



Coastal Zones and Urbanization

SUMMARY FOR
DECISION-MAKERS



IHDP

International Human Dimensions Programme
on Global Environmental Change



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IMPRINT

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Dimensions Programme on Global
Environmental Change (UNU-IHDP)

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ISBN 978-3-944535-32-6
e-ISBN 978-3-944535-33-3

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Cover-Photo: UN Photo / Kibae Park
Suggested Citation:
UNU-IHDP. (2015).
Coastal Zones and Urbanization.
Summary for Decision-Makers.
Bonn: UNU-IHDP.

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Seek a greater understanding of urbanization and what drives it.

Consider managed retreat or even relocation.

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FOREWORD

The world map shows us that most major cities are located by water, and many in ocean coastal zones. Coastal zones have historically been a natural place for human settlements as they typically offer ready access to water and fertile soil. Coastal zones have never ceased to attract people, and urban expansion in recent years has become quite rapid. As we admire the rising skyscrapers of coastal cities and celebrate the prosperity that comes with them, recent studies are sending some alarming messages – coastal cities are facing serious risks.

Hazards associated with climate change – flooding due to sea level rise and coastal inundation, for example – are often highlighted in media and various policy documents. The potential impact of the hazards, however, is largely driven by the increasing concentration of population and economic activities in coastal cities. Studies show many major cities in the world could suffer serious losses due to flooding over the next decades.

It is important to recognize that climate change is not the only factor that brings about the risks coastal cities face. Over-extraction of groundwater and over-concentration of skyscrapers are blamed for the sudden appearance of sink holes in cities. Also, the same level of hazard will have very different ramifications in different cities and different parts of the same city depending on the local capacities to deal with it.

There is a lack of awareness, or more precisely, the translation of awareness into action in urban development policy and planning practices. Asian coastal cities, for example, are at the top of the list for potential losses due to flooding, but many development decisions and planning practices are carried out as they always have been – business as usual.

Like many other problems, there is no ready-made solution, which is in part due to the lack of scientific understanding of the complex interactions and compound effects of the risks. This underscores the importance of further scientific research into coastal zones and urbanization, a relatively new field. But multiple scenarios of potential risks can and should be developed and tested against any major development and management plans.

What we do in coastal cities, and when, will determine the magnitude of the risks, and the effectiveness of our efforts to address them. It is important to recognize that coastal cities are among the major drivers of the changes that cause the problems. Coastal cities are also where most of the

economic and innovation capacities reside. Harnessing the power of cities today to better prepare for tomorrow would be an effective and economical way of addressing these problems.

This Summary for Decision-Makers is a wake-up call, more than anything else, to the present and potential risks associated with coastal zones and rapid urbanization there. It highlights the issues involved, identifies critical questions, and offers recommendations for actions that can be taken now to inform policy and ultimately reduce the risks or their impacts.

Xuemei Bai

June 2014

Introduction

A report (Hallegatte et al., 2013)¹ issued by the Organisation for Economic Co-operation and Development in August 2013 forecasts a troubling future for life in coastal cities around the world.

By 2050 – less than 40 years from now – large coastal cities can expect a nine-fold increase in flood risk, according to the report. Yet as the level of risk on the coast increases, coastal populations continue to grow.

The study looked at 136 cities and concluded that current defenses and strategies are largely inadequate. Without action, the annual price tag on global flood losses could reach US\$1 trillion in socio-economic loss, property damage, compromised biodiversity, and more. Such severe flooding would mean the loss of coastline, the loss of infrastructure, and likely, as history has shown, some loss of life. Additionally, such flooding would likely weaken fisheries, nearby agriculture, ports, and other industries and enterprises, and diminish human well-being and the ecosystem services provided by the coastal zone.

The causes are rooted chiefly in development policy. They are rooted in the policies that leave little choice for the poor and marginalized but to migrate or remain in at-risk urban areas, including many low-lying riverine and tidal areas. They lie in the development failures that prevent systematic upgrading and support for these communities so that, over time, the numbers of the vulnerable poor have grown exponentially. The situation is amplified by climate change which causes sea-level rise which is further complicated, in some coastal cities, by land subsidence (the caving in or sinking of land). New migrants to the coast will be drawn there by perceived economic opportunity, among other fac-

tors, even though coastal life will become increasingly challenging and risky without major intervention and policy ingenuity.

