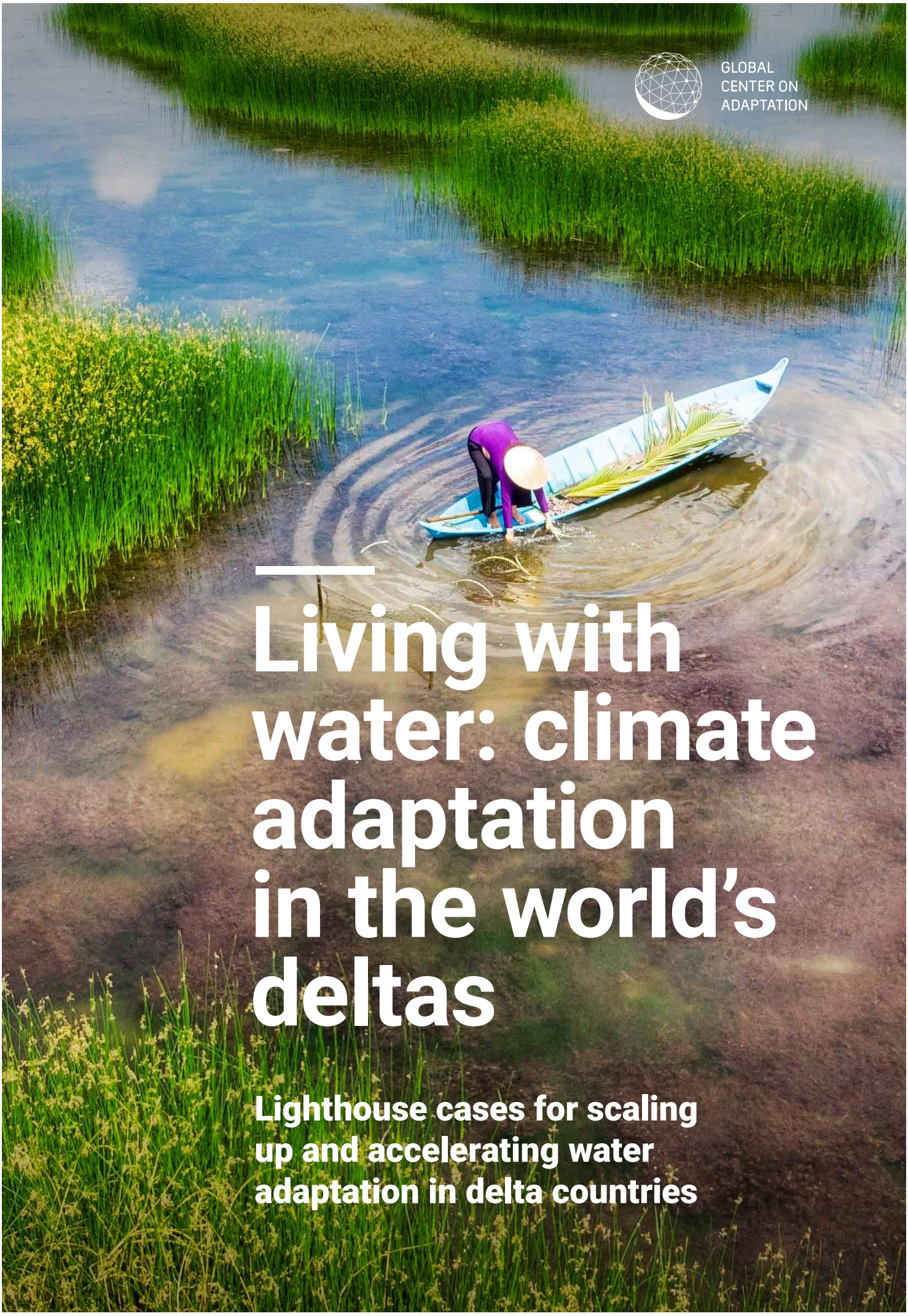

Living with water: climate adaptation in the world's deltas

Lighthouse cases for scaling up and accelerating water adaptation in delta countries

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FOREWORD

Over the centuries, deltas have given rise to some of the world's greatest cities—and those cities have always been open to the world. They have thrived not only in the trade of goods, but also in the exchange of ideas. Today, as the world faces up to the need to adapt to climate change, it has never been more important for delta countries to learn from one another.

That is the thinking behind this 'lighthouse' report, which brings together inspiring case studies from around the globe to galvanize governments and citizens to help the half a billion people living in delta communities who are imperiled by climate change.

A recent IPCC report stated with 'high confidence' that deltas will face 'high to very high risks' in the future from rising sea levels, even under scenarios in which the world rapidly reduces emissions of greenhouse gases and minimizes the rise in global temperatures[1].

It is becoming increasingly clear that the environment of deltas is already changing and we need to change with it. We need to learn to work together to become more resilient. We must adapt.

There are bright spots and pockets of innovation everywhere, from the experimental concept of the 'double dike' in the Netherlands to the permeable groins reshaping Bangladesh's Jamuna river—solutions that understand and work with nature's systems, that are anchored in long-term and holistic policy frameworks. Solutions that must be implemented and scaled up at speed.

With collaboration, knowledge can grow and spread as it is in turn passed onto other delta regions to help them adapt to their own climate problems. These efforts must be underpinned by predictable budgets and governance mechanisms that enable agile planning and effective coordination among different administrative entities. Local communities must be empowered to identify, prioritize, implement, and monitor climate-adaptation solutions.

Our hope is that international co-operation, collaboration and ambition to find ways to adapt will act in the coming years as a shining beacon for all delta regions struggling with the impacts of climate change. It won't be easy, but mutual support will be key to success.

Patrick Verkooijen
Chief Executive Officer
Global Center on Adaptation

Ban Ki-moon
8th Secretary-General of the United Nations
Chair, Global Center on Adaptation

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Part 1

Summary Report

INTRODUCTION

Lighthouses show where to go—and where to avoid. The 'lighthouse' case studies in this Delta Report explore best practices in climate adaptation and resilience interventions in delta countries.

The report is intended primarily for an audience of governments in delta countries: policy-makers, central and federal governments, and local governments including mayors and municipal councils. It aims to raise delta adaptation efforts up the political agenda by highlighting significant achievements and good practices where learning can be shared, supporting the policy dialogue on water adaptation and resilience, unlocking avenues for collaboration among policy-makers and technical advisors, and building awareness and capacity.

The report's secondary intended audience is financiers, insurance companies, water experts, and practitioners. It sheds light on financial opportunities, risks and barriers for institutional and private investors, and other economic stakeholders related to climate-change adaptation in delta countries.

CLIMATE-CHANGE ADAPTATION IN DELTAS

Deltas are complex systems. With their fertile flood plains, they are home to abundant biodiversity and the rich soils make them attractive for agricultural production. With their plentiful natural resources and strategic location for water transport—linking upriver to overseas—they have become home to the world's largest cities and ports.

Most deltas are densely populated. Five hundred million people live in delta and coastal urban regions today, and that is expected to increase by 50 percent by 2050[2]. Many deltas are engines for economic growth, and have higher GDP per capita than the economies in which they are located—for example, the Gulf of Mexico, the deltas of the rivers Rhine, Nile, and Paraná, and many deltas in East and South-east Asia. The Mekong Delta supports a population of 20 million people and approximately a quarter of Vietnam's GDP. The reverse is often true in less-developed regions, however, including parts of Africa[3].

The impact of climate change will be most acutely expressed through water: there will be more floods and droughts, and sea levels are projected to rise by 0.5 meters by 2050 and over a meter by 2100. Ninety percent of disasters are water-related. This makes deltas particularly vulnerable to climate risks[4]. Cities in deltas also share the challenges faced generally by urban areas, such as rising poverty, income inequality, and population growth in unregulated settlements. Land subsidence and environmental degradation add to the complexity of the challenge.

Rising sea levels will put large parts of many deltas at risk of submergence, especially in areas where land is subsiding due to over-extraction of groundwater. Climate experts predict that by 2050, rising sea levels will submerge some 17 percent of Bangladesh and displace about 20 million people[5].

Rising sea levels will also increase saline intrusion, threatening the water and food security of large vulnerable populations. The Mekong Delta accounts for 12 percent of Vietnam's land area, but—at the time of writing—accounted for an estimated 40 percent of the country's agricultural GDP and more than half of its expanding agro-food exports[6]. Demand for water is forecast to increase by 55 percent by 2050[7]. The number of people living with water scarcity will grow to 3.1 billion[8]. Almost 70 percent of the population in deltas live in areas that are particularly susceptible to coastal erosion[9] and flooding[10].

Without urgent action on adaptation, the projected losses in some delta regions are large enough to stifle entire economies: for example, 9 percent of GDP per capita in the Volta Delta and 19.5 percent in Bangladesh. These losses will come from damage to infrastructure, crop production and fishing. The indirect consequences, such as the loss of livelihoods and food security, would be severe[11].

Addressing adaptation in deltas at scale has proven to be complex and challenging, for multiple reasons. Most cities and river basins lack integrated climate-adaptation plans: even when many stakeholders might see clearly what needs to happen, lines of accountability may be unclear, technologies inaccessible, financing unavailable and

capacity lacking. Structural interventions are expensive and require long-term investments that are often beyond the reach of many governments.

Water management in deltas is complicated by their dependence on what happens in the upstream river basin, often bringing in cross-boundary complexities. Even in the same jurisdiction, responsibilities and budgets for water management tend to be fragmented over government levels and bodies. A study of 11 delta cities showed that many, such as Rio de Janeiro, face challenges related to ownership of issues being split across different departments and agencies[12].

Political will and administrative commitment at all levels is essential to raise climate adaptation on the agenda in delta countries: increasing awareness of climate risk and appropriate policy responses, mainstreaming in public and private-sector decision-making, building capacity across formal institutions and informal stakeholders, developing policies and regulations, agile planning, and securing clear financial commitments from the public and private sector. Stakeholder participation and coordination is particularly essential in transboundary delta regions to align interests across communities.

