Investigating Urban Coastal Resilience in the Age of Climate Change

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An aerial view of Bayan Lepas, Penang, Malaysia / Credit: [lemonmelon via Unsplash.]

Table of Contents

Introduction

Humans have been building cities for no longer than the past 8,000 years. In that same period, the global rate of sea level rise was slow, allowing for vast urban coastal areas to develop and expand. Now, as rising seas and greater storm surges could cost urban coastal areas more than US$1 trillion a year by 2050, governments and communities need to determine how to build secure and sustainable cities in the current reality: A world experiencing unprecedented climate change.

So what does resilience in an urban context mean, and how can journalists effectively cover actions, solutions and initiatives – or the lack of – in their home communities? That's one focus of EJN's new two-year project, Covering Coastal Resilience, which launched in January 2022 with funding from the Kingfisher Foundation. The project seeks to support journalists in reporting about coastal resilience issues globally as the effects of climate change become more and more pronounced.

Using our February and April 2022 webinars as a starting point, this tipsheet provides a baseline for understanding the threats confronting our world's coastal urban areas from San Francisco to Shanghai, and the disproportionate capacity of communities in different countries to take action. It also offers strategies for journalists looking to investigate whether potential solutions are scalable, replicable, sustainable and equitable on the ground.

"Around the world, sea level rise is predicted to worsen over time, and the costs associated with adapting to these new realities will increase both economically and socially," says Lucienne Noel, EJN's Thematic Expert in Coastal Resilience.

"Communities and their leaders urgently need accurate data and accountability, and journalists are in the right position to provide reliable information in terms of not only the crisis we face, but solutions and strategies, too," she added.

Using our February and April 2022 webinars as a starting point, this tipsheet provides a baseline for understanding the threats confronting our world's coastal urban areas from San Francisco to Shanghai, and the disproportionate capacity of communities in different countries to take action.

We encourage journalists to use these chapters to guide their reporting on coastal resilience, as they cover the causes and impacts of sea level rise, coastal erosion and flooding, and investigate whether the solutions their cities are implementing are adequate, scalable, replicable, sustainable and equitable on the ground.

Chapter 1 – What we mean when we say resilience

Every year during the rainy season, the streets of Hoi An, Vietnam are flooded / Credit: Toomas Tartes via Unsplash.

In this tipsheet, we will occasionally use scientific or industry terminology to explain certain issues and solutions. We will define them as we go, and you can also access additional information in our terms section at the end of the tipsheet.

Resilience at its most basic level simply means the ability of a system – be it the human body after an illness, a town after an earthquake, an ecosystem after a drought – to bounce back from a negative event. On the coasts, these negative events often come in the form of hurricanes, flooding and erosion, among other threats. To effectively build resilience, systems and communities must undergo a process of adaptation, strengthening the ability of the community to rebound before the event takes place – so when it does, they're ready.

Historically, resilience measures have come in many forms: Construction projects like seawalls or levees are often the go-to method to keep water out of cities, yet they can be controversial. Improved storm shelters that include space for livestock and are built to withstand increasingly severe storms are another one. But coastal resilience doesn't always mean physical barriers or construction: Increasingly, it also includes the restoration of natural barriers such as mangroves and coral reefs, plus providing diverse livelihood options, increased food security, accessible medical care, improved information distribution, resettlement to a safer location and more.

"More than 11,000 disasters have occurred over the last 50 years, and they've all been attributed to weather, climate and water-related hazards," says Moushumi Chaudhury, the Community Resilience Program Director at The Nature Conservancy, during our February 2022 webinar. Those disasters in total caused 2 million deaths and US$3.6 million in economic losses, according to a 2021 report from the World Meteorological Organization.

The problem is clear: Nearly 2.4 billion people live within 100 kilometers of the coast today. And, more than half the world's population lives in urban areas, with the number projected to increase to 68 percent by 2050, according to estimates by the United Nations. As climate change and urbanization both continue to increase, the number of people impacted by coastal climate impacts will go up, as well.

"The world and coasts especially are becoming more and more urban," says Stefanie Tye, a Research Associate in the Climate Resilience Practice at the World Resources Institute. "A lot of these cities are actually near or in … coastal areas, so this means more people and more segments of the economy will be exposed to these coastal climate threats."

Tye also spoke at our February webinar, sharing her research on what makes coastal resilience solutions successful on the ground. Above all, she said, it's important for everyone to understand the importance of including resilience planning in all sectors, including journalism.

"Because climate impacts will affect every element and every aspect of human society, this means that it also needs to be integrated and considered at all levels of government and across sectors," she said. "This is why integrating adaptation – or 'mainstreaming' adaptation – is a must."

Flooding, hurricanes, subsidence, landslides, erosion, saltwater intrusion, biodiversity loss, food insecurity, public health: The threats to cities and the people who live in them are diverse and interconnected. Solutions often serve the privileged sections of society, leaving out poorer and marginalized communities who lack the resources and capital to act. Journalists have the unique ability to highlight these social dimensions and investigate whether proposed solutions are designed to cater to all community members – but first, the media needs to understand the threats in more depth.

Let's dive deeper into the threats facing urban coastal areas and potential solutions on the table.

Chapter 2 – The origins of flooding

During heavy rain, Hong Kong's engineers track municipal drainage systems through a smartphone app / Credit: JohnIsl via Flickr.

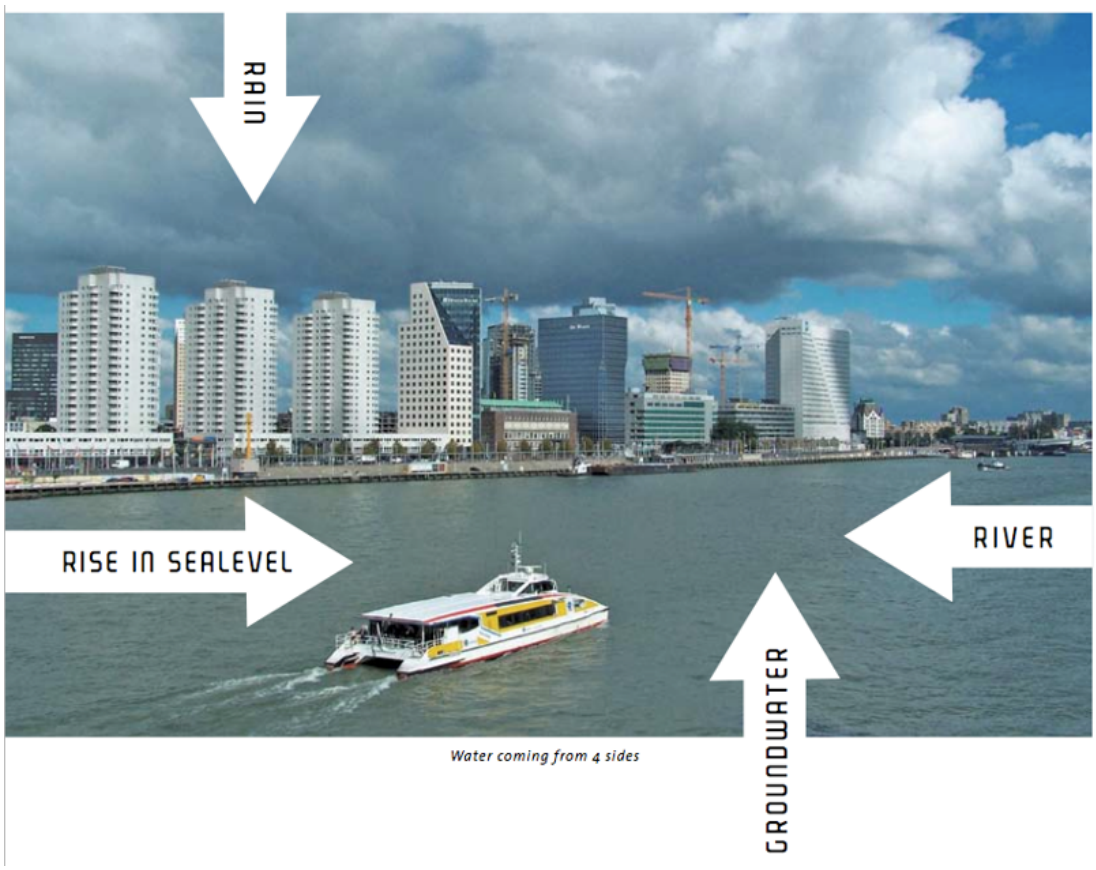
The sea level has risen 8-9 inches since 1880. It may not sound like a lot, but in the United States, for example, flooding at high tide is 300 percent to more than 900 percent more frequent than it was 50 years ago. As the sea level rises, water height at high tide becomes even higher, spilling over into city infrastructure such as roads, mass transit, electric lines, hospitals, sewage pipes and more. City residents experiencing a major flood could lose power and clean water for long periods of time and be forced to evacuate without knowing when or if they can return.

