Global Gateway

NbS Capacity Building – Session 2

Approaching Nature-based Solutions (NbS) in Urban & Industrial Environments

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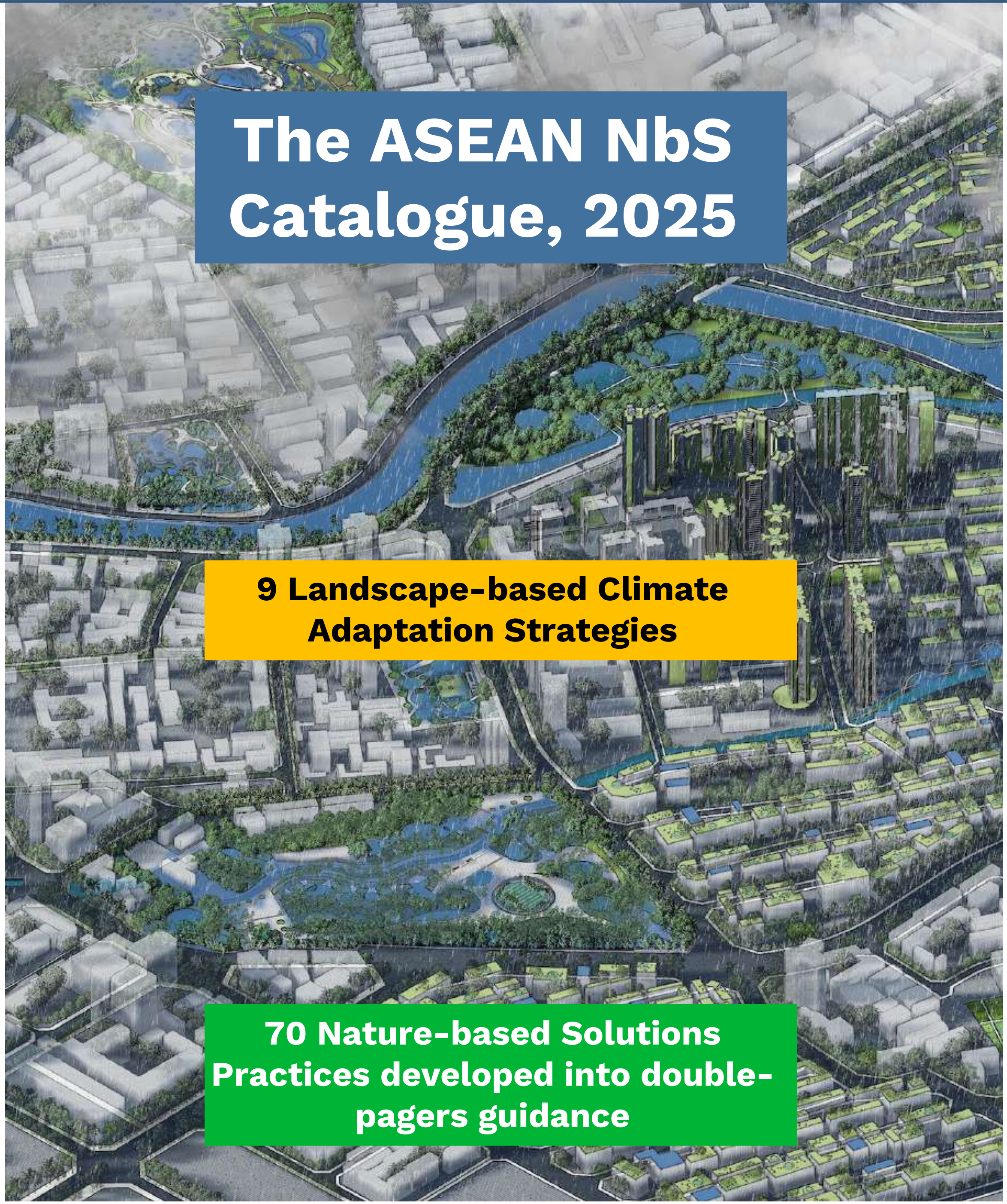
Technical Assistance Facility to
the Green Team Europe Initiative (TAF-GTEI)
TAF-GTEI is a project funded by the European Union in partnership with ASEAN



The ASEAN NbS Catalogue, 2025

9 Landscape-based Climate Adaptation Strategies

70 Nature-based Solutions Practices developed into double-pagers guidance

PUBLICATION SET

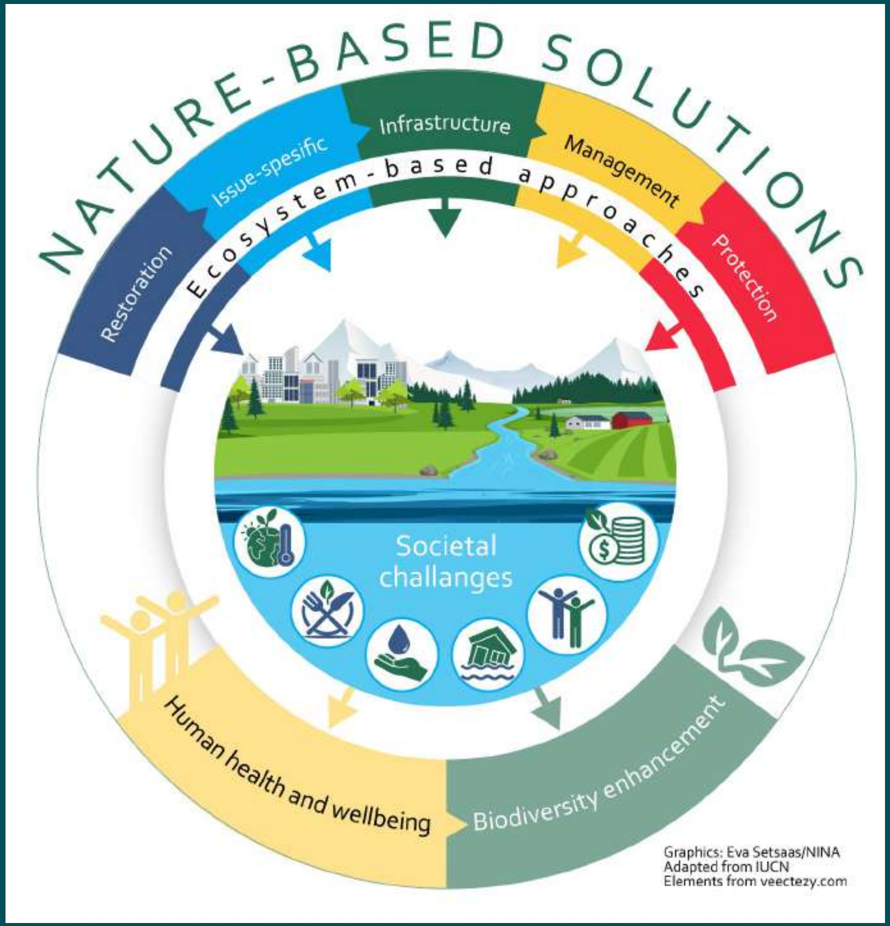
Nature-based Solution Studies in ASEAN Member States

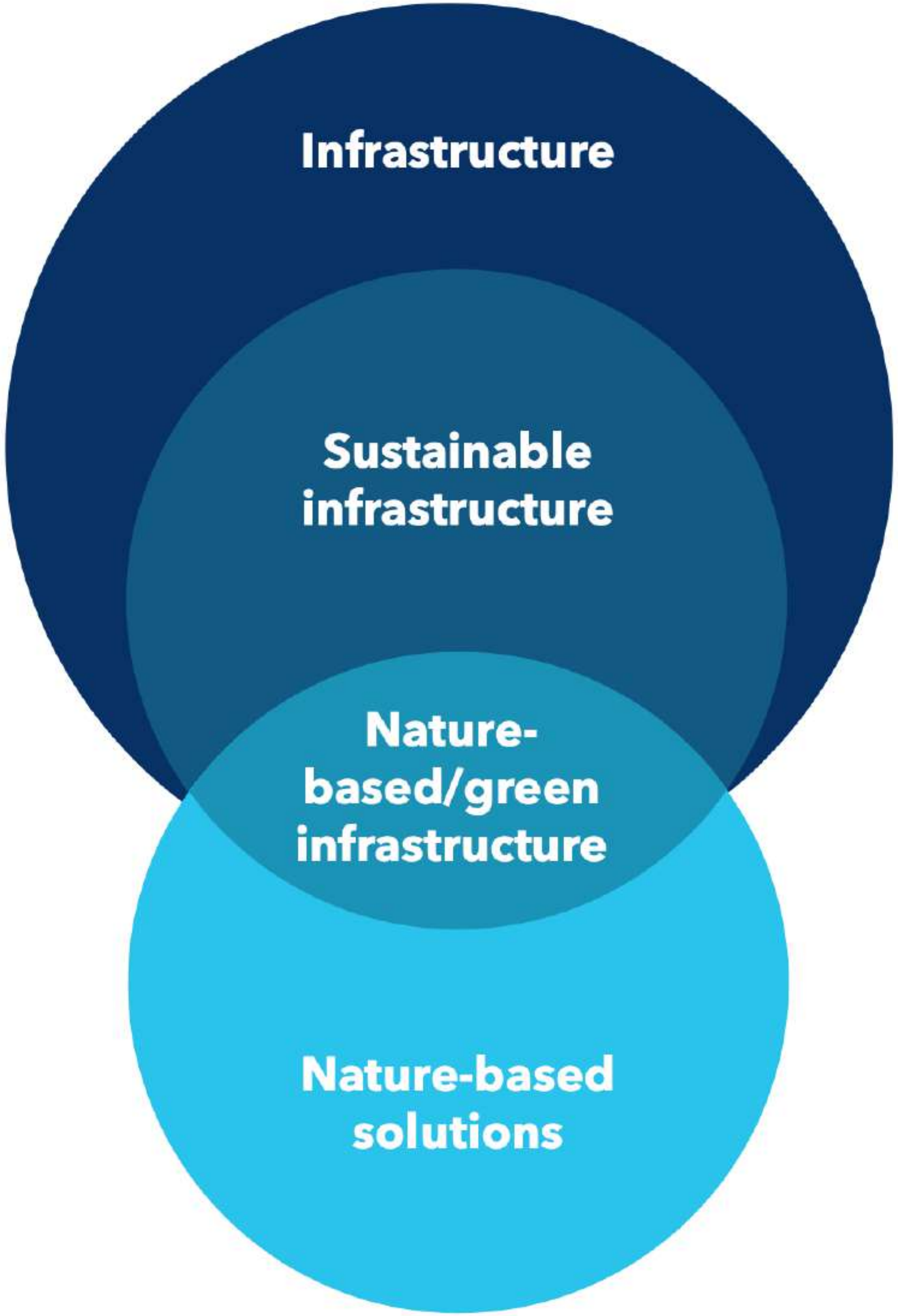
Access reports here

Nature-based Solutions (NbS) are

"Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"

IUCN



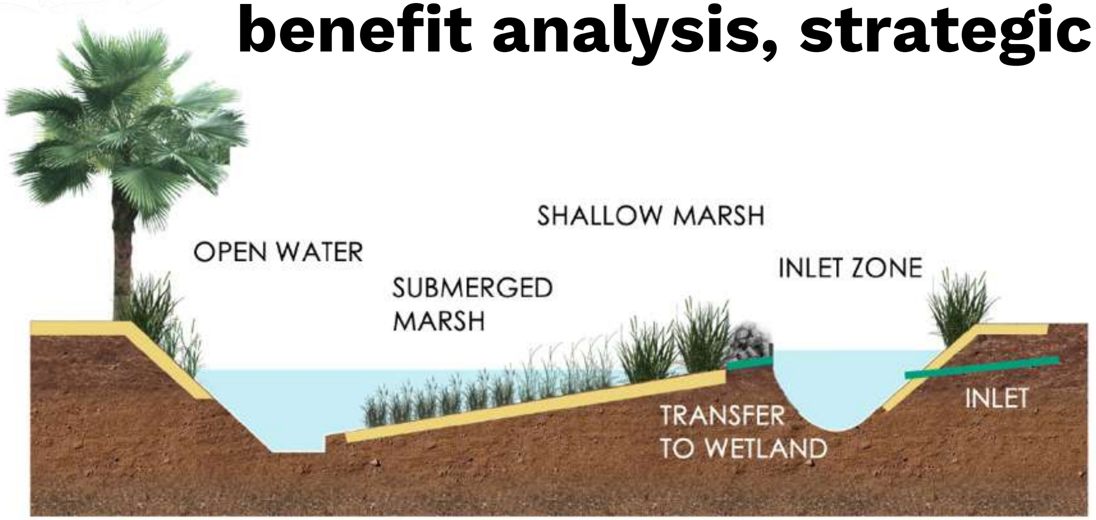


The “Grey to Green Transition"

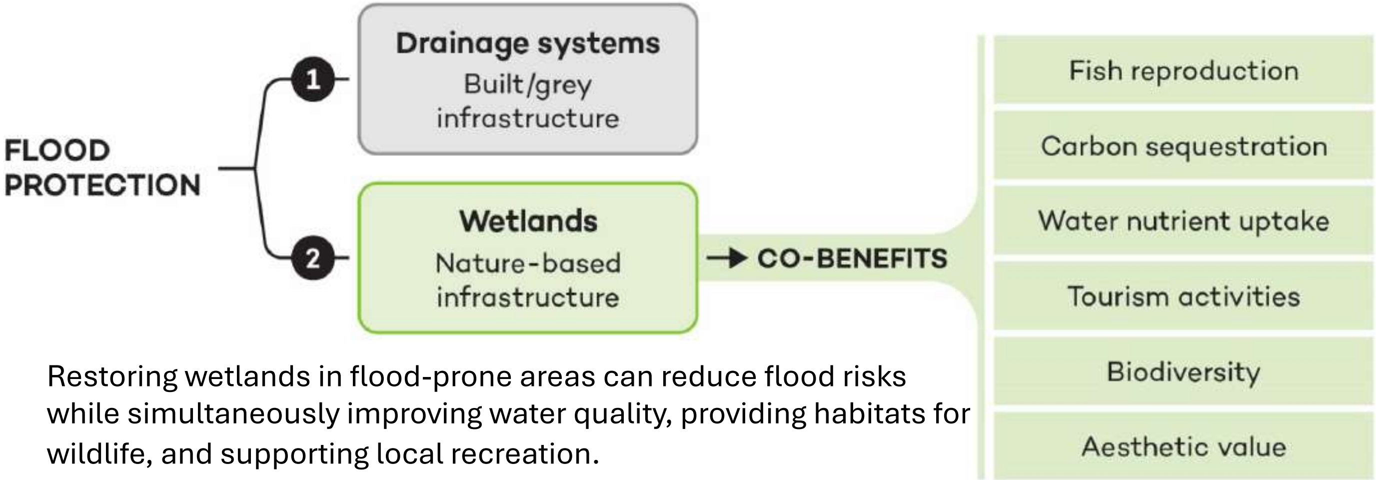
“Green Infrastructure (GI) is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services.
It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings.”

European Commission, 2013

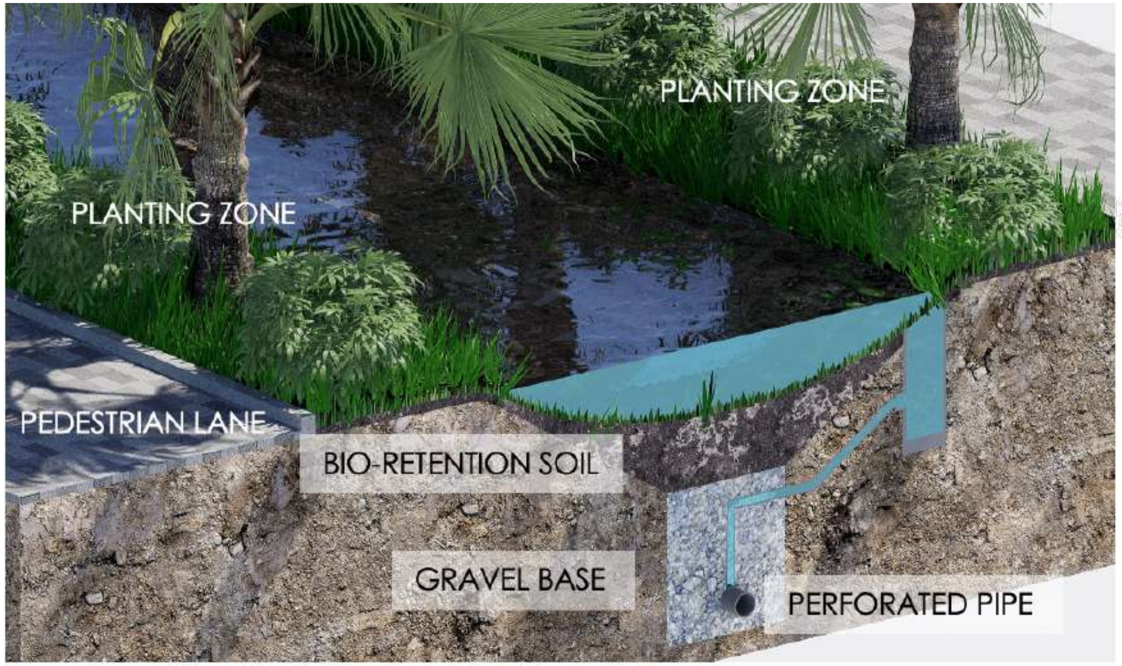
Approaching an NbS Project: Identifying co-Benefits, Conducting a cost-benefit analysis, strategic roadmap and scaling-up phases



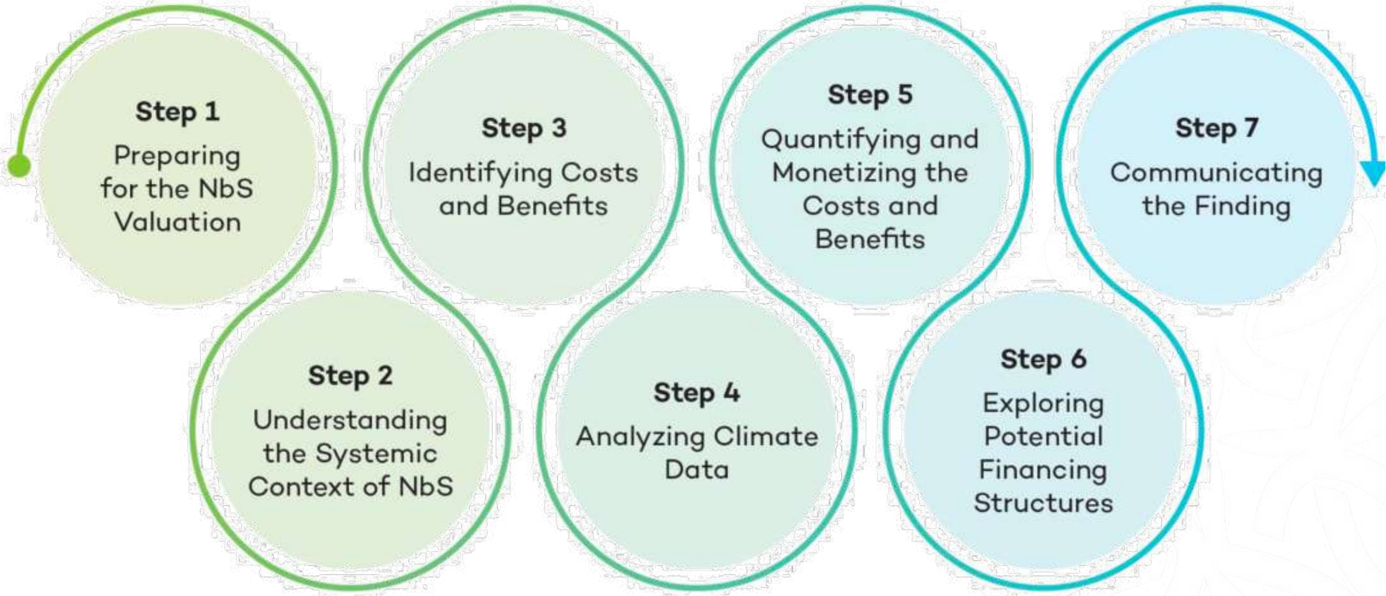
Constructed wetland for storm water management - section



Restoring wetlands in flood-prone areas can reduce flood risks while simultaneously improving water quality, providing habitats for wildlife, and supporting local recreation.



Bioswale typical section. Source: Citilinks



NbS-27: GREEN & BLUE ROOFS AND FACADES

Green and blue roofs, along with vegetated facades can mitigate urban heat island effects and enhance resilience to climate events, as they integrate vegetation layers that provide cooling through evapotranspiration and shade, reducing ambient and building temperatures. Blue roofs incorporate water retention systems to manage stormwater, effectively mitigating risks from intense rainfall and cloudbursts. In Southeast Asia, where rapid urbanization, high humidity, and frequent extreme weather events amplify vulnerability to climate impacts, they can support urban farming, enhance biodiversity by attracting pollinators, and host solar panels to optimize energy generation, all while providing recreational spaces for urban dwellers. These hybrid NbS can also incorporate smart technologies for dynamic water storage management, helping cities to address seasonal flooding. Socially and economically, green and blue roofs can improve urban liveability by creating aesthetic landscapes, reducing energy costs for cooling, and supporting local economies through urban agriculture or green jobs. Integrating native, drought-tolerant, and water-absorbent plant species that enhance functionality and reduce maintenance needs, green roofs foster climate resilience by promoting sustainable urban ecosystems and increasing community adaptation capacity.

LANDSCAPES SUPPORTED

EbA (ECOSYSTEM-BASED APPROACHES)

| URBAN HEAT MITIGATION | STORMWATER MANAGEMENT | BIODIVERSITY ENHANCEMENT

| WATER CYCLE REGULATION | FLOOD RESILIENCE | ENERGY EFFICIENCY

MAIN PROBLEMS ADDRESSED

FLOOD CONTROL

AIR QUALITY IMPROVEMENT

URBAN HEAT ISLAND

ECOSYSTEM SERVICES AND ACTIONS

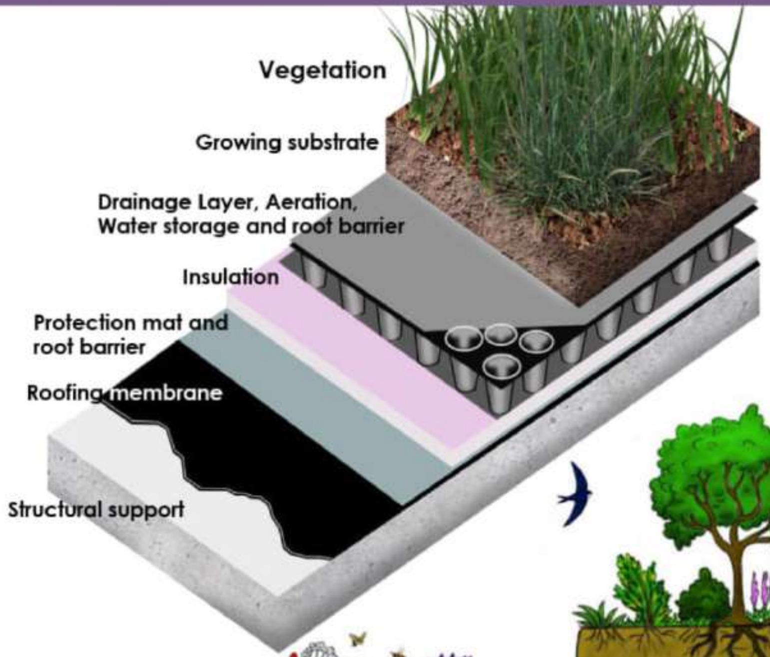
SUPPORTING
- Habitat creation for biodiversity, including pollinators and urban wildlife.
- Soil formation and nutrient cycling through planted systems and organic matter accumulation.