Promising adaptation interventions are emerging, supported by technical innovations, but the scale and pace of implementation needs to be accelerated. The world's deltas are not only where the challenges of the 2030 Agenda for Sustainable Development are felt most acutely, but also where there are the most opportunities to make progress and validate innovations that could be more widely applicable.

THE DELTA COALITION AND GCA

The Delta Coalition was formed in 2016 to address these shared challenges and facilitate adaptation efforts at the highest political level. Comprised of 13 countries with prominent deltas, the coalition forms partnerships across north-south political and geo-political differences, promoting knowledge-sharing on deltas, adaptation, resilience, and sustainable urban development. The coalition succeeded in putting the need for sustainable urban deltas into the Urban Agenda.

Most importantly, the coalition allows delta countries to jointly create good practices, fuel innovation, and unlock the capital needed for the implementation of projects that will reduce vulnerability to climate change.

The coalition has been successful in highlighting pressing issues, but now wants to take the next step to translate dialogue into action.

METHODOLOGY

This report is based on existing research, gray literature and reports, discussions with key informants, and interviews conducted by local partners and consultants with practitioners, representatives of local communities, government officials and civil society.

Through a series of case studies, the report sets out to answer the overarching question: *What are the key bottlenecks and enablers to accelerate and scale water-related adaptation interventions in Delta regions based on best practice examples?*

The cases were strategically selected to represent a balanced spread of the world's deltas: across a range of geographies and income levels, and addressing a variety of pressures—floods, drought, subsidence, salinization, water security—through diverse solutions that have the potential to be scaled and replicated in other contexts.

Each case study looks at a particular delta: its characteristics; the key water-related threats posed by climate change; an intervention that has been made to address those threats; and what other deltas can learn from that intervention.

Each case study was led by a main author with responsibility for collating and analyzing existing sources of information, and conducting interviews with key informants. All authors worked from common terms of reference, developing the case studies using a common analytical framework covering technological, institutional, ecological, and economic aspects of the intervention and its success factors. Case studies were reviewed by local and international stakeholders and as much as possible by representatives from concerned governments.

Given that the case studies represent a wide range of geographies, governance systems, income levels, and climate conditions, key findings and recommendations are representative and applicable across a wide range of conditions—though care must be taken to adapt the presented good practices before adopting and implementing them.

EXECUTIVE SUMMARY

Deltas are among the places most vulnerable to the impacts of climate change: floods, droughts, and rising sea levels causing coastal flooding and saline intrusion into groundwater. Many are also densely populated, hotspots for biodiversity, and engines for economic growth and human development.

Many deltas still lack integrated climate-adaptation plans, in part because of the difficulties of aligning responsibilities and budgets across government levels and bodies. Without action on adaptation, the impacts of climate change on delta regions could stifle entire economies and severely impede progress toward the 2030 Sustainable Development Goals. Yet the nature of deltas also provides opportunities to make progress and validate innovations.

In the absence of adaptation interventions, losses will range from an average of 9 percent of GDP per capita in the Volta Delta to 19.5 percent in Bangladesh, caused by damages to infrastructure as well as losses in crop production and fishing.

The 'lighthouse' case studies in this Delta Report explore good practices in climate adaptation and resilience interventions in delta countries. The case studies were selected strategically to ensure a wide and diverse representation of different hydrological, climatological, social-economic, and geographic conditions. On the basis of this diverse and representative range of cases, key findings have been formulated to inform adaptation practices elsewhere. This report also aims to build political support for further accelerating and scaling up climate adaptation in delta countries.

Lighthouse case studies

Paraná Delta, Argentina: creating synergies between climate mitigation and adaptation through improved delta management. The Paraná Delta—covering more than 20,000 square kilometers—has long been neglected, despite its proximity to major cities, in part because of difficulties aligning across different layers of government. Severe drought and wildfires provided the impetus for fresh attempts to improve governance effort, based on meeting Argentina's commitments to its Nationally Determined Contribution to the Paris Agreement. Agreements between national and provincial governments have led to the setting up of a network of bases in national parks to conserve wetlands and support sustainable socio-economic activities.

Bangladesh Delta Plan 2100: combining water resources management and disaster risk management. The Ganges-Brahmaputra-Meghna Delta is home to nearly 200 million people and its flood plains cover two-thirds of Bangladesh. The government was supported by the World Bank and the government of the Netherlands to define a comprehensive development plan, BDP 2100. Its US$ 38 billion investment portfolio is based on an adaptive delta management approach which seeks to work in harmony with natural hydrological systems and favors smaller, 'no-regret' interventions, phased over time, over large, irreversible one-off projects. Successful implementation will depend on clearly defined responsibilities among government departments, predictable financing, community participation, and private-sector partnerships.

The Mira river basin, Colombia: engaging communities through food security. Ethnic groups who live in the Mira river basin have long been marginalized, and are now struggling with the impacts of climate change. The governments of Colombia and Ecuador are engaging communities to participate in a food-security and nutrition intervention, combining climate-resilient traditional practices with scientific knowledge to develop Village Adaptation Plans.

Demak, Indonesia: a partnership between local communities and government for nature-based solutions. The 'Building with Nature' approach aims to rehabilitate the mangrove greenbelt, which protects against coastal erosion, by constructing permeable dams from local natural materials to create new mudflats that mangroves can reclaim. The technique faced challenges because there was too much land subsidence from groundwater extraction. The economic side of the intervention—incentivizing the community to maintain the mangrove greenbelt by improving aquaculture—was a success. An investment of €8 million is on course to achieve break-even within five years.

Beira, Mozambique: a programmatic and collaborative approach to urban resilience. Beira's municipal government and the Netherlands have worked together since 2012 in an equal, long-term partnership to support urban resilience. The partnership is distinctive in its focus on process, rather than setting specific upfront objectives, to enable adaptability as circumstances change. For example, the process of developing an urban master plan built knowledge and relationships among stakeholders that later enabled the rapid leveraging of over US$ 200 million in international funds for flood protection infrastructure in response to Cyclone Idai. The partners are now exploring various ways to create a market for affordable, flood-resilient housing.

The Wadden Sea region, the Netherlands: long-term political and budgetary commitment supported by a systems approach. The Netherlands has a long history of adapting to water-related risks, and has developed a fourth layer of government for water management. The lessons of the centuries—including the need for broad-based public support, long-term political commitment, and taking decisions at the lowest possible level—have now been applied to a proactive approach to managing climate risk. A shift from a focus on technical solutions to working with nature can be seen in the Wadden Sea region, through solutions with multiple functions—such as the 'double dike', which is helping with sediment management and cultivation of seafood, as well as protecting from coastal floods.

The Mekong Delta: living with water, rather than trying to control it. The Mekong Delta is the world's third-largest, accounting for 18 percent of Vietnam's GDP and population. In the 1970s and 1980s, a 'rice first' policy of intensive agriculture saw massive engineering projects to manage water flows. Gradual realization that these were ecologically unsustainable has led to a new approach that embodies four key lessons for delta management: think of the delta as a living organism; look beyond the economic rationale for the delta's development; ensure integrated planning and regional coordination; and apply the 'no-regrets' principle in the planning for adaptation to climate change.

Key findings

There is an urgent need to improve understanding of what works in delta environments, and share lessons and information across countries for scaling up. The case studies show that numerous practical adaptation solutions have demonstrated results.

Climate adaptation in delta areas is a complex issue best looked at through a systems lens. In any particular delta, adaptation strategies require an in-depth and scientific understanding—especially of the delta's natural systems—and a strong baseline that includes analysis of risk exposure and drivers of change. This in turn requires better, open-access climate data collection.

While action is required immediately, climate-change adaptation is a long-term game. Making deltas more climate resilient requires thinking in terms of decades, and creating legal and political frameworks that are conducive to long-term, integrated planning. Frameworks must be agile and flexible enough to change tack when needed, given the high levels of uncertainty involved in climate change.

Communities must be at the center of adaptation planning and action. Vulnerable groups in delta areas face issues—such as poverty, malnutrition, and lack of access to sanitation—that are hard to distinguish from climate impacts. Their meaningful participation must be embedded in approaches that address all their concerns and engage them in co-creating solutions.

Nature-based solutions, combining 'green' and 'gray' infrastructure, are promising but need urgent scaling. They are often also conducive to achieving multiple objectives, such as creating local jobs in operations and maintenance while building climate resilience.

Deltas need dedicated governance structures organized on water management principles. Deltas often cut across administrative and national boundaries, creating significant governance challenges.

Dialogues and planning frameworks on water and climate adaptation in deltas need to be better integrated. Mainstreaming them in Nationally Determined Contributions and National Adaptation Plans is a promising approach.

There are many relative low-cost policy options. These include reshaping incentives for private-sector engagement, land-use planning, agricultural subsidies, and climate-responsive safety nets.

Nonetheless, adaptation in deltas needs an increased level of long-term financing commitments. Financial resources should be targeted to those who need adaptation most, but many low-income countries do not have the necessary resources. Innovative financial instruments are needed, such as climate resilience bonds and debt-for-resilience swaps. Development partnerships should go beyond the typical five-year project cycle.

Post-Covid recovery plans provide an opportunity to enhance adaptation in deltas. Governments can leverage economic recovery packages to implement approaches that improve the health and economic stability of communities alongside their climate resilience.

KEY MESSAGES

Deltas are vital drivers of economic growth, biodiversity and human development, but highly vulnerable to the impact of climate change.

Deltas tend to be economic and ecological hotspots because of their highly fertile soils and connectivity through inland waterways, and are conducive to intense human activity. Rapid climate-change effects, in particular rising sea levels combined with floods, are having immediate negative impacts in deltas, and projected trends will see far-reaching impacts on human and economic development, and ecologies. Without adaptation measures, damages to infrastructure as well as losses in crop production and fishing could cause average GDP losses of up to 19.5 percent. The indirect consequences, such as the loss of livelihoods and food security, could be even more significant[13]. For example, climate-related disasters are expected to force 63 million people across South Asia to evacuate their homes and migrate by 2050, if the global community fails to limit warming to well below the Paris Agreement goal of 2°C. This will most acutely affect the security and wellbeing of women and girls.