This problem is compounded when the city is built on relatively flat land: In Dar es Salaam, Tanzania, for example, 8 percent of the city already lies below sea level, posing intense flood risks for residents living close to the ocean. Plus, with rapid population growth in the last few years, unplanned informal settlements have expanded into areas that frequently flood, putting poorer communities at high risk. Without access to adequate drinking water, sewage or medical care, these communities are extremely vulnerable.

Ultimately, water needs a place to go: When cities or communities build on top of floodplains or fill ponds for development purposes, they remove permeable soil that could absorb water and reduce flood risks, replacing it with concrete or other impermeable materials. In India, for example, this is a common issue, with experts calling for better regulation of catchment areas to reduce flood damage.

This flooding can get much worse when a hurricane hits. Climate change is also causing storm events to increase in intensity and frequency, leading to high amounts of rainfall, wind and coastal flooding. And the water can come from multiple different sources, says Dr. Kristina Hill, a professor at the University of California, Berkeley who specializes in urban planning, sea level rise and climate change.

Speaking at our April 2022 webinar, Hill explained what's called compound flooding, which is when a flooding event comes from different water sources such as groundwater, rainfall, rivers and sea level. This type of flooding can be extremely difficult to solve, and it can also be the most deadly.

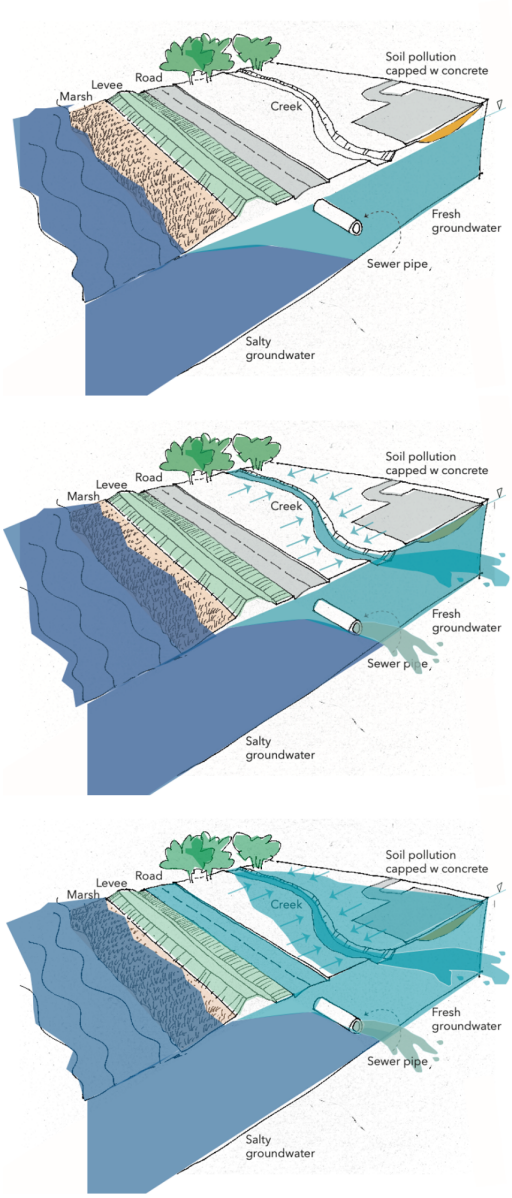


A diagram demonstrating compound flooding, with potential water sources including rise in sea level, groundwater, rain and rivers / Credit: Rotterdam Water Plan 2.0 via Kristina Hill.

In particular, Hill encouraged journalists to pay attention to groundwater. Groundwater is essentially rain stored in the soil, gradually flowing toward the ocean. It's above sea level, so when the sea rises, so does the water in the soil. As groundwater rises, it can intersect with underground city infrastructure, including transit systems, sewer pipes, pollution and more.

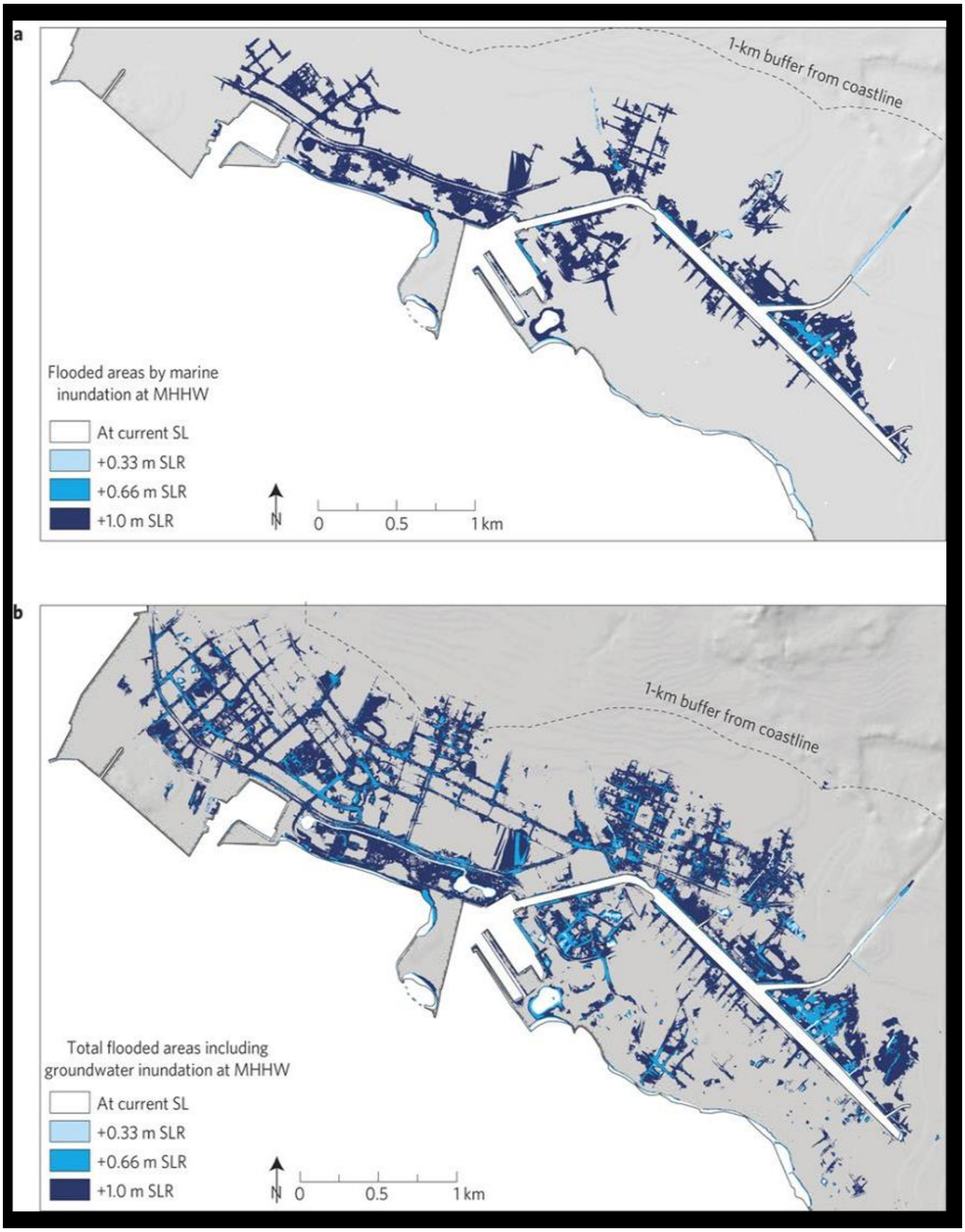
These impacts are not limited just to communities living directly next to the ocean – Hill cited research in her presentation that sea level rise could cause groundwater impacts as far as 6 kilometers from the shoreline.

