flows
- fish migration
- ecological quality
- transboundary tensions



High ambition pathway

- Stand-still approach
- no large new dams
- >2100 small new hydropower facilities

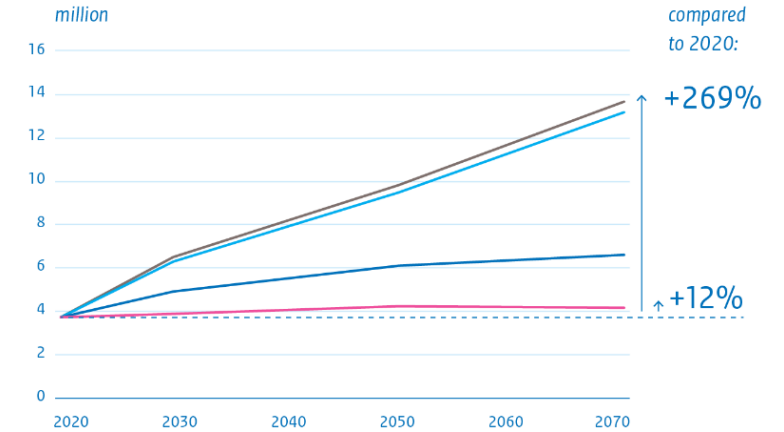
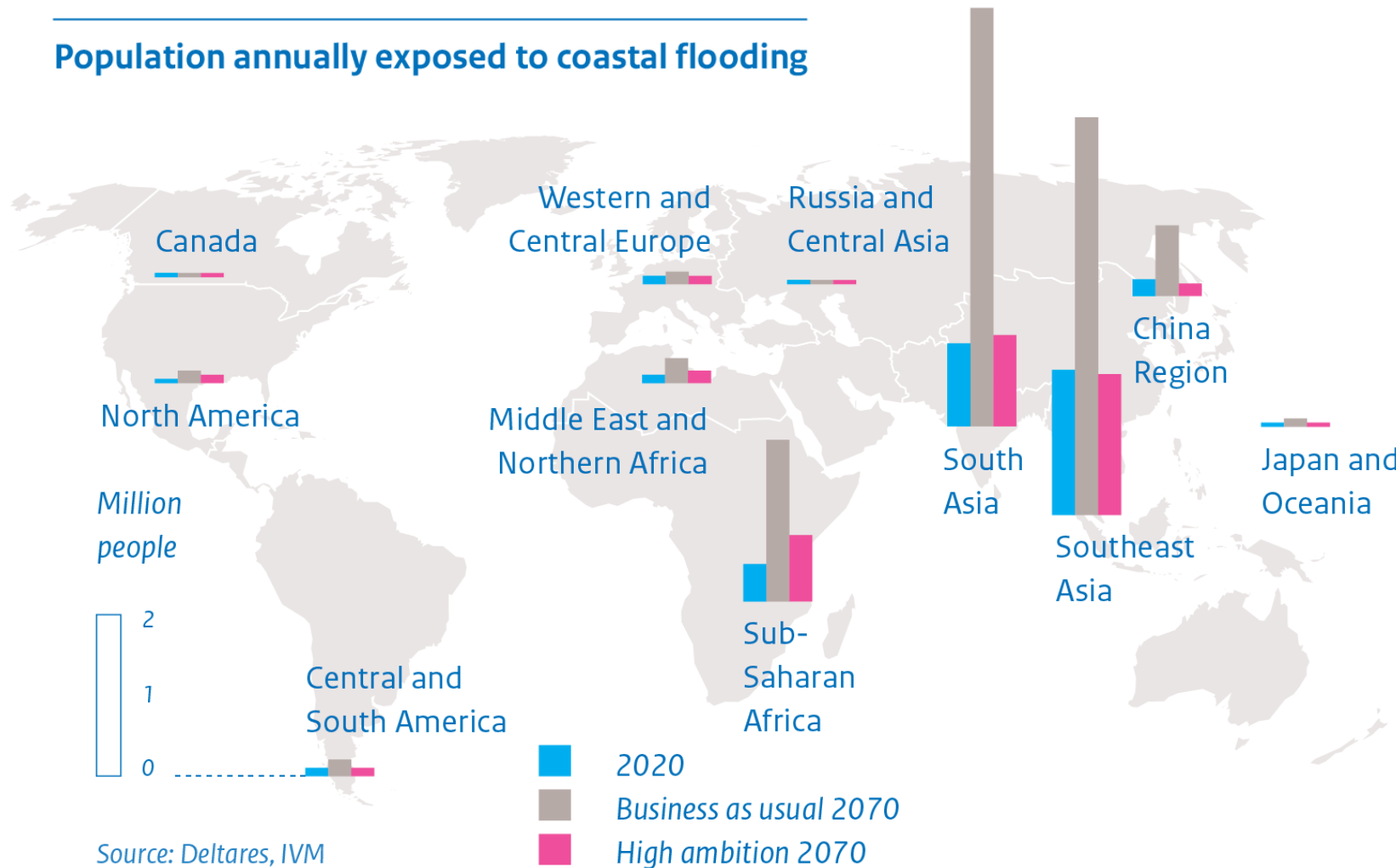
High demand for sand and gravel for construction negatively affects sediment flows to the deltas and coasts.





High ambition pathway: population exposed to coastal flooding can be strongly reduced

Population annually exposed to coastal flooding



- Business as usual
- Low ambition
- Moderate ambition
- High ambition

Cities are hotspots of exposure: high urgency to adapt

2 Billion people live in deltas, coastal zones, islands, many of them in cities



Water and climate should be on any table

○ 1 million
○ 10 million



Source: PBL



Buenos Aires
From 14.4 million in 2020 to 15.6 million in 2070

Dhaka
From 21.0 million in 2020 to 39.9 million in 2070

Istanbul
From 17.1 million in 2020 to 20.6 million in 2070

Shanghai
From 20.7 million in 2020 to 23.6 million in 2070

Mumbai
From 17.1 million in 2020 to 28.6 million in 2070

Karachi
From 16.2 million in 2020 to 28.1 million in 2070

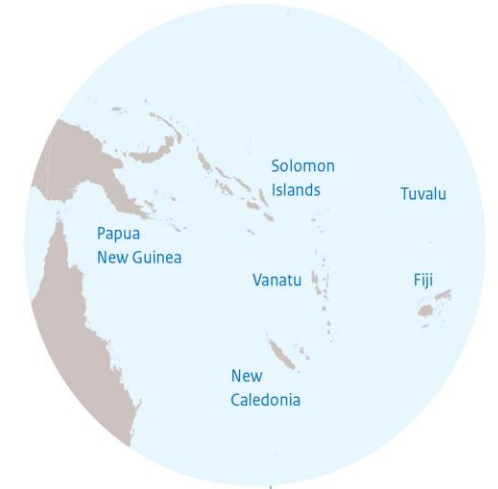
Jakarta
From 10.7 million in 2020 to 12.4 million in 2070

Mauritius

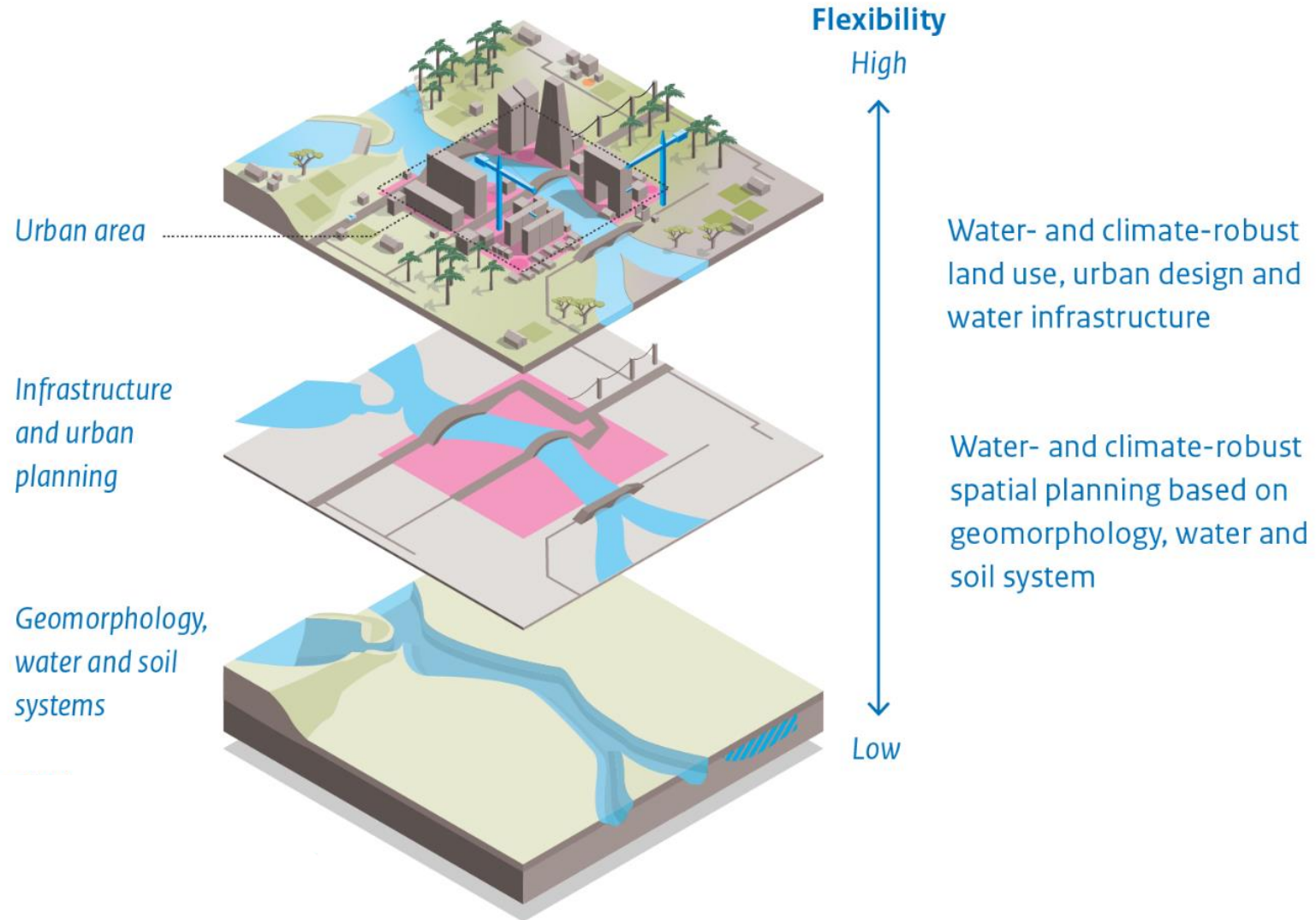
Maldives

■ Population in delta and coastal cities in 2020
■ Population increase in delta and coastal cities in 2070

○ 1 million
○ 10 million



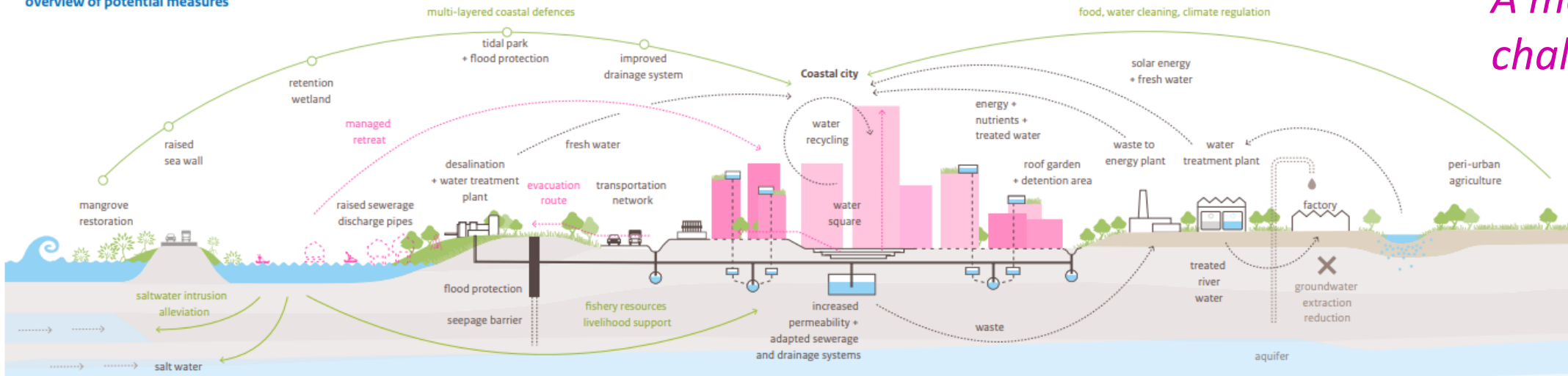
Sustainable cities: water and soil systems should be leading



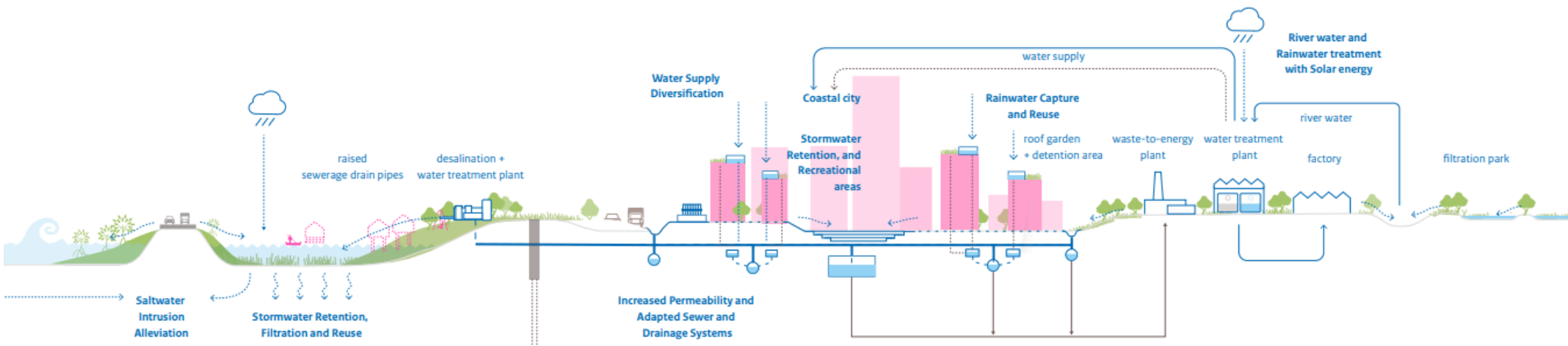
Sustainable cities: water and soil systems should be leading



Cities in deltas and coastal landscapes:
overview of potential measures



A major design challenge



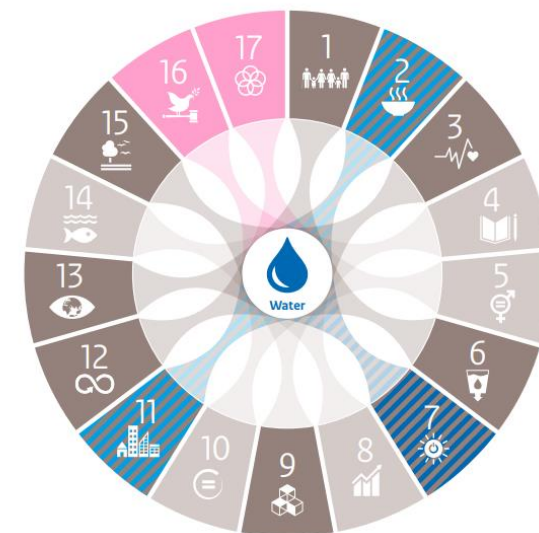


Overall conclusions: the high ambition pathways makes the difference

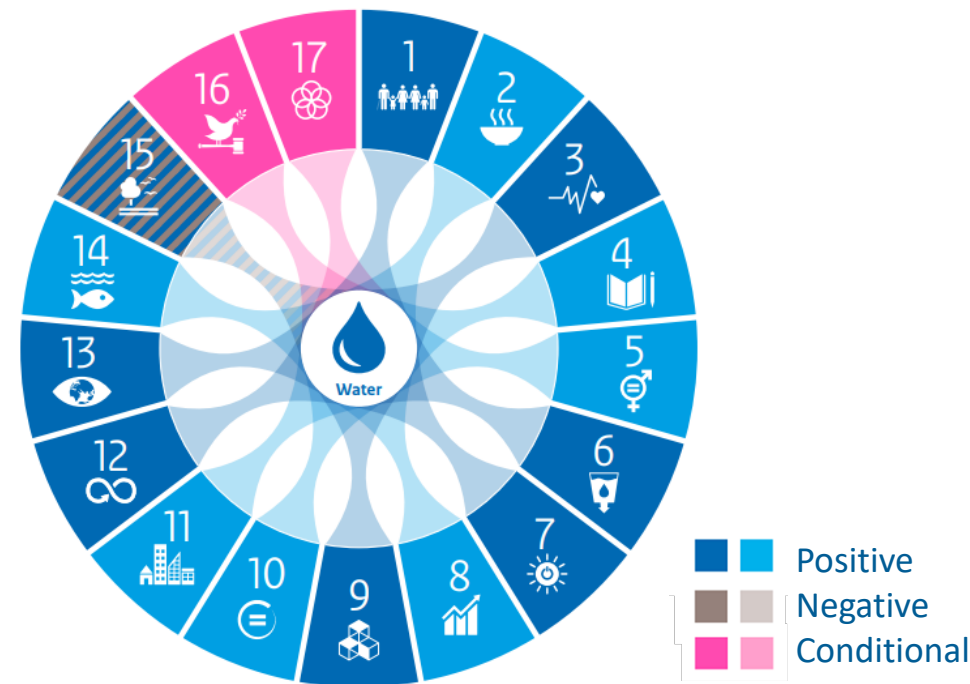
- Flood risks, water use and subsidence can be strongly reduced
- Maybe 950 up to 3700 new dams upstream: further decrease of sediment flows can be halted (*stand-still*)
- Nutrient emissions to coastal seas can be reduced and ecological quality improved
- Many co-benefits for the SDGs
- ***The water sector cannot do it alone!***



SDGs, Business-as-usual scenario 2070



SDGs, High ambition pathway 2070

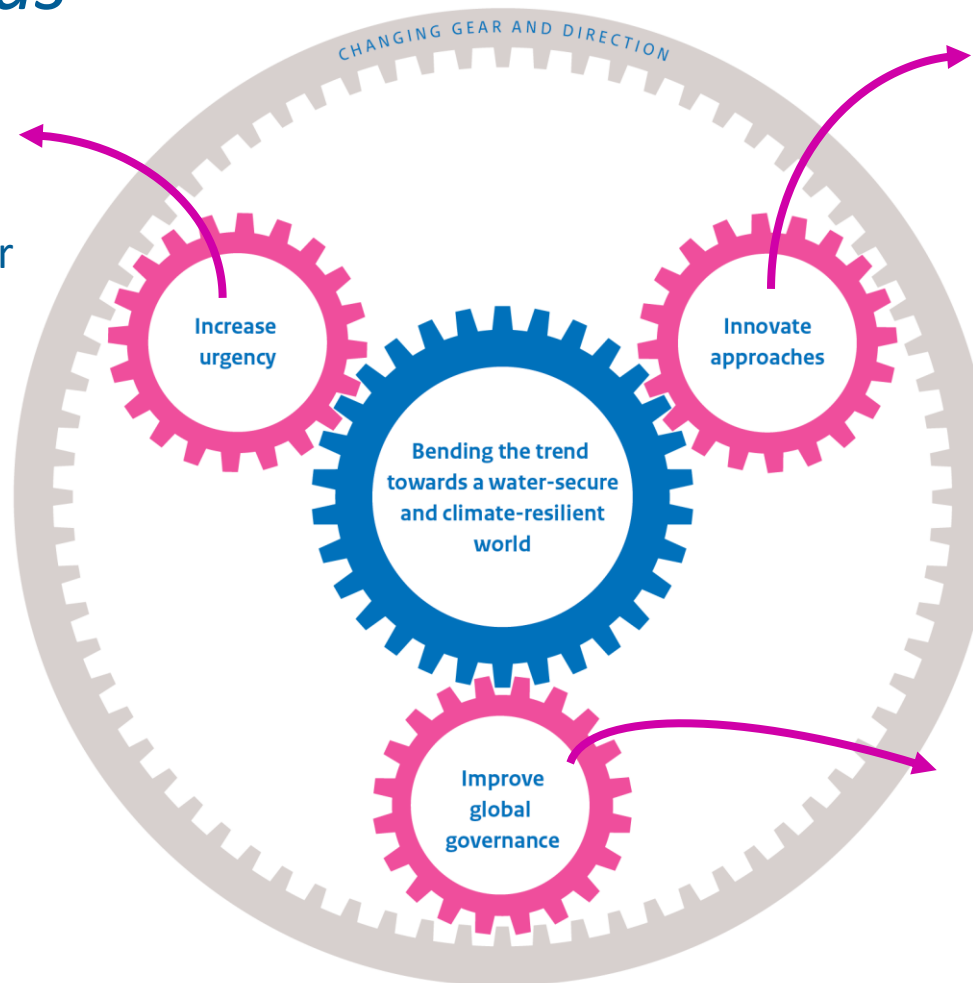




The way forward; radically different policies required: *Three focus areas: nine turnarounds*

Increase urgency

1. Acknowledge the value and pivotal role of water
2. Valuing water: beyond economic efficiency
3. Act now, but think and plan way beyond 2030



Innovate approaches

1. Adopt a river-basin and eco-system based approach
2. Develop a high ambition pathway
3. Improve policy coherence across sectors

Improve global governance

1. Strengthen the global governance
2. Scale up and align global funds
3. Build a shared water agenda



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We have to act now!