The Global Commission for Adaptation's flagship report 'Adapt Now' proposed 'three revolutions' to accelerate the pace and ambition of adaptation in:

- **Understanding:** To ensure that climate risks are fully understood and reflected in the decisions that public and private actors make.

- **Planning:** To improve policy and investment decisions.

- **Finance:** To mobilize the funds necessary to accelerate adaptation and channel them to priority actions.

These three revolutions are particularly important in deltas.

UNDERSTANDING

Climate adaptation in delta areas is a complex issue best looked at through a systems lens. Deltas are complex and adaptation measures need to address social, environmental, hydrological, and economic interdependencies. Developing and designing adaptation strategies and measures requires an in-depth and scientific understanding of entire delta systems in all their different aspects.

Better, open-access climate data collection is required for adaptation action in deltas. Disaggregated climate data needed for delta analysis should be widely shared and understood by local communities, the private sector, and local and national policy-makers, to enable coordinated action.

Understanding nature is indispensable to take adaptation actions. Several of the case studies illustrate how costly it can be to intervene in a delta's natural system without a thorough understanding of how it works—and how seeking greater harmony with nature is the right direction for delta management.

A strong baseline that includes climate risk exposure and main drivers of change is required for each delta. In Bangladesh, BDP 2100 identified the delta's main drivers of change, and pressures on them, as a starting point for developing adaptive strategies. In Mozambique, Beira municipality had already invested in analyzing disaster risk exposure and preparedness when Cyclone Idai hit, so plans for further adaptation measures and investments to build back better could be drawn up quickly and effectively.

Better understanding is required of what works in delta environments for urgent scaling up and sharing across countries. The case studies show that numerous practical adaptation solutions have demonstrated results. The Delta Coalition will continue to extract and share lessons from adaptation action around the world.

PLANNING

Climate-change adaptation is long-term, but action is required immediately. Making deltas more climate resilient requires thinking in terms of decades given the sheer magnitude of investments needed and the time nature takes to restore and regenerate itself. Long-term investments must be coordinated with community-level modular adaptation plans and actions. As the Demak case shows, for example, mangrove-mud coasts are recoverable in the right conditions, but the process takes many years. Adaptation mechanisms need to be supported by a legal and political framework that is conducive to long-term integrated planning. Given the high level of uncertainty, planning for adaptation needs to be revisited on a regular basis to ask if its current pace will be able to keep up with the increasing speed of climate change-induced impacts.

Communities must be at the center of adaptation planning and action, and should co-create solutions. Vulnerable groups in delta areas face issues that are often more pressing than climate change—such as poverty, malnutrition, and poor access to safe water supply and sanitation services—and climate-related impacts largely appear indistinguishable to them from everything else they must cope with on a daily basis. Meaningful participation of local communities must be embedded in approaches that address all these concerns and engage them in identifying and implementing solutions. Climate-adaptation actions in deltas can achieve multiple objectives, including job creation, poverty eradication, improved services, and livelihoods. The Wadden Sea case shows how developing a comprehensive agenda required intense consultation between different government agencies, civic-society representatives, industry and local stakeholders. The cases in Bangladesh and Mozambique show how external partners—such as the World Bank and the Dutch government, respectively—can convene forums that strengthen existing multi-stakeholder dialogues.

Maladaptive policies and subsidies need to be identified and reformulated. Highly indebted countries will not have sufficient resources for large-scale adaptation investments in deltas, especially while coping with the Covid-19 pandemic. However, many policies can be reformed to benefit vulnerable communities without much fiscal burden. These include incentives for private-sector engagement in adaptation investments, land-use planning, reformulation of agricultural subsidies to promote climate-smart agriculture, and climate-responsive safety nets.

Multi-dimensional adaptation frameworks are essential to scale up and accelerate adaptation in deltas. To ensure that individual adaptation measures address interdependencies and do not cause adverse effects elsewhere, such frameworks need to be long-term and

strategic, take a systems approach, and use the latest science. The cases of Bangladesh, the Netherlands, and Vietnam illustrate the development of frameworks aimed to last 25 years and more.

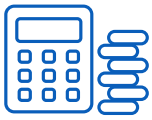
Adaptation planning must be robust, but also flexible and agile to cope with high levels of uncertainty. The concept of adaptive delta management, illustrated in the Bangladesh case, involves identifying tipping points during the planning phase that might trigger the need for a change in approach. Beira's partnership with the Netherlands deliberately did not set specific project goals upfront, instead developing a vision and building a process to work toward it. In the Netherlands, the Delta Programme has a built-in fixed review point every six years to ask whether new developments or insights warrant policy adjustments. Agile processes can be impactful only with firm, long-term financial and political commitment that creates certainty.

Deltas often cut across administrative and national boundaries, creating significant governance challenges. The Mekong Delta case, for example, shows how actions taken in upstream countries and provinces impact areas downstream. Dedicated delta governance structures need to be organized on water management principles. The Wadden Sea case shows how this can work well, while Vietnam is creating a mechanism to align the actions of delta provinces. Multilateral projects with transboundary design and implementation—as in the Mira case study—offer promising frameworks for addressing coordination challenges, if they are anchored in appropriate governance structures.

Dialogues and planning frameworks on water and climate adaptation in deltas should be better integrated. International and national dialogues on water and climate adaptation are largely disconnected. Raising the profile of deltas, and mainstreaming adaptation actions on water in Nationally Determined Contributions and National Adaptation Plans, can help to integrate them.

Nature-based solutions combined with traditional 'gray' infrastructure must be part of the planning process. Success stories are increasingly bringing well-deserved recognition to the promising approach of nature-based thinking. However, most successful applications at scale so far have combined 'green' and 'gray' infrastructure, as with the Wadden Sea case. Nature-based solutions also need supportive policy frameworks and institutional capacity: in the Demak case, the government developed national guidelines for permeable structure designs, facilitated by a capacity building program. Recognizing the agency and expertise of local communities is critical as they need to be involved in operations and maintenance for nature-based solutions to work. The case studies from Argentina, Indonesia, and the Netherlands vividly illustrate the pivotal contribution of local stakeholders, which can potentially also strengthen local livelihoods and job opportunities.

FINANCE

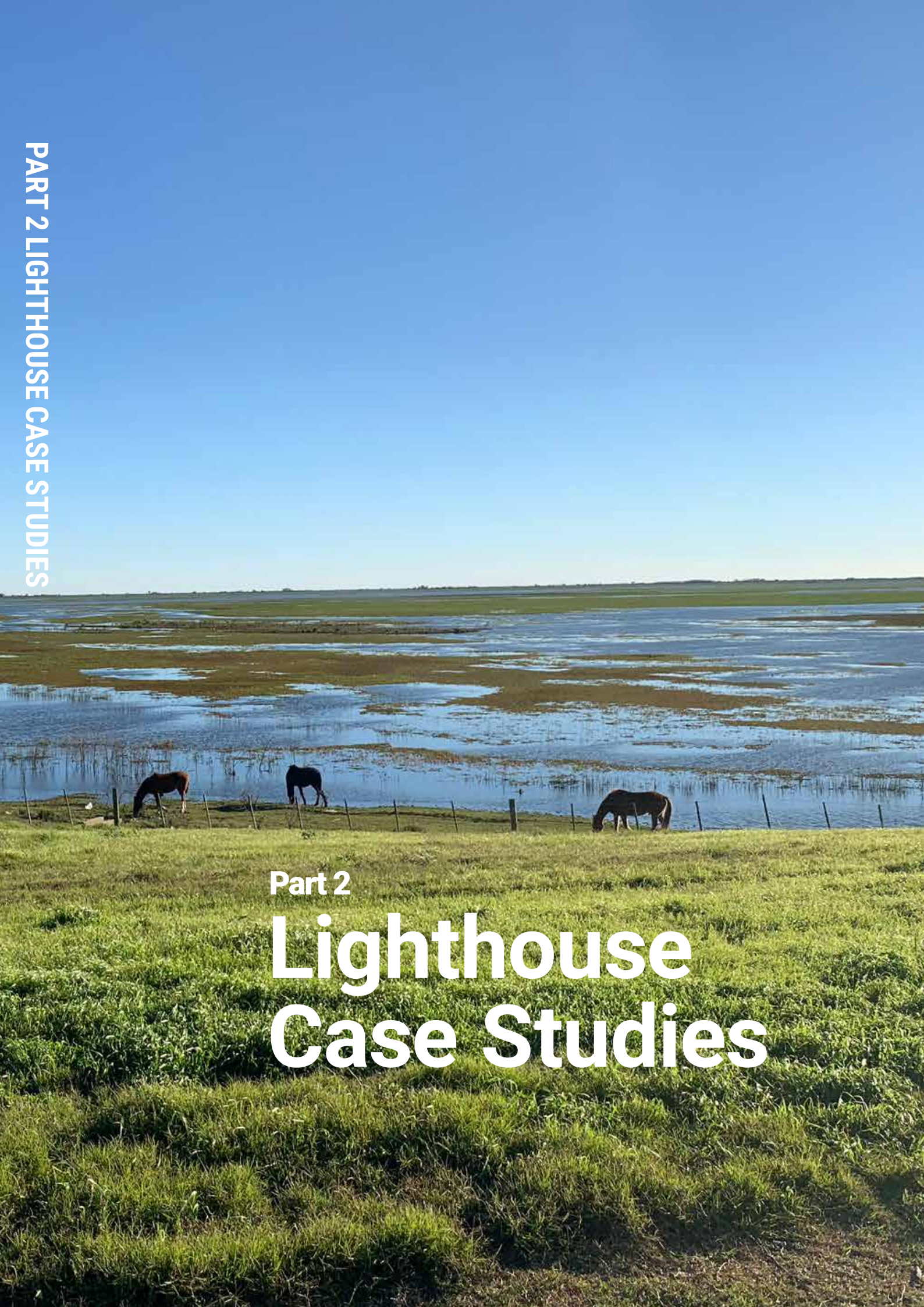


Post-Covid recovery plans provide an opportunity to enhance adaptation in deltas. Massive resources are being mobilized for the post-Covid recovery, but only a fraction of those announced so far support climate adaptation. Governments can leverage economic recovery packages to implement approaches that improve the health and economic stability of communities alongside their climate resilience.