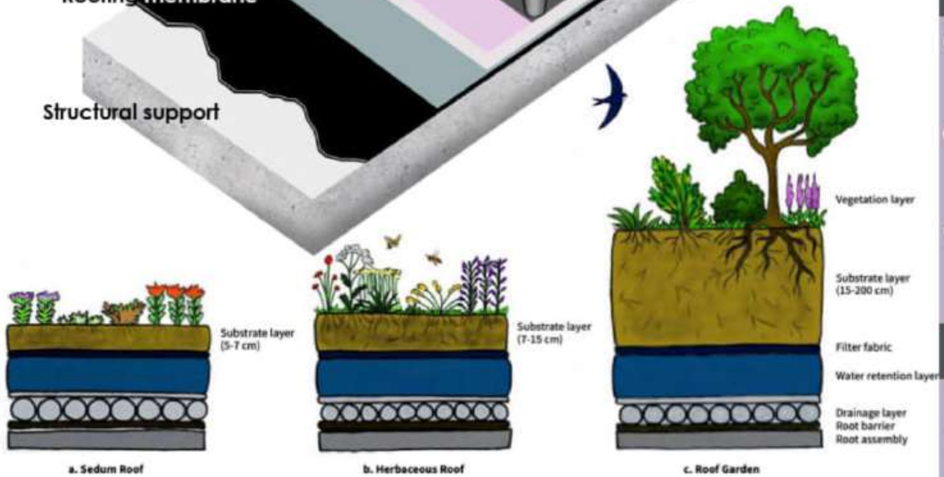
REGULATING
- Mitigating the urban heat island effect through evapotranspiration and shading.
- Managing stormwater by retaining and slowing runoff, reducing urban flooding risks.

PROVISIONING
- Supporting urban agriculture and rooftop farming for local food production.
- Capturing and storing rainwater for reuse in irrigation or building systems.

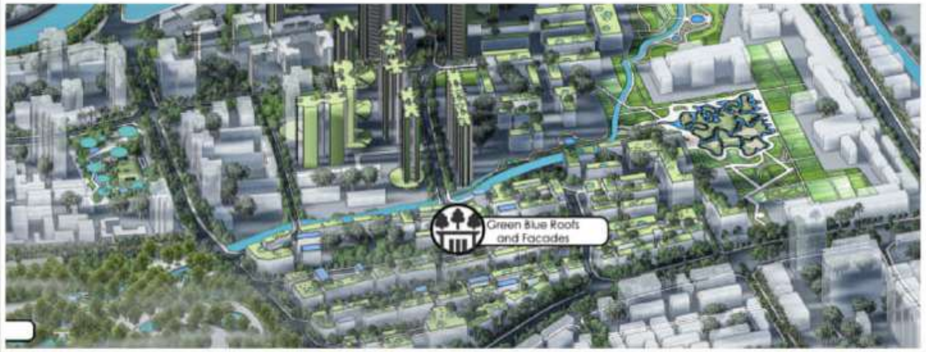
SOCIAL BENEFITS
- Providing green recreational spaces that improve mental health and community cohesion.
- Enhancing urban aesthetics and property values, creating more attractive and livable cities.

NbS-27: GREEN & BLUE ROOFS AND FACADES





Green roof layer scenarios and landscape and climate functions : Sedum roof, Herbaceous roof and roof garden



PROJECT'S CHALLENGES & RISKS

- **High Maintenance Costs**: Regular upkeep, including irrigation, pest control, and structural inspections, can be expensive and resource-intensive.
- **Structural Limitations**: Many buildings in Southeast Asia, especially older or informal structures, may lack the load-bearing capacity to support green or blue roof systems.
- **Climate-Specific Plant Selection**: Identifying and sourcing resilient native plants that can thrive in extreme heat and humidity while withstanding heavy rains can be challenging.

NbS co-BENEFITS AND THEIR INDICATORS

Urban Heat Island Mitigation
Reduction in surface temperatures by 2–4°C, measurable via infrared thermal imaging.

Stormwater Management
Retention of rainfall, monitored through water runoff volume sensors.

Improved Air Quality
Reduction in particulate matter (PM2.5) levels, tracked using air quality monitors near installations.

Biodiversity Enhancement
Increase in pollinator visits and bird species diversity, assessed through regular biodiversity surveys.

Energy Efficiency
Decrease in building cooling energy demand by 10–15%, measured through energy consumption logs.

Social Well-being
Increased use of rooftop spaces for recreation or urban farming, quantified through user surveys and activity counts.

COST ANALYSIS

Direct Costs
Installation costs range from $75 to $250 /m2 for green roofs and $150 to $400 /m2 for blue roofs.

Indirect Costs
Maintenance expenses, including irrigation and structural inspections, typically range from $5 to $15/m2 annually.

Time Horizon
Project lifespan of 20–50 years, with discount rates between 3–7% for long-term sustainability projects in Southeast Asia.

Direct Benefits
Energy savings of $1–$3/m2/year from reduced cooling needs, and stormwater fee reductions ranging from $0.50 to $2/m2/year

Indirect Benefits
Enhanced property values and avoided health costs due to better air quality.

Risk Assessment
structural damage from improper design or maintenance.

REFERENCES:

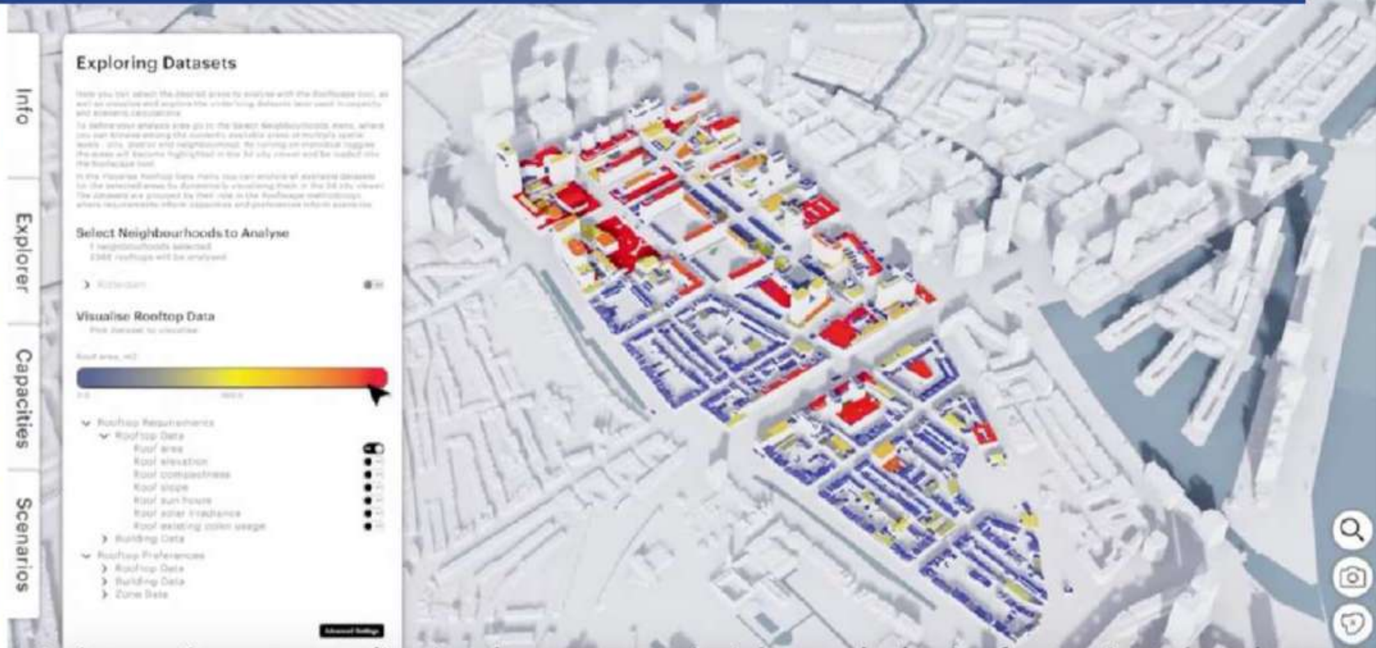
Singapore : Marina Barrage Green Roof 10,000 m2 rooftop garden and Kampung Admiralty, vertical urban village.
Netherlands, Smart Green-Blue Roofs of Resilio Project, Amsterdam.

IMPLEMENTATION OPPORTUNITIES:

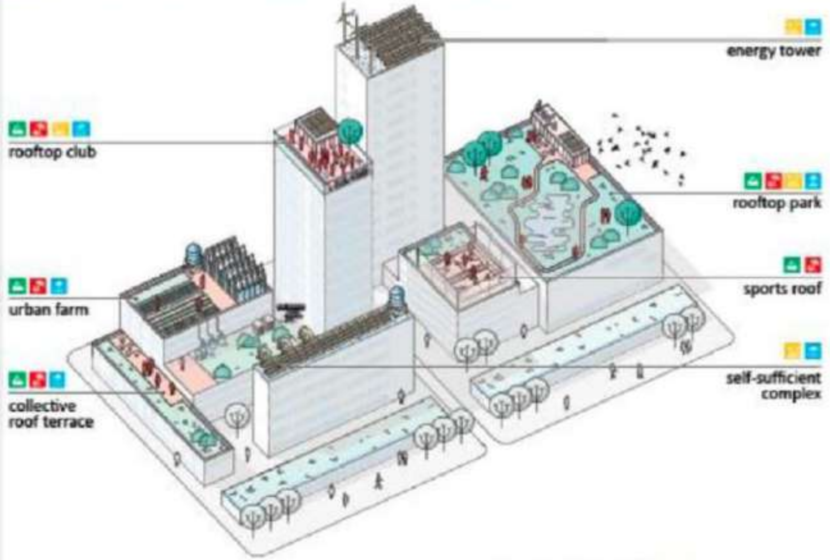
Jakarta: Menteng and Sudirman areas.
Metro Manila: Quezon City and Makati.
Bangkok: Sukhumvit and Silom.
Cambodia, Phnom Penh: Tonle Bassac, BKK1.
Myanmar, Yangon central urban districts: Dagon Township.

NbS-27: GREEN & BLUE ROOFS AND FACADES

ASSESSING GREEN-BLUE ROOF OPPORTUNITIES AT CITY-LEVEL



An interactive, open application that generates insights on the basis of extensive urban datasets



Rotterdam's plans to develop a Multifunctional Green Roof Strategy

Rotterdam has over 18 square kilometres of underutilized flat rooftops, presenting a significant opportunity for urban development. Addressing this, MVRDV, in collaboration with Superworld and the Municipality of Rotterdam, has developed the RoofScape prototype. This visualisation engine integrates municipal urban data to offer concrete suggestions for rooftop uses—such as green spaces, water retention, residential, and social areas—based on an impact matrix defined by the city.

Heavy structures like homes or offices (purple), energy-generating infrastructure (yellow), green spaces (green), rainwater collection (blue), technical equipment (grey), social spaces (red), and transportation improvements (orange). The analysis includes building height, roof area, compactness, slope, function, age, energy potential, view quality, and heritage status, as well as area-based factors like access to public space, green corridors, flood risk, and urban heat island effect.

9 Climate-sensitive Landscape Categories ready for NbS Application and Scale-up in Synergy

1 **Flood responsive Riverine and Deltaic Landscapes**

2 **Adaptative Sandy Shorelines**

3 **Adaptative Coastal Mangroves**

4 **Climate-smart and Resilient Cities**

5 **Green & Blue Eco-Industrial Areas and Ports**

6 **Regenerative Agriculture**

7 **Healthy Forests and Natural Habitats**

8 **Wildlife Corridors for Ecological Connectivity**

9 **Regenerative Seascapes and Marine Habitats**

1

Climate-Smart Cities and Multi-scale Urban Resilience:

The path to Water Sensitive Urban Design (WSUD) and Climate Adaptive Communities

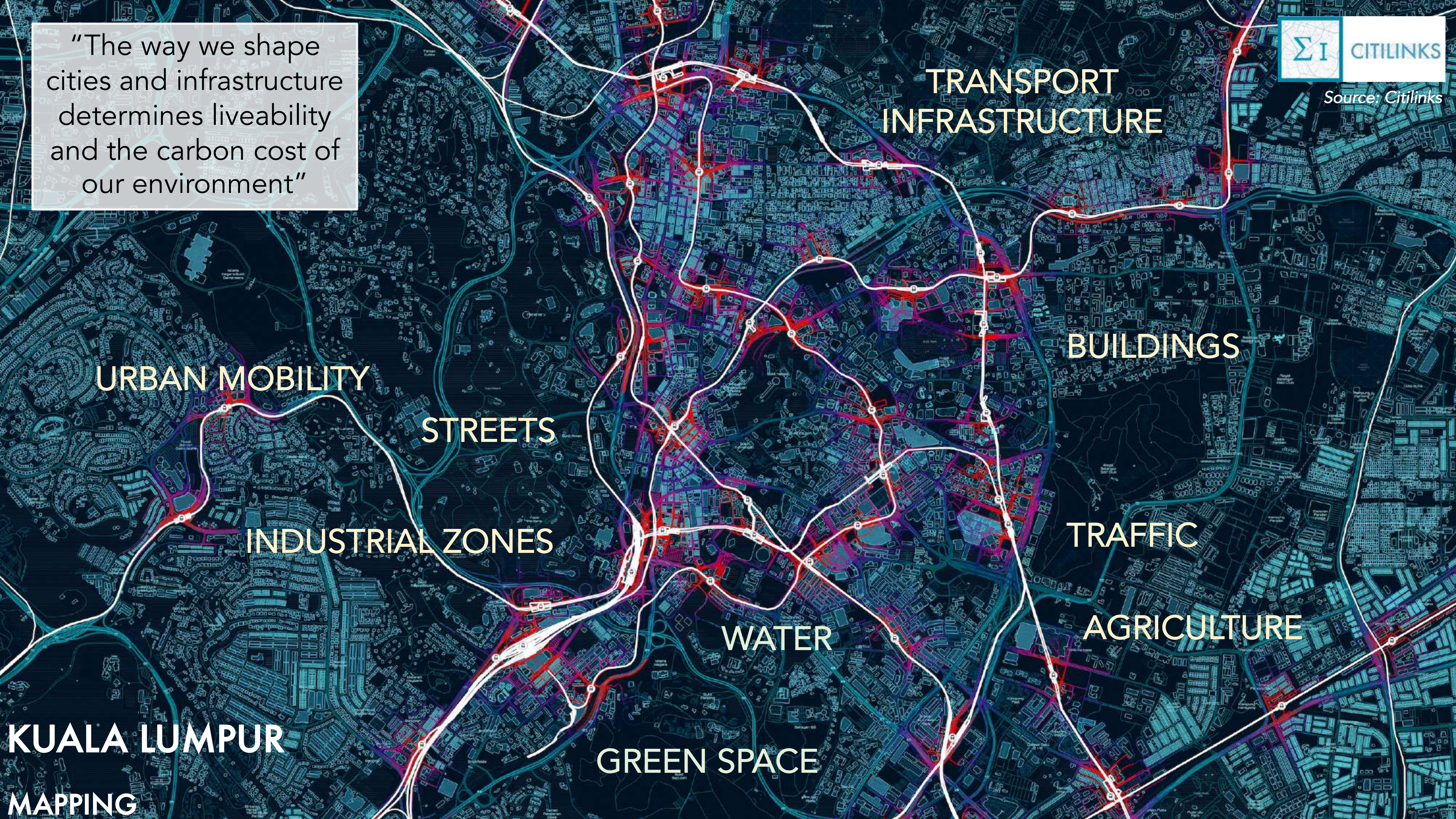
2

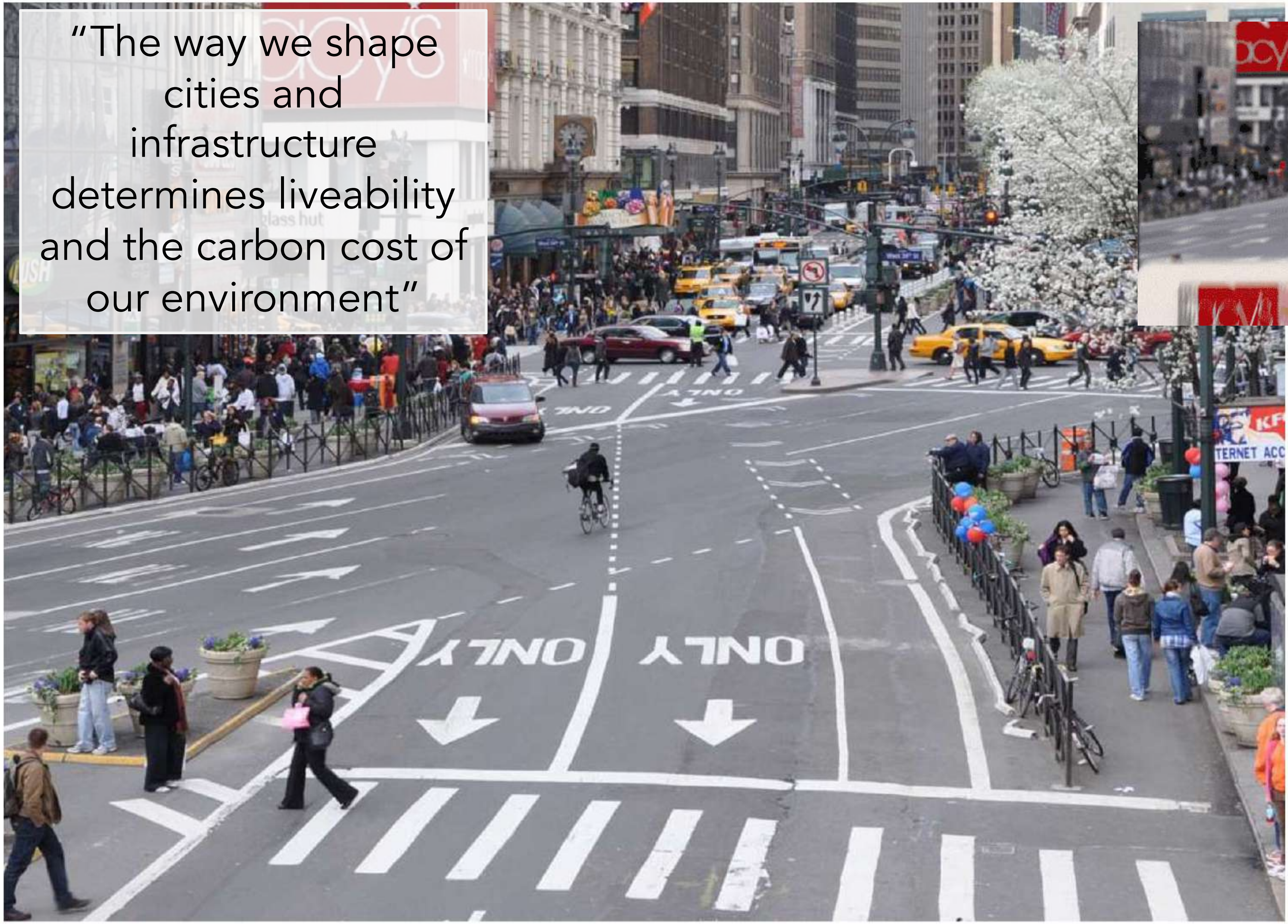
Green & Blue Industrial Areas and EIPs :

Shaping Low Impact Productive Landscapes

Climate-Smart Cities and Multi-scale Urban Resilience: The path to Water Sensitive Urban Design (WSUD) and Climate Adaptive Communities

CSL04 **Climate-smart & Resilient Cities**


"The way we shape cities and infrastructure determines liveability and the carbon cost of our environment"
CITILINKS
Source: Citilinks
TRANSPORT INFRASTRUCTURE
BUILDINGS
URBAN MOBILITY
STREETS
INDUSTRIAL ZONES
TRAFFIC
AGRICULTURE
WATER
GREEN SPACE
KUALA LUMPUR
MAPPING



"The way we shape cities and infrastructure determines liveability and the carbon cost of our environment"

What does the "grey to green transition" really mean for our cities

and how can we make it happen?

