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Vulnerable Natural Infrastructure in Urban Coastal Zones

May 2013

Problem Statement and Key Messages

Coastal ecosystems such as mangroves, delta systems, and coral reefs are increasingly at risk due in large part to settlement and development along rapidly urbanizing coasts. The resulting degradation of these ecosystems, especially the degradation of natural infrastructure, increasingly exposes coastal cities and their inhabitants to more frequent and severe natural hazards and disproportionately impacts poor populations who often rely on these ecosystems for livelihoods, food, and other essential benefits.

Key Messages

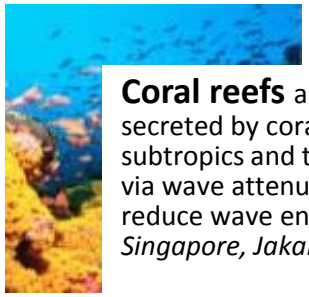
1. Large coastal cities are especially vulnerable to worsening hazards due to natural infrastructure degradation. Evidence shows that the rate of degradation is increasing, especially in Asian countries, which are the most at-risk region due to high numbers of coastal poor and projected future climate change impacts in the region.
2. The total population of urban coastal poor is increasing rapidly (~125 million today, rising at twice the global population growth rate). They are disproportionately vulnerable to coastal ecosystem degradation loss due to their reliance on natural infrastructure, especially in medium and emerging cities, where natural infrastructure has not been wholly degraded, and the risk of future degradation threatens communities who rely on ecosystem services such as income generation, food production, and water treatment.
3. While multilateral funding sources such as the UN and the Global Environment Facility are providing significant investments (approximately $460 million) for coastal management and climate change adaptation, very little of that money is currently focused on natural infrastructure in urban settings.
4. Recent actions and commitments by a range of public and private actors to address this problem suggest that this is an increasingly dynamic space. There is growing demand from governments to support climate change adaptation efforts that reduce vulnerability of poor populations. Additionally, an expanding portfolio of green infrastructure solutions and ecosystem valuation tools indicate that the dynamism in this space has potential to approach a positive tipping point.
5. There may be an opportunity to reframe the narrative around climate change vulnerability to include natural infrastructure and elevate new solutions that enhance ecosystem services to protect the coastal poor.
6. A preliminary estimate based on expert interviews and baselines from existing projects indicate the potential to impact 5-10 million poor people in large coastal cities who are primarily vulnerable to loss of life and property. Additionally work in medium and emerging cities could potentially impact 3-8 million coastal poor people who are primarily vulnerable to loss of livelihood and basic services.

Natural Infrastructure Typologies

Various coastal ecosystems provide coastal protection by attenuating waves.

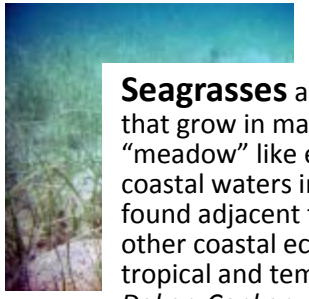
Oyster reefs are made by a number of distinct groups of bivalve mollusks which live in marine or brackish habitats. While found in the tropics, large oyster reefs are predominately found in temperate waters, like the east coast of the United States. Oyster reefs provide coastal protection via wave attenuation and erosion protection (1-2). *Examples New Orleans, Virginia Beach, and Shanghai.*

Coastal salt marshes provide coastal protection by attenuating waves and stabilizing shorelines (1). The former is accomplished by reducing wave heights as function of per unit distance across marsh vegetation, the latter via soil accretion, reducing erosion, and increases in marsh elevation. Coastal marshes are found in temperate and high-latitude regions. *Examples: New Orleans, Virginia Beach, and New York.*



Coral reefs are made from calcium carbonate secreted by corals. Shallow-water reefs are found in the subtropics and tropics. They provide coastal protection via wave attenuation during storm events, and can reduce wave energy by up to 97% (3). *Examples: Singapore, Jakarta, Ho Chi Minh City, and Manila.*

Mangroves replace salt marshes in the subtropics and tropics, and consist of many different types of trees and shrubs that live in saline coastal habitats. Mangrove trees grow in low-oxygen soil, where slow-moving waters allow fine sediments to accumulate. *Examples: large cities in India, Bangladesh, Vietnam, and Indonesia.*



Seagrasses are a specialized group of flowering plants that grow in marine environments, often forming large "meadow" like environments. They occur in shallow coastal waters in sand mud substrates, and are often found adjacent to coral reefs and mangroves. Unlike other coastal ecosystems, seagrasses can be found in tropical and temperate environments (4). *Examples: Dakar, Conkary, Lagos, and Manila.*

Sand beaches and dunes form at low-lying coastal margins where sand transported by oceanic waves and wind combine with vegetation to produce dynamic geomorphic structures. Sandy-shore ecosystems include both marine and terrestrial components. *Examples can be found at all latitudes and cover approximately 34% of ice-free coastlines.*

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Natural Infrastructure Primer

Natural Infrastructure Co-Benefits: In addition to coastal protection and risk reduction from storm events, all of these coastal ecosystems, and others, provide significant co-benefits to society. This includes consumptive uses (e.g., food), direct non-consumptive uses (e.g., recreation), indirect consumptive uses (e.g., pollution control), and nonuse values (e.g., biodiversity conservation).

	Nearshore Coral Reefs	Seagrasses	Salt Marshes	Mangroves	Sand Beaches & Dunes
Raw Materials and Food: generates geomorphological structure (e.g., sand and sediment), and biological productivity and diversity	✓	✓	✓	✓	✓
Erosion Control: provides sediment stabilization and soil retention in vegetation root structure		✓	✓	✓	✓
Water Purification (and Catchment): provides nutrient and pollution uptake		✓	✓	✓	✓
Maintenance of Fisheries and Wildlife: provides reproductive habitat and nursery grounds	✓	✓	✓	✓	✓
Carbon Sequestration		✓	✓	✓	✓
Nutrient Recycling: provides biogeochemical activity, sedimentation, and biological productivity	✓				
Tourism, Recreation, Education, and Research: provides a unique and aesthetic landscape that also supports high-levels of biodiversity	✓	✓	✓	✓	✓

Millions of people depend on natural infrastructure for a range of ecosystem system services including food production, income generation, water treatment, and protection from hazards.

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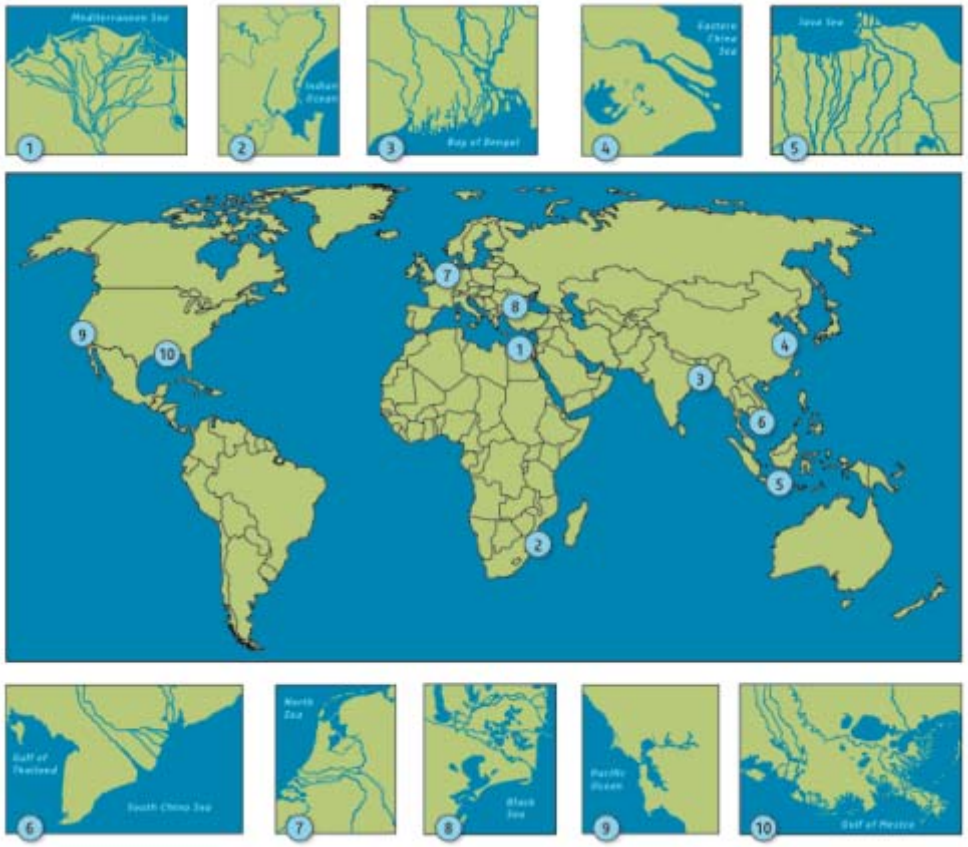
Natural Infrastructure Primer

Deltas often have dense human populations and are important centers of economic activity. Many deltas are also areas of ecological importance, often hosting a suite of coastal and river ecosystems. Deltas are vulnerable to change: major drivers of change are population growth, economic development, climate change, and subsidence.

Cities Located on Deltas are Particularly Vulnerable to Impacts from Increased Storm Surges and Flooding Events



1. Nile, Egypt
2. Incomati, Mozambique
3. Ganges-Brahmaputra-Meghna, Bangladesh
4. Yangtze, China
5. Cillwung, Indonesia
6. Mekong, Vietnam
7. Rhine-Meuse, The Netherlands
8. Danube, Romania
9. California Bay-Delta, USA
10. Mississippi, USA

Definition of Key Terms

Term	Definition
Coastal Zones	Low-lying areas below 10 meters above sea level, bordering major water formations such as oceans or deltas. (IPCC) Note: Low-lying coastal zones can include areas up to 100km from the shoreline; 14 of the top 20 US cities are located within 100km of the coast and are considered coastal (USGS); the coastal region also provides critical services for over two billion people worldwide who live within 100km of the coast or estuaries, as well as inland populations ("Ecosystem Services for Poverty Alleviation", ODG-DEV, 2008).
Land Use/ Land Use Change	Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used to describe the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover.
Natural Infrastructure	The interconnected network of natural and undeveloped areas needed to maintain and support the ecosystems that provide a wide array of environmental, health, and economic benefits, including but not limited to mitigating climate change impacts and sustaining clean air and water. (US EPA)
Poor/Poverty	Living on less than $2 per day or without resources sufficient to meet their needs.
Resilience	The capacity of individuals, communities and systems to survive, adapt, and grow in the face of stress and shocks, and even transform when conditions require it.
Wetlands	An area that is regularly saturated by surface water or groundwater. Examples of wetlands include swamps, bogs, fens, marshes, and estuaries.

Executive Summary

Coastal ecosystem degradation increasingly contributes to the vulnerability of urban coastal populations, both in terms of loss of life and property, and loss of ecosystem benefits. Loss of life and property is most relevant for coastal cities with significant ecosystem degradation and little remaining natural infrastructure, typically large coastal cities with a population over 2 million people, where the poor often have minimal, if any, natural or other protections against hazards. In many medium and emerging cities, poor populations are vulnerable to the loss of ecosystems benefits as they still rely on coastal ecosystems for a variety of other essential services such as food production and water treatment, and are particularly vulnerable to coastal ecosystem degradation. Asia is the most at-risk region from both vulnerability perspectives due to projected climate change impacts, large vulnerable urban coastal populations, and the rapid pace of natural infrastructure degradation.

Current land use policies could lead to irreversible losses in essential natural infrastructure. Rapid growth, especially in medium/emerging coastal cities, could outpace coastal restoration efforts, leading to permanent degradation of natural infrastructure and loss of protection provided to poor populations. Sea level rise and ocean acidification, combined with current coastal development plans, could lead to the loss of 60% of both global mangrove and coral reef areas within a generation.

Due to ecosystem degradation, the benefits from the natural coastal infrastructure are being lost faster than the benefits from substitute infrastructures that can replace them. Where natural infrastructure has been degraded, green and gray infrastructure approaches have seen some success, particularly in US and Europe. However, the success of these approaches varies widely from city to city, and implementation has largely been limited to large cities in developed countries. Cities in developing countries typically lack the means (e.g., access to external financing) to implement large green and gray infrastructure solutions.

There are several opportunities to advocate for natural infrastructure as an essential pillar of the resilience of coastal cities. The most promising areas of opportunity include shifting the focus of climate adaptation efforts, especially at the city level, to incorporate natural infrastructure-based approaches as a means of reducing the vulnerability of poor urban coastal populations, while in parallel developing, piloting, and up-scaling natural and green infrastructure solutions, as well as the tools for vulnerability assessment, ecosystem valuation, and analysis of trade-offs.

What is the scale and scope of the problem? Why is the problem pressing?

Scale: Why It Is Important

Natural infrastructure in urban coastal zones, especially in medium and emerging coastal cities, provides a range of ecosystem services to coastal populations, including protection against natural hazards.

- Natural infrastructure, including wetlands (e.g., marshes, mangroves), coastal systems (e.g., estuaries), and coral reefs, provide coastal populations with services such as food production, livelihood sources, water treatment and sanitation services, and provision of cultural benefits.
- The Rekawa mangrove-lagoon ecosystem in Sri Lanka averages $60,000 per hectare per year worth of erosion and damage protection.
- NOAA estimates coral reefs provide up to $375 billion in benefits/year globally.

Degradation of coastal ecosystems has led to significant loss of natural infrastructure and associated services, especially in large coastal cities.

- 50% of wetlands have been lost since 1900 (mangroves, marshes, etc.).
- Trends of loss are forecasted to continue; coral reef area could fall 60% (to 100K sq. km) over the next 30 years without changes in human activity.

Urban coastal zones are experiencing rapid growth and increasing concentrations of poverty (i.e., population living on <$2/day).

- Today, the global coastal poor population is estimated at 250 million, of which more than half are living in coastal cities.
- Poor urban coastal population may double by 2050; population density in coastal zones is growing twice as fast as non-coastal zones to 2050.
- An average, 13% of people living in coastal floodplains are below the US poverty rate, suggesting a minimum of 850,000 people below the poverty line are at high risk.

Large coastal cities are especially vulnerable to hazards such as seasonal weather events, storms, and other impacts of climate change.

- Effects of hazards include gradual sea level rise, seasonal inundation, storm winds, tidal surge, coastal land subsidence, and erosion.
- Since 1980 the frequency of floods and storms has doubled while the number of people they affect globally has grown almost 3.5X (60 million in '12).
- The OECD estimates the size of the population vulnerable to natural hazards in the top 10 coastal cities will quadruple and affect 81 million by 2070.

Scope: Global Relevance

Growth of coastal urban zones, reliance on coastal ecosystem services, and ecosystem degradation are all global phenomena.

- The World Bank projects that by 2025 at least 65% of the urban population on each continent will reside in low-elevation coastal zones.
- According to UNEP, 70% of the global coastal population lives within 30 miles of an estuary, 45% within 30 miles of a mangrove forest, and 31% within 30 miles of a coral reef.
- Wetland ecosystems are found on every continent except Antarctica, and their rate of loss continues to increase.

Asia is the most at-risk region due to high numbers of coastal poor, rapidly degrading ecosystems and resulting natural infrastructure loss, and projected climate change impacts in the region.

- According to the UN and ODG-DEV, 80% of coastal poor and 70% in high-risk flood zones globally are located in Asia.
- USAID estimates 340 million depend on coastal ecosystems for livelihoods across the Coral Triangle alone (Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste).

Africa's risks arise largely from seasonal flooding, made worse by rapid coastal concentration and poor defenses.