ECOSYSTEM SERVICES AND THE COASTAL ZONE.

“Coastal and estuarine ecosystems around the world cover only 6% of the global surface, yet they contribute almost 38% of the total estimated global value of ecosystem services (Costanza et al., 1997). The resources and services they provide, both ecological and societal, have historically made them ideal locations for settlement, and more recently for major urbanisation.”

Source: Pelling, M. and Blackburn, S. (eds) (2013). *Megacities and the Coast: risk, resilience and transformation*, Routledge, London.

Broadly speaking, the Ramsar Convention on Wetlands (Ramsar, 2011)² identifies the following ecosystem services generally provided by all wetlands in:

- Flood control
- Groundwater replenishment
- Shoreline stabilization and storm protection
- Sediment and nutrient retention and export
- Water purification
- Reservoirs of biodiversity
- Wetland products
- Cultural values
- Recreation and tourism

1 Hallegatte, S., Green, C., Nicholls, R.J., and J. Corfee-Morlot, J. (2013). *Future Flood Losses in Major Coastal Cities*. *Nature Climate Change*, (3), p. 802–806. Available at: <http://www.nature.com/nclimate/journal/v3/n9/full/nclimate1979.html>

2 Ramsar (2011). *Wetland ecosystem services*. The Ramsar Convention on Wetlands. Available at http://www.ramsar.org/cda/en/ramsar-pubs-info-ecosystem-services/main/ramsar/1-30-103%5E24258_4000_0__

In a June 2012 report (World Bank, 2012),³ the World Bank also sounded the climate change alarm bells, noting that projected increases in sea level and the frequency and severity of tropical storms will endanger coastal cities such as Jakarta, Bangkok, and Ho Chi Minh City.

In fact, a flood control system built for Ho Chi Minh City over 10 years ago is already in dire need of a major overhaul, an endeavour valued in the neighborhood of \$2 billion. Obsolete after only a decade (Washington Post, 2013).⁴ Many problems of that kind, where infrastructure investments do not meet the long-term needs of the growing cities, can be associated to the conservative city-planning approach ignoring the fragility of non-urban ecosystems and therefore continuously reproducing a distorted relationship between the city and the environment.⁵

The extent of sea level rise will depend in part on the extent of climate change mitigation efforts. Due to past greenhouse gas emissions, a rise of 50 cm by the 2050s could be unavoidable. If the global temperature increase can be held to 2 degrees through climate change mitigation efforts, we could keep the increase to 70 cm by 2100. Without effective mitigation, and if the global temperature increase is 4 degrees, then we could be looking at a 100 cm increase in global mean sea level by 2100. However, the distribution of sea level rise is not expected to be even. For example, in South East Asia, levels will be 10–15 cm higher than the global mean (World Bank, 2012).⁶

COASTAL CITIES AT RISK.

“Future Flood Losses in Major Coastal Cities” concludes that the following cities are most at risk in terms of overall cost of flood damage: 1) Guangzhou, 2) Miami, 3) New York, 4) New Orleans, 5) Mumbai, 6) Nagoya, 7) Tampa, 8) Boston, 9) Shenzhen, and 10) Osaka. Guangzhou, Miami, New York, and New Orleans alone account for 43% of the forecast total global losses.

When forecast losses are measured as a percentage of GDP, developing countries move up the list. These countries have less sophisticated infrastructure, fewer existing flood and storm defenses, and larger, poorer populations. The 10 most vulnerable cities when measured as percentage of GDP are: 1) Guangzhou, 2) New Orleans, 3) Guayaquil, 4) Ho Chi Minh City, 5) Abidjan, 6) Zhanjing, 7) Mumbai, 8) Khulna, 9) Palembang, and 10) Shenzhen.

“In most of these cities, the poor are most at risk as rapid urbanization has pushed them into the most vulnerable neighborhoods, often in low-lying areas and along waterways prone to flooding.”