For example, many cities have sewer systems designed to draw excess floodwater back out into the ocean. But for urban areas that also experience earthquakes or ones that haven't updated their infrastructure in a long time, pipe cracks will allow that rising groundwater inside, blocking their original purpose and pushing floodwater into the street through drain covers before it ever comes from the shoreline. Plus, if urban areas are also struggling with solid waste management, clogged pipes can also easily overwhelm a system during a flood.



An illustration showing the progression of rising sea level and its impact on groundwater and infrastructure behind the levee / Credit: Kristina Hill.

Despite the seriousness of the issue, not everyone is paying as close attention to groundwater as they should, Hill said. For example, in this model showing projected flooding in Honolulu, Hawaii, the difference between Map A (without groundwater rise included) and Map B (with groundwater rise included) is stark.



Two predicted flooding models for Honolulu, Hawaii. Map A, top, shows flooding if the ocean was the only water source. Map B, bottom, demonstrates how much more severe flooding will be, taking groundwater rise into account / Credit: Rotzoll, K. & Fletcher, C. H., 2012, via Kristina Hill.

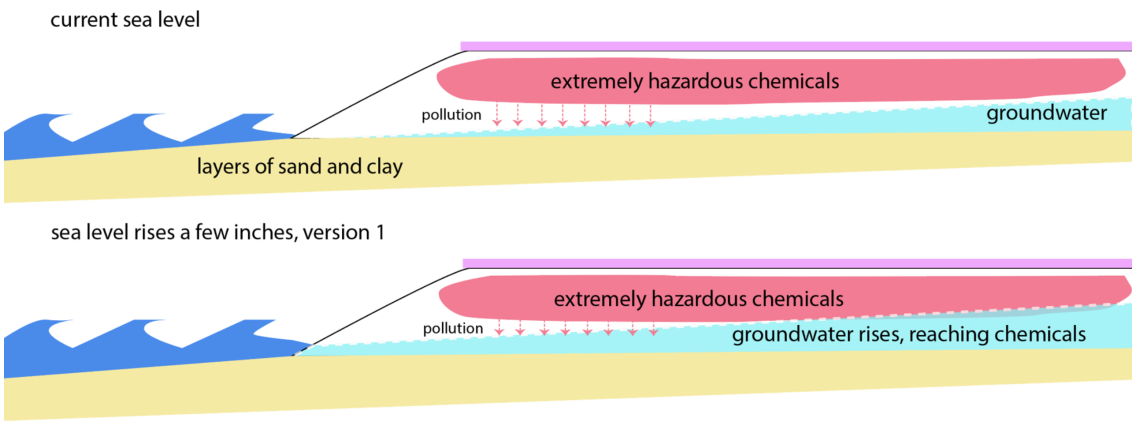
For journalists seeking to investigate how their governments are preparing for sea level rise, she recommends exploring whether their models and projections include groundwater rise in the soil and the resulting effects of saltwater intrusion. That's her main message and story idea suggestion: Pay attention to the water underground.

"The infrastructure we've built that's meant to carry floodwater away is actually going to allow floodwater to come up into the street and create spot flooding and eventually permanent flooding," Hill said.

Journalists can ask city officials when sewer infrastructure was last updated, and whether or not maintenance crews are aware of cracks or serious leaks. Are there particular areas of the city that may be at high risk for this type of flooding and saltwater intrusion, and how could they be protected effectively?

Rising groundwater can also intersect with another important environmental issue: Pollution. In many cities, there's a long history of industrial or military sites with extensive soil contamination. Hill said in California and the United States, governments often handled the contamination by "capping" the pollution site with concrete, essentially covering it up with a parking lot. Although this does protect the pollution from spreading when it rains, it does not protect it against groundwater. As the groundwater rises and intersects with the polluted soil, the contamination can resurface and spread to previously uncontaminated areas.

"Everything we've ever made comes back to haunt us as coastal groundwater rises into those old, contaminated soils," Hill said.



At the top, the illustration demonstrates the state of capped pollution with the current sea level. The bottom graphic demonstrates how increased sea level will cause the groundwater to rise into the capped pollution, allowing it to remobilize / Credit: Kristina Hill.

Chapter 3 – It's about more than just water

Meant to stem erosion, seawalls of enormous granite blocks — which now line more than 60 percent of the coast in Kerala, India — actually contribute to erosion by preventing the natural restoration of sand and sediment / Credit: Mary-Rose Abraham.

Along with the risks of flooding, saltwater intrusion into drinking water and agricultural areas can pose major health risks for communities. As the sea rises and saltwater comes further and further inland, the water used for cooking, cleaning and in health care can increase in salinity. This increase has been shown to cause high blood pressure, heighten the risks of preeclampsia during pregnancy and lead to higher infant mortality, according to a 2019 study in Bangladesh.

- Read more: In Two Corners of Bengal's Coast, 'Fire' and Water Hold Women Hostage

Add to that the constant threat of landslides and destabilized structures, such as the ones that occurred in Mumbai, India in July 2021. Dozens were killed when a wall collapsed and enveloped several homes. The monsoon that caused the landslides also hit a water purification plant that left some residents without clean water for days. Elsewhere in the United Kingdom's Thames Estuary, coastal erosion is literally causing homes to fall off the side of cliffs and into the sea, with residents barely escaping with their lives. Left with very little, the communities are placing all their efforts into fighting the government for compensation and resettlement assistance for those who have already lost their homes – and the homes that will be next.

- Read more: What Will Be the Future of England's Thames Estuary Settlements?

It's important for journalists to consider all angles on a disaster, before and after it occurs. If resilience measures aren't in place in time for a major storm or disaster event, what government programs are available to assist survivors in rebuilding their homes and their lives – and is rebuilding similar homes in the same flood- or landslide-prone area actually the right way to build their resilience? Asking critical questions about why a particular initiative is in place can yield you interesting investigative angles.

Issues of resettlement, relocation and migration are a big piece of this story, too. When large populations migrate into urban areas, they're often living in temporary, informal settlements and on less desirable land. Investigating who can afford to stay and protect their property versus who has no choice but to leave, plus where they will go and why is a very important story – as is asking government officials in urban areas receiving that population growth how they plan to support their new residents. Journalists have a key role to play in understanding what trends are emerging in their communities related to livelihood loss, migration and urbanization.

"If hundreds of millions of people have to leave their homes to go live in larger cities, that's an internal economic disaster and a cross-border political and territorial challenge," Hill said.

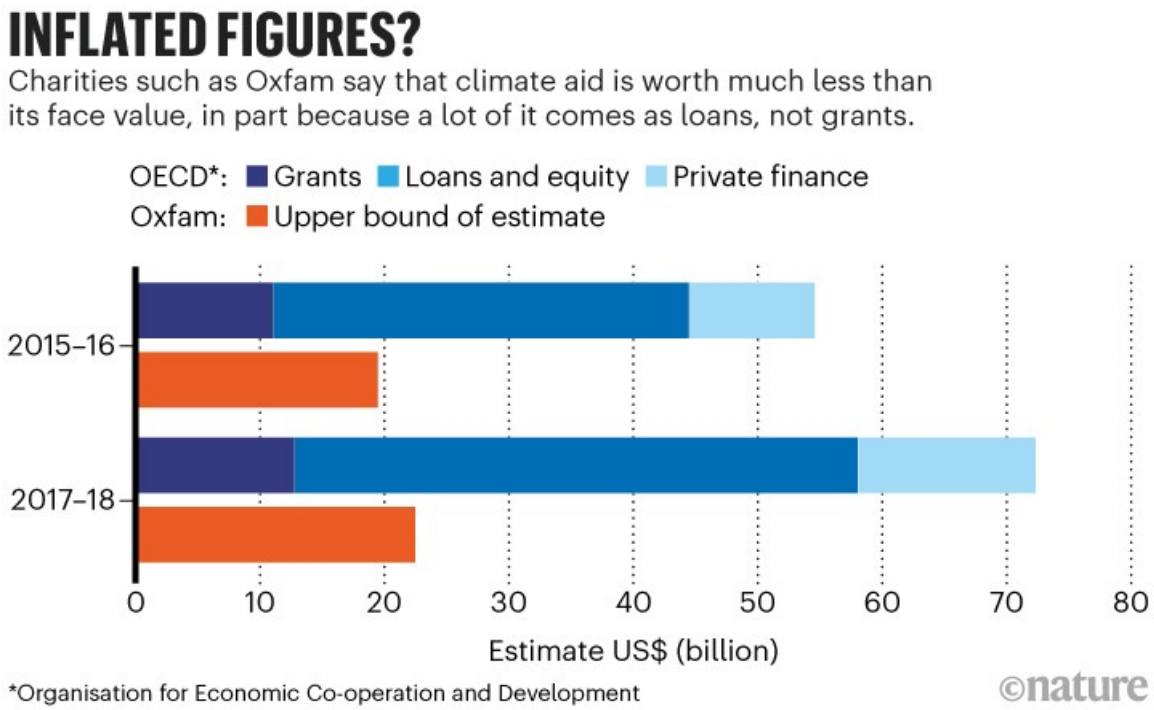
Regardless, building resilience is hard, especially when you're always reacting to new threats. For countries that are constantly navigating natural disasters like earthquakes, wildfires, landslides or storm events, it's hard to find the time and the capital to even think about developing long-term initiatives to build resilience.