*If we wait for the perfect knowledge and time,
we will become specialists in waiting ...*

QR report





STRENGTHENING CLIMATE RESILIENCE IN COASTAL AREAS

29/06/2023

Mikaela Rambali, Adaptation Policy Analyst and Advisor to
OECD Head of Climate, Biodiversity and Water Division



The importance of coastal zones



- Coastal zones host important ecosystems
- Coastal ecosystems provide valuable services

90% of world's fisheries depend on coasts throughout their life



- High population density
- 40% of the world's population
- 20% of the global land surface

75% of the largest urban agglomerations are located in coastal zones



- Fisheries and aquaculture
- Coastal tourism
- Shipping

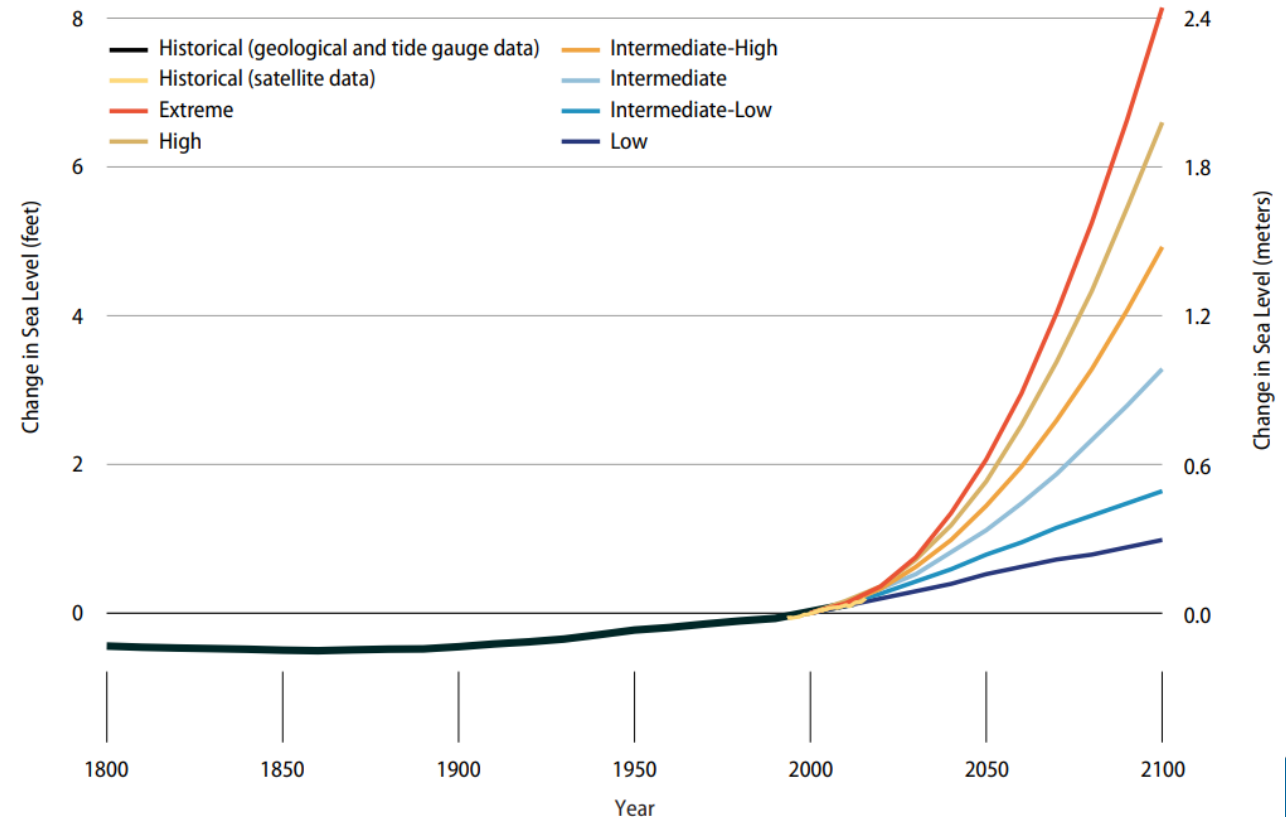
85% of tourism income in the USA



The impacts of climate change in coastal zones

- **Sea-level rise** will intensify coastal flooding. By 2100, floods will affect 360 million people
- **Ocean warming** will affect coastal ecosystems (coral reefs and mangroves) that are essential for biodiversity and support the livelihoods of many coastal communities
- **Extreme storms** might become more intense in some regions. In the past 20 years, storms have killed over 200 000 people and generated economic losses of USD 1.4 trillion

Sea-level rise scenarios, 1800-2100



Source: USGCRP (2018)



The human drivers behind the increasing risks

- **Urban development and land use changes**
 - Ecosystem loss, land subsidence, saline intrusion, water pollution
- **Exploitation of coastal resources**
 - Overexploitation of fisheries, corals, mangroves, etc. causing erosion and ecosystem degradation
- **Human activities on the coast and upstream of river basin**
 - Excessive freshwater extraction; Alter sediment supply (e.g. land clearing, mining); water pollution





Urgent policy action is needed

Coastal adaptation can significantly reduce climate risk using a combination of *protection*, *accommodation* and *retreat* strategies

- **Coastal ecosystem protection** can reduce damage costs by 2-3 orders of magnitude.
- **Nature-based solutions** can significantly help reduce flood damage while also delivering other benefits, e.g. for climate mitigation, biodiversity, or tourism.

An estimated 35% of people exposed to coastal flooding globally benefit from NbS storm surge protection (coral reefs, wetlands)





OECD practices highlighted in National Adaptation Plans

Nearly all OECD countries have information provisions

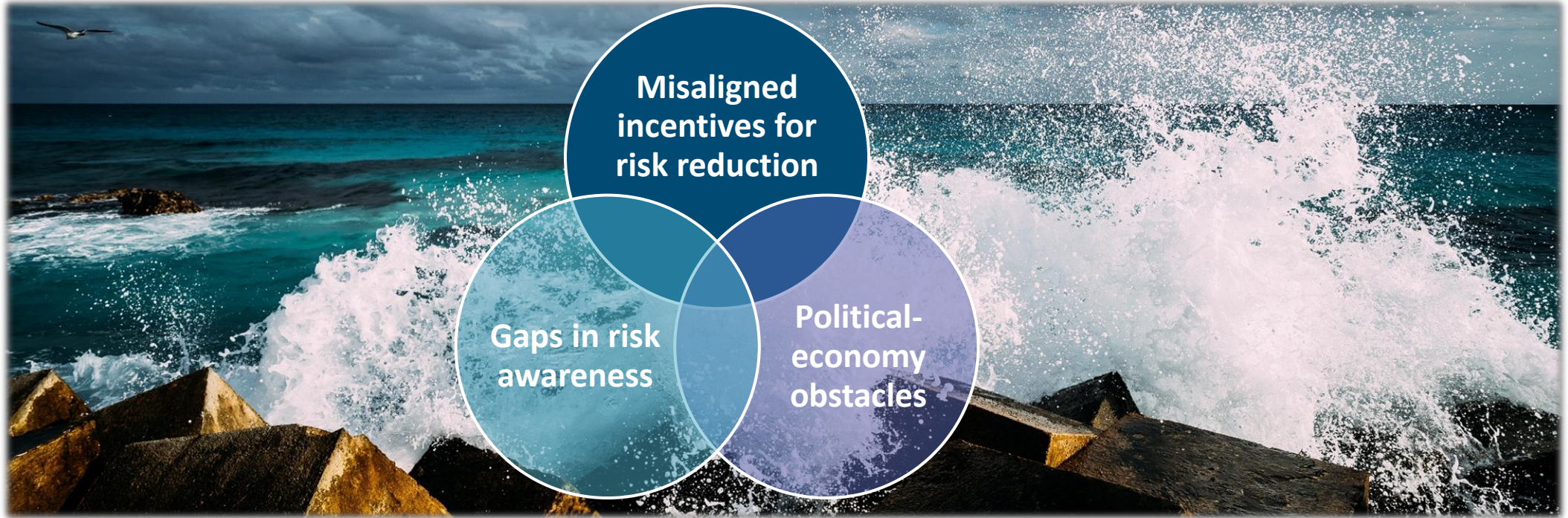
- Climate projections
- Combined them with socio-economic information
- Communicating risk information

About half refer to their regulatory and economic instruments

- Land-use planning
- Building codes and standards
- ICZM
- Risk-based insurance schemes
- Property risk disclosure



Remaining barriers to strengthen climate resilience



National governments



Local governments



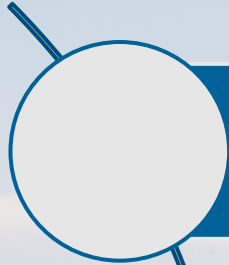
Property developers



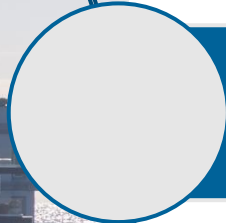
Property owners



What leads to successful adaptation? – Key takeaways for national governments



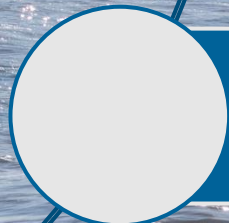
Engage stakeholders early and substantively



Plan for the future & prevent lock-in to unsustainable pathways



Align actors' responsibilities, resources and incentives

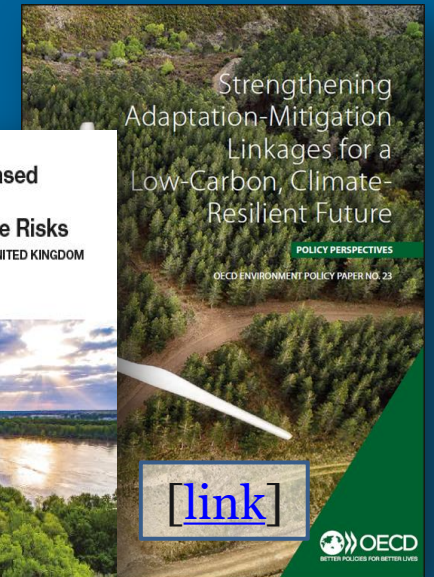
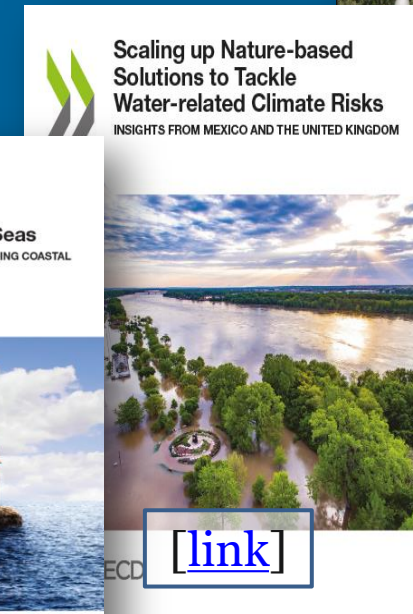
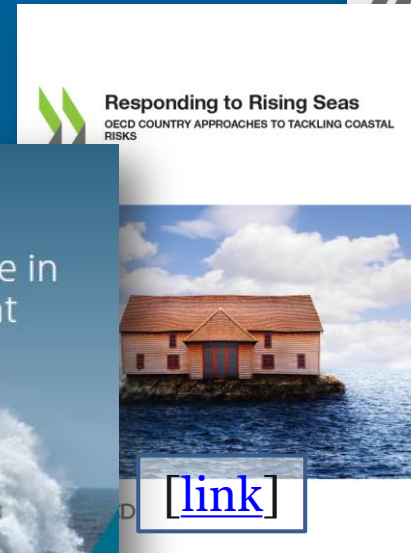
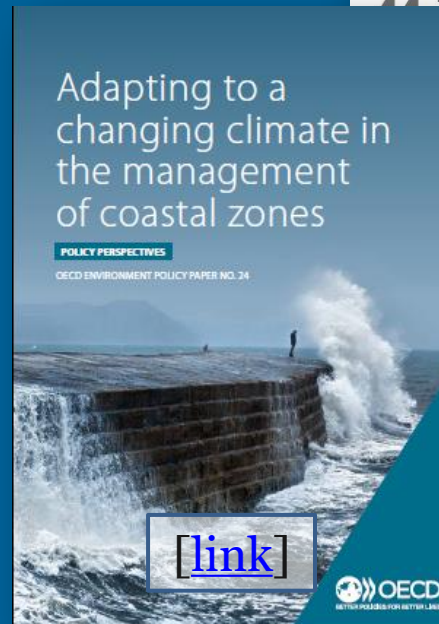


Explicitly consider distributional and equity implications of policies





Thank You



Mikaela.Rambali@oecd.org

<https://www.oecd.org/climate-change/theme/resilience/>



**GOVERNMENT
OF
GHANA**



**GHANA
HYDROLOGICAL
AUTHORITY**

CLIMATE RISK ASSESSMENT AND INVESTMENT PRIORITIZATION IN ACCRA, GHANA COASTAL ZONE: BUILDING RESILIENCE FOR A SUSTAINABLE FUTURE

JOHN KISSI

GHANA HYDROLOGICAL AUTHORITY

Outline of Presentation

- **HYDRO INTRODUCTION**
- **COASTAL REGIONS OF GHANA**
- **LOCAL RISKS & CHALLENGES**
- **COASTAL PROTECTION WORKS**
- **CLIMATE ADAPTATION INVESTMENT PRIORITIES IN ACCRA**
- **PRIORITY 1: GAMA COASTAL PROTECTION AND CLIMATE RESILIENCE**
- **PRIORITY 2: FLOOD FORECASTING AND MANAGEMENT TO CREATE CLIMATE RESILIENCE**
- **CONCLUSION**

Introduction

- Ghana Hydrological Authority (HYDRO) is the state institution established by an ACT of Parliament (ACT 1085) in 2022 under the Ministry of Works and Housing (MWH) with the responsibility for monitoring all rivers and surface water bodies in Ghana; providing engineering consultancy services in hydrology, water resources, drainage engineering, coastal engineering and related fields for the Government of Ghana.

Technical Sections of Hydro:

- *Drainage and Flood Control Works*
- *Coastal Protection Works*
- *Operational and Applied Hydrology*
- *Land and Hydrographic Survey*
- *Quantity Survey*

COASTAL REGIONS



Coastal Regions

WESTERN REGION
approx. 195km coastline
length

Coastal towns:

- *Axim*
- *Sekondi – Takoradi*
- *Dixcove*
- *Busua*
- *Half Assini*
- *Akwidaa*

CENTRAL REGION
approx. 142km coastline
length

Coastal towns:

- *Cape Coast*
- *Elimina*
- *Winneba*
- *Apam*
- *Anomabo*
- *Senya Beraku*
- *Gomoa Fetteh*

GREATER ACCRA
approx. 131km coastline
length

Coastal towns:

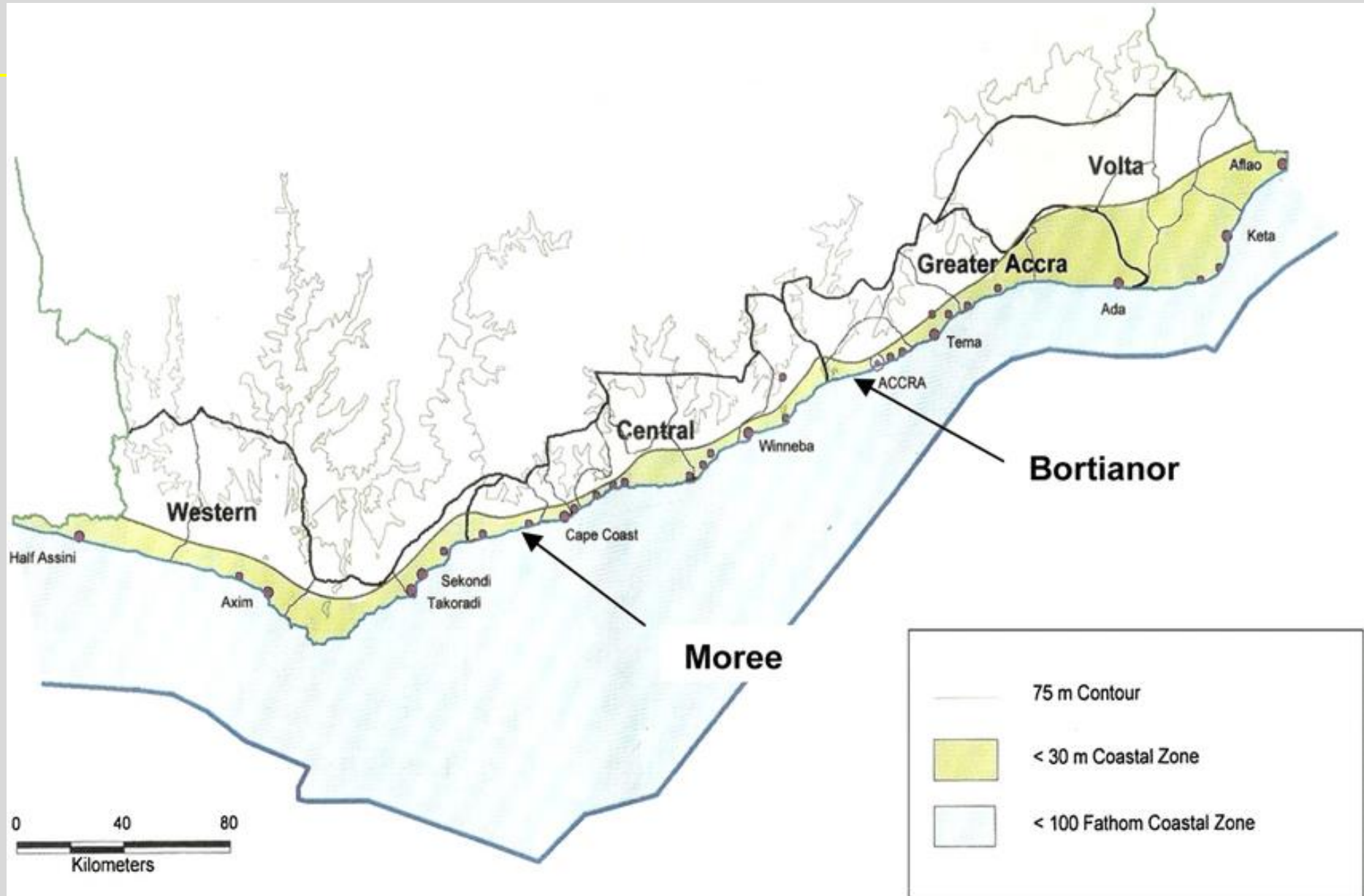
- *Accra*
- *Ada*
- *Ningo – Prampram*
- *Teshie*
- *Tema*
- *Osu*
- *Nungua*
- *Labadi*
- *Dansoman*

VOLTA REGION
approx. 79km coastline
length

Coastal towns:

- *Keta*
- *Ada Foah*
- *Aflao*
- *Keta-Angaw*
- *Anyanui*
- *Denu*

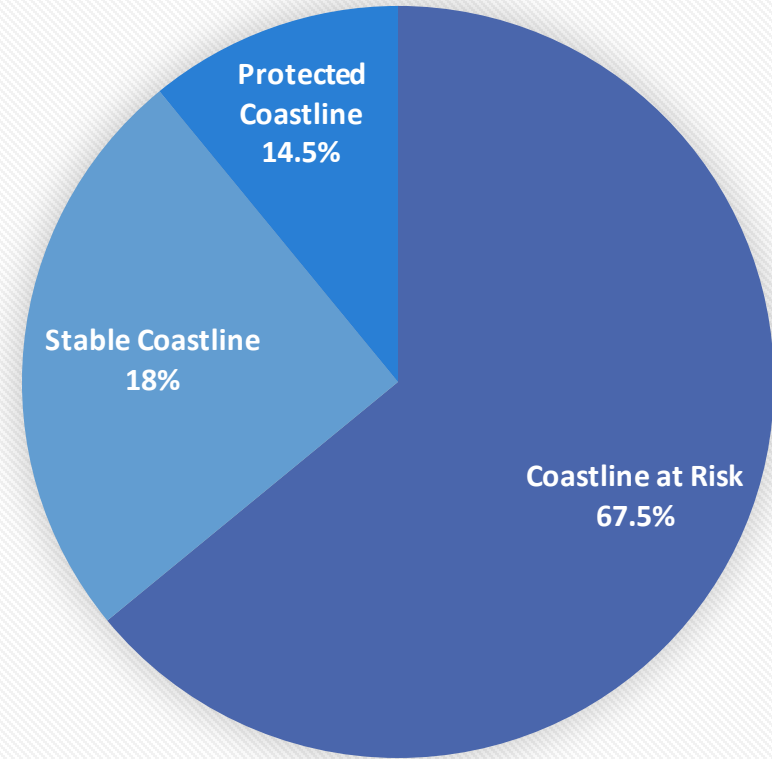
MAP OF COASTAL ZONE OF GHANA



Details of coastal protection works in coastal regions

Protected Coastline	Stable Coastline	Coastline at Risk
80km	100km	370km

Percentage of Shoreline



■ Coastline at Risk ■ Stable Coastline ■ Protected Coastline



COASTAL PROTECTION



Local Risks & Challenges

- Inadequate funding for Coastal Protection works and research
- Inadequate emergency response and
- Lack of coastal floods early warning systems
- Natural Challenges: Storm surge, sea level rise, high tidal wave
- Inadequate sensitization of local communities on human activities causing coastal erosions. Eg illegal sand winning
- Loss of lives, properties and livelihoods in coastal communities
- Environmental degradation of coastal areas

Local Risks & Challenges

- Interaction between Surface Water, Riverine and Tidal Flooding.



