IV Foro deTourismo Sostenible

Responding to Global Warming Impacts on Small Islands

ADAPTION + MITIGATION

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MINCOMERCIO
INDUSTRIA Y TURISMO

TODOS POR UN NUEVO PAÍS
PAZ EQUIDAD EDUCACIÓN

2017
AÑO INTERNACIONAL DEL TURISMO SOSTENIBLE PARA EL DESARROLLO

Challenges and Opportunities on **GLOBAL WARMING**

Most urgent issue of our time

- CO2 Reduction + Capture
- Begin Immediate Adaption to short and long term impacts
- Improve resilience of landscapes + coastal zones, marine life and vegetation
- Protect the most vulnerable populations

The next 50 years of **Global Warming**

- 11% of the world's population: **800 million people vulnerable to GW impacts**
- **2016 hottest year on record** above pre-industrial levels.
- **Highest CO2 levels in 3 million years**
  - 2015 reached 400 ppm. NOW 410 ppm
- **1-2 meter sea level rise** PLUS storm surge
- Global warming: **100 million people into poverty**

Global Warming Issues

Caribbean One of the most Vulnerable

- Sea level rise (SLR)
- Extreme weather (hurricanes)
- Loss of coral reefs
- Sea Rise I m-3m 2050 – 2100
- Disease, dengue fever
- Loss of infrastructure (roads, airports, hospitals)
- Loss of biodiversity…endemic plants and animals

Global Warming Impacts on populations

- **Water shortage:** reduced rainfall and increased evapotranspiration affecting vitality + productivity of vegetation
- **Flooding**, particularly in the built environment and floodplains as a result of increased rainfall and frequent storm events
- **Rising sea levels:** significant landscape impacts in coastal areas
  - displacement of communities, social infrastructure, biodiversity and landform configurations
  - Sea surge protection
- **Uninhabitable**: select locations too hot
  - conflict over access to water, energy and food (e.g. Syria)

The next 50 years of Global Warming

- **0.7% of world's forests are coastal mangroves**, yet they store 5 X as much carbon/hectare as tropical forests
  - loss to sea level rise
- By 2030 world needs **$600 trillion in new infrastructure**
  - Make it green and low carbon
- **2 billion new urban dwellers** while reducing carbon footprint
- To **avoid exceeding 2°C limit we need to reduce *GHGs 40% below 1990 level by 2025*.**

ADAPTION Techniques
Rising Sea Levels + Urban Heat Islands

Characteristics of Small islands

- Small land **masses surrounded by ocean**,
- Located in **regions prone to natural disasters**
- Tropical areas have relatively large populations for occupied area
- **High growth rates and densities.**
- **poor infrastructure and limited natural, human and economic resources**,
- **populations dependent on marine resources** to meet their protein needs.
- economies **reliant on a limited resource** base and subject to external forces,

Impacts of Global Warming on Small Island

- Sea level projected to rise rate of **1 m by 2080**
- **high vulnerability** and **low adaptive capacity**, small islands have legitimate concerns about their future
- **emit less than 1% of global greenhouse gases**,
- need to **reallocate scarce resources**
- **Implement strategies to adapt** to the growing threats of global warming
- Sea level projected to rise rate of **1 m by 2080**,
- great challenges and high risk, especially to low-lying islands that might not be able to adapt

Small Island Impacts

- As the natural resilience of coastal areas may be reduced, the ‘costs’ of adaptation increases
- **land loss, soil salinisation** and low water availability would be likely to threaten the sustainability of island agriculture and food security
- *projected human costs include an* ***increase in the incidence of vector- and water-borne*** **diseases** in many tropical and sub-tropical islands
- **settlements/infrastructure are located in coastal areas**, which are highly vulnerable not only to sea-level rise (SLR) but also to high-energy waves and storm surge

Small Island Impacts

- **infrastructure located in coastal areas**, which are highly vulnerable to sea-level rise (SLR) and high-energy waves and storm surge
- Temperature…rainfall changes…loss of coastal amenities affects tourism
- **cultural assets** (e.g., sites of worship and ritual), near the coasts, considered vulnerable
- **Focus efforts on enhancing resilience and implement appropriate adaptation measures as urgent priorities**
- integration of risk reduction strategies into key sectoral activities (e.g., disaster management, integrated coastal management and health care planning) should be pursued as part of the adaptation planning process for climate change

Socio-economic stresses

- External pressures such as
  - terms of trade, impacts of globalisation (both positive and negative), financial crises, international conflicts, rising external debt, and internal local conditions such as rapid population growth,
  - rising incidence of poverty, political instability, unemployment, reduced social cohesion, and a widening gap between poor and rich, together with the interactions between them (ADB, 2004).
- Most settlements located in coastal locations also hosting the main port, international airport and centre of government activities.
- Heavy dependence on coastal resources for subsistence

Pressure on island resources

- limited sources of freshwater.
- limestone islands have no surface water or streams and are fully reliant on rainfall and groundwater harvesting.
- water stress at the current levels of rainfall input, and extraction of groundwater is often outstripping supply.
- **pollution of groundwater** is often a major problem, especially on low-lying islands. Poor water quality affects human health and carries water-borne diseases.
- **Water quality** linked to health issues andpotential effects on the well-being of the inhabitants of small islands

Pressure on tourism resources

- **Coral cover across reefs in the Caribbean has declined by 80% in 30 years, a result of continued pollution, sedimentation, marine diseases, and over-fishing**
- Beach-based tourism (Barbados) and the marine diving based ecotourism (Bonaire) both negatively affected by climate change through beach erosion in and coral bleaching.
- Caribbean **38% of the total current beach could be lost with a 0.5 m rise** in sea level,
  - lower narrower beaches being the most vulnerable, reducing turtle nesting habitat by one-third

Interactions between human and physical stresses

- **External pressures contribute to vulnerability** to climate change
  - **energy costs**, population movements, financial and currency crises,
  - increasing debt. rapid population growth,
  - **increase economic growth through exploitation of natural resources** such as forests, fisheries and beaches,
  - **weak infrastructure,** increasing income inequality, **unemployment**, rapid urbanisation, growing gap between demand for and provision of health care and education services, weakening social capital, and **economic stagnation**

Other relevant conditions

- small islands have long developed and **maintained unique lifestyles, adapted to their natural environment.**
- **Traditional knowledge,** practices and cultures, strongly based on community support networks and, in many islands, a subsistence economy is still predominant
- **Societal changes**….population growth, increased cash economy, migration of people to urban centres and coastal areas, growth of major cities, increasing dependency on imported goods which create waste management problems, and development **of modern industries such as tourism** have changed traditional lifestyles in many small islands.

Agriculture, fisheries and food security

- **Local food production** is vital to small islands, even those with very limited land areas.
- dependence on plant resources ranged from 91% in Comoros, 88% in Jamaica, 85% in Seychelles to 65% in Fiji, 59% in the Bahamas
- Projected impacts of climate change
  - **extended drought and loss of soil fertility and degradation** as a result of decreased precipitation
- **Fisheries** contribute significantly to GDP; consequently the socio-economic implications of the impact of climate change on fisheries are important
- Effects of climate change on tuna fishing…a decline in stock and a migration

Loss of Biodiversity

- Islands have a **unique biodiversity through high endemism** (i.e., with regionally restricted distribution) caused by **ecological isolation**
- Human **well-being on islands is heavily reliant on ecosystem services such as amenity** value and fisheries
- Historically, **isolation implies immunity from threats** such as invasive species causing the extinction of endemics.
- Islands **vulnerable to coastal flooding** and decreased extent of coastal vegetated wetlands
- Detectable influence on **marine and terrestrial pathogens**, such as coral diseases and oyster pathogens, in addition to coral bleaching,
- Caribbean, a **0.5 m sea-level rise causes a decrease in turtle nesting habitat by up to 35%**
- Hurricane-induced mortality of trees after 21 months was 5.2%/yr; seven times higher than mortality levels during non-hurricane periods

Human settlements and well-being

- Caribbean **more than half of the population live within 1.5 km**
- important facilities such as hospitals are frequently located close to the shore
- Changes in sea level, and frequency of storm events have serious consequences for these land uses..
- Traditional housing styles, techniques and materials were resistant to damage and/or could be repaired quickly. Moves away from traditional housing have increased vulnerability to thermal stress, slowed housing reconstruction after storms and flooding
- impact human health and well-being, mostly in adverse ways.
- island suffer severe he**alth burdens from climate-sensitive diseases**, including morbidity and mortality from extreme weather events, certain vector-borne diseases, and food- and water-borne diseases

Economic, financial and socio-cultural impacts

- **Small economies more exposed** to external shocks, such as extreme events and climate change,
- **Many rely on one or a few economic activities** such as tourism or fisheries.
- Caribbean, hurricanes cause loss of life, property damage and destruction, and economic losses of billions of dollars
- **Grenada Hurricane Ivan in 2004**.
  - Damage assessments indicate that, in real terms, the country's socio-economic development has been set back at least a decade by this single event that lasted for only a few hours

The Bahamas:Survey Grade GPS Elevation Data

Harbour Island: The Bahamas

Legend

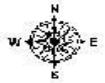
Major Resorts

Type

- Commerical
- Residential

Survey Grade GPS Elevation (m)

- 0.5m SLR
- 1m SLR
- 2m SLR
- 3m SLR
- 3.5m SLR



Infrastructure and transportation

- **INFRASTRUCTURE** tends to occupy coastal locations.
- **closure of roads, airports and bridges** due to flooding and landslides, and damage to port facilities.
- TRANSPORTATION sector alone, **affects other sectors** and services including tourism, agriculture, the delivery of health care, clean water, food security and market supplies.
- Need to introduce and **EXPAND RENEWABLE ENERGY** technologies in small islands

Grenada and Hurricane Ivan

- **Grenada 2004, as a category 4**
  - 28 people killed,
  - Damages **2 times current GDP**,
  - 90% of housing stock damaged,
  - 90% of guest rooms in the tourism sector damaged or destroyed, **29% GDP,**
  - losses in telecommunications **13% GDP,**
  - damage to schools and education infrastructure **20% GDP**,
  - losses in agricultural **10% GDP** will not contribute to GDP or earn foreign exchange for 10 years,
  - damage to electricity installations **9% GDP**,
  - damage to eco-tourism and cultural heritage sites**, 60% job losses**
  - prior to Hurricane Grenada was on course to experience an economic growth rate of approximately 5.7% per annum but negative growth of around -1.4% per annum is now forecast.

Impacts Reduce attraction of Islands

- **Tourism importance is increasing** since their economies depend on tourism,
- Impacts of climate change on tourism resources in small islands has significant effects, both direct and indirect (Bigano et al., 2005; Viner, 2006).
- Sea-level rise and **increased sea water temperatures and accelerate beach erosion,** cause degradation of natural coastal defences such as mangroves and coral reefs, and result in the loss of cultural heritage on coasts affected by inundation and flooding.
- **Sustainability of 300 island tourism resorts in Caribbean** to be compromised by rising sea level, beach erosion and saline contamination of coastal wells, a major source of water supply for island resorts (Tan and Teh, 2001).
- **Shortage of water** and **increased risk of vector-borne diseases** send tourists away from small islands,
- **Warmer climates in the higher-latitude** countries result in a reduction of people who want to visit small islands in the tropical and sub-tropical regions.

Adaptation: practices, options and constraints

- **Overall vulnerability of small island are a function of 4 interrelated factors:**
  - the **degree of exposure** to climate change;
  - their **limited capacity to adapt** to projected impacts;
  - **adaptation to climate change is not a high priority**, given the more pressing problems that small islands have to face;
  - the **uncertainty associated with global climate change projections**
- **environmental conditions and the socio-economic well-being of populations on small islands *will worsen unless adaptation measures are put* in place to reduce impacts**