"If you're dealing with hurricanes and earthquakes, you don't have the bandwidth to deal with the slow incremental change represented by sea level rise," Hill said. "That's a big problem for everyone who has those disaster events. California fire? Super distracting for us. Hurricane Maria? Super distracting for Puerto Rico and other countries in the Caribbean."

In low- and middle-income countries (LMICs), these problems can be further exacerbated given the limited support from wealthier nations. At COP15 in Copenhagen in 2009, those wealthy nations pledged to support LMICs with US$100 billion a year to fund climate adaptation and mitigation. 12 years later, we are nowhere near that target, and the countries who signed the pledge don't even agree on accounting methods. In 2019, the countries contributed $80 billion to

LMICs, according to estimates by the OECD, yet a significant portion of the money came from loans that receiving countries would need to pay back.

And no one is in agreement on those numbers, either: Another report from Oxfam says that 2019 number is more like US$19 billion because the majority are loans and not all are fully climate-related. A Nature article from 2021 quotes several experts saying that many countries count general aid or development projects as climate-related even if their main focus is elsewhere, such as road construction.



A graph from Nature demonstrating the percentage of OECD-reported climate financing that comes from grants, loans and equity and private finance in the blue bars. In orange, the estimated real value of that money based on research by Oxfam / Credit: Nature.

There's also an imbalance in the type of financing that's prioritized: The Nature article explains that the vast majority of money has funded projects to mitigate climate change and reduce emissions, with a small fraction going toward adaptation or projects that serve both aims. Quoted in the article was Jessica Omukuti, a climate finance expert from the University of Oxford, who had this to say: Reducing emissions is something that helps the world, while adaptation efforts are viewed as only benefiting the country receiving aid. As a result, policymakers in wealthier countries anticipate receiving more praise for reducing emissions for the planet than funding adaptation for a single community, she said.

That's also where the loans come from, the article explains, because adaptation efforts do not generally generate profit the way that mitigation projects such as solar farms and electric cars can, making them less attractive for investors especially from the private sector. And, most of this financing goes to middle-income countries because they often have the capacity and training to submit strong proposals for funding, whereas low-income countries may not.

Journalists from wealthier countries can do a lot to hold governments accountable on these pledges. What did your country pledge to give at Copenhagen in 2009, and how have they lived up to that? How are development projects reported to the OECD, especially ones that may have a minor climate change focus but overwhelmingly fund other issues? What types of projects are funded (mitigation or adaptation) and who decides that?

In lower- and middle-income countries, journalists can ask similar questions, on the flip side. Who is funding resilience or mitigation projects in your country? Is it a loan, and what are the stipulations, such as the interest rate, implementation timeline, payment or project deadlines and more? What strings are attached to certain grants or payments, and how does that affect their use? What resources does your government have to apply for international financing?

Hill said understanding the complete picture is critical to reporting on potential government initiatives and solutions for these issues.

Chapter 4 – Case study: The cost of sea level rise in coastal, urban Cambodia

The overview of Bak Prea village, located at the edge of the Tonle Sap floodplain in Battambang province, Northwestern Cambodia / Credit: Sokummono Khan.

"When you think about fishers and farmers in many parts of the world, they depend on cues from the weather – what season it is, what the weather's doing – to be able to time planting the crops or whether to go fishing or not," says Dr. Furqan Asif, who spoke at our April 2022 webinar about his research on climate migration and urbanization in Cambodia.

As climate change makes those cues unpredictable, Asif explained, it's becoming increasingly difficult to make a living in Cambodia, where 6 million people are employed by the national fisheries sector. Increased storms make it dangerous to fish in the open ocean, warming ocean temperatures are changing fish migration patterns and coastal towns are increasingly threatened by erosion and sea level rise.

As the younger generations grow up in rural areas without job opportunities, they're leaving for urban areas elsewhere in Cambodia and Thailand. That migration can put pressure on city resources and infrastructure that are already stretched thin and make them increasingly vulnerable to climate change.

"If you have a high concentration of people in an urban environment but they're living on marginal land with limited opportunities, that's just going to cause a domino effect of problems," Asif said. "It requires decision makers with imagination and courage [to act]."

Take the case of Sihanoukville, for example. Asif said the coastal city in Cambodia's southwest region has undergone massive and rapid urban development, including apartment buildings and casinos. Overwhelmingly, Asif said, it's being funded by Chinese investment – Sihanoukville is a major city in China's Belt and Road Initiative. That development is not necessarily taking coastal resilience into account, with construction continuing right onto the city's coastline.

Images of Sihanoukville side-by-side but years apart. On the left, an image of Sihanoukville before 2019. On the right, Sihanoukville today after a total investment of US$1.3 billion, with US$1.1 billion coming from China alone / Credit: Furqan Asif.

There are some major policy gaps fueling this trend, Asif explained. There's a lack of information about the projects in development, including what their environmental impacts may be, and spatial and urban planning documents for cities are not always made publicly available. There's also inadequate climate change data in Cambodia, and when research is available, it's often poorly integrated across sectors. Asif remembers the country's Minister of Environment saying at one point that he had no data on saltwater intrusion, for example.

This haphazard urban development often means wealthier areas receive better resilience planning.

In 2011 and 2012, when Bangkok, Thailand, experienced some of the worst monsoon flooding in recent memory, water flooded the expressways built above the city – and revealed some inequalities. "The areas that were walled, which is where the urban elites hung out and lived, they were protected, but because the water increased it pushed toward the areas that were less well-off, where the urban poor

lived," said Asif. "You're seeing the consequences of this uneven urban resilience planning live."

These regions are not alone in these challenges. Consider: What climate and environmental data is available in your region, and how are government agencies using it? When was it last updated and what scales are available – national, regional and/or smaller? Does the data include research on livelihoods, migration, health outcomes, disproportionate impacts on marginalized communities and other issues beyond only climate science?

These issues underscore the importance of building equitable climate resilience plans that include all city residents, especially the most vulnerable. How can journalists investigate proposed or existing coastal solutions in their communities, taking into account these important considerations?

Chapter 5 – Old solutions, new problems

Unprotected sides of houses along the water opening in Dordrecht, the Netherlands / Credit: Amar Guriro.

The Netherlands historically used windmills to pump groundwater for hundreds of years, emptying the lowlands of water so they could be used for agriculture. This also served as a solution for excess floodwater, critical in a country where one-third of the land is below sea level. But this old solution, still in place in some areas today, created a problem in itself: When you pump water out of the ground, you also hasten land subsidence, exacerbating the very problem you're trying to solve.

Subsidence is a common threat these days. In some places in the Netherlands, the land is sinking on average by 8 millimeters a year, and in other areas in the country, it's believed to be as much as several centimeters. But the low-lying country is not alone: Research by Unesco in 2020 found that 19 percent of the world's population could face the effects of subsidence by 2040, including major urban areas like Jakarta, which has sunk more than 2.5 meters in the last decade, and many cities in Iran, which has one of the fastest rates of land sinkage at 25 centimeters a year – making these regions all the more susceptible to sea level rise.

Solutions like groundwater pumping are quickly going out of style, Hill said, as governments realize that more adaptive solutions are needed to stay ahead of the rising sea. The same is true of seawalls or dikes: For example, it would cost an estimated US$37-77 billion to build a seawall around San Francisco Bay in the

Windmills in Alblasserdam, a town in the western Netherlands. This region is known for high concentrations of windmills / Credit: Vishwas Katti via Unsplash.