Coastal Protection Activities

- Monitors the country's coastline
- Investigating coastal erosion problems.
- Design and supervision of coastal protection schemes.
- Measures: Revetments, Groynes, Breakwater, Gabions and Jetties

Hard Engineering measures



Dansoman Sea Defense Project



Anomabo Coastal Protection Project



• 82% COMPLETE



GHANA
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New Takoradi Coastal Protection Project (Phase III) at Elmina



The 5km project is currently **85% complete**

Komenda Coastal Protection Project



CLIMATE RISK ASSESSMENT AND INVESTMENT PRIORITIZATION

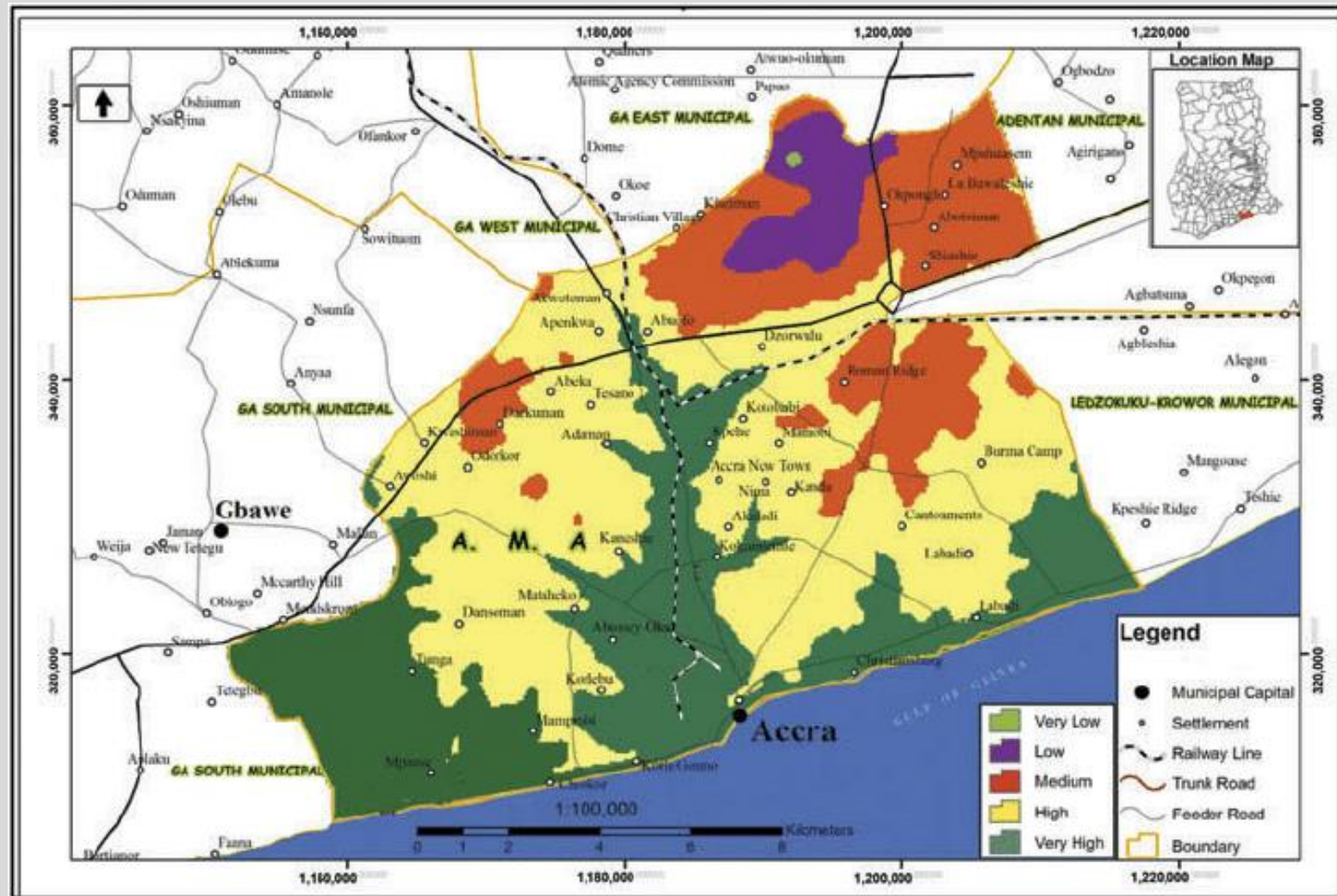


OVERVIEW OF ACCRA COASTAL ZONE

GREATER ACCRA approx.
131km coastline length

Some Coastal towns include:
Accra, Ada, Ningo –
Prampram, Teshie, Tema, Osu,
Nungua, Labadi and
Dansoman

Area of focus is the Greater
Accra Metropolitan Assembly
(GAMA)



VULNERABILITY OF ACCRA

- Accra's low-lying topography;
- High levels of seasonal rainfall and occasional high intensity rainfall within the city;
- Rising sea levels due to climate change;
- Increased incidence in tidal waves and storm surges
- Increasing rate of coastal erosion.

FLOOD AND EROSION MANAGEMENT

Flood Management:

- The GAMA+ area is projected to see an increase in floods due to torrential rains, storm surges, coastal erosion and sea-level rise.
- Need to establish a pro-active and integrated approach to managing flood hazards and risks

Erosion:

- Coastal erosion arising from sea-level rise due to climate change is affecting coastal and delta communities in GAMA+.
- Soil erosion in GAMA+ watersheds is increasing due to high climate variability with intense rainfall, and land-use and cover change.
- Addressing erosion hot-spots, particularly on the coast, will be important to build resilience and adapt to climate change.

CLIMATE CHANGE IMPLICATIONS

- **Sea-level rise** – Inundation and displacement of wetlands, lowlands coastal erosion, increased storm flooding, shorelines changes, salinization, rising water tables and impeded drainage.
- **Precipitation intensity** – increased flood risks in coastal lowlands
- **Physical Impacts:** damage to critical infrastructure, interrupted access for emergency services, degradation of building materials and structures
- **Social Impacts:** threat to life, decreased agricultural production, health risk,
- **Economic impacts:** loss of livelihoods/income, loss of employment in marine industries, depleted resources
- **Environmental Impacts:** damage to ecosystem, pollution, impact on biodiversity

FLOOD AND EROSION MANAGEMENT

CURRENT STATUS:

- Coastal erosion and sea level rise has led to the loss of coastal infrastructure
- Estimated sea level rise rate of 3.32 mm/year
- The ocean claims between 1.5 to 4 meters of the national coastline annually.
- Historically, the Accra shoreline has been eroding in most places at an average rate of -1.11 m/year (1974-2014).

FUTURE OUTLOOK:

- With global warming sea level rise is projected to increase by up to ca. 35 mm per year, leading to further coastal erosion and flooding.
- Based on recent modelling, the Ghana shoreline position will have receded inland by an average of 52 m by 2080 .
- This implies an average rate of inland advance of the shoreline of 2.7 m/year: more than double the past baseline rate of erosion.

MEDIUM TERM NATIONAL DEVELOPMENT POLICY FRAMEWORK (2022 – 2025) OF GHANA

Medium-term policy objective: **“Improve coastal and marine management”**.

Relevant Climate adaptation strategies include:

- Promote investment in hard control structures including gabions and boulders;
- Promote an integrated approach to reducing coastal floods, erosion and degradation involving all relevant stakeholders;
- Facilitate effective inter-agency coordination of coastal management programmes;
- Support the development of comprehensive coastal development, planning and regulatory frameworks.

CLIMATE ADAPTATION INVESTMENT PRIORITIES

- World Bank financed Greater Accra Resilient and Integrated Infrastructure Development Project (GARID)
- African Development Bank-financed Greater Accra Sustainable Sanitation and Livelihoods Improvement Project (GASSLIP)
- West Africa Coastal Areas Resilience Investment Program (WACA) – Sustainable measures
- Initial stages for West Africa Coastal Inundation Forecasting Initiative (WACIFI)
- Initiation of the Ghana Delta program to build a long-term, solid multi scale, multi stakeholder, multi sector framework to deal with present and upcoming delta issues.

CLIMATE ADAPTATION INVESTMENT PRIORITIES

	Project Costs		Investment Opportunity	
	Development Phase	Full Project	Development Phase	Full Project
	million USD	million USD	Million USD	million USD
Priority 1: GAMA coastal protection and climate resilience	6.2	156.2	6.2	130.0
Priority 2: Flood forecasting and management to create climate resilience	0.3	12.9	0.3	8.0
Priority 3: Densu river basin and delta adaptation to climate change	1.1	72.6	1.1	60.0
Priority 4: GAMA climate resilient water supply	2.7	103.5	2.7	80.0
Priority 5: LIUC revitalisation and climate adaptation program	1.7	57.4	1.7	45.0
Priority 6: A climate resilient Accra through improved urban drainage	0.4	64.0	0.4	55.0
Total (million USD)	12.4	466.6	12.4	378.0

CLIMATE ADAPTATION INVESTMENT PRIORITIES

GAMA COASTAL PROTECTION AND CLIMATE RESILIENCE

Investment Opportunity

Project Type:	Coastal defense against climate change induced sea-level rise and coastal erosion
Size:	Floods: 75 km coastline (GAMA) protection; Projected erosion due to sea level rise: 2.7 meters / year
Location:	Coastal areas along GAMA's coast line, Ghana
Initial Estimated Total Project Costs:	CAPEX: USD 156 million
	Development Costs: USD 6.2 million
Total External Funding Required:	CAPEX: USD 130 million
	Development Phase: USD 6.2 million
Sector:	Floods & Erosion
Development Status:	Early
Potential Financing Sources:	Existing project, Government budget, Bilateral donor, Multilateral donor, Foundation/grant & Climate finance
Potential beneficiaries	2.3 million people
Lead Government Agency	Ghana Hydrological Authority with GAMA RCC and Ministry of Works and Housing
SDG focus:	11. Make cities and human settlements inclusive, safe, resilient and sustainable.
Development and Poverty Reduction Potential:	Coastal protection from sea-level rise and erosion supports the development of Low-Income Urban Communities (LIUCs) in GAMA.

GAMA COASTAL ZONE PROTECTION AND CLIMATE RESILIENCE

Key Components

- Component 1. Hydrodynamic model for GAMA coast and Pre-feasibility Study report to underpin decision for GAMA coastal defence project
- Component 2. Feasibility study, detailed design, RFP documentation, tender and contractor(s) selection
- Component 3. Operational Sand-Motor, mangroves, and other infrastructure for GAMA coastal defence and resilience
- Component 4. Ghana Hydrological Authority to develop and use its full capacity to monitor the effectiveness of the constructed measures in the GAMA coastal area

CLIMATE ADAPTATION INVESTMENT PRIORITIES

FLOOD FORECASTING AND MANAGEMENT TO CREATE CLIMATE RESILIENCE

Investment Opportunity

Project Type:	Hydro-Met network, Early Warning System, Flood Disaster Response and Resilience Platform
Size:	Floods – Early warning for ca. 3,000km ²
Location:	GAMA
Initial Estimated Total Project Costs	Full Project: USD 12.9 million Development Costs: USD 300,000
Total External Funding Required:	Full Project : USD 130 million Development Phase: USD 6.2 million
Sector:	Water Resources & Floods
Development Status:	Mid
Potential Financing Sources:	Existing project, Government budget, Bilateral donor, Multilateral donor & Climate finance
Potential beneficiaries	2.27 million people
Lead Government Agency	Ghana Hydrological Authority, NADMO, Water Resources Commission, Ghana Meteorological Services
SDG focus:	11.b Substantially increase holistic disaster risk management at all levels 13.1 Strengthen resilience and adaptive capacity to climate related hazards and natural disaster
Development and Poverty Reduction Potential:	Early warning systems and disaster response reduce the impact of flood disasters on downstream vulnerable communities living in flood prone areas

CLIMATE ADAPTATION INVESTMENT PRIORITIES

FLOOD FORECASTING AND MANAGEMENT TO CREATE CLIMATE RESILIENCE

Key Components

- Component 1. Operational Hydro-Met network and DTM for Upper Densu basin and GAMA
- Component 2. Hydro-Meteorological models and set-up commercial hydro-met services
- Component 3. Flood forecasting & early warning system for GAMA+
- Component 4. Flood emergency response system for GAMA+
- Component 5. Flood Resilience Platform and Media ‘climate-urbanisation-resilience

Conclusion

- Enhanced resilience and reduced vulnerability to climate-related impacts.
- Protection of vulnerable communities, infrastructure, and economic activities.
- Ghana Hydrological Authority to have enhanced capacity to engage other stakeholders in implementing climate-resilient strategies, and
- Focus on seeking funding for investment in coastal and climate adaptations and management strategies.

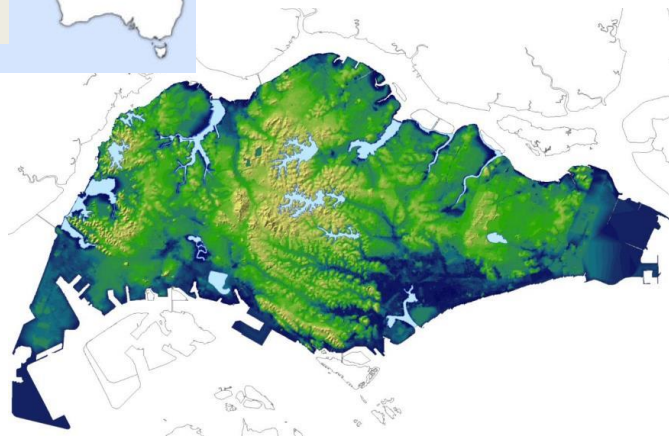
Thank You.

Singapore's Approach Towards Coastal Protection

Chang Chian Wui
Consultant (Coastal Protection)
PUB, Singapore's National Water Agency
29 Jun 2023



Singapore is low-lying and vulnerable to flooding



Dark blue shades- Areas with elevation lower than 5.0m above mean sea level

LOW-LYING

About 30% of land area < 5m from mean sea level
Sea levels could reach 4 – 5m taking into account extreme high tides, storm surge and sea level rise

SMALL & DENSELY POPULATED

Small island state of 730km² with one of the highest population densities in the world

SURROUNDED BY THE SEA

Affected by conditions in Andaman Sea / Malacca Straits and South China Sea

TROPICAL EQUATORIAL CLIMATE

Abundant rainfall with mean annual ~2000mm with intense tropical convective rains (up to 150 mm/hr)

Singapore is committed to turn the crisis into an opportunity

1



2

PUB appointed as the national coastal protection agency in 2020 to develop and lead the implementation of coastal protection measures in Singapore

3



Coastal protection is one of our key strategies to **build a Resilient Future under the Singapore Green Plan 2030**

OUR OBJECTIVES



Prevent loss of
lives



Minimise damage to assets
and infrastructures



Preserve functionality of land

OUR STRATEGIES

- 01 Build continuous line of defence to keep out rising seas
- 02 Additional localised protection for critical infrastructure
- 03 Source-pathway-receptor approach for stormwater management

APPROACHES

1

Holistic Risk Assessment



2

Flexible & Adaptive



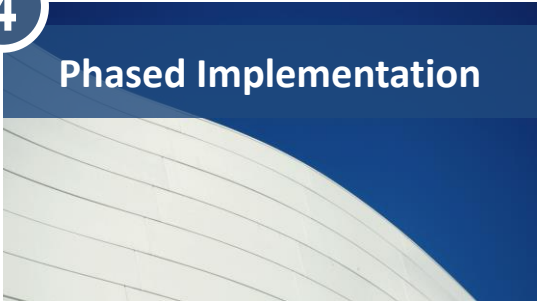
3

Integrated Planning



4

Phased Implementation



5

Capability Building



6

Shared Stewardship



1

Holistic Risk Assessment



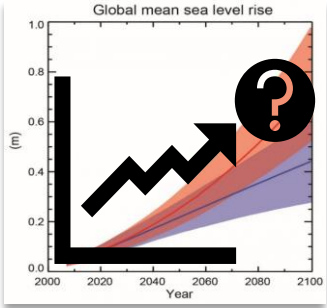
Coastal-Inland Flood Model

- ▶ Simulates **combined effects** of extreme sea levels and inland floods
- ▶ Allows **continuous** review of flood risks based on **latest available data** from climate science
- ▶ **Predictive** capability

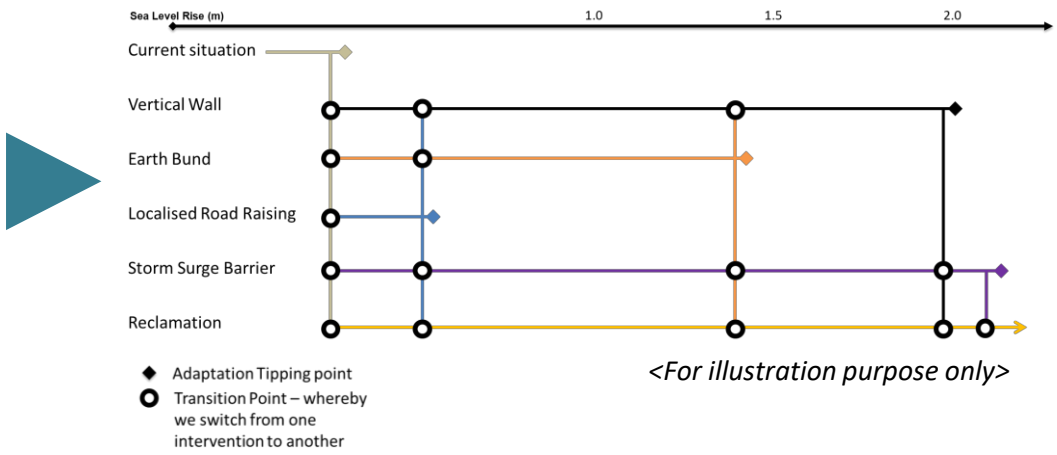
2

Flexible & Adaptive

Uncertainties



Adaptation Pathways



Adaptation Pathways

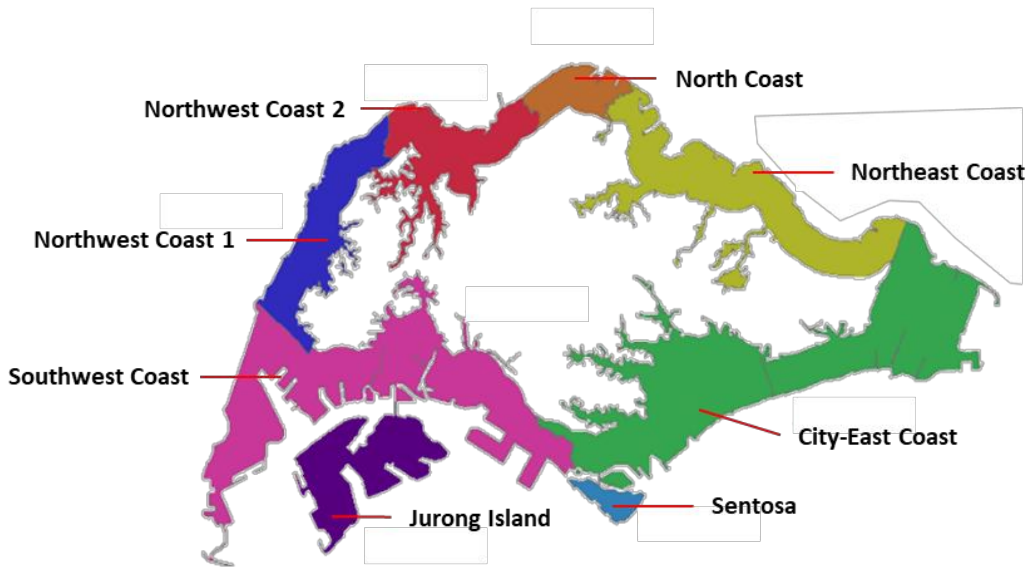
- ▶ Identify **range** of options that are flexible and adaptive to climate uncertainties
- ▶ **Sequence** options over time to form “pathways”



Multi-Functionality

- ▶ Land scarcity, but highly-varied land use
- ▶ **Value creation** through achieving multi-functionality
- ▶ Opportunity for **nature-based solutions** (NbS)

Phased Approach



- ▶ Site-specific studies (SSS) for different segments to be done progressively, starting with City-East Coast
- ▶ Phased implementation of measures to avoid bunching up of resources

5 Capability Building

*A **dedicated research programme** to **holistically** address Singapore's flood protection challenge against climate change and **build long-term capability***

Centre of Excellence

Coastal Protection and Flood Management Research Programme (CFRP)

Applied Research

Living Lab



Communications & Engagement

- Understanding the problem
- Awareness of challenges
- Recognise opportunities

EDUCATE



3-part edu-tainment series on coastal protection



“Our Coastal Conversation” – community dialogue

ENGAGE

- Contributing ideas and aspirations
- Acknowledging trade-offs

- Playing a part to co-develop solutions
- Building community resilience

EMBRACE



Deploying flood barriers at a residential house

- Integrate development planning
- Drive and coordinate efforts in coastal protection

GOVERNMENT

- Build knowledge through R&D
- Grow local capability & train workforce

EXPERTS & IHLS

INDUSTRY

- Develop innovative applied solutions
- Design and construct flood protection infrastructure

COMMUNITY

- Support coastal protection endeavour
- Provide constructive feedback and co-create solutions



Thank You



Integrated Coastal Zone Management

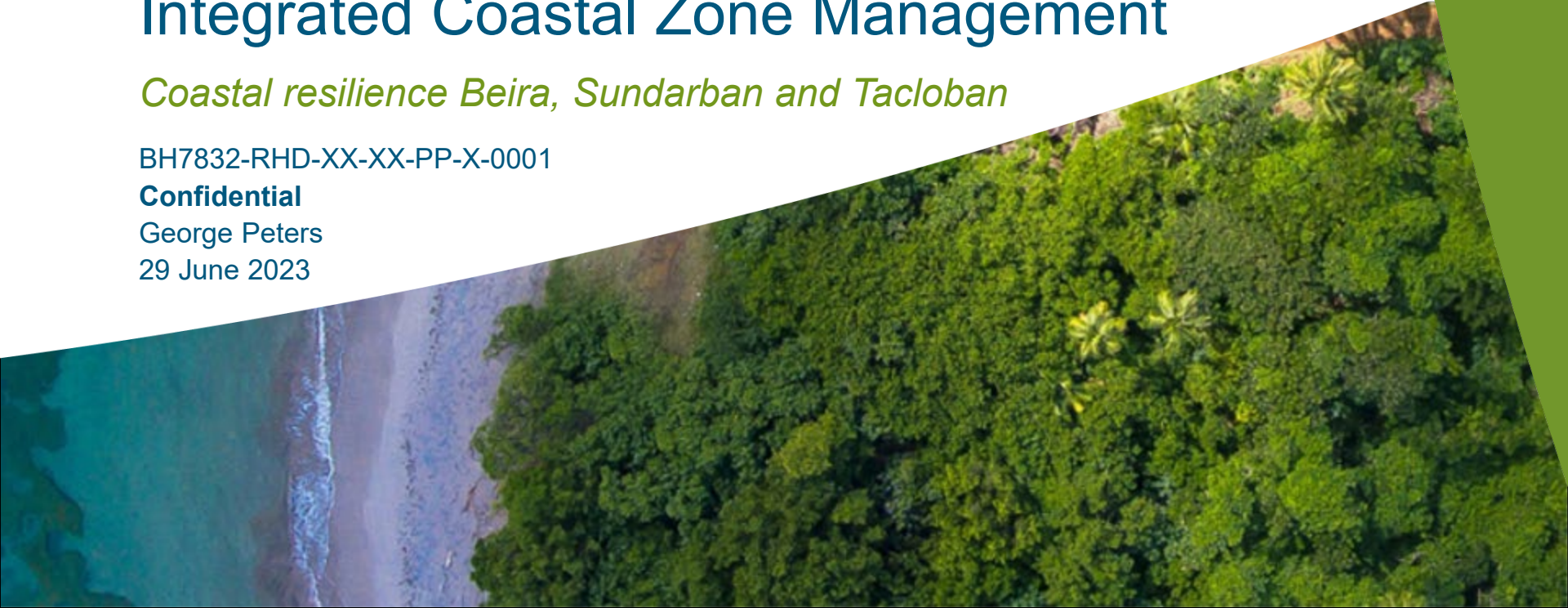
Coastal resilience Beira, Sundarban and Tacloban

BH7832-RHD-XX-XX-PP-X-0001

Confidential

George Peters

29 June 2023



George Peters MSc

- **Global Director Climate Resilience** at Royal HaskoningDHV
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- **E** george.peters@rhdhv.com
- **W** www.royalhaskoningdhv.com
- P.O. Box 1132, 3800 BC Amersfoort, The Netherlands