New York Whydrive Grey to Green Transition project, CITILINKS

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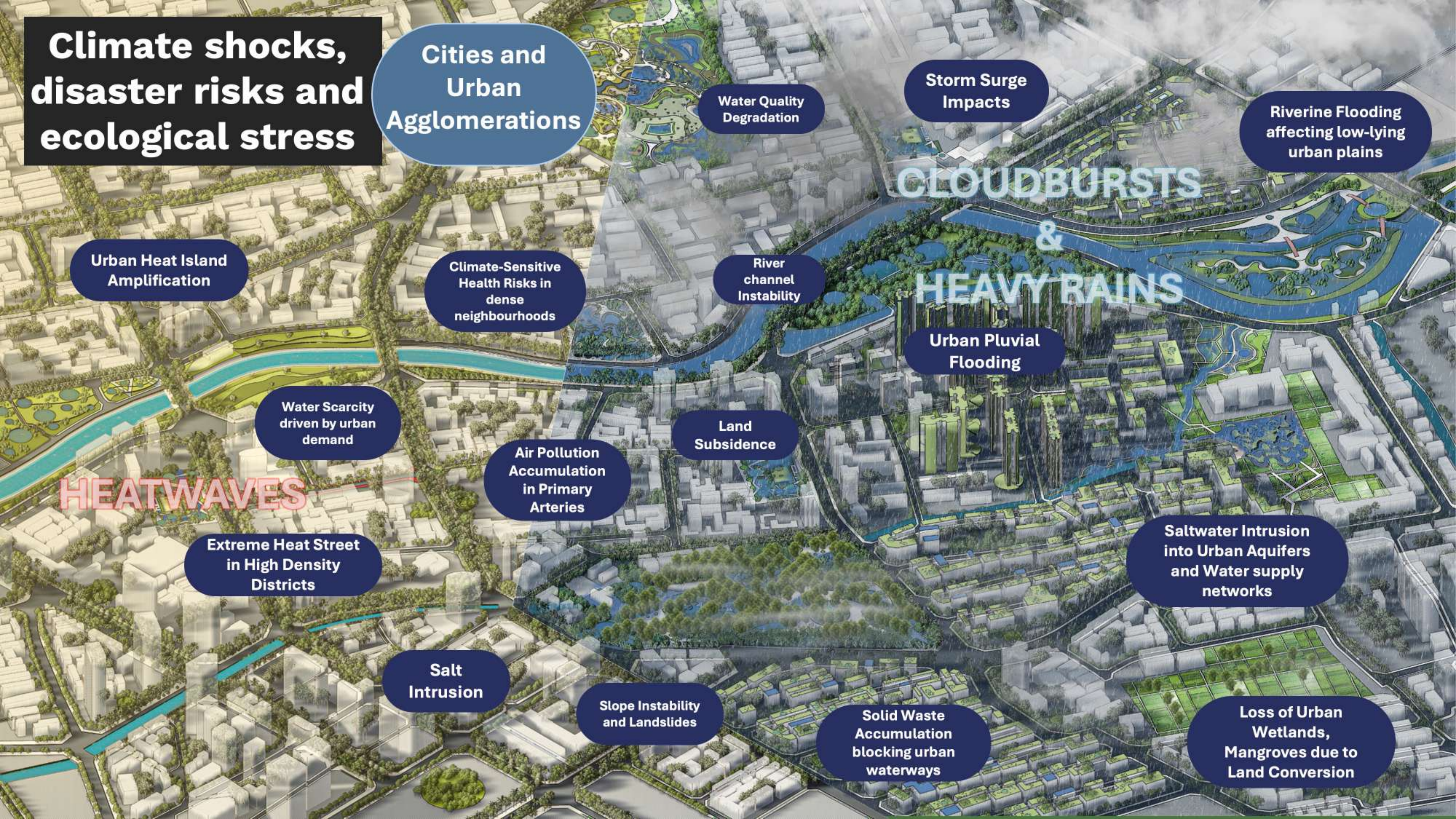
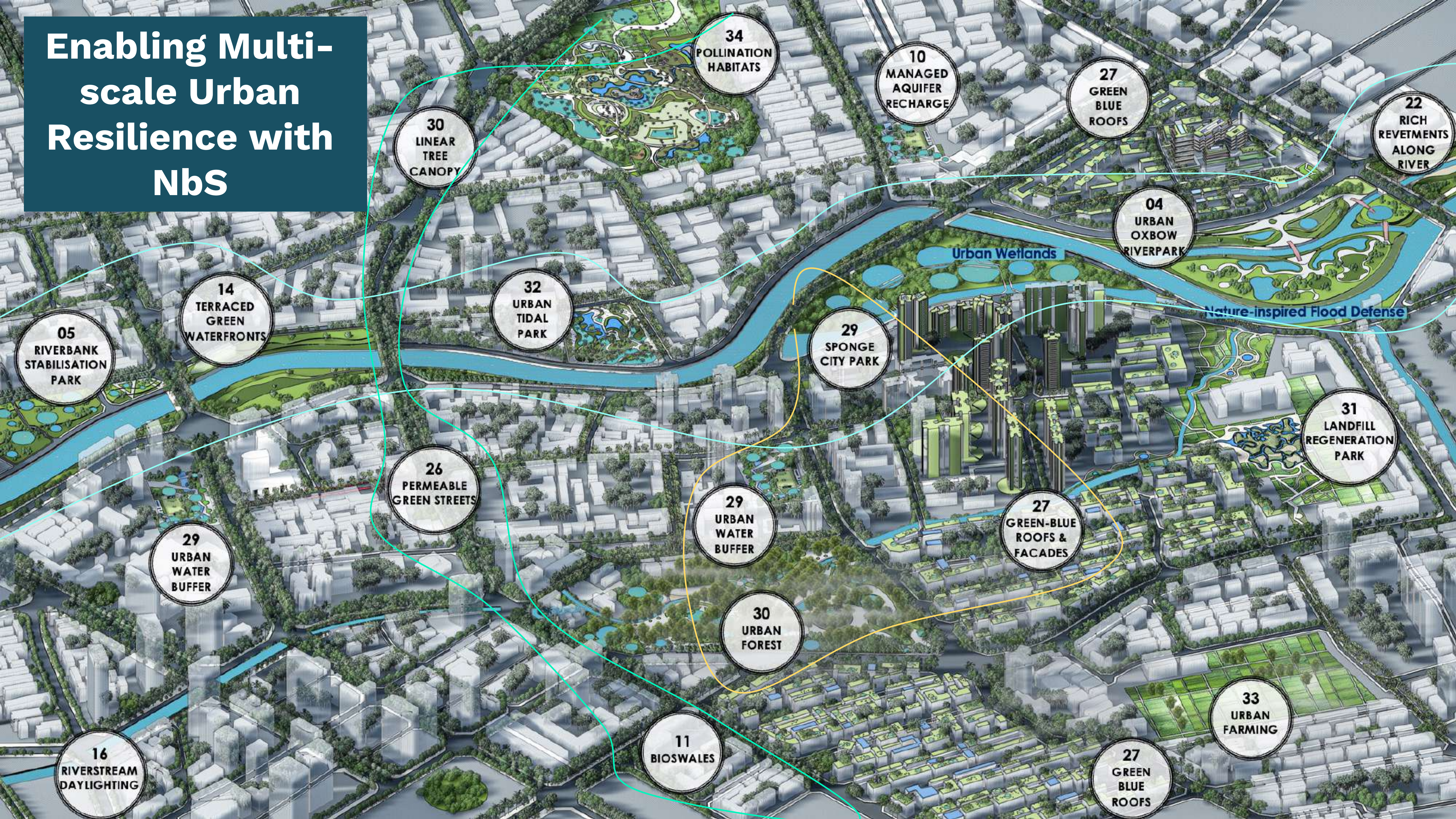

Climate shocks, disaster risks and ecological stress
Cities and Urban Agglomerations
Water Quality Degradation
Storm Surge Impacts
Riverine Flooding affecting low-lying urban plains
CLOUDBURSTS & HEAVY RAINS
Urban Heat Island Amplification
Climate-Sensitive Health Risks in dense neighbourhoods
River channel Instability
Urban Pluvial Flooding
Water Scarcity driven by urban demand
Land Subsidence
Air Pollution Accumulation in Primary Arteries
HEATWAVES
Extreme Heat Street in High Density Districts
Saltwater Intrusion into Urban Aquifers and Water supply networks
Salt Intrusion
Slope Instability and Landslides
Solid Waste Accumulation blocking urban waterways
Loss of Urban Wetlands, Mangroves due to Land Conversion

Enabling Multi-scale Urban Resilience with NbS



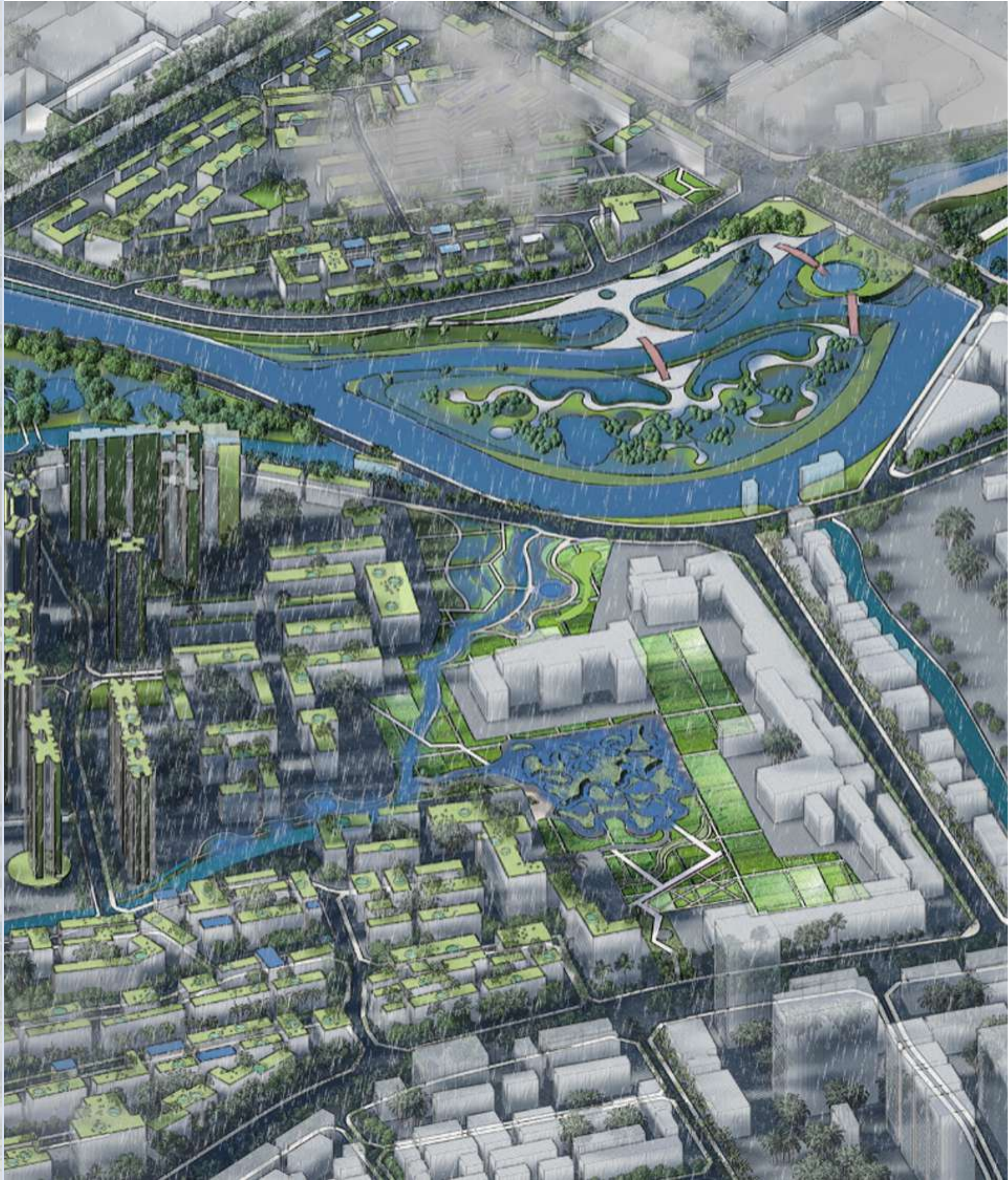
How NbS support Multi-scale Urban Resilience in Southeast Asia

Managing Water Extremes Across Scales and Communities

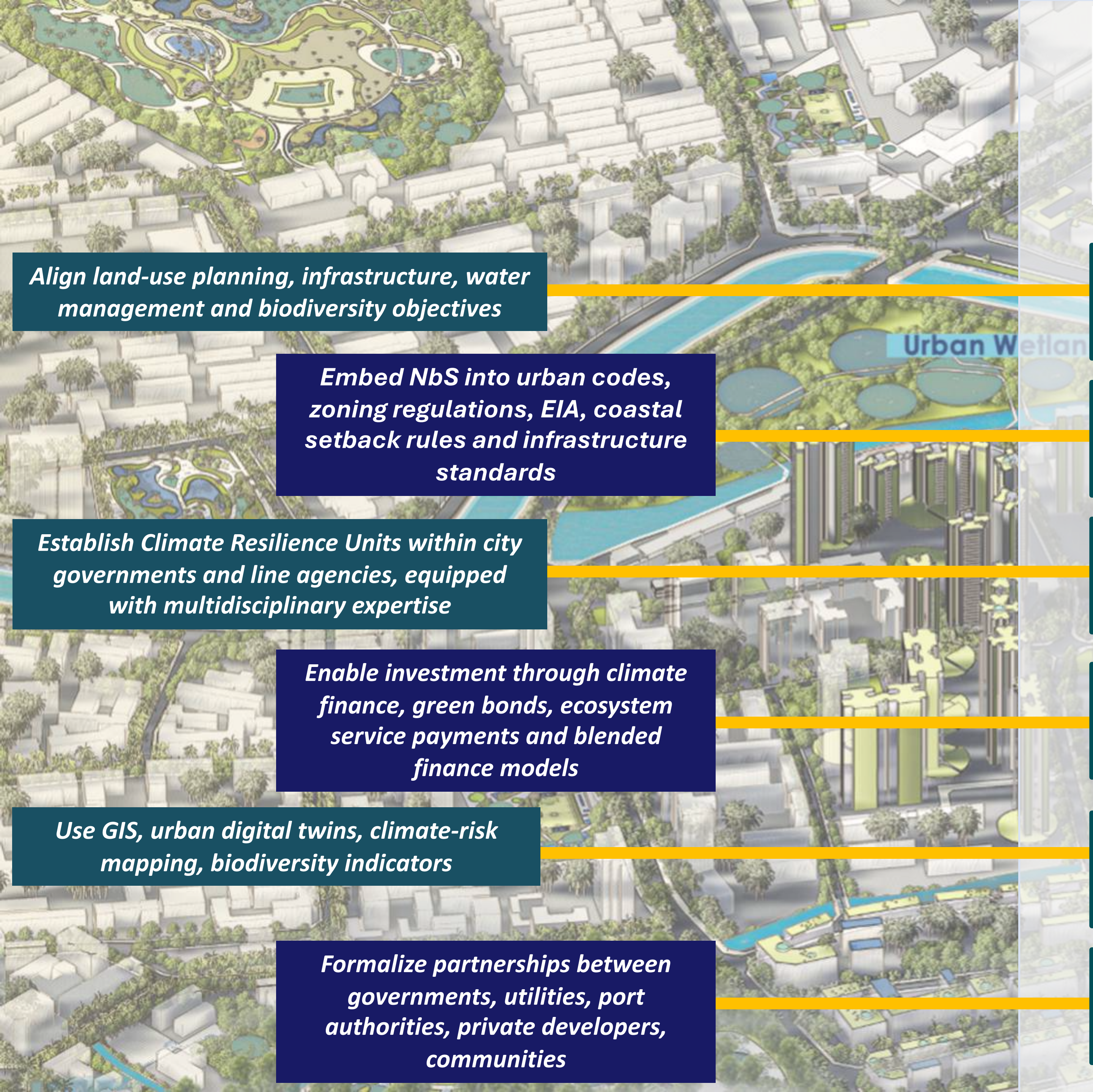
Reducing Heat and Improving Urban Livability & Thermal Comfort

Protecting & Reinforcing Urban-Economic Systems

Restoring Ecosystems while Strengthening Social Resilience



Institutional Enablers for Nature-positive Urban Governance

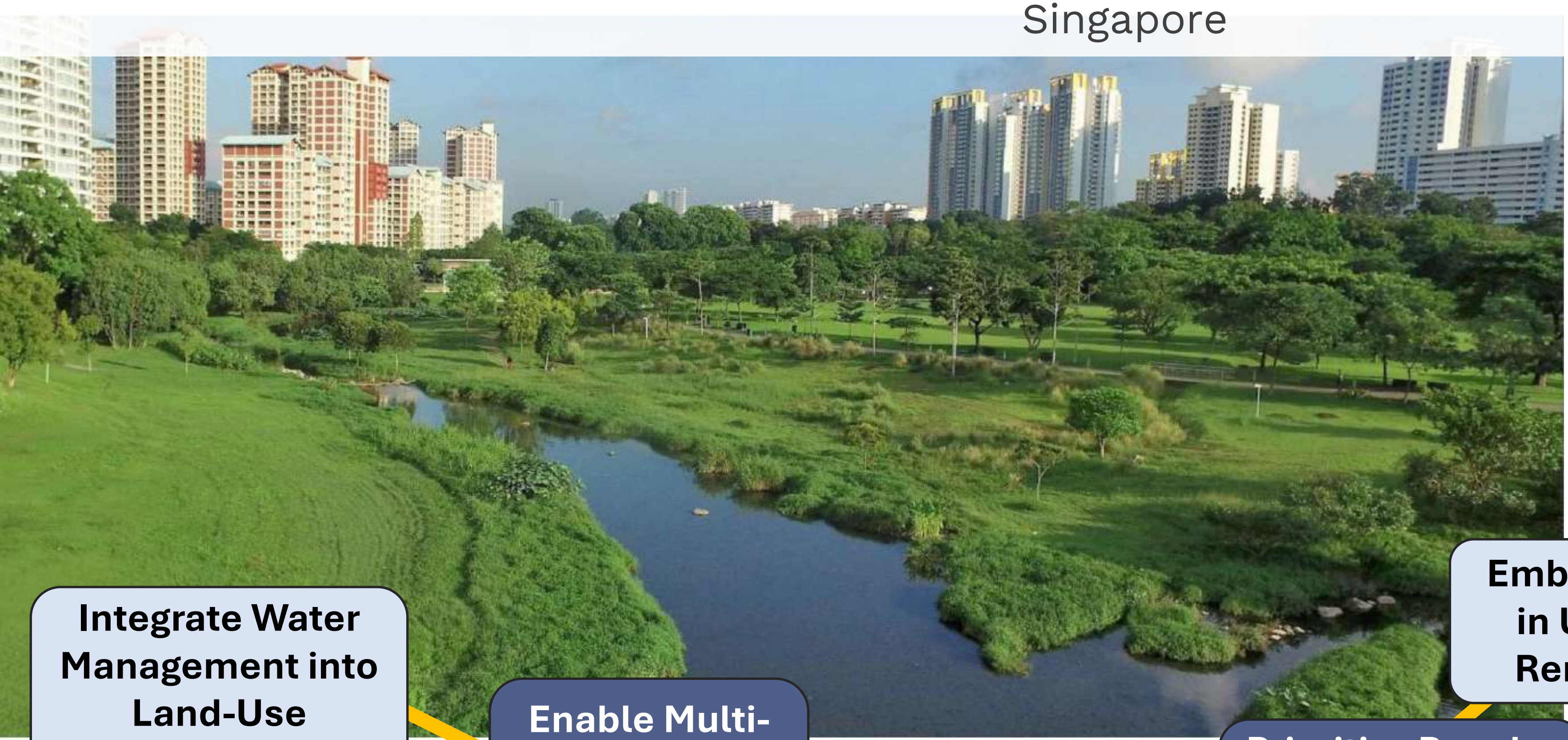


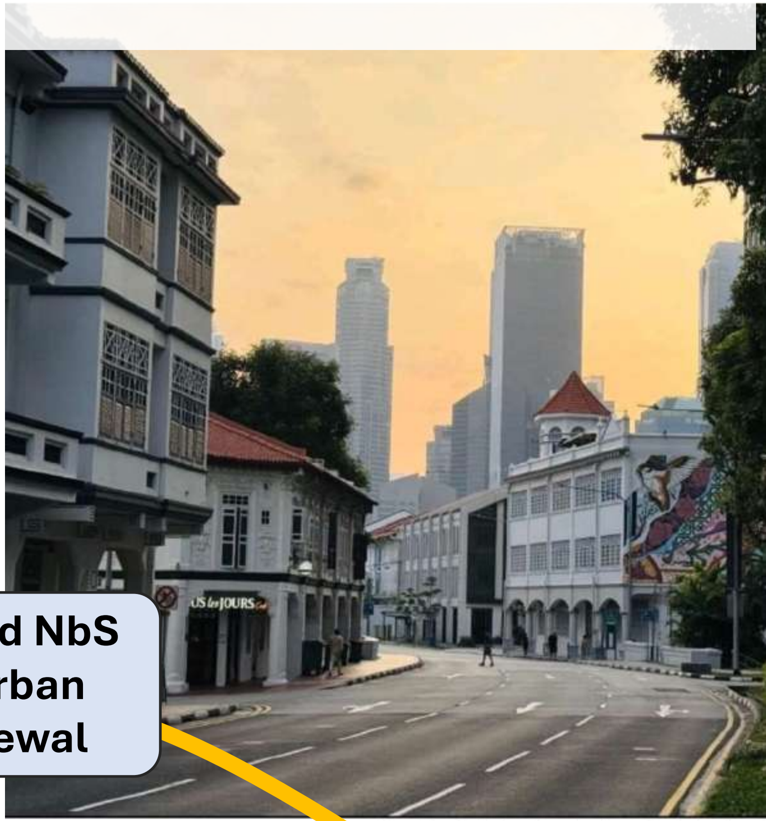
Align land-use planning, infrastructure, water management and biodiversity objectives	***Integrated Urban Environmental Planning Frameworks***
Embed NbS into urban codes, zoning regulations, EIA, coastal setback rules and infrastructure standards	***Clear Legal & Regulatory Mandates for NbS***
Establish Climate Resilience Units within city governments and line agencies, equipped with multidisciplinary expertise	***Dedicated Institutional Capacity & Technical Units***
Enable investment through climate finance, green bonds, ecosystem service payments and blended finance models	***Sustainable Financing & Incentive Mechanisms***
Use GIS, urban digital twins, climate-risk mapping, biodiversity indicators	***Data, Monitoring and Decision-Support Systems***
Formalize partnerships between governments, utilities, port authorities, private developers, communities	***Multi-Stakeholders Governance & Community co-Management***

How NbS support Multi-scale Urban Resilience in Southeast Asia

How to enable Climate Adaptation and NbS into Water Sensitive Urban Design

Singapore





Integrate Water Management into Land-Use Planning

Enable Multi-scale Connectivity of NbS

Coordinate Governance & Decision-Making

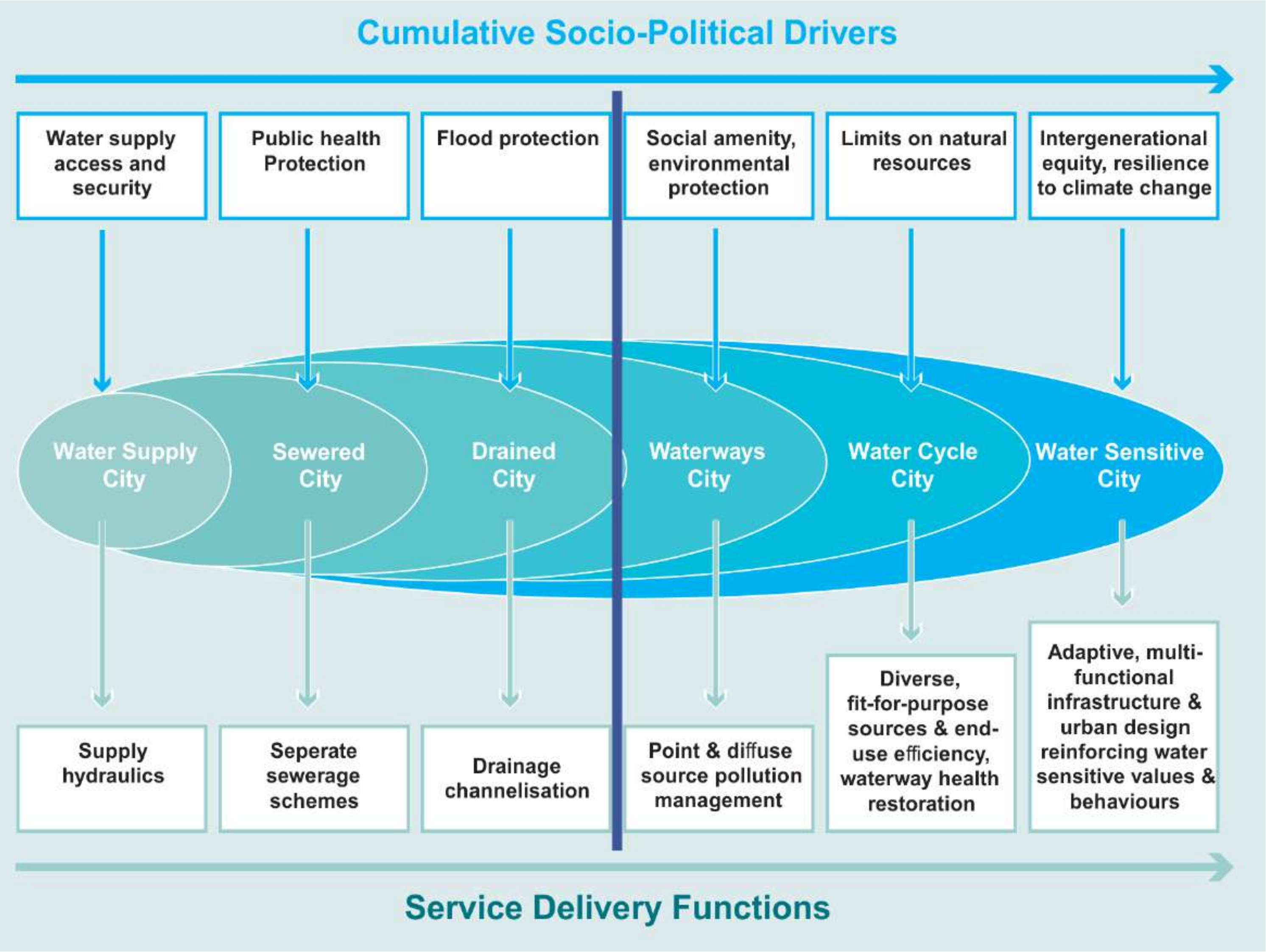
Prioritize People-centric & Adaptive Approaches