- Due to a range of factors (degradation, urbanization, etc.), the OECD predicts that by 2070 the population exposed to natural hazards in Lagos will grow ten times to more than 3 million, making it one of the top 15 exposed cities in the world. Developed land in Lagos rose 30% while natural vegetation cover dropped 35% between 1986-2002.
- The World Bank conservatively estimates 10 million Africans depend on coastal ecosystems through livelihoods in the fisheries sector alone.

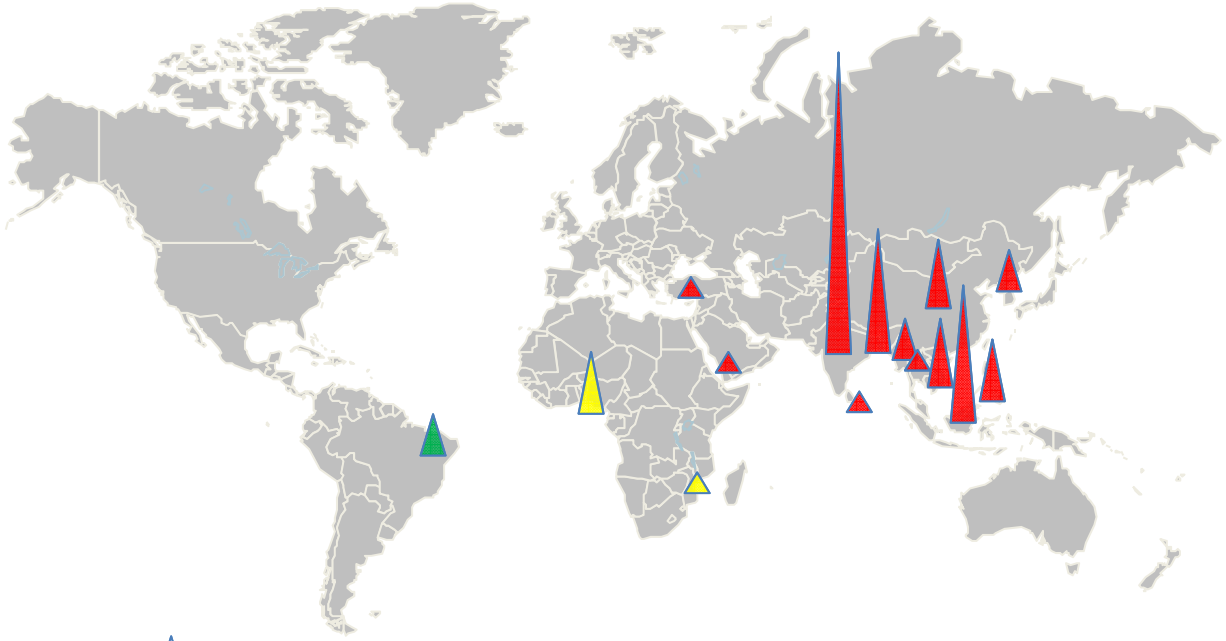
In the US the Gulf Coast and Eastern Seaboard face disproportionate threats from natural hazards.

- The OECD estimates the largest exposed populations to climate change are in Miami (2 million), New York (1.5 million) and New Orleans (1.1 million).
- In the top 17 U.S. coastal cities, 6.5 million people face increased risk from storm surges and flooding. That number will rise to 12.5 million by 2070.

What Is the Scale and Scope of the Problem?

Geographic Distribution of the Global Coastal Poor Population

Continent	Country	% Global Coastal Poor
Asia	India	27% (68M)
Asia	Indonesia	13% (34M)
Asia	Bangladesh	9% (23M)
Asia	Vietnam	5% (12M)
Asia	China	5% (12M)
Asia	Philippines	4% (11M)
Africa	Nigeria	4% (9M)
Asia	Myanmar	2% (6M)
S. America	Brazil	2% (6M)
Asia	North Korea	2% (4M)
Asia	Yemen	1% (4M)
Asia	Thailand	1% (4M)
Africa	Mozambique	1% (3M)
Asia	Turkey	1% (3M)
Asia	Sri Lanka	1% (3M)



200 million of the world's coastal poor are located across 15 countries, of which more than 90% are located in Asia

Source: "Ecosystem Services for Poverty Alleviation: Marine and Coastal Situational Analysis," ODG-DEV et. Al., 2008.

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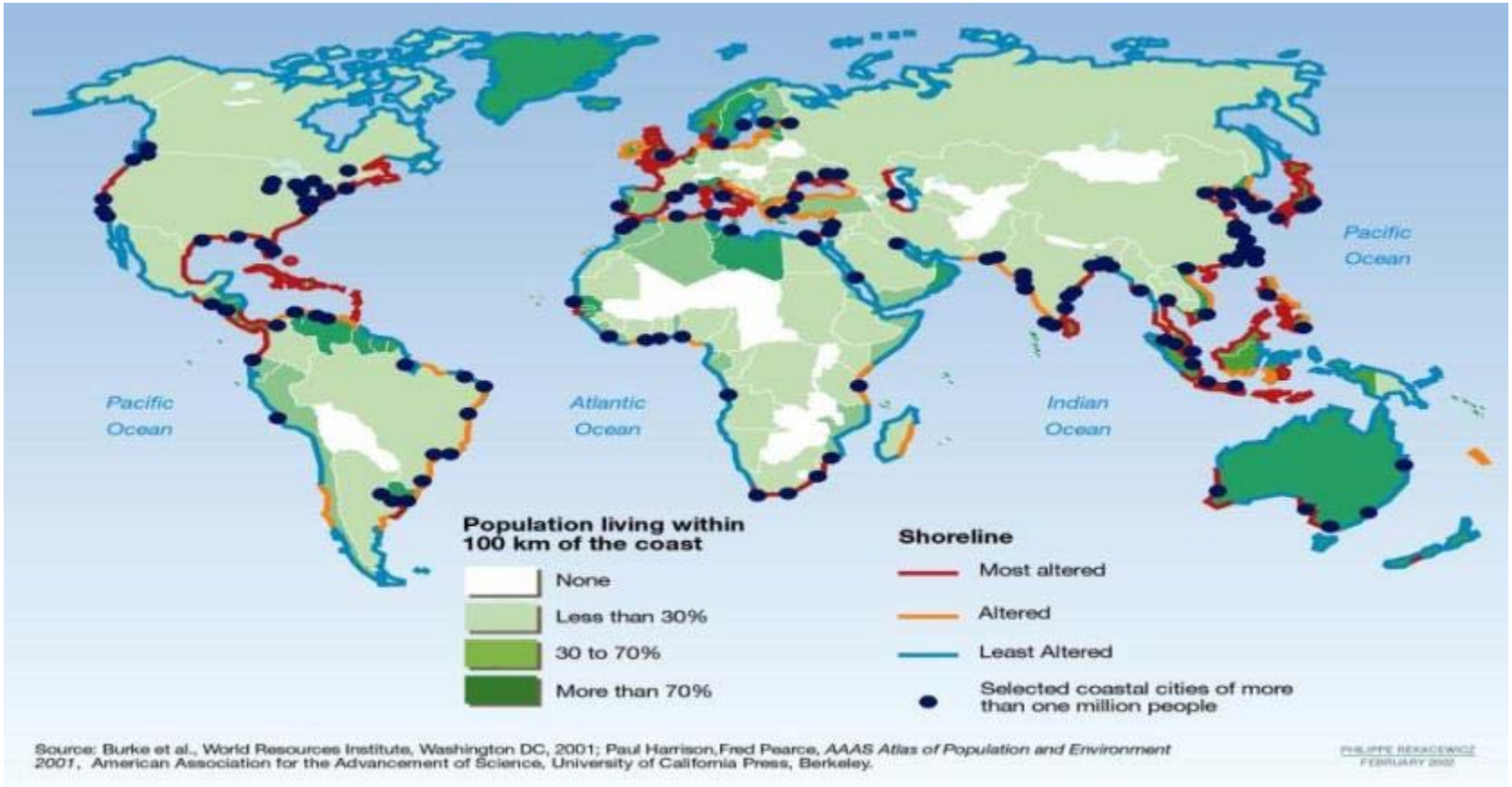
What Is the Scale and Scope of the Problem?

Geographic Distribution of the Global Coastal Population and Shoreline Development



Extensive global coastal development over the past century has destroyed half the world's wetlands, and in the most altered coastal areas, such as US and Asia, it has led to increased vulnerability to hazards, particularly for the urban coastal poor.

Source: UNEP; Work Resources Institute; Atlas of Population and Environment; American Association for the Advancement of Science.

What is the impact on the lives of poor or vulnerable people? What are the gender dimensions?

Impact on the Lives of the Poor or Vulnerable

Coastal poor populations are disproportionately vulnerable to the degradation of coastal ecosystems because they are more reliant on the services provided by natural infrastructure for a wide range of benefits such as income, food production, water treatment, and protection.

- Of the world's 1.1 billion poor, 90% depend on some type of forest (such as coastal mangrove forests) for at least part of their income.
- More than 50 million employed globally through small-scale fisheries in developing countries are in coastal or marine areas and are thus heavily reliant on coastal and marine natural infrastructures to sustain their livelihoods.
- A study of coastal mangroves in Orissa state in India found statistically significant evidence that the loss of mangrove forests increased the probability of death during a major cyclone event by approximately 10%.

In large coastal cities, poor populations are less reliant on coastal ecosystems for their livelihoods, but they are more vulnerable to coastal hazards because they have little remaining natural infrastructure for protection.

- According to the International Housing Coalition, "Many informal settlements in coastal cities are in low-lying areas, making them more subject to the effects of increased storm activity…Over the longer term, they are the first areas affected by sea level rise."
- It is estimated Mumbai lost approximately 40% of its mangrove cover in the past decade because of reclamation for housing, treatment facilities, commercial projects, and the expansion of slums.
- According to the IIED, "Poorer groups not only get hit hardest by the combination of greater exposure to hazards and a lack of hazard-removing infrastructure, but also have less capacity to adapt after disaster…[they] receive less support from the state and very rarely have insurance protection."

In medium and emerging coastal cities, natural infrastructure loss doubly impacts the poor because they rely on local ecosystems for service provisions otherwise unavailable, or that would need to be purchased (e.g., food, homebuilding materials, clean water).

- Degradation of the Sundarbans of India and Bangladesh, the world's largest mangrove forest, threatens the income of over 4.5M people.
- According to the WRI, growing human settlements in Kampala have destroyed more than half of urban wetlands in the area, leading to steadily deteriorating water quality in the discharge area of Murchison Bay of Lake Victoria, leading to rising treatment costs for Kampala's drinking water.
- Degradation of the East Kolkata Wetlands in Bangladesh directly threatens the livelihoods of 200,000 urban and peri-urban poor who directly depend on its resources for protection and sustenance.

Women and children in urban coastal zones can be disproportionately impacted by natural disasters and loss of ecosystem services.

- According to the IUCN, women and children are 14 times more likely to die than men during a disaster (in the case of the tsunami that followed the 2004 Sumatra earthquake, 75% of casualties suffered in India were women and children).
- According to the Global Fund for Women, in cases of displacement following disasters, women are made immediately vulnerable to aid distribution inequality, sexual violence, forced labor, and often face greater challenges than men to achieve livelihood restoration.
- Livelihoods derived from coastal ecosystems, such as salt farming, are important sources of income for women in particular; on deltaic coasts, women who are responsible for their households' water collection are disproportionately burdened by freshwater ecosystem degradation.

The urban coastal poor are disproportionately vulnerable to ecosystem degradation because they are the most reliant on the services ecosystems provide.

What are the root causes at play? What systems failures are causing or exacerbating the problem?

Natural infrastructure degradation is a key driver of vulnerability, and a number of underlying root causes and system failures exacerbate the vulnerability of the urban coastal poor.

System Failures: Underlying constraints that exacerbate the vulnerability of the urban coastal poor.

Legal System

Urban coastal communities often have limited property rights, low engagement in land use decisions, and are not empowered to advocate for their rights to access ecosystem benefits.

Economic System

Gaps and biases in information about ecosystem benefits and degradation costs result in under-valuation of natural infrastructure by government and market actors.

Political System

Political leaders are often incentivized to discount long-term impacts and low-probability events, which leads to neglect for the protection and enhancement of natural infrastructure.

Natural System

The environmental system is failing to balance against drivers of climate change and other human activity, leading to increased frequency of extreme weather events, sea-level rise, and natural infrastructure degradation.

Root Causes: Main drivers that directly* contribute to vulnerability

Coastal Settlement Patterns

Social ties, pursuit of economic opportunity, and availability of low-cost housing lead poor people to co-locate in areas that are more vulnerable to coastal natural hazards.

Land Use Change

Tourism and industrial development, especially port development, often leads to the privatization of the coast, exclusion of the local poor, and degradation of the ecosystem.

Education and Awareness

Misperceptions of vulnerability to long-term and low-probability hazards result in under-valuing the benefits of natural infrastructure by urban populations.

Migration and Urbanization

Populations are increasingly concentrated in urban areas, especially coastal cities, leading to increased exposure to coastal hazards such as storms and flooding.

Waste and Pollution

The release of pathogens, metals, toxins, and oxygen-depleting substances and other waste and pollution in urban coastal zones contributes to coastal degradation.

Government Effectiveness

Governments have fragmented views of what drives vulnerability, and local and national governments have incentives that are often misaligned.

*Note: Some drivers also indirectly contribute to increased vulnerability through interaction with other drivers (e.g., urbanization is a driver of waste and pollution).

What are the prevailing perspectives on this problem?

Coastal protection consists of three basic approaches. The hybrid approach of integrating gray and green infrastructure represents a shift in thinking toward working with nature versus against it, and is becoming more common in developed countries. The poor are not a priority focus in any of these approaches.

	Gray Infrastructure *Most governments, Developers, Architecture/Engineering/ Construction (AEC)*	Gray-Green Infrastructure *Early Adopters within Government Agencies and AEC, Research Institutions*	Natural Infrastructure *Conservation Groups, some Government Agencies, few AEC*
Perspective	**Gray Infrastructure uses engineering to provide coastal protection for economic development and security. Natural infrastructure is largely ignored.** • Building gray infrastructure (e.g., seawalls, breakwaters, or dams) has been the primary approach for protecting coastal areas. • Calculating the costs and benefits of gray infrastructure has become relatively straightforward.	**Gray-Green Infrastructure uses engineering to build *with* nature to provide coastal protection for economic development and security.** • Strong evidence now exists that hybrid gray-green approaches provide cost-effective coastal protection; this approach is gaining attention across sectors (NGO, government, and private). • Research and pilot projects are underway to assess and improve hybrid green-gray infrastructure approaches.	**Natural infrastructure uses natural coastal ecosystems to provide dynamic coastal protection and other ecosystem services.** • Natural infrastructure can offer several advantages such as ecosystem co-benefits. However, its limitations have yet to be defined, and methodologies to evaluate its performance and cost-effectiveness are in their infancy. • It is unclear how much protection from large storm events natural infrastructure can provide on its own.
Limitations	• Gray infrastructure depreciates in value over time. In contrast, natural infrastructure often appreciates in value. • Most gray infrastructure is static and does not respond to changing boundary conditions like rising sea levels.	• Successful examples exist, but scaling could be difficult. This is partly due to scientific knowledge gaps and weak incentives for engineering firms to innovate and integrate green infrastructure into business as usual approaches for coast.	• In many densely populated urban areas the natural infrastructure has been so degraded that restoring natural systems, like wetlands, by itself will not suffice to address future risk.
Recent Examples	• In Lagos, Nigeria, land is being reclaimed for a new development (EkoAtlantic), using 90 million cubic meters of sand dredged offshore from the coast. An 8km long concrete seawall is currently under construction to protect the new city.	• In Singapore, the Building with Nature consortium is testing multifunctional coastal protection through hard structures such as seawalls with habitat promoting tiles. • In the Netherlands, vegetation placed in front of dikes reduce wave heights that degrade the dike by 80%.	• Large-scale mangrove restoration projects in rural areas in Asia (e.g., Bangladesh, India, Thailand, and Vietnam). • IUCN's Ecosystems Protecting Infrastructure and Communities project is targeting six countries (Chile, Nepal, China, Burkina Faso, Senegal, and Thailand).