Source: Future Flood Losses in Major Coastal Cities (OECD) as reported at <http://www.worldbank.org/en/news/feature/2013/08/19/coastal-cities-at-highest-risk-floods>

³ World Bank (2012). *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*. The World Bank. Available at <http://documents.worldbank.org/curated/en/2012/11/17097815/turn-down-heat-4%C2%B0c-warmer-world-must-avoided>

⁴ The Washington Post (2013). *Climate change threatens trouble in the near future, World Bank says. June 19*. Available at http://www.washingtonpost.com/business/economy/climate-change-threatens-trouble-in-the-near-future-world-bank-says/2013/06/18/1ba2bcea-d83d-11e2-a9f2-42ee3912a0e_story.html

⁵ Swilling, M. and Annecke, E. (2012). *Just Transitions: Explorations of Sustainability in an Unfair World*. Cape Town and Tokyo: UCT Press and United Nations University Press.

only sustainable option – is hard and fast climate change mitigation. Other options are palliatives only and increasingly expensive ones.

These solutions need to bring together large-scale with street-level engineering to allow science to reach beyond the formal urban plan to those many people who are marginalized or excluded. New governance mechanisms are also needed to improve the integration of local ecological and social or cultural values into development that is likely to be increasingly framed by risk-management decision-making.

As with all global challenges, what's required are innovation, cooperation, investment, and political will.

This short summary aims to advance the conversation and generate greater interest among today's decision-makers and tomorrow's, for coastal zone flooding is a long-term issue. There are long-term risks for coastal zone populations and ecosystems, but also long-term opportunities to advance ingenuity, promote cooperation, and achieve success for the sake of future generations. It is critical that an increased focus on risk in development strategy and discourse does not obscure – and indeed should accentuate – existing imperatives for advancing social justice, equity, and environmental sustainability. There is a danger that development gains and aspirations are triaged in a drive for security. Governance mechanisms and science agendas are needed to confront this concern head on (Pelling and Blackburn, 2013).⁸

The World Bank has committed large sums of money to flood prevention projects, an effort that could reduce the resources available to advance other elements of its overriding mission to alleviate global poverty.

While development banks and governments are spending money to adapt to future flooding, and new attention is being paid to the issue globally, it remains true that coastal zone urbanization and flooding is not a very mature area of study and policy development. Concerns for future urban sustainability under a climate-change-affected world are now placing greater emphasis on the need to bring together the considerable expertise and practice around related areas of coastal and urban policy.

What we call for is new thinking and new cooperation in addressing the issue of coastal zone flooding. The solution is not simply a levee here, and a reinforced port there. While such projects are frequently necessary, the approach needs to be more comprehensive and integrated, and it needs to address social and ecological impacts as well as physical and economic ones. Science, policy, and traditional knowledge need to come together to underpin a robust, cooperative, and participatory policy framework resulting in better allocation of international financial resources. We look for dialogue and better communication among government, civil society, and community groups representing those people most affected by coastal urbanization.

For coastal city populations and assets faced with accumulated development failures (UNDP, 2004)⁷ and increasing climate change impacts, standard engineering and technical solutions are unlikely to be adequate. The future is already being felt through the rising exposure to coastal hazards on concentrated populations of the poor and wealthy; on critical infrastructure, including hazardous industrial and energy production plants; and on regional and global hubs for trade. At a minimum, the emerging future extends the range of those with a stake in urban coastal development and risk management. The primary tool for long-term risk reduction – and likely the

6 World Bank (2012). *Turn Down the Heat: Why a 4°C Warmer World Must be Avoided*. The World Bank. Available at <http://documents.worldbank.org/curated/en/2012/11/17097815/turn-down-heat-4%C2%B0c-warmer-world-must-avoided>

7 UNDP (2004). *Reducing Disaster Risk: A Challenge for Development*. *United Nations Development Programme*. Available at <http://www.undp.org/content/undp/en/home/librarypage/crisis-prevention-and-recovery/reducing-disaster-risk--a-challenge-for-development.html>

8 Pelling, M. and Blackburn, S. (2013). *Megacities and the Coast: Transformation for resilience: A preliminary review of knowledge, practice and future research*. *International Geosphere-Biosphere Programme*. LOICZ, June 2011. Available at http://www.loicz.org/imperia/md/content/loicz/hotspots/urbanization/Megacities_and_the_coast_report_4_6_2011.pdf.in LOICZ INPRINT 1/2013.

WHAT MAKES COASTAL CITIES MORE VULNERABLE TO FLOODING AND OTHER HAZARDS?