• **Adaptation in deltas needs an increased level of long-term financing commitments.** Mobilization of financial resources from all sources for climate-smart economic development of deltas will have a significant positive impact on human development, too. However, many low-income countries do not have the necessary resources and need concessional loans or risk guarantees. Developing strategic frameworks and plans requires a long-term partnership that goes beyond the typical five-year project cycle.

• **Climate adaptation in deltas needs new sources of finance and new instruments.** More public and private-sector investment and new financial instruments are needed to help vulnerable communities in deltas, such as climate resilience bonds and debt-for-resilience swaps.

• **Financial resources should be targeted to those who need adaptation most.** Vulnerable local delta communities need greater capacity to access these funds. Scaling up of tools such as adaptation micro-finance and micro-insurance can support adaptation efforts in deltas.



Part 2

Lighthouse Case Studies

CASE STUDY

CLIMATE ADAPTATION PRACTICES IN THE PARANÁ DELTA, ARGENTINA

SUMMARY

The Paraná Delta has long been a territory of slow-onset transformations, despite its proximity to major cities. However, in recent decades it has come under increasing pressure from accelerated changes in land use, notably the unfettered expansion of cities, while enduring the consequences of the rapid rise of industrial agriculture in Argentina (notably soybeans), that have tended to displace cattle production to the delta, among other areas.

Climate-change impacts such as floods, droughts, fire outbreaks, and the hydrologic effects of sea-level rise contribute to heightened vulnerability in the delta. However, national response to climate change is providing a framework for action to protect it. This links wetland conservation programs with Argentina's efforts to establish its low emissions long-term climate strategy, meet the objectives of its Second Nationally Determined Contribution to the Paris Agreement, and implement its National Adaptation Plan. 'Conservation lighthouses' could be the start of a more systematic response to support climate-change adaptation.

THE PARANÁ DELTA

The Paraná is the most important river of the La Plata basin, which is second only to the Amazon basin in South America in terms of its size, length, and water discharge. A huge mosaic of highly heterogenous wetland systems, it covers 22,587 square kilometers[14] and is part of the widespread wetland system of Argentina, which in total covers about 600,000 square kilometers—more than one-fifth of the country.

The delta's hydrology is determined by the streamflow of the Paraná, Gualeguay and Uruguay rivers, tidal and storm surges from the Río de la Plata estuary, and local rainfall[15]—which in turn is influenced by the El Niño and La Niña weather systems.

Over the last several decades, the construction of more than 150 hydroelectric power dams has transformed the upper section of the Parana river basin and its tributaries into a succession of lakes, affecting its flow, discharge, and ecology[16].

Paraná Delta, Argentina

The Paraná Delta is subject to natural pulses of floods and droughts, which are one of its distinctive characteristics. Climate change and land-use changes are affecting the delta, primarily by increasing the occurrence of those pulses[17], altering erosion and sedimentation processes, and increasing the frequency and intensity of storm surges[18].

The delta is located close to important cities and metropolitan areas, such as Gran Rosario, Santa Fe, and Buenos Aires, with its 14 million inhabitants.

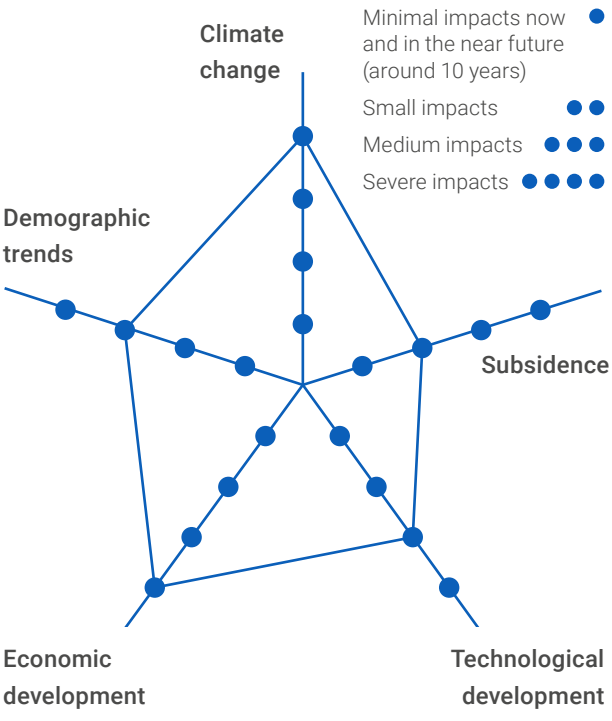
Before the 16th century, diverse indigenous groups were settled in the Paraná Delta, but after Spanish colonization, the lands were occupied through immigration flows of Spanish and criollos (people of Spanish descent born in Latin America) in dispersed and mostly precarious settlements[19]. By the late 19th century, the population settled in the delta was engaged primarily in fruit cultivation, supplying the nearby cities, as well as fishing, hunting, and later on forestry and small-scale livestock production[20].

In the 1960s, a series of floods and frosts devastated plantations and caused mass migration to nearby cities in search of stable employment[21]. A new development model for the delta was then adopted as a consequence of the deployment of a supposedly long-term (but short-lived) national development strategy[22] aimed at fostering basic industry (steel, cement, aluminum, pulp and paper). The consequent change in the scale of forestry production led to the construction of ditches and levees, which progressively altered the landscape, especially in the Lower Delta area.

Since the mid-1990s, a process of rapid land-use change has taken place. The adoption of innovative technologies and a new business model in agriculture, in conjunction with patterns of markedly higher precipitation, resulted in a vast expansion of agricultural production[23] in the Pampas, displacing livestock production from traditionally cattle-raising areas to other areas, including the Paraná Delta.

Additionally, the unplanned growth of cities in proximity to the delta has led to the development of new urbanization typologies, such as gated communities[24], with privately-developed flood protection schemes, that adversely affect surrounding areas.

Figure A: Drivers of change in the Paraná Delta



Today, the population of the delta is estimated to be around 25,000 inhabitants[25]. With a population density of just over one inhabitant per square kilometer[26], it is one of the most sparsely populated areas in the whole country.

Governance in the Paraná Delta is complex. It is under national jurisdiction, as well as that of three provinces—Entre Ríos, Santa Fe, and Buenos Aires—and 19 municipalities (or departments). Land-use planning and zoning are carried out at the municipal level, while natural resources are governed at the provincial level, so the provinces have a relevant role over key territorial decisions. The delta includes 34 protected areas, three of them regulated by international treaties. The overlap of jurisdictions at different levels makes the design and implementation of environmental policy complex.

Communication across levels of government has historically not been smooth. Co-operation between government and the private sector in the delta—from small-scale co-operatives to large producers—has ebbed and flowed. Civil society is involved in debating public policies and monitoring processes through research institutions and environmental NGOs. Lack of financial resources has been a persistent problem.

DELTA CONSERVATION AND THE PARIS CLIMATE AGENDA

By the early 2000s, it was clear that the expansion of agriculture, forestry, and livestock production, as well as the increase of gated communities and other private developments, was undermining the sustainability of the delta system. In 2008, these trends converged in an environmental emergency: a severe drought and the systematic use of fires to eliminate vegetation that had no forage value for livestock led to the loss of at least 11 percent of the land cover in just one year[27].

These circumstances prompted the National Secretariat for the Environment and Sustainable Development to seek a new inter-jurisdictional consensus on environmental planning. The federal government and three provincial authorities developed the 'Integral Strategic Plan for the Sustainable Management and Conservation of the Paraná Delta Region' (Plan Integral Estratégico para la Conservación y Aprovechamiento Sostenible del Delta del Paraná, PIECAS-DP)[28].

PIECAS-DP is the only comprehensive plan ever conceived for the delta. It establishes guiding principles for risk management, environmental conservation, and sustainable economic development[29]. A strategic environmental assessment and a baseline study were carried out in 2011[30], followed in 2014 by the dissemination of guidelines and recommendations, with each province setting out its own vision[31].

In 2015, a change of policies under a new national administration curtailed implementation of the PIECAS-DP for four years. In 2020, the accession to power of the previous administration promoted the plan's renaissance. In addition, a severe drought combined with a widespread and massive number of fire outbreaks led the Ministry of Environment and Sustainable Development to declare a state of emergency in the region and prohibit the use of fire for productive activities for 180 days, reinforcing the rationale for a strategic approach in the delta.

Severe environmental impacts throughout 2020 also prompted the same ministry to update the PIECAS-DP. This time, the plan gained momentum from being reconfigured in the context of the Sustainable Development Goals Agenda 2030 and Argentina's climate policy, including on adaptation.

Further, there is a focus on using nature-based solutions in the design and implementation of adaptation actions. In terms of mitigating greenhouse gas emissions, Argentina's ability to meet its revised Nationally Determined Contribution will depend on its ability to limit deforestation, forest degradation and fires, promote absorption by carbon sinks and preserve carbon sequestration by wetlands, including large peatlands and both marine and riverine wetlands.

In our view, action to conserve the Paraná Delta has a vital role to play in contributing to the success of Argentina's long-term decarbonization pathways. The Paraná Delta is still one of the world's least disturbed delta systems, and remains highly efficient in sequestering carbon in its soil and biomass[32].

THE CONSERVATION LIGHTHOUSES NETWORK PROGRAM

As part of the first phase of the relaunched plan, in 2020 the government created and launched the Conservation Lighthouses Network (CLN) program, with defined work plans and committed human and financial resources[33]. This program consists of the creation of operational bases for environmental management and extension, such as the early detection of fires, prevention, control and involvement under situations of high environmental risk, and other conservation and ecosystems management interventions[34].

A 'conservation lighthouse' is defined as a 'base with permanent scientific and technical personnel, equipped with boats, vehicles, drones, control systems, weather station, communication and environmental monitoring equipment[35].' A network of these lighthouses is now being created across the delta—mostly (but not exclusively) in National Parks, under the scope of the National Parks Administration and the Ministry of Environment and Sustainable Development.