Enhancing society together



Requirements of
stakeholders



Added value to
client and society



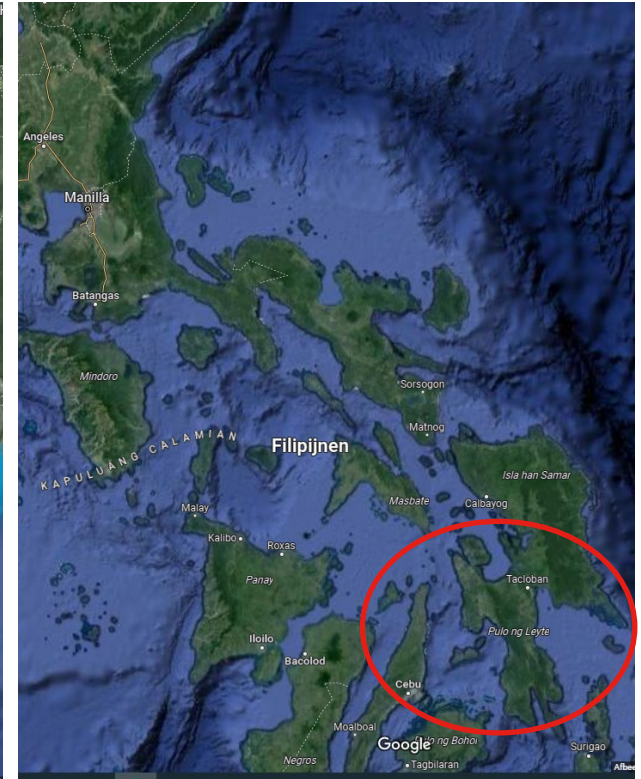
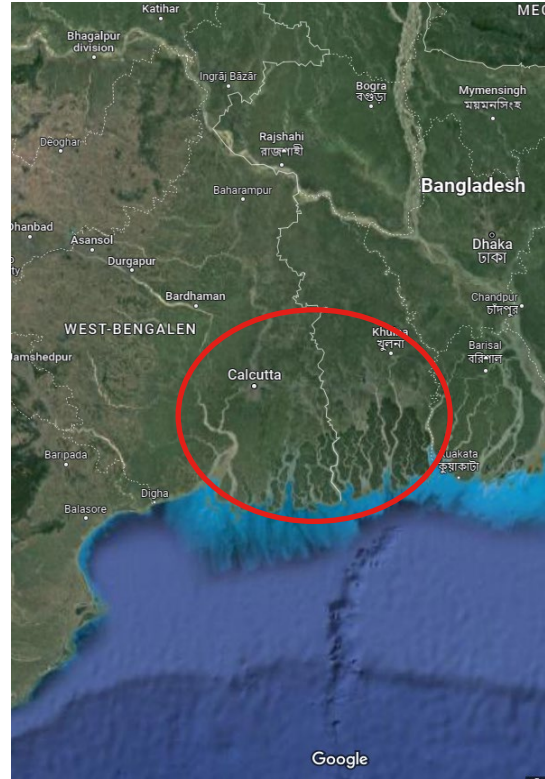
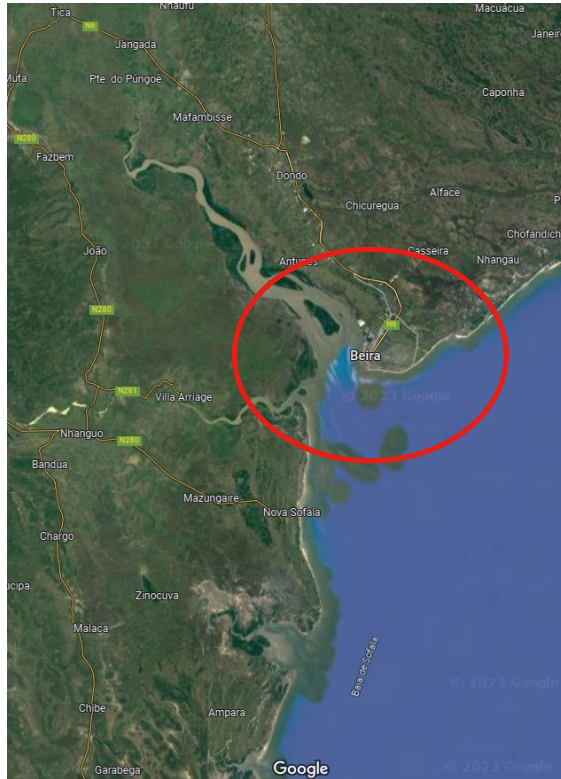
Future-proof



Resources and
Energy

Our ambition is to run a financially healthy business by putting our collective intelligence into practice with clients and partners to have a positive impact on people, our living environment and the economy

Coastal resilience Beira, Sundarban and Tacloban



Coastal protection plan for city of Beira, Mozambique

Partners Deltares, Witteveen + Bos and TU Delft University



Coastal protection plan for city of Beira, Mozambique

Partners Deltares, Witteveen + Bos and TU Delft University



Coastal protection measures Beira

- Natural dune restoration with vegetation
 - Rock revetment
 - Simple flood wall/ L-wall
 - Repairs and strenghtening old seawall
 - Clay dike connecting to higher grounds
- Important generic measures:*
- Early Warning System
 - Nursery and revegetation plan for coastal belt
 - Technisch Assistance/ capacity building O&M



Final decision after (intensive) stakeholder discussions about effectiveness and O&M efforts:

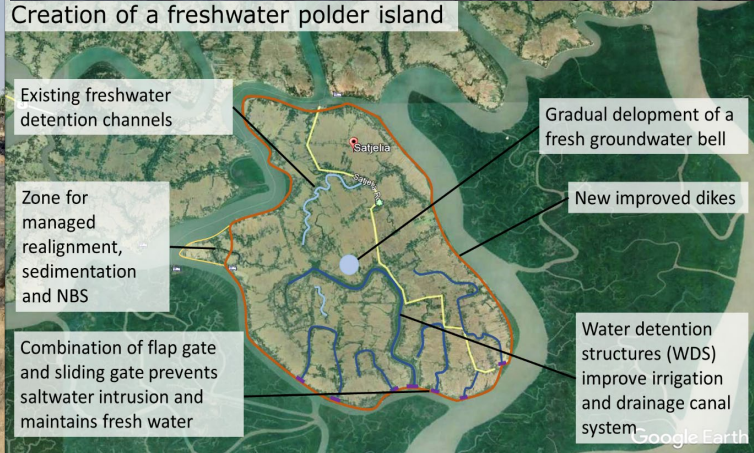
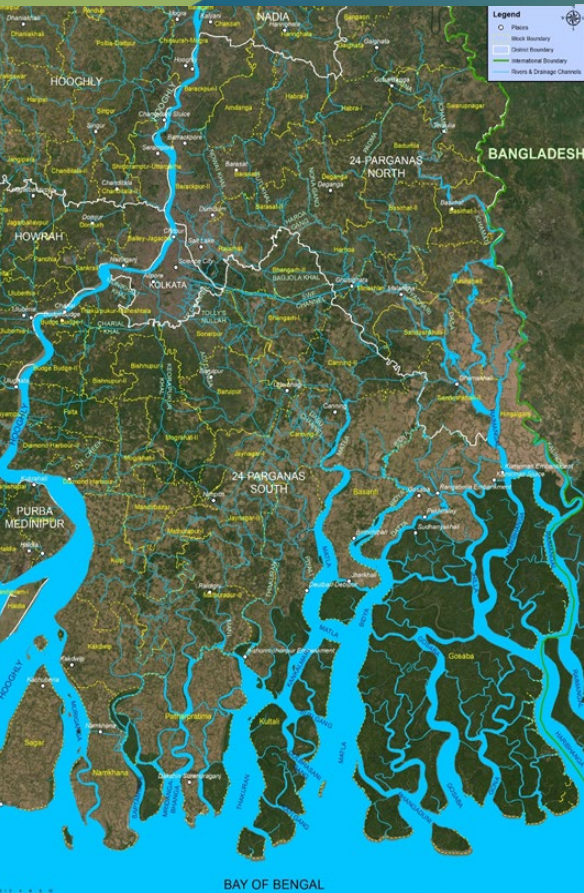
- Natural dune restoration/ strengthening selected as preferred flood protection (yellow line).
- Hard solution a lot more expensive (investment costs), and not considered sustainable/ sufficiently adaptive towards the future (morphological uncertainty).
- Only locally apply hard solutions and only in sheltered area (stretch 2).
- Combined with foreshore nourishment buffer for erosion compensation (25 years buffer).

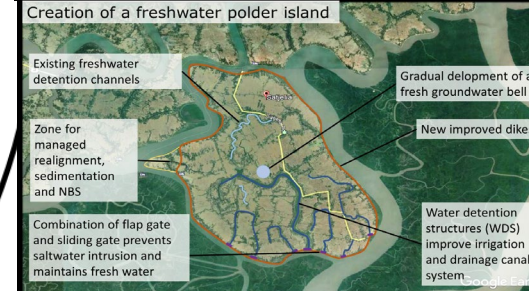
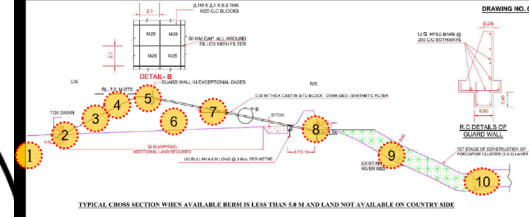
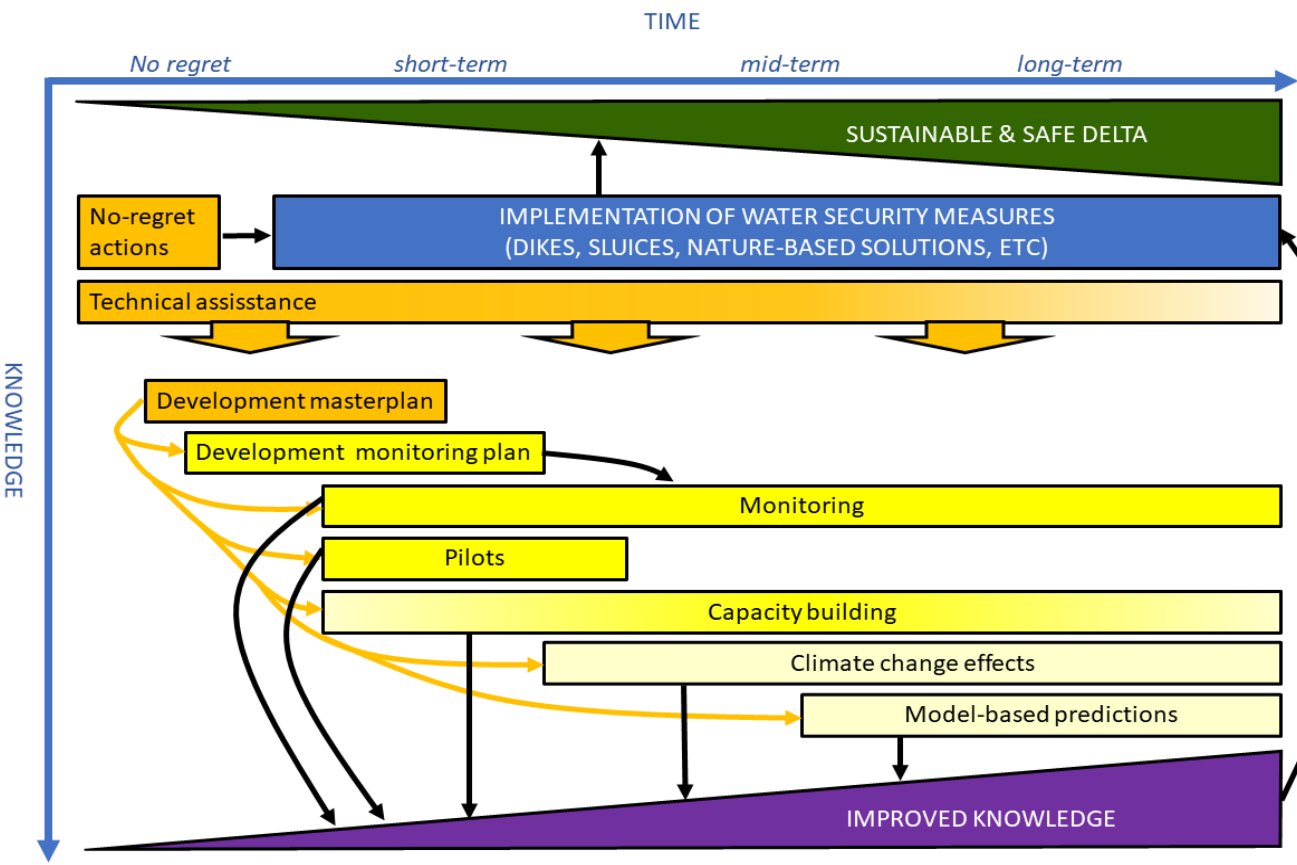


Coastal protection plan for Sundarban, India

Partners Deltares and Rijkswaterstaat







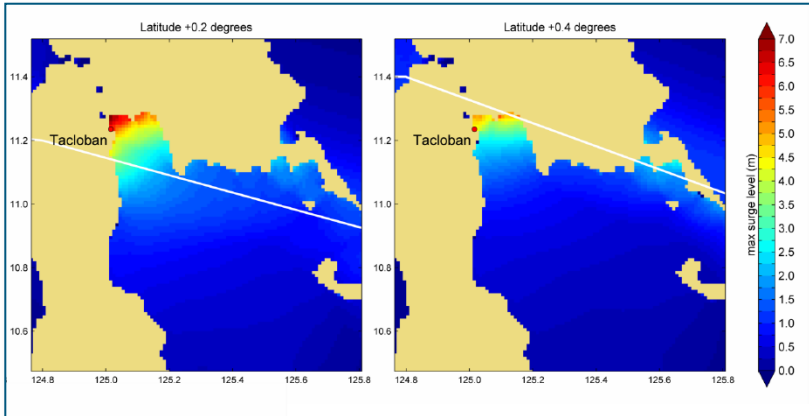
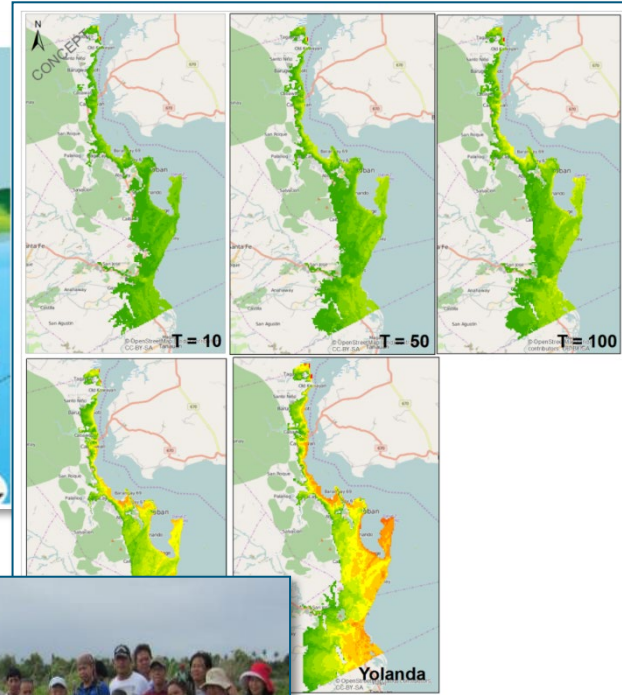
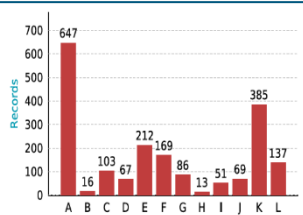
What?	Chapter	By whom?	NR	ST	MT	LT
1 Masterplan for the Greater Sundarban Basin	2.1-2.5	I&WD i.c.w. relevant sectoral ministries, departments	✓			
2 Adaptive Delta Management Plan for Sundarban Delta	2.1-2.5	I&WD i.c.w. relevant sectoral ministries, departments	✓			
3 No regret adaptation in current practice for Flood Resilience	2.2	I&WD	✓			
4 No regret adaptation in current practice for NBS	2.4	I&WD, DoE, DoF, NGO's	✓			
5 Data collection, and planning of monitoring program	2.2-2.3, App-4	I&WD	✓			
6 Risk based vulnerability assessment	2.2	I&WD	✓			
7 Conceptual design of embankments	2.2	I&WD	✓			
8 Short-listing the right NBS for the Sundarban	2.4	I&WD, DoE, DoF	✓			

Coastal protection strategy for Tacloban, Philippines

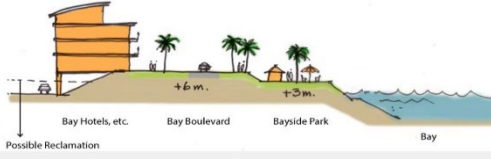
Partners Deltares, Red Cross, Van Oord, Arcadis, Wetlands International and Rebel Group



Label	Name	Code	Value	%
A	Fisherman	Fisherman	647	33.1
B	Farmer	Farmer	16	0.8
C	Market or street vendor	Market_or_street_vendor	103	5.3
D	Labourer (e.g. in port)	Labourer_e_g_in_port	67	3.4
E	Construction	Constructon	212	10.8
F	Driver	Driver	189	8.6
G	Housewife	Housewife	86	4.4
H	Domestic services (e.g. nanny or cleaner)	Domestic_services_e_g_nanny_or_cleaner	13	0.7
I	Government employed	Government_employed	51	2.6
J	Private service	Private_service	69	3.5
K	Small business	Small_business	385	19.7
L	Other	Other	137	7.0
Total			1955	99.9



Coastal protection strategy for Tacloban, Philippines



Lessons learnt, major take aways

1. Future proof, scenario thinking, adaptive pathways, let's keep it transparent
2. Measures (both soft where possible and hard where needed) require maintenance
3. Lack of knowledge on the design and effectiveness of soft solutions. Knowledge base is behind on more traditional hard solutions. Need for pilots to validate, fill knowledge gaps!
4. There is no alternative for a project live cycle approach
5. Monetising benefits can be complex, for urban, social and environmental goals
6. Timing of the project is important, are stakeholders ready to start?
7. How about succession planning, cap. building at client side and major stakeholders?
8. Pilot projects are great spin offs, keeping momentum, bridging the (project)gaps
9. Blue print for coastal resilience in Philippines, now used for other areas
10. Roadmaps balance both short and long term goals, there is enough for everyone!

We look forward to working with you.

For more information visit our website:

<https://global.royalhaskoningdhv.com/climate resilience>



[linkedin.com/company/royal-haskoningdhv](https://www.linkedin.com/company/royal-haskoningdhv)



[@RHDHV](https://twitter.com/RHDHV)



[facebook.com/RoyalHaskoningDHV](https://www.facebook.com/RoyalHaskoningDHV)



COASTAL ZONE MANAGEMENT: MANHATTAN

Matthijs Bouw

founding principal One Architecture & Urbanism
Professor of Practice, Director of Urban Resilience Program, Weitzman School of Design

one architecture
new york city amsterdam



ADAPTATION TO A CHANGED CLIMATE



Integrated Coastal Zone Management: A Canadian Perspective

Global Commission on Adaptation

Joanna Eyquem PGeo. ENV SP. CWEM. CEnv.
Managing Director, Climate Resilient Infrastructure
Intact Centre on Climate Adaptation
joanna.eyquem@uwaterloo.ca

June 29, 2023



Generously supported by



Outline

2

- Climate Change and Coastal Communities in Canada
- Status of Integrated Coastal Zone Management
- Recent Initiatives



Intact Centre on Climate Adaptation

3

- Applied research centre on Climate Adaptation with a **national focus**
- Bilingual [resources](#)

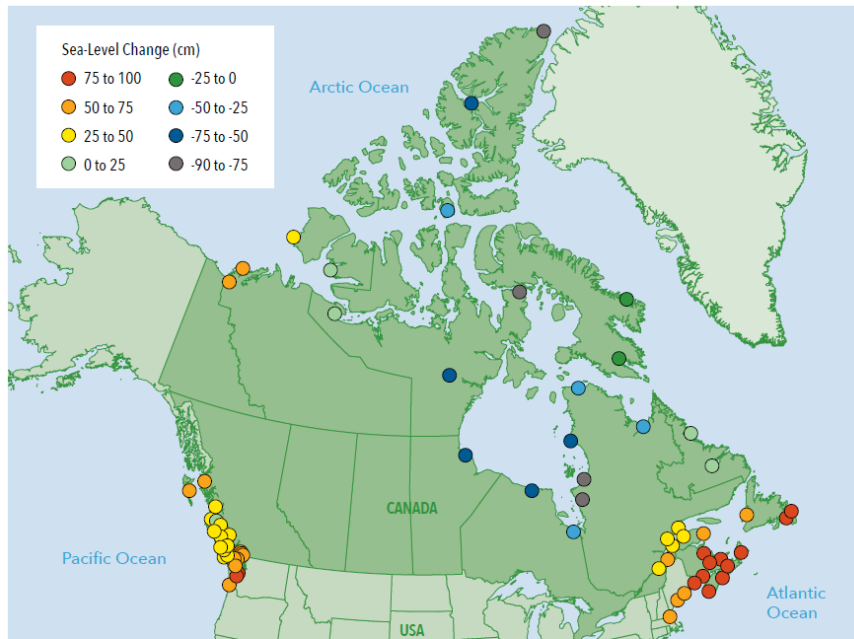
Two main goals:

- To influence the national conversation about climate change to address **climate adaptation**
- To help **residents, communities, governments and businesses** to reduce risks associated with climate change and extreme weather events



Canada's Marine and Great Lakes Coasts

4



Great Lakes

- More extreme variation in water levels (high and low)
- Frequency and intensity of severe storms has already increased (1951-2017)
- Drought, severe storms, and flooding may amplify erosion, sewage overflow, interference with transportation, and flood damage.