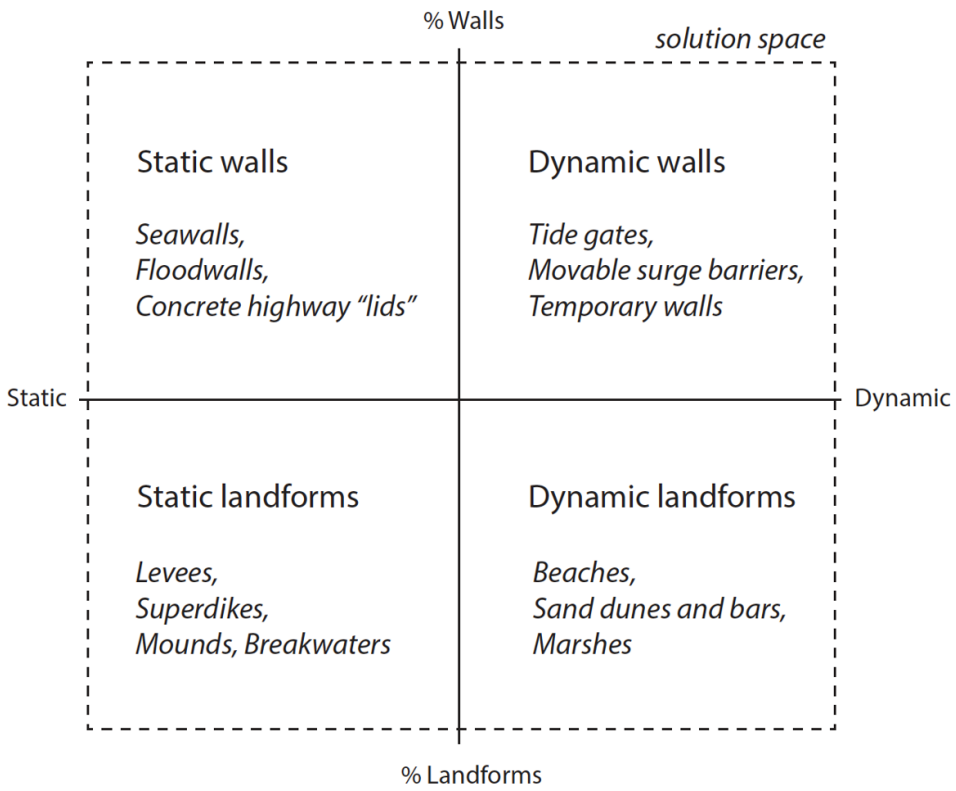
United States to protect against only one meter of sea level rise, and it would be almost double the price to protect against two meters. But if groundwater rises behind the levee or sea level rise increases beyond the wall's protection, the land will flood anyway, Hill explained.

"If you build a wall and the sea level rises beyond the height that that wall was designed for, you end up having to take that wall out," Hill said. "You have to take it out and replace it, which is much more expensive than something like a levee or sand dune system where you can just add material as time goes by."

She walked through four categories of built solutions that have been employed: Fixed walls, such as seawalls and floodwalls; dynamic walls, such as tide gates, temporary walls and movable surge barriers; fixed landforms, such as levees, mounds and breakwaters; and dynamic landforms such as engineered beaches or marshes. Often, these solutions are used together to complement each other, but they carry very different pros, cons – and prices.

For example, while fixed walls like seawalls may be common, they can also be counter-adaptive: Walls can disrupt natural processes like habitat migration, longshore ocean currents and sediment transportation, leading to coastal erosion

and biodiversity loss. And, unlike the gentle slope of a beach or marshland where wave energy is naturally dissipated, the energy is reflected when it hits a seawall, potentially causing danger to anyone using boats in the vicinity.



A diagram demonstrating the four categories of built solutions on two axes. The blue arrows demonstrate increasing transformability as you go down, and increased biodiversity value as you go across. As shown by the diagram, dynamic landforms carry the highest transformability and biodiversity value while also being the cheapest / Credit: Kristina Hill.

Hill said the issue of intergenerational equity is an important one for journalists to investigate: Are governments taking future generations into account, or are they only planning for the relatively short-term? How are policymakers choosing solutions that will allow for resilience in 100, 200 or 300 years, and even longer? How much money is being spent on a solution that may need to be torn down several generations later and/or doesn't solve the long-term problem?

That brings us to the trillion-dollar question: If traditional solutions for flooding and sea level rise are limited, where should governments and communities invest time and effort instead?

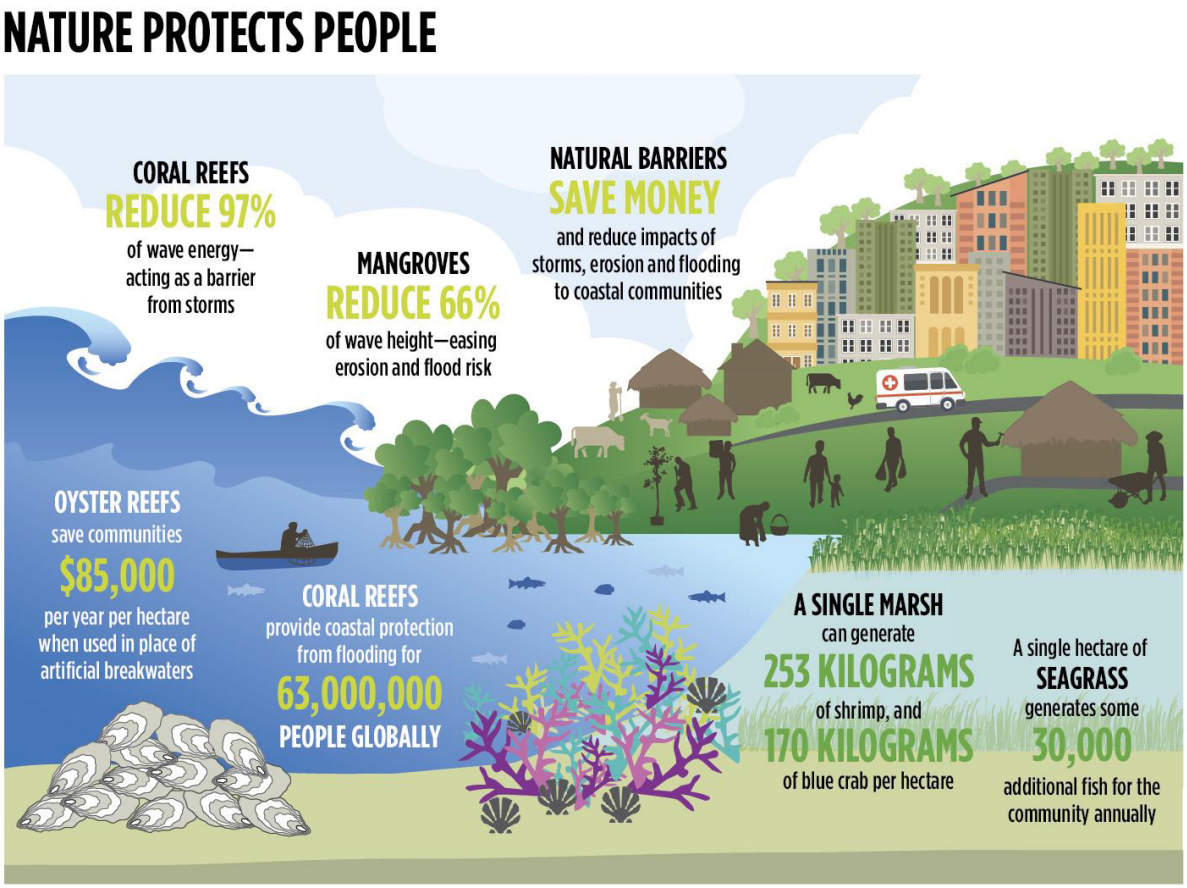
Chapter 6 – A new way of thinking about resilience

Rows of mangroves in the ejido of San Crisanto, in the state of Yucatan in southeastern Mexico / Credit: Emilio Godoy.