Specifically, the national and provincial governments signed formal agreements to establish conservation lighthouses in the National Parks of Pre-Delta (Entre Ríos), Islas de Santa Fe (Santa Fe), Ciervo de Los Pantanos (Buenos Aires), and the Municipality of Villa Constitución (Santa Fe) including its Isla del Sol nature reserve. Agreements are in progress for the Biosphere Reserve of San Fernando (San Fernando, province of Buenos Aires) and the Isla Botija (Zárate, province of Buenos Aires). The agreements address the need to preserve natural and cultural heritage, recover degraded ecosystems, develop scientific research, and engage local people to strengthen their knowledge on the impact of fire[36].

The CLN program's objectives are to prevent, detect and control not only fires, but also other illegal activities. These include poaching, irregular construction and unsustainable production practices which may lead to wetland and biodiversity loss and water and soil pollution. The program aims to strategically link communities, civil-society organizations, scientific institutes, universities, and different

jurisdictions to protect natural resources and cultural heritage, as well as support sustainable socio-economic activities.

The CLN program directly includes local inhabitants, empowering them as 'delta guardians' through training activities and knowledge transfer to improve their socio-economic situation. The program includes the launch of local sustainable development and training projects for island communities (called PADAS[37]), with funding provided by the National Parks Administration.

Although it is still in the very early stages of development, the program has already registered a significant success in getting this far: it has generated the political will to overcome the longstanding obstacles to co-operation between different levels of government and civil society.

SCALABILITY AND REPLICABILITY

There is high potential for scalability and replicability, as the plan calls for a network of conservation lighthouses (based on the concept of 'Ecological Networks'[38]), so it can be expanded. The lighthouses can be in National Parks or other protected areas not necessarily under national supervision. The program could also be implemented in other deltas, and eventually beyond wetland areas, oriented to local problems as circumstances require—from fires to floods, erosion or salinity control.

The Paraná Delta is not the only territory of Argentina that is experiencing the impacts of unsustainable production practices, extended land-use changes and climate change. Similar issues are affecting Santa Fe, Buenos Aires, Entre Ríos, Córdoba, San Luis, Salta, Tucumán, Corrientes, Misiones, La Rioja, Chaco, and Catamarca. All these provinces have preserved areas in which conservation lighthouses could be established if the budget can be found and the various governments agree on the principles. Furthermore, there is a political will to discourage unsustainable and uncontrolled practices in the territory, such as intentional fires. The Law N° 27604/20 recently modified the Law of Fire Management (N°26815/13), establishing that burnt lands will not be allowed to change their use, be divided or sold for 60 years.

CONCLUSION

Wetlands are disappearing all over the world. Over the decades, well-intentioned efforts to develop the Paraná Delta have reflected a lack of understanding about their inherent value. Today, this value is increasingly well understood: wetlands are important carbon sinks and help to address the impacts of climate change.

Wetland areas should bring together and make consistent the conversations on climate-change adaptation and mitigation policy, and integrated water management plans. Land-use planning and water management should be informed by the periodic development of updated hydrological scenarios to include changes in precipitation, sea levels and sediment dynamics[39].

The experience in the Paraná Delta also shows that work to preserve the unique biogeographic and ecological characteristics of a wetland ecosystem requires careful consideration of local social-cultural factors. In the Argentinean context, the Paraná Delta is being transformed even though its importance and ecological functions are better understood than those in other wetlands, which makes the latter more vulnerable to anthropic transformation and to rapidly increasing impacts of climate change.

Fundación Torcuato Di Tella, coordinator of the Delta Alliance Argentinean Wing

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CASE STUDY

BDP 2100: MANAGING WATER RESOURCES AND DISASTER RISK IN BANGLADESH

Bangladesh occupies the world's largest delta, making it highly vulnerable to recurrent natural disasters. However, the delta, if properly managed, could also be an engine of economic growth. The country recently adopted the Bangladesh Delta Plan 2100 (BDP 2100), a water-centric techno-economic plan that combines water resources management (WRM) with due focus on disaster risk management (DRM). Its mission is to: 'ensure long-term water and food security, economic growth, and environmental sustainability, while effectively reducing vulnerability to natural disasters and building resilience to climate change through managing water and disaster risk and other delta challenges through robust, adaptive and integrated strategies, and equitable water governance.'

The investment plan comprises a portfolio worth around US$ 38 billion of interconnected projects, infrastructure investments and institutional reforms. The investments will be informed by short-term strategies based on an adaptive delta management approach. Realizing their full benefits will require sustained effort to maintain implementation momentum.

Given the complexity of deltas and the uncertain impacts of climate change, delta development plans need to be based on strategies that are flexible as well as long-term and comprehensive. Many aspects of the BDP's design can serve as a model for other deltas, provided they are adjusted to reflect local context, customs and conditions.

A BRIEF HISTORY OF MANAGING WATER-RELATED RISKS IN THE WORLD'S LARGEST DELTA

The GBM Delta, formed by three major rivers—the Ganges, Brahmaputra (also known as the Jamuna), and Meghna—is home to nearly 200 million people, with one of the world's highest population densities. Its flood plains cover two-thirds of Bangladesh (about 100,000 square kilometers), as well as parts of West Bengal and Assam, in India (Figure B). Bangladesh is extremely vulnerable to climate-change impacts, including higher precipitation during tropical cyclones, river and tidal flooding, more intense storm surges as sea levels rise, and water deficits during the dry season linked to glacial retreat in the Himalayas.

Figure B: The GBM Delta

The region has a history of water-related natural disasters, which tend to hit the poor the hardest. Only after three major floods in the mid-1950s did a formal institutional structure and planning process for water management emerge, with a 20-year master plan in 1964 marking the beginning of water-sector planning in what is now Bangladesh. The plan was based on a strategy for flood control, drainage and irrigation improvement to increase agricultural production. The impact of Cyclone Bhola in November 1970 led to substantial improvements in disaster response planning and preparedness.

Bangladesh became independent in 1971 and a World Bank member country in 1972. From the outset, it invested in a wide range of actions to reduce disaster risks and build resilience. The country's success is often cited in arguments for greater investment in disaster risk management (DRM). In 2001, the government prepared a National Water Management Plan, coordinating the work of national and regional agencies, local governments, and other stakeholders. Bangladesh was one of the first countries to focus on climate change, preparing a National Adaptation Programme of Action in 2005.

Around 2012, the government started developing a comprehensive development plan for the delta region that would integrate water resources management (WRM), DRM and economic growth—the BDP 2100, which was launched in 2018. Bangladesh reinforced its international leadership role in climate adaptation in 2020 by taking up the presidency of the Climate Vulnerable Forum and inaugurating the first South-Asian regional office of the Global Center on Adaptation (GCA) in Dhaka.

Alongside climate change, drivers of change in the delta include economic development (irrigation, industry, fisheries, navigation, and road transport); technological development (especially in agriculture, civil/hydraulic engineering, ICT, and energy); upstream activities (especially the construction of dams and barrages, and water withdrawals or diversions by upstream countries); demographic trends (population growth, urbanization, and migration); and land subsidence (both natural and human-induced).

Together these factors are creating growing pressures—sea-level rise, seasonal flooding and waterlogging, droughts, river and coastal erosion, landslides, sedimentation, soil and water salinization, deteriorating surface-water quality, groundwater stress and pollution, environmental degradation, reduced water supply and sanitation services, and transboundary water management—affecting the country's natural resources directly and its use of land, water and vital infrastructure and systems indirectly.

Development through a comprehensive, adaptive WRM approach

The government's mainstreaming of coastal development, WRM, DRM, and climate-change adaptation in its development strategies culminated with the adoption of an integrated, long-term development strategy, anchored in the development of its delta—the BDP 2100. World Bank-supported initiatives on coastal and urban climate resilience helped shape the principles underlying the BDP 2100, and the bank supported the government by bringing together development partners to coordinate activities and financial assistance; identifying and disseminating best practices; and strengthening the government's capacity for planning, implementation, coordination, and monitoring and evaluation.

Multiple bank operations are ongoing in Bangladesh involving DRM and/or WRM, not necessarily focused on the GBM Delta. Most were designed and are often implemented by multidisciplinary teams representing sectors such as agriculture, water, climate change and disaster risk management, transport, environment, and urban development, and covering aspects from finance and trade to innovation and resilience. The dollar figures added in parentheses represent ongoing financial assistance, though this is not an exhaustive account of World Bank support to Bangladesh in the GBM Delta.

Coastal Embankment Improvement Project, Phase I (US$ 400 million): supports the rehabilitation and upgrading of polders[40] to guard coastal areas against tidal flooding and storm surges, which are expected to worsen due to climate change; and enhancing agricultural production by reducing saline intrusion. The project is also developing a framework for polder design. It involves local communities in planning,

implementation, and monitoring. CEIP has helped attenuate the impacts of cyclones and flooding; improve emergency response; increase agricultural productivity and food security; and create employment opportunities. CEIP was conceptualized as a long-term program, including preparatory work for future programming. Phase II is currently under discussion.

Bangladesh Weather and Climate Services Regional Project (US$ 89 million): strengthens the government's capacity to deliver and improve access to reliable weather, water, and climate information services.

Multipurpose Disaster Shelter Project (US$ 375 million): aims to reduce vulnerability to climate change and natural disasters across nine coastal districts by constructing 550 new cyclone shelters, improving 450 existing shelters, and constructing and/or rehabilitating climate-resilient access and evacuation roads to connect them. These shelters are multipurpose—they normally serve as schools. In May 2020, during Cyclone Amphan, over two million people were safely evacuated to disaster shelters.

Urban Resilience Project (US$ 173 million): strengthens government agencies' capacity to respond to emergency events and reduces the vulnerability of new buildings in Dhaka and Sylhet. The project seeks to create an enabling environment for coordinated, locally managed DRM based on effective response, reinforcing existing infrastructure and ensuring resilient construction. The project is part of a larger program on urban resilience, which includes the US$ 116 million Urban Building Safety Project financed by the Japan International Cooperation Agency.

Climate Adaptation and Resilience for South Asia Project (US$ 39.5 million): this regional project supports data, analytics and decision-making in the water, transport, agriculture, finance and planning sectors, developing regional standards, guidelines, policies and capacities, and financing innovative and technology solutions for climate adaptation and resilience.