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What has and has not worked?

	What Has Not Worked	What Has Worked
Efforts to Alter Coastal Land Use Incentives and Decisions	• **Efforts to incorporate the full social value of ecosystems in decision-making lack a standardized methodology or approach and have yet to be adopted in large scale or become mainstream in land use or infrastructure investment planning.** While we do see some successful applications of payments for ecosystem services (PES), as well as some increased use of broader ecosystem valuation methods being incorporated into benefit-cost analyses for planning and investment decisions, these activities remain limited in scale or scope and have not lead to fundamental changes in how private or public actors are accounting for the true value of ecosystems and natural infrastructure.	• **Availability and awareness of tools developed to more accurately evaluate risks and value ecosystem benefits of coastal natural infrastructure** to inform decision-making, mainly in developed countries. As a result there exists more information than ever on successful restoration of natural infrastructure for coastal protection and how to evaluate the tradeoffs involved in planning and implementation.
Efforts That Involve Technology-Based Solutions	• **Applying a "one-size-fits-all" approach to implementing hard coastal defense structures** such as breakwaters, seawalls, and dikes. While hard structures can serve valuable defense purposes, the variability of ecological systems into which they are placed makes it difficult to predict their long-term ecological impacts. "Coastal squeeze" between the sea and the hardened coastline is resulting in significant erosion and natural infrastructure loss. This can lead to impacts on local ecosystems and scale to affect regional systems as well. Introducing such hard structures can destroy local habitats, accelerate coastal erosion and serve as "stepping stones" that permit the entrance of non-indigenous invasive species.	• **Approaches that rely on locally appropriate** "green infrastructure" such as rooftop gardens and permeable concrete, which have seen success in many US cities. Also, "soft structures" such as beach nourishment and artificial reef creation have seen significant experimentation and uptake. In some cases, managed realignment that deliberately breaches hard infrastructure to allow for coastal migration via the creation of wetlands has been successful.
Efforts to Build Collective Action	• **Global government convenings and directed coastal policies and regulations** have largely not succeeded in protecting natural coastal infrastructure or providing a voice to vulnerable urban communities. There is little evidence to suggest global convenings on climate change or related issues have led to action on coastal natural infrastructure and how it can impact the resiliency of the urban poor. In addition, coastal city governments, in developing countries in particular, have poor records of land use management and/or regulation enforcement. They either lack the resources or the will to make effective coastal management a priority.	• **Building partnerships between public and private sectors** to implement solutions and involve communities in coastal management, such as TNC's work to coordinate decision-making in Eastern US to protect communities and the natural features that safeguard them. • **Empowering local communities through community co-management** schemes has shown potential in pilot projects (India, Senegal, Indonesia, etc.) to improve livelihoods of coastal communities and restore natural infrastructure.

Natural Infrastructure is a relatively immature solution space. New models and knowledge pertaining to effective solutions is emerging, but innovation and wider adoption of approaches is needed.

2) Dynamism Assessment

Purpose

The Dynamism Assessment aims to identify the primary opportunities that could be catalyzed to address the problem. It also aims to identify emerging issues and future trends that could influence these opportunities, and the potential risks or uncertainties that could inhibit transformative change.

Key Findings

- Pressure from societal, environmental, and technological forces has created three areas of dynamism in which there is both potential for impact and increasing traction: growing support for climate adaptation efforts, an expanding portfolio of tools and solutions, and increasing experimentation with community-led and market-based approaches.
- There are two promising positive tipping points (increased collective action at the city level and an altered financial decision calculus informing decisions about coastal development), as well as negative tipping points and thresholds to be avoided, including land use changes that could irreversibly impact coastal ecosystems and persistent economic weakness in the US.
- Several emerging drivers of future change are population growth and coastal urbanization, the rise of self-determination in developing countries, climate change, and the evolution of larger cities as leading actors and collaborators.
- Accelerated climate change, limited city government cooperation and capacity, and coastal retreat are potential risks that could negate any of the positive outcomes of a future initiative, while the effects of uncertainties such as public sector incentive alignment, private sector incentive alignment, and technological breakthroughs remain uncertain.

What forces are creating windows of opportunity?

Forces Contributing to Dynamism	Areas of Dynamism
• Rising social and economic costs and damage due to increasing frequency and severity of natural hazards that disproportionately impact poor and vulnerable coastal urban communities (e.g., Hurricane Katrina, Hurricane Sandy, tsunamis in South and East Asia) • Increasing number and diversity of people that are benefiting from coastal living and that are more exposed to natural hazards, as well as a growing array of stakeholders such as insurance companies and national governments that are paying costs of damage to valuable assets in coastal cities (e.g., Munich RE's efforts to promote awareness of the effects of climate change)	• Growing demand and support for climate adaptation efforts that reduce the vulnerability of poor urban coastal populations to natural hazards. • Expanding portfolio of tools, including both natural and green infrastructure solutions and instruments for vulnerability assessment, ecosystem valuation, and trade-off analysis. • Increasing experimentation with community-led and market-based approaches, such as payments for ecosystem services.
• Growing recognition, especially in scientific community, that some climate impacts will not be averted in near-term and will require adaptation • Growing pools of funding for climate change mitigation and adaptation interventions available from top bilateral and multilateral donors, especially at the city level (e.g., Clean Development Mechanism and recent World Bank efforts to help cities tap into global carbon financing) • Global actors raising awareness of climate impacts and consolidating political will to support climate adaptation measures • Experimentation with innovative financing mechanisms for natural infrastructure projects (e.g., EKO Asset Management and partners' launch of The Natural Infrastructure Innovative Financing Lab)	
• Growing experience and measurement accuracy in the monetization of ecosystem services (e.g., new ecosystem service valuation tools developed by TNC) • Increasing experimentation with Payments for Environmental Services (PES) schemes, especially by private foundations and NGOs (e.g., Moore Foundation, World Wildlife Fund) • Experimentation with technologies (e.g., for wetland restoration) that is enabling new natural, green, and gray solutions to be deployed; approaches that rely on locally appropriate 'green infrastructure' such as rooftop gardens and permeable concrete, have also seen success in some US cities • Increasing demand for community-based approaches in view of success in other sectors (e.g., community co-management of fisheries)	
• City governments gaining political power to make investments in local public goods with co-benefits of enhanced economic competitiveness and improved social and environmental sustainability (e.g., C40 Cities collaborating to implement climate-related actions that will benefit all city residents) • Growing understanding from public actors and the environmental conservation community of the need for participatory planning and local resource management, to understand full costs and benefits of environmental resources	

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How do we know these opportunities are gaining traction?

Areas of Dynamism	Evidence of Traction
Growing demand and support for climate adaptation efforts that reduce the vulnerability of poor urban coastal populations to natural hazards.	• Jakarta's plan for 2010-2030 calls for incorporating risk reduction into long-term spatial planning through approaches that include mangrove forest restoration and a provision of open space for anticipated increases in intense rainfall. This political will is also manifest in large-scale adaptation infrastructure projects, including a coastal defense project to protect from tidal surges and the Jakarta Urgent Flood Mitigation Plan. • Governor Andrew Cuomo of New York State proposed updating building standards to improve resilience and committed to assisting and relocating home and business owners in hurricane-vulnerable areas, signaling increased political commitment to adaptation and recognition of the economic costs of natural hazards. • Three cities in Vietnam: Dong Hoi, Can Tho, and Hanoi, have completed plans that include vulnerability assessments and priority-setting, demonstrating political commitment to mitigating coastal populations' vulnerability.
Expanding portfolio of tools, including both natural and green infrastructure solutions and instruments for vulnerability assessment, ecosystem valuation, and trade-off analysis.	• The Natural Capital Project, a collaboration between Stanford University's Woods Institute for the Environment, The Nature Conservancy, WWF, and the University of Minnesota's Institute on the Environment, has used its InVEST tool to help provincial and county planners in China base land use plans on areas of critical importance for ecosystem services, assist the largest private landowner in Hawaii in land-use decisions across 10,500 hectares on the North Shore of O'ahu, and integrate ecosystem services into spatial planning in Sumatra, Indonesia. • A $40 million gift to NYU will fund research into cities and the urban environment, including the development of tools to research and mitigate the vulnerability of urban populations exposed to natural hazards. • Cities and counties like Ann Arbor, Milwaukee, Montgomery, Philadelphia, Prince George, and Washington, DC, are incorporating green infrastructure into their stormwater management systems, mimicking natural hydrologic cycle processes.
Increasing experimentation with community-led and market-based approaches, such as payments for ecosystem services.	• As of January 2011, Conservation International had nine potential Payments for Ecosystem Services Conservation Agreements (CAs) in analysis and design phase, a sign of the organization's commitment to build on its portfolio of 55 CAs benefiting nearly 100,000 people and covering approximately 3 million hectares of natural habitat, and reflecting increasing recognition by market actors that PES schemes have potential to be efficient and sustainable. • From 2010-2011, the David and Lucile Packard Foundation and the Washington-based Bullitt Foundation each awarded ~$1 million in grants to projects building community around natural infrastructure, signaling an increasing demand for community-based approaches in view of signs of success in related sectors (e.g., fisheries). • The World Bank currently has two upcoming Payment for Ecosystem Services (PES) projects related to watershed management: in Espirito Santo, Brazil, and Guerrero, Mexico; the World Bank "is conducting intensive research on the links between PES and poverty, and has developed guidelines for pro-poor PES."

Policymakers and the public are accepting new ways of assessing vulnerability and valuing coastal ecosystems. Dynamism in these areas is leading to the deployment of new solutions to build resilience of cities to natural hazards.

What are the primary opportunities that could address this problem?

Related to the dynamic spaces identified, there are potential intervention points that could be explored by various actors.

Political Support	Resources & Capabilities	Innovative Solutions
Growing demand and support for climate adaptation efforts that reduce the vulnerability of poor urban coastal populations to natural hazards.	***Expanding portfolio of tools, including both natural and green infrastructure solutions, and instruments for vulnerability assessment, ecosystem valuation, and trade-off analysis.***	***Increasing experimentation with community-led and market-based approaches, such as payments for ecosystem services.***
Convening: Make connections between governments, conservation organizations, public interest groups, and the private sector to design natural infrastructure projects	**Building evidence base:** Develop a research base, guidelines, and standards for natural infrastructure investment and ecosystem planning in urban areas.	**Piloting:** Test innovative projects and PES schemes
Influencing: Empower and influence existing networks to prioritize and act on this issue.	**Training:** Promote best practices and train urban planners to incorporate pro-poor natural infrastructure into urban design.	**Innovative Financing:** Working with partners from different sectors, including insurance companies, infrastructure firms, and local and national governments, create innovative financing mechanisms for natural infrastructure investment and maintenance.
Messaging: Shift discussion from a focus on climate change and disaster risk reduction to a broader view on productive ecosystems, the services they provide to cities, and the role they play in sustainable growth.	**Knowledge Dissemination:** Provide support and visibility to innovative approaches to ecosystem management, inclusive urban planning and sustainable land use policies. Disseminate key lessons in a systematic and additive manner.	**Incentivizing:** Support new methodologies to incentivize ecosystem-friendly urban growth strategies that support the needs of poor communities.

Highlighted initiatives reflect the most dynamic opportunities for further exploration.

What potential tipping points are emerging?

	Description	What would have to happen to reach this tipping point?
Positive Potential Tipping Points (Actions & events that could catalyze large-scale positive change)	• **Local officials and organizations in cities lead pursuit of climate adaptation and coastal management solutions.** Cross-city collaboration networks are strengthening, empowering local actors and easing exchange of strategies and best practices for improving urban resilience and protecting vulnerable and poor communities. This includes adoption of green infrastructure and other tech-based solutions.	• Continued expansion of leading networks and prioritization of natural infrastructure on the agenda within these networks. Leading networks include: Connecting Delta Cities (CDC), 16 major deltaic cities, part of the C40 Cities; The Mega-Cities Project; and ICLEI-Local Governments for Sustainability.
	• **Tools, incentives, and financial institution approaches are aligned to account for coastal management and ecosystem benefits.** Increasing storm frequency has led providers of financing and insurance to rethink how they make investments, price risk, and determine coverage. Providers such as Munich Re and Caribbean Catastrophe Risk Insurance Facility are linking products to local risk minimization measures.	• Greater awareness of these solutions and development of new tools and approaches to catalyze wider interest across the financial sector.
Negative Potential Tipping Points (Thresholds beyond which there is no going back)	• **Current land use policies could irreversibly impact coastal ecosystems.** Rapid growth in coastal cities could outpace coastal restoration efforts, leading to permanent degradation of natural infrastructure and loss of protection provided by ecosystems to poor populations. Mangroves, for example, are disappearing three to five times faster than global forests overall, and the direct loss of mangroves to urban development is typically permanent.	• Maintaining the current trajectory of land use decision making will bring about this negative tipping point on its own. • However, if pressures for short-term growth in urban coastal zones continue to grow, accelerated coastal degradation will actually bring out this tipping point sooner than expected
Too Early to Tell	***These could potentially be tipping points (positive or negative) but will require further monitoring to define and size:*** • **Persistent economic weakness in the developed world could undermine financial support for coastal natural infrastructure initiatives.** As national and city governments prioritize economic growth and job creation over vulnerability reduction and environmental sustainability, funding for ecosystem management could fall short. • **Climate impacts could devastate natural infrastructure**. While the pace and extent of future sea level rise is uncertain, a 1 meter rise could result in the loss of more than 60% of the world's coastal wetlands and ocean acidification may decimate coral reefs.	

What are emerging issues and future trends that could influence these opportunities?

Continued Trend of Urbanization

- The economic, political, and social opportunities of urban zones continue to attract record numbers of inhabitants. Coastal population density is projected to grow twice as fast as non-coastal zone population zone density to 2025, and the density of urban coastal zones is forecast to grow between 30-40% by 2050.
- In particular, medium and emerging coastal cities are growing rapidly at 2.4% per year, even faster than large coastal cities (2.1%).
- Policy makers and local governance institutions have a bias to pursue short-term solutions to alleviate immediate pressures on resources without addressing root causes of such pressures.
- In addition, the most rapid coastal urbanization will continue to take place in the developing world and disproportionately attract the very poor. This will exacerbate the challenges faced by developing coastal cities that are growing fast, are resource constrained, and have large and growing vulnerable populations.

Rise of Developing World Self-Determination

- Strengthening institutions, increasing availability of resources, and the growing political will of the developing world will increasingly influence not just how the issue of coastal natural infrastructure and how it relates to the poor and vulnerable in coastal urban areas is addressed, but by whom.
- Central to this trend is and will be the tension between the desire of the developing world to grow economically without constraints, as the developed world did before it, and the constraints of a resource-limited world.
- Increasing self-determination from developing country leaders in addressing growing vulnerability of the urban coastal poor could lead to increased local engagement, greater localized context and relevance of solutions, and improved implementation of interventions and outcomes.
- Developing countries will push to be a provider of solutions and a full collaborator, not simply an aid recipient. This will affect any potential interventions, and will force actors in the developed world to rethink approach, design, and goals.