Hill said dynamic landforms, when compared to their fixed counterparts, have three major advantages. First of all, of the four categories discussed, dynamic landforms are the cheapest option. But in addition, they support biodiversity, including ecosystem services that humans regularly utilize, and they can be transformed over time by future generations as the planet continues to change.

"It's very, very important to focus on adaptation in place, and where that's possible is by moving dirt around, not by building concrete and steel structures that are expensive to maintain and eventually become a liability," Hill said. Adaptation in place refers to building resilience in a particular location rather than resorting to migration or resettlement.

This is also where nature-based solutions come in. Nature-based solutions involve protecting or restoring natural barriers to sea level rise, including beaches and marshes but also coral reefs, mangroves and other coastal ecosystems. Chaudhury of The Nature Conservancy explained that this restoration can provide many benefits across the wide range of coastal climate impacts, not just flooding.



An illustration demonstrating the variety of nature-based solutions that could be employed as coastal resilience measures, including coral reefs, oyster reefs, marshes, seagrass and mangroves / Credit: Moushumi Chaudhury.

"Some ecosystems, like mangroves, can also have mitigation benefits," Chaudhury said. "It helps people cope with disasters, but also helps reduce greenhouse gas emissions." Marshes and mangroves, for example, serve as carbon sinks by trapping greenhouse gases from the atmosphere and can also provide critical habitats for fish and marine life. In turn, increased populations of marine animals help provide livelihoods for coastal communities.

Coral reefs by themselves can reduce on average 97 percent of wave energy. Right now, reefs protect 200 million people around the world and it's estimated they are worth US$6 billion in revenues globally. Mangroves can be equally useful buffers: Just 100 meters of mangroves can reduce wave height by 66 percent, and research shows they prevent more than US$65 billion in property damages and reduce flood risk for some 15 million people a year, Chaudhury shared.

Mangroves also have another special ability: "Mangroves keep pace with moderate sea level rise," Chaudhury said, meaning as the ocean continues to rise, so do the mangrove forests.

- Read more: Healthy Mangroves Build a Resilient Community in the Philippines' Palawan

In urban areas, Chaudhury said, nature-based solutions are often hard to imagine because they've long been destroyed or removed to make way for coastal development. But it's still possible to use nature-based solutions to protect cities, often in combination with built infrastructure like levees.

"In most urban cases, you do see more built infrastructure because there are very little natural resources left along the coast," she said. "You can complement it with other ecosystems that may not be directly in front of the city, but on the periphery."

How can communities – and journalists – think beyond resilience? While increased information and accountability about resilience measures is urgently needed, it's also important for journalists to explore measures that can mitigate climate change's impacts and draw down emissions in urban centers. For example, coastal wetlands such as salt marshes, mangroves and seagrasses can store five times as much carbon as tropical forests over the long term, according to Project Drawdown, and they can also reduce wave energy from storm surges. Two questions for journalists to consider: How could ecosystem restoration provide both a coastal resilience measure and a mitigation one? Are planners in your city considering ways mitigation and adaptation might be combined?

In some countries, governments and communities are investing in other unique solutions. In China, for example, some urban areas like Shanghai have joined a 'sponge city' program, which stipulates that 80 percent of urban land must absorb or reuse 70 percent of incoming stormwater. In the Maldives, the lowest-lying country in the world, government officials are considering building a floating city and using land reclamation to increase the height of certain islands.

There's also the Billion Oyster Project on the US East Coast, which aims to restore New York Harbor's status as an estuary home to millions of oysters. The name is not an exaggeration: They plan to restore one billion oysters to the harbor by 2035, through public education initiatives and volunteer programs. Not only do oyster reefs provide habitat for hundreds of species, but they can also help protect the city from major storm damage.

Elsewhere, a group in Qatar has been deploying artificial reefs for decades to help live reefs recover from disease and damage so they can better protect Qatar's coastline. Often called "reef balls," these artificial structures provide places for live coral to attach and grow. Building artificial reefs using human technology is not new: Researchers in Singapore are doing similar work with Lego blocks.

Hill highlighted another key solution starting to gain traction: "If you want to use a cheaper shoreline strategy, you need a city that can flood," Hill said. In Germany, for example, the residents of Hamburg have learned to live with the water: In an area of the city called the HafenCity, the first floor has been hardened to prevent damage from flooding. Above the first story, there are emergency walkways for people to use when the district floods, allowing the city to continue business-as-usual and avoid shutting down. Waterproof parking lots contain residents' cars, as well.

A photo from the HafenCity area of Hamburg, where you can see the second-story emergency walkway and hardened first floor to protect against flooding / Credit: Kristina Hill.

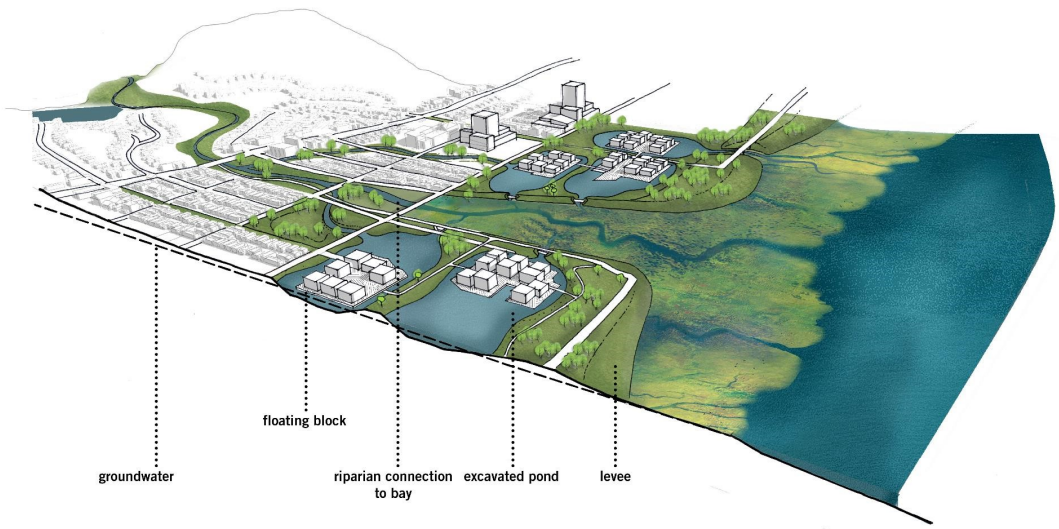
“The key thing is, people can live with the flooding, they don’t have to evacuate,” Hill said. “The future of this will be to build new buildings with their foundations in the water, foundations that are designed to be in the water."
Hill also cited artificial ponds in Rotterdam, a city in the Netherlands, that could receive stormwater from surrounding districts and provide housing and recreational options, and the super-dike system in Osaka, Japan, which would allow buildings to be developed on top of the river dike. Building city infrastructure that exists alongside water and accepting that water is going to be part of the city’s future is a powerful shift in policy for city leaders, Hill said.

Journalists can look into their city’s five or 10-year plans and ask city planners whether this approach is on their radar.

An example of what these artificial ponds could look like in Rotterdam / Credit: Kristina Hill.

Hill believes multi-pronged approaches – such as the combination of urban infrastructure like the HafenCity with nature-based solutions like marshland – will be needed to future-proof coastal cities. In this diagram, you can see what that might look like: Marshes or beaches would separate the ocean from city infrastructure and reduce wave energy. In areas where groundwater is rising and traditional buildings would fail, cities can dig artificial ponds and float prefabricated housing developments in the water. The combination of the marsh or beach areas

and artificial ponds would allow the city's levees to be smaller or nonexistent, allowing residents to live with – and on – the water.



A sketch of a proposed tidal city, where marshland and artificial ponds are used to reduce wave energy and protect city infrastructure / Credit: ABC Team, Resilient by Design Challenge, 2018, via Kristina Hill.

Chaudhury agreed with Hill that it's important to consider solutions that don't involve new construction. The Nature Conservancy is exploring whether insurance for nature-based solutions, such as coral reefs, could provide the necessary capital to protect coastal communities. In Mexico, for example, TNC worked with the government to insure their coral reefs, triggering a payout if a storm reached a certain velocity that would cause significant damage.

In October 2020 when Hurricane Delta hit, the project was tested: With windspeeds of 100 knots, the insurance policy was triggered and a payout of US$850,000 was provided to several volunteer reef brigades, who spent the next two years collecting broken coral and stabilizing more than 2,000 coral colonies in the affected areas. It takes time, Chaudhury said, but it worked. Insurance policies for coastal resources like mangroves, marshes and coral reefs are an emerging idea, and one that journalists can look into in their home communities.