Adaptive measures in the Maldives

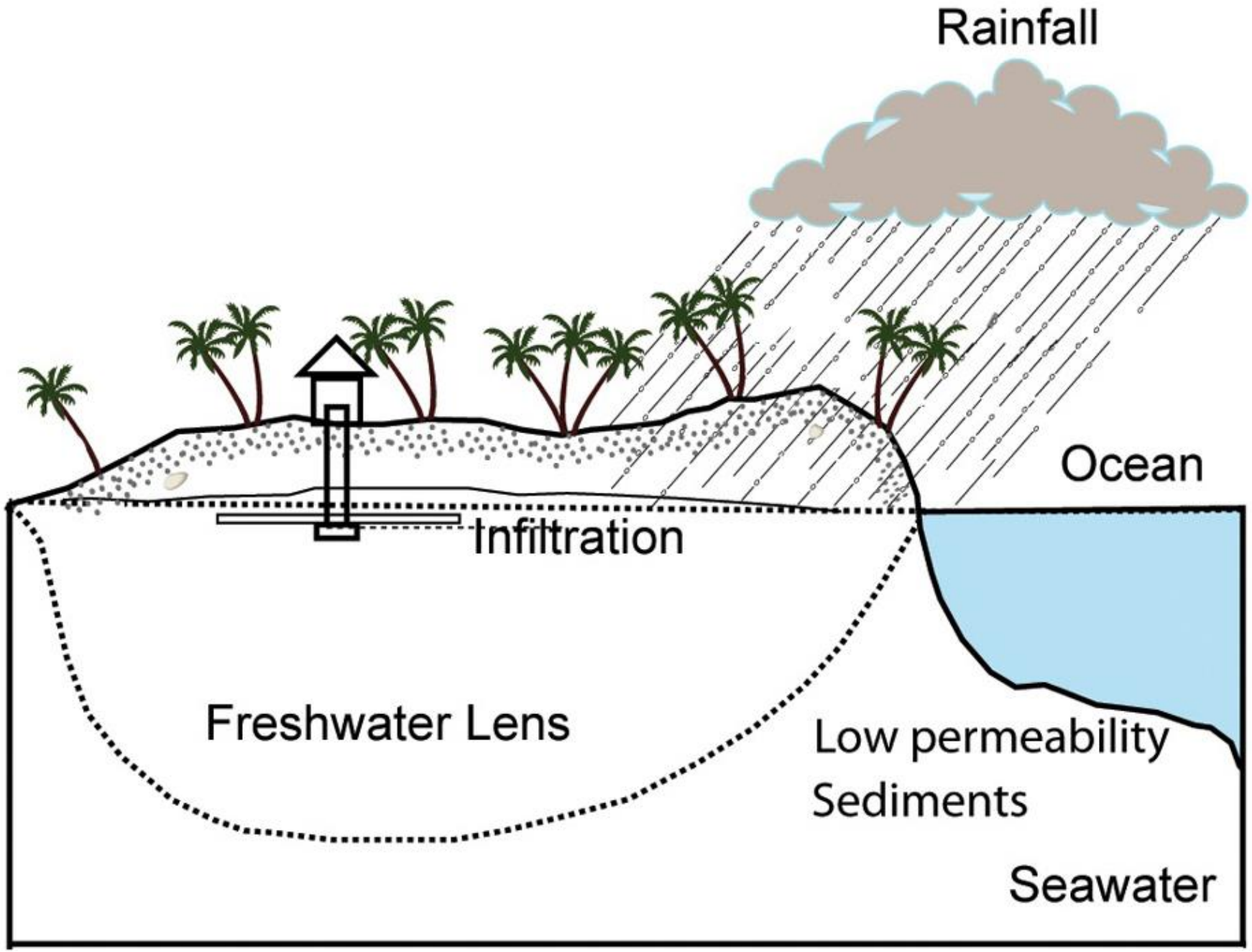
Infrastructure and settlement damage	Protection of international airport Upgrading existing airports Increase elevation in the future
Damage to coral reefs	Reduction of human impacts on coral reefs Assigning protection status for more reefs
Damage to tourism industry	Coastal protection of resort islands Reduce dependency on diving as a primary resort focus Economy diversification
Agriculture and food security	Explore alternate methods of growing fruits, vegetables and other foods Crop production using hydroponic systems
Water resources	Protection of groundwater Increasing rainwater harvesting and storage capacity Use of solar distillation Management of storm water Allocation of groundwater recharge areas in the islands
Lack of capacity to adapt (both financial and technical)	Human resource development Institutional strengthening Research and systematic observation Public awareness and education

Proposed **Columbia Climate Change** Action….**CCC**

- 1. **Emphasise the urgency for adaptation** action and the need for **financial resources** to support such action.
- 2. **Protect freshwater** both in terms of water quality and quantity.Water is a multi-sectoral resource that impinges on all facets of life and livelihood, including security. It is a problem at present and one that will increase in the future.
- 3. **Integrated planning and management**, be that related to water resources, the coastal zone, human health, or tourism.
- 4. **Tourism policies adaptation and measures that are proactive rather than reactive,**
- **5. Support a mix of adaption, mitigation, and wider environmental management measures;**
- climate change adaptation policies and measures can **generate valuable co-benefits** such as enhanced energy security and environmental protection.

Adaptation of ‘natural’ ecosystems in island environments

- focused on:
  - (1) **protecting ecosystems that are projected to suffer** as a consequence of climate change and sea-level rise
  - (2) **rehabilitating ecosystems degraded** or destroyed as a result of socio-economic developments.
- **some corals may be able to adapt to higher sea surface** and air temperatures by hosting more temperature-tolerant symbiotic algae
- **Mangrove forests can migrate inland**, as they did during the Holocene sea-level
- **restoration and rehabilitation of damaged mangrove and reef ecosystems** can be seen as ‘planned’ adaptation mechanisms aimed to increase natural protection against sea-level rise and storms, and to provide resources for coastal communities


Rainfall
Ocean
Infiltration
Freshwater Lens
Low permeability
Sediments
Seawater

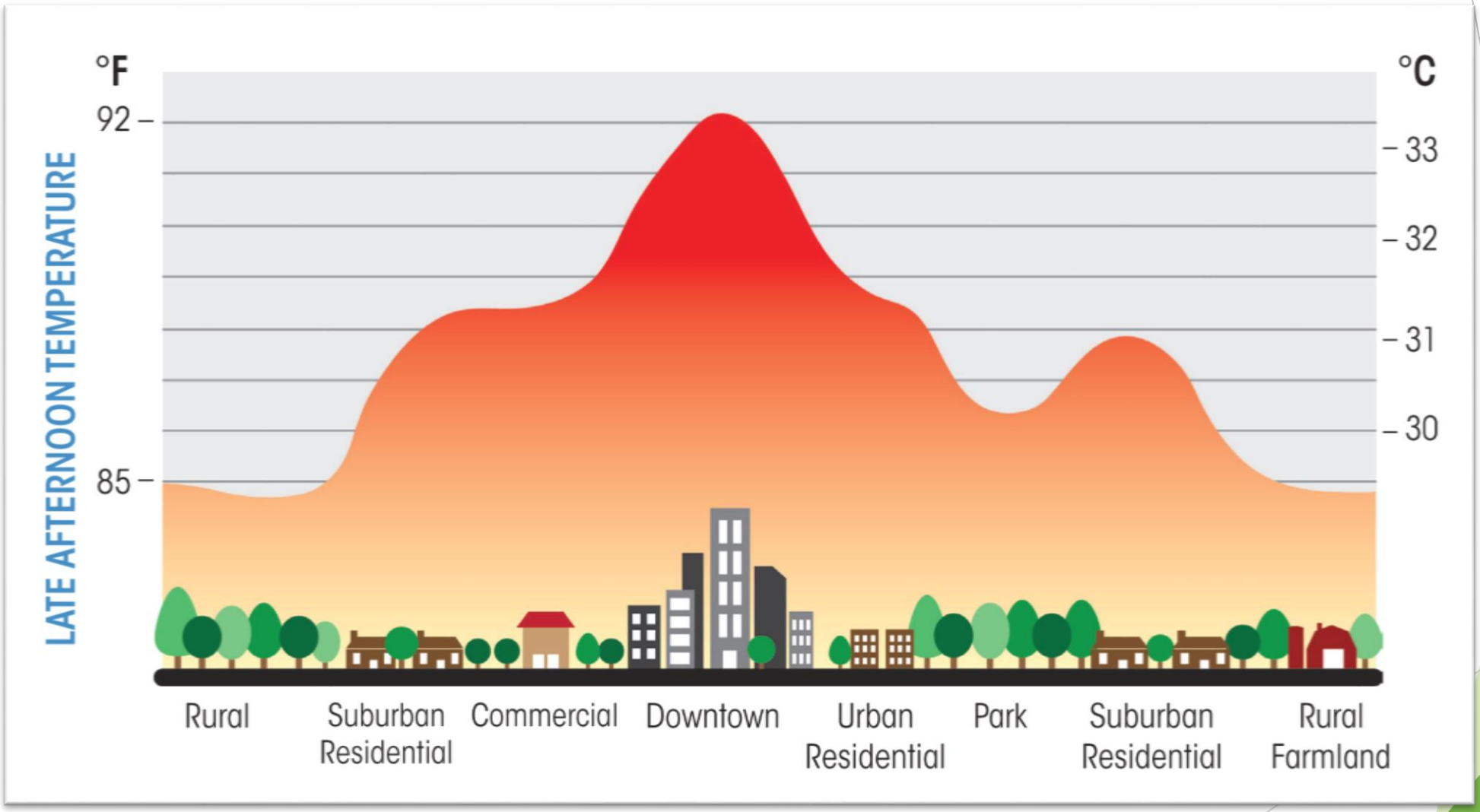
Enhancing Adaptive Capacity

- Adaptive capacity and resilience strengthened through the **application of traditional knowledge** and past experience of environmental changes.
- Traditional island assets,
  - subsistence and traditional technologies, skills and knowledge, and community structures,
  - coastal areas containing spiritual, cultural and heritage sites, great risk from climate change, and particularly sea-level rise.
- **Train locals in marine and island resource management**

Implications for sustainable development

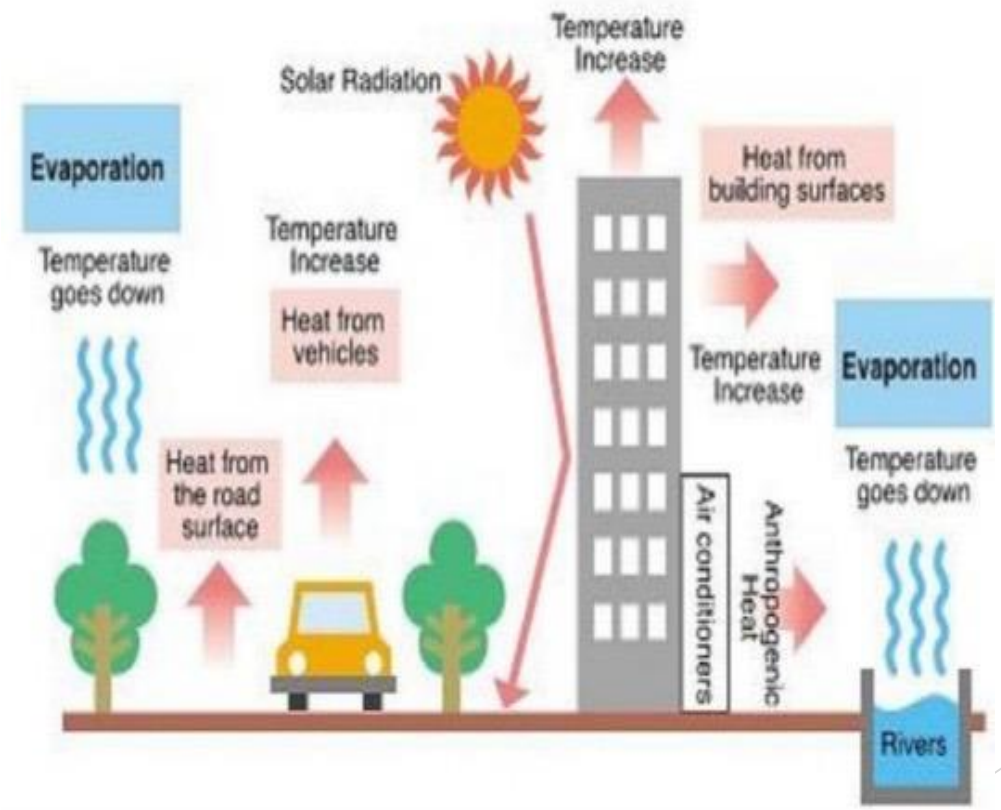
- **Economic, social and environmental linkages between climate change and sustainable development**, and their implications for poverty alleviationrelevant to small islands.
- Climate change poses such a serious threat to poor, vulnerable developing countries that if left unchecked, it will become a **"…major obstacle to continued poverty reduction" (**
- small islands view **climate change as one of the most important challenges to their achievement of sustainable development.**
- In the Maldives, sea-level rise would so seriously damage the fishing and tourism industries that GDP would be reduced by more than 40%.

URBAN HEAT ISLANDS

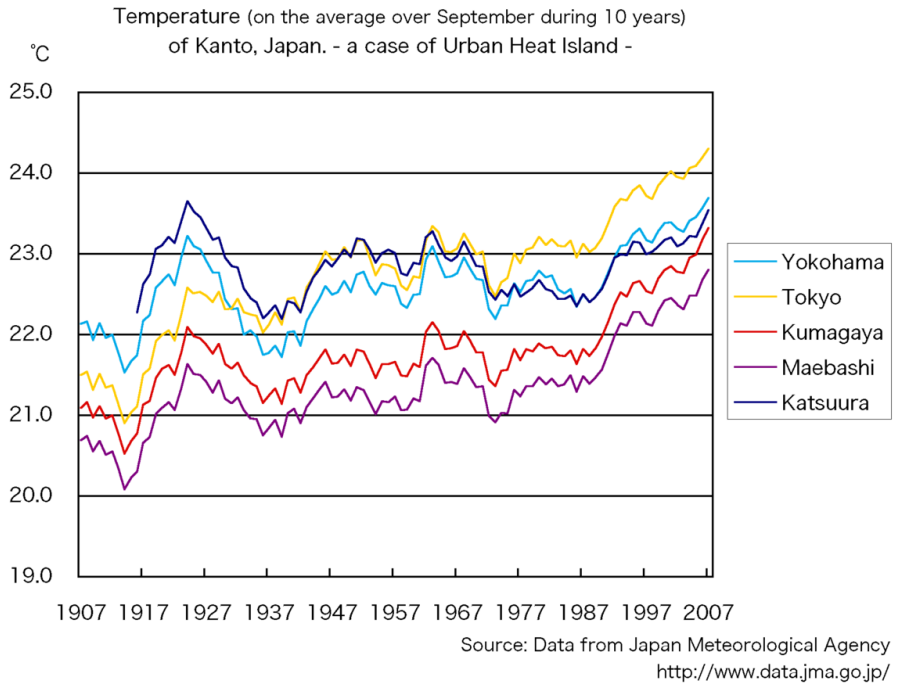


Urban Heat Islands

- Hottest day in 2017 becomes the norm by 2050
- Paris temperatures same as Fez by 2030
- **Bogata same as Dubai by 2050**
- Reduce Urban heat islands
  - Shade and evapotranspiration
  - Green roofs/walls
  - Permeable pavement



Urban Heat Islands



- Hot, sunny summer day, roof and pavement surface temperatures can be 50–90°F (27–50°C) hotter than the air
- Shaded or moist surfaces (especially in rural surroundings) remain close to air temperatures
- Air temperatures in cities, particularly after sunset, can be as much as 22°F (12°C) warmer than the air in neighboring, less developed regions

Negative Impacts

Increased Energy Consumption

- Elevated urban temperatures increase energy demand for cooling.
  - **1.5–2.0% for every 1°F (0.6°C) increase in air temperatures**, starting from 68 to 77°F (20 to 25°C), suggesting that 5–10% of community-wide demand for electricity is used to compensate for the heat island effect.
- **Increase electricity demand**, as well as peak demand,
  - on hot summer weekday afternoons, when offices and homes are running cooling systems, lights, and appliances.
  - During extreme heat events, exacerbated by urban heat islands, the demand for cooling can overload systems.