- **Elevation:** Most coastal cities are at sea level, or very close to sea level, making them more vulnerable to flooding caused by increases in sea level, storms, and tidal waves.
- **Topography:** Many coastal cities (but certainly not all) are surrounded by mountains and other topographic features that can generate extreme precipitation. Many more lie on estuarine or other low-lying topography exposed to riverine as well as coastal flooding.
- **Land Use:** Many coastal cities are hubs of intensive industrial activity, including oil refining, drawing migrant labor and generating exposure for people as well as infrastructure that may be critical for national or even regional and global economic and business continuity. With urban development, there is a high proportion of impervious spaces (relative to green space) in coastal cities. This increases flood impacts as flood waters cannot be absorbed by pavement and built infrastructure. Urbanized landscapes also contribute to the high temperature of coastal cities relative to the less-settled areas that surround them.
- **Sea/Land Breezes:** tidal waves can be moderated by the interaction of air, land, and water along the coast, but development in some cities impedes this ecosystem service. Coastal breezes can also concentrate and re-circulate pollutants, thereby affecting air quality and compounding the health effects of high temperatures.
- **Population Density:** High population density, especially in low-income and at times informal settlements, generates concentrated human exposure and challenges the capacity of transport systems in evacuation and of response and reconstruction capacity. Where exposed high-density populations are also wealthy, this has implications for the sustainability of insurance, especially where the state is the insurer of last resort.

Key Questions

WHAT IS URBANIZATION AND WHAT DRIVES IT? WHAT ARE THE CHALLENGES POSED BY COASTAL URBANIZATION?

Urbanization is the term used to describe the growth of cities and towns relative to the population of rural areas. It is a phenomenon that has taken place for millennia as the total global population has grown. It is believed that the process of urbanization first began in ancient Mesopotamia, as early as 4500 BCE, as settlements grew and joined together to form towns and cities. The most successful of these cities would attract the migration of less prosperous tribesmen seeking a better life. And so cities grew (Ancient History Encyclopedia, 2014).¹⁰ And so cities continue to grow.

What drove urbanization in ancient days is largely what has always driven urbanization – the real and perceived presence of greater economic opportunity, although today’s urbanization is complex and driven by a number of factors. Whether because of the lure of larger markets, the emergence of factories, or other economic attractions, people have long sought urban settings.

The economic appeal of coastal cities in particular is heightened by the impacts of ports and port-related activity and, for many centres, tourism centred around coastal attractions. In early

times, as today, our coastal cities are integral cogs of the machinery of international trade.

Aside from economic drivers, urban areas continue to attract people for a wide variety of reasons. The other side of the urbanization coin is rural exodus. As people leave rural areas, local populations and economies are less able to sustain a robust infrastructure of schools, hospitals, stores, and other facilities and services that contribute to human well-being. The weakening or disappearance of these social goods compels people to consider urban migration. It becomes a self-fulfilling prophecy.

Coastal zones have the added attribute of their aesthetic, attracting retirees in the developed world and others who enjoy a coastal view and lifestyle. And of course as coastal centres welcome migrants, they also experience natural growth, expanding their populations even further.

It is interesting to note that with the rapid expansion of coastal populations, cities are expanding into areas that were previously unsettled because planners at the time recognized that certain areas were flood prone. Ho Chi Minh City is one example of this unfettered expansion into risky terrain.

THE INCOME ADVANTAGE ON THE COAST.

“China’s coastal cities enjoy a large income advantage – a factor of two to one over other urban areas – demonstrating strong geographic and cumulative urban agglomeration advantages. These intracity differentials are in addition to the significant productivity advantage of urban areas over rural areas in China.”

Source: Urbanization and Growth, 2009, M. Spence, P. Clarke Annez, and R. M. Buckleyeds.

¹⁰ Ancient History Encyclopedia (2014). Urbanization. Available at <http://www.ancient.eu.com/urbanization/>

WHAT ARE THE RISKS OF COASTAL URBANIZATION TO POPULATIONS AND ECOSYSTEMS?

“From an environmental perspective, there is a double disadvantage to excessive (and potentially rapid) coastal settlement. First, uncontrolled coastal development is likely to damage sensitive and important ecosystems and other resources. Second, coastal settlement, particularly in the lowlands, is likely to expose residents to seaward hazards such as sea-level rise and tropical storms, both of which are likely to become more serious with climate change.