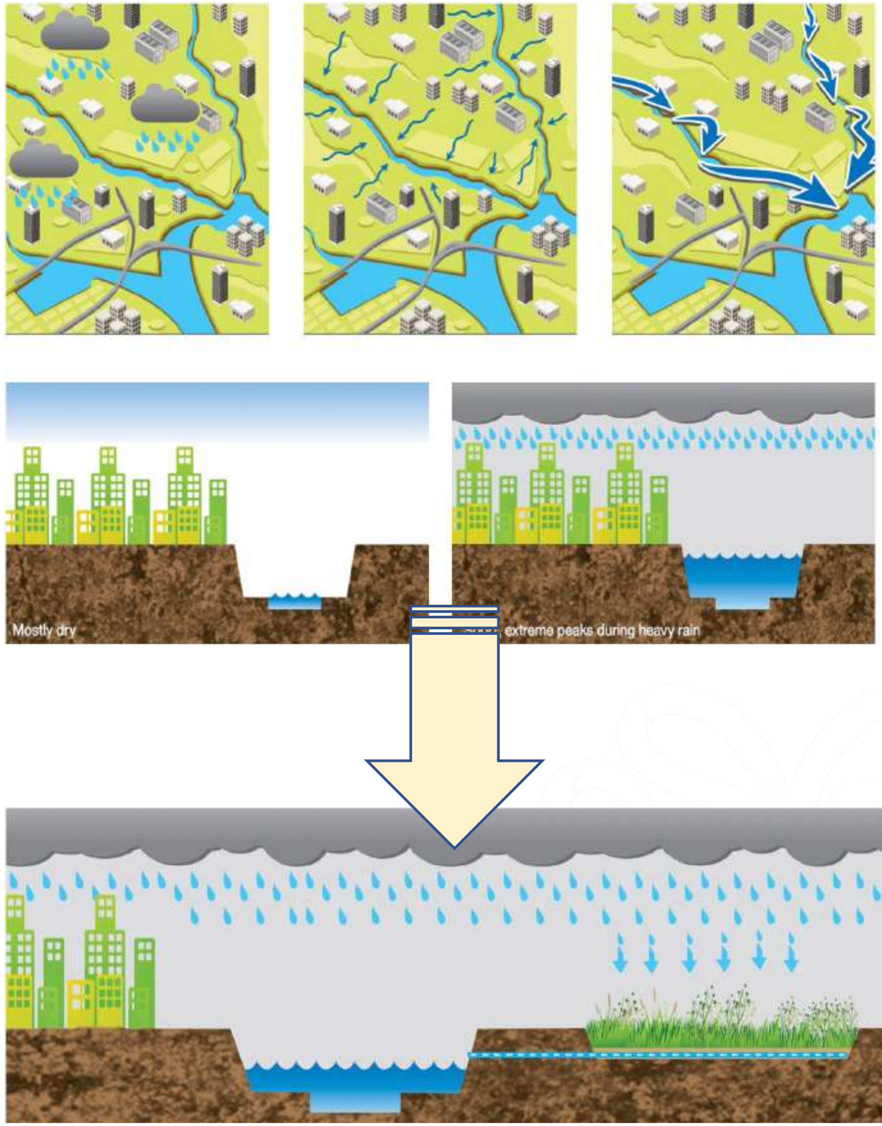
Embed NbS in Urban Renewal

Align Street & Mobility Design with Heat Reduction and Water-sensitive Planning

How NbS support Multi-scale Urban Resilience in Southeast Asia

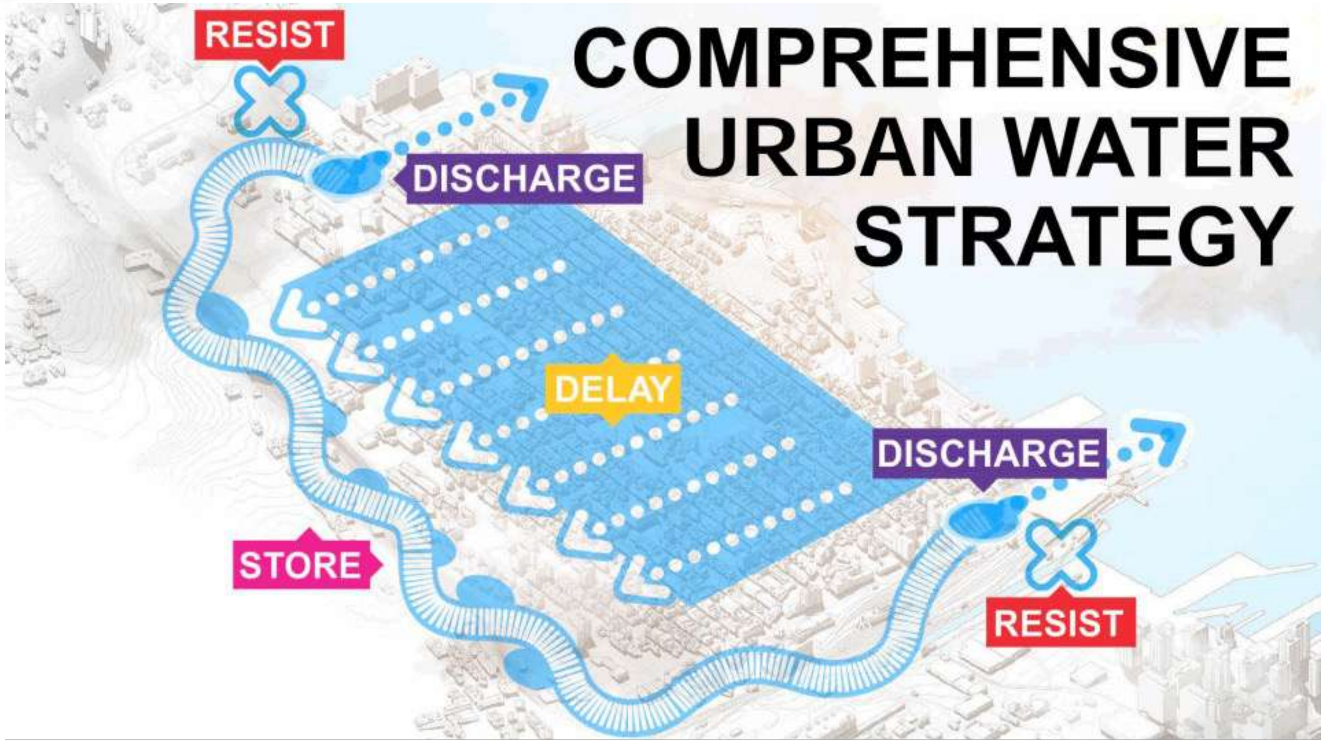
The path to Water Sensitive Urban Design (WSUD)





How NbS support Multi-scale Urban Resilience in Southeast Asia

The path to Water Sensitive Urban Design (WSUD)



EVERY URBAN DISTRICT SHOULD BE PREPARED TO FLASH FLOOD AND STORM SURGE.

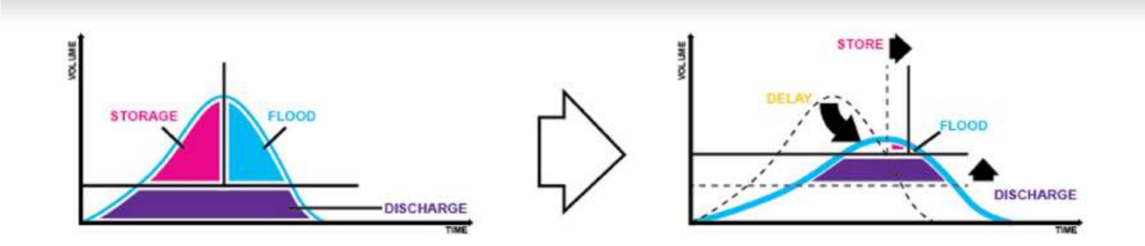
THIS APPROACH IS A COMBINATION OF 4 STRATEGY :

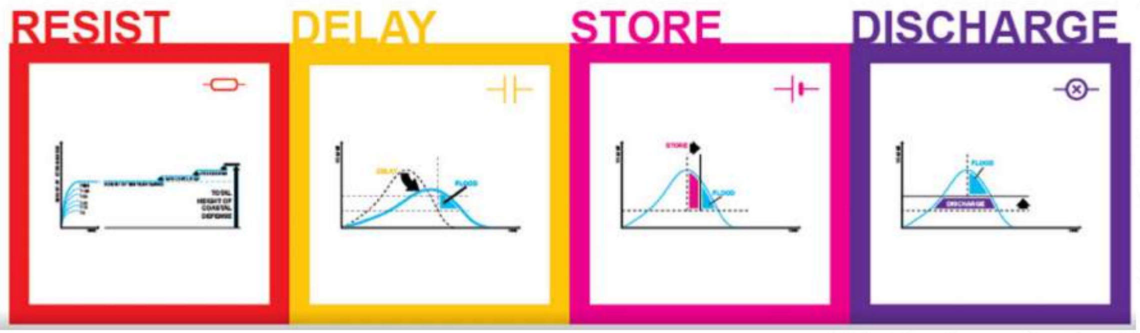
RESIST, DELAY, STORE, DISCHARGE

THE STRATEGY DEPLOYS BOTH **HARD INFRASTRUCTURE** AND **SOFT LANDSCAPE**

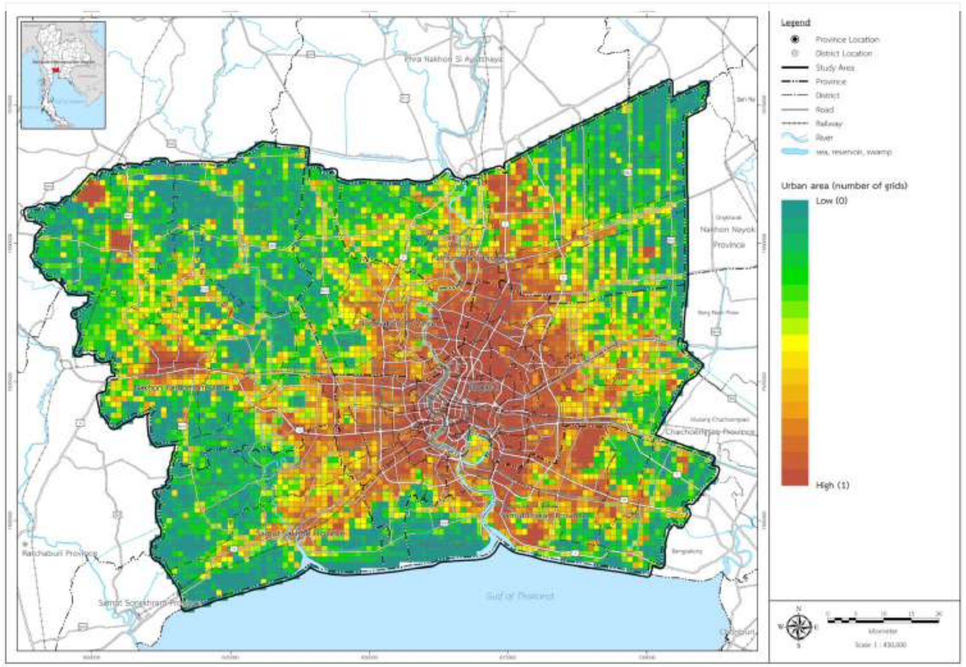
- FOR WATERFRONT DEFENSE (RESIST)
- ENABLE THE URBAN FABRIC TO SLOW DOWN WATER (DELAY)
- GREEN CIRCUIT TO TRAP WATER (STORE)
- WATER PUMPS TO SUPPORT DRAINAGE (DISCHARGE).

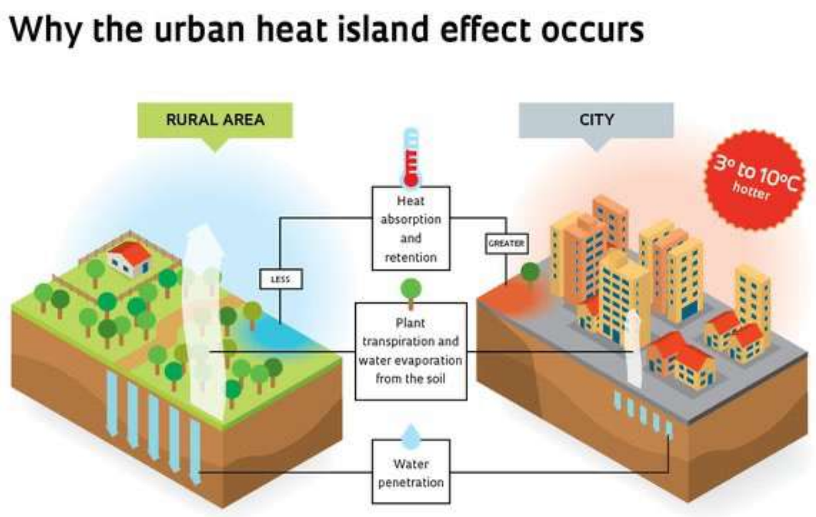
RESIST	DELAY	STORE	DISCHARGE
HARD INFRASTRUCTURE AND SOFT LANDSCAPE FOR WATERFRONT DEFENSE	*POLICY GUIDELINES AND URBAN INFRASTRUCTURE TO SLOW RAINWATER RUNOFF*	*CIRCUIT OF INTERCONNECTED GREEN INFRASTRUCTURE TO STORE AND DIRECT EXCESS RAINWATER*	*WATER PUMPS AND ALTERNATIVE ROUTES TO SUPPORT DRAINAGE*



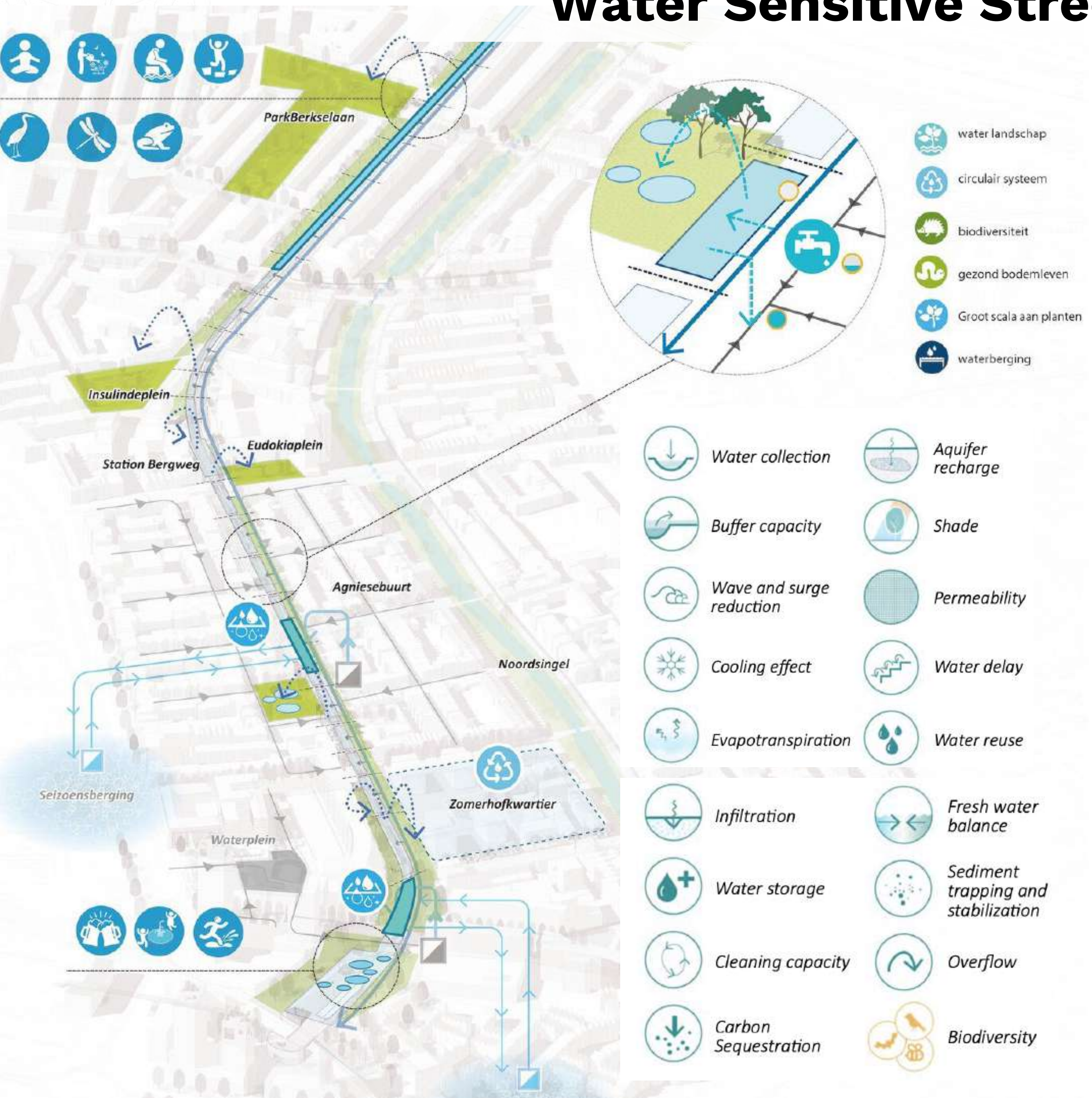


How NbS support Urban Heat Island Effect Mitigation by Rethinking Streets and Buildings





Water Sensitive Street & Road Design

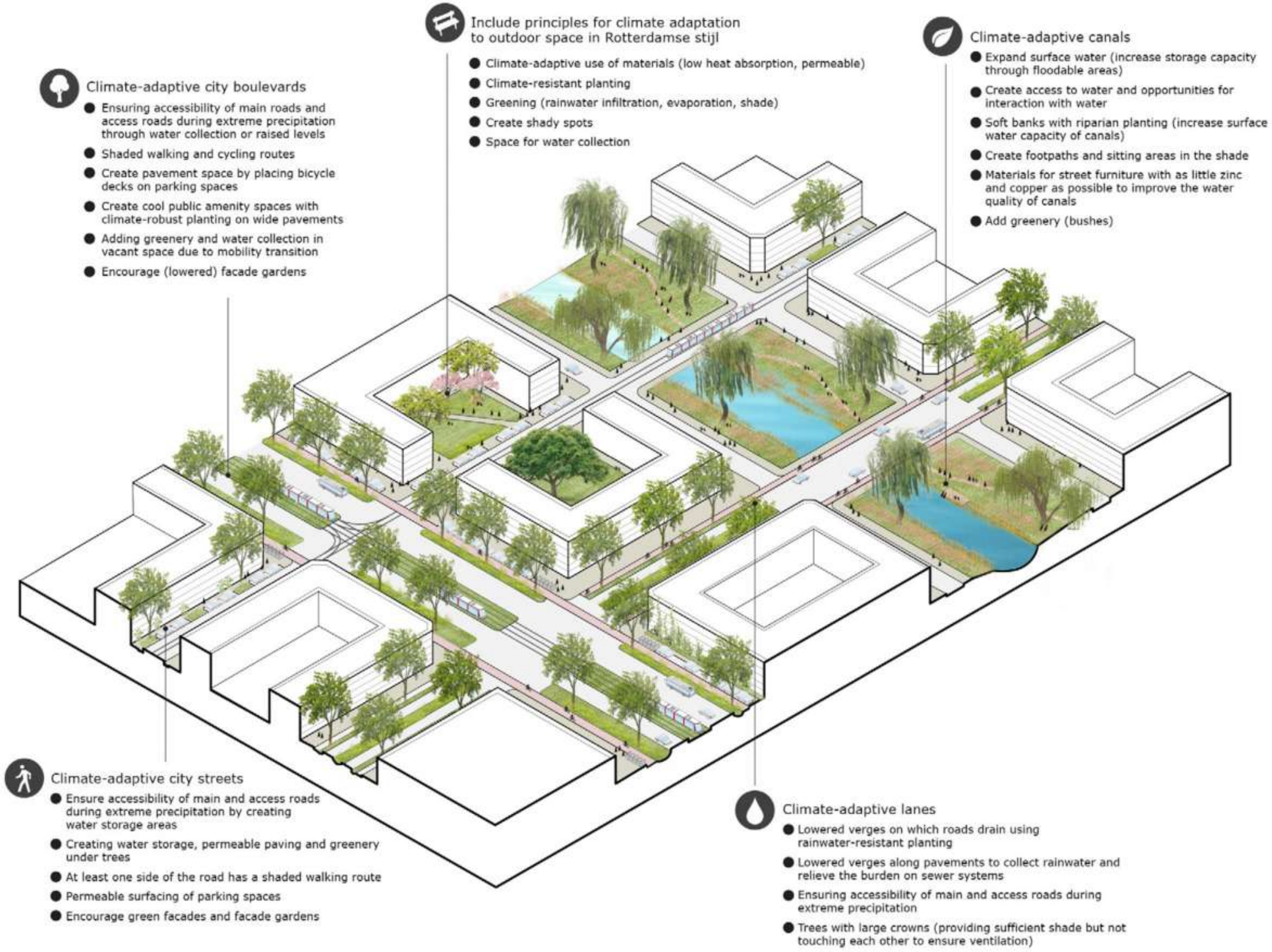


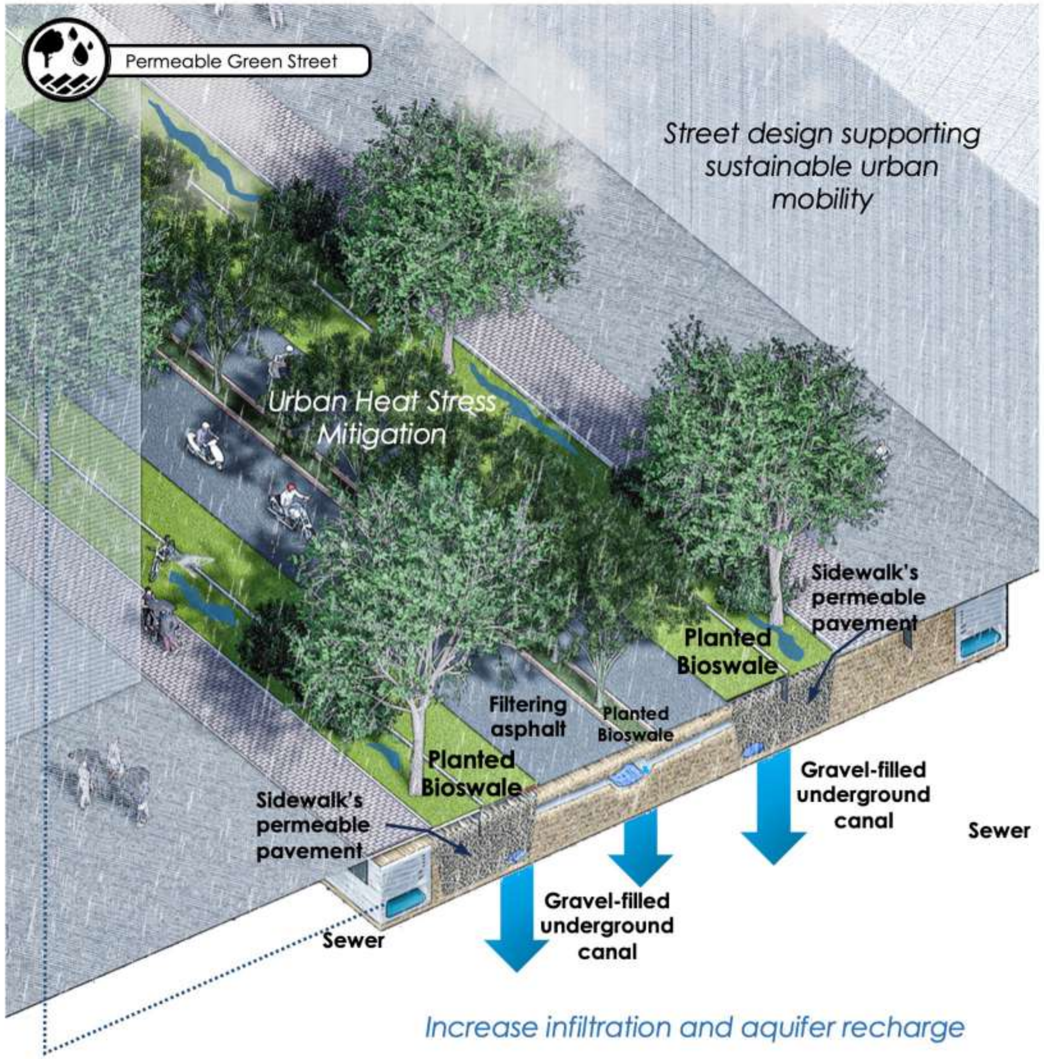
HOW TO INITIATE GREEN & BLUE STREET DESIGN?