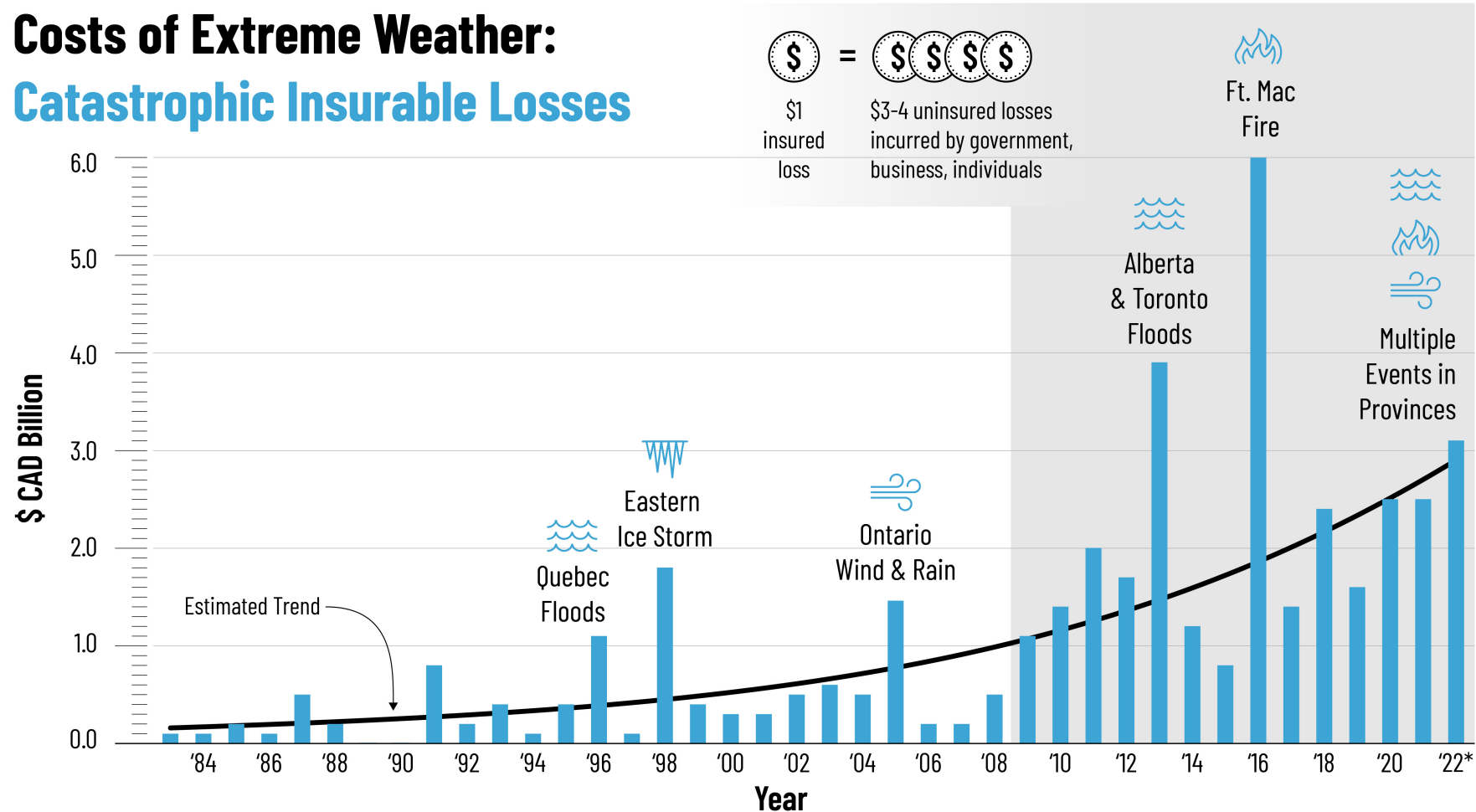
Marine Coasts

- Relative sea-level change
- Storm surge
- Changing sea ice conditions

- Coastal erosion
Dynamics are changing
May also be caused by human intervention

Not « just » an environmental issue....

Costs of Extreme Weather: Catastrophic Insurable Losses



- Most recently over \$2billion insured losses
- Most losses are not insured.
- Catastrophic losses are not all “financial”, particularly with extreme heat

Source: IBC Facts Book, PCS, CatIQ, Swiss Re, Munich Re & Deloitte

*2022 preliminary values in 2022\$ CAN, corrected for inflation and per capita wealth accumulation.

Hurricane Fiona – September 24, 2022 (Canada)

6

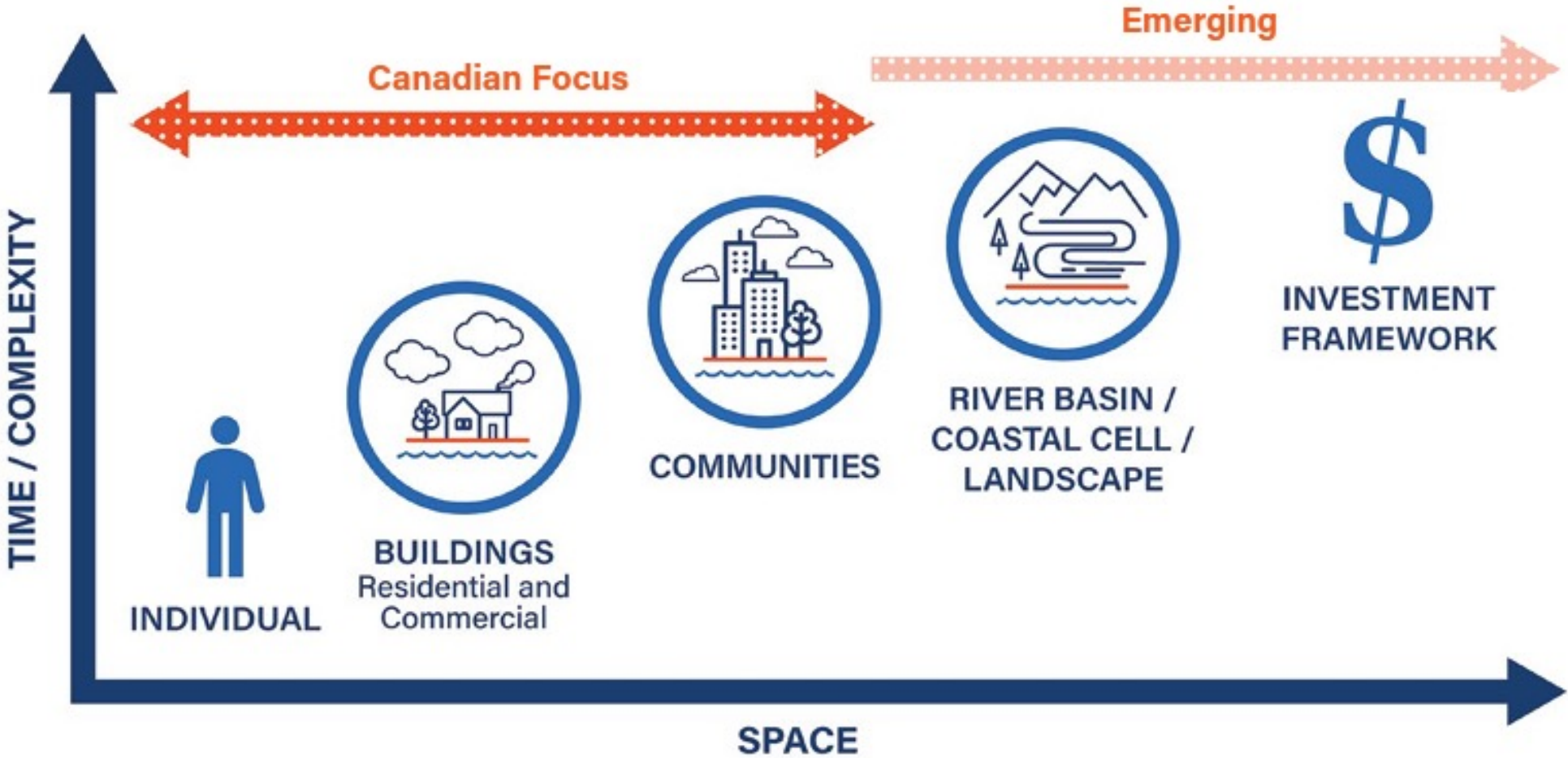
- Category 4 Atlantic hurricane
- **Costliest and most intense tropical or post-tropical cyclone to hit Canada on record.**
- Major flooding in Quebec's Magdalen Islands, southeastern New Brunswick, Prince Edward Island, northeastern Nova Scotia, and southern Newfoundland.
- Over \$800M CAD in insured damages
- More than 500,000 customers left without power, including 80% of all Nova Scotia customers and 95% of Prince Edward Island customers



Adapt-action is required at different scales



Focus of Flood Resilience Guidance and Standards in Canada



This is not the answer....

8



- Moratorium in Prince Edward Island is prohibited until a coastal zone policy is developed.

<https://www.thestar.com/news/canada/2023/02/01/after-controversial-development-pei-suspends-new-shoreline-protection-projects.html>

National Adaptation Strategy – Launched this week!

9

- By 2027, 80% of coastal communities and 60% of businesses located in coastal regions are implementing adaptation actions to increase climate resilience and reduce the economic impacts of climate change.
- **NEW Climate-Resilient Coastal Communities Program** to increase the resilience of communities along Canada's coasts by applying a new, systems-based approach to integrated, regional-scale projects.

Canada's National Adaptation Strategy: Building Resilient Communities and a Strong Economy



<https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/national-adaptation-strategy.html>

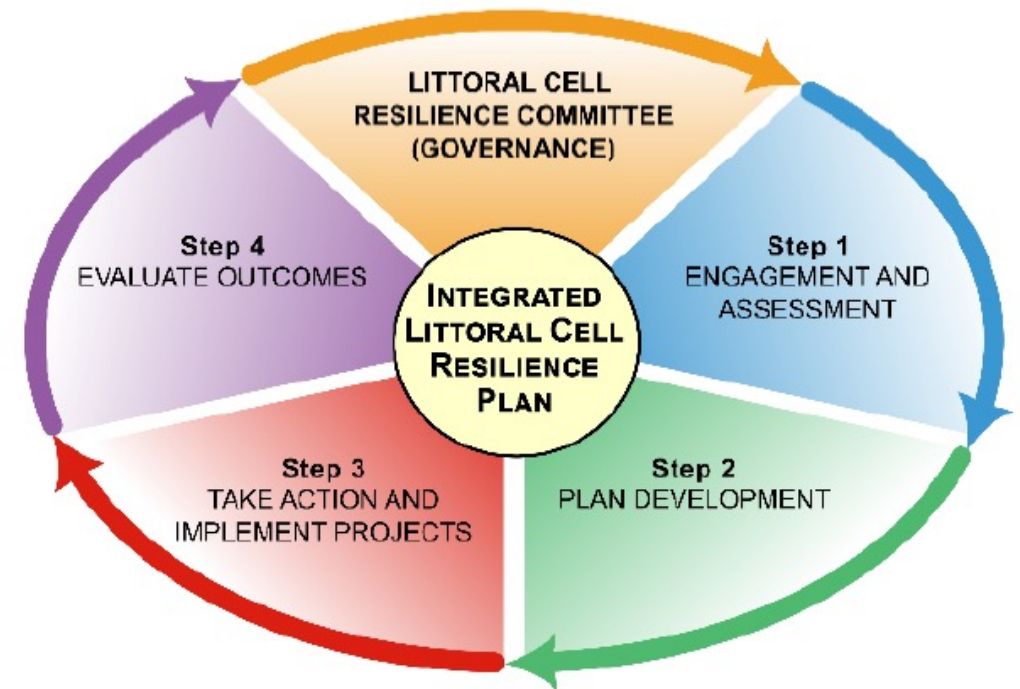
Recent Strategic Coastal Management Initiatives

10

- Development of a Coastal Resilience Framework for the Canadian Great Lakes
- Federal and Provincial partnership to establish a resilience framework using Lake Erie as a pilot



<https://zuzekinc.ca/ResilienceFramework/>

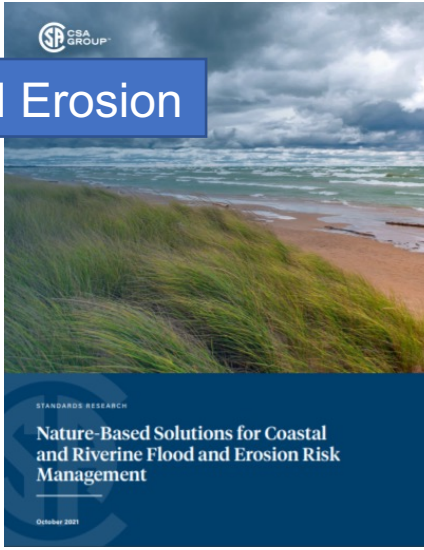


- **Shoreline Management Planning National Guidance**
 - Project recently started between Standards Council of Canada and Intact Centre on Climate Adaptation
 - Not a simple task due to jurisdictional division of responsibilities

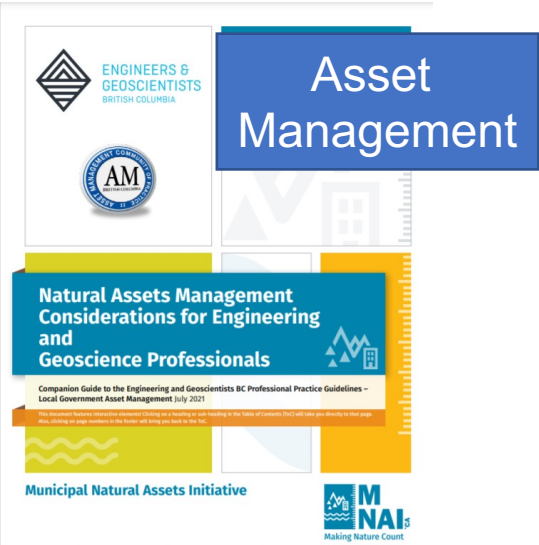
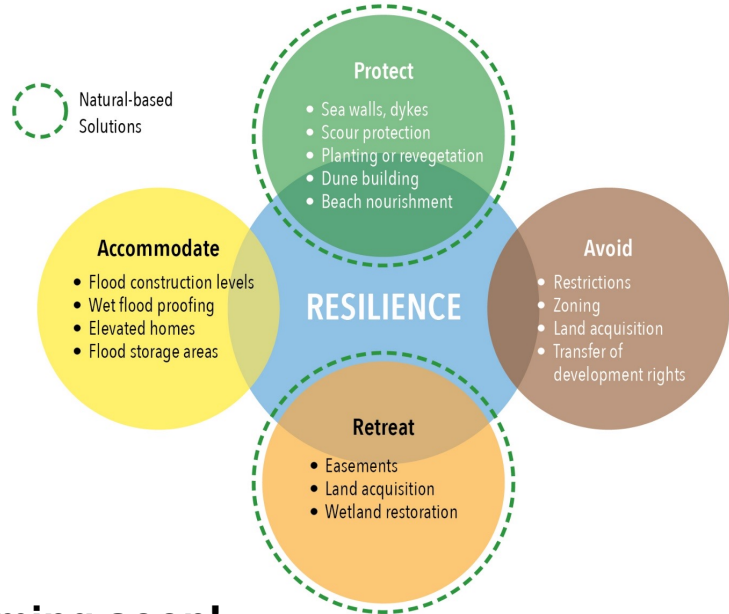
Rapidly Evolving Canadian NbS Guidance



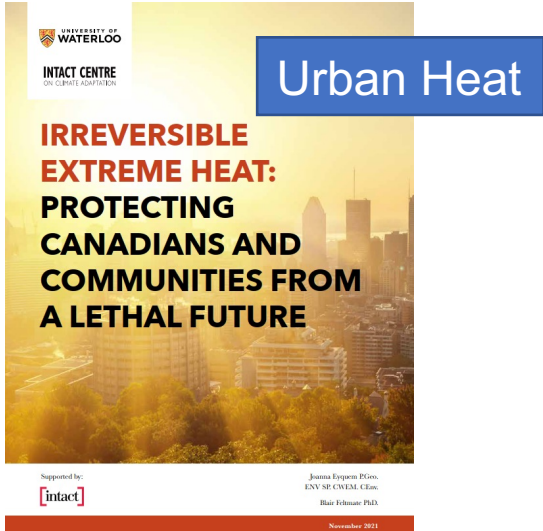
Flood and Erosion



Coasts



Asset Management



Urban Heat

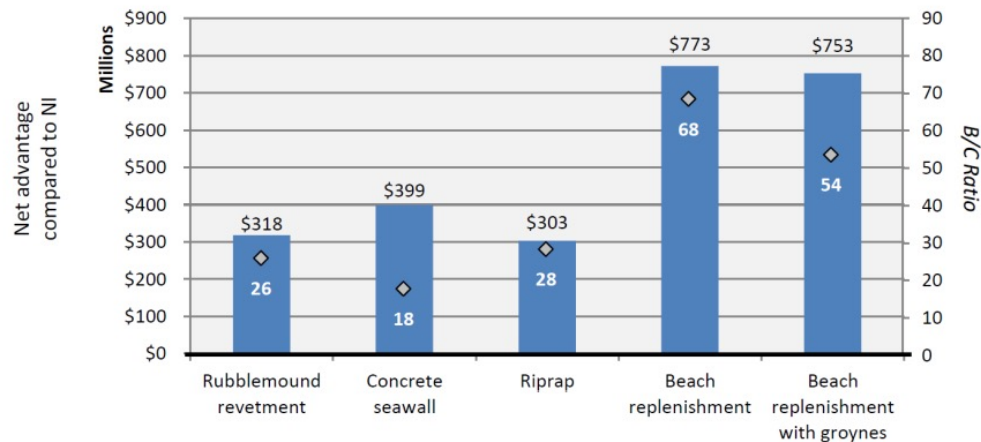
Coming soon!

Nature-based Infrastructure for Coastal Resilience and Risk Reduction (National Research Council Canada)

- Key Sections on
- Systems Approach
 - Governance
 - Engagement

Cost-Benefit Analysis: Percé, Quebec (Ouranos)

Five alternatives assessed for Anse du Sud (heart of Percé):



CBA compared to non-intervention - Beach nourishment most beneficial option over 50-year period considered.

Benefit-cost ratio: 68:1

Large benefits from tourism industry

Source: Circé, M., et al. 2016, Ouranos

<https://www.ouranos.ca/wp-content/uploads/Synthesis-report-ACA-Quebec-final.pdf>

Type of Impact	Negative Impacts	Positive Impacts
Related to erosion	<ul style="list-style-type: none"> Loss of land Complete or partial loss of residential or commercial buildings Loss or damage to public infrastructure 	
Related to flooding	<ul style="list-style-type: none"> Damages to land Damages to residential or commercial buildings Damages to public infrastructure Emergency evacuation Debris clean-up Traffic congestion or detour 	
Economic	<ul style="list-style-type: none"> Reduced land value Loss of goods and commercial revenues Loss of tourism revenues 	<ul style="list-style-type: none"> Gain in tourism revenues
Environmental	<ul style="list-style-type: none"> Loss of natural habitats Loss of fishing spawning grounds 	<ul style="list-style-type: none"> Improvement in fish spawning grounds
Social	<ul style="list-style-type: none"> Loss of sea view Loss of sea access Decline in the coast's recreational use Reduced quality of life (anxiety, insecurity, etc.) Deterioration in the landscape Deterioration in historical and cultural heritage 	<ul style="list-style-type: none"> Improvement in the coast's recreational use Improvement in quality of life (security) Improvement in the landscape

Communities Working Strategically Together

13

- Mud Bay Nature-based Foreshore Enhancements Project
- Partnership between City of Surrey, City of Delta and Semiahmoo First Nation.

<https://www.surrey.ca/services-payments/water-drainage-sewer/flood-control-and-prevention/coastal-flood-adaptation-projects/mud-bay>

The Living Dyke Solution

A living dyke uses nature to provide flood protection. The concept is based on the idea of establishing a gentle, raised slope to help natural marshes keep up with sea level rise. Our goal is to help the marsh lining Boundary Bay adapt to one metre of sea level rise.



Adaptation, Decolonization and Reconciliation

14

CONVENTIONAL APPROACH



“Language changes our design thinking”

DEREK LEE, PRINCIPAL, PWL PARTNERSHIP,
SEA2CITY DESIGN TEAM LEAD



NEW APPROACH



<https://vancouver.ca/green-vancouver/sea2city-design-challenge.aspx>

ACKNOWLEDGE: spaces are retrofitted or relocated over time to improve their resilience and better care for and steward natural systems.

- **HOST:** a dynamic place where water, nature, and culture are welcomed and stewarded. Human uses are flexible, adaptable, and leave a light-touch. Infrastructure works with nature to enhance resilience.

- **RESTORE:** a revitalized and rehabilitated shoreline that restores natural functions, features, and ecosystems and includes improved flood protection for upland communities.

Key Conclusions

15

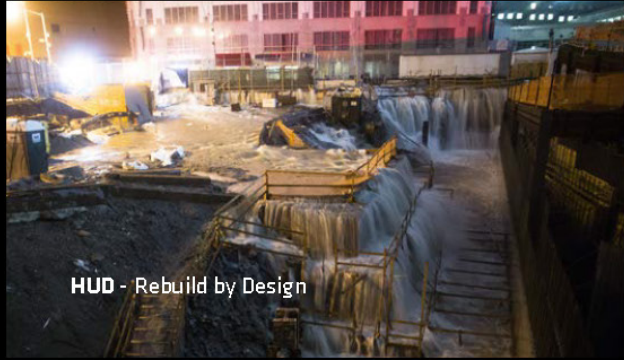
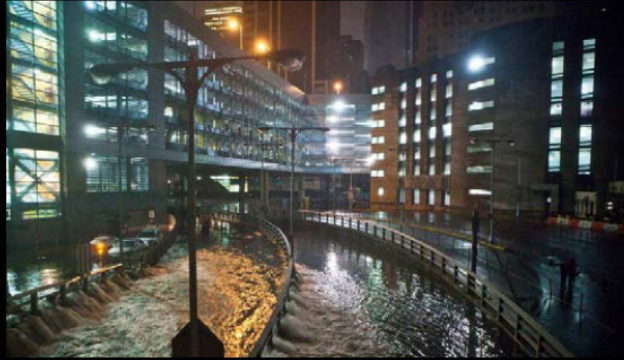
1. Coastal communities are on the frontlines of climate change in Canada.
2. Federal, provincial and local governments need to work together on a strategic approach for Canada
3. Integrated Coastal Zone Management is not in place, but several initiatives are working in the right direction.