Bangladesh Regional Waterway Transport Project (US$ 234 million): aims to improve inland water transport, which plays a vital role in trade and personal transportation, along the Chittagong-Dhaka-Ashuganj regional corridor.

Bangladesh Water Platform: a technical assistance program that advises the government on policy, coordinates activities on WRM, develops pipeline projects and promotes dialogue on transboundary water collaboration between Bangladesh, Bhutan, India, and Nepal.

Southern Asia Water Initiative: supports various activities to enhance regional co-operation in sustainably managing major Himalayan river systems.

DELTA MANAGEMENT THROUGH INTEGRATED WRM AND DRM

Bangladesh's ambitions to reach upper middle-income status and eliminate extreme poverty by 2030 require effective WRM and DRM. The Delta, if properly managed, can be an engine of growth. This realization led to the development of the BDP 2100 by the government, with support from the Netherlands and the World Bank based on a 2015 memorandum of understanding. Approved in September 2018, BDP 2100 aims to sustainably manage water, ecological, environmental, and land resources. While it mainly looks at the delta agenda up to 2050, its vision is defined to 2100 as many of today's decisions will have implications on that timescale.

BDP 2100 represents a break with the country's traditional approach to WRM, which is focused on food security, flood protection, and groundwater management. It takes a comprehensive, integrated, multisectoral, adaptive, and sustainable approach to water and land management. The General Economics Division of the Bangladesh Planning Commission is responsible for coordination and monitoring for BDP 2100 implementation and updating.

BDP 2100's investment plan (BDP/IP) comprises a portfolio of projects, infrastructure investments and institutional reforms, prepared by the government with World Bank support. The investments will be informed by short-term strategies based on an adaptive delta management (ADM) approach. Its purpose is to ensure that the right investments are made at the right time—neither too early nor too late—by identifying tipping points that signal the need for a change in approach, such as building new embankments rather than improving existing ones.

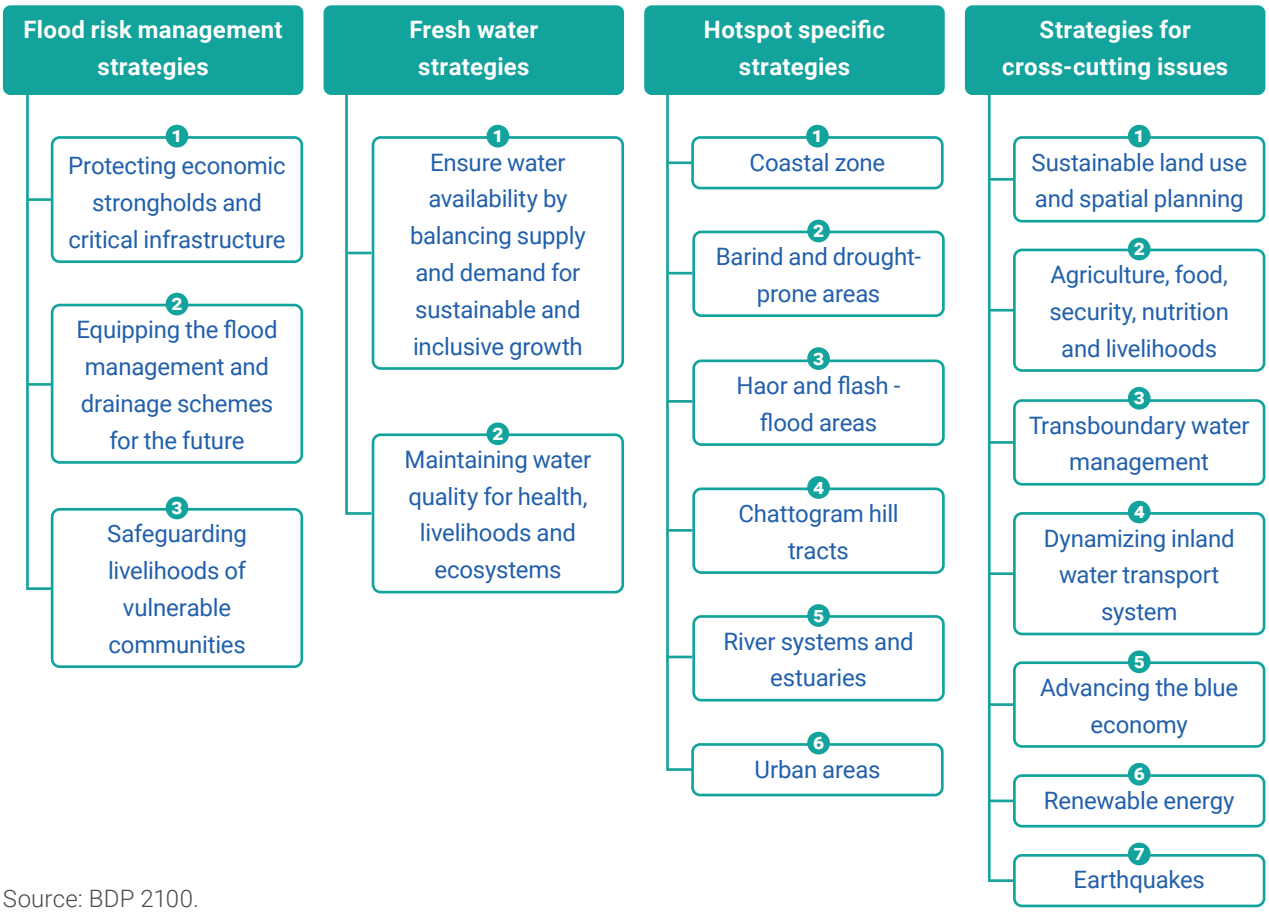
An ADM approach favors smaller interventions, phased over time, to large, irreversible one-off projects. It prioritizes 'no-regret' investments and avoids projects that do not stand up under realistic climate scenarios. It considers the interactions between projects, land use, and water management. It prefers working in harmony with natural hydrological systems rather than attempting to change them and promotes the efficient use of resources based on cost-benefit analyses. Broad participation, investments in knowledge, and innovation are key to successful ADM.

The **2030 Water Resources Group** is an important initiative in support of BDP 2100's implementation— a public, private, and civil-society partnership hosted by the World Bank that supports country-level collaboration toward sustainable WRM. It could serve as a model—in terms of set-up and agenda—for promoting stakeholder dialogue and collaboration in other countries.

Applying ADM principles means the BDP/IP considers the impacts of projects individually and in combination. Changing circumstances—including climate change, demographic changes, and economic growth—may require adjustments in the design, selection, prioritization, and phasing of projects. The BDP/IP includes financing arrangements and mechanisms. The government's five-year plans will include funding for specific projects and programs.

BDP 2100 includes national strategies and strategies

Figure C: BDP 2100 Strategies



Source: BDP 2100.

directed at hotspots—groupings of districts and areas with similar hydrology, facing similar natural hazard and climate-change risks. These strategies were tested for robustness to climate change and built around four pillars (Figure C): the first two deal with nationwide challenges, the third with strategies specific to one hotspot, and the fourth with multisectoral strategies relevant to more than one hotspot (Figure D).

BDP/IP has a planning horizon through to 2030 and has identified 65 infrastructure projects and 15 institutional and knowledge development projects, together worth US$ 38 billion. All infrastructure projects could start within the next eight years, though construction may extend over decades. Similar projects in different hotspots are grouped for the purpose of knowledge gathering, capacity building, and policy reforms. Flood control, riverbank erosion, and river management together account for 35 percent of priority project expenditures: they will lay the basis for growth by reclaiming land, enhancing its use for job creation, revitalizing water transport and increasing resilience to climate change.

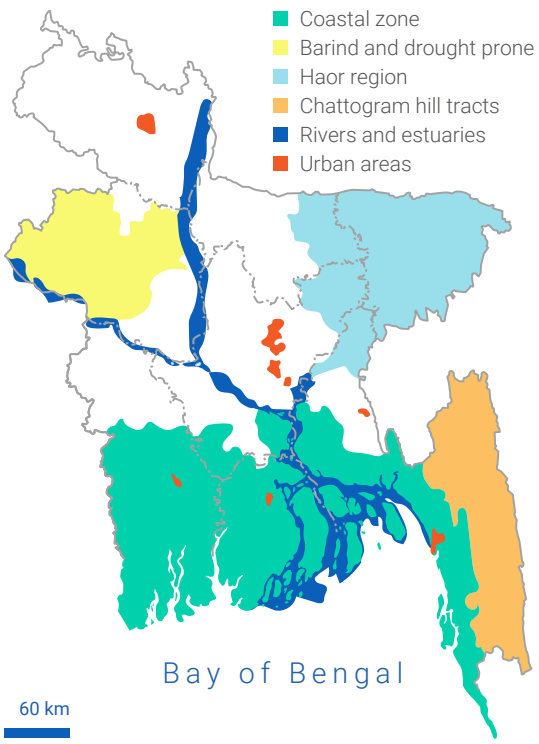
Some of the priority projects currently under development by the government, with World Bank support, include:

1. Jamuna River Economic Corridor Development Program: will create opportunities for economic growth by stabilizing the river's course along a stretch of 205 kilometers between Sirajganj and the Indian border, making it navigable year-round and enabling road and rail transport to switch to water. The program will use innovative 'building with nature' approaches such as top-blocked permeable groins to train the river, risk-based decision support systems to support actuarial analyses for flood insurance, fuel-efficient vessels, and smart aids for navigation.

2. Dhaka Rivers Ecological Restoration Project: aims to enhance the ecological condition and transport capacity of the rivers and canals around Dhaka, which are compromised by pollution from the textile industry and untreated discharge of human waste into the environment.

3. Resilient Infrastructure Building Project (US$ 400 million): using risk assessment tools to prioritize sites, the project will finance shelters and associated community infrastructure, last-mile connectivity, local emergency preparedness and response, and community-based DRM in villages vulnerable to flooding.

Figure D: BDP 2100 Hotspots



Source: BDP 2100.

4. Climate Smart Agriculture and Water Management Project (US$ 120 million): will rehabilitate flood control, drainage and irrigation infrastructure, creating an enabling environment for climate-smart agriculture and fisheries.