Along with insurance policies, carbon credits can be another tool for protecting and conserving important coastal ecosystems. In Mexico and Kenya, EJN grantees Emilio Godoy and Sharon Atieno both spent time reporting on communities selling carbon credits to protect and restore their mangrove forests. In Mexico, it's the country's first carbon credits program.

It's clear there are a lot of ideas for urban resilience out there, and they all won't be effective in every type of city. That's where journalism can come in – identifying other cities that share your community's problems and learning what they're doing about it. Which solutions are being employed in your region, and have officials considered the best option for your city? If initiatives are being implemented, how did officials come to that decision and who was involved in the decision-making? How much will it cost and who is financing it? Does it address the wider scope of issues beyond flooding or sea level rise, such as pollution, public health, clean water, accessible health care and more? Is the solution being implemented in a participatory way that includes marginalized groups, such as women and gender minorities, the poor, Indigenous communities and others?

"Closing the gap between policies and plans and action on the ground is possible," said Tye from the World Resources Institute. "There is here a great opportunity for the media not just to cover disasters and tragedies but also solutions, lessons, positive stories and even stories of averted disasters."

Chapter 7 – Story themes

A resident of Bandengan subdistrict in Pekalongan City fetches water at a communal collection facility / Credit: Suaramerdeka.com / Isnawati.

Loss and damage, climate financing and investment

- *Using insurance and property tax as a resilience tool.* Programs like the one The Nature Conservancy worked on in Mexico are part of a new set of tools for financing resilience projects in countries that may not otherwise be able to fund them. What are other unique financing or funding models that could work in your community? For example, increases in property tax, environmental impact bonds or revolving loan funds are all mechanisms that cities have considered and implemented. Finance journalists, this is where you come in.

- *Foreign investment and financing.* Investment programs like China's Belt and Road Initiative can bring a large amount of foreign capital into a city, often fueling development and construction that doesn't take resilience into account. The foreign companies or governments doing the investing get to reap the profits, without having to confront the coastal damage their funding could be causing. In some cases, those countries might be financing coastal resilience projects within their own borders to protect their people yet supporting the creation of damaging infrastructure elsewhere. What's happening in your hometown, and who is financing it?

- *Loss and damage.* Wealthy nations contribute the vast majority of emissions and also have the capital to implement resilience initiatives to protect their people,

unlike many low- and middle-income countries. Despite promises at global summits to finance resilience in LMICs, known as the loss and damage debate, enough funding has not materialized. Where does the funding come from for resilience projects in your community? Keep an eye out for loans and other financial models that have many strings attached, such as specific deadlines for use. If you're in a wealthier country, how has your government lived up to their climate finance pledges?

Urban planning, zoning and development

- *Zoning and urban development authorities.* City urban planners, zoning officials and other authorities who review and approve permits for new construction or projects are important people to develop relationships with as a journalist. What priorities do these authorities have when it comes to zoning, project development, funding and stakeholder engagement? What directives are they receiving from the city, state or national government that is affecting development and resilience in your city? Have these agencies shared any progress toward policies to ensure new coastal projects include environmental impact assessments or built-in resilience measures?

- *Disaster preparedness plans.* Clear plans for addressing disasters, especially ones that may become more frequent and intense due to climate change, is an important part of urban coastal resilience. Who creates disaster preparedness plans for your city and how often are they updated? How is the latest research on climate impacts in your region incorporated into the plans? What stakeholders are involved in decision-making and are representatives of marginalized and/or vulnerable communities included? How do the adaptive approaches to resilience discussed in this tipsheet factor in?

- *Climate gentrification.* For decades, it was ocean-view properties that the wealthy historically desired, leaving areas at higher ground for the poorer and red-lined communities. Now, the tide is turning as those coastal areas are becoming inundated with flooding and other climate impacts. As wealthy people move away from the coasts and onto that higher ground, those communities are facing gentrification and displacement. Initiatives to increase resilience, while often well-intentioned, can also cause home and rent prices to soar, pricing out the original residents; an influx of wealthy people into marginalized communities can have the same effect. How are situations like this manifesting in your city and what steps are government officials taking to mitigate the impact on marginalized communities?

- *Cultural and community relocation.* Many resettlement, land buyout or relocation programs for at-risk coastal residents focus on the individual or the

household, not wider communities or neighborhoods. This focus is causing what some are calling cultural displacement: When at-risk communities are unable to stay together, causing residents to feel adrift in their new living areas. For communities that may share a culture, religion or language and have community-run schools, restaurants, religious institutions and other shops intentionally located there, this can be extremely isolating. How could governments prioritize larger efforts to relocate that would prevent this kind of displacement?

Political leadership, partnerships and priorities

- *Identifying the responsible party.* It's important to understand who's responsible for enforcing, enacting or implementing policies to strengthen resilience at the national, provincial, state and local levels. What abilities do individual cities or towns have to enact their own coastal resilience projects, and what support might be available from state or national government? Is responsibility shared between agencies – such as the health department, development authorities, environment ministry – and how are they working together?

- *Political leadership.* How do your political leaders talk about climate change? Do they address coastal impacts directly or talk more generally about its effects? How do issues of climate change and coastal resilience play out during an election year and on the campaign trail? Are questions about climate policies included in political debates? What promises do political candidates make and how can you as a journalist hold them accountable when they take office?

- *Collective action.* Where and how are people taking action to ask for improved coastal resilience infrastructure and initiatives? What are they asking for and how is the government responding? What partnerships might exist between the private sector, government, NGOs and communities and how are those relationships faring?

Public health, livelihoods, biodiversity and food security

- *Saltwater intrusion.* In this tipsheet, we discussed how consuming increasingly saline water can pose intense health risks for communities, particularly children, women and other gender minorities. Yet, the extent and the risks of saltwater intrusion are often under-researched and under-reported around the world. Are the communities in your region aware of these risks, and are they doing anything about it? What have doctors observed about reproductive health and pregnancy outcomes that could relate to salinity?

- *Food security and livelihoods.* Fish and seafood are a huge component of the diets in many countries around the world, especially in coastal communities. Coastal agriculture is also an important livelihood in many countries. These foods matter both because they are historically common and because they often carry cultural significance. As climate change accelerates, changing fish migration routes, increased or decreased rainfall, severe storms, drought, flooding, evacuation or relocation, and other issues can threaten food security and cultural preservation. How is climate change changing diets in your region? How are communities adapting?

- *Biodiversity loss.* Along with climate change's impacts on human communities, it's also deeply affecting the ecosystems where they live. Along with the habitat destruction and fragmentation that comes with urbanization and development on the coastline, erosion and sea level rise can further destroy crucial habitats for shoreline and intertidal species who depend on beaches and shore zones for nesting and other activities. Without clear planning and impartial environmental impact assessments, even well-intentioned coastal resilience initiatives could further degrade these habitats. As an alternative to a human-centered story, you could consider: what species are threatened by sea level rise in your country and how could coastal infrastructure make that worse? How can biodiversity conservation be included in your city's coastal resilience plans?

Chapter 8 – Terms & resources

Aerial view of the city of Santos, coast of São Paulo, Brazil. Most of the population lives on the island of São Vicente, and on the hill, the most vulnerable populations are subject to landslides / Credit: Anderson Bianchi.