Attitudes Around Climate Change

- Climate-related stresses (e.g., increased temperatures, de-oxygenated dead zones, shifting currents, altered patterns of precipitation, sea-level rise, ocean acidification, and increases in extreme weather events) will cause continued significant degradation of coastal natural infrastructure, though the exact distribution and impacts of these effects remain only estimates at this time.
- Those coastal urban zones in the developing world with the largest vulnerable populations, and the populations most dependent on coastal natural infrastructure, are also those with the least resources and capability to protect and enhance those natural assets.

Evolution of Larger Cities as Leading Actors

- Large cities are increasingly global centers of communication, commerce, culture, and leadership. This development is creating a more consolidated access point for change, creating direct access to local decision makers.
- City governments are increasingly leveraging their close relationships with local businesses, residents, and institutions to implement new policies quickly and decisively, no longer waiting for slower moving and often dysfunctional international or national agreements.
- Growing networks such as C40 (representing 58 global cities, 18% of global GDP, and nearly 10% of the global population) are creating highly dynamic channels of innovation, information sharing, and proactive leadership on issues highly relevant to the vulnerability and resilience of the urban coastal poor. Other examples include the World Mayors Council on Climate Change, Global City Indicators Facility, World Energy Cities Partnership, World Class Cities Partnership, and more.

Increases in urbanization and frequency and severity of coastal hazards will lead cities in the developing world to play key roles in planning and leading adaptations efforts.

What are potential risks or uncertainties?

Interventions in this space are subject to a range of factors that could derail or diminish impact.

Risks	**PUBLIC SECTOR INCENTIVE ALIGNMENT**	• National governments may choose to ignore or deprioritize growing threats and increasing vulnerability of urban coastal populations. Lack of government funding or activity on this issue may indicate to communities that the resulting effects of ecosystem degradation are a problem they must deal with on their own and progress on the development of apt solutions may be stalled.
Risks	**LOCAL GOVERNMENT CAPACITY GAPS**	• Municipal governments, particularly in developing countries, often lack capacity and will to effectively enforce and regulate coastal management policies. Where sufficient capability for partnership can be found, full support and cooperation is vital to ensuring success of any intervention aiming to alter local incentives and improve local coastal management systems.
Risks	**PUBLIC AWARENESS/ PRIORITIZATION**	• Strong shifts of public sentiment can rapidly accelerate or decelerate actions to protect and enhance coastal natural infrastructure. Hurricane Sandy significantly shifted awareness levels of the threat of coastal hazards along the US East Coast. It is unknown, however, whether a) additional disasters will move public opinion; b) where those disasters will occur; and c) how lasting the shift will be.
Uncertainties	**CLIMATE CHANGE AND OCEAN ACIDIFICATION ACCELERATION**	• The increasing effects of climate change, such as sea level rise and ocean acidification, will have devastating impacts on remaining coastal natural infrastructure. If climate change impacts accelerate, interventions to protect natural infrastructure could be largely or entirely negated by losses.
Uncertainties	**PRIVATE SECTOR INCENTIVE ALIGNMENT**	• As costs mount from rising coastal hazards, significant shifts by influential private actors could lead to big changes. For example, as insurance companies change how they assess risk for coastal communities, significant movement of assets by the private sector away from coasts in some areas could change the landscape of coastal vulnerability as people follow those assets away from coastal areas.
Uncertainties	**TECHNOLOGY AS POSITIVE OR NEGATIVE ACCELERATOR**	• Future technological innovations are unknown, and may have positive or negative impacts on coastal ecosystems. They may build solutions that make us better equipped to live in vulnerable areas or make the areas in which we live less vulnerable, but it is impossible to predict unintended consequences.
Uncertainties	**COASTAL RETREAT STRATEGIES**	• In some areas where the need for intervention is highest (i.e., Bangladesh) extreme solutions such as coastal retreat strategies may ultimately be employed as the only lasting solution. Such a scenario may reduce vulnerability for intended beneficiaries, but it should be noted such strategies would also negate any positive impact created by other interventions to increase the resilience of such areas.

3) Landscape Assessment

Purpose

The Landscape Assessment aims to identify the key players and opinion leaders in the field, which organizations are doing innovative work, who provides funding, and gaps in funding.

Key Findings

- Coastal natural infrastructure is of interest to a wide range of actors, including public donors, global partnerships, planning and engineering firms, NGOs, foundations, and local governments. Most projects are funded and implemented through collaboration between partners of different types.
- Increasing levels of funding are directed at communicating the economic benefits of conservation and restoration. However, most projects in the field of coastal natural infrastructure lack financial sustainability mechanisms. They solely rely on a combination of donor aid and local public funding.
- In 2010 and 2011, grant funding for coastal infrastructure from US foundations averaged $23M per year. Of this, more than 60% came from five foundations and over 80% was spent in the US. With the exception of the Aga Khan Foundation, all of the large foundations leading in this space are based in developed countries.
- Common focus areas of US foundations supporting natural infrastructure for the poor and vulnerable include moving towards a resilient green economy narrative, improving knowledge and awareness of ecosystem services, supporting coastal restoration and flood protection, building community support to protect ecosystems, and building the capacity of key government institutions.

Who are the key players and opinion leaders in the field?

While the concept of natural infrastructure investments that benefit the urban coastal poor is a relatively immature area of study, there are several organizations working on coastal preservation in concert with local communities.

Public Donors	• Bilateral donors (e.g., top donors Japan, Germany, and France) fund 70% of pertinent official development assistance, while multilateral agencies (e.g., World Bank, EU) fund 30%. • Emerging donors include the United Arab Emirates, which gave $98M in official development assistance in 2011 to areas related to natural infrastructure in coastal areas.
Global Partnerships	• The International Union for the Conservation of Nature, the Natural Capital Project, and the Resilience Alliance bring together stakeholders of different types ,while the Global Environmental Facility channels the funding efforts of multilateral public donors. • Emerging global partnerships focused on urban resilience include C40 Cities, Corporate EcoForum, and Global Facility for Disaster Reduction and Recovery
Risk Assessment, Planning, Design, and Engineering Firms	• Private insurance companies and catastrophic risk modelers such as Munich Re, Tokyo Marine Holdings, and EQECAT promote natural infrastructure and allow local governments to assess the value of natural infrastructure in a disaster scenarios, while environmental engineering firms such as CTI Engineering International, MWH Global, and CH2M HILL design solutions for urban resilience.
International and Local NGOs and Research Institutions	• International NGOs such as the World Wildlife Fund, the Nature Conservancy, Wetlands International, and Conservation International partner with local public and private actors. • Research institutions such as universities produce evidence bases and reports that guide the programmatic and advocacy work of NGO and public actors.
Foundations and Philanthropic Initiatives	• US-based foundations such as the Moore Foundation, the Packard Foundation, the MacArthur Foundation, the McKnight Foundation, and the National Fish and Wildlife Foundation support interventions pertinent to natural infrastructure degradation in urban coastal areas. • Emerging actors include the Prince Sadruddin Aga Khan Fund for the Environment.
Local City Governments	• US cities, including City of New York, focus on locally relevant infrastructure but develop technologies and best practices that could be of use to cities in other parts of the world. • In Surabaya, Indonesia's second largest city, the city government has established the Partnership Based Mangrove Conservation Area with local villages, private businesses, NGOs, and local universities.

Who are the key players and opinion leaders in the field? What are the potential gaps in current funding?

There are several key players and opinion leaders across sectors in the field of natural infrastructure and urban resilience. Many are starting to incorporate issues of urban poverty and vulnerability into elements of their work.

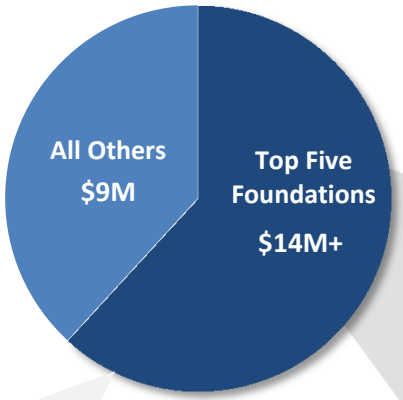
Sector	Key Player/ Opinion Leader	Description
Private Sector	Munich RE	**Applying Risk Management to Disaster Prevention.** Global reinsurer Munich RE is among those leading the movement within the insurance industry to promote awareness of the effects of climate change on social vulnerability and improve resilience for all members of society.
	EQECAT	**Modeling Catastrophe Risk for Coastal Cities.** EQECAT supports insurance and financial services clients with a risk modeling platform that identifies disaster-vulnerable areas of a city.
	Tokyo Marine & Nichido Fire Insurance	**Planting Mangroves to Mitigate Damages Caused by Storms.** Japan's leading insurance company*, Tokyo Marine & Nichido is planting mangroves in SE Asia and advocating for the benefits of mangroves.
	PK Das & Associates	**Incorporating Natural Infrastructure into Design.** Mumbai-based architecture and design firm working on a suite of projects to restore waterfronts while incorporating natural infrastructure.
	EKO Asset Management	**Developing Innovative Financing for Natural Infrastructure Projects.** EKO Asset Management and partners recently committed to launching The Natural Infrastructure Innovative Financing Lab.
Civil Society	Gordon and Betty Moore Foundation	**Changing the Conservation Narrative.** Moore grants support the development and understanding of interventions that recognize vulnerable poor populations' economic stake in conservation.
	The Nature Conservancy	**Valuating Nature's Benefits.** The Nature Conservancy works to measure the value of nature to those who benefit from its services, including coastal poor populations in vulnerable urban environments.
	World Wildlife Fund	**Preserving Ecosystem Services.** WWF works to promote conservation of natural infrastructure that provides economic and natural hazard mitigation benefits to poor populations.
Public Sector	World Bank	**Funding Ecosystem Management.** The World Bank, whose institutional focus is on poor populations, funds a range of projects aimed at managing ecosystems sustainably for the populations that they support, including payments for ecosystem services schemes.
	C40 Cities Climate Leadership Group	**Uniting Cities to Address Climate Risks.** C40 unites approximately 60 major cities to implement climate-related actions that will benefit all city residents, including those most vulnerable to the adverse effects of climate change.

*Excluding life insurance companies.

Who is providing funding in this space?

Funding Landscape: Key Observations

- Over 2010-11, philanthropic foundation grants averaged $23M annually to projects pertaining to natural infrastructure protecting coastal communities.
- Philanthropic funding is concentrated: five private foundations provide approximately $14M.
- Government funding can be significantly greater: NYC alone has committed to $75M per year to 2030 for green infrastructure.
- While multilateral funding sources such as the UN and the Global Environment Facility are providing significant investments (approximately $460M) for coastal management and climate change adaptation, very little of that money is currently focused on natural infrastructure in urban settings.



Includes approximately $3.6M for projects not targeted only to poor populations

Foundation	Amount
Gordon and Betty Moore Foundation	$5.6M
The David and Lucile Packard Foundation	$2.6M
The John D. and Catherine T. MacArthur Foundation	$2.5M
The McKnight Foundation	$2.2M
The National Fish and Wildlife Foundation	$1.7M

While funding for coastal management and climate adaptation is significant, very little is currently focused on natural infrastructure in urban settings.

Source: Comparison data from Foundation Center; Aga Khan Foundation.
Notes: Excludes grants from Rockefeller Foundation; reported figures are average of 2010 and 2011 annual total grants coded for relevance to coastal natural infrastructure.
The Aga Khan Foundation's Prince Sadruddin Aga Khan Fund for the Environment, established with $10M in 2006, does not release grant details, but does fund projects related to vulnerability of poor populations to natural disasters.

How are funding trends expected to change over time?

Several active conservation funders' efforts are beginning to take a more holistic view of the problem, incorporating ecosystem services into the goals of improved resilience and economic and social development.

Common Focus Areas of US Foundations Supporting Natural Infrastructure for the Poor and Vulnerable

Move Towards Resilient Green Economy Narrative	Communicating how improvements in resilience and sustainability that stem from natural infrastructure and other ecosystem benefits contribute to the economic competitiveness of a city. *(Examples: Kresge Foundation, Moore Foundation, UNEP)*
Improve Knowledge and Awareness of Ecosystem Services	Growing the evidence base in support of conservation and restoration interventions by assessing ecosystems on the basis of the full spectrum of services and benefits that they provide to local populations. *(Examples: Moore Foundation, McKnight Foundation, Packard Foundation)*
Support Coastal Restoration and Flood Protection	Focusing on urban areas recently struck by natural disasters, mobilizing the political, financial, and social will to rebuild and restore coastal infrastructure to be stronger and more resilient than it was prior to disaster. *(Examples: Packard Foundation, Kresge Foundation, Coca-Cola Foundation)*
Build Community Support to Protect Ecosystems	Emphasizing the need for conservation to have buy-in from local communities, namely by involving relevant stakeholders, from local public institutions to citizen participants, and weaving a protective human partnership around at-risk ecosystems. *(Examples: Packard Foundation, Ford Foundation)*
Build the Capacity of Key Government Institutions	Providing technical and financial support to national, state and local governments, recognizing that government institutions responsible for long-term resilience planning are under-resourced for essential functions such as regulatory enforcement. *(Funder examples: Bullitt Foundation)*

The diversity of donor perspectives represents an opportunity to reframe the broader narrative toward the importance of ecosystems for inclusive economic development. While the need to address this problem is most acute in the developing world, specifically Asia, most of the funding is directed toward projects in the US.

Source: Based on analysis of grant descriptions from Foundation Center and position papers published by top US foundations supporting coastal natural infrastructure.

Rockefeller Foundation
Innovation for the Next 100 Years

Communications Audit

Coverage Drivers

- As one would expect, the biggest driver of overall coverage was natural disasters, including Hurricanes Ivan, Katrina, Rita, Gustav, Irene, and Sandy, along with the Asian tsunamis in 2004 and 2011. These events garnered significant attention in the news, followed by opinion pieces and analysis of what lessons were – or should be – learned from the disasters, along with discussions about proposed policy changes for government and business.
- Climate change also drove conversation and coverage, particularly around efforts to mitigate and/or adapt to projected sea-level rise and erosion.

Gap Analysis

- There is little coverage focused on private-sector solutions, specifically what NGOs or foundations are doing to protect vulnerable coastal regions.
- While much of the coverage had economic themes, little was discussed about community-based approaches that coastal regions can take to help mitigate flooding caused by natural disasters and sea-level rise. There was little discussion about how local leaders are preparing their coastal communities for natural disasters and sea-level rise.
- There was little mention about innovative methods used to preserve and bolster natural infrastructure.

Volume, Geography and Tone

- The overall volume of coverage was enormous due to articles about disasters. Coverage was refined to focus more on natural infrastructure and the role of coral reefs, mangroves, etc., in protecting coastal areas. These topics garnered moderate coverage. There was moderate social conversation with 6,000 mentions in the last 12 months.
- Outside of the US and European (mostly UK) outlets, the majority of coverage originated in and focused on India, Indonesia, and China, which demonstrates the specific development challenges these three regions face along coastal zones.
- The tone was factual, with more reporting than commentary; articles focused on economic realities and costs/benefits of investing in prevention versus dealing with clean up after storms. In the US particularly, there appears to be a strong focus on technological innovation rather than coastal preservation.

Communications Opportunity

Highlights from Coverage

- The news cycles for this issue are largely driven by natural and manmade disasters, including Hurricanes Sandy and Katrina, and the 2004 Tsunami. This suggests an opportunity to position spokespeople to provide expert commentary on topics related to natural infrastructure in the immediate aftermath of disasters and to brief reporters who will be assigned to cover the individual disasters.
- The issue is often framed economically, with a focus on the larger cost/benefit analysis of prevention versus recovery, and conflicts between the tourism sector and local communities. There is little framing of the issue as one that directly impacts poor populations.
- Developing countries that are focused on preserving natural infrastructure fail to properly enforce coastal development restrictions, which suggest that improved communications and public awareness could serve to promote better preservation efforts by government and private actors.
- Media coverage in China and Indonesia both focused on the ecological benefits of limiting construction along the coastline, including China's efforts to build coastal preserves to protect wetland forests in Guangdong and Guangxi, areas of increased urbanization that impact mangrove living space.