- Transform a road or an avenue into a green and blue corridor with landscape strategies
- Prevent floods and collect stormwater upstream to protect downstream area from water floods and pollution
- Create soft water reservoirs that can be used by local communities during dryer seasons
- Integrate green infrastructure and green transport infrastructure for pedestrians and bicyles
- Reintroduce biodiversity in the urban environment
- Insert small green spaces in order to reduce urban heat effects in urban areas with lack of green coverage
- Create a permeable and depolluted road that allows infiltration and aquifer recharge

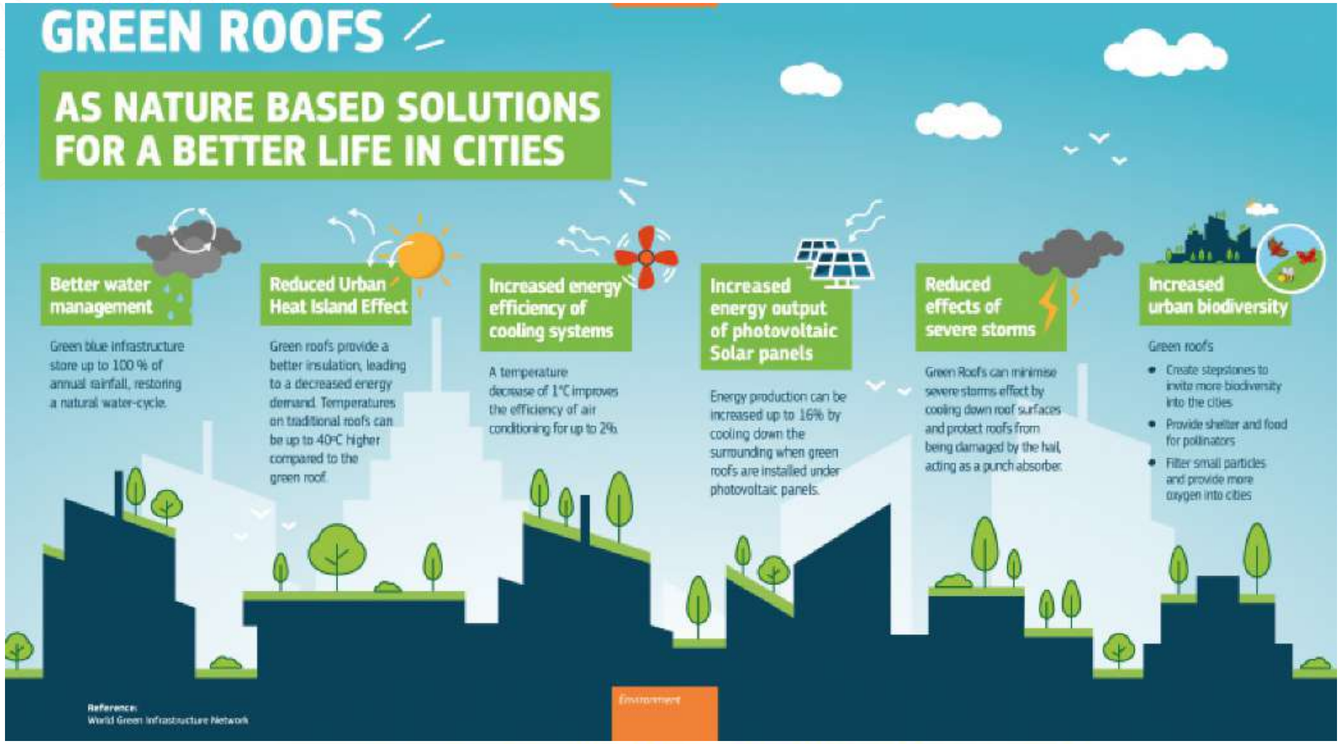
How NbS support Multi-scale Urban Resilience in Southeast Asia

The path to Water Sensitive Urban Design (WSUD)





Permeable Green Street Section. *Source: Citilinks*

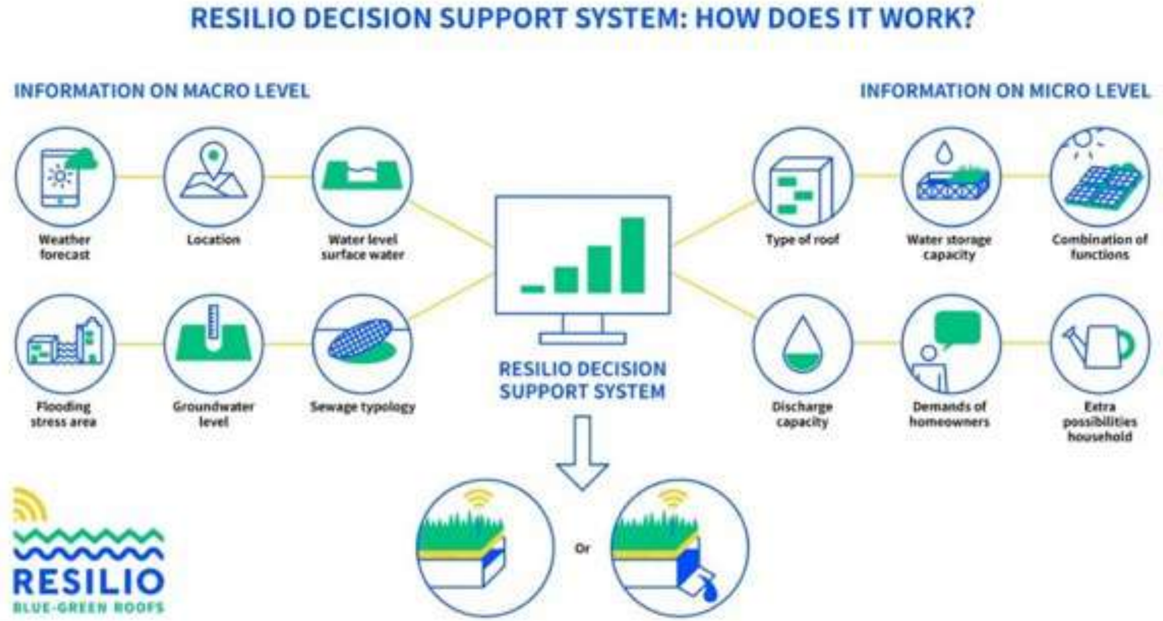


THE ROLES AND ADVANTAGES OF GREEN ROOFS

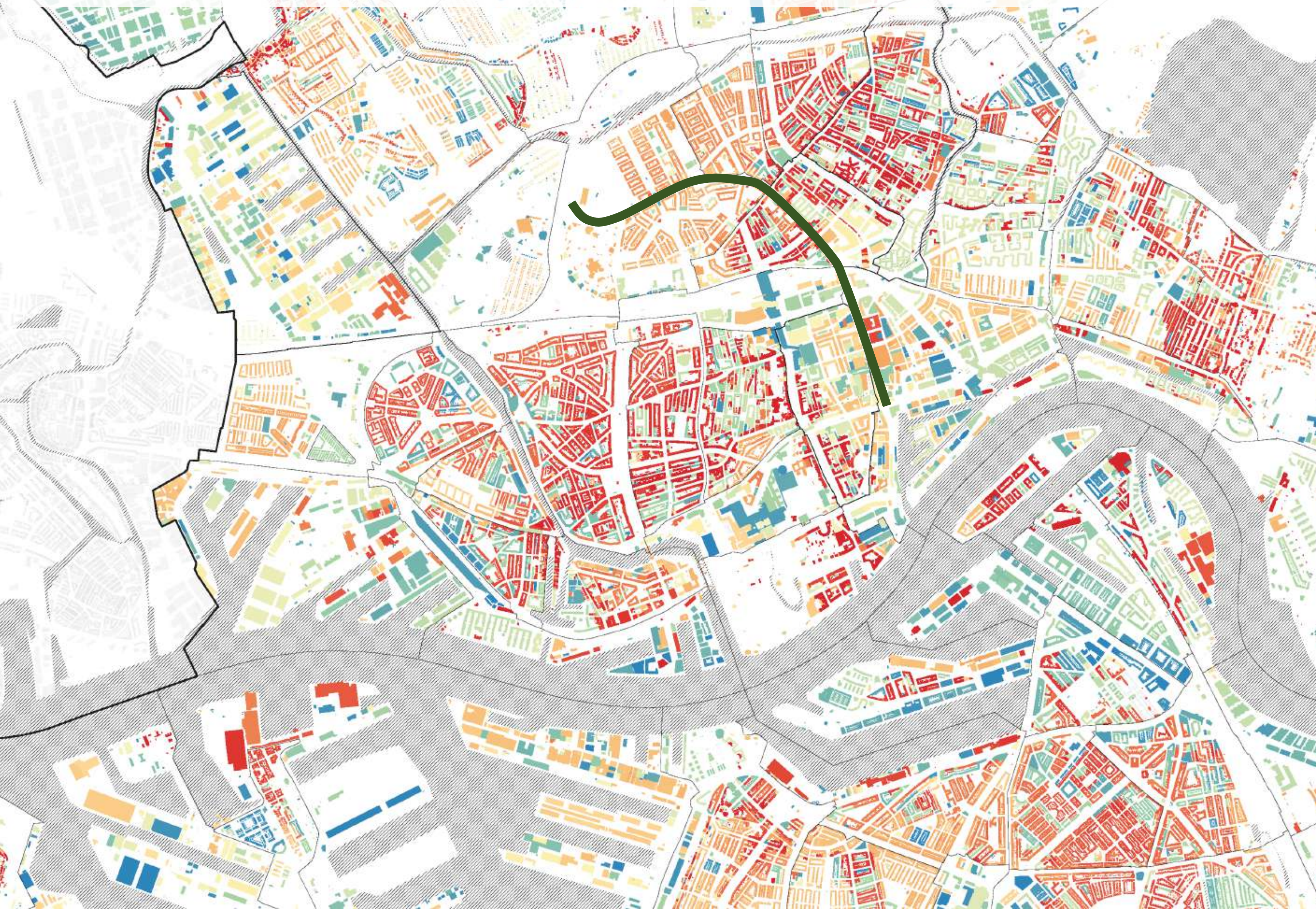
- **Flood protection** during extreme rains (intensity of up to 60 mm/h) is the principal rationale for storing water on the roof. Because the apartment complexes are in flood-prone regions, the storage provided by blue-green roofs reduces flood risk.

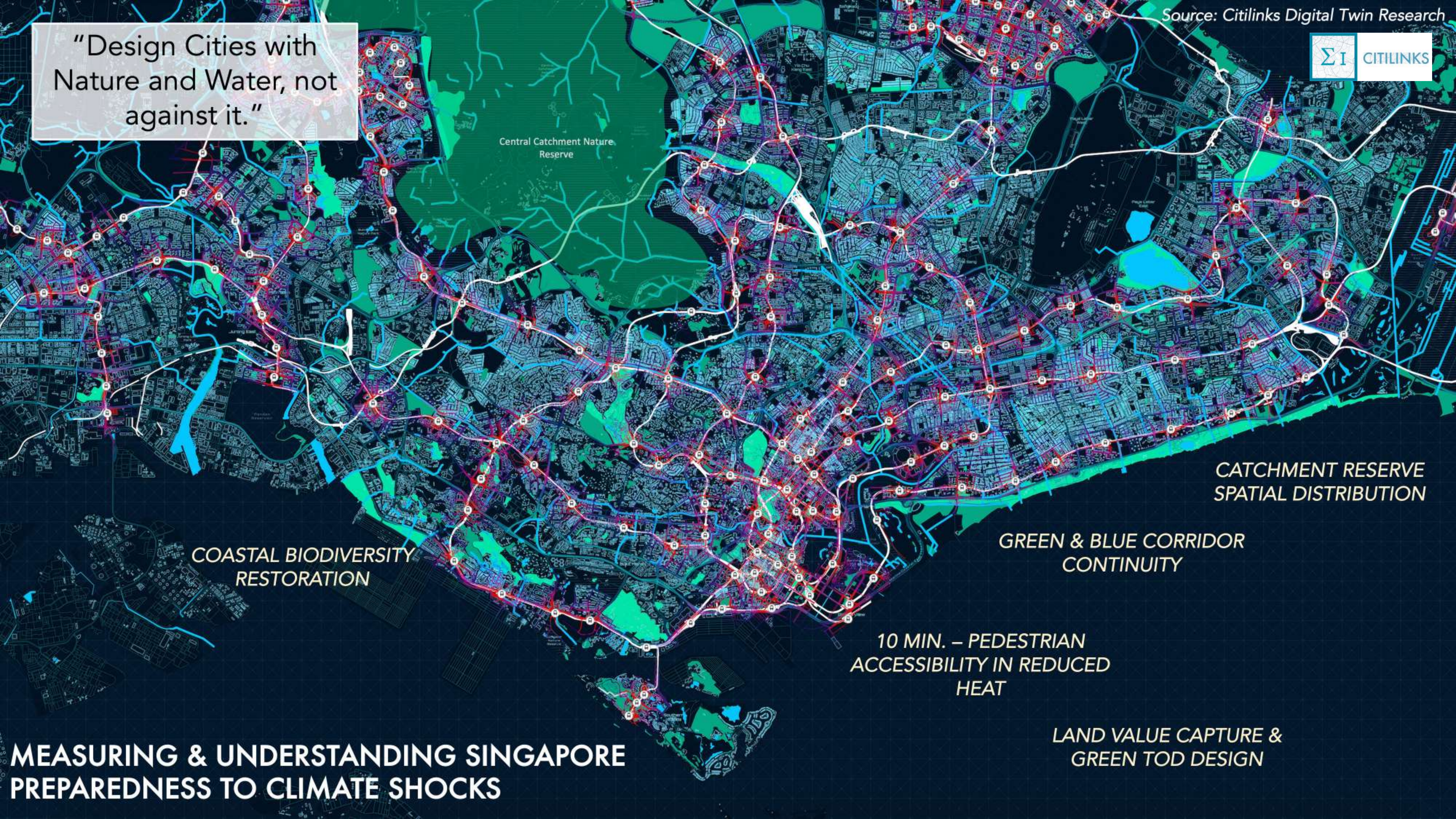
- Blue-green roofs also contribute to **Urban Biodiversity**. This contribution is maximized when the construction and design are based on planning methodologies that take into account the surroundings, wildlife, and exposed roof conditions.

- The roofs boost building insulation while also aiding in microclimate control by **minimizing the Urban Heat Island effect**.

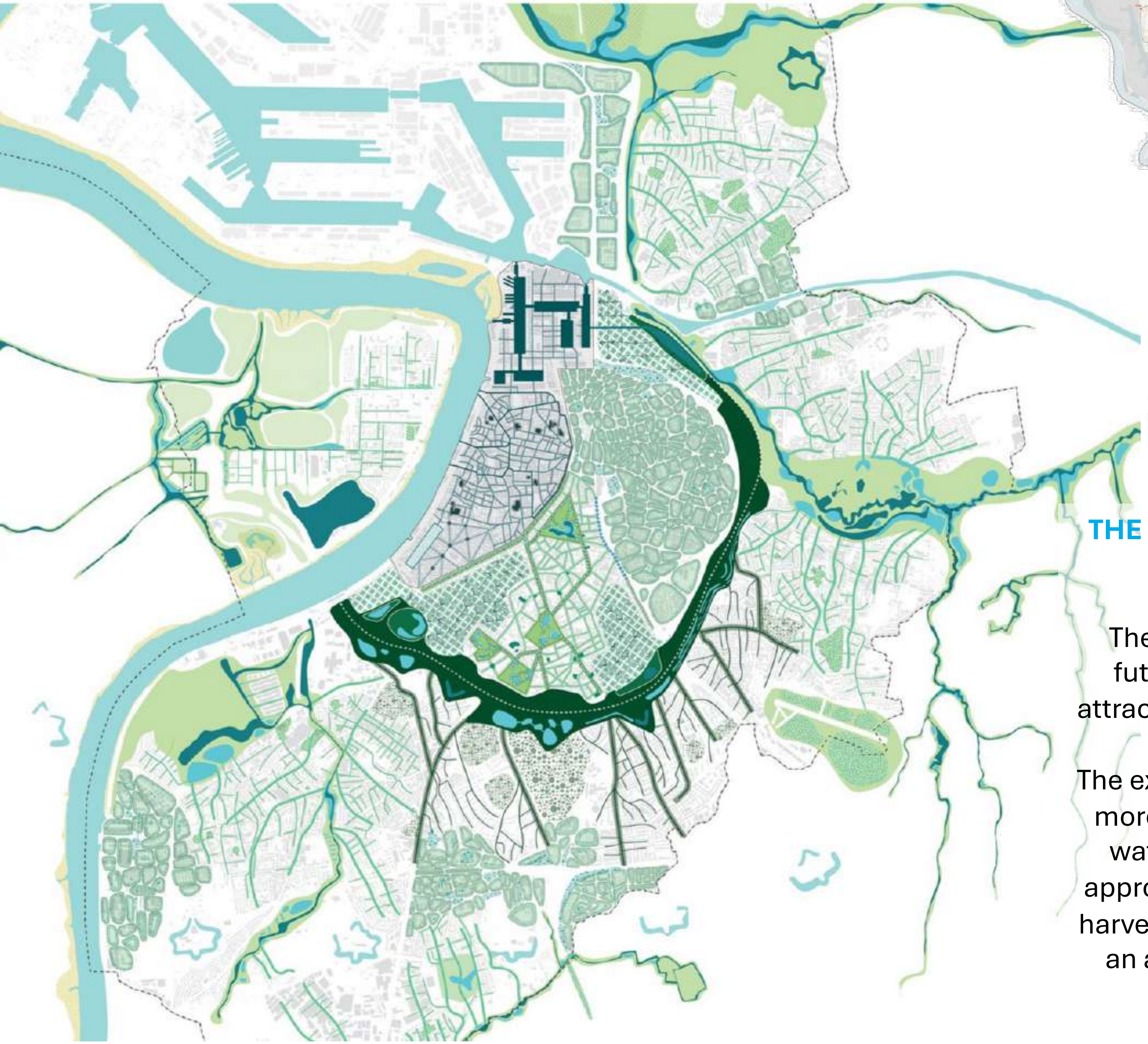


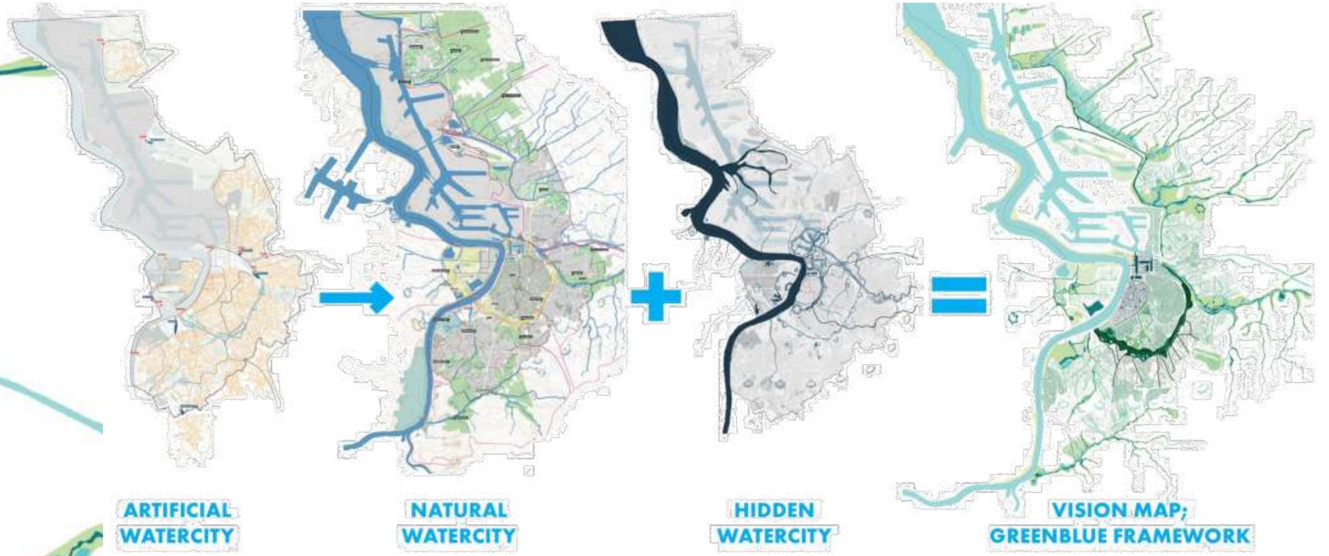
Monitoring & Mobilizing Green Roof Potential at City-Level: The Rotterdam Approach