Unfortunately, such environmental considerations do not have the influence on settlement patterns that they deserve” (McGranahan et al., 2007).¹¹

Even as the risks to coastlines and coastal communities become more widely known, the population along the water grows seemingly unabated. The more human settlement, the more infrastructure is needed. With coastal urbanization, the more people and the more built capital are at risk. From a social perspective, many coastal cities, particularly those in the developing world, have areas of significant poverty, with society’s most vulnerable people the least able to provide protection for themselves and their families against floods and storms. Amplifying the challenge is the fact that the poor in coastal cities will find themselves settling on cheaper, low-lying lands, those that are most vulnerable to floods and storm impacts. This phenomenon becomes more pronounced as populations grow more rapidly and spread even farther down the coast. African coastal cities are said to be physically spreading by 4% a year as their populations grow (The Economist, 2012).¹²

“Urbanization and global environmental change have created gross inequities, with some people, often the most vulnerable, suffering a disproportionate burden of ill effects.” (Boone and Fragkias, 2012).¹³

Pelling and Blackburn (2013) note that the rapid urbanization of coastal cities – especially “megacities” of 10 million or more people – is extremely taxing on ecosystems. Some of the impacts are:

- Accelerated subsidence (the caving in or sinking of land) in some coastal cities, caused by excessive building, the significant extraction of groundwater, the pollution of soil and groundwater reserves, and resource extraction.
- Pollution and the disturbance of habitat, causing significant changes in the populations and resilience of species.
- The heightened vulnerability of coral reefs, coastal wetlands, tropical mangroves, and other natural features that contribute to the beauty and resilience of coastal areas.
- Diminished water quality in oceans and estuaries.

URBANIZATION AND CLIMATE CHANGE.

“Urbanization and climate change are arguably the two most significant pressures shaping human wellbeing and ecological integrity today. Nowhere are these two processes more intensely linked than on the coastal zone where cities are both concentrated sites in the production of environmental risk through pollution and consumption practices, while also being at risk from the impacts of local and global environmental change.”

Source: <http://www.loicz.org/science/hotspot/Urbanization/index.html.en>

¹¹ McGranahan, G., Balk, D., and Anderson, B. (2007). *The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones*. Environment and Urbanization, 19(1) p. 17-37. Available at <http://sustainabledevelopment.un.org/getWSDoc.php?id=2393>

¹² The Economist (2012). *A sea of riches: Coastal waters could feed many more Africans, but need better protection*. Feb 18. Available at <http://www.economist.com/node/21547867>

¹³ Boone, C.G. and Fragkias, M. (eds) (2012). *Urbanization and Sustainability: Linking Urban Ecology, Environmental Justice and Global Environmental Change*. Springer Dordrecht, 2013 edition.

WHAT SORT OF ADAPTIVE STRATEGIES ARE POSSIBLE?

In 1888 (Scientific American, 1888)¹⁴ the massive Brighton Beach Hotel on Coney Island in New York was moved 600 feet back from the coast. Beach erosion had put the structure at risk. The hotel was 500 feet long and weighed 6,000 tons. To move the popular resort, it was jacked up by a large number of workers, placed on 120 railcars, and then moved gently by six locomotive engines.

“For many months there has been a marked tendency on the part of the water to wear away the sandy beach upon which the building was erected,” Scientific American reported on the reasons for the move. “During the past winter this tendency increased, and assumed alarming proportions. It is possible that the erection of protecting bulkheads on the neighboring property had the effect of creating a scouring action on the part of the waves and currents.”

Fast forward to 2007 and New York is still grappling with how to adapt to life as a large city on the coast. The mayor, Michael Bloomberg, released a strategy for dealing with the impacts of climate change as a coastal city called PlaNYC. Recognizing current and future flood risk, the plan calls for wetland protection, large-scale tree planting, and changes in building codes to consider the city’s future resilience to storms and flooding.

The future came earlier than expected when Hurricane Sandy hit the east coast in 2012. A revised plan followed in June 2013, taking into account the elements of the 2007 plan and other considerations, including:

- A network of levees and floodwalls to protect key infrastructure, including food distribution centres and hospitals;
- Storm-surge barriers to prevent river and creek water from backing up into residential parts of the city;
- A re-thought Manhattan protected by a levee and natural barriers like wetlands, beaches, and sand dunes;
- Incentives to building owners to keep vulnerable electrical equipment higher up above the ground;
- Requiring hospitals and other facilities to meet more stringent resilience standards; and others.