White Space Recommendation

Natural disasters will drive coverage; climate change and flooding will garner interest among journalists. The white space is to generate more consistent focus on protecting natural infrastructure as the best use of public and private funds. Some outlets are cutting dedicated environmental reporters, and are bringing new reporters to cover stories about disasters. There is a need to educate them on this issue to shift focus to natural infrastructure in resulting stories.

5) Impact Assessment

Purpose

The Impact Assessment presents an early view of the impact potential in this space, outlining how we think change could happen based on the dynamism assessment and using scenarios to illustrate different impact ranges.

Key Findings

- Learning from the Search suggests high-level outcomes including increased recognition of natural infrastructure benefits, expanded markets for ecosystem services, expanded and inclusive access to financing, improved decision-making processes, and enhanced community co-management systems.
- An analysis of vulnerable urban coastal populations surfaced South and Southeast Asia as priority regions for this work. Other relevant regions include Sub-Saharan Africa, ranging from West African coastal urban zones in Nigeria to East African coastal urban zones in Mozambique. In the United States, the Eastern Seaboard and the Gulf Coast were also identified as areas for potential intervention. Further geographic priority-setting for a potential Initiative should consider additional variables, including availability of local partnerships and level of dependence on coastal natural infrastructure.
- Preliminary macro-level estimates on target populations suggest the potential to impact urban populations broadly, but with limited direct effects and transformative change for poor communities specifically. An illustrative impact goal related to work in medium and emerging cities could include 100,000 coastal poor people, who are vulnerable to loss of livelihood and basic services. Similarly work in large coastal cities could potentially impact 300,000- 1 million coastal poor people who are vulnerable to loss of life and property. While these numbers are in the realm of possibility over the lifetime of an initiative, further work will be needed to validate, refine, and explore the depth of potential impact on intended beneficiaries.

How We Think Change Could Happen

Areas of Dynamism That Could be Catalyzed Towards High-level Outcomes

Rising social and economic costs and damage due to coastal hazards in urban coastal zones

Growing experience and measurement accuracy in the monetization of ecosystem services

Growing support for climate adaptation interventions and technologies with potential for wider adoption, especially at the city level

Increasing availability of and experimentation with market and community-based solutions

Increasing recognition of economic and social value of ecosystem services for the resilience of urban communities

Expanding portfolio of tools, including natural and green infrastructure solutions, ecosystem valuation, and trade-off analysis

High-level Outcomes That Would be Required to Achieve the Impact Goal

Increased recognition of natural infrastructure benefits for strengthening the resilience of coastal communities by economic and policy actors

Improved decision-making processes to integrate the full value of natural infrastructure into coastal development planning

Expanded and inclusive access to financing for natural and green infrastructure investment

Expanded markets for ecosystem services in urban coastal zones that are accessible and equitable to the poor

Enhanced community co-management that promotes ecosystem stewardship and equity

Potential Impact Goal

Protected and enhanced coastal ecosystems to improve the long-term resilience of urban communities.

Illustrative Scenarios for Impact

These scenarios present selected choices around which a potential development strategy could be designed.

Scenario 1: Large Coastal Cities

Vulnerability to loss of life and property is highest among populations living in large coastal cities, especially those living in informal low-income settlements.

More of the natural infrastructure in large urban zones has been degraded from human activity and, as such, populations in large cities are less dependent on ecosystems for basic services. However as there is less natural infrastructure remaining, there are both acute and gradual risk to life and property, from seasonal floods, coastal storms, and sea level rise.

Possible interventions to increase resilience in large coastal cities may include enhancing natural infrastructure as well as incorporating green infrastructure and gray infrastructure, and bio-mimicry into land use strategies.

What was measured: size of population, vulnerability to hazards, size of poor population.

Scenario 2: Medium and Emerging Coastal Cities

Vulnerability to loss of livelihood and basic services is highest in medium and emerging coastal cities.

Medium and emerging coastal cities have not experienced the extent of natural infrastructure degradation seen in larger cities. Communities in medium-sized cities depend on coastal natural infrastructure for incomes and livelihoods, water and waste treatment, as well as cultural and other benefits from coastal ecosystems. The resilience of these communities is threatened by future ecosystem degradation.

Possible interventions to prevent further ecosystem loss and preserve the resilience of medium and emerging cities may include ecosystem restoration and enhancement programs that promote sustainability, education, and livelihood generation.

What was measured: size of population, size of poor population, number reliant on ecosystem services.

The types of vulnerabilities vary by size of city and extent of ecosystem loss. Interventions are likely to benefit urban populations broadly rather than poor communities specifically.

Note: Vulnerability is defined as the propensity or predisposition to be adversely affected, e.g., by natural hazards or loss of ecosystem benefits

Illustrative Scenarios for Impact Vision of Scale

Affected Populations	*Possible Solution Spaces*	*Vision of Scale*
Coastal communities facing vulnerability to loss of life and property. • ~575 million people globally live in large coastal cities. • ~75 million people in large coastal cities are poor and highly vulnerable to coastal hazards.	Mangrove restoration projects in urban areas	**Example Drawn on**: Vietnam. **Direct Impact**: improved flood protection for ~50,000 people living in the immediate area. **Indirect Impact**: large scale restoration could yield increased resilience of 4-8 million urban residents in Vietnam.
	Coastline redevelopment of large port city	**Example Drawn on**: "Carter Road Seafront" in Mumbai. **Direct Impact**: development of port that includes restoration of 1.25km of mangroves. **Indirect Impact**: increased coastal protection.
Coastal communities facing vulnerability to loss of livelihood and basic services. • ~165M live in coastal medium & emerging cities globally. • ~50 million poor people dependent on natural infrastructure for livelihoods, including fishermen and those providing associated services.	Community-based mangrove reforestation and disaster preparedness program	**Example from**: rural Vietnam. **Direct Impact**: 9,000 hectares of mangroves, and 100km of sea dike, providing increased storm protection to ~350,000 people living in immediate area. **Indirect Impact**: increased storm protection, awareness , and preparedness for 2 million people.
	Community-based coastal restoration projects in medium and emerging cities in Southeast Asia	**Example Based on**: coastal communities impacted by tsunami. **Direct Impact**: restoration of 1,000 hectares of mangroves and protection of 100km of coral reefs and 4km of sand dunes. **Indirect Impact**: desalinated water, and other improved ecosystem services leading to improved livelihoods for ~50,000 people.

* Examples of project goals and impacts in the field are referenced in the Appendix.

Appendix

Appendix Outline

Content in the Appendix	Slide Number	Summary of Content
Definitions	40-42	• Provides definitions of key terms used through the Decision Intelligence Document
Typology of Coastal Ecosystems	43-45	• Highlights coastal wetlands and coral reefs as the most valuable coastal ecosystems due to their regulating and cultural services, although valuations can vary widely • Argues that coastal ecosystems provide natural infrastructure to urban coastal poor populations and presents city-specific examples of opportunities for impact
Scale of Ecosystem Degradation	46-47	• Demonstrates that mangrove forests and coral reefs are degrading rapidly, especially in Asian countries
Global Distribution of Flood Risk	48	• Presents evidence that Asian countries are home to the largest populations located in high-risk urban flood zones
Distribution of Urban Poverty and Flood Risk	49	• Argues that Asian coastal cities are home to the largest poor populations globally and that interventions should aim to reduce vulnerability in these cities • Recognizes that localized threats will mean need for localized solutions
Funding Landscape	50-52	• Indicates that ODA relating to cities and natural infrastructure is concentrated in a few top donors and focused mainly on water issues in Asian countries • Demonstrates philanthropic funds from US foundations are mainly concentrated in ecosystem management, adaptation planning and ecosystem services in the US
Scope of Potential Impact	53-54	• Provides an indicative estimate of the scale of potential impact, arguing that impact is best expressed in terms of different types of vulnerability across coastal cities • Presents city-specific illustrative examples of the scope of potential impact in both developed and developing countries
Potential Impact of Green Infrastructure	55	• Describes and provides examples of benefits that green infrastructure can provide to urban poor populations, including increased flood protection, improved health, increased social capital, decreased costs, improved food security, and job creation
Examples of Initiatives in the Space	56-60	• Examples of programs and initiatives related to coastal ecosystems and natural infrastructure with high level impact goals and budgets where available.
Sources	61-63	• Cites sources of information that informed the findings throughout the document

Definition of Key Terms (1/3)

Term	Definition
Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.
Climate change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Coastal zones	Low-lying areas below 10 meters above sea level, bordering major water formations such as oceans or deltas. (IPCC) Note: Low-lying coastal zones can include areas ranging up to 100km from the shoreline; 14 of the top 20 US cities are located within 100km of the coast and are considered coastal (USGS); the coastal region also provides critical services for over two billion people worldwide who live within 100km of the coast or estuaries as well as inland populations ("Ecosystem Services for Poverty Alleviation", ODG-DEV, 2008).
Disaster	Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery.

Definition of Key Terms (2/3)

Term	Definition
Ecosystem services	Components of nature directly enjoyed, consumed or used to yield human well-being. Examples include fresh water, timber, climate regulation, recreation and aesthetic values.
Exposure	The presence of people; livelihoods; environmental services and resources; infrastructure; or economic, social, or cultural assets in places that could be adversely affected.
Flood	The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.
Governance	The way government is understood has changed in response to social, economic, and technological changes over recent decades. There is a corresponding shift from government defined strictly by the nation-state to a more inclusive concept of governance, recognizing the contributions of various levels of government (global, international, regional, local) and the roles of the private sector, of nongovernmental actors, and of civil society.
Green infrastructure	Green infrastructure refers to a set of solutions to maintain healthy waters, provide multiple environmental benefits and support sustainable communities. Unlike single-purpose gray stormwater infrastructure, which uses pipes to dispose of rainwater, green infrastructure uses vegetation and soil to manage rainwater where it falls. Benefits include stormwater management, flood mitigation, and air quality management. (US EPA)
Hazard	The potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources.

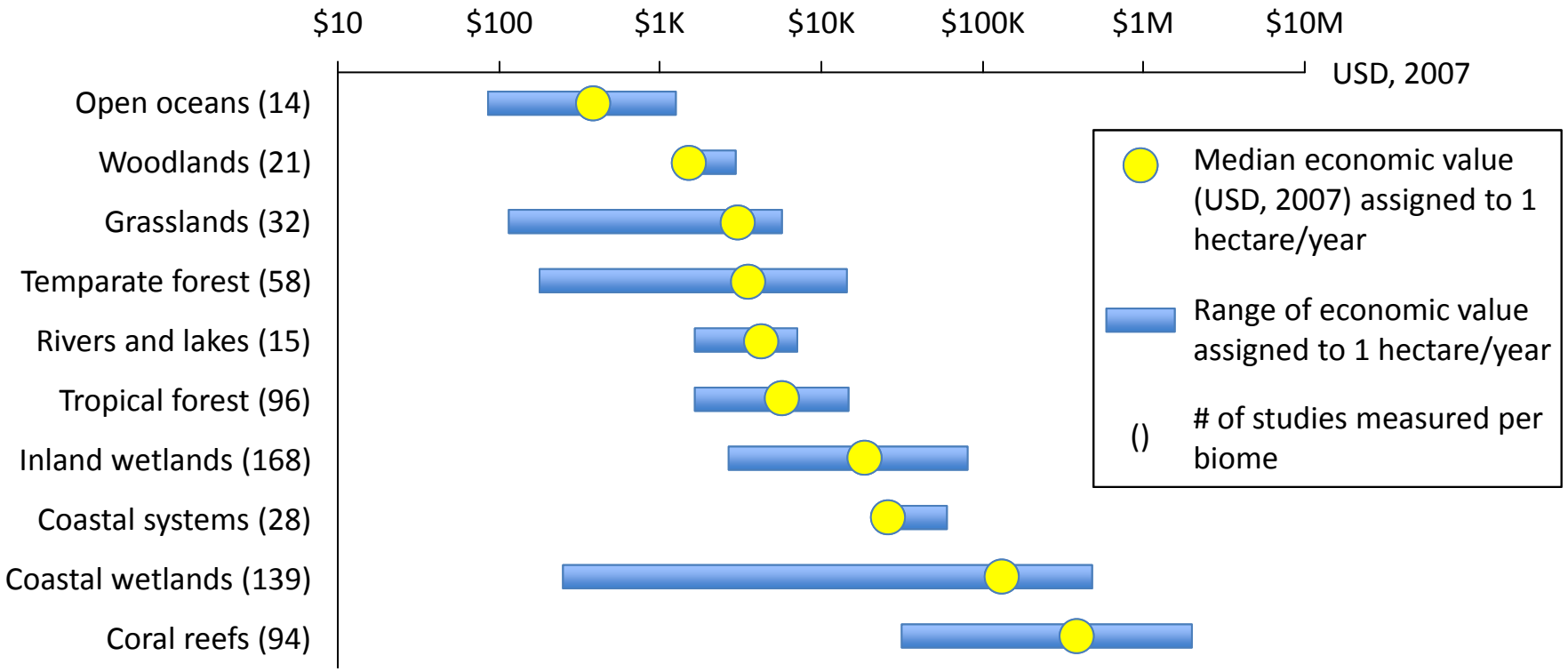
Definition of Key Terms (3/3)

Term	Definition
Land use / land use change	Land use refers to the total of arrangements, activities, and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover.
Natural infrastructure	The interconnected network of natural and undeveloped areas needed to maintain and support ecosystems that provide a wide array of environmental, health and economic benefits such as mitigating climate change impacts and sustaining clean air and water. (US EPA)
Poor/poverty	Living on <$2 per day or without resources sufficient to meet their needs.
Resilience	The capacity of individuals, communities and systems to survive, adapt, and grow in the face of stress and shocks, and even transform when conditions require it.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Vulnerability	Propensity or predisposition to be adversely affected due to high exposure to risks including loss of life/health, livelihood, and property (e.g., from natural hazards)
Wetlands	An area that is regularly saturated by surface water or groundwater. Examples of wetlands include swamps, bogs, fens, marshes, and estuaries.

Typology of Coastal Ecosystems (by ecosystem value)

Estimated monetary values of ecosystem services per selected biome

Coastal natural infrastructure provide an array of services to the urban coastal poor, including protection. Exact estimates of natural infrastructure value range by type and specific location



Valuations can vary widely, but natural infrastructure wetlands cover a minimum of 1.2B hectares (~10% of global land area), with services valued as high as $2.1M/hectare

Source: "Global estimates of the value of ecosystems and their services in monetary units," de Groot, et al. Ecosystem Services, July 2012

Typology of Coastal Ecosystems & Services

Type of Coastal Ecosystem	Type of Ecosystem Services Provided				Natural Infrastructure for Urban Coastal Poor
	Provisioning	Regulating	Habitat Support	Cultural	
Coastal Wetlands *(e.g., mangroves, tidal marshes, salt water wetlands)*	• Fresh water supply • Fuel/ bldg. material	• Water purification • Waste treatment • Protect v. flooding	• Nursery services • Gene pool protection	• Recreation/tourism (*)	• Source of clean water • Storm and flood protection
Coastal Systems *(habitat complexes, e.g., deltas, shallow seas, rocky shores, dunes, estuaries)*	• Food production (fisheries) • Aquaculture	• Nutrient cycling • Protect v. erosion • Protect v. flooding (*)	• Nursery services	• Recreation/tourism • Aesthetic info.	• Erosion protection • Tourist attraction
Coral Reefs	• Food production (fisheries) • Building materials	• Maintenance of water quality	• Gene pool protection	• Recreation/tourism • Aesthetic info.	• Employment/income • Food production • Tourist attraction • Cultural/community values
Other Wetlands *(e.g., floodplains, inland swamps/ marshes, peatlands)*	• Fresh water supply	• Reg. water flows • Nutrient cycling • Protect v. hazards	• Gene pool protection	• Aesthetic info.	• Storm and flood protection

Value of services <$1k per ha; $1k-$10k per ha; $10k-$50k per ha; $50k-$100k per ha; >$100k per ha; (*) Very few studies conducted

Source: TEEB (2010); de Groot et al. (2010); "Ecosystem Services for Poverty Alleviation: Marine and Coastal Situational Analysis," UEA (2008).