"Design Cities with Nature and Water, not against it."
Source: Citilinks Digital Twin Research
CITILINKS
Central Catchment Nature Reserve
CATCHMENT RESERVE SPATIAL DISTRIBUTION
GREEN & BLUE CORRIDOR CONTINUITY
COASTAL BIODIVERSITY RESTORATION
10 MIN. – PEDESTRIAN ACCESSIBILITY IN REDUCED HEAT
LAND VALUE CAPTURE & GREEN TOD DESIGN
MEASURING & UNDERSTANDING SINGAPORE PREPAREDNESS TO CLIMATE SHOCKS

Planning Water-Sensitive Urban Resilience with at City-Level: The Case of the Antwerp WaterPlan (Belgium)





THE NEW APPROACH OF WATER PLANNING FOR A CITY: THE CASE OF ANTWERP, BELGIUM

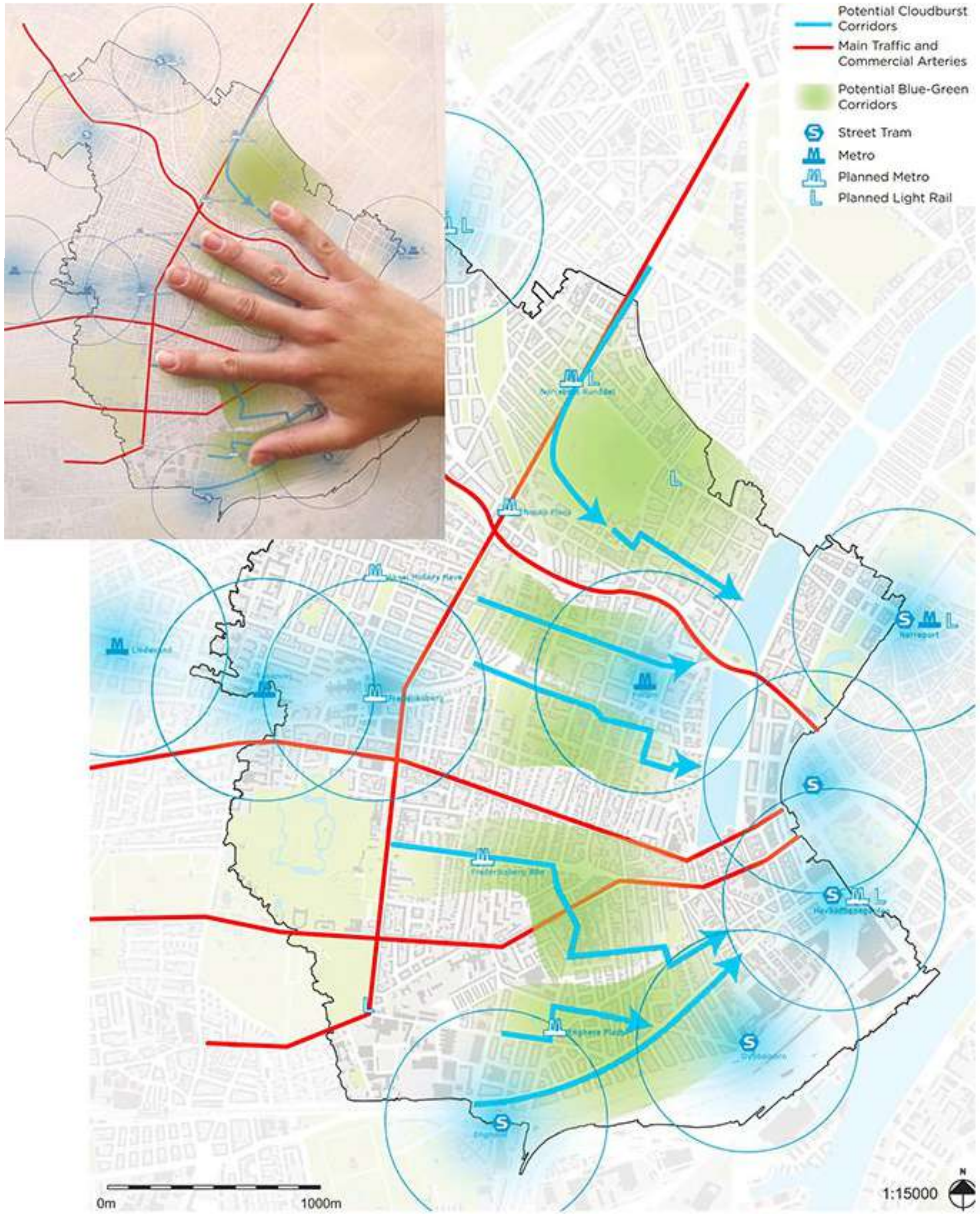
The Waterplan of Antwerp gives an inspiring vision of how the city has to approach future projects to get ready for a climate with larger extremes. This also makes an attractive living environment made for all inhabitants of Antwerp that offers flexibility to be able to continue to adapt to a changing future.
The extreme drought of 2022 shows how important it is to make our urban environment more water sensitive. Collect and store water when there is too much and reuse this water when there is too little. In Belgium and the Netherlands, this water sensitive approach leads urban design. Rainwater from the roof and its surrounding area will be harvested and cleaned in the roofpark by natural processes and afterwards is stored in an aquifer. In times of drought, the stored water from this aquifer can be reused for irrigation of the planting.

Planning Water-Sensitive Urban Resilience with at District-Level:

Capturing and Retaining Stormwater in the Streets of Copenhagen (Denmark)

INTEGRATING RESILIENT STREETS & URBAN PONDS WITHIN THE URBAN CANAL NETWORK

Copenhagen works on the transformation of its streets and public spaces into blue-green infrastructure that can absorb the impacts of cloudburst events.
Spatial design for resilience distinguishes safety zones and floodable areas with high retention capacity.



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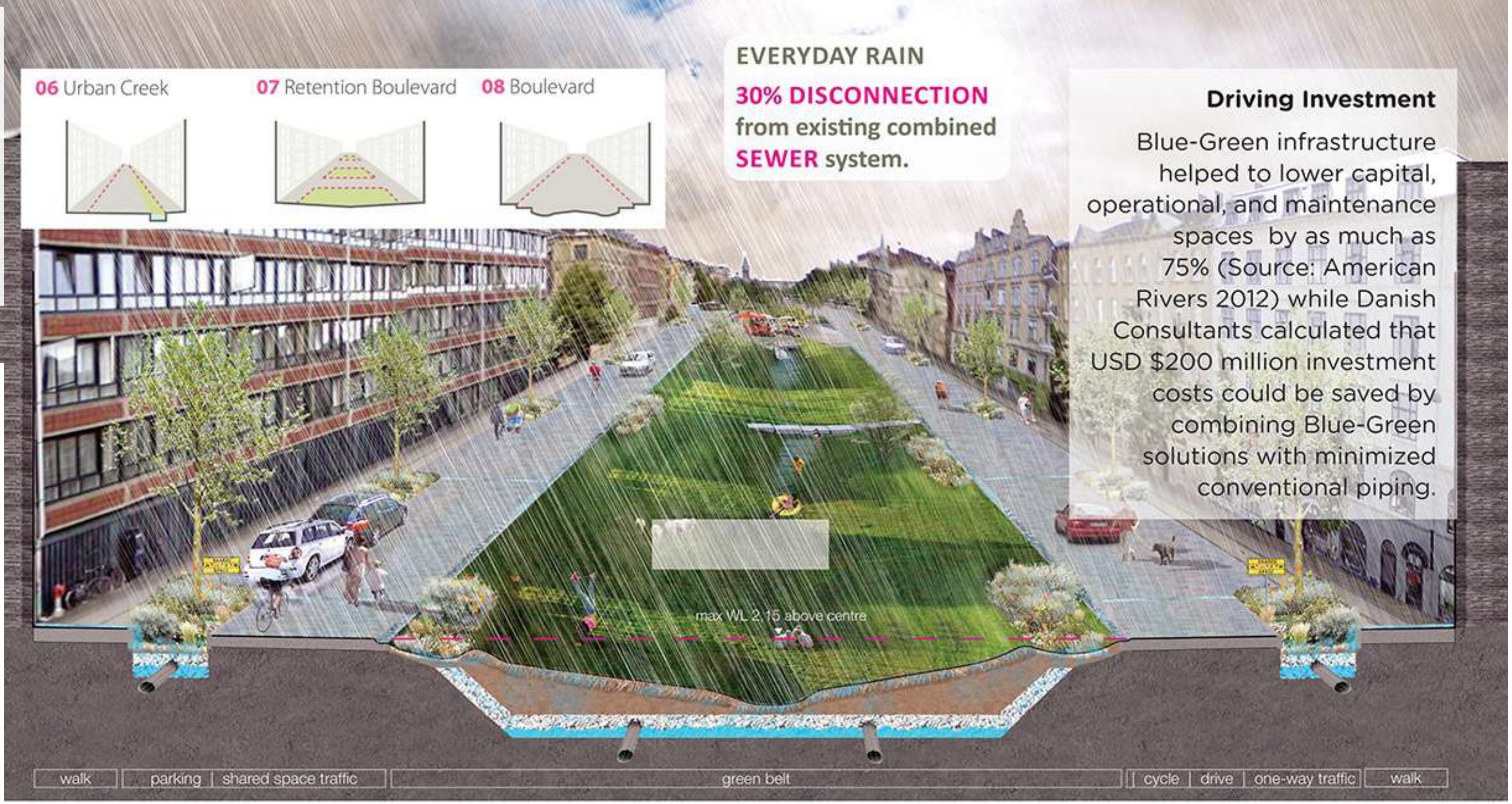
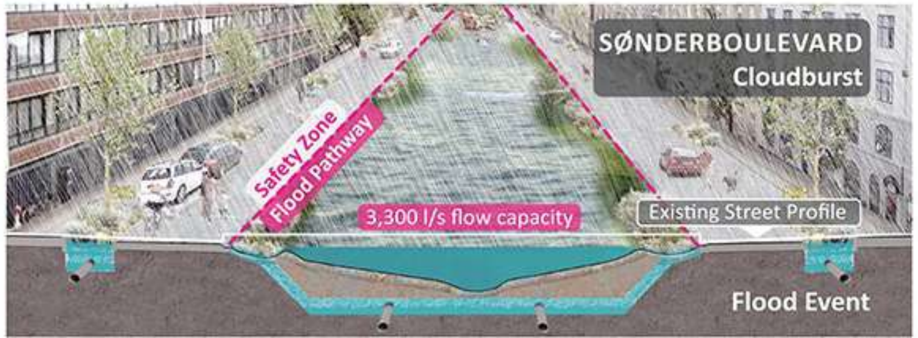
Copenhagen works on the transformation of its streets and public spaces into blue-green infrastructure that can absorb the impacts of cloudburst events.

Spatial design for resilience distinguishes safety zones and floodable areas with high retention capacity.

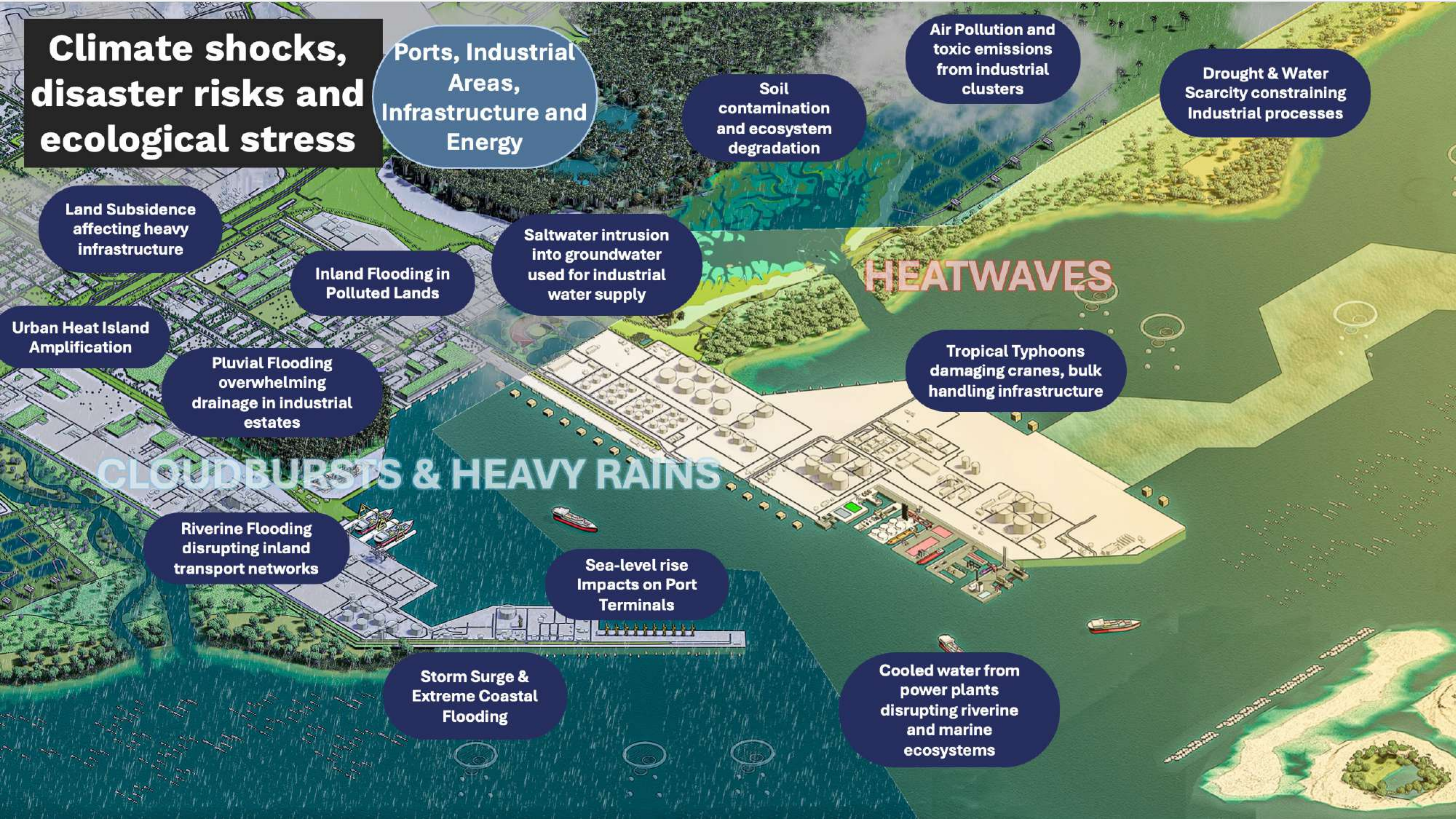


Rain Event Handled within Multi-Functional Tools including Urban Creek, Retention Boulevard, and Boulevard

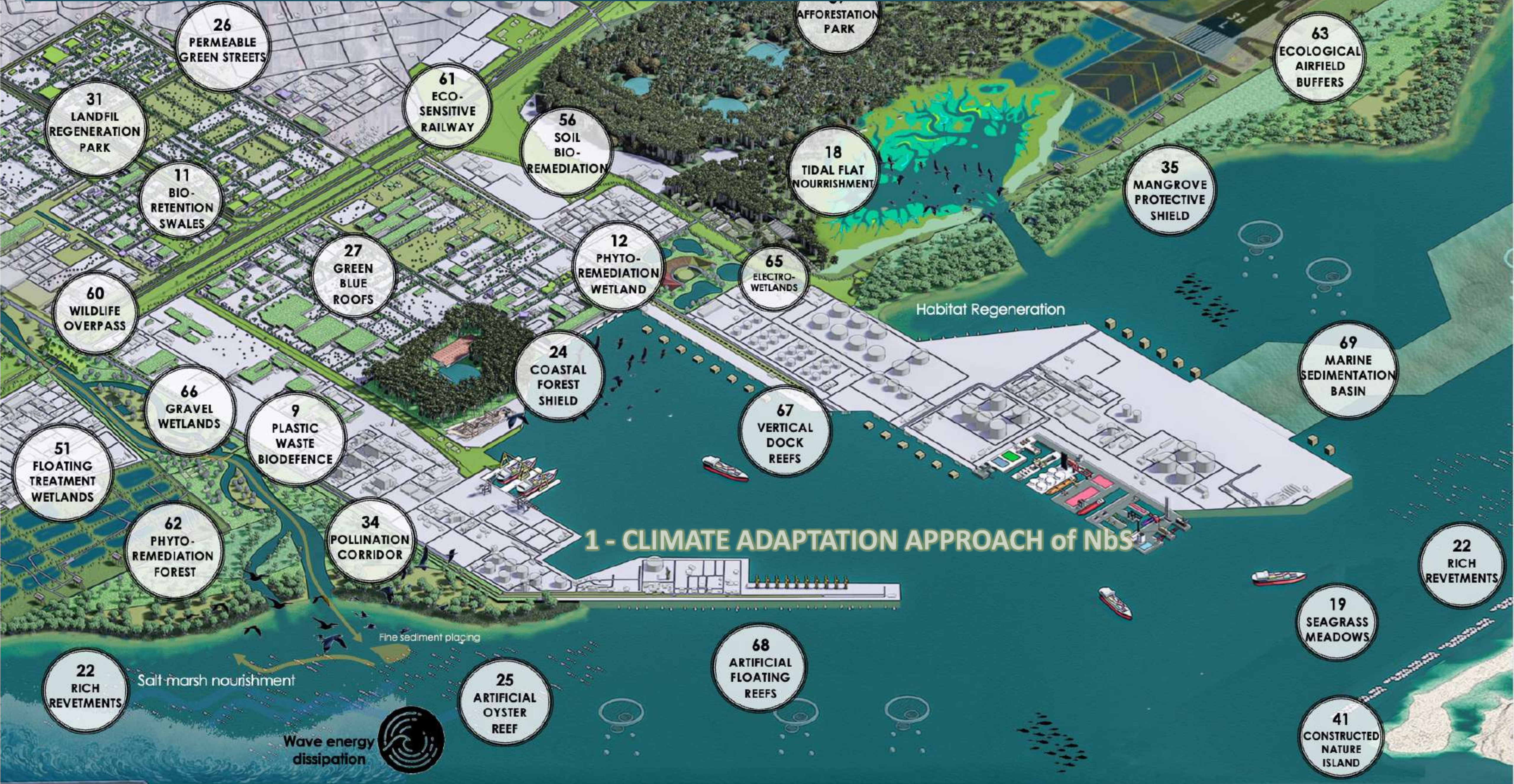


Green & Blue Industrial Areas and EIPs : Shaping Low Impact Productive Landscapes

CSL05 **Eco-Industrial Areas and Ports**


Climate shocks, disaster risks and ecological stress
Ports, Industrial Areas, Infrastructure and Energy
Soil contamination and ecosystem degradation
Air Pollution and toxic emissions from industrial clusters
Drought & Water Scarcity constraining Industrial processes
Land Subsidence affecting heavy infrastructure
Inland Flooding in Polluted Lands
Saltwater intrusion into groundwater used for industrial water supply
HEATWAVES
Urban Heat Island Amplification
Pluvial Flooding overwhelming drainage in industrial estates
Tropical Typhoons damaging cranes, bulk handling infrastructure
CLOUDBURSTS & HEAVY RAINS
Riverine Flooding disrupting inland transport networks
Sea-level rise Impacts on Port Terminals
Storm Surge & Extreme Coastal Flooding
Cooled water from power plants disrupting riverine and marine ecosystems

Enabling Low-Impact and Resilience of Industrial Areas with NbS



NbS-65: ELECTRO-WETLANDS

Electrowetlands are a combination of constructed wetlands with bioelectrochemical systems to support energy production, stormwater filtering, water depollution, and regenerative agriculture in Southeast Asia. By harnessing microbial fuel cells, electrowetlands generate electricity from organic waste decomposition while simultaneously removing pollutants like nitrogen, phosphorus, and heavy metals from stormwater and wastewater. These systems enhance agricultural productivity by recycling nutrient-rich treated water for irrigation and reducing chemical input reliance. Technically, they offer efficient pollutant breakdown and renewable energy generation.

Socially and economically, they improve rural livelihoods through decentralized energy access, lower water treatment costs, and enhanced food security. The Bioelectrochemical Wetland System (BEWS) in Kunming, China integrates constructed wetlands with microbial fuel cells to treat wastewater and generate electricity. This system effectively removes over 85% of nitrogen and phosphorus and up to 95% of organic pollutants, while producing electricity (up to 0.5 watts per square meter) through microbial activity. The treated water is reused in agriculture, reducing fertilizer costs and improving water quality, making it a sustainable and low-maintenance solution for water pollution, energy production, and agricultural support, particularly suitable for rural areas in Southeast Asia.

LANDSCAPES SUPPORTED

EbA (ECOSYSTEM-BASED APPROACHES)

- WATER QUALITY IMPROVEMENT
- ENERGY PRODUCTION
- WASTEWATER TREATMENT
- ECOSYSTEM RESTORATION
- CLIMATE RESILIENCE
- AGRICULTURE SUPPORT

MAIN PROBLEMS ADDRESSED

- BIODIVERSITY LOSS
- CARBON SEQUESTRATION
- FOOD SECURITY

ECOSYSTEM SERVICES AND ACTIONS

SUPPORTING

- Enhances habitat for various species by restoring wetland ecosystems.
- Facilitates the cycling of nutrients through electrochemical and microbial processes.

REGULATING

- Improves water quality by removing pollutants from wastewater.
- Mitigate the impacts of water pollution and nutrient overloads in aquatic ecosystems.

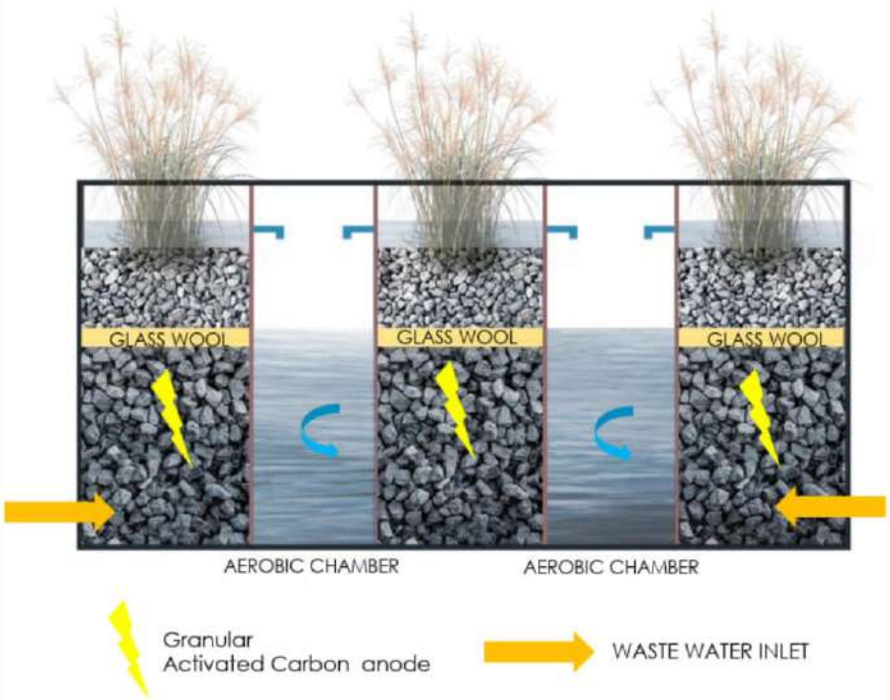
PROVISIONING

- Generates renewable energy through microbial fuel cells, providing sustainable electricity.
- Offers a low-cost, effective way to treat wastewater and recycle it for use in agriculture or other applications.