Joanna Eyquem PGeo. ENV SP. CWEM. CEnv.
Managing Director, Climate Resilient Infrastructure
Intact Centre on Climate Adaptation
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Intact Centre - Tools and Guidance:
<https://www.intactcentreclimateadaptation.ca>



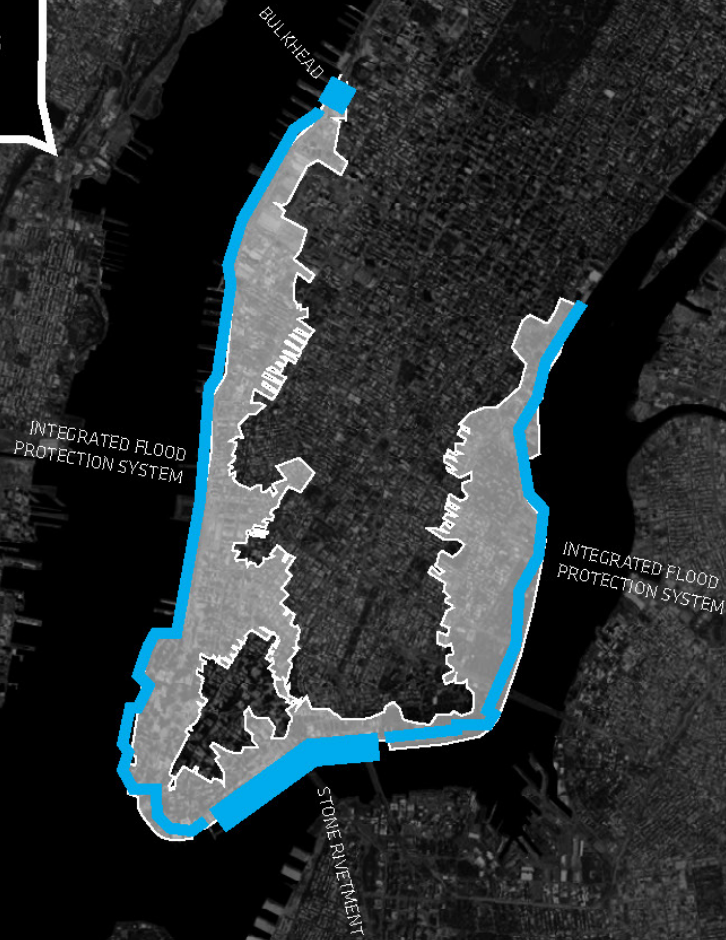


HUD - Rebuild by Design

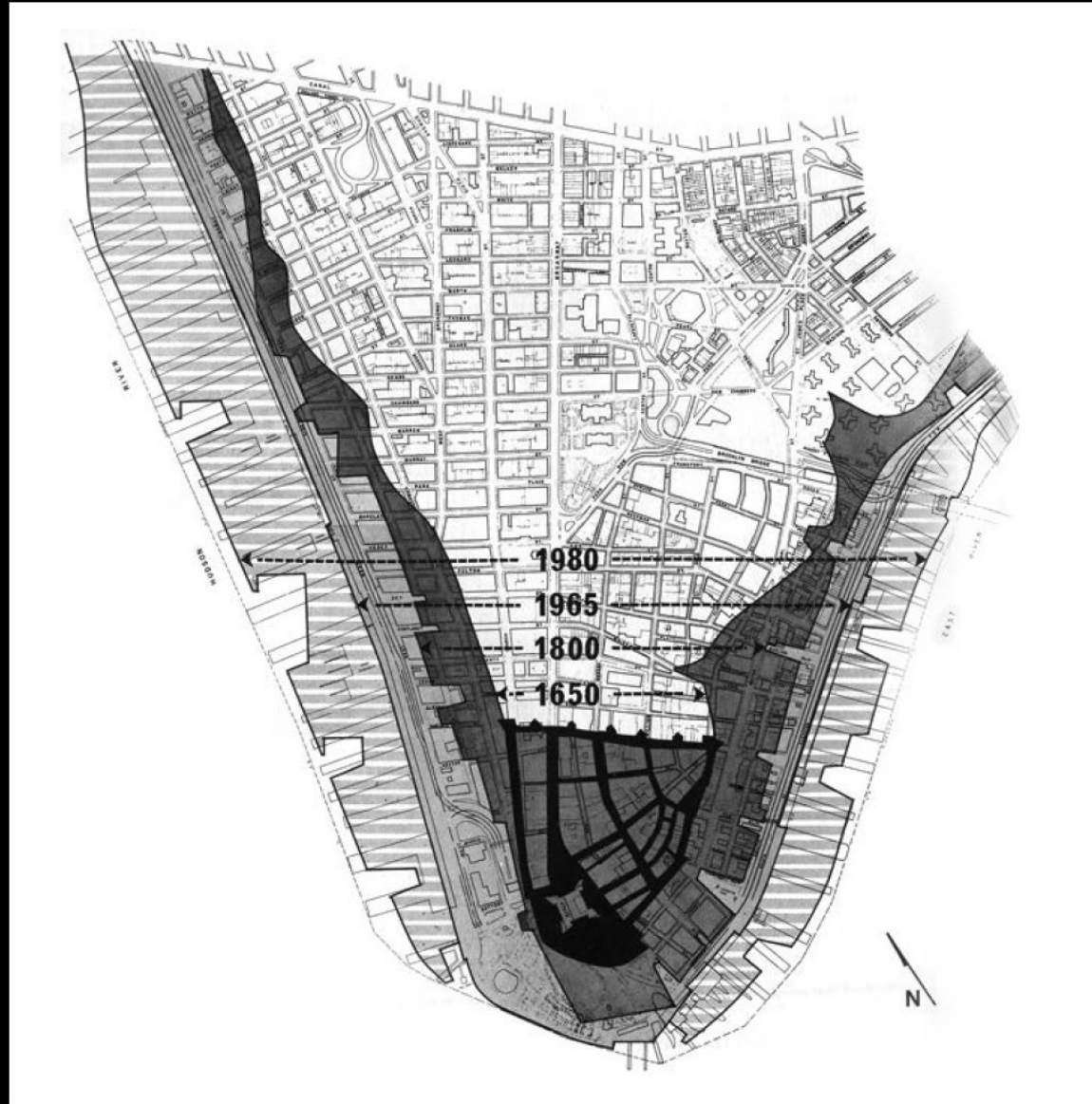


BIG TEAM

SIRR REPORT RECOMMENDS
MANHATTAN, 8 CONTINUOUS
MILES OF INTEGRATED
COASTAL PROTECTION!







FEMA FLOOD ZONE







PROGRAM



INFRASTRUCTURE



+

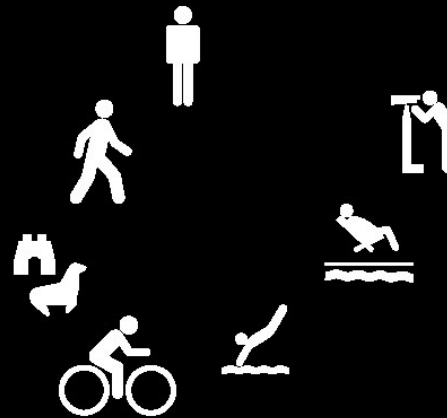


RESILIENCY INFRASTRUCTURE

PEOPLE!



+



RESILIENCY INFRASTRUCTURE

PROGRAM



TWO ROUNDS OF PUBLIC WORKSHOPS


 AN INITIATIVE OF PRESIDENT OBAMA'S HURRICANE SANDY REBUILDING TASK FORCE AND HUD
 ESTA ES UNA INICIATIVA DE RECUPERACIÓN TASK FORCE DEL PRESIDENTE OBAMA Y HUD
 一个总统所倡议的 SANDY 飓风灾后重建任务
 WWW.REBUILDDESIGN.ORG

L.E.S. PUBLIC WORKSHOPS ON NEIGHBORHOOD FLOOD PROTECTION

TALLERES PUBLICOS SOBRE LA PROTECCIÓN CONTRA INUNDACIONES EN COMUNIDADES

下东区街坊防洪公开研讨会

MONTHSIDE MEETING 北镇会议 MONDAY, FEB. 3RD 6 - 9PM LUNES, 3 DE FEBRERO, 6 - 9PM 周一, 2月3日, 6 - 9PM LOWER EASTSIDE GIRLS CLUB 101 AVENUE D	MONTHSIDE MEETING 北镇会议 MONDAY, FEB. 10TH 6 - 9PM LUNES, 10 DE FEBRERO, 6 - 9PM 周一, 2月10日, 6 - 9PM HAMILTON MADISON HOUSE 50 MADISON STREET
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FREE FOOD
 COMIDA GRATIS
 免费食物

FREE RAFFLES
 RAFFLES GRATIS
 免费抽奖

FREE CHILDCARE (OVER AGE 5)
 CUIDO DE NIÑOS GRATIS (MAYORES DE 5 AÑOS DE EDAD)
 免费儿童看护 (5岁以上)

REBUILD BY DESIGN IS DEVELOPING FUNDABLE SOLUTIONS TO BETTER PROTECT RESIDENTS FROM FUTURE CLIMATE EVENTS.
 RECONSTRUIR POR DISEÑO ES EL DESARROLLO DE SOLUCIONES QUE PUEDE SER FINANCIADA PARA PROTEGER MEJOR
 A LOS RESIDENTES DE FUTUROS EVENTOS CLIMÁTICOS.
 重建设计正致力于可资助的解决方案用以更好的保护居民免受未来的气象灾害困扰。

QUESTIONS? CONTACT... ¿PREGUNTAS? PÓNGASE EN CONTACTO CON... 问题? 联系方式... LILIAN MEJIA @lilmejia@qoles.org 212-358-1231


 AN INITIATIVE OF PRESIDENT OBAMA'S HURRICANE SANDY REBUILDING TASK FORCE AND HUD
 ESTA ES UNA INICIATIVA DE RECUPERACIÓN TASK FORCE DEL PRESIDENTE OBAMA Y HUD
 一个总统所倡议的 SANDY 飓风灾后重建任务
 WWW.REBUILDDESIGN.ORG

L.E.S. PUBLIC WORKSHOPS ON NEIGHBORHOOD FLOOD PROTECTION

TALLERES PUBLICOS SOBRE LA PROTECCIÓN CONTRA INUNDACIONES EN L.E.S.

下东区街坊防洪公开研讨会

	MONDAY, MARCH 10TH LUNES, 10 DE MARZO 星期一, 3月10日 7 ⁰⁰ AM - 7 ²⁰ PM RUTGERS COMMUNITY CTR 200 MADISON ST
	TUESDAY, MARCH 11TH MIÉRCOLES, 11 DE MARZO 星期二, 3月11日 6 - 8 ^{PM} GIRLS CLUB 101 AVENUE D @ 8 TH STREET NEED TRANSPORTATION? CONTACT JULIAN NECESITA TRANSPORTE? LLAMA A JULIAN 需要交通服务? 联系人: JULIAN JULIAN MORALES (212) 358-1231

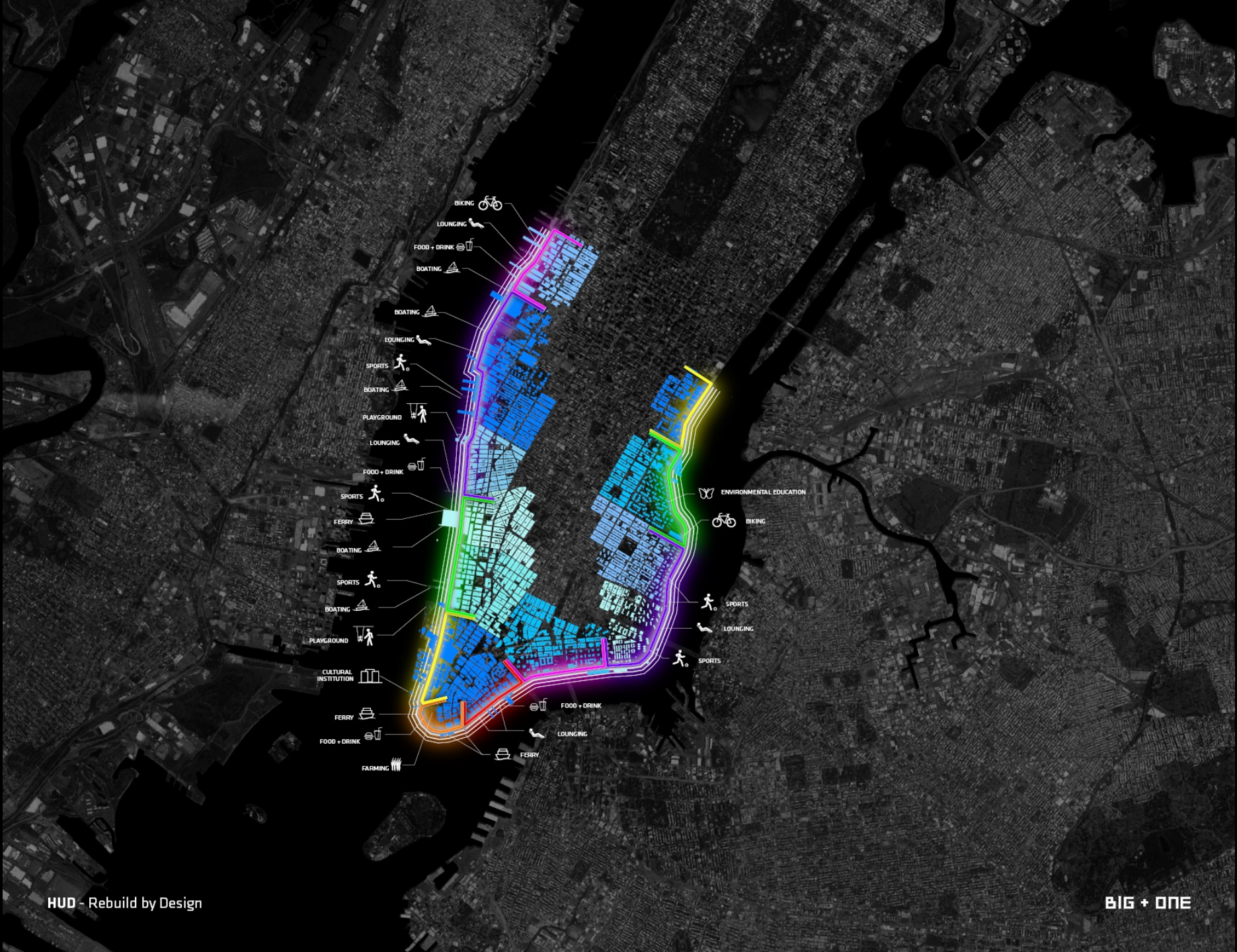
REBUILD BY DESIGN IS DEVELOPING STRATEGIES TO PROTECT FROM FLOODING ALONG THE EAST RIVER WATERFRONT.
 PLEASE JOIN US TO LEARN AND GIVE FEEDBACK ON THIS INITIATIVE. WE WANT TO HEAR FROM YOU!
 RECONSTRUIR POR DISEÑO ESTA EXPLORANDO ESTRATEGIAS PARA LA PROTECCIÓN DE INUNDACIONES ALREDEDOR DEL
 EAST RIVER WATERFRONT. POR FAVOR, ÚNASE A NOSOTROS PARA APRENDER Y DAR OPINIONES!
 重建设计致力于寻找并开发东河沿岸的防洪策略。
 请加入我们来更多了解这些创新策略并请提出反馈建议, 我们会虚心接受。

FREE FOOD
 COMIDA GRATIS
 免费食物

FREE RAFFLES
 RAFFLES GRATIS
 免费抽奖

FREE CHILDCARE (OVER AGE 5)
 CUIDO DE NIÑOS GRATIS (MAYORES DE 5 AÑOS DE EDAD)
 免费儿童看护 (5岁以上)

QUESTIONS? CONTACT LILIAN / PREGUNTAS? LLAMA A LILIAN / 问题? 联系人: LILIAN LILIAN MEJIA @lilmejia@qoles.org 212-358-1231









THE BRIDGING BERM
ADA ACCESSIBLE RAMPING CONNECTIONS



THE BIG U - FROM BIG U TO SMALL Us



**SMALLER Us
MEANS SMALLER AREAS
AND MANAGEABLE SCALES**

4.9米
年 海拔 4.2米
0年 海拔 3.7米
2年 海拔 3.4米
河河岸 海拔 2.4米

ONE 韧性纽约 ONE RESILIENT NYC

Sea Level Rise in NYC | 纽约海平面上涨

NYC | 曼哈顿韧性设计

HFD | 曼哈顿金融区韧性设计

THE BIG U

HOSPITAL ROW | 医院街

ESCR | 曼哈顿东区沿海韧性设计

BMCR | 布鲁克林桥城哥马利沿海韧性设计



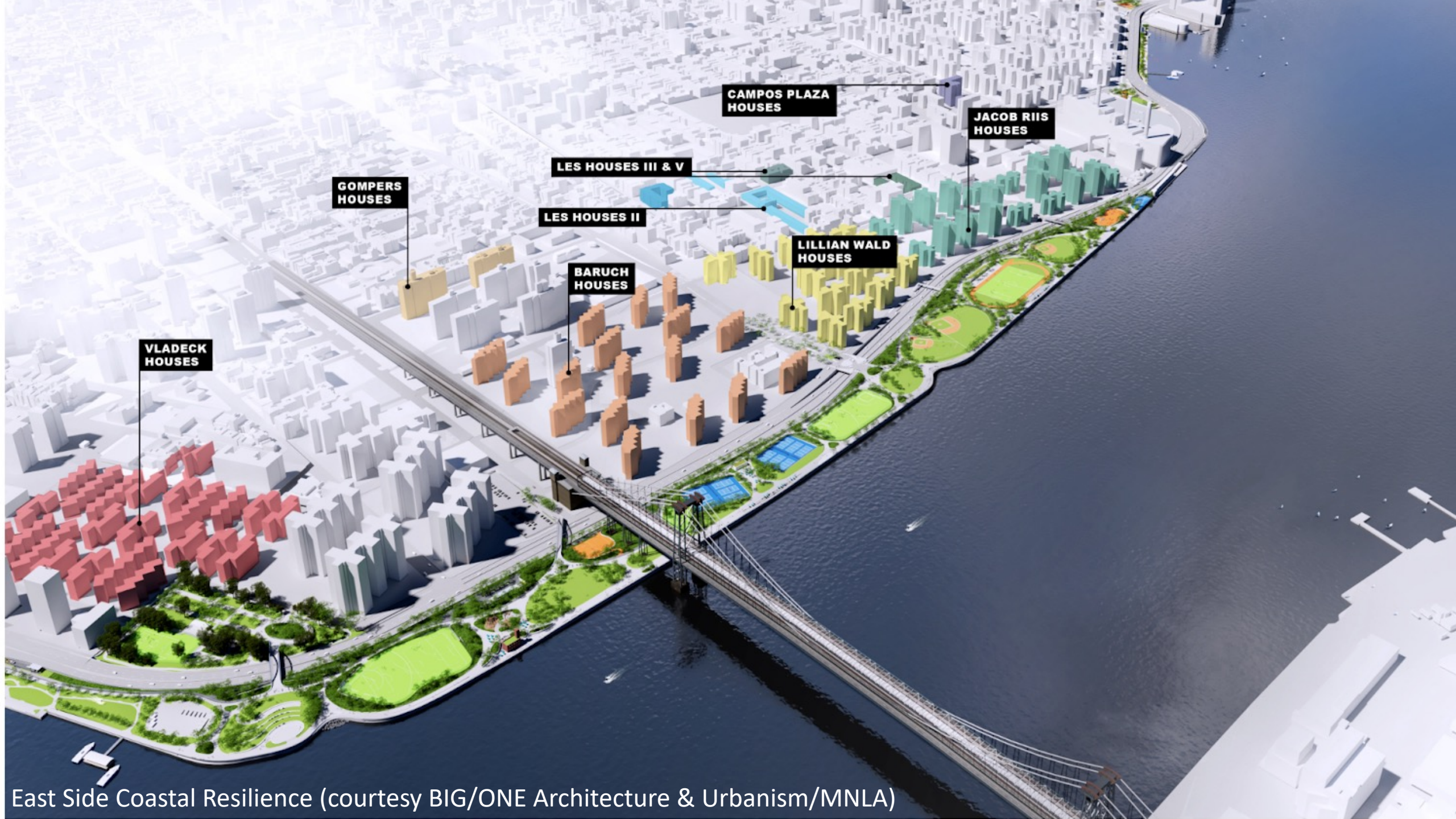
Shenzhen Design Week (courtesy ONE Architecture & Urbanism)



THE BIG U

PHASE 1: EAST SIDE COASTAL RESILIENCY





**VLADECK
HOUSES**

**GOMPERS
HOUSES**

LES HOUSES II

**BARUCH
HOUSES**

**CAMPOS PLAZA
HOUSES**

LES HOUSES III & V

**JACOB RIIS
HOUSES**

**LILLIAN WALD
HOUSES**

East Side Coastal Resilience (courtesy BIG/ONE Architecture & Urbanism/MNLA)

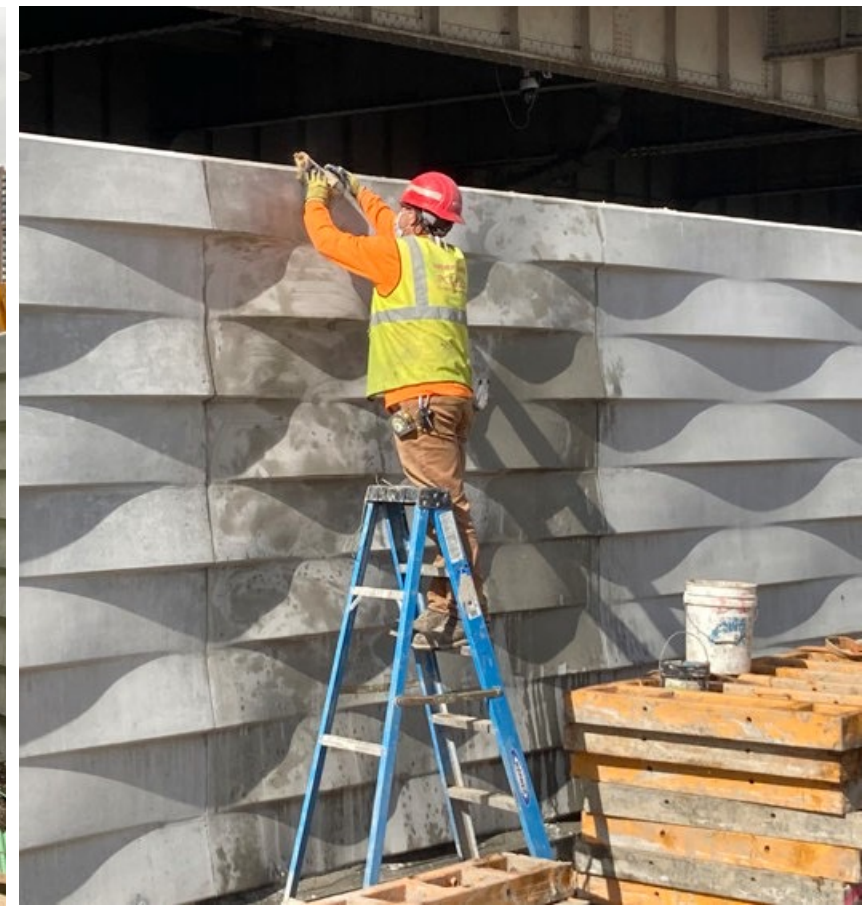
ARCHITECTURE

ESC
R



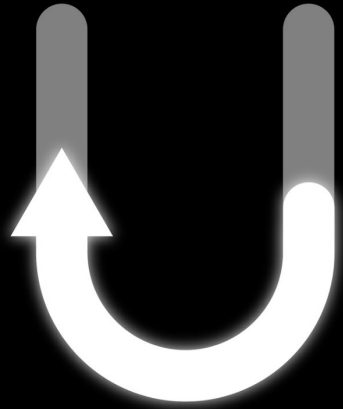
ARCHITECTURE

ESC
R





ESCR construction (photo by Dean Moses)