Typology of Coastal Ecosystems (impact examples)

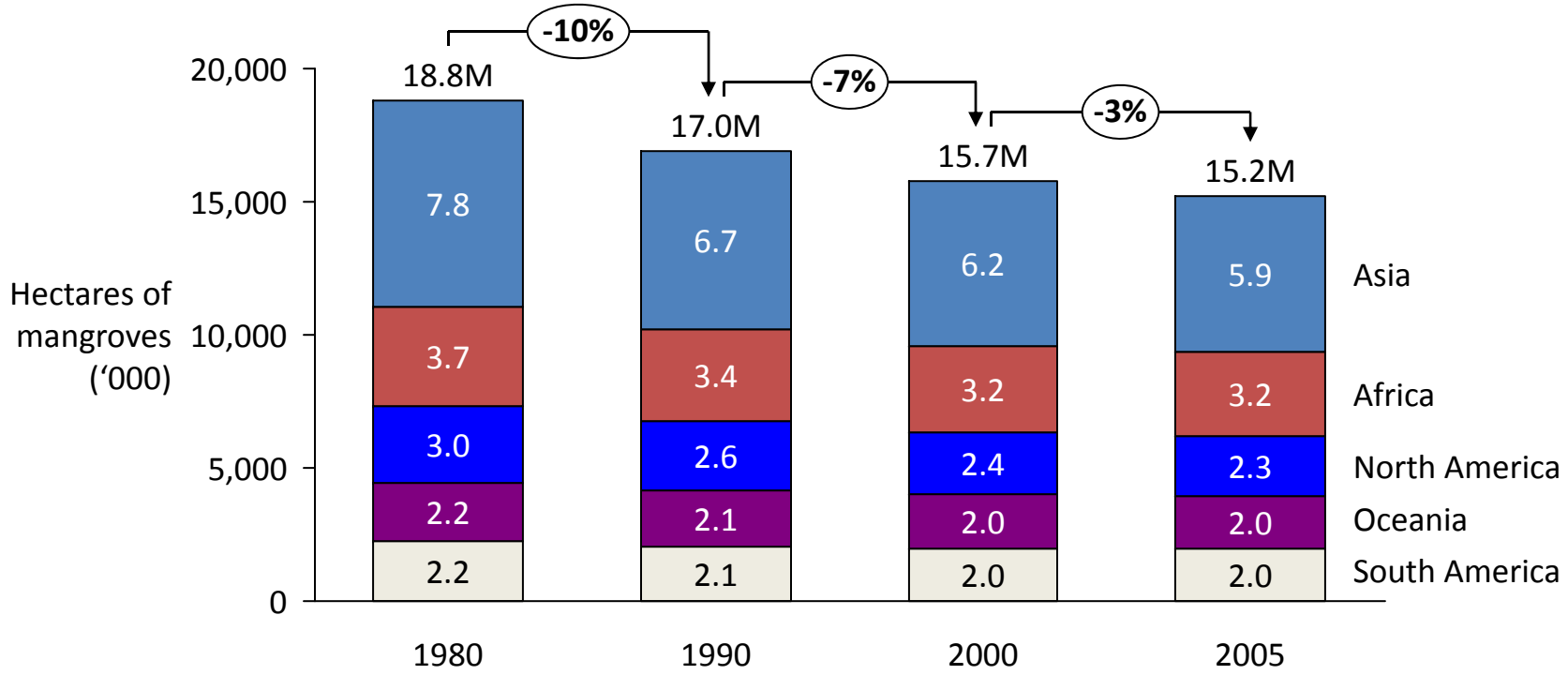
Mapping cities by types of ecosystems they have, or have had, **can be interesting academically but is not actionable** as **many cities rely on multiple ecosystems** (i.e. Coastal systems, coastal wetlands, and other wetlands are all relevant to Dhaka and Jakarta is a deltaic city that is home to mangroves and vulnerable coral reefs)

Type of Coastal Ecosystem	Current Context	Opportunity for Impact	Select Examples
Coastal wetlands *(i.e. Mangroves, tidal marshes, salt water wetlands)*	• Rapid population growth and city expansion (Lagos spread from 200 sq. km to 1,140 sq. km 1960-2000) and widespread mangrove destruction continues to increase vulnerability by decreasing water filtration and storage, spreading disease and increasing exposure to rising coastal hazards in developing coastal cities	• Restoration can bolster resiliency of local infrastructure & systems, particularly serving and protecting the poor	• **Alexandria** • **Ho Chi Minh City** • **Lagos** • **Mumbai**
Coastal systems *(habitat complexes, e.g., deltas, shallow seas, rocky shores, dunes, estuaries)*	• Development and population growth in cities such as Abidjan and Tianjin have led to both polluted coastal waters and overfishing that have led to significant declines in marine fisheries	• Support local livelihoods and food production by protecting integrity and sustainability of local coastal systems	• **Abidjan** • **Tianjin**
Coral reefs	• Estimated coral reef associated tourism revenue is in excess of $125 million across Indonesia annually • According to the World Resources Institute, ~60 million people across Indonesia live within 30 KM of a coral reef • +70% of Philippines coral reefs degraded from human activity	• Sustain livelihoods through preservation of live reefs • Coastal hazard protection through restoration	• **Jakarta** • **Manila**
Other wetlands *(i.e., floodplains, inland swamps/ marshes, peatlands)*	• Rapidly growing cities like Dhaka face shrinking wetlands (30% loss '05-'11), exacerbating persistent flooding and declining groundwater levels - leading to increased land subsidence vulnerability	• Restoration of wetlands provides essential ground-water storage and runoff, preventing spread of disease and stabilizing cities	• **Dhaka** • **Kolkata** • **Shenzen**

Scale of Ecosystem Degradation (mangroves)

Global mangrove area by region, 1980-2005

50% loss of global wetlands such as mangroves since 1900, and continued recent losses in high risk zones have raised vulnerability of those coastal poor who need its services most



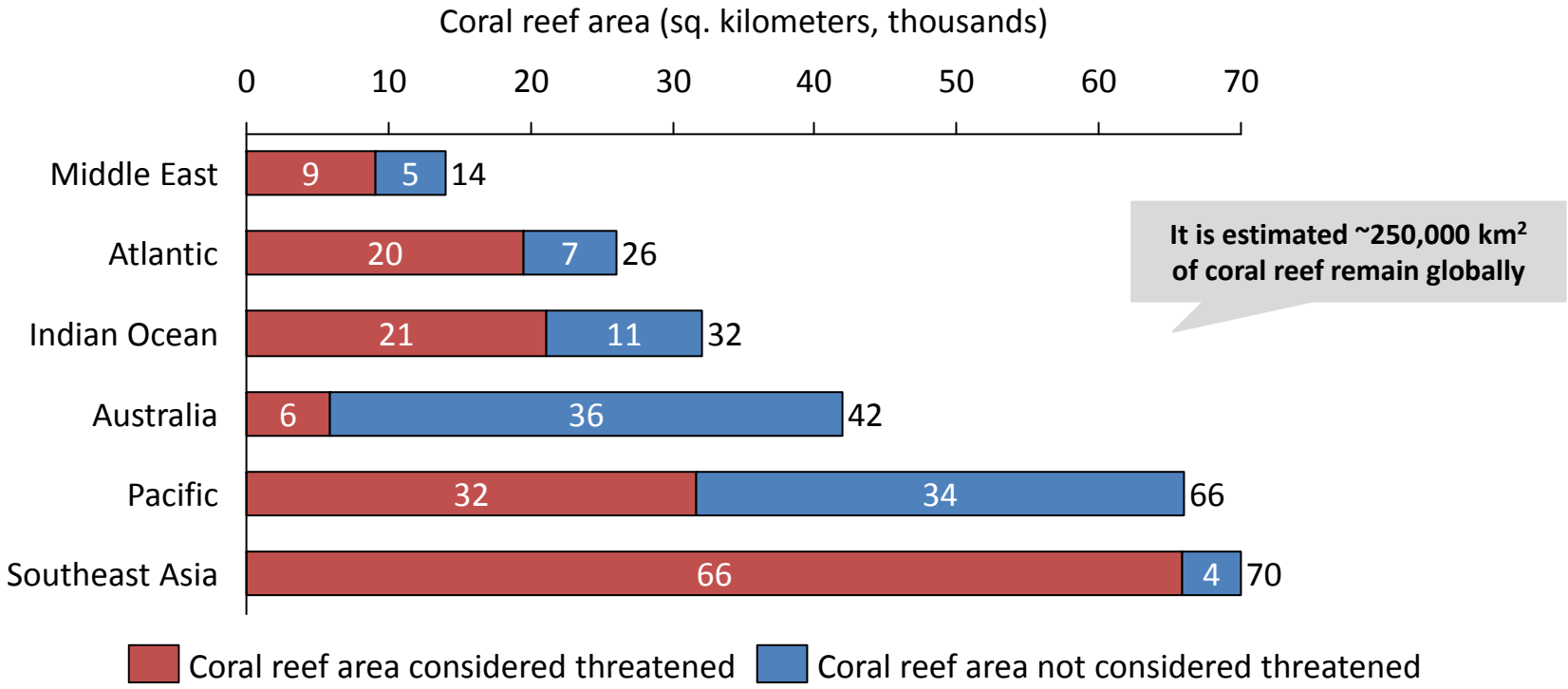
Between 1980-2005, global mangrove area fell by 4M hectares (approximately 20%), with the highest losses experienced across Asia and North America; it is projected 60% of global mangrove forest area could be lost in the next 20-40 years

Source: "The World's Mangroves: 1980-2005," FAO Forestry Paper 153. Food and Agriculture Organization of the United Nations, 2007.

Scale of Ecosystem Degradation (coral reefs)

Global distribution of coral reef area

Over the past 20 years, it is estimated approximately 20% of global reef area has been lost, while much more of the remaining area remains under threat



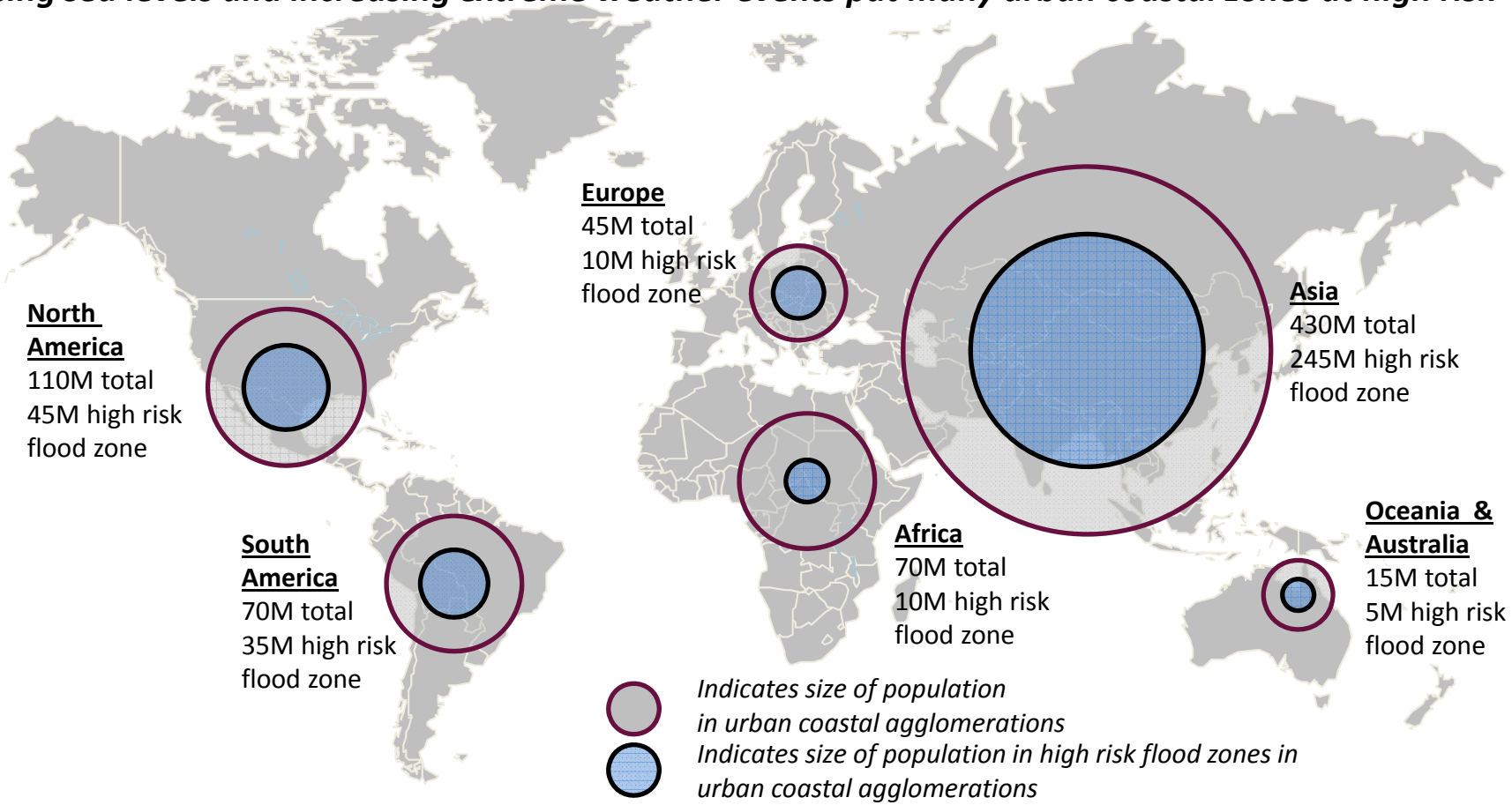
In the next 30 years, an estimated 60% of remaining coral reef area could be lost; in Asia, nearly 95% of remaining coastal reef area is threatened

Source: "Reefs at Risk: Revisited," WRI, 2011

Global Distribution of Urban Flood Risk (by continent)

Population in large urban areas vs. population in high risk urban flood zones

Rising sea levels and increasing extreme weather events put many urban coastal zones at high risk