SOCIAL BENEFITS

- Reduces waterborne diseases by improving water quality in surrounding communities.

NbS-65: ELECTRO-WETLANDS



CONSTRUCTED WETLAND MICROBIAL FUEL CELL SYSTEM
SOURCE : https://doi.org/10.1016/j.cej.2023.141686

PROJECT'S CHALLENGES & RISKS

- **Technical Complexity**: The design and operation of electrowetlands require specialized knowledge and expertise, which may be lacking in some regions.
- **High Initial Costs**: Setting up electrowetlands systems involves significant upfront investment in infrastructure and technology.
- **Limited Scalability**: Due to the high space requirements, it may be challenging to scale electrowetlands for large urban areas.
- **Environmental Sensitivity**: Changes in local environmental conditions (e.g., water temperature, pH levels) can affect the efficiency and stability of electrowetland systems.

NbS co-BENEFITS AND THEIR INDICATORS

Water Quality Improvement
Removing pollutants, with an indicator being reduced levels of nitrogen and phosphorus in treated water.

Carbon Sequestration
The vegetation in electrowetlands helps sequester carbon.

Biodiversity Support
They provide habitat for various species.

Energy Production
Contribute to renewable energy, with an indicator being the amount of electricity generated from the electrochemical process.

Flood Mitigation
By regulating water flow, they can help reduce flooding risks.

Community Health Improvement
By improving water quality and managing wastewater, electrowetlands can reduce waterborne diseases.

COST ANALYSIS

Direct Costs
Setup costs including materials and labor can range from $200k to $500k per hectare.

Indirect Costs
Ongoing maintenance costs, including monitoring, cleaning, and energy, can amount to $10k to $50k/year per site.

Time Horizon
The expected time horizon for electrowetlands to show tangible results is 5 to 10 years.

Direct Benefits
Direct benefits include the reduction of wastewater treatment costs.

Indirect Benefits
Indirect benefits include ecosystem services like improved biodiversity and carbon sequestration.

Risk Assessment
Key risks include the potential failure of the electrochemical process or operational issues, which can result in repair costs.

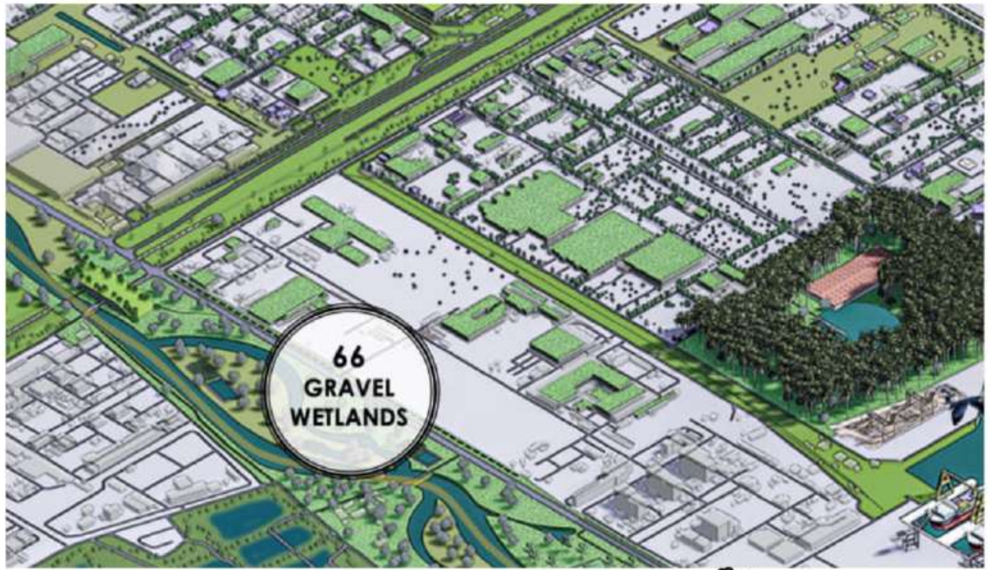
REFERENCES:

China, Kunming, The Bioelectrochemical Wetland System (BEWS) integrates constructed wetlands with microbial fuel cells to treat wastewater and generate electricity.

IMPLEMENTATION OPPORTUNITIES:

Indonesia, Jakarta: Electrowetlands could treat polluted water while providing better water quality.
Vietnam, Ho Chi Minh City: Addressing wastewater management in areas with rapid industrial growth.

NbS-66: GRAVEL WETLANDS



Gravel wetlands are engineered systems designed to mimic the functions of natural wetlands by using gravel substrates, vegetation, and microbial activity to manage stormwater, treat wastewater, and enhance biodiversity. These systems are particularly suited for implementation along roadsides in urban, industrial, and rural areas of Southeast Asia, where rapid urbanization and industrial expansion have increased water pollution and flood risks. Technically, gravel wetlands filter pollutants, trap sediments, and remove nutrients such as nitrogen and phosphorus, making them effective for water quality improvement. They enhance urban and rural aesthetics, create green buffers along roads, and stabilize soils to prevent erosion. Socially, gravel wetlands provide co-benefits such as recreational spaces, educational opportunities, and improved resilience against climate impacts like flooding and heat stress. By combining ecological functionality with landscape and community benefits, gravel wetlands offer a sustainable, low-maintenance solution that supports the region's environmental and social priorities.

LANDSCAPES SUPPORTED

EbA (ECOSYSTEM-BASED APPROACHES)

| FLOOD MANAGEMENT | EROSION CONTROL | WATER QUALITY IMPROVEMENT
| BIODIVERSITY CONSERVATION | CLIMATE RESILIENCE | HABITAT CONNECTIVITY

ECOSYSTEM SERVICES AND ACTIONS

SUPPORTING
- **Habitat Creation**: Provide habitats for aquatic and semi-aquatic species, enhancing biodiversity.

REGULATING
- **Water Quality Improvement**: Remove pollutants such as nutrients, sediments, and heavy metals from stormwater and wastewater.

PROVISIONING
- **Water Resource Management**: Store and slowly release treated water for potential reuse in irrigation or other non-potable applications.

SOCIAL BENEFITS
- **Aesthetic and Recreational Value**: Enhance landscapes along roads and offer opportunities for community engagement and education.

MAIN PROBLEMS ADDRESSED

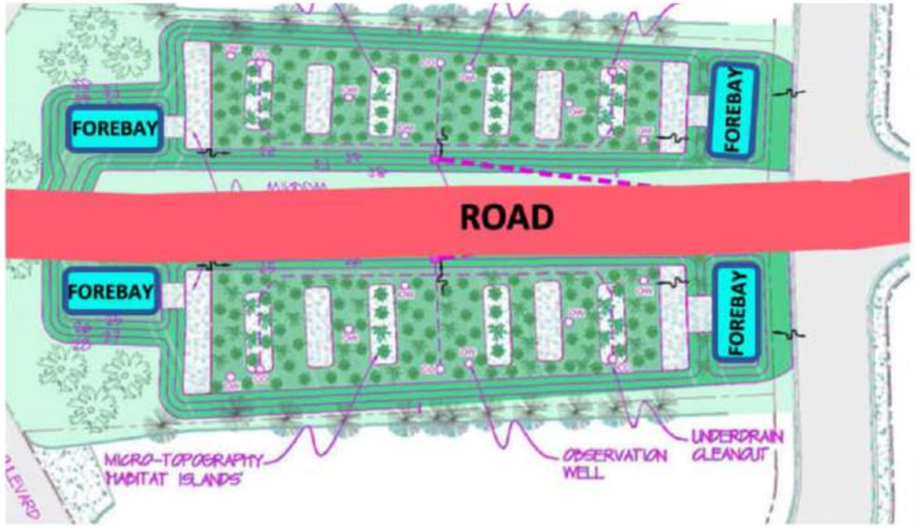
BIODIVERSITY LOSS

SOIL EROSION

AIR QUALITY IMPROVEMENT

FLOOD CONTROL

NbS-66: GRAVEL WETLANDS



PROJECT'S CHALLENGES & RISKS

- **High Initial Costs**: Gravel wetlands require significant upfront investment, which may be challenging for local governments with limited budgets.
- **Maintenance Needs**: Regular sediment removal, vegetation management, and monitoring are necessary, but lack of funding or technical capacity can hinder long-term functionality.
- **Land Availability**: Securing suitable land in densely populated urban areas or along busy roads can be difficult due to competing land uses.
- **Climatic Extremes**: Heavy rainfall, prolonged droughts, or flooding in Southeast Asia can impact the performance and structural stability of gravel wetlands.

NbS co-BENEFITS AND THEIR INDICATORS

Improved Water Quality
Reduction in nutrient and pollutant concentrations in outflow water.

Flood Risk Mitigation
Volume of stormwater retained and peak flow reduction during heavy rainfall events (m3).

Biodiversity Enhancement
Increase in the number and diversity of aquatic and terrestrial species within the wetland.

Urban Cooling
Measurable reduction in temperature in areas around the gravel wetland compared to grey surfaces.

Aesthetic and Recreational Value
Community satisfaction surveys and increased use of wetland-adjacent spaces for recreational activities.

Erosion Control
Reduction in sediment deposition downstream or along adjacent land areas.

COST ANALYSIS

Direct Costs
Initial construction costs : from $100k to $200k per ha (excavation, gravel, plants, and labor).

Indirect Costs
Annual maintenance costs: from $5k to $10k per ha, covering sediment removal and monitoring.

Time Horizon and Discount Rate
Project life expectancy is around 20–25 years, with a discount rate of 3–7% for cost-benefit analysis.

Direct Benefits
Water treatment savings around $50k to $80k /ha/year, depending on pollutant loads and water quality.

Indirect Benefits
Urban cooling and biodiversity enhancement can provide $10k to $20k/ha/year in non-market benefits.

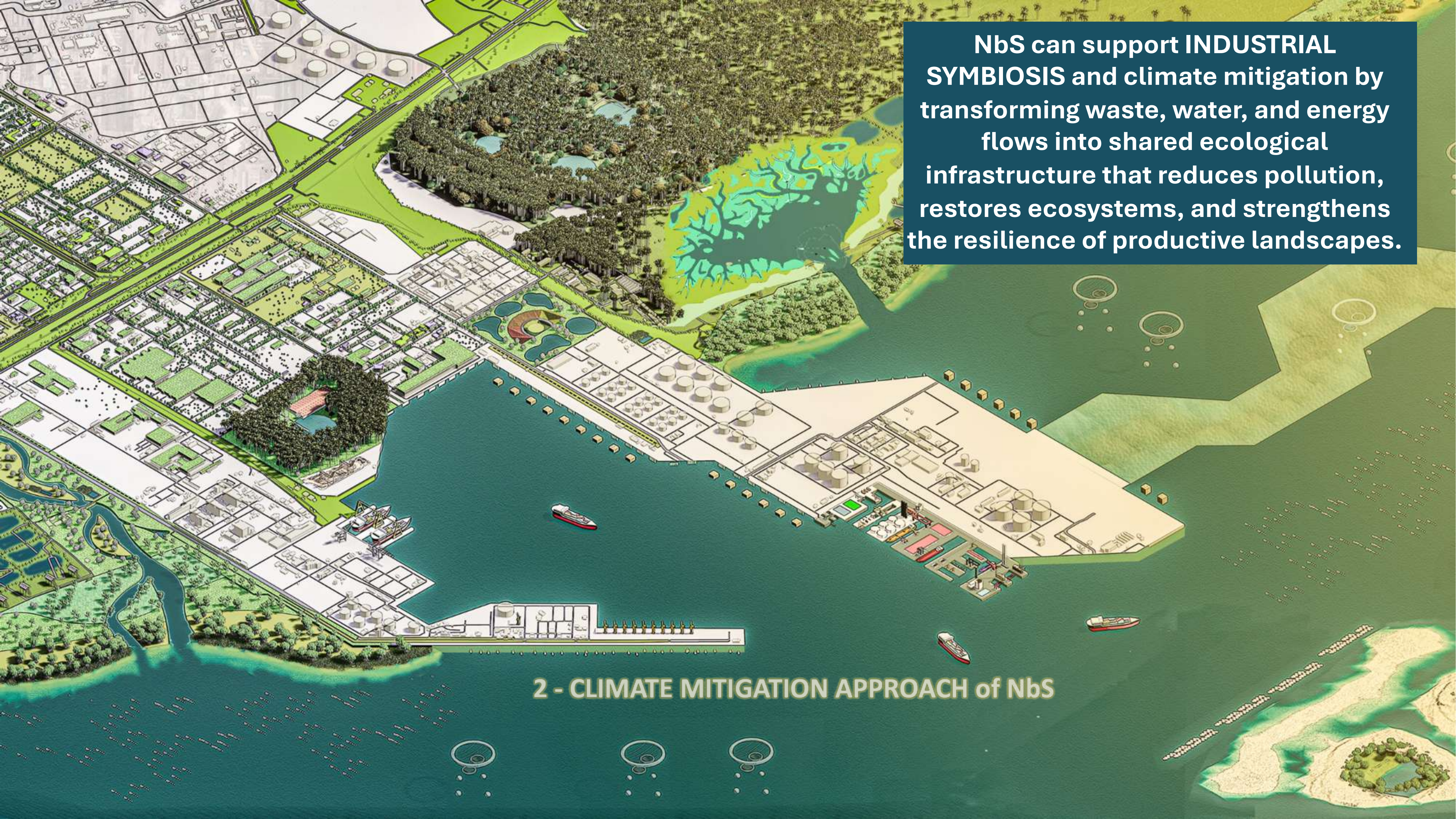
Risk Assessment
Potential risks (e.g. flooding or structural failure) might incur $5 to $15k per ha for periodic repairs or adaptive measures.

REFERENCES:

Singapore, Changi Airport Gravel Wetland.
Thailand, Bangkok, Suan Luang Rama IX Park.
Malaysia, Johor Bahru,UTM Campus Wetland.
Indonesia, Yogyakarta Urban Wetland Project.

IMPLEMENTATION OPPORTUNITIES:

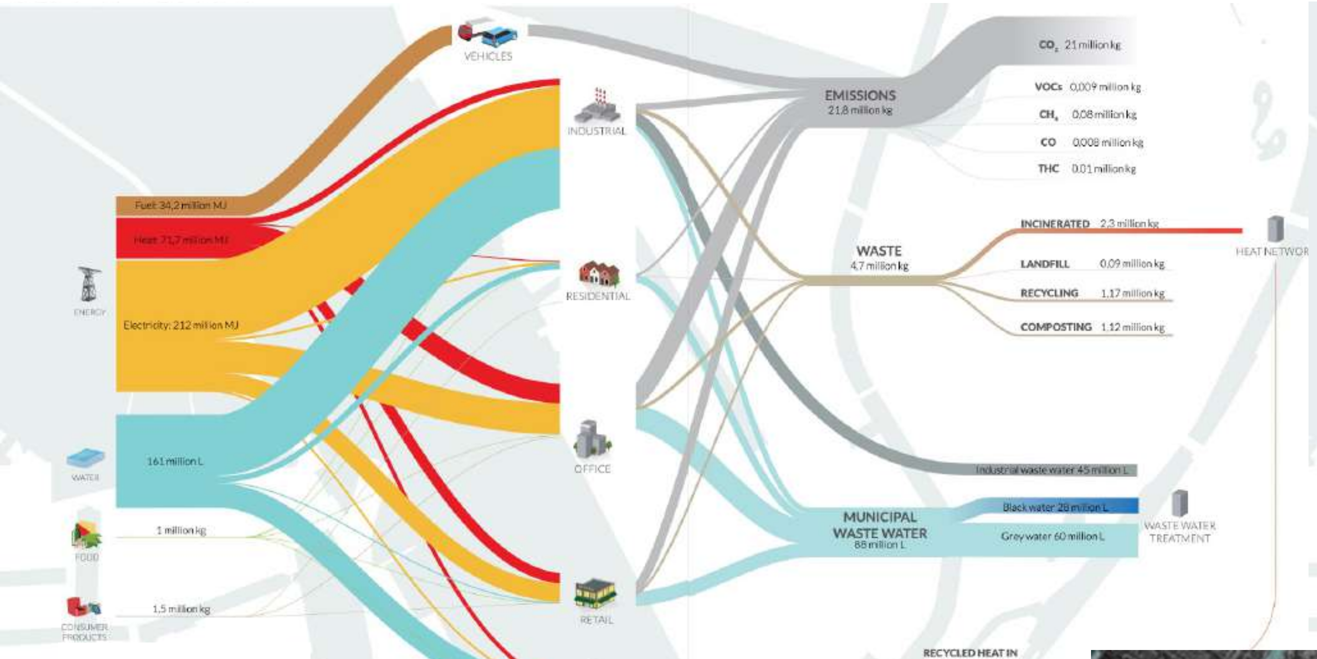
Indonesia, Jakarta's riverbanks and low-lying urban zones.
Vietnam, HCMC and Hanoi's road corridors and urban green spaces.
Greater Manila agglomeration.



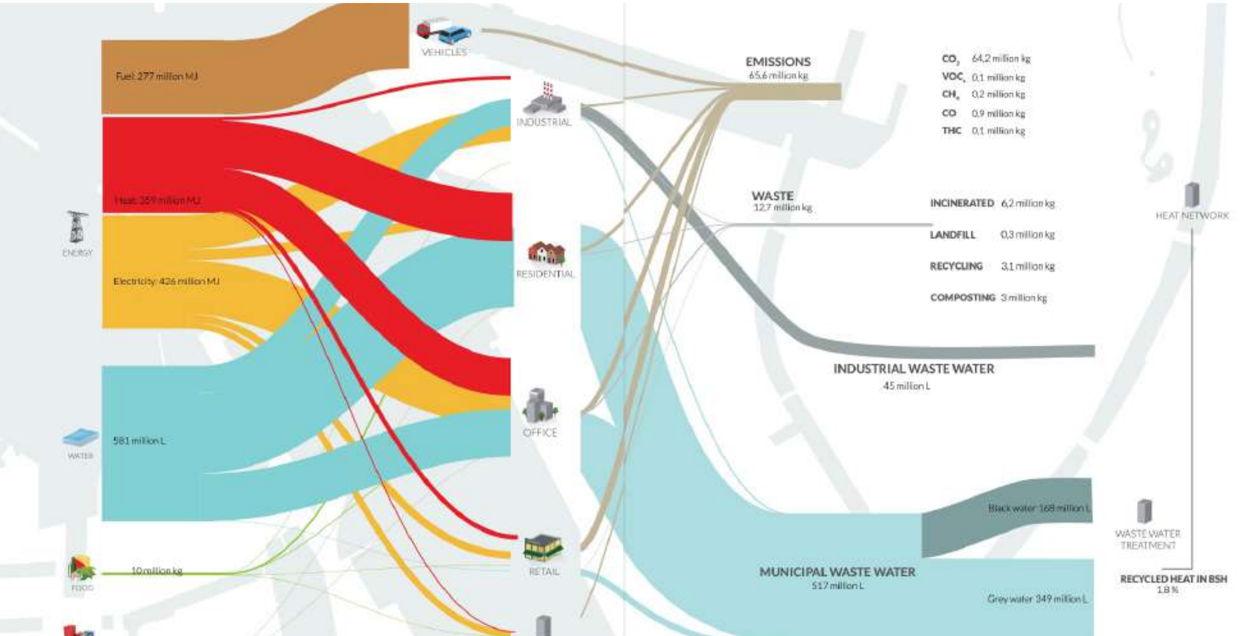
NbS can support INDUSTRIAL SYMBIOSIS and climate mitigation by transforming waste, water, and energy flows into shared ecological infrastructure that reduces pollution, restores ecosystems, and strengthens the resilience of productive landscapes.