Negative Impacts

Elevated Emissions of Air Pollutants and Greenhouse Gases

- The primary pollutants from power plants include:
  - **Sulfur Dioxide (SO_2)** is one of a group of gases called sulfur oxides (SO_x).
  - **Nitrogen Dioxide (NO_2)** is one of a group of gases called nitrogen oxides (NO_x).
  - harmful to human health and the environment, NO_2 is of greater concern
  - **Particulate matter (PM),** mixture of small particles and liquid droplets that get into the air. Once inhaled, these particles can affect the heart and lungs and cause serious health effects.
  - **CO is a colorless**, odorless gas that can be harmful when inhaled in large amounts.
  - **Mercury**

Negative Health Impacts

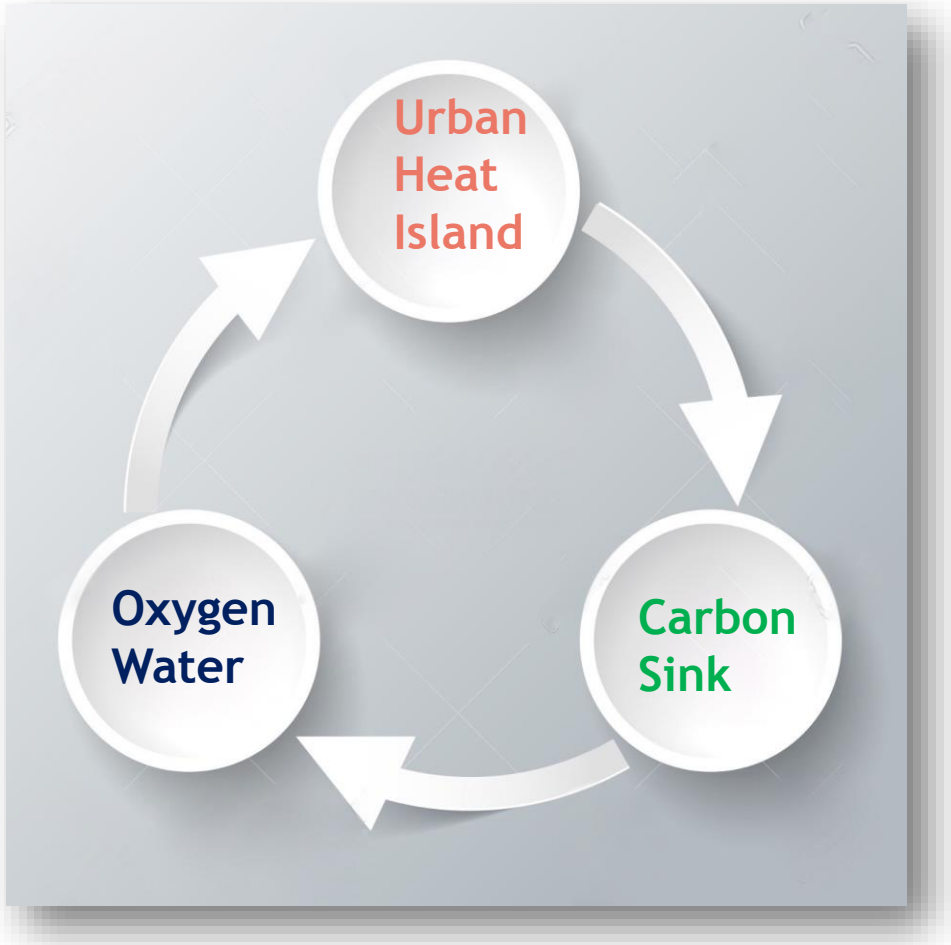
- **Compromised Human Health and Comfort**
- contributes to general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality
- **Sensitive populations**, such as *children, older adults, and those with existing health conditions,* are at particular risk from these events.
- from 1979–2003, **excessive heat exposure contributed to more than 8,000** premature deaths in US. Exceeds the number of mortalities resulting from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

Negative Impacts

Impaired Water Quality

- High pavement and rooftop surface temperatures heat stormwater runoff. Pavements that are 100ºF (38˚C) can elevate initial rainwater temperature from roughly 70ºF (21ºC) to over 95ºF (35ºC).[4]
- Heated stormwater generally becomes runoff, which drains into storm sewers and raises water temperatures in streams, rivers, ponds, and lakes.
- Water temperature affects aquatic life, metabolism and reproduction of many aquatic species.
- Rapid temperature changes in aquatic ecosystems from warm stormwater runoff can be particularly stressful, even fatal to aquatic life.

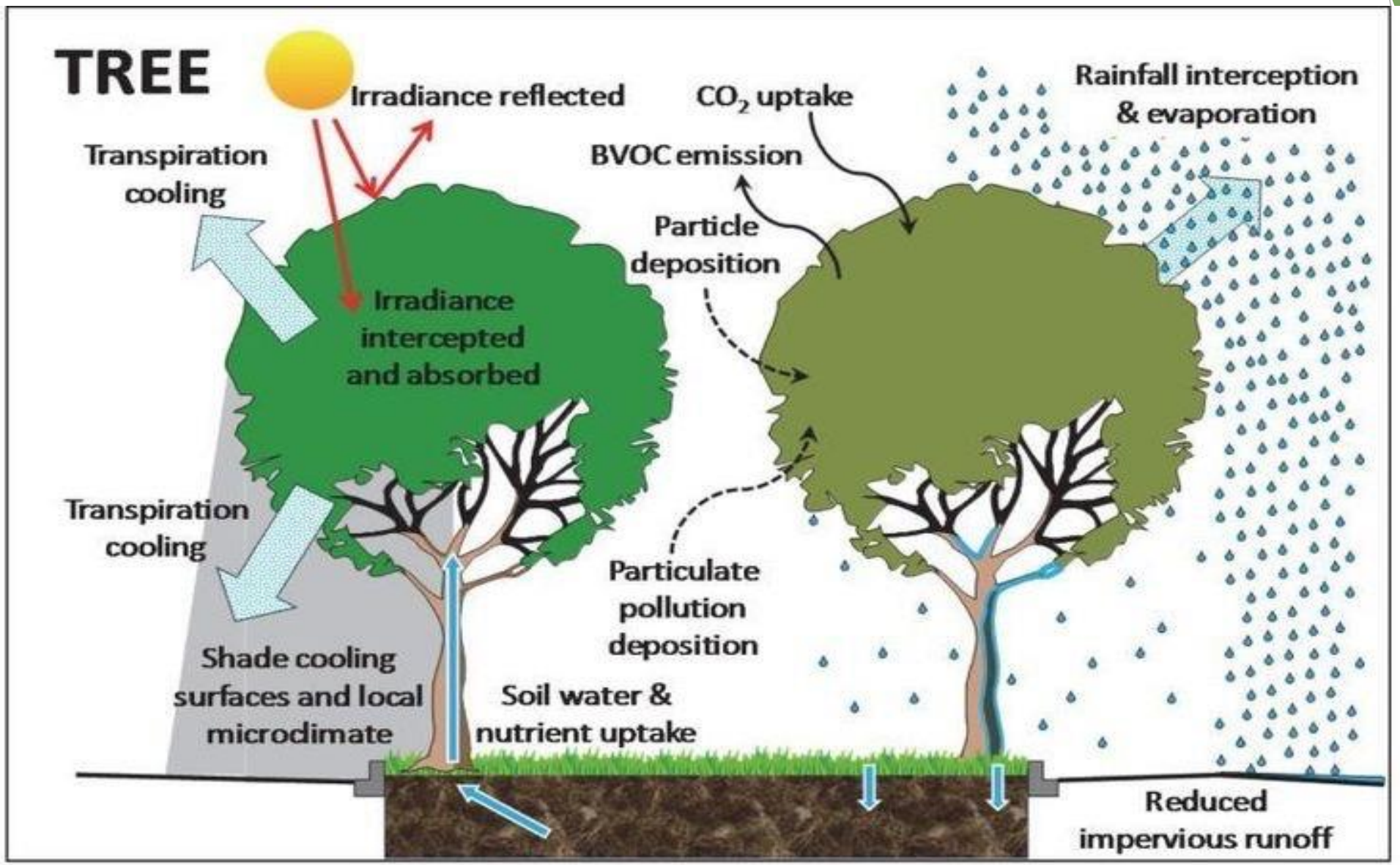
ADAPTION: Temperature reduction + sequestration and CO2 (offsetting)



- **Urban Heat Island**
  - Shade vegetation, water features
  - UV and pollution reduction
  - Network of green infrastructure
- **Carbon Sink**
  - Biomass storage (trees and grass)
  - Grey water recycling
  - Topsoil and composting
- **Oxygen and evapotranspiration producing**
  - CO2 offsetting
  - Reduced water temperature

Reduce Urban Heat Islands

- **Vegetation lowers surface + air temperatures** (shade and evapotranspiration). Shaded surfaces may be 10–20°C cooler than peak temperatures of unshaded ares.[1]
- **Evapotranspiration PLUS shading** reduces peak summer are temperatures by 1–5°C.
  - **Evapotranspiration cools air by using heat from the air to evaporate water.**
- Vegetation useful as a mitigation strategy;
  - Strategically planted around buildings (shade windows, walls, roof), playgrounds, pedestrian streets, parking lots, schoolyards



BVOC = Biological volatile organic compounds

Urban Heat Islands

- **SHADE:** reduces sunlight hitting pavement by 70% - 90%
  - Surface temperature reductions ranging from 11-25C for walls + roofs
  - Vines on wall temperatures and found reductions of up to 20°C.
  - Shade reduces the temperatures inside parked cars by 25°C
- **NATURAL VENTILATION**
  - Vegetation and landforms direct cooler airflow

Carbon Storage and Sequestration

- **Trees remove carbon from the atmosphere** and store (sequester) it. As trees die or deposit litter and debris on the ground carbon is sequestered to the soil.
- **Carbon cycle:** trees capture carbon and store in soil,
- 1 acre of topsoil stores 10X the vegetation
- Carbon sequestered by urban trees in US: 24 million tons/year,
- Urban forest carbon storage density is just over 25 tons per hectare (9,300 m2)

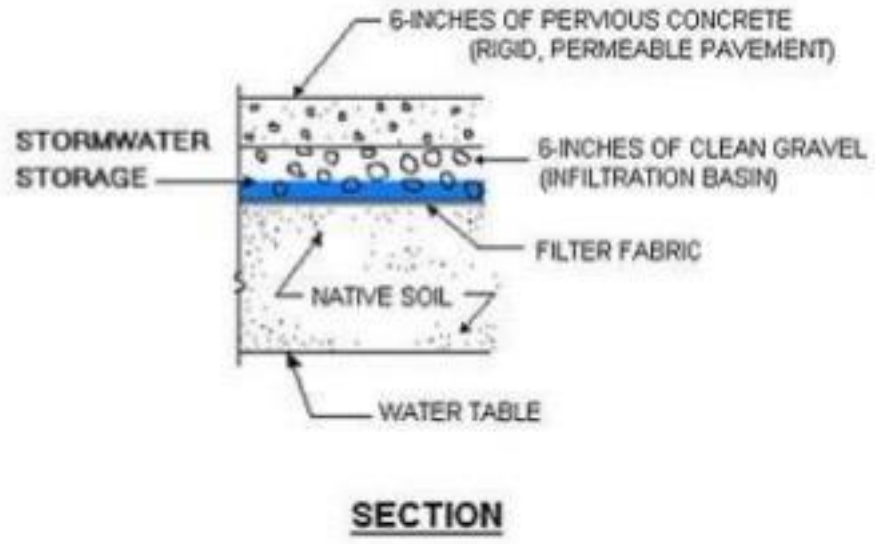
VEGETATION + GHG Reduction

- **Trees/vegetation** decrease energy demand which decreases fossil fuel burning and lower carbon emissions
  - Cooling (summer) and heating (winter)
- Direct **energy savings** from shading could reduce carbon emissions in U.S. cities by 2% to 5%.
- 15,000 trees reduce CO2 emissions by 1500 tons

VEGETATION:
Air quality + GHG Reduction

- **LEAVES remove pollutants** from the air ("dry deposition")
  - In US 800,000 tons/year ($4 billion)
- **PARKED VEHICLES**: Lowers vehicle *evaporative emissions* of volatile organic compounds (VOCs), a pollutant in the formation of ground-level ozone
- Reduce exposure to UV Radiation
- Reduce GHG emissions by reducing energy demand.