The Bangladesh Water Platform is supporting implementation of the BDP 2100 through analytical studies, a water-sector public expenditure review and a diagnostic report[41] identifying the main water challenges and priorities for the next decade. It argues that water requires not only more funding—over the last decade, the government spent 0.6–0.8 percent of GDP on the sector, with plans to increase to 2.5 percent by 2030—but also wiser spending, with more funds earmarked for data collection and operations and maintenance.

Additional sources of financing will be needed to cover the BDP/IP's overall requirement of around US$ 38 billion through to 2030. The government is working to attract this funding, including from the private sector, by exploring policy reforms such as introducing a comprehensive water risk management framework; letting water accounting guide the distribution of water-sector resources; and adopting cost recovery (based on the 'user pays' and 'polluter pays' principles) for public services.

Key building blocks of new approach to delta management

Prioritizing investment projects and institutional reforms with the following characteristics:

Safety-first approach. Investing in erosion and flood control through riverbank and coastal protection and interagency coordination of water-related policies, including DRM, sets the stage for cost-effective, follow-on investments and crowding in the private sector. Protecting livelihoods in disaster-prone areas also boosts socio-economic development.

Sustainable and climate-resilient nature. Flood and erosion-control activities prioritize nature-based solutions, reflect the participation of multiple stakeholders and sectors, secure funding for projects, and allocate resources to operations and maintenance.

Comprehensive approach to adaptation. Investing in preventing and preparing for climate-related disasters, and strengthening governments through policy reforms and institutional capacity building.

Multisectoral approach. Addressing areas including flood risk management; fresh water; sustainable land use and spatial planning; agriculture, food security, and livelihoods; transboundary WRM; inland water transport; the blue economy; renewable energy; and earthquake risks.

Flexible approach. ADM ensures the flexibility to consider different climate scenarios and exogenous factors when updating the rolling medium-term strategies and national five-year plans.

Inclusive design. The government consults on projects with a wide range of stakeholders as relevant, including polder and riverbank communities, local government institutions, civil society, the media, water and land transport associations, traders and trade bodies, academia and research institutions, and environmental NGOs.

High economic returns. Investments in improving the navigability of rivers, by reducing flood risk and river and coastal erosion, tend to benefit multiple sectors and have high economic returns.

Promoting conjunctive water use in agriculture. Increasing the use of surface water in irrigation helps address groundwater depletion. Gravity-fed irrigation also contributes to greenhouse gas mitigation. The BDP/IP has identified surface-water irrigation projects, but none is planned in the short term. Given the projected increase in demand for water, investment may be needed sooner than anticipated.

Creating jobs and rehabilitating climate migrants. Climate-resilient delta development aims to create employment opportunities in sectors such as fisheries and irrigation, for people who would otherwise be forced to migrate to cities due to climate-change impacts.

Developing an innovative water risk management framework. The government is keen to develop, with World Bank support, a comprehensive, water-related risk management framework in line with BDP 2100. The first step is getting communities to reduce the risks of local floods, groundwater depletion, and coastal erosion through local actions. This requires evaluating tradeoffs: for instance, between strengthening polders—which risks saline waterlogging—and permitting accretion of sediments during monsoons, while increasing agriculture and aquaculture production in the dry months. Risks that cannot be dealt with at the community level are addressed through water adaptation plans at district, division, and national levels. The government transfers some risks to the insurance market, but bears the risk of the highest-impact disasters itself.

CHALLENGES RELATED TO IMPLEMENTATION

BDP/IP infrastructure investments will require years to build. As these investments are interconnected, their full economic benefits will be realized only if implementation momentum is maintained. This will require a sustained, long-term effort: managing the investments; aligning planning, implementation, and financing activities with BDP 2100; improving interagency and intersectoral coordination; and designing adequate financing modalities for public-private partnership projects.

As part of the BDP 2100 governance arrangements, institutional improvements and policy reforms are underway. In 2019, the country signed an agreement with the Netherlands government for support in creating an enabling environment. Some BDP 2100 institutions have already been established—such as the Delta Governance Council, an inter-ministerial forum headed by the Prime Minister, that gives strategic direction. The Project/Programme Selection Committee will select projects to be implemented, while the Delta Commission will prepare and update annual spending programs. The World Bank will also support the government to identify medium to long-term reforms.

The BDP 2100 includes a strategy for regional co-operation, given that 93 percent of Bangladesh's total renewable water resources originate in India, Nepal, or China. It provides for third-party facilitation, such as through the Indus Treaty between India and Pakistan, with World Bank support. The World Bank Group stands ready to act as a broker to promote water-sharing agreements and river basin development that can improve regional connectivity—through increased navigation and port access, and development and sharing of hydropower—along with sectors including water quality, DRM, the blue economy, and climate resilience.

Some issues identified in the 2001 water plan will have to be addressed by the BDP 2100 implementation process, such as the need for decentralization and national land-use plans based on spatial planning. Local government decentralization is also important for effective WRM and sustainability.

Scalability and replicability

Given the complexity of deltas and the uncertain impacts of climate change, delta management plans need to be based on flexible, long-term, and comprehensive strategies. Many aspects of the BDP's design can serve as a model for other deltas, provided they are adjusted to reflect local customs and conditions. These include:

- Securing high political buy-in and broad stakeholder support, based on extensive consultations from the design stage onward.
- Adopting innovative, nature-friendly approaches based on the concept of 'giving more space to water' by designing solutions that not only seek to enhance safety, but also to garner social, environmental, and economic benefits, such as multipurpose dikes.
- Identifying the delta's main drivers of change and their resulting pressures, taking these as the starting point for the development of adaptive strategies.
- Conducting baseline studies on thematic areas relevant to the delta in question.
- Basing investment and policy decisions on evidence-based tools, such as flood exposure mapping, datasets on water supply stress, geospatial technologies, and sectoral studies.
- Developing strategies for specific hotspots and for cross-cutting aspects of delta development.
- Earmarking funds for operations and maintenance of water infrastructure and delta governance.

Potential challenges that have to be considered include:

• The difficulty of folding existing development policies and sectoral plans into one comprehensive, multisectoral plan that addresses climate change, the environment, biodiversity, agriculture, fisheries, forestry, internal water transport, energy, and land management as well as their interaction with water.

• Impacts of upstream investments on downstream (transboundary) users and vice versa.

• Impacts of transboundary water projects (e.g. hydropower or multipurpose dams) on the delta.

• Unforeseen long-term landscape changes associated with erosion and sedimentation caused by interventions in the delta, such as river course stabilization and land reclamation.

• The need to downscale global circulation models to generate locally relevant, high-resolution, and reliable data as the basis for climate-informed investment design and planning.

Delta planning is a never-ending process that requires data to be continually collected and analyzed, to support research and modeling in areas such as:

• Hydrological and geomorphological modeling, with special attention for river flow and quality, siltation and sedimentation, sea-level rise and other climate-change impacts.

• Possible long-term implications of land reclamation from major rivers and the sea.

• Polder management and significant land governance reforms.

• Nature and extent of land subsidence and ways to slow it down.

• Development of crop varieties that are resilient to salinity and waterlogging.

CONCLUSION: THE ROAD AHEAD

The implementation of BDP 2100 is only just starting. Putting ADM into practice will require an enabling environment in which agencies and ministries have clearly defined responsibilities and a mechanism for coordinating their policies and activities. Adequate and predictable financing will be essential, in terms of (i) the overall amount, (ii) its distribution over shorter-term strategies, DRM, climate-change mitigation and adaptation, operations and maintenance, and pollution control, (iii) ADM-related investments such as modeling, and (iv) supporting institutions such as governance bodies, water user groups, and stakeholder forums.

Even meeting all these requirements will not be enough. While integrated WRM addresses supply-side issues, co-operation among users is necessary to resolve demand-side issues. Bangladesh has developed mandatory provisions for community participation in water management[42], an approach that needs further nurturing. Given the transboundary issues involved, regional coordination is also needed to address issues such as navigation, port access, shared development and use of hydropower, and more timely and accurate forecasting of floods and droughts.

As the objectives pursued by delta management are generally considered public goods, the public sector typically takes the lead in this area. Yet private-sector partnerships have proven effective in various aspects, including pollution control, operations and maintenance of polders and embankments, and water-supply service provision in urban and rural areas.

Multiple development partners—including the Netherlands, Japan, Germany, the United Kingdom, France, Canada, the UNDP, FAO, and various multilateral development banks e.g. the WB, ADB—have pledged their support for implementing BDP 2100. The World Bank is ready to help convene and coordinate development partner activities.

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CASE STUDY

COMMUNITY PARTICIPATION IN CLIMATE ADAPTATION THROUGH A FOOD SECURITY PROJECT IN COLOMBIA

CLIMATE CHANGE AFFECTING ETHNIC GROUPS IN THE MIRA RIVER BASIN

The Mira river basin is one of the most climate-sensitive and food-insecure regions in Latin America[43]. This transboundary river basin covers more than a million hectares, with slightly over half in Colombia and the rest in Ecuador[44]. The 90.8 kilometer-long Mira River connects to a large variety of ecosystems, from mangroves along the Pacific coast through humid tropical forests to cloud forests and scrublands at the river's origins, 4,800 meters above sea level in the Andes mountain range. The watershed, with its highly diverse flora and fauna, is internationally recognized as a biodiversity hotspot[45]. The delta's ecosystems are likely to be strongly impacted by climate change; some are highly sensitive to even small changes in temperature and water availability[46].

The region is inhabited primarily by two ethnic groups: the indigenous communities of the Awá, or 'people of the mountains,' as they call themselves in their native language, Awapít, and the Afro-Colombian communities descended from former slaves who found refuge in the region after the abolition of slavery in the early 19th century[47].

Both groups have historically been marginalized. They continue to face inequality, poverty, insufficient food for consumption, and high levels of malnutrition. In 2010, the chronic malnutrition rate in Nariño department was 17 percent, almost four points higher than the Colombian average[48]. Chronic malnutrition is typically related to factors such as food shortages, insufficient food intake, gastrointestinal diseases, violence, the use of glyphosate, and lack of access to medical centers[49]. Barbacoas municipality recorded an alarming 36.5 percent mortality rate in children under the age of five in 2017, compared to Colombia's national average of 13.8 percent[50]. The region's Unsatisfied Basic Needs index (UBN) was 21.59 percent, compared to 14.13 percent nationally, in 2018[51].