The cost of this adaptive plan is estimated to be about US\$20 billion (The Economist, 2013).¹⁵

New York is one example of a city that is trying to demonstrate a commitment to future resilience based on risk to floods and storms. There are other examples.

In East Africa, where resources are more limited and where poverty alleviation is an overriding policy priority, such dramatic investments in infrastructure are less plausible. Kithiia (2011)¹⁶ in a study of the coastal cities of Dar es Salaam and Mombasa, encourages urban planning to consider climate change adaptation as a means to reduce vulnerability (Kithiia, 2011). The study also shines a light on the importance of communities taking responsibility for their own resilience to the extent possible. The author sees people “transforming every opportunity into positive action,” for example, by organizing as groups focused on reforestation of degraded coastal areas, thereby producing a natural sea wall and other benefits.

In the United Kingdom, where the House of Commons in 1998 endorsed the concept of “managed realignment” for some areas as a long-term coastal strategy, the think tank, “Building Futures,” has framed the debate around the broad options of retreat, defend, or attack (Building Futures, 2010).¹⁷

14 Scientific American (1888). 58 (15) April 14. Available at <https://archive.org/stream/scientific-american-1888-04-14/scientific-american-v58-n15-1888-04-14#page/no/mode/2up>

15 The Economist (2013). *You’re going to get wet, Americans are building beachfront homes even as the oceans rise*. June 15. Available at <http://www.economist.com/news/usa/21579470-americans-are-building-beachfront-homes-even-oceans-rise-youre-going-get-wet>

16 Kithiia, J. (2011). Chapter 4: Climate change adaptation and mitigation in East African coastal cities: need, barriers and opportunities. In *Megacities and the Coast: Transformation for resilience: A preliminary review of knowledge, practice and future research*. LOICZ, June 2011. Available at http://www.loicz.org/imperia/md/content/loicz/hotspots/urbanization/Megacities_and_the_coast_report_4_6_2011.pdf

17 *Building Futures* (2010). *Facing Up To Rising Sea Levels*. Available at <http://www.buildingfutures.org.uk/projects/building-futures/facing-up>

URBAN COASTAL ZONES: SNAPSHOTS OF SUCCESS

An environmentally friendly city is a resilient city: In the city of Rizhao, China, on the Shandong Peninsula, it was reported in 2007 that 99 percent of households in the central part of the city were using solar water heaters, and most public lighting was also powered by solar. The penetration of solar power in Rizhao's suburbs and nearby villages is also significant. Rizhao's clean environment has helped to attract tourists, foreign direct investment, international events, and university communities. Before the solar project, Rizhao was an ordinary Chinese city with a lower average per capita income than other similar cities in the area. The solar project was the result of supportive government policies and financial support; strong political will at the local level; and effective, local solar panel producers who were able to improve their products. Rizhao is an example where effective policies and stakeholder cooperation can make a difference (Bai, 2007).¹⁹

Planning at a municipal level: In 2012, Cartagena, Colombia, was the first coastal city in South America to produce guidelines for adapting to climate change. In response to dire forecasts for Colombia's coastal zones, the country developed a national action plan to look at coastal vulnerability and adaptation. Following some initial studies in 2008, a revision of Cartagena's land-use plan was proposed to integrate adaptation thinking into municipal planning. The initiative was coordinated by the Institute of Marine and Coastal Research (INVEMAR) along with the local government and Colombia's Ministry of Environment. The 2012 document, the first major output of this collaboration, presents specific adaptation guidelines. The guidelines are seen as a critical foundation for building Cartagena's resilience through adaptation planning, zoning policies, and other initiatives. The national government is watching Cartagena's progress as lessons learned could influence implementation of the National Adaptation Plan and actions taken by other coastal cities. Dialogue among stakeholders continues (CDKN, 2013).²⁰

"Retreat" tells us to move infrastructure and housing farther away from the coastline and higher up. This approach allows waters into coastal cities, but minimizes catastrophic flooding. "Defend" speaks to adding sea walls, levees, and other physical defenses to prevent water

from entering coastal cities. The "attack" approach focuses on options to reclaim and expand onto the water.