COOL PAVEMENT



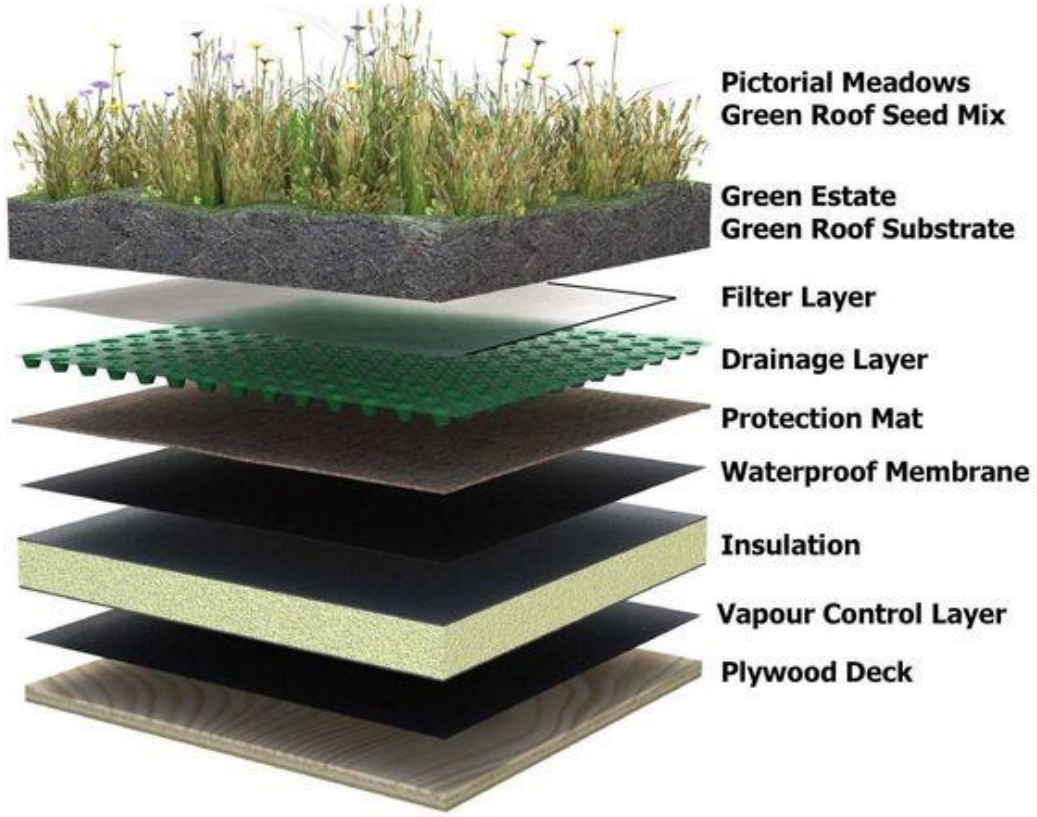
SECTION

- Paving materials that **reflect solar energy, enhance water evaporation** …cooler than conventional pavements.
- Conventional paving summertime temperatures of 120-150°F (45-67°C), transferring heat to **air and stormwater.**
- Cool pavements **uses existing permeable paving technologies** (asphalt, concrete) PLUS use of coatings or grass paving.
- **Reduce stormwater runoff and improved water quality:** water soak into pavement +soil, reducing runoff and filters pollutants.
- **Lowers the temperature of runoff**: less thermal shock to aquatic life

Cool pavement

GREEN ROOFS AND WALLS

- Vegetation on a green roof shades surfaces and removes heat from the air through **evapotranspiration.**
- Rooftop surfaces can exceed ambient air temperatures by up to 50°C.
  - Surface of a vegetated rooftop can be cooler than the ambient air
- **Reduction in building energy consumption: 10% - 16%**



Green Roofs and Walls

- Near-surface air temperature above a green roof is about 4°C cooler than that over the conventional roof
- Surface temperature reductions ranging from 11°C – 25°C
- Soil protects underlying layers from exposure to wind and ultraviolet radiation.
- **Habitat for birds**, insects and bees, Purifies the air
- Toronto: Adding green roofs to 50% of available surfaces downtown would cool the entire city by 0.1 to 0.8°C.
  - Irrigating these roofs could further reduce temperatures by about 2°C.

Green Walls

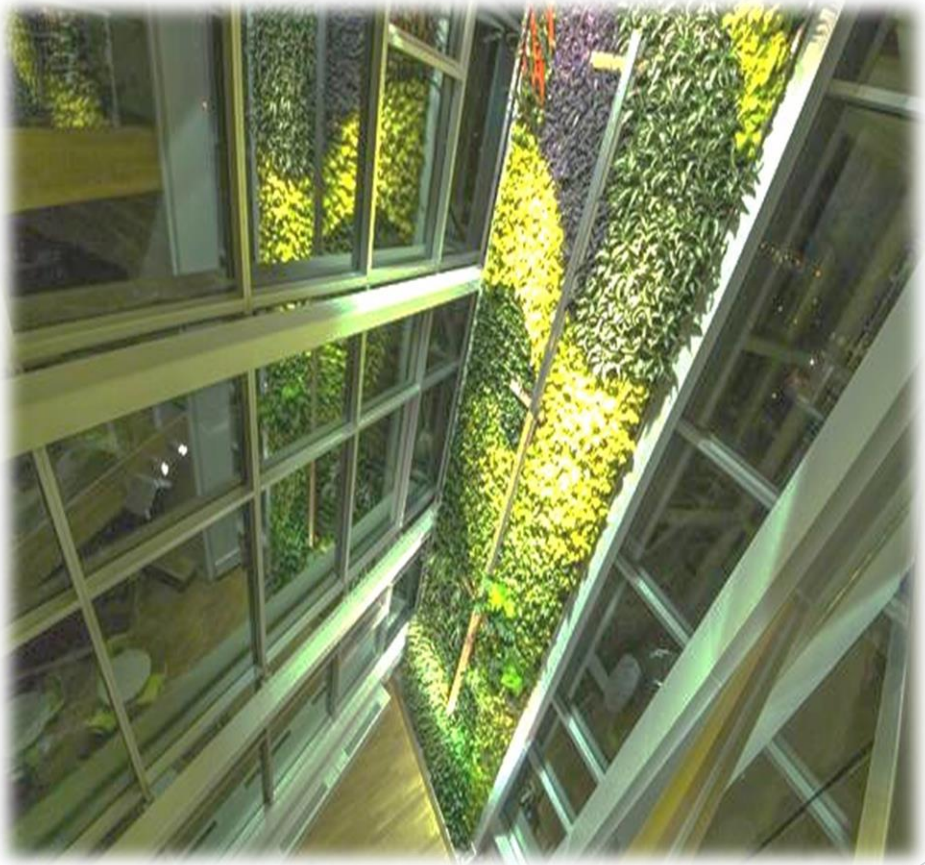
Singapore: **64,000 square meters (over 688,000 square feet)** of vertical gardens.

Increase surface in the US: 25%/year, Toronto City Bylaw.

Dejardins Building in Montreal: 110,000 plants, 42 plant species,

65 m high, hydroponic system

Living piece of art



“Living walls, eco walls, bio-walls”

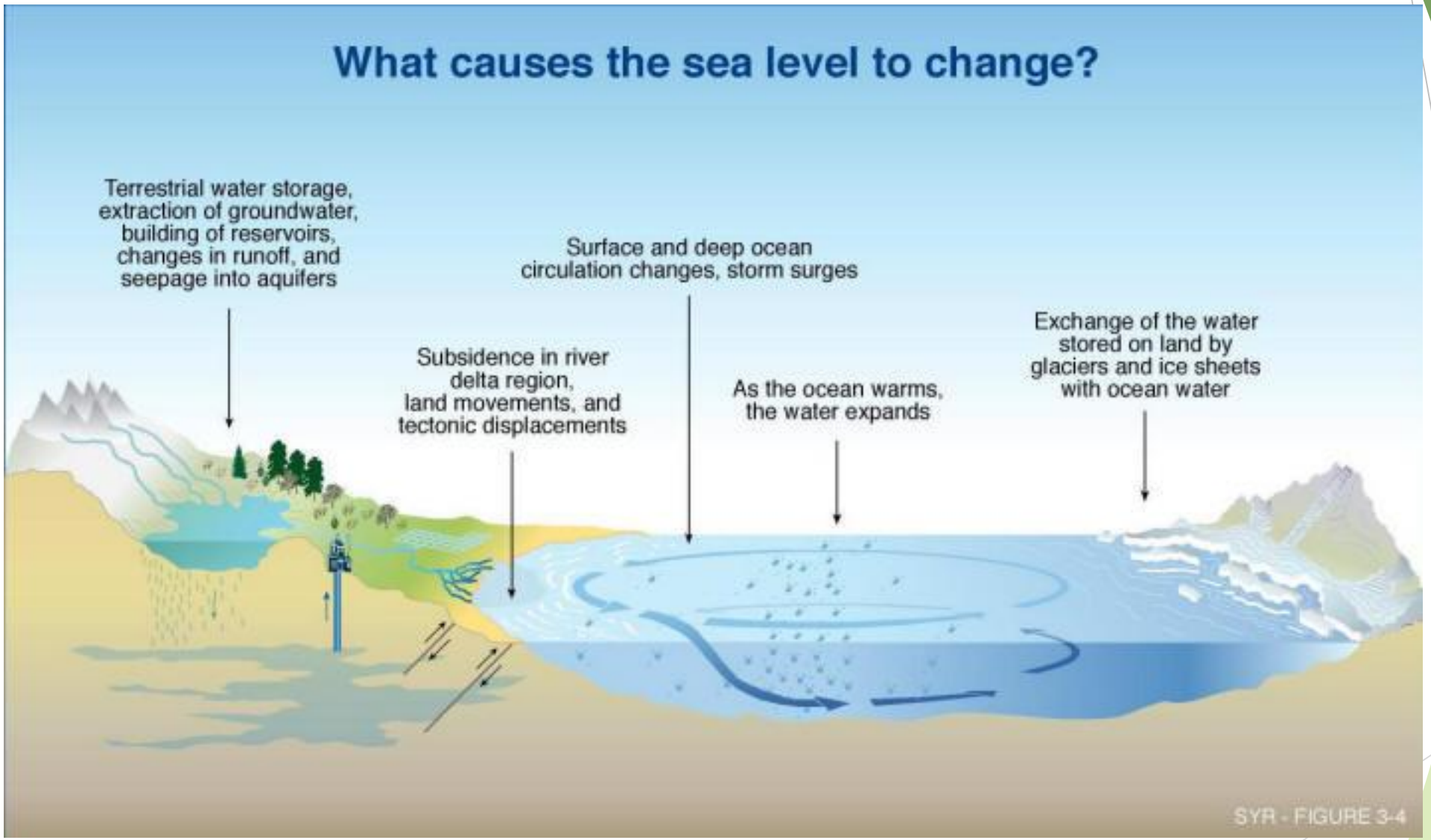
Vines on wall temperatures reductions of up to 20°C

Urban Design and Urban Geometry

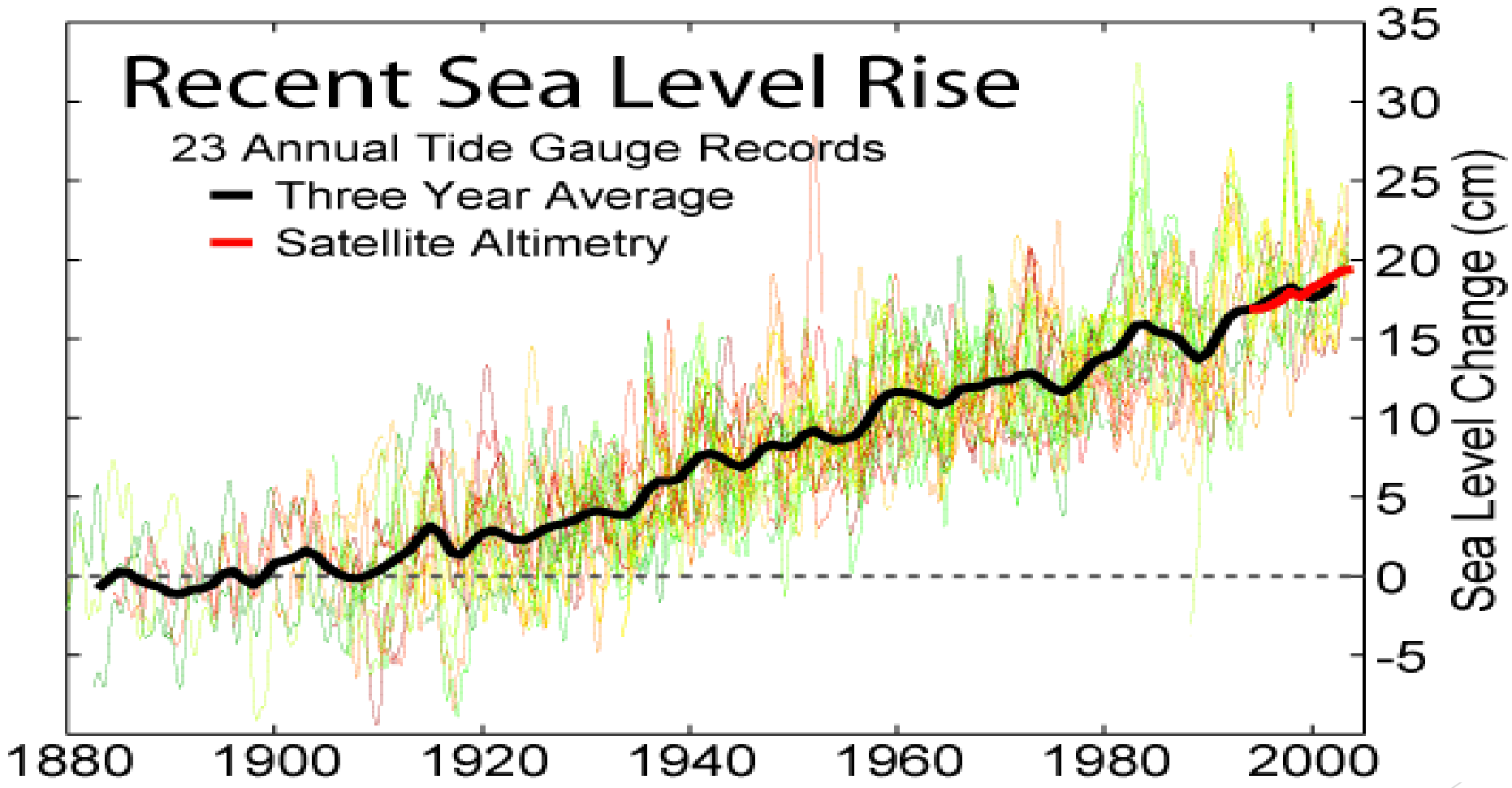
- **Street width-height ratio**
  - Influence/control airflow and increase natural ventilation (passive cooling)
  - dispersion of suspended particles and polluting gases
- **Urban Geometry**
  - Expand use of canopies
  - Reduce amount of solar energy reaching buildings + surfaces lowers temperatures indoors and out