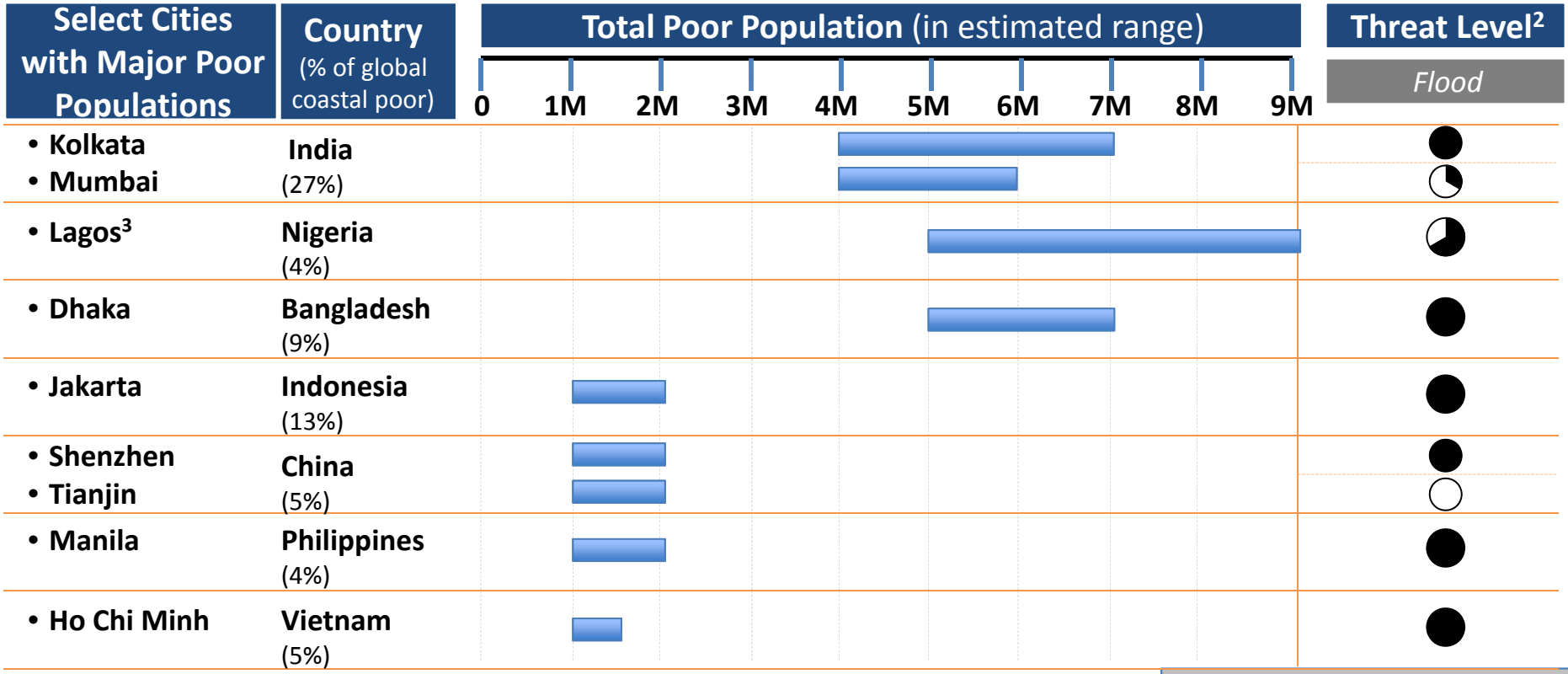


>750M live in 'high risk' urban flood zones and 70% live in Asia; poor and vulnerable populations often reside in these areas

Source: United Nations Department of Economic and Social Affairs, Population Division

Distribution of Urban Poverty and Flood Risk (by city)

Seven countries are home to roughly 67% of the global coastal poor population[1]. Six of these countries, save for Nigeria, are located in Asia. Within these countries we have estimated the poor populations for a select number of the largest cities with the largest poor populations.



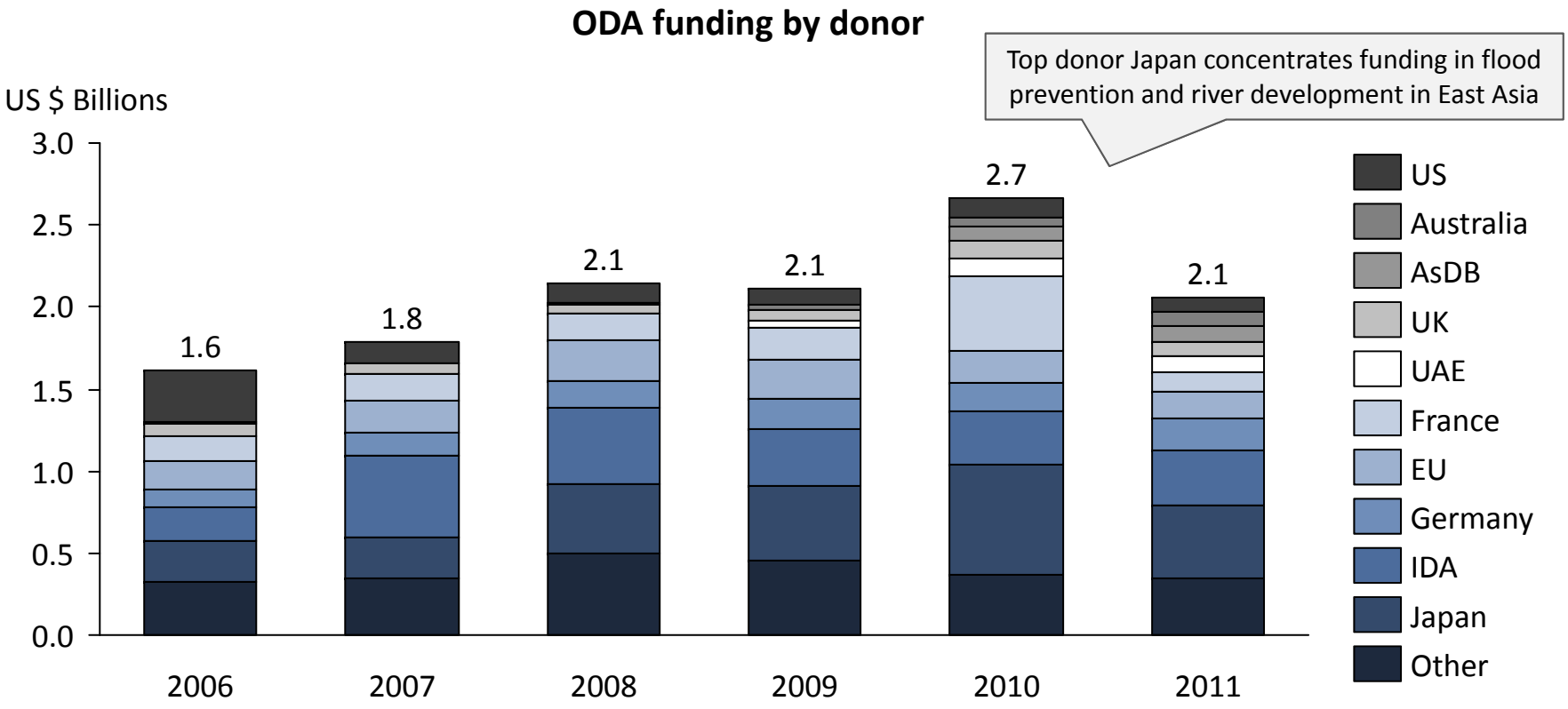
Several cities offer the opportunity to reach more than a million poor and vulnerable – but localized threats will mean need for localized solutions

No threat *Low threat* *Medium threat* *High threat*

Note: (1) Poor is defined as those living on less than $2 per day. Estimates are necessary because of differing methodologies in local measurement of poor; (2) UN DESA, World Urbanization Prospects, 2011; (3) Wide estimate due to poor data and high population volatility

Funding Landscape (sources of ODA)

ODA Funding Landscape: Key Observations



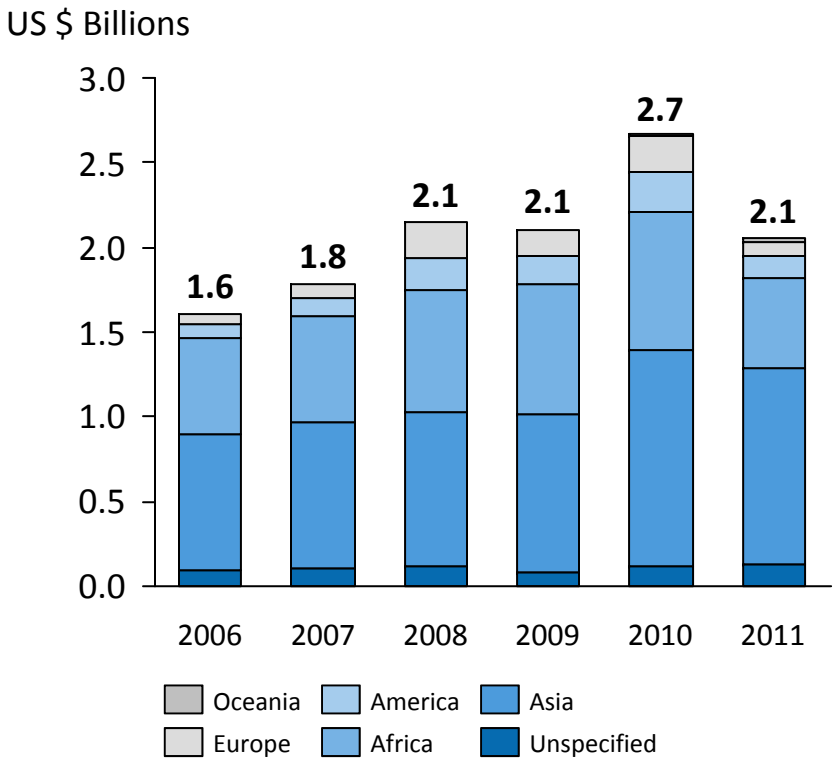
Japan and IDA lead ODA to areas pertinent to natural infrastructure and bilateral donors comprise the bulk of ODA to these areas overall

Source: OECD Creditor Reporting System
Notes: Includes funding for water resources policy/administration management, river development, flood prevention/control, and urban development and management from all OECD-reporting donors

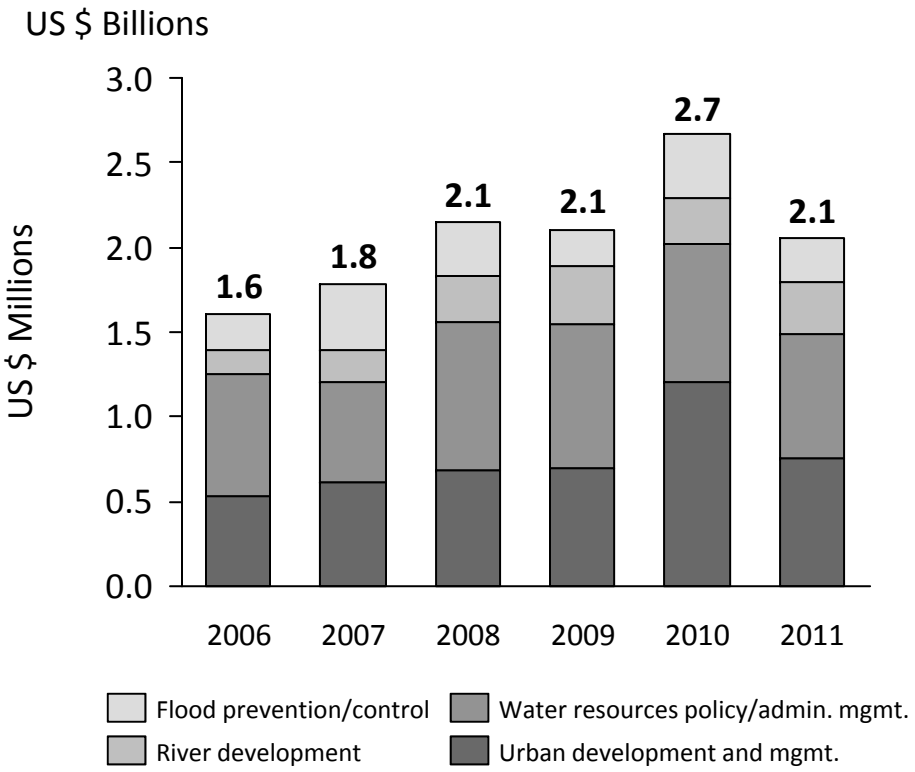
Funding Landscape (uses of ODA)

ODA Funding Landscape: Distribution of Funding

ODA funding by region



ODA funding by sub-sector



ODA for sectors relating to vulnerable natural infrastructure is mainly concentrated in Asia and Africa and focused on water resources

Source: OECD Creditor Reporting System

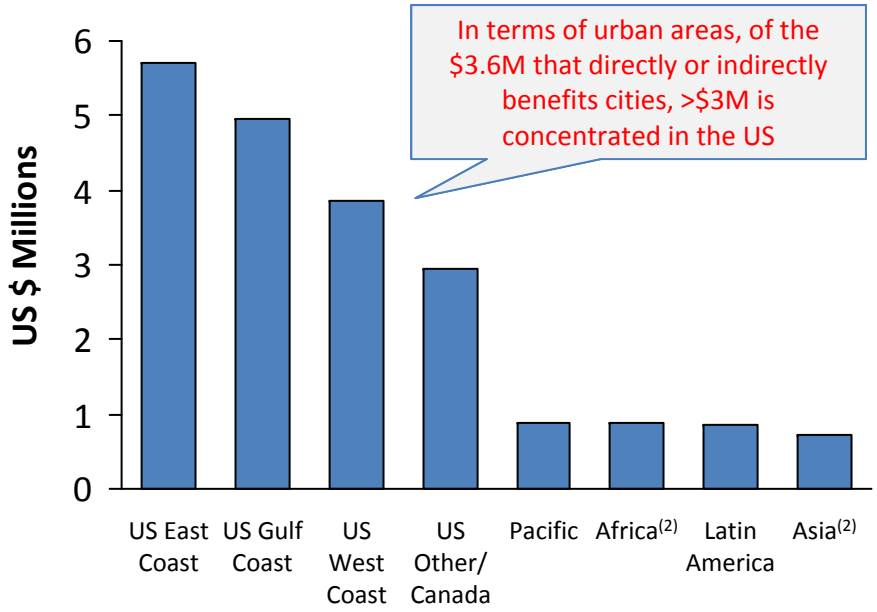
Notes: Includes funding for water resources policy/administration management, river development, flood prevention/control, and urban development and management from all OECD-reporting donors

Funding Landscape (uses of philanthropic funds)

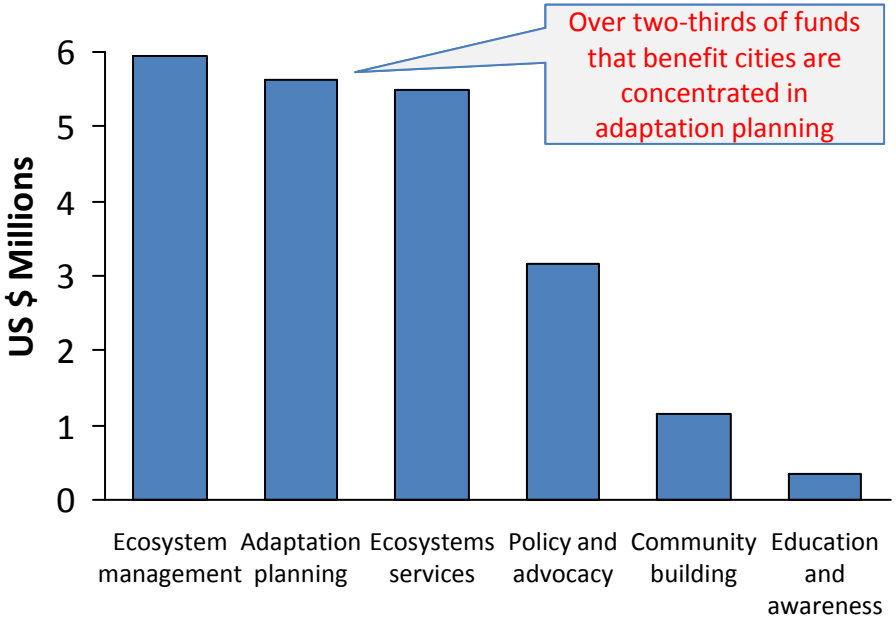
Philanthropic Funding Landscape: Distribution of Funding