The Intergovernmental Panel on Climate Change (IPCC, 2001)¹⁸ has identified a number of "managed retreat" policy approaches taken around the world. Citing Titus (1998), the IPCC notes that "the most common mechanisms for managed retreat are *setbacks* that require new development to be a minimum distance from the shore, density *restrictions* that limit development, and *rolling easement policies* that allow development on the condition that it be removed to enable wetlands to migrate landward." The IPCC examples include the following:

- In Aruba and Antigua, new development must be 50 m inland from the high-water mark.
- In Barbados, the building setback along sandy coasts is 30 m from the mean high-water mark; along coastal cliffs the setback is 10 m from the undercut portion of the cliff.
- In Canada, the coastal province of New Brunswick has remapped its coast to delineate the landward limit of coastal features. Setback for new development is defined from this limit.
- In Sri Lanka, "no-build zones" have been established as have setbacks of 60 m.
- In the United States, aside from the initiatives described above, the states of Maine, Massachusetts, Rhode Island, and South Carolina have implemented rolling easement policies to ensure that wetlands and beaches can migrate inland as sea level rises.

¹⁸ Intergovernmental Panel on Climate Change (2001). Resilience and Vulnerability. In *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Available at <http://www.ipcc.ch/ipccreports/tar/wg2/index.php?idp=301>

¹⁹ Bai, X. (2007). *Cityscape Rizhao: Solar-Powered City*. In *2007 State of the World: Our Urban Future*. The WorldWatch Institute. Available at <http://www.worldwatch.org/files/pdf/State%20of%20the%20World%202007.pdf>

²⁰ *Climate and Development Knowledge Network (2013). Embedding climate change resilience in coastal city planning: Early lessons from Cartagena de Indias, Colombia*. Climate and Development Knowledge Network, February 2013. Available at <http://cdkn.org/wp-content/uploads/2013/02/Cartagena-inside-story-final.pdf>

Key Recommendations

SEEK A GREATER UNDERSTANDING OF URBANIZATION AND WHAT DRIVES IT. With rapid urbanization, cities consume a growing portion of the world's energy resources, produce a growing portion of the world's greenhouse gases, and generate a massive proportion of the world's economic activity. While we know that large cities are vulnerable to rapid global environmental change, they are also positioned to contribute positively to sustainable development through innovative local policy-making, technological ingenuity, and grand municipal leadership. While to date there has been some important research and dialogue bringing together the humanities, the social sciences, and the physical sciences to understand urbanization and its impacts on the environment and on human well-being, more is needed.

Policy-makers, institutes, and academics are urged to engage with each other in order to gain a better understanding of the issues, to better shape current policy, and to better anticipate future policy needs – to the extent that is possible. The objectives are to ensure that policy-making becomes increasingly policy-based, and that research is optimally aligned with policy needs.

“Policymakers need facts, empirical evidence, and theories on how to plan and manage cities and urbanization during the contemporary era of rapid change and environmental uncertainty.... We need a science of urbaniza-

tion. This science would focus on the fundamental laws of the urbanization process: its origins, development, organization, emergent properties, and connections to other social and biophysical processes” (Solecki et al., 2013).²¹

CONSIDER MANAGED RETREAT OR EVEN RELOCATION. As ocean waters rise and claim land from the coast, coastal cities could consider strategies of managed retreat (or managed realignment). The coastline is moving inland around the world. Moving populations, buildings, and infrastructure farther back from the existing coast to a place that considers future sea level rise and future flood risk is seemingly dramatic, but is indeed a potential solution. Even the prospect of complete relocation of coastal cities merits serious discussion in some cases, and will become more important to consider in the future.

Of course, such options require significant planning and investment. And it is important to note that such considerations are very much place-based. New York City and Palembang present different challenges to policy-makers, engineers, and planners. What works in one jurisdiction, is not likely to automatically work in another. The capacities of governments to act in developed countries and developing countries vary significantly.

Another essential consideration is that to be truly successful, managed retreat and relocation efforts must be accompanied by a commitment to improving coastline resilience.

CONSIDER COMBINED PERSPECTIVES AND APPROACHES. Decision-makers are urged to address rapid urbanization by considering a blend of approaches that include hard engineering (such as breakwaters and sea walls); technology (such as early warning systems to anticipate floods); and natural approaches (such as the planting of mangroves to promote coastal resilience).