RISING SEA LEVELS + STORM SURGE

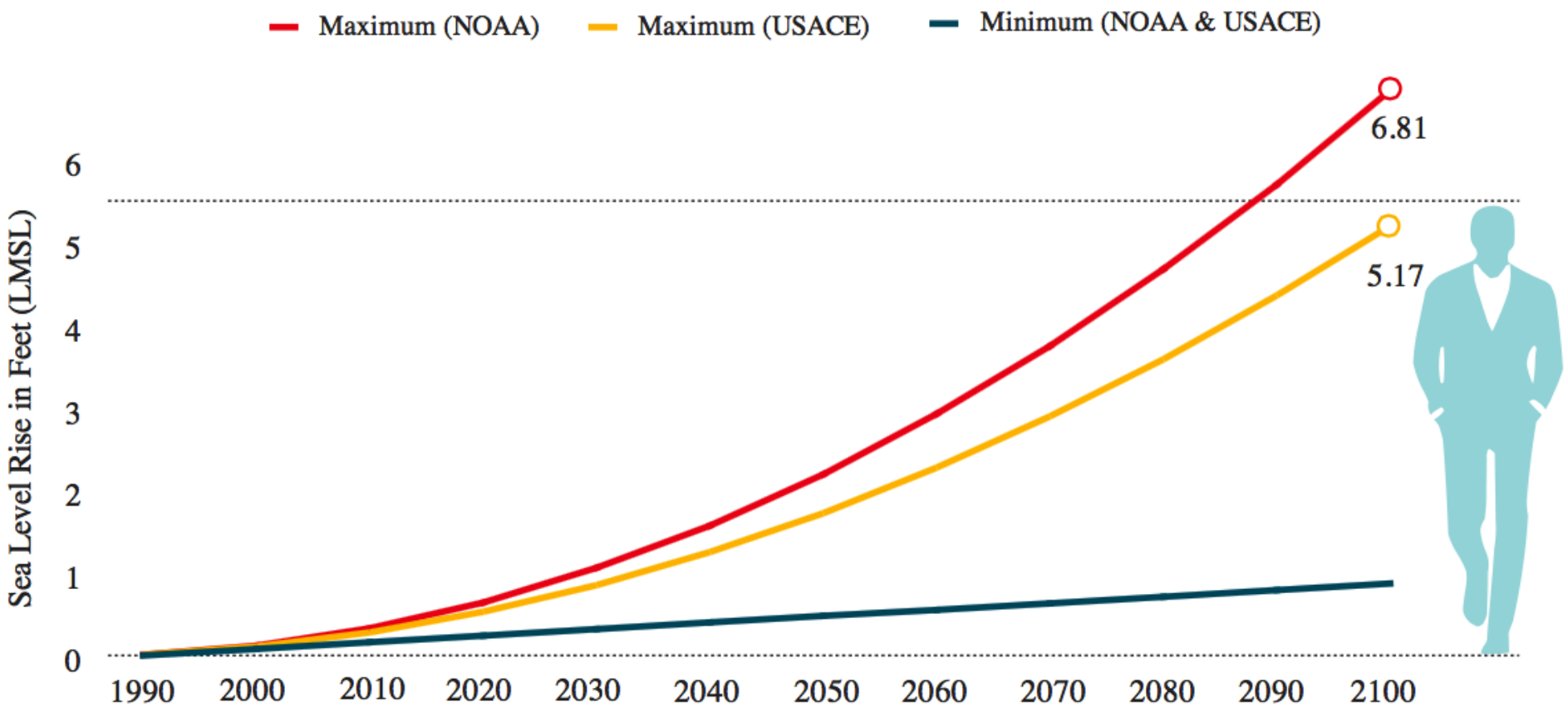
Coastal Adaption


What causes the sea level to change?
Terrestrial water storage, extraction of groundwater, building of reservoirs, changes in runoff, and seepage into aquifers
Subsidence in river delta region, land movements, and tectonic displacements
Surface and deep ocean circulation changes, storm surges
As the ocean warms, the water expands
Exchange of the water stored on land by glaciers and ice sheets with ocean water
SYR - FIGURE 3-4

RISING SEA LEVELS



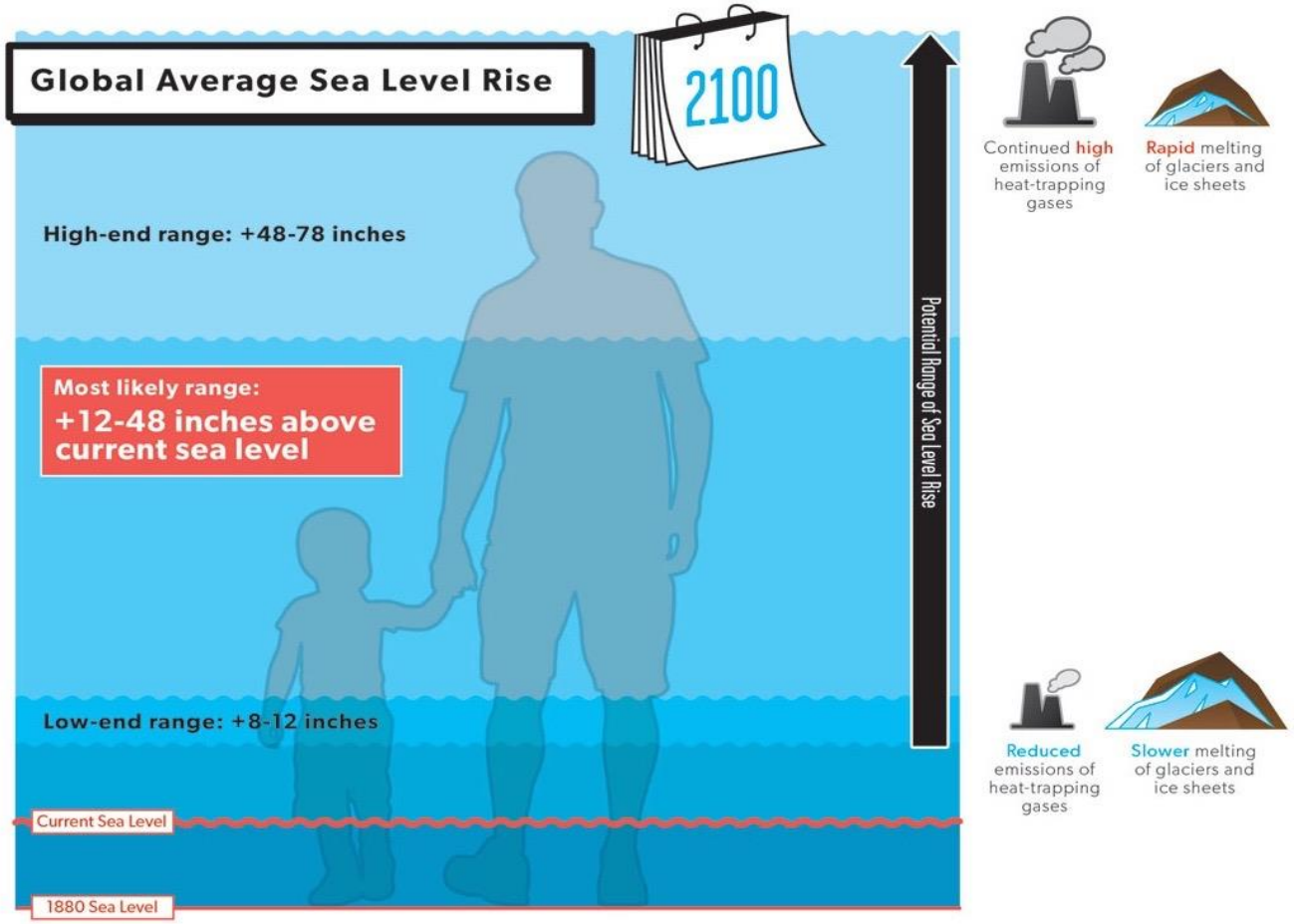
Projections to 2100



NOAA: National Oceanic and Atmospheric Administration. USACE: United States Army Corps of Engineers.

Island and Coastal Cities Impacts

The choices we make today will determine how high sea level rises this century, how fast it occurs, and how much time we have to protect our communities.



Continued **high** emissions of heat-trapping gases

Rapid melting of glaciers and ice sheets

Reduced emissions of heat-trapping gases

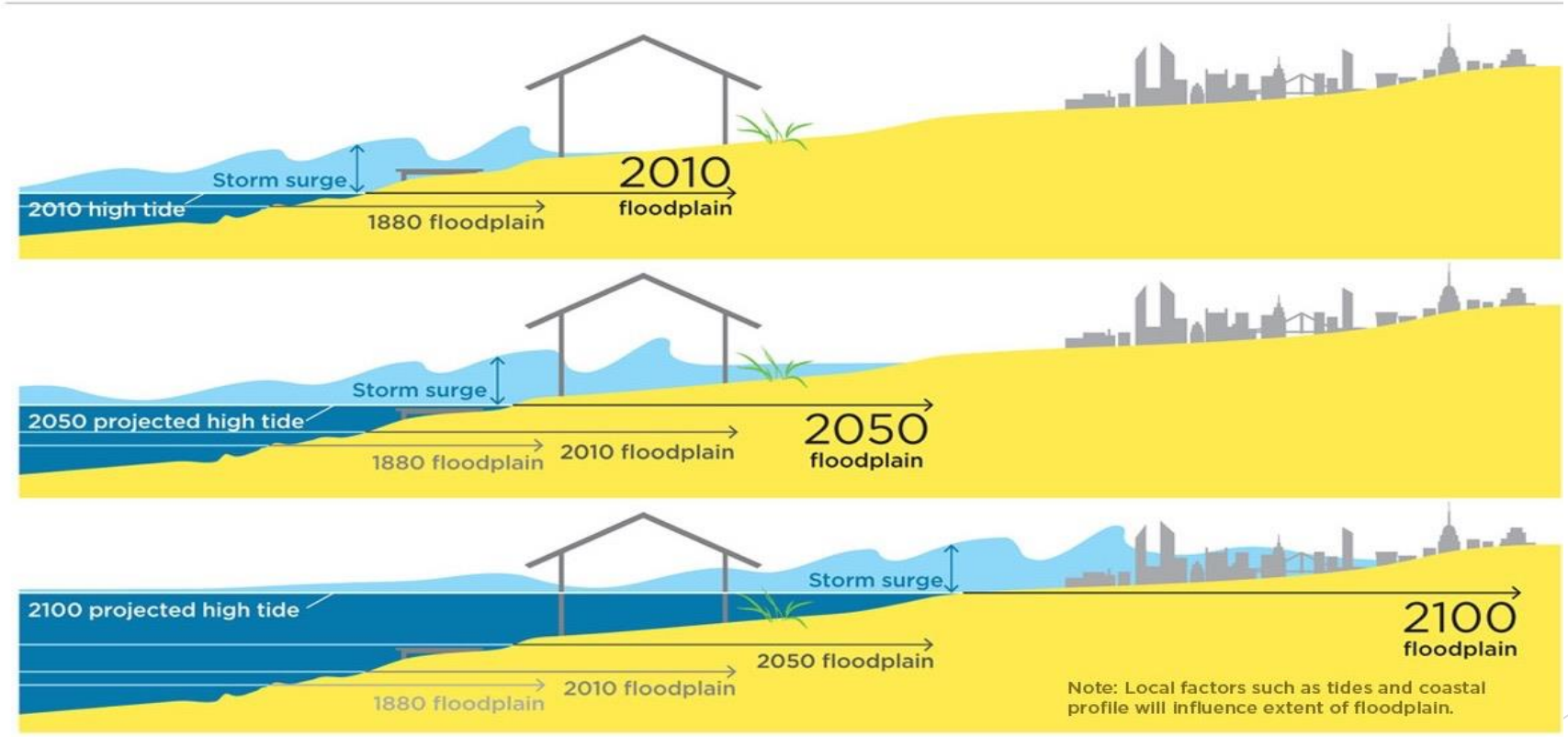
Slower melting of glaciers and ice sheets