LOWER MANHATTAN COASTAL RESILIENCY

COASTAL STORMS

**BY 2050, NEARLY 1/3
OF BUILDINGS IN LOWER
MANHATTAN WILL BE AT
RISK FROM A 100 YEAR
STORM SURGE.**

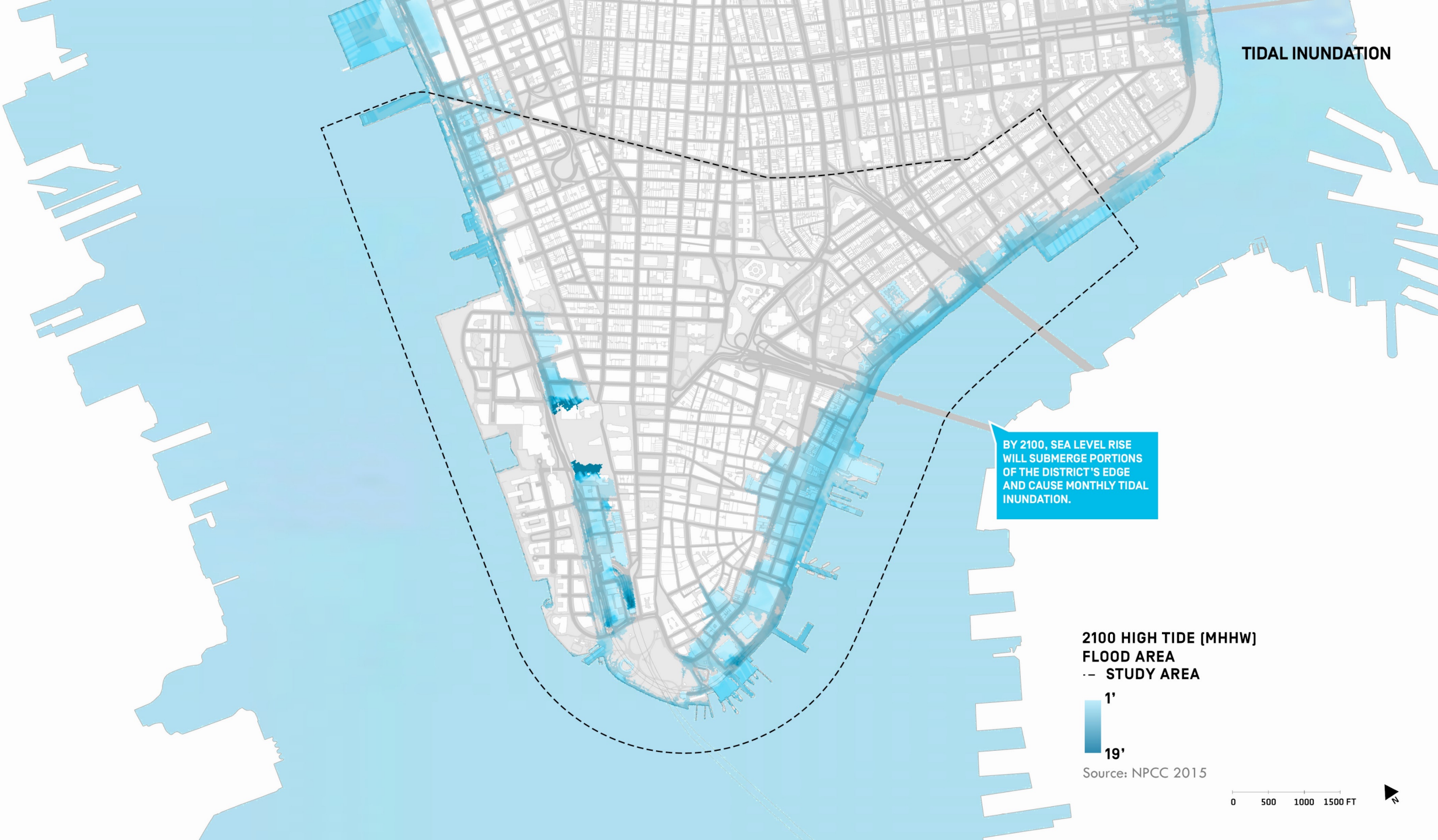
**BY 2100, MORE THAN
50% WILL BE.**

- 1' 19' 2050 100-YR COASTAL STORM FLOOD
- 2100 100-YR COASTAL STORM FLOOD
- STUDY AREA

Source: NPCC 2015

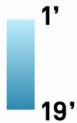


TIDAL INUNDATION



BY 2100, SEA LEVEL RISE WILL SUBMERGE PORTIONS OF THE DISTRICT'S EDGE AND CAUSE MONTHLY TIDAL INUNDATION.

2100 HIGH TIDE (MHHW)
FLOOD AREA
-- STUDY AREA



Source: NPCC 2015

0 500 1000 1500 FT



GROUNDWATER TABLE RISE

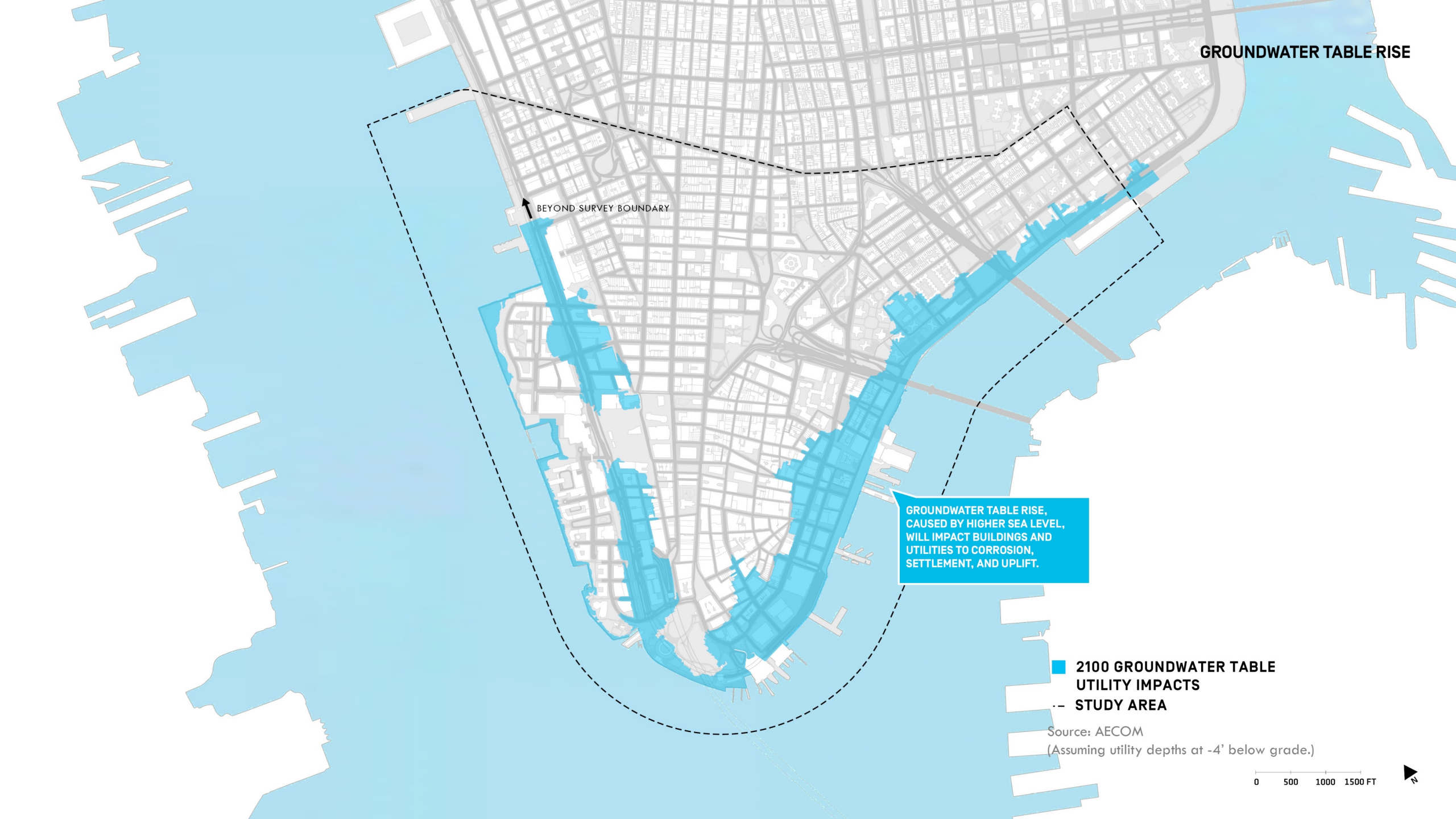
BEYOND SURVEY BOUNDARY

GROUNDWATER TABLE RISE,
CAUSED BY HIGHER SEA LEVEL,
WILL IMPACT BUILDINGS AND
UTILITIES TO CORROSION,
SETTLEMENT, AND UPLIFT.

**2100 GROUNDWATER TABLE
UTILITY IMPACTS**
-- **STUDY AREA**

Source: AECOM
(Assuming utility depths at -4' below grade.)

0 500 1000 1500 FT

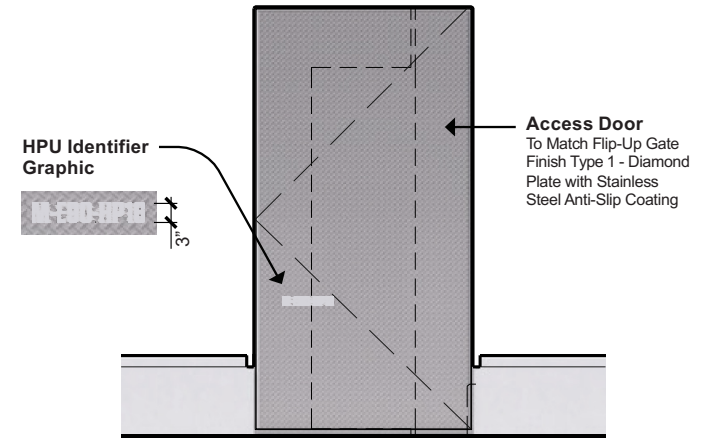
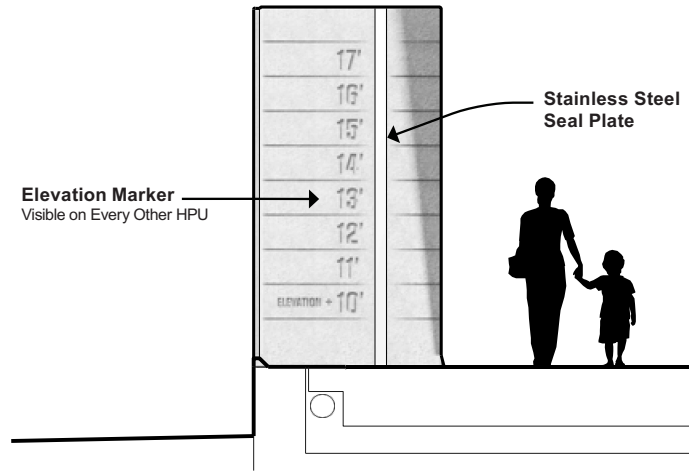
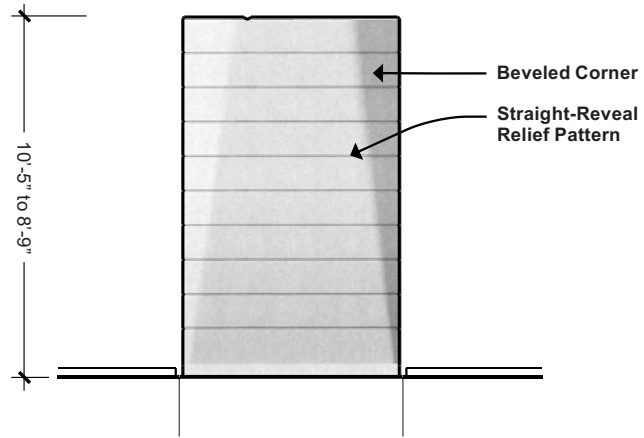
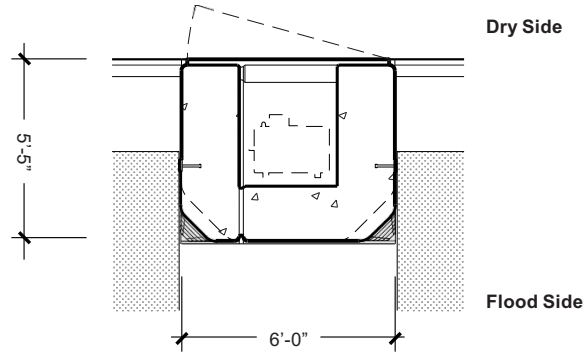




Brooklyn Montgomery Coastal Resilience (courtesy AECOM/ONE Architecture & Urbanism)

ARCHITECTURE

BMC
R



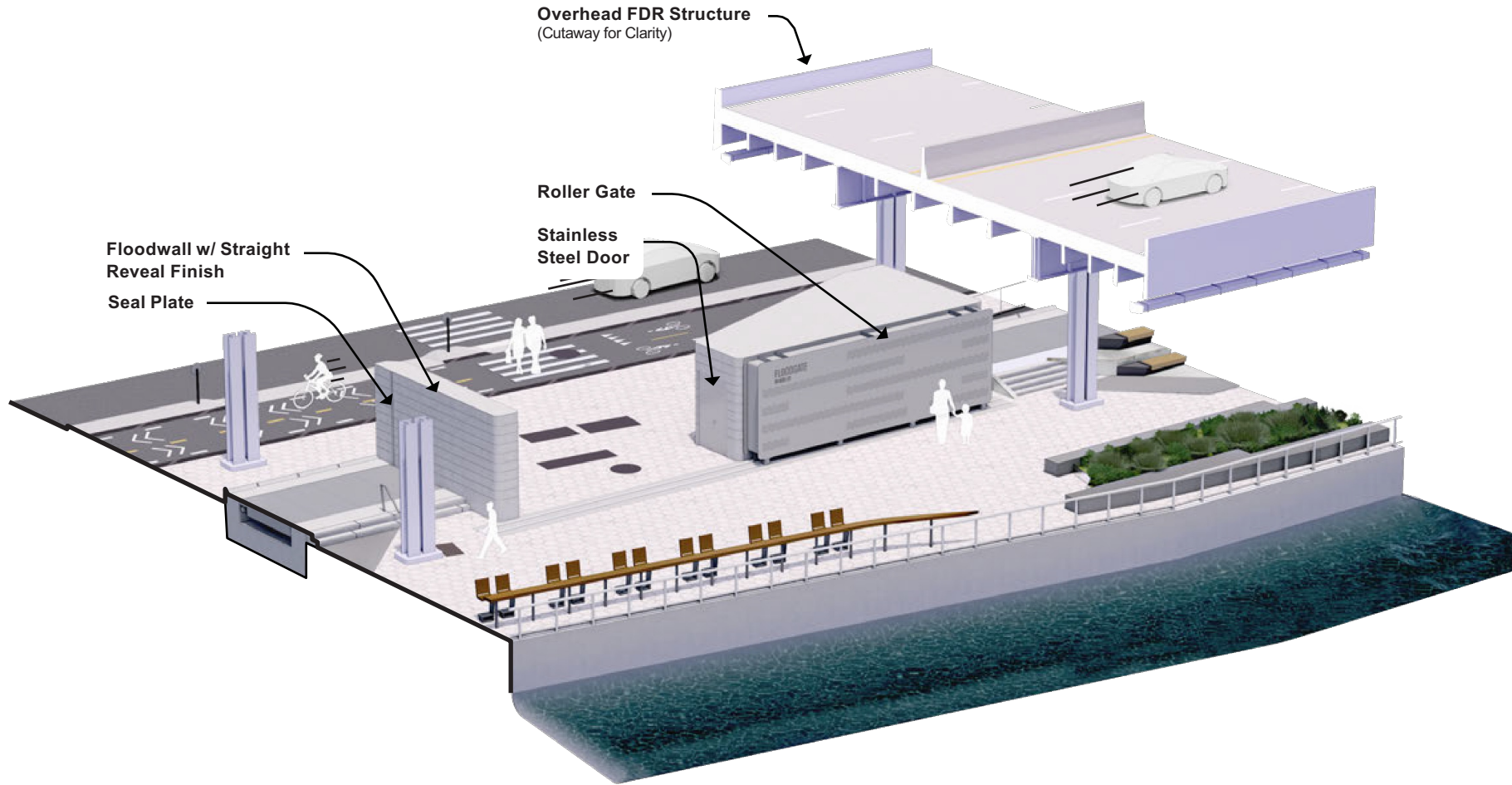
FLOOD SIDE ELEVATION

SIDE ELEVATION

DRY SIDE ELEVATION

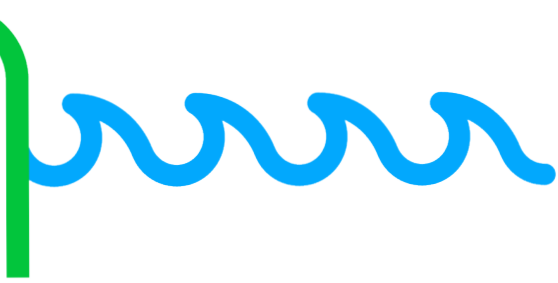
ARCHITECTURE

BMC
R



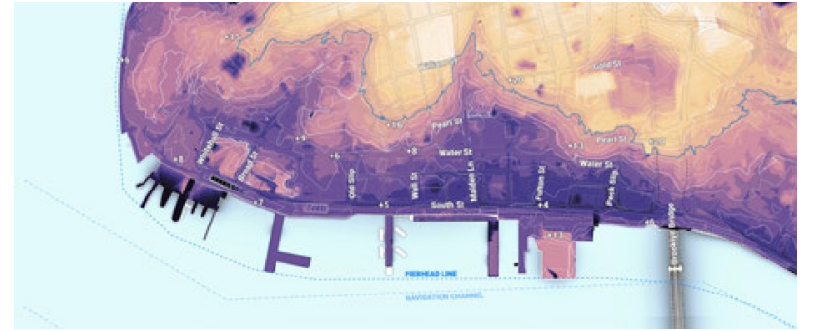
FiDi and Seaport

Climate
Resilience
Plan



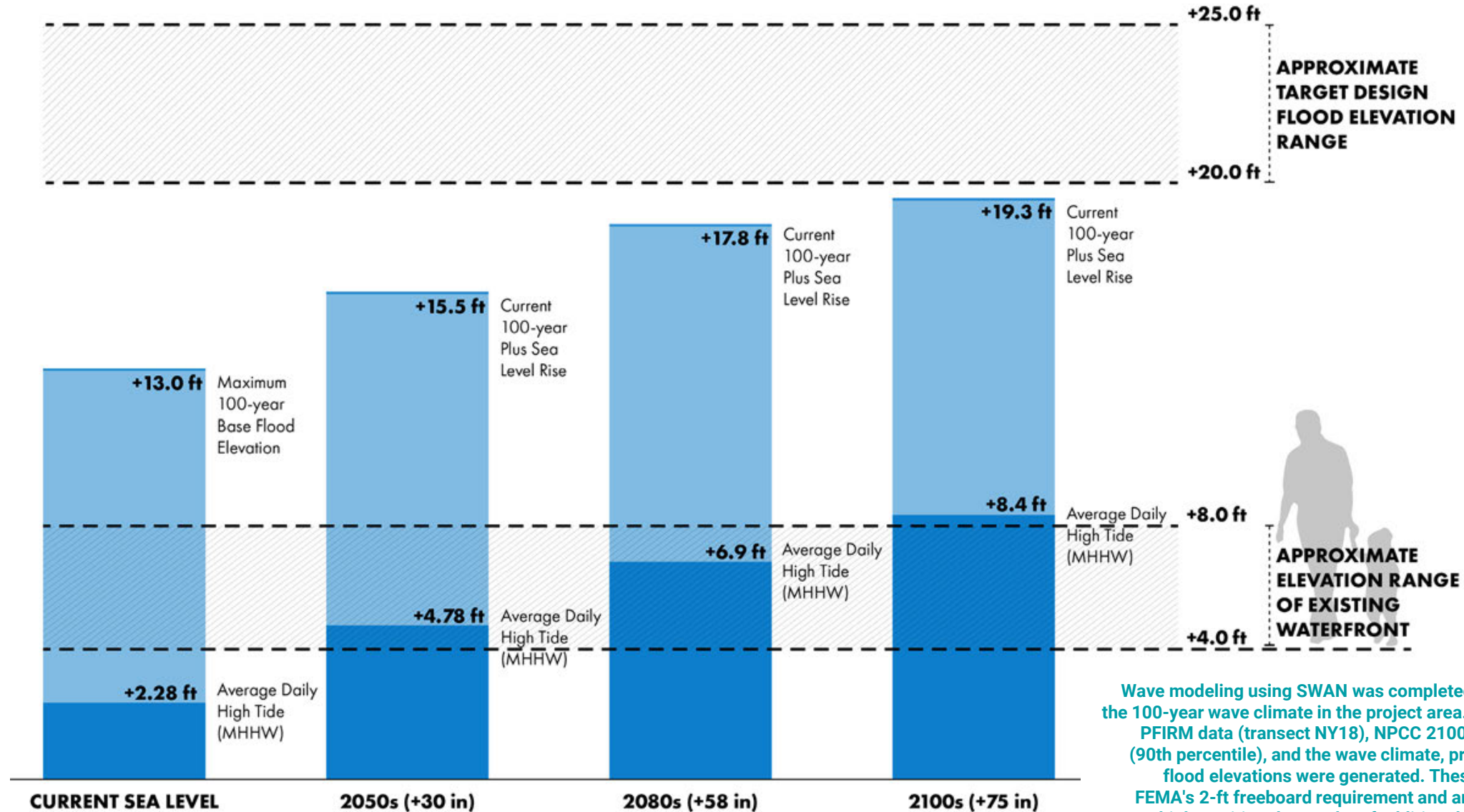
URBAN DESIGN AND INFRASTRUCTURE

Fidi-Seaport Resilience Master Plan



Coastal Defense

Preliminary Design Flood Elevation Targets



Wave modeling using SWAN was completed to characterize the 100-year wave climate in the project area. Based on FEMA PFIRM data (transect NY18), NPCC 2100 SLR projections (90th percentile), and the wave climate, preliminary design flood elevations were generated. These values include FEMA's 2-ft freeboard requirement and are conservatively high awaiting the results of additional modeling and an overtopping analysis.