- Investment is heavily concentrated in the US, primarily in the Gulf and East Coasts
- Africa and the Pacific see significantly less philanthropic funding

Private funding by target region(1)



Private funding by sub-sector(1)

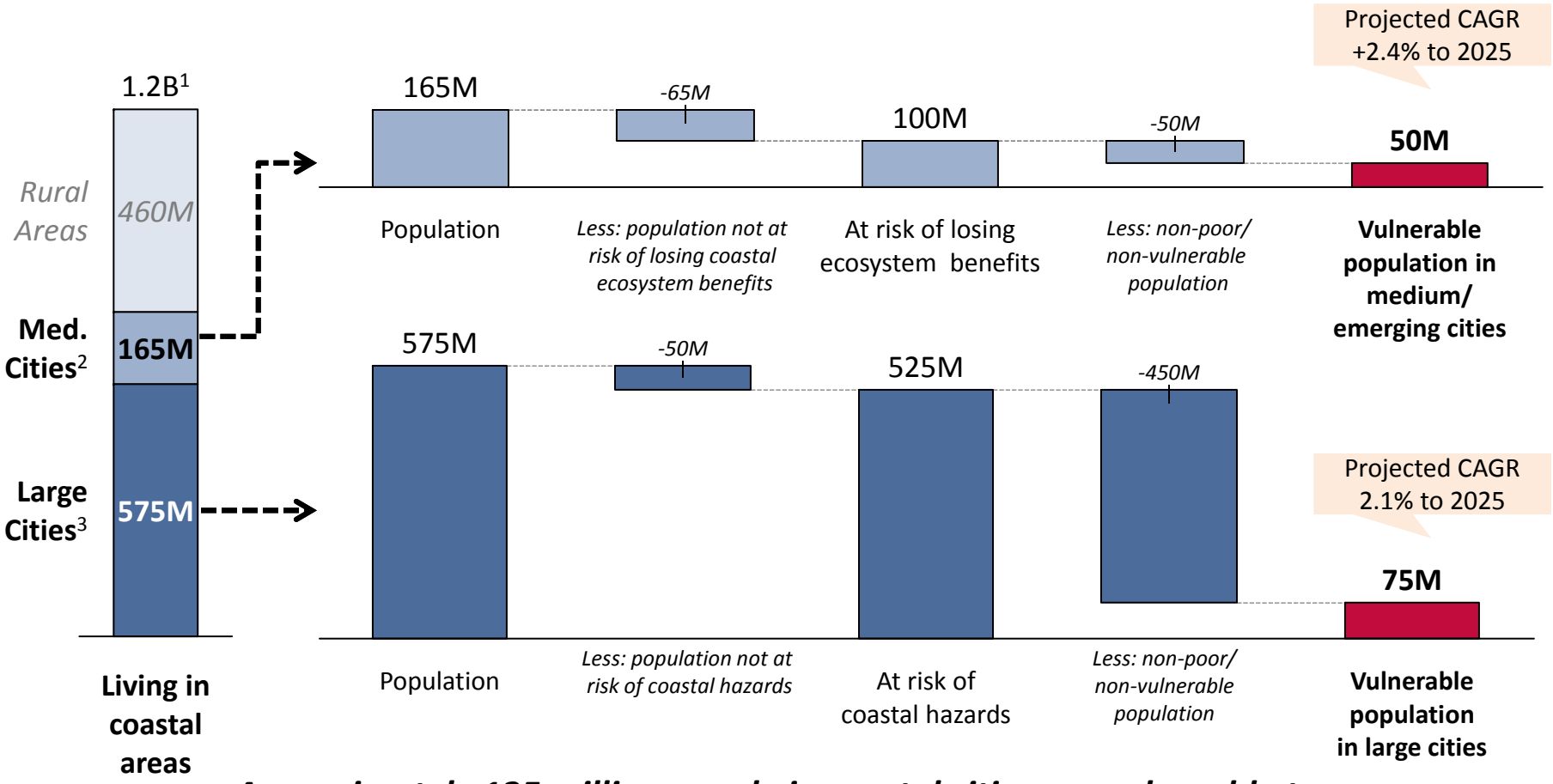


Philanthropic funds from US foundations are mainly concentrated in ecosystem management, adaptation planning and ecosystem services in the United States, but typically do not directly involve poverty reduction through these areas

Source: Comparison data from the Foundation Center
Note: (1) Average of funding for years 2010 and 2011; (2) Excludes funding from the Aga Khan Foundation, which works primarily in Asia and Africa

Scope of Potential Impact (primary segmentation)

Vulnerable Populations in Large and Medium/Emerging (Med.) Coastal Cities



Approximately 125 million people in coastal cities are vulnerable to either natural hazards or loss of natural infrastructure

Note: (1) Equal to 23% of global population and defined as people living within 100m of sea level and 100km from a coast according to Nicholls, 2003. (2) Medium/ Emerging Cities defined as 750K-2M. (3) Large Cities defined as 2M+.

Scope of Potential Impact (secondary segmentation)

Primary Segmentation	Examples per Secondary Segmentation for Scope of Impact (illustrative)		
	Coastal city typology	Opportunities for Learning	Windows of Opportunity at the Municipal/National Level
Vulnerability to loss livelihood and basic services	• **Dhaka, Bangladesh** – Located in the world's largest delta system, Dhaka faces a growing crisis as the degradation of wetlands exacerbates groundwater depletion, which speeds land subsidence, which exposes Dhaka to even greater vulnerability from its many coastal hazards. • **Lagos[1], Tianjin…**	• **Sundarbans, India** – Multi-million dollar projects conducted over several years are lacking in the space but the Livelihoods Fund is in execution phase of 3 mangrove restoration projects of the $2.5M - $5M+ scale and can provide invaluable insights into the best methods of achieving essential success factors such as community buy-in. • **Ho Chi Minh City, Senegal…**	• **Costa Rica** – Following rapid deforestation and biodiversity loss in the 1980s, the Costa Rican government introduced innovative mechanisms in the 1990s to mainstream a high valuation of ecosystems for their carbon fixation, hydrological services, biodiversity protection and provision of scenic beauty. • **The Coral Triangle, Ecuador…**
Vulnerability to loss of life and property	• **Manila, Philippines** – Located just above sea level built on the alluvial deposits of the Pasig River, the city is highly vulnerable to cyclones, sea-level rise, floods and droughts. In 2009, tropical cyclone Ketsana displaced nearly 500K and killed more than 300. Projected sea rise could displace +2.5 million people and inundate 5,000 hectares of the Manila Bay coastal area • **Jakarta, Mumbai…**	• **Netherlands** – The Dutch government adopted a "dynamic preservation" policy regarding the national coastline in 1990 in areas not protected by dikes, dams and storm surge barriers. Relying heavily on nourishment as the principal method to combat erosion, the strategy can offer lessons to other innovators. • **Queensland, Portugal…**	• **New York, USA** – Following Hurricane Sandy, the value of coastal ecosystems and natural infrastructure has been prioritized, at least temporarily. The NYS 2100 Commission put forth sweeping and significant recommendations for investments in such defenses. Opportunities are likely to arise from this momentum. • **New Orleans, Maldives…**

Note: (1) *Italic text* represent additional potential examples. It should be noted these are non-exhaustive and are only meant to provide a preliminary indication of potential geographic focus areas globally

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Potential Impact of Green Infrastructure

Overview of Benefits of Green Infrastructure for the Urban Poor

Increased flood protection

- Impervious gray infrastructure alters the natural hydrology, preventing infiltration of water into the ground and increasing exposure to water pollutants. Green infrastructure can prevent overflow and pollutant exposure.

Improved health

- Green infrastructure can provide significant benefits to urban air and water, by serving as a low cost treatment system simply by conducting natural processes (i.e. creating oxygen, filtering wastewater).

Increased social capital

- Green infrastructure has been proven to revitalize blighted neighborhoods by enhancing street life and community aesthetics, increasing property values, providing free recreation, creating jobs and leading even to reduced crime.

Decreased costs

- Energy efficient green buildings can lead to significant cost savings for energy costs and reduce burdens on particularly the urban poor.

Improved food security

- Green infrastructure can lower food costs for the urban poor by creating space to grow produce that can supply an urban center. Otherwise urban poor often pay more than rural poor for their food, with less selection and poorer quality due to their location.

Examples

- **Lagos, Nigeria –** A study of a poor neighborhood found heavy rains led to 2-4 days of flooding, with 6 lost man hours per person per incident, simply due to poor infrastructure design that could be improved with permeable materials, green roofs, etc.
- **Michigan, USA –** Completed construction of 9 built and 5 natural acres of wetlands that filtered stormwater before it entered the nearby Rouge River. Replacing a wastewaster discharge system, a study found the wetlands reduced total solids in the water by 80%, phosphorus by 70% and oxygen depleting substance and heavy metal concentrations by 60%.
- **Dhaka, Bangladesh** – A compost generating project has helped generate 1,200 new jobs while eliminating waste and creating fertile soil for urban food production

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Examples of Initiative Goals and Impacts

Initiative/Study	Description	Timeline	Cost (in $US)	Impact	Benefits to Coastal Population
Central Kalimantan peat land project (CKPP)	The project aimed to address poverty and environmental issues in the peatlands of Central Kalimantan. The project was carried out in Indonesia by a Consortium of four NGO's and the local University, led by the Wetlands International. The project interventions in terms of peat fire prevention, integrated water management, poverty reduction and conservation of remaining peat swamp forests and biodiversity were directly contributing to the goals of the CBD, the Wetlands Convention (Ramsar) and were relevant to the achievement of the goals of the Kyoto protocol.	2005-2008	$8 million	-Restoration of 50,000 hectares of degraded peatland by building 16 large dams and over 150 small blocks –Reduction of CO2 emissions by 5 Million tons per year -Re-greening 1500 hectares of degraded peat land -Strengthening conservation of the Sebangau National Park -Improving fire security in 150,000 hectares -Creating economic alternatives and health facilities in 17 villages	(i) Hydrological restoration of degraded peat swamp forests: Socialization of the issues and solutions with communities, followed by building and maintenance of dams by those communities. (ii) Fire prevention and fire fighting (iii) Livelihood measures: Provision of micro-credits and other opportunities for community-based development; development of livelihood strategies integrated with government planning, and investment in health facilities focused at improving nutrition and pre-and post-natal care. (iv) Re-greening of hydrological restored peat land areas: Community-based re-greening using commercially valuable indigenous peat swamp tree species, including fire resistant species.

Source: Wetlands International

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Examples of Initiative Goals and Impacts

Initiative/Study	Description	Timeline	Cost (in $US)	Impact	Benefits to Coastal Population
Green Coast Project	The goal of this project was to restore livelihoods of the coastal communities impacted by the Tsunami in Sri Lanka, India, Indonesia, Thailand and Malaysia, by advancing the recovery of coastal ecosystems. 3 main components: (i) Ecological and socio-economic assessment studies (ii) Community-based coastal restoration: Small Grants Facilities provided grants for community-based organizations and NGOs engaged in restoration of coastal forest (mangroves) and other ecosystems and, at the same time, provided incentives for communities to rebuild their livelihoods or start small scale enterprises. (iii) Policy & Communications	2005-2008	$6.8 million	-A total of 177 micro, small and large size restoration projects were implemented, benefitting a total of 91,000 tsunami affected people in the 5 countries. -A total of 1,000 hectares of coastal and mangrove forest was successfully replanted with 2 million seedlings, -100 hectares of coral reef & sea grass beds were protected and 4 km of damaged sand dunes were restored.	-Total of 12,500 households benefitted directly from improved livelihoods as their agricultural land has been desalinated -More than 1,000 drinking wells were cleaned and the 177 projects provided options to start small scale enterprises such as eco-tourism, small scale fish farming, handicrafts, etc. -A total of 122,000 people benefited from raised awareness and were educated on the key assets of coastal ecosystems for coastal communities.

Source: Wetlands International

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Examples of Initiative Goals and Impacts

Initiative/Study	Description	Timeline	Cost (in $US)	Impact	Benefits to Coastal Population
Coastal Alabama Restoration Project (The Nature Conservancy, Alabama Dep't of Conservation, Dauphin Island Sea Lab, Mobile County and University of South Alabama)	Created living shoreline at four sites, an estimated 1.5 miles of shoreline. The main sites are located at Coffee Island Alabama Port. Vertical oyster reefs were constructed using different reef types: REEFBLKsm system, Reef Balls, bagged oyster shell, and HESCO barrier breakwaters.	January 2011-summer 2012	$2.9M (average cost is $1.5M/mile of oyster breakwater)	Two miles of coastal protection created. Physical and biological monitoring of the breakwaters shows their effectiveness in shoreline protection, oyster protection, and fish production.	In addition to ecosystem services benefits, socioeconomic survey measured the impact of the infusion of stimulus funds and job creation into coastal communities from the project: project employed 33 full time worker and contributed to paychecks for 83 positions in coastal Alabama community.
Bangladesh Mangrove Restoration	The largest mangrove afforestation project in the world, developed to protect the lives and properties of coastal communities from cyclone and storm damage. An area of 120,000 ha was afforested.	1980 - 1990	$20M USD (planting only)	Survival rates of the planted mangroves after 5 years ranged from 29% – 52% for a *Sonneratia apetala* species of mangrove; 30 – 60% for *Avicennia*. After an intense cyclone in April 1991 many mangrove plantations were damaged by later on showed signs of recovery indicative of a self-repairing system.	People have benefitted from the stabilization of new land formed by deltaic deposits ("char" lands) and coastal protection. (Field, 1996).

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Examples of Initiative Goals and Impacts

Initiative/Study	Description	Timeline	Cost (in $US)	Impact	Benefits to Coastal Population
Community-based Mangrove Reforestation and Disaster Preparedness Programme in Vietnam	8,961 ha of mangroves created in 66 communities, 100km stretch of sea dike line protected	1994 – 2010 (16 years) Funded by Danish Red Cross 1994 - 2005. Funded by Japanese Red Cross 2005 – 2010.	$8,885,000 total program expenditure $843 USD = costs to create one ha of mangroves	Restored mangrove system led to a reduction in wave height from 4m to 5m and prevented all damage to the sea dike.	350,000 direct beneficiaries. 2 million indirect beneficiaries better protected by mangroves and other trees. Local people benefit from storm protection although experience frustration at not being able to pursue more profitable uses of the land (such as crab collection or shrimp farming).
Re-development of 1.25 km of Mumbai coastline, “Carter Road Seafront”	PK Das Associates in India designed and oversaw the re-development included the integration of regenerated mangroves	2001 - 2002	$274,095	Development at the Carter Road seafront regenerated the mangroves, previously used as a dumping ground.	Coastal protection and reclamation of public space for get-togethers and cultural events.

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Examples of Initiative Goals and Impacts

Initiative/Study	Description	Timeline	Cost (in $US)	Impact	Benefits to Coastal Population
Climate and Disaster Risk Reduction Strategy	The Nature Conservancy has embarked on a plan to reduce coastal and inland flooding in six of the world's most vulnerable countries, showing that investments in ecosystem protection and restoration are viable and cost-effective natural solutions.	2013 - 2020	$11M per year. Additional strategies and activities would grow TNC's spending to $16m - $19M per year.	• Natural coastal infrastructure improvements • Shaping of national policy, institutional arrangements, and financial architecture to harmonize adaptation, DRR, and development plans, and to increase public and private investments in natural infrastructure.	• Restoration and protection of floodplains, coasts, and other natural infrastructure that buffer human populations and critical infrastructure.

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