Sea Rise in Caribbean

- Increased concerned about climate change in Caribbean generally and some islads (Bahamas, Barbados, Cuba¡ in particular.
- Combining hazard maps for five climate-related risks **(huriccane, floods, landslides, droughts, and sea level rise)**
  - Based on population density and adaptive capacity data:
- **Adaptive capacity** to climate change is very low;
- 50% of population extremely vulnerable to climate change;

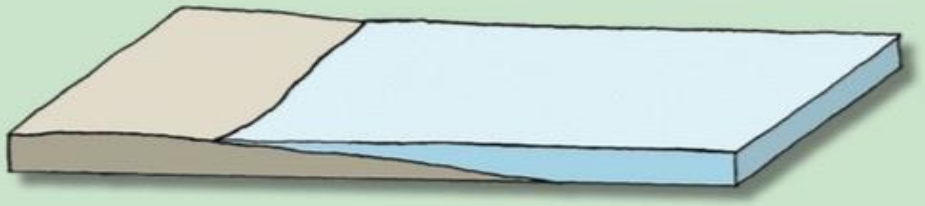
SEA LEVEL RISE ADAPTION

RISING SEA LEVELS

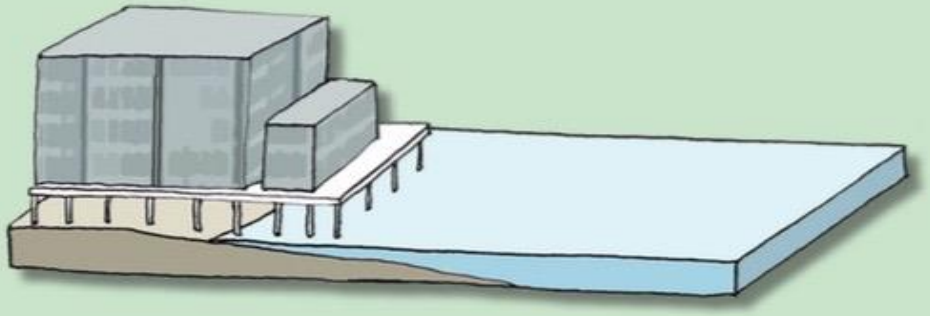


Infrastructure Options

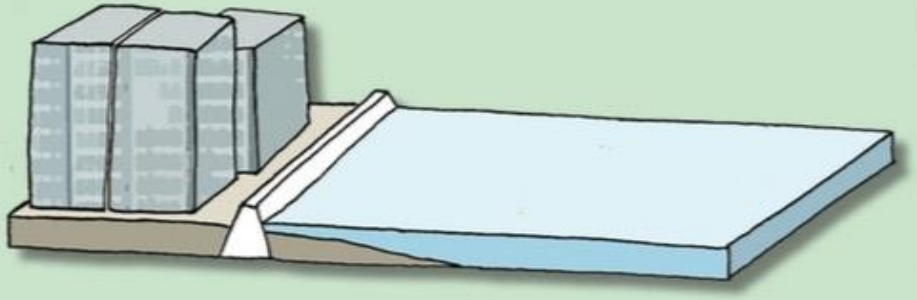
Infrastructure Options



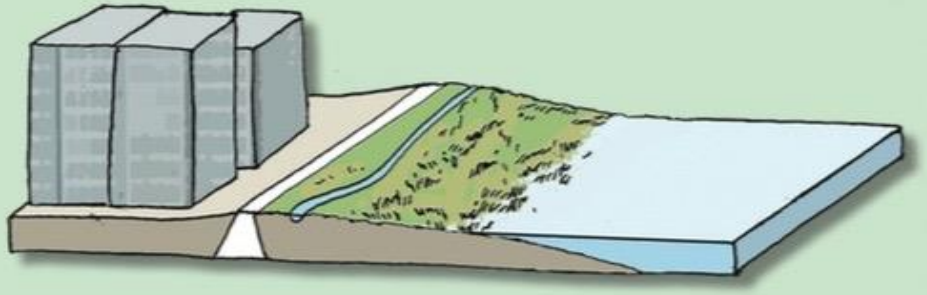
1. RETREAT FROM SHORELINE



2. FLOOD-PROOF STRUCTURES



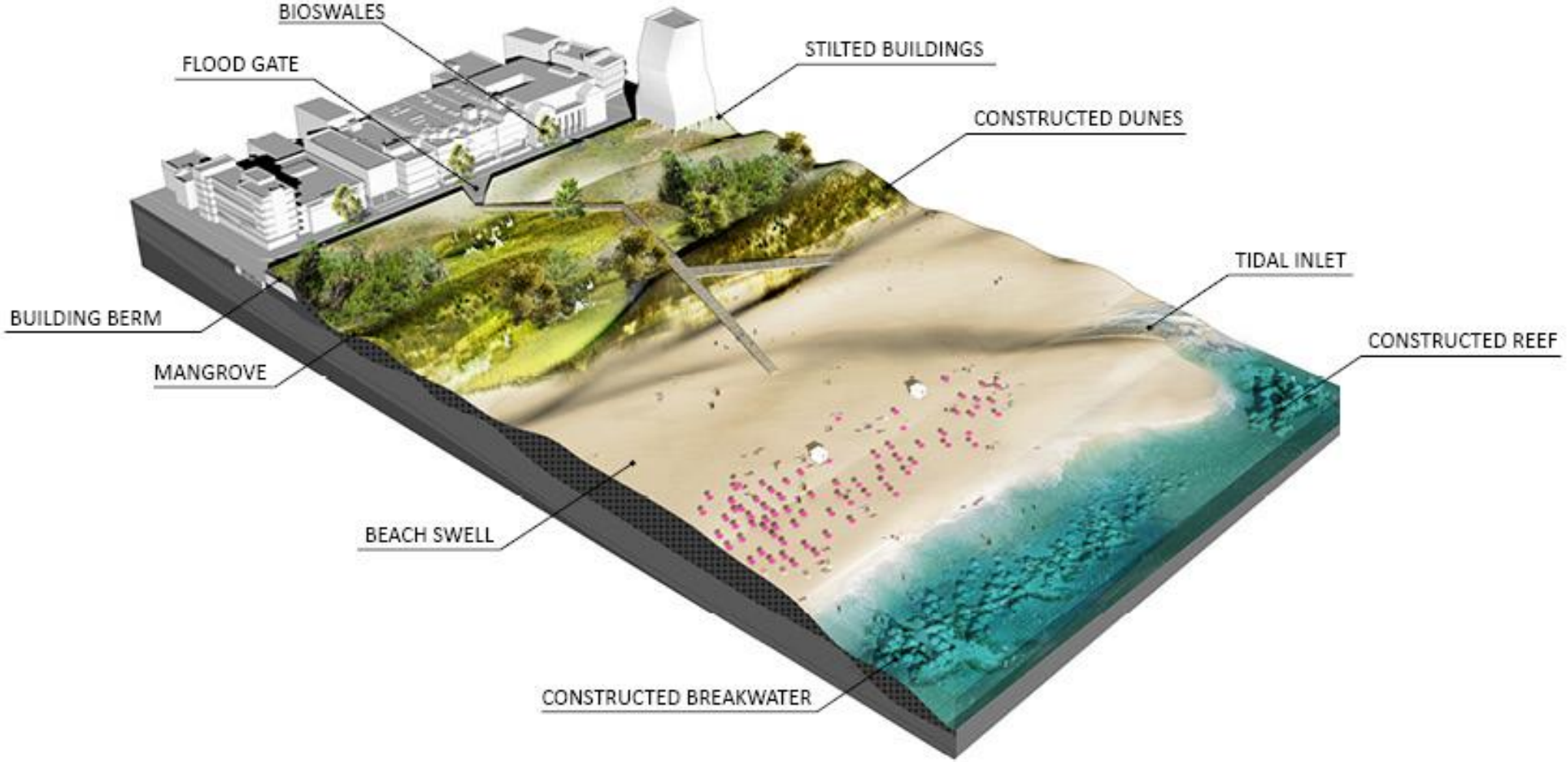
3. BUILD LEVEES



4. RESTORE NATURE

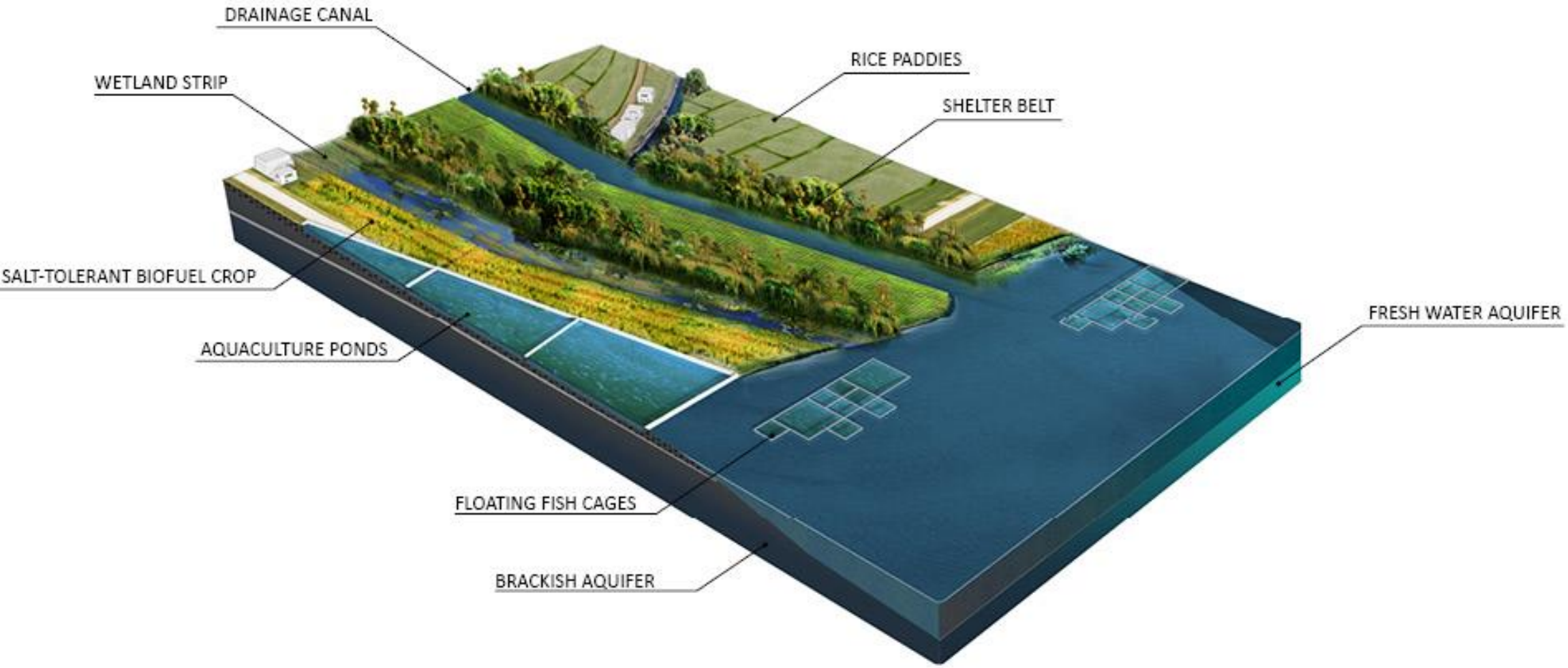
MIAMI, FLORIDA, USA

SOUTH BEACH: TOURIST COMMUNITIES



NILE RIVER DELTA, EGYPT

GHARBIA: AGRICULTURE

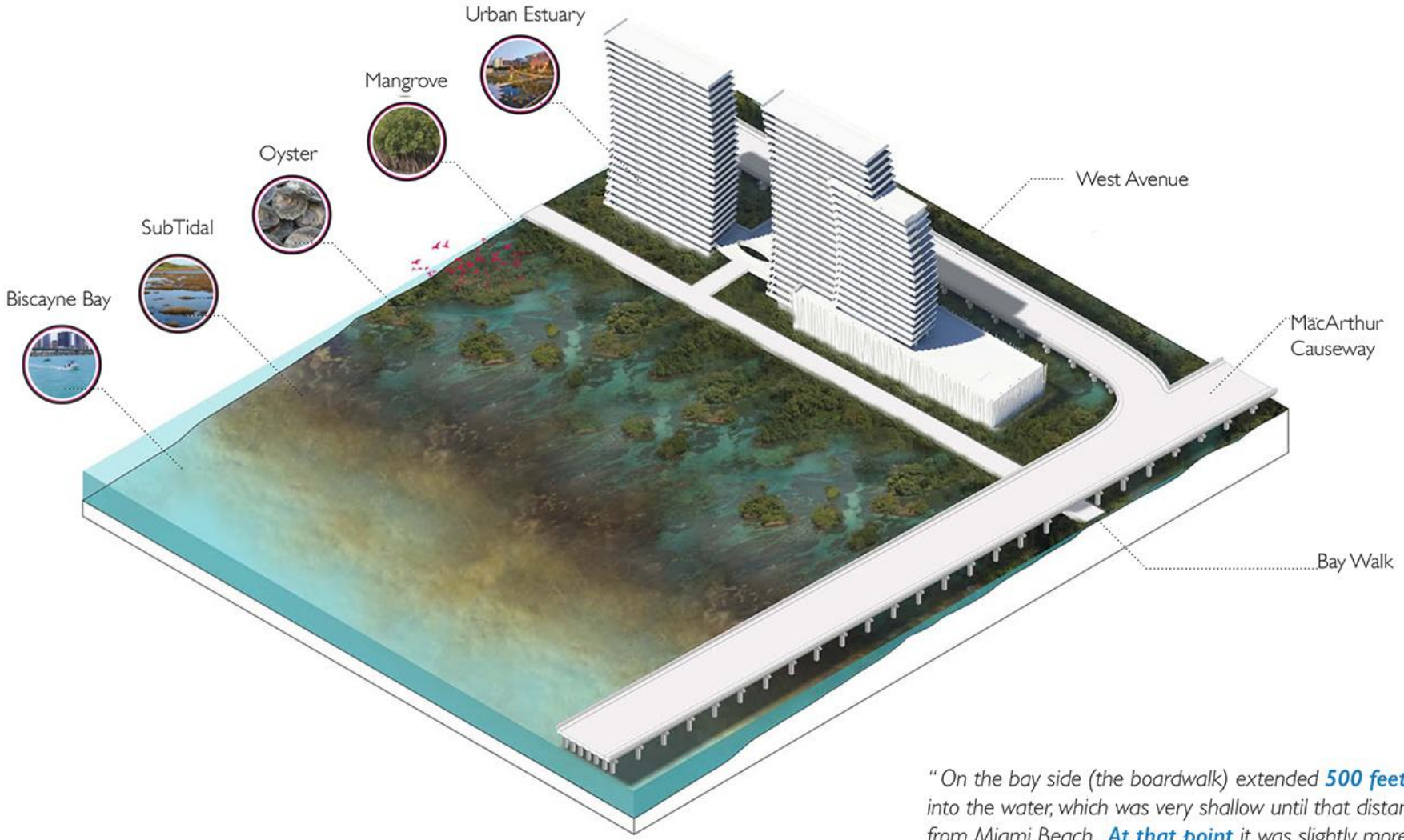


BROOKLYN, NY, USA

BROOKLYN NAVY YARD: INDUSTRY

SHANGHAI, CHINA

LUJIAZUI: FINANCIAL DISTRICT



*"On the bay side (the boardwalk) extended **500 feet** into the water, which was very shallow until that distance, from Miami Beach. **At that point** it was slightly more than **three feet deep**."*

Miami Herald
July 28, 1929

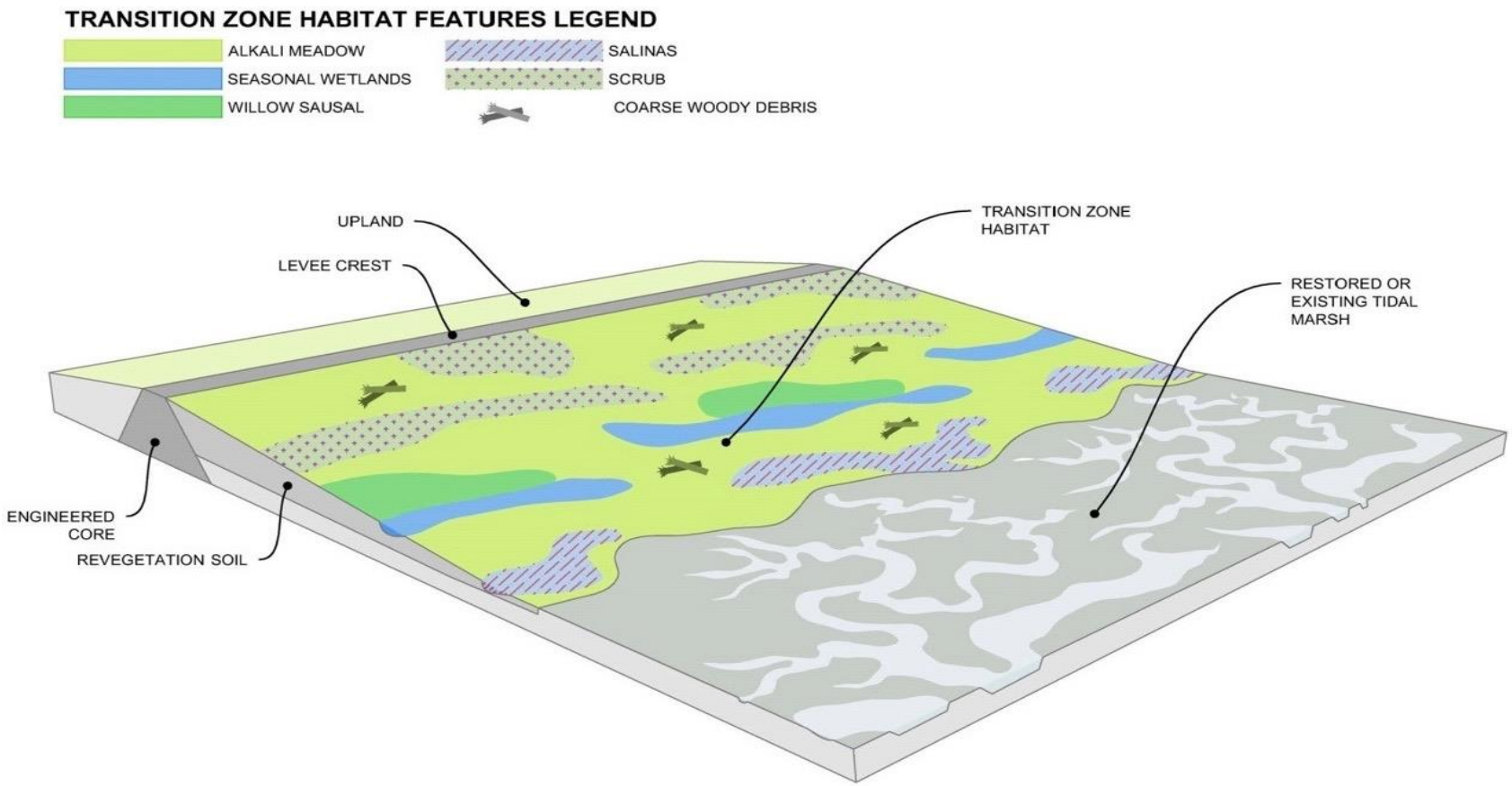
Ecosystem protection and management

- **Reduce non-climate stresses;**
  - Access and control nutrient input/pollution, invasive species,
  - Removing hard structures (e.g., bulkheads, seawalls) that disrupt sediment transport and are impediments to shoreline migration