21 Solecki, W., Seto, K.C., and P. J. Marcotullio, P.J. (2013). It's Time for an Urbanization Science, Environment, January-February. Available at <http://www.environment-magazine.org/Archives/Back%20Issues/2013/January-February%202013/urbanization-full.html>

Additionally, legislative and policy approaches should be considered. New laws could determine how and where new coastal development takes place; policies that in essence subsidize people to live in risky coastal areas – like the former U.S. insurance subsidy to householders on flood plains – should be eliminated; residential home insurance in flood-prone coastal areas could become more difficult to obtain; and strict building codes could ensure that new structures are as resilient as possible.

It is important that all policy options are carefully assessed before enacted to ensure that they are not, in fact, maladaptive, and that to the extent possible, unintended undesirable consequences are foreseen and mitigated. For example, what might happen to nearby agricultural zones if breakwaters and sea walls are erected to protect coastal urban centres? And if a negative result is anticipated, can it be mitigated? Related to this, national and municipal governments need to work together to ensure effective implementation of policies and programs. Sound national policy is sometimes challenged by local interests – this is a challenge that needs to be addressed and overcome (Bai et al., 2014).²²

We must remind ourselves as societies, civil servants, and decision-makers that we are not forced to choose between natural approaches and technical solutions. Indeed, true human ingenuity is reflected by the embrace of integrated solutions to complex problems. This applies also to seeking combined solutions that can be seen both as adaptation and mitigation measures leading to lower-carbon urban futures.

As with all areas of policy-making, success is more likely to emerge when processes include extensive and meaningful public consultation and decision-making isn't merely a top-down exercise. Policy-makers are urged to engage community groups representing the people who are most affected by urbanization in the coastal zone.

INTEGRATION, COOPERATION, AND CHAMPIONSHIP. Related to our call for a greater understanding of the drivers and process of urbanization, and urban system dynamics and interactions with global environmental change, the discussion of policy frameworks also needs to keep pace.

It is especially important to stress that local interests, needs, and claims are commonly un-

derrepresented within contemporary global, international, and national instances and agencies driving the process of adaptation to the projected sea-level rise. Coastal management requires effort at local, regional, national, and international scales. And it requires an approach that does not ignore the non-urban parts of the coastal zone. The focus, therefore, needs to be on policy coherence so that jurisdictions work together to ensure effective, long-term solutions.

As the climate change debate intensifies, coastal cities in particular need to be seen as places of risk, but also as places of innovation and opportunity in the effort to address climate change and its impacts.

Such innovation requires investment and leadership; ingenuity and dialogue among a widening base of stakeholders, including those people most affected. While Local Governments for Sustainability (ICLEI) and others have demonstrated thought leadership; and while C40 Cities Climate Leadership Group (C40) and Connecting Delta Cities (CDC) have highlighted the importance of networking on coastal issues, more dialogue and cooperation are needed.

Above all, action is urged. In a world of competing interests and competition for resources, it is all too easy for policy-makers to say one thing – however well-intentioned – only to have other results emerge. As coastal waters rise and we learn more about potential impacts on urban centres, the window is open for civil society and community groups to step forward to keep the dialogue moving forward and hold decision-makers accountable.

22 Solecki, W., Seto, K.C., and P. J. Marcotullio, P.J. (2013). It's Time for an Urbanization Science, *Environment*, January-February. Available at <http://www.environment-magazine.org/Archives/Back%20Issues/2013/January-February%202013/urbanization-full.html>

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This Summary for Decision-Makers is a wake-up call, more than anything else, to the present and potential risks associated with coastal zones and rapid urbanization there. It highlights the issues involved, identifies critical questions, and offers recommendations for actions that can be taken now to inform policy and ultimately reduce the risks or their impacts.

The Land-Ocean Interactions in the Coastal Zone Project (LOICZ), established in 1993, aims to provide science that contributes towards understanding the Earth system in order to inform, educate and contribute to the sustainability of the world's coastal zone. The Urbanization and Global Environmental Change Project (UGEC) was launched in 2005 to seek to provide a better understanding of the interactions and feedbacks between global environmental change and urbanization at the local, regional, and global scales through an innovative conceptual and methodological framework.

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ISBN 978-3-44-944535-32-6

COASTAL ZONES AND URBANIZATION

This Summary for Decision-Makers is a joint initiative of the International Human Dimensions Programme on Global Environmental Change (UNU-IHDP), the Land-Ocean Interactions in the Coastal Zone Project (LOICZ), and the Urbanization and Global Environmental Change Project (UGEC).