Examples of in-depth journalism:

- FloodList – news outlet covering global flooding issues
- The broken $100-billion promise of climate finance – and how to fix it – Nature
- Climate gentrification threatens Miami's last affordable housing – Documentary from CBS News
- As sea level rises, Miami neighborhoods feel rising tide of gentrification – Covering Climate Now
- History at risk: Port Maria, birthplace of Jamaica's first slave revolt, braces for climate change impact – Unbias the News
- Climate change is stretching Mumbai to its limit – The Atlantic
- An Impossible Choice: The Pacific's Climate Crisis – The Guardian special series
- Shifting Sands: Carolina's Outer Banks Face a Precarious Future – Yale Environment 360
- Can restoring mangroves protect Miami from rising seas? – National Geographic
- Where Will Everyone Go? – A special report on climate migration from ProPublica and The New York Times Magazine
- Urban Poor Struggle to Adapt as Rising Seas Threaten to Remap Metro Manila – Philippine Daily Inquirer two-part series
- Rising Seas Threaten World's Airports – NikkeiAsia
- Lessons in Climate-Driven Relocation: The Narikoso Case – MaiTV Fiji

- Vietnam's Massive Ecotourism Charade – Mekong Eye
- Parts of Northern Java Slowly Disappear as Rising Seas Exact Their Toll – Tirto.id
- Rising Seas threaten the Gullah Geechee culture. Here's how they're fighting back – National Geographic

Guidance for journalists:

- Urban Resilience in the Age of Climate Change: A Webinar for Journalists – EJN webinar
- Living Between Land and Sea: A Webinar for Journalists on Covering Coastal Resilience – EJN webinar
- The Effects of Using Saline Water in the Bay of Bengal Region – EJN webinar
- Guide to Investigating Sea Level Rise – Global Investigative Journalism Network
- Reporting on Climate Adaptation – The Donald W. Reynolds Journalism Institute at the University of Missouri School of Journalism

Research and data sources:

- The Future We Don't Want report on sea level rise and coastal flooding – C40 Cities
- Weather-related disasters increase over past 50 years – World Meteorological Organization
- People and Oceans factsheet – UN Ocean Conference
- Understanding climate change and global sea level – Climate.gov
- People and the changing nature of coral reefs – Regional Studies in Marine Science journal
- Mangroves for Coastal Defence: Guidelines for coastal managers and policy makers report – The Nature Conservancy
- The Nature Protects People Learning Platform with guides and tools on nature-based solutions – The Nature Conservancy
- Coastal Resilience Mapping Portal and Training Videos – The Nature Conservancy
- Natural Solutions Toolkit – The Nature Conservancy
- The global flood protection benefits of mangroves – Nature Scientific Reports
- Coastal wetland restoration and coastal wetland protection – Project Drawdown
- Preliminary investigation of the effects of sea level rise on groundwater – U.S. Geological Survey
- Impacts of salinity intrusion in community health: A review of experiences from coastal Bangladesh – Healthcare (Basel) scientific journal
- Climate finance provided and mobilised by developed countries – OECD
- Climate Finance Shadow Report 2020: Assessing progress towards the $100 billion commitment – Oxfam
- Transitioning to Sponge Cities: Challenges and Opportunities to Address Urban Water Problems in China – Water scientific journal

- Coastal infrastructure: A typology for the next century of adaptation to sea level rise – Frontiers in Ecology and the Environment
- Building Coastal Resilience in Bangladesh, the Philippines, and Colombia: Country Experiences with Mainstreaming Climate Adaptation – World Resources Institute
- 6 Keys to Turn Coastal Resilience Plans into Action – World Resources Institute
- Climate Gentrification: Methods, Gaps, and Framework for Future Research – Climate, Ecology and People scientific journal

Terms:

- **Resilience:** Resilience means the capacity to recover quickly from difficulties. In coastal and climate change contexts, resilience refers to the ability of a community or ecosystem to bounce back from negative events such as major storms, flooding, landslides, livelihood loss, public health issues and more. Resilience is a trait, an ability, that a system has or needs to develop.

- **Adaptation:** Adaptation refers to the actions through which a system becomes better suited to its environment. It's a process, one that can be used to build resilience, such as a community adapting to frequent storms by restoring their mangrove forests to reduce flood risk.

- **Mitigation:** Mitigation refers to the actions through which the severity or seriousness of a particular event or issue is reduced, in this case, climate change. Mitigation is also a process, a series of steps that could be taken to reduce emissions, increase carbon sinks and more, overall reducing the severity of climate change's impacts on our planet.

- **Groundwater:** Groundwater refers to any freshwater located underground, stored in the cracks and spaces within the soil. It's slow-moving, making its way to the nearest flowing body of water and eventually the ocean. Groundwater can be accessed in several ways: Extraction using wells or pumps; natural discharge at springs or seeps; and wetland or oasis formation. Aquifers, where wells are generally placed, are layers of groundwater, typically bound by rock, gravel or sand. Not all groundwater forms an aquifer, but all aquifers are groundwater. The way groundwater behaves has a lot to do with the type of soil and the climate, so it's important to conduct research on your region to understand the specific local nuances.

- **Compound flooding:** Compound flooding occurs when two or more sources of water – such as lakes, rivers, the ocean, rainfall, groundwater – flood simultaneously or close together, causing more flooding than would have happened with only one source.

- **Subsidence:** Subsidence refers to the sinking of the earth's surface because of the movement of materials underground. Oil and natural gas extraction, groundwater pumping, mining and earthquakes can all cause subsidence. It

can happen suddenly, such as when a sinkhole forms, or it can happen over time, such as urban areas that are slowly losing ground.

- **Saltwater intrusion:** Saltwater intrusion refers to the encroachment of saltwater from the ocean into fresh groundwater. Typically, because fresh groundwater is constantly moving toward the ocean, this movement prevents saltwater from moving toward land. At a certain point, the two waters mix at the "zone of transition" and eventually become saltwater as you go further out into the ocean. As the sea level rises, saltwater moves further and further inland, causing the freshwater underground to become increasingly salty as the zone of transition moves inland as well. This can also occur because of excessive groundwater pumping.

- **Climate gentrification:** Gentrification refers to the changes in the character of a neighborhood that cause higher rents and/or store prices. It can lead to the displacement of current residents to make way for wealthier ones, and it particularly affects marginalized communities. Climate gentrification refers to this same process when climate change is the driver of change in a particular community. For example, as hotter temperatures make certain areas unlivable, wealthy people will move to cooler climates and price out existing residents by increasing the value of the neighborhood. Efforts to increase resilience can also cause gentrification if they are not implemented appropriately.

- **Dynamic versus fixed:** Fixed forms of coastal infrastructure, such as seawalls, dikes and canals, can't be moved or changed easily and they don't change over time as the ecosystem changes. Dynamic infrastructure, such as the Dutch Sand Engine project, complement or work along with existing coastal processes and ecosystems to provide coastal benefits without interfering with the natural system. Fixed infrastructure exclusively refers to human-built things, as natural infrastructure is inherently dynamic. Dynamic infrastructure can also be modified over time as sea level continues to rise or coastal conditions change.

- **Seawalls:** A seawall is an artificial, static wall that prevents floodwater from entering a specific area. They require constant maintenance and will eventually need to be removed and replaced entirely – it is not possible to increase the height of a seawall, for example, without removing it and starting over. Seawalls can accelerate erosion and halt other important coastal processes because they interfere with the natural flow of sediment along the coast, and they can also cause habitat fragmentation for coastline species.

- **Levees:** A levee is a wall made from natural or artificial materials that is used to block floodwater from entering a specific area. Levees specifically protect land that is normally dry from flooding and storm surges. They can also be used to divert rivers. Levees are different from seawalls in that they can be continuously adapted and rebuilt to serve changing needs over time

without needing to tear them down and restart. Levees can also be prone to erosion, depending on how they are built.

- **Dikes:** A dike is a wall made from natural or artificial materials that is used to block water from a particular area that would normally have water. Although similar to a levee, that is the primary difference: While levees are used to keep water away from naturally dry land, dikes are typically used to keep water away from naturally wet land. However, in practice, the words levee and dike are often used interchangeably.

- **Landforms:** A landform refers to a natural feature of the planet, such as hills, mountains, bays, islands, salt marshes, beaches and more. These features are created through tectonic processes underground or by ocean currents. In a coastal resilience context, landforms are features humans utilize for flood risk or coastal protection uses. Resilience initiatives can make use of existing coastal landforms, or landforms can be restored in places they have been depleted (e.g., marshlands) or engineered in places where they don't already exist (e.g., beaches).

- **Nature-based solutions:** Nature-based solutions is a term often used to refer to types of initiatives that include natural elements and features in their planning, as opposed to human-made infrastructure like buildings. Some examples of nature-based solutions include mangroves, marshes, coral reefs and seagrass. Dynamic landforms are also a type of nature-based solution.

- **Living shoreline:** A living shoreline is a type of nature-based solution where plants, reefs, sand and other landforms are used on a coastline to reduce erosion and flood risk while maintaining the natural processes taking place on that coast. Also known as vegetative shorelines, these features can also provide habitats for coastal species and serve as carbon sinks, removing greenhouse gases from the atmosphere.