- **Protect key ecosystem features;**
  - oysters which build reefs or kelp forests that provide a physical substrate
- **Restore structure and function;**
  - Restore marshes to balance increase in sea level rise
  - Remove the tidal restrictions to salt marshes and restore hydrology including sediment trapping
  - Increase belowground biomass

Rising Sea Levels + Hurricane Surge: Ecosystem protection and management

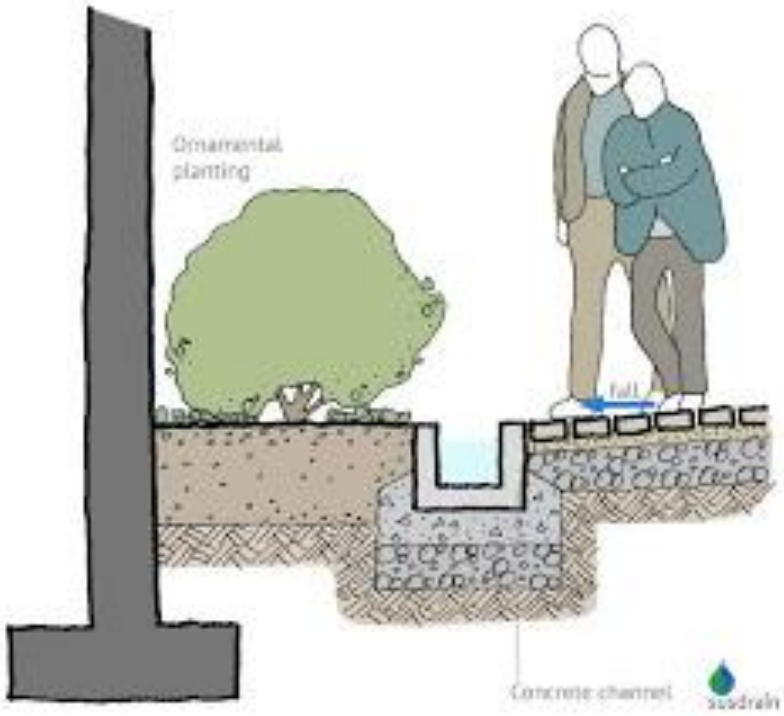
- **Support evolutionary potential**: biodiversity improves resilience
  - maintain multiple locations of habitats to ensure sufficient genetic diversity to allow for natural selection and adaption to ocean acidification;
  - seamless network of marine parks, sanctuaries, refuges and reserves
- **Protect refugia**; identify and provide protection to areas that offer resilient and resilience to maintain refuge status;
  - Establish coastal parks as resilience research areas
- **Relocate organisms;** human facilitated transplantation of the species; e,g marine translocation of sea otters

Living Levee + Dunes



Sustainable Drainage Systems (SDS)

Sustainable Drainage Systems

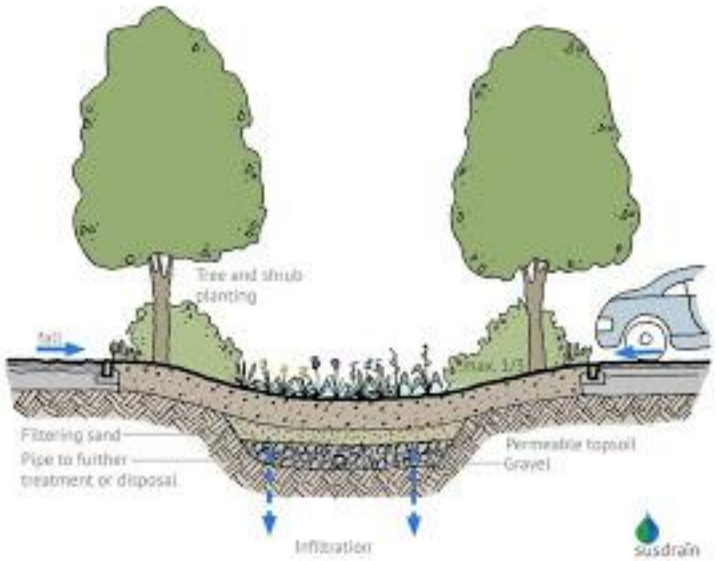


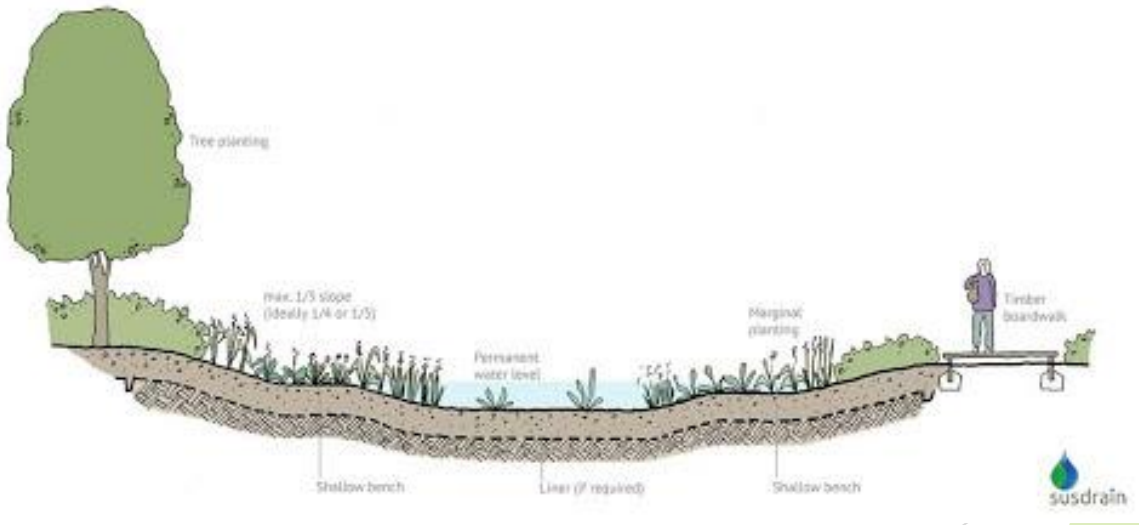
RESPONSE TO FLOODING + COASTAL SEA SURGE

- Slows surface water run-off, reducing impact of flooding
- Prevents water pollution
- Reducing the risk of sewer flooding during heavy rain
- Recharging groundwater to help prevent drought
- Provided valuable habitats for wildlife, urban vegetation and topsoil
- Creating green spaces for people in urban areas.