FiDi-Seaport Climate Masterplan (courtesy ONE Architecture & Urbanism/Scape)

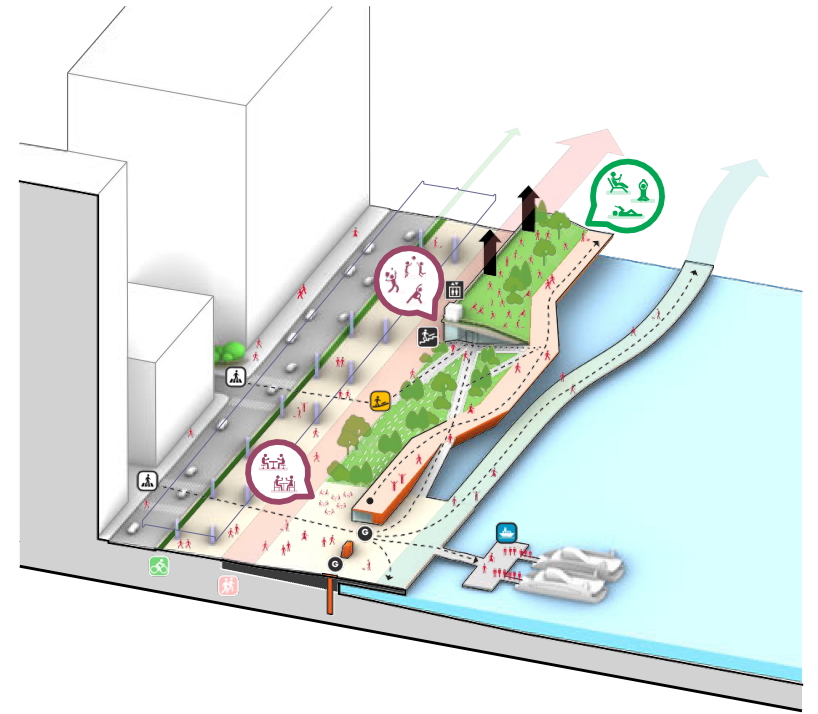
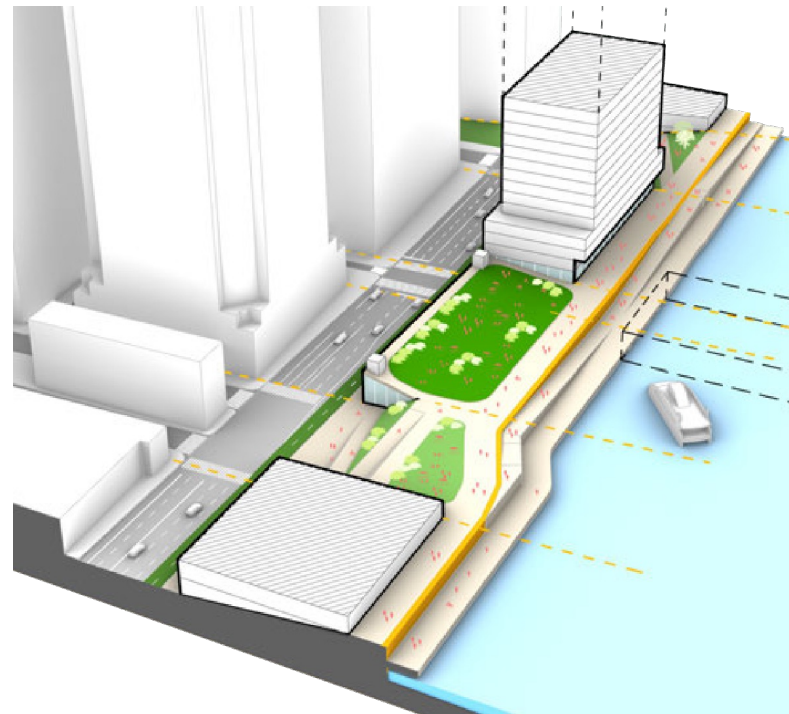
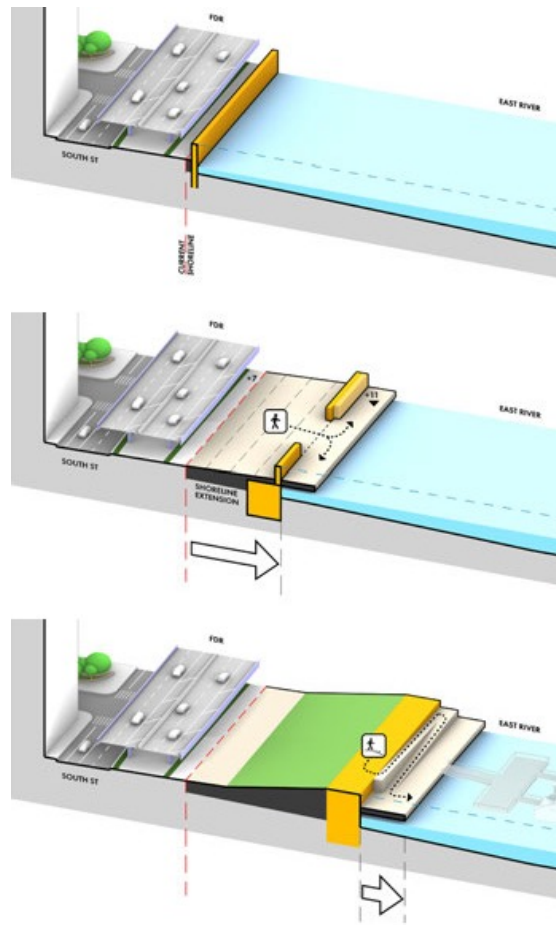
URBAN DESIGN AND INFRASTRUCTURE

Fidi-Seaport Resilience Master Plan



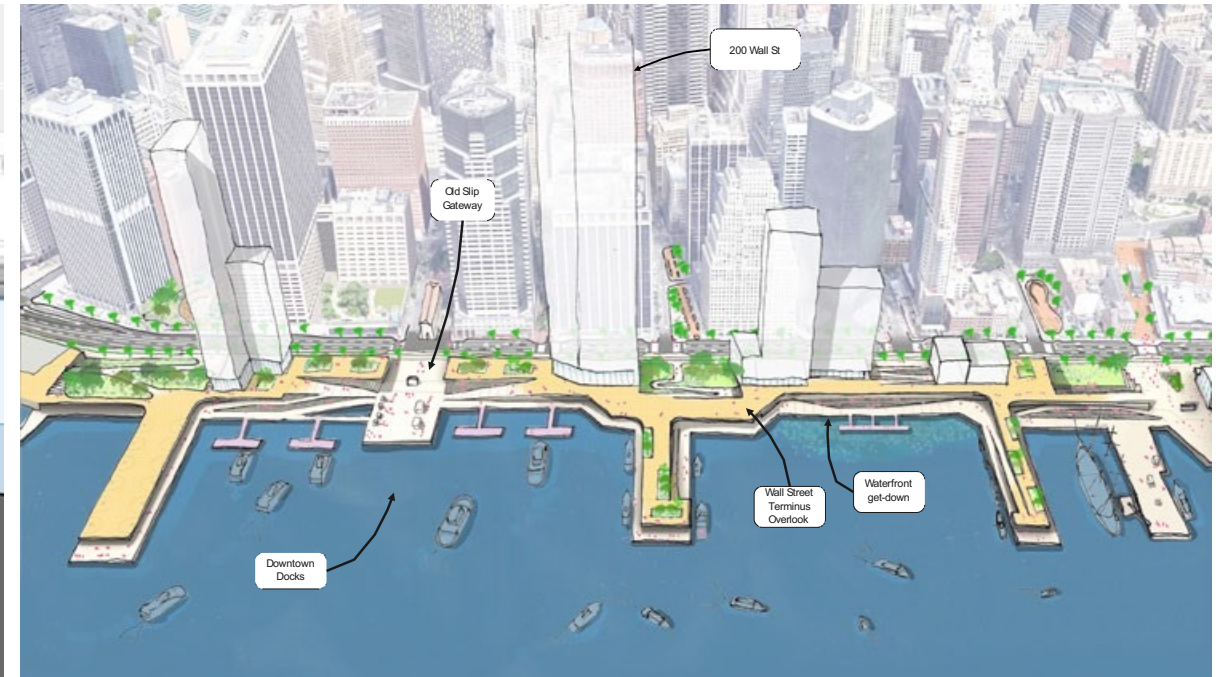
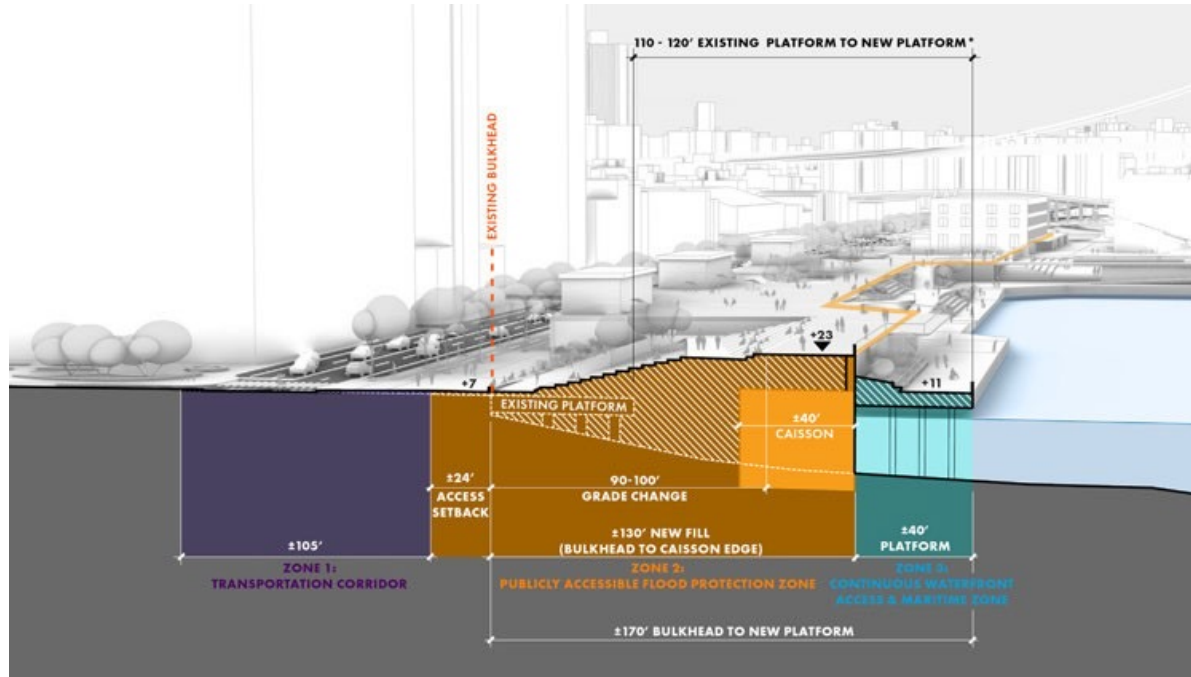
URBAN DESIGN AND INFRASTRUCTURE

Fidi-Seaport Resilience Master Plan



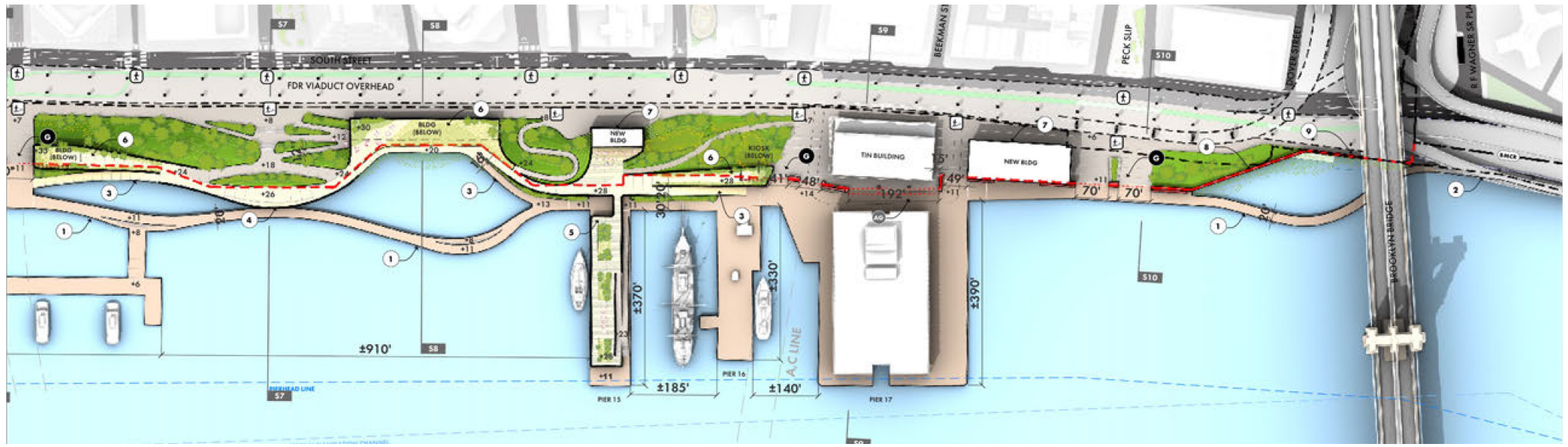
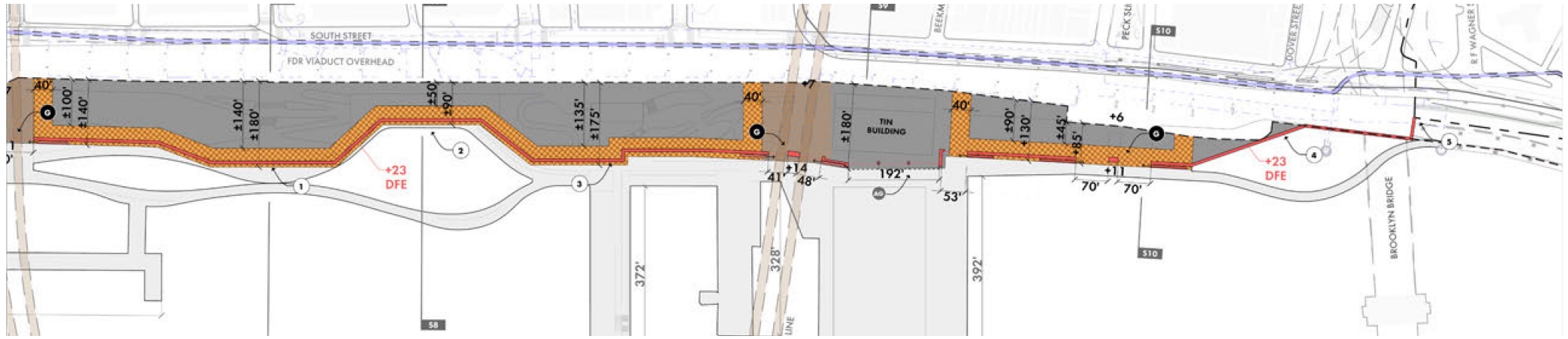
URBAN DESIGN AND INFRASTRUCTURE

Fidi-Seaport Resilience Master Plan



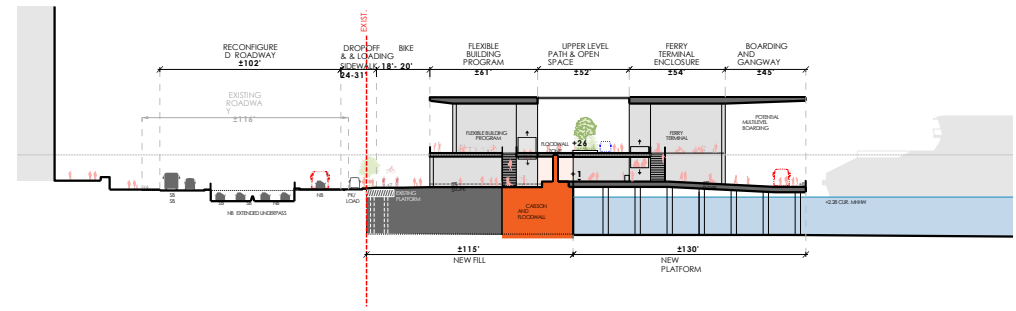
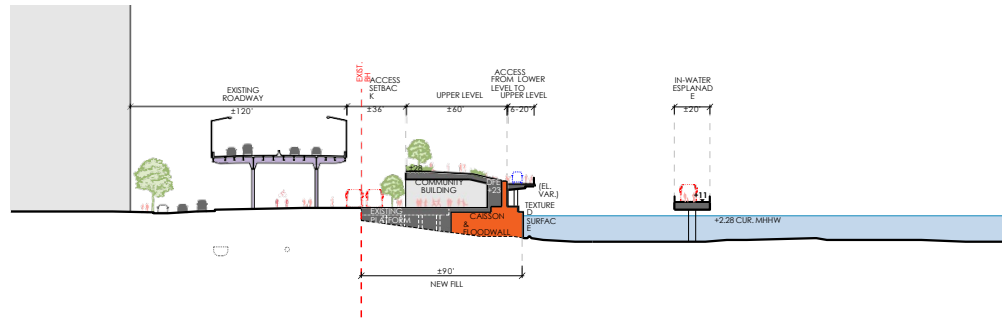
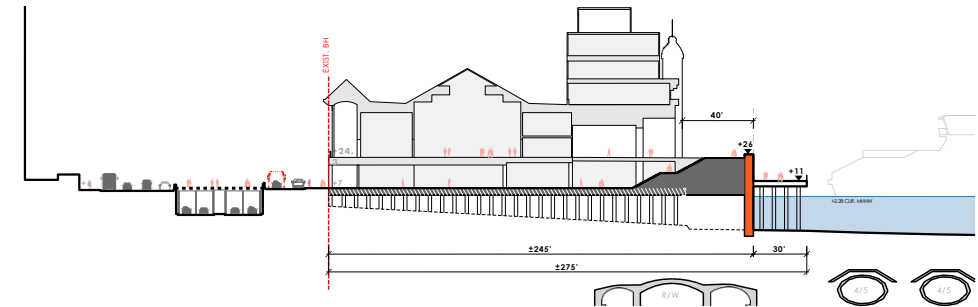
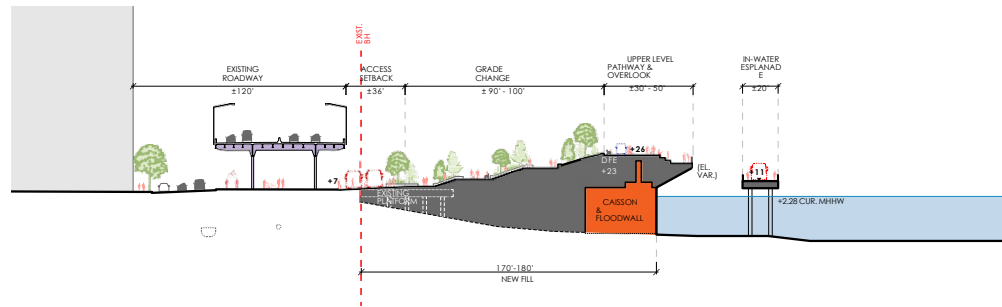
URBAN DESIGN AND INFRASTRUCTURE

Fidi-Seaport Resilience Master Plan

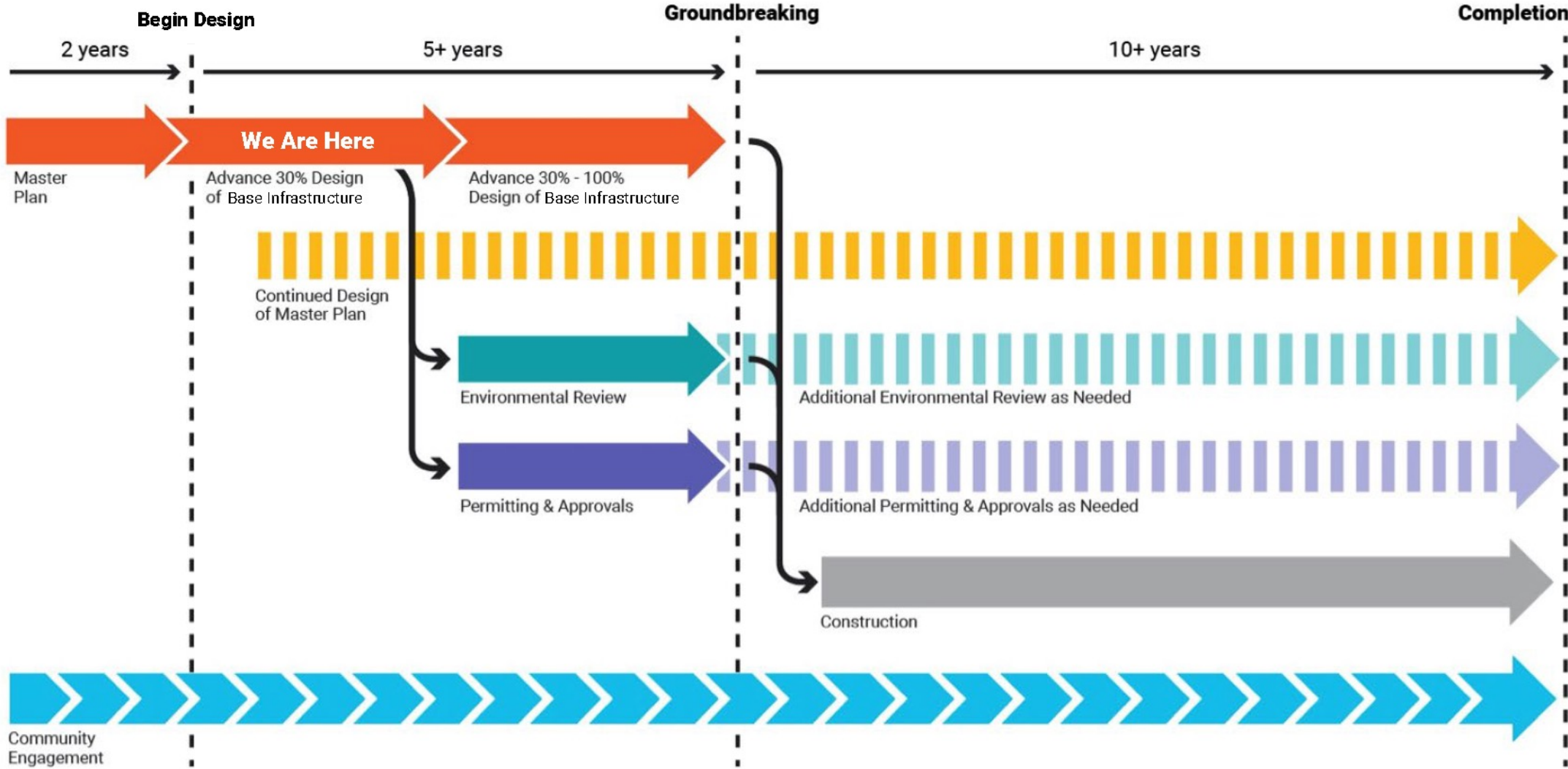


URBAN DESIGN AND INFRASTRUCTURE

Fidi-Seaport Resilience Master Plan



Where We Are in the Planning Process





- [The Geography of Future Water Challenges Bending the Trend Report](#)
- [OECD Environment Policy Paper – Adapting to a changing climate in the management of coastal zones](#)
- [Resilient Future under the Singapore Green Plan 2030](#)
- [NYC Financial District and Seaport Climate Resilience Master Plan](#)
- [Webinar Recording](#)

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GLOBAL
CENTER ON
ADAPTATION