2 - CLIMATE MITIGATION APPROACH of NbS

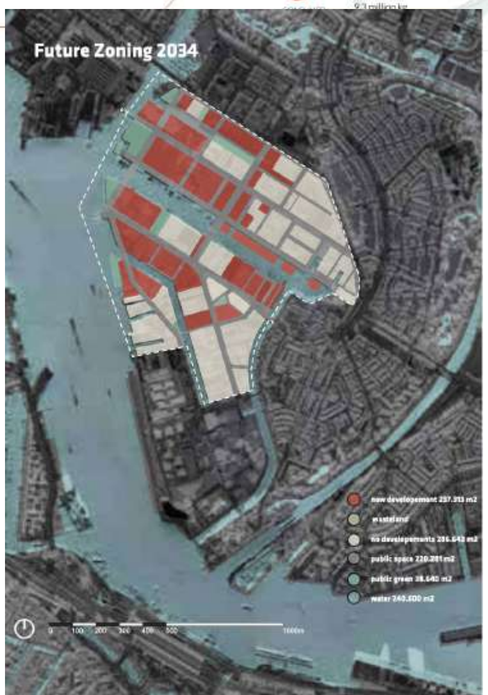
Measuring and optimising human activity inputs/outputs of one industrial area in Amsterdam



2015

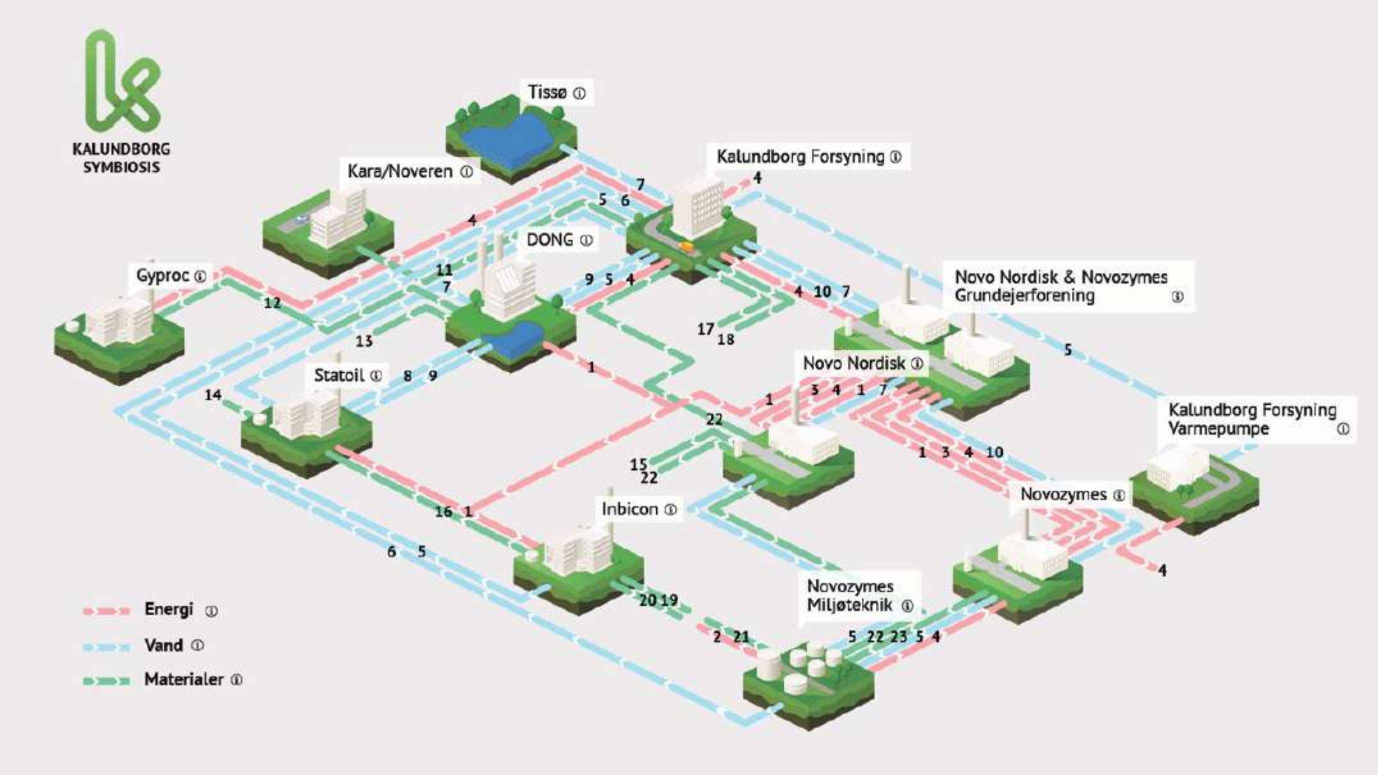


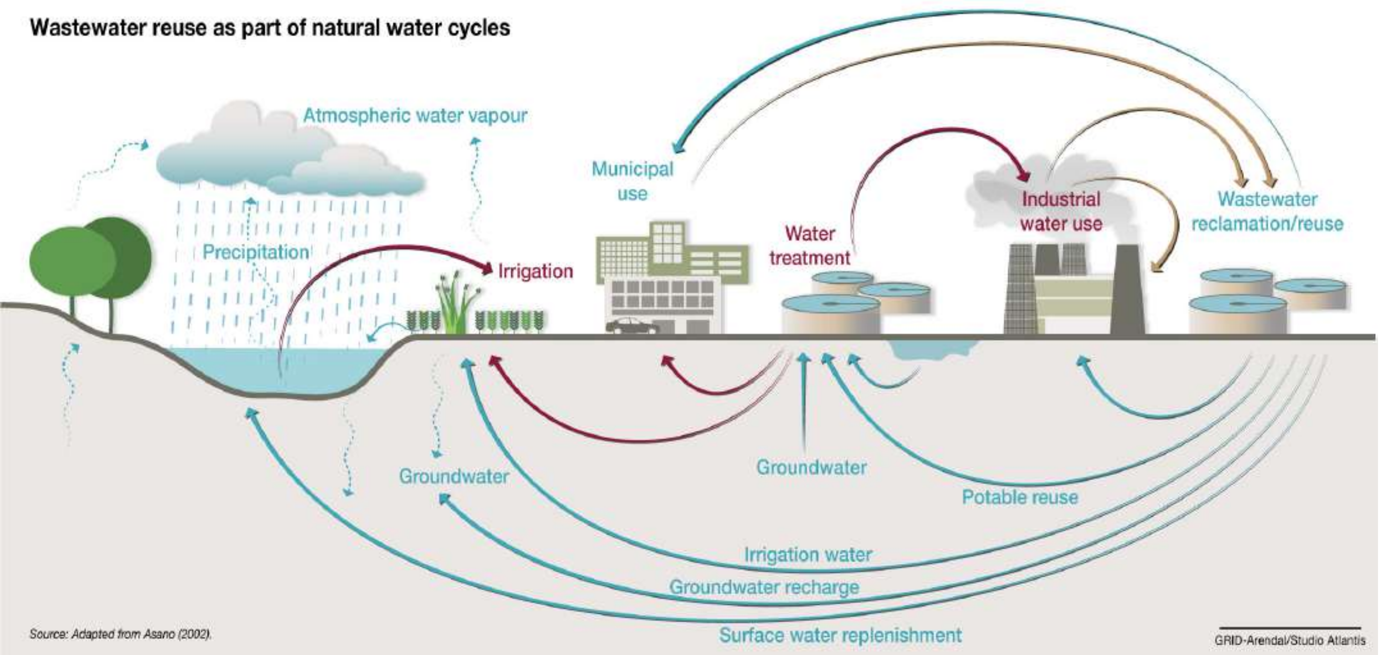
2034



Nature-based solutions in Buiksloterham are being integrated in land use management and industrial planning to reduce GHG emissions by treating wastewater, capturing pollutants, and restoring soils and vegetation, turning waste streams into productive local resources.

By integrating NbS with urban and industrial symbiosis, the district will optimize material, energy, and water flows, supporting sustainable GDP growth while enhancing ecological resilience





HOW CAN NbS support INDUSTRIAL SYMBIOSIS ?

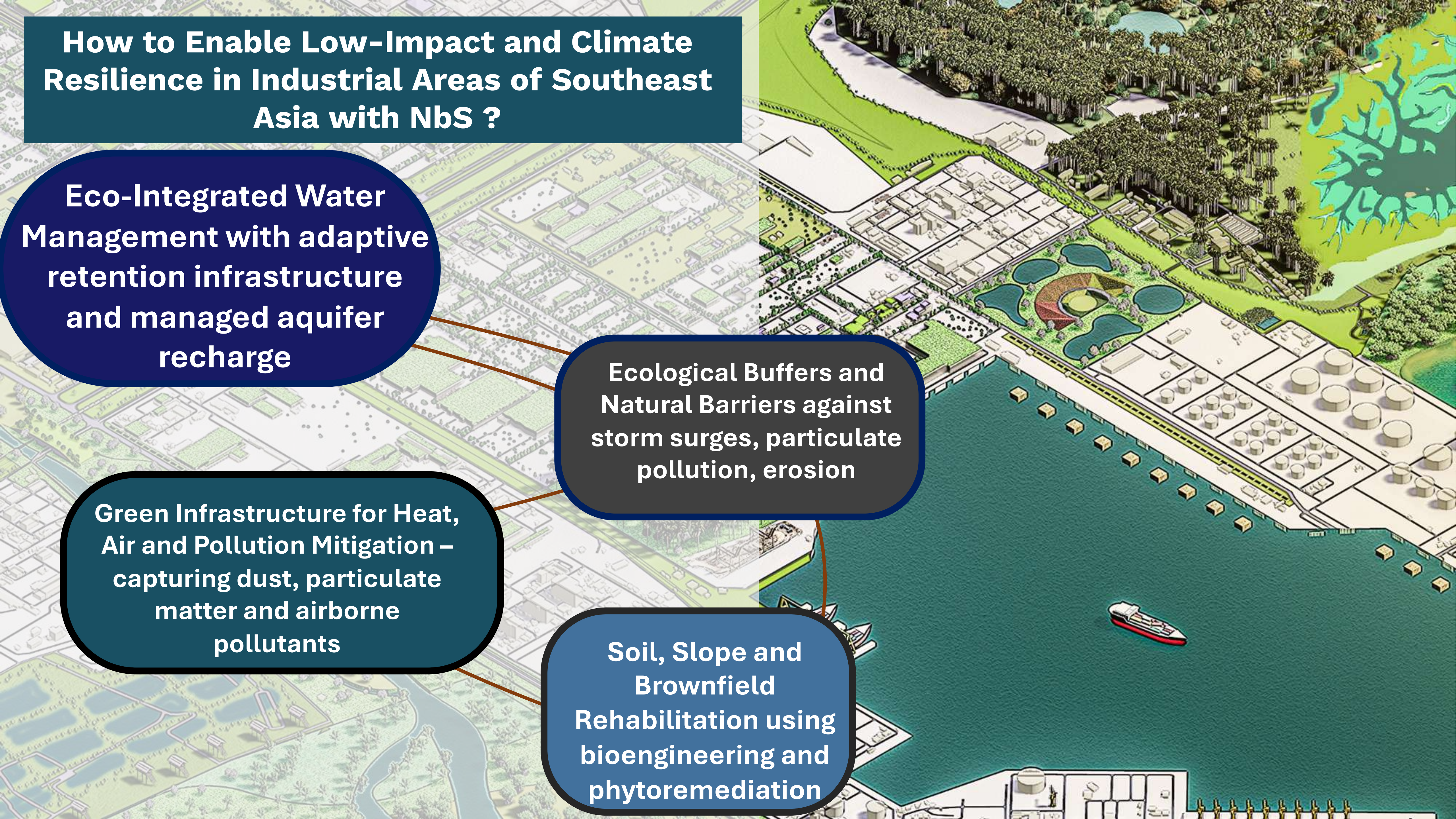
Planning green, low impact and circular industrial areas require the implementation of a governance tool to operate in a more sustainable way and limit its carbon footprint :

- **by creating synergies between industries to consume less energy together**
- **by offering ecological compensation to every new development project (restoration and preservation of natural areas)**

From water drained to water sensitive and safe industrial areas: The way to prevent water overconsumption and pollution.

Considered as a hidden resource, wastewater can be treated, recycled and reused to minimize its adverse effect on the ecosystem and the human health. This will result in improved water quality by drastically reducing the proportion of hazardous chemicals and materials that end up in the water bodies.

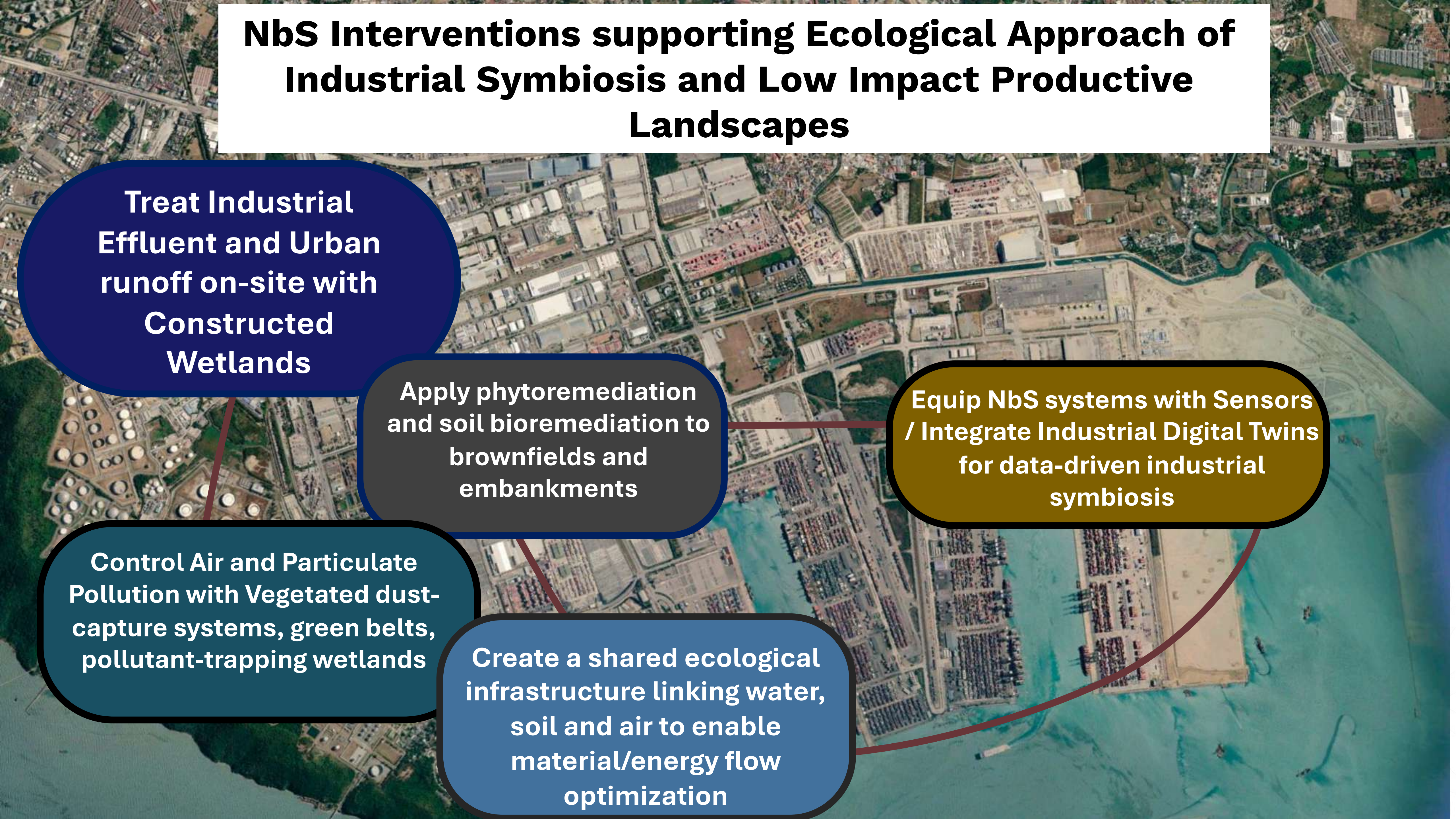
How to Enable Low-Impact and Climate Resilience in Industrial Areas of Southeast Asia with NbS ?



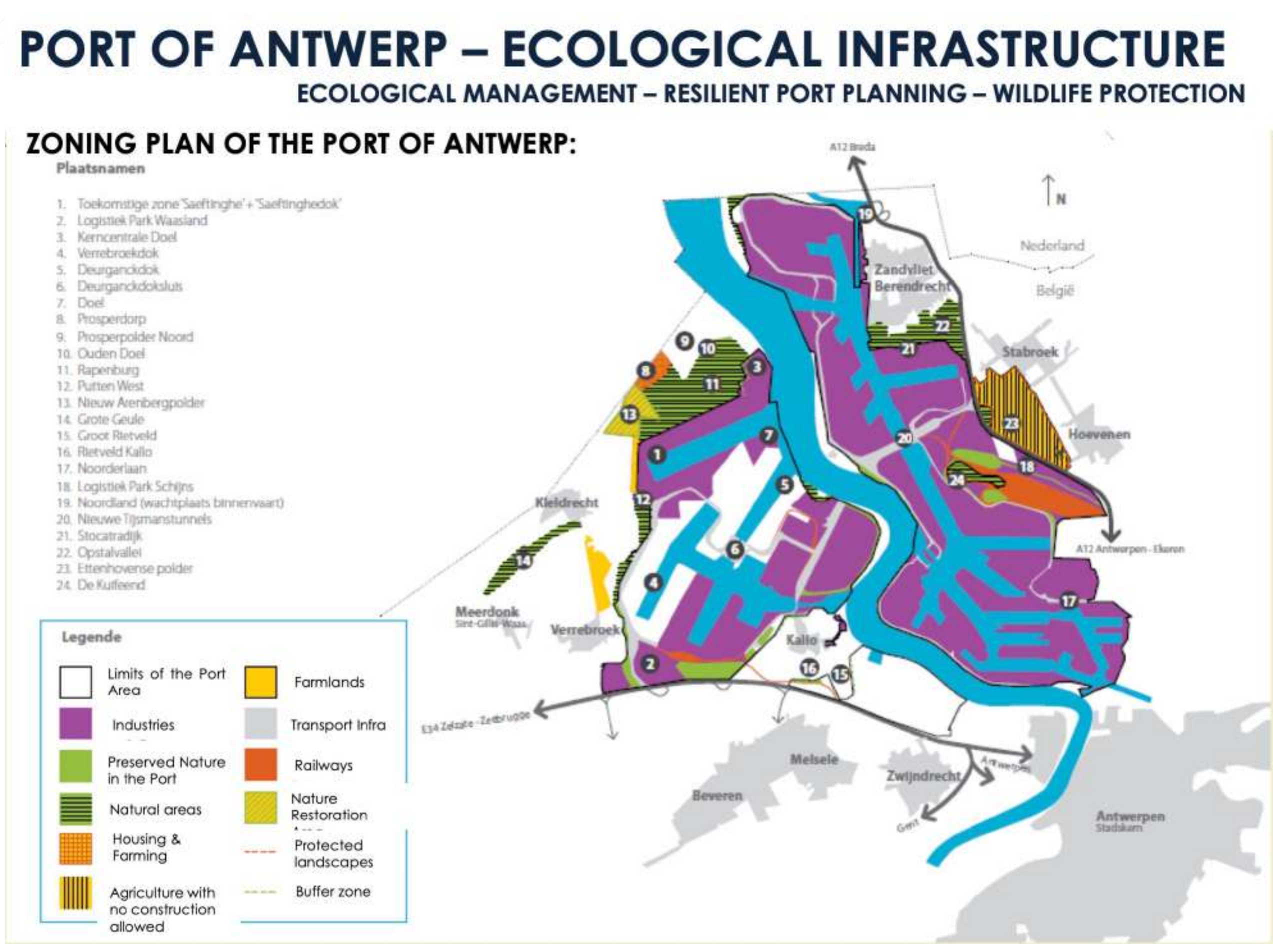
- Eco-Integrated Water Management with adaptive retention infrastructure and managed aquifer recharge
- Ecological Buffers and Natural Barriers against storm surges, particulate pollution, erosion
- Green Infrastructure for Heat, Air and Pollution Mitigation – capturing dust, particulate matter and airborne pollutants
- Soil, Slope and Brownfield Rehabilitation using bioengineering and phytoremediation

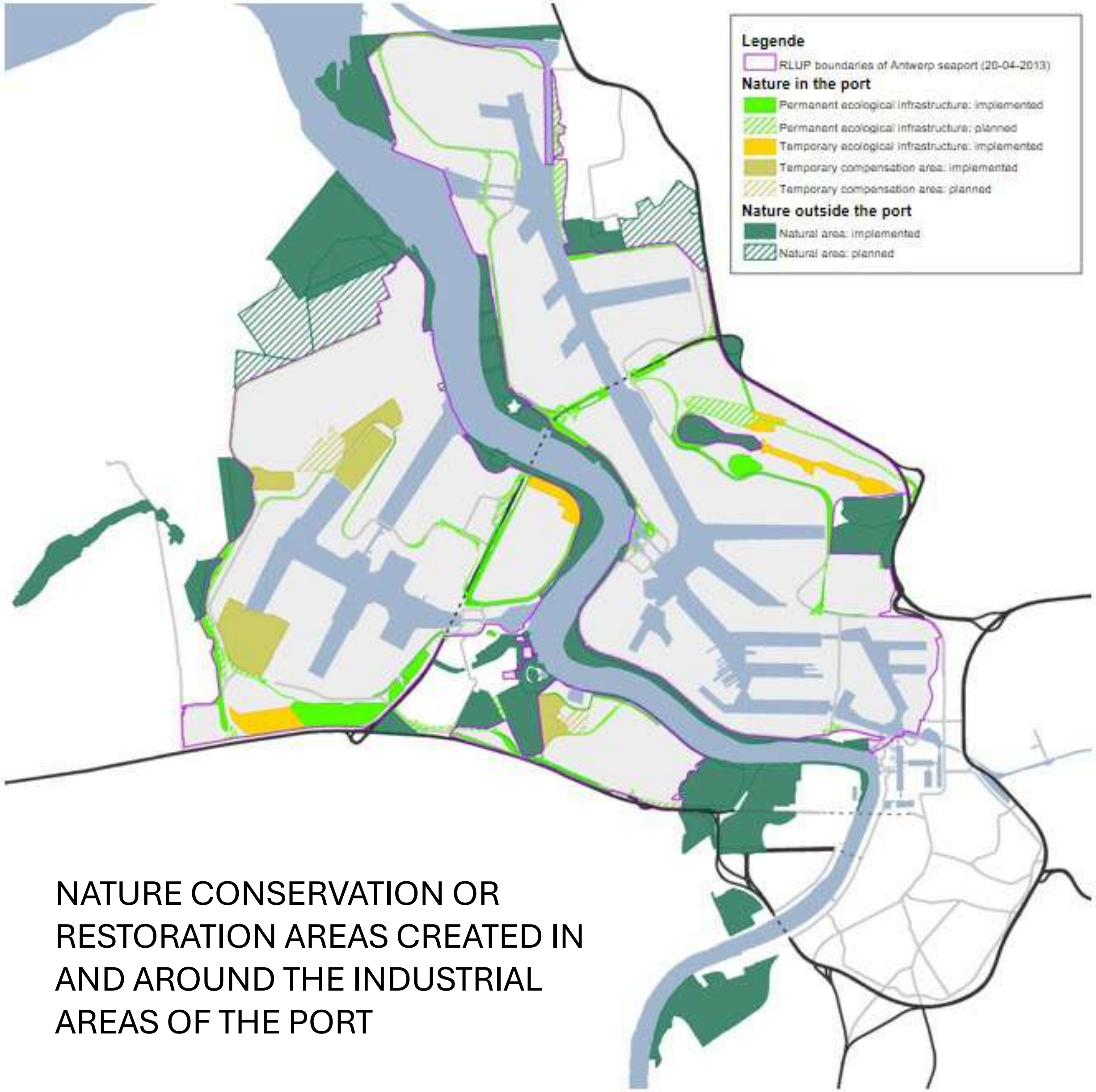

Institutional Enablers for Nature-positive Industrial Zone Governance & Symbiosis
Maximise Synergies between Industrial Operations and Ecosystem Services
Strategic Land Use & Ecological Planning with Compensatory restoration of nature
Mandatory NbS, Green Building Codes, Habitat Restoration obligations and Ecosystem services
Policy, Regulatory and Incentive Frameworks
Smart Governance systems using digital monitoring technologies for Water, Waste, Energy
Dedicated Institutional Units with Technical Expertise
Implement circular water management, wastewater reuse, decentralised energy solutions
Integrated Resource Management Systems
Green bonds, blended finance, climate funds
Green Finance and Market-based Mechanisms
Co-governance among industries, habitat buffers, shared resource systems
Collaborative Multi-Stakeholder Governance

NbS Interventions supporting Ecological Approach of Industrial Symbiosis and Low Impact Productive Landscapes



Planning Port Expansion in synergy with Compensatory Measures and Land Use Management to Enhance Renaturation and Resilience. The case of ANTWERP





The industrial port city of Antwerp has determined nature restoration areas to compensate the amount of industrial activities and polluting emissions. The city is experiencing a quota of green area to restore biodiversity and soil permeability per carbon footprint unit per industrial unit.

NATURE CONSERVATION OR RESTORATION AREAS CREATED IN AND AROUND THE INDUSTRIAL AREAS OF THE PORT

Planning Port Expansion in synergy with Compensatory Measures and Land Use Management to Enhance Renaturation and Resilience. The case of ANTWERP

The development of new industrial areas with impermeable soils, heat island effects and (air, noise, soil) polluting emissions have to be compensated by the reinsertion of ecological habitat and wetlands that will regulate and mitigate the impact of industrialisation.

The Port of Antwerp's Approach aims to have 50% of the area dedicated to restored or extended wetlands and protected water streams.

Bringing back Nature, City and Industry together with multi-scale NbS: The gradual Green Port City Redevelopment of Rotterdam (NL)

Rotterdam's Tidal Parks along the River: Combining Climate preparedness and urban liveability in post-industrial landscapes

Thank you for your attention!

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