Sustainable Community Drainage Systems

Large area covered by pavements in community areas (+-30%-45%),



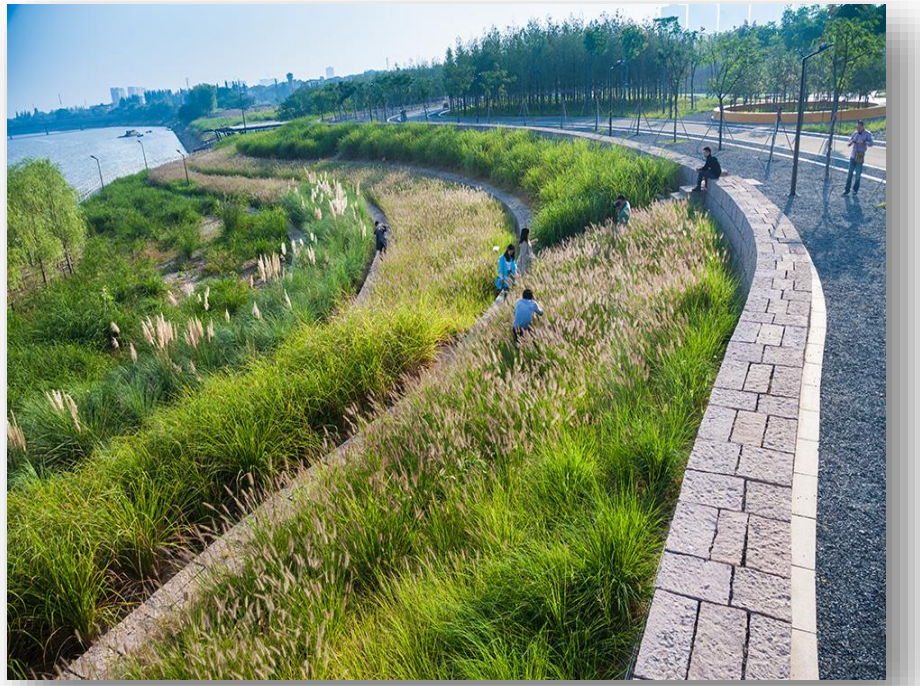


Sustainable Urban Drainage

Sea Level Rise + Surge: Resilient Design

Elevating transportation (3 m), habitat restoration

Sea level Rise and Flooding Adaption



Elevated Structures

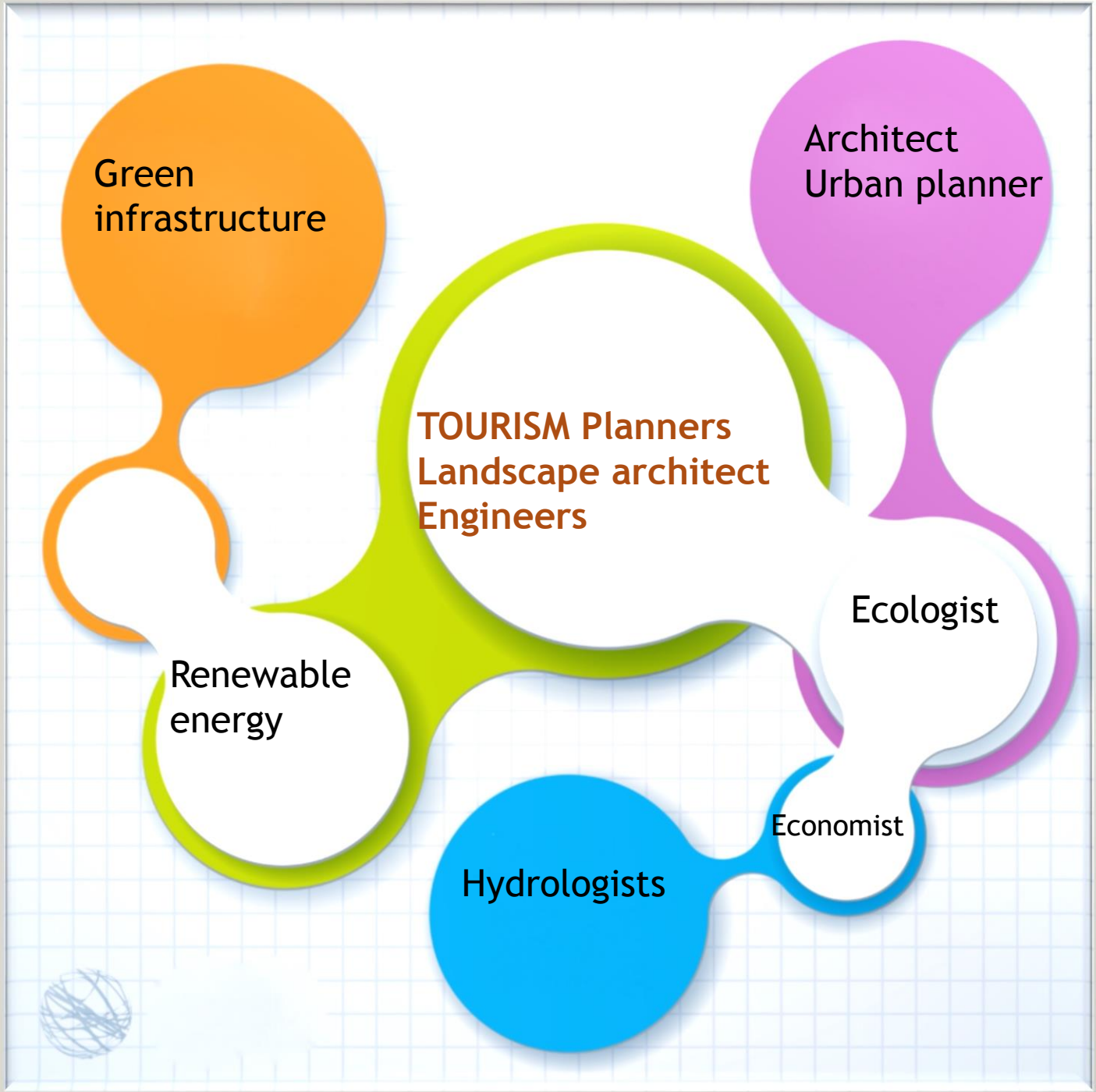
Elevated Homes

Floating Structures

Floating City

Global Warming
Role of Planners, Architects and Designers

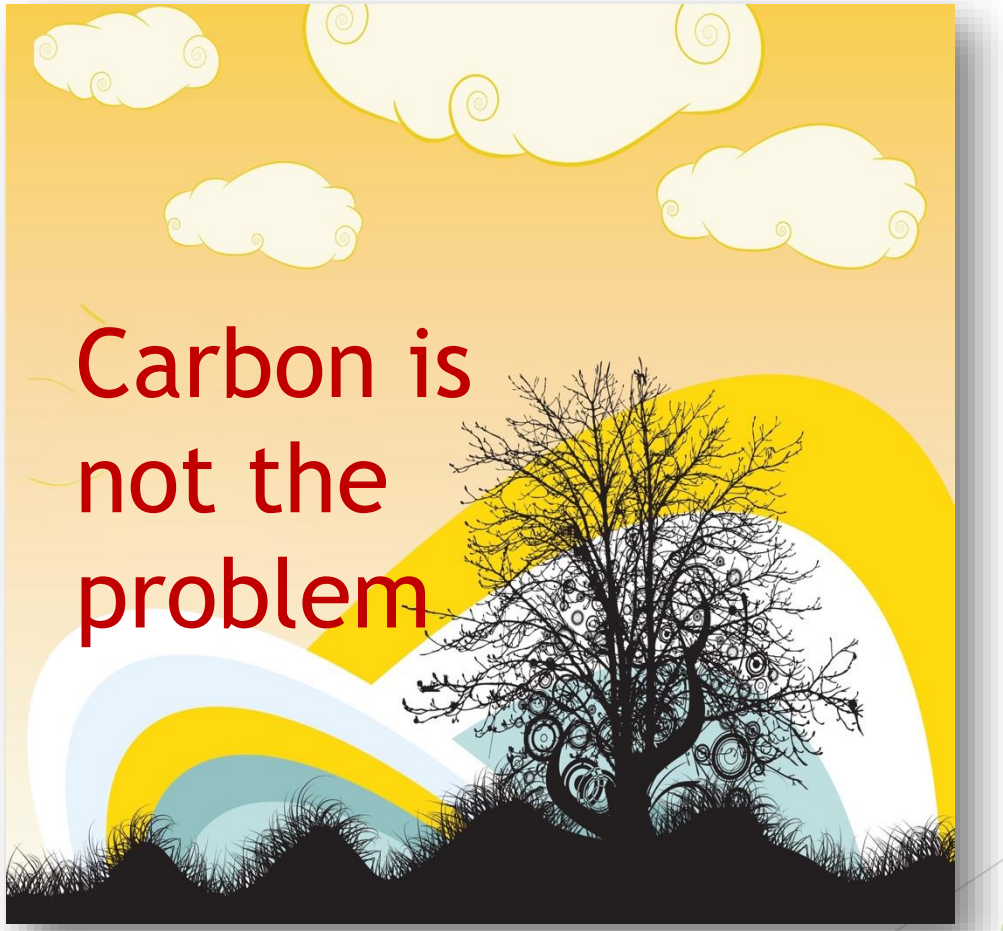
A time for LEADERSHIP + COOPERATION


Green infrastructure
Architect
Urban planner
TOURISM Planners
Landscape architect
Engineers
Ecologist
Renewable energy
Economist
Hydrologists

Role of the Planners and Designers

- **Regenerated coastal zoness**
  - planned, designed and managed for global warming.
- **Improved understanding** of the impact of global warming on ecosystems and vegetation
- Provide food, water storage and flood mitigation
- **Protect biodiversity, increase resilience,** enhance soils
- **INNOVATE:** New solutions

Y una cosa más….



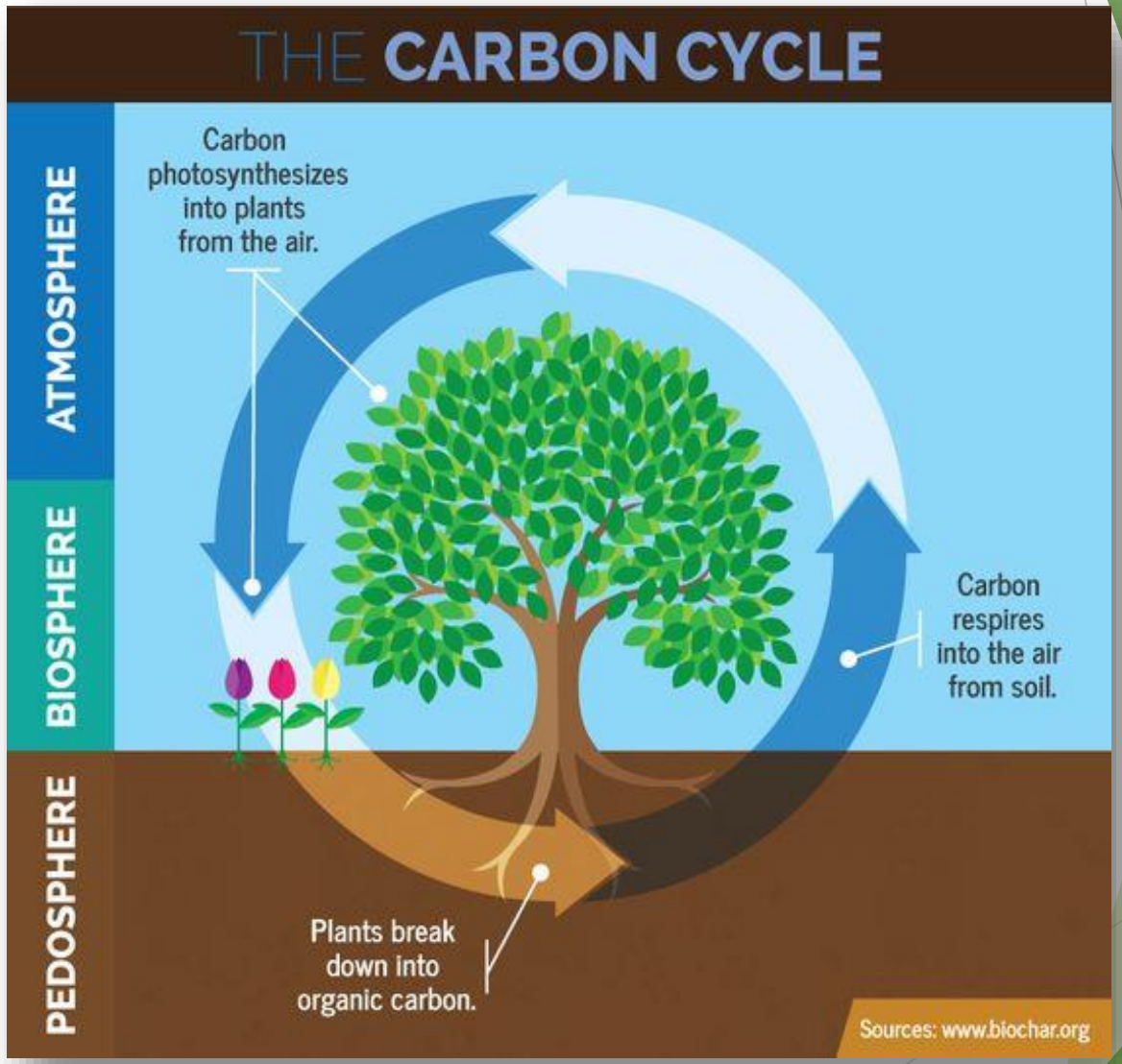
THESE ARE THE OPTIONS

What are our responsibilities?

What will be our response?

TOPSOIL + COMPOST

- Quality Soil
- Protect your coatline
- Convert carbon to nutrient soil
- Protect water supply
- Healthier more resilient plants



Gracias por su atención