The region has been a hotspot for violent conflicts related to illegal economic activities and revolutionary armies: 77.5 percent of the victims are Afro-Colombian and 18.4 percent

indigenous, and over half are women[52]. Despite recent peace agreements, in remote rural areas the government still has only a limited local presence.

The consequences of unsustainable land-management practices in recent years are now developing into an existential threat to local people. Planting of crops on unsuitable slopes, monoculture, and pesticides are together resulting in increased erosion and decreased availability of clean water. The forests are being over-exploited—in 2017 alone, over 5,047 hectares were deforested in Nariño[53]. Afro-Colombian and Awá communities depend on the land and the ecosystem services it provides, but their ancestral knowledge—which has kept them in balance with their natural environment—is being eroded. The dense forest provides timber and firewood to build homes and cook, and is the primary source of food in the form of fruits, leaves, and roots. The Awá and Afro also grow maize, banana, manioc root, cacao, and native fruits, while the vast mangrove ecosystem supplies fish, mollusks, crustaceans, crabs and oysters.

Climate change and the El Niño Southern Oscillation are expected to continue to increase the region's mean temperature, which has already risen by 1°C since 1960[54]. According to IDEAM[55] climate scenarios, temperatures will rise by a further 2.6°C by 2100 and rainfall patterns will be more erratic and extreme[56]. Extreme rainfall events cause landslides, damaging the region's already poor infrastructure and impacting livelihoods by blocking access to markets. Agricultural production is highly vulnerable to pests, such as weevil and screw worm, which are likely to become more aggressive with increasing temperatures, while extreme rainfall events are linked to the banana leaf disease Black Sigotaka[57]. In 2015-16, El Niño caused an intense drought that resulted in widespread forest fires, reduced water access, and lower crop yields, drastically reducing local incomes.

AN INTERVENTION COMBINING FOOD SECURITY WITH CLIMATE ADAPTATION

Recognizing the increasing climatic pressures on the vulnerable communities in the Mira river basin, in 2018 the governments of Colombia and Ecuador together started a five-year, US$ 14 million program called 'Building adaptive capacity to climate change through food security and nutrition actions in vulnerable Afro and indigenous communities in the Colombia-Ecuador border area.' This bi-national initiative also contributes to peace-building efforts and reconciliation.

Mira river basin, Colombia

Funded by the Adaptation Fund and implemented by the World Food Programme (WFP), the project benefits about 20,000 people, including 9,500 living in 70 communities or villages across six municipalities in Colombia—Ricaurte, Barbacoas, La Hormiga, Orito, Puerto Asís, and San Andres de Tumaco.

Both Colombia and Ecuador have constitutional provisions on citizen participation and multiculturalism, enshrining the rights of ethnic minorities to self-governance and protection of their cultural identity, specifically their traditional practices for natural resource management[58]. The project focuses on local knowledge, abilities and opportunities, and its design—using a community-based participatory planning approach—promotes community ownership.

The governance structures and coordination mechanisms of the region's Afro-descendent and Awá populations are incorporated in the project's structure. The project collaborates with a wide range of local implementing partners, including Gran Familia Awá, the Community Council

Network of the Southern Pacific Area (RECOMPAS), the Alto Mira-Frontera and Bajo Mira community councils, UN Women, WWF, Semillas de Agua, and autonomous regional corporations such as Corponariño and Corpoamazonía.

The program partners recognized that community participation is essential from the design phase. Starting two years before implementation, local communities were included and consulted. All exercises were designed to share ownership and build trust between project staff and local people, from visits to local adaptation initiatives developed by communities, to workshops held in their territories. Though this sometimes meant progress was slower, it was also more robust. The integrated objectives of adaptation to climate change, poverty reduction and food security were designed to ensure the buy-in of vulnerable rural communities and sustain action.

The project supports communities to define Village Adaptation Plans (VAPs), which, through a bottom-up approach, inform the formulation and implementation of the Comprehensive Territorial Climate Change Management Plans for the Nariño and Putumayo departments in Colombia. These plans, PIGCCT by the Spanish acronym, are regional instruments established in Climate Change Law 1931 of 2018 that identify, evaluate, prioritize, and define measures and actions for adaptation and mitigation to be implemented in the regions.

The departmental plans set out adaptation measures considering traditional indigenous and local knowledge, and aim to reduce climate vulnerabilities by identifying opportunities to diversify livelihoods, for agroforestry solutions, or for supply-chain improvements. They in turn inform Colombia's Nationally Determined Contribution, which has goals related to planning across all the Colombian territory, and contributes to achieving Article 7 of the Paris Agreement on considering traditional knowledge in adaptation policies.

Two years after the program's inception, the comprehensive participatory process of developing the VAPs has produced a catalog of traditional and innovative adaptation solutions that are suitable for the specific communities, including:

• Planting *zygia longifolia*, locally known as *chiparo*, a forest species that has heavy roots and can be used to retain soil on riverbanks and slopes that are prone to erosion and landslides.

• Reviving traditional food-preservation techniques such

as drying, smoking, and salting to help store food in a context of increasing temperatures and risks from floods, pests, and fungi.

• Adding value in the cacao supply chain—the communities have traditionally sold cacao seed and will receive technical support to help them improve their incomes by grinding the seed and preparing chocolate to sell into new markets.

Currently, communities and project staff are in a collaborative process of identifying and prioritizing the measures due to be implemented from early 2021 onwards.

The local communities are also closely engaged in the co-development of knowledge and expertise, including a participatory early-warning system. Currently baseline data is being collected on hydrometeorology, crop growth, and yield levels. The project trained communities in phenology, the study of biological lifecycles, to help them recognize and describe the phases of local crops and their relationship with the climate, enabling project staff to capture this knowledge.

The communities have also been equipped with basic instruments to collect precipitation and temperature data in their villages. This will benefit local administrations by providing detailed and reliable information to help take decisions in risk reduction and preparation for emergencies. Building local skills in collecting and analyzing data will assist the communities to make better farming decisions, such as planting crops at the right time, irrigating more during droughts, preparing drainage ditches to cope with heavy rains, and applying fertilizer when rain removes nutrients from the soil.

The WFP, in coordination with the national government, is participating in local committees to share the technical and traditional knowledge it has gained from the project. These committees, known as Mesas Técnicas Agroclimáticas, involve dialogue between diverse local actors, including researchers, technical experts, representatives of the public and private sector, and farmers. By promoting better understanding of the climate, they are contributing to local discussion on resilient crop production practices.

A GENDER-SENSITIVE PROGRAM APPROACH

As climate change will particularly affect poor and disadvantaged groups, the program is designed to address the nexus between climate change and wide-ranging socio-economic sources of vulnerability, notably gender inequality. The project aims to empower women and enhance their role in adapting to climate change.

Women currently have limited access to land ownership, education, and health services. While they make up the majority of the labor force in mangrove shellfish harvesting and smallholder farming operations, they have limited roles in decision-making. There is also an urgent need to address violence against women and girls. Across Colombia, 77 percent of domestic violence cases target women. In these communities, an incredible 34 percent of all women aged between 45 and 49 have reported physical violence[59].

When communities are hit by adverse hydro-meteorological events, such as floods and prolonged droughts, women are generally excluded from loans, aid programs, and insurance, reducing their capacity to cope and adapt. The project understands that only vigorous, pro-poor and gender-sensitive planning can enable impoverished and marginalized communities to develop sustainable and resilient livelihoods. Some interventions will be led by women, or include them, with special efforts to strengthen the transfer of traditional knowledge to the next generation.

Key lessons for state-coordinated, locally led action

Two years into the program, five key lessons can be identified.

1. Meaningful participation of local communities at all levels of decision-making leads to better project outcomes. The target groups face socio-economic issues that often seem a higher priority than climate-related hazards, but that cannot be addressed in isolation from climate adaptation. An integrated approach to building both the prosperity and resilience of local communities, addressing issues that the community itself prioritizes, maximizes the chance of more sustainable progress.

2. Community participation depends on the effective building of trust. This was especially challenging in a context where the Afro and Awá communities have historically linked the presence of the state with land control and restriction of their activities. Involving communities from the design phase not only shaped the project technically, but also began to build trust that later facilitated dialogues with regional and national government on priority issues identified by the communities.

3. Finding ways to combine the valuable knowledge of local communities with new scientific findings can spur innovative and effective action, as well as bolster local ownership and increase the chances of long-term local commitment.

4. Project sustainability is rooted in an appropriate governance structure that coordinates between administrative levels in a way that does justice to the complexity of the situation. The Afro and indigenous

communities dwell in both Ecuador and Colombia, requiring a design that respects formal national bodies as well as the ethnic groups' own informal, customary governance structures.

5. Active participation of the national government can facilitate 'bottom-up,' evidence-based policy design. The Ministry of Environmental and Sustainable Development worked with international organizations, such as WFP, and communities in an integrated way to align project activities with the national goals of adaptation to climate change and risk management. A clear example of this vertical correspondence is how the VAPs contribute to the regional adaptation planning processes and achievement of the NDC.

CASE STUDY

BUILDING WITH NATURE IN DEMAK, INDONESIA

SUMMARY

The mangrove-mud coast of North Java, Indonesia, is eroding rapidly. Mangroves are being converted into aquaculture, and large-scale groundwater extraction induces land subsidence. The Indonesian government responded by piloting the Building with Nature (BwN) approach in the Demak district of Central Java province[60]. The aim was to rehabilitate the mangrove greenbelt, equip communities to maintain it, and boost aquaculture productivity in a sustainable way.

Permeable structures were constructed from local natural materials in an effort to stop or reverse coastal erosion by trapping sediment that mangroves can recolonize. Some aquaculture ponds were also reconverted to mangrove habitat. Community ownership was built through dialogue, capacity building in coastal field schools, and a financial incentive mechanism called bio-rights: in return for their engagement in conservation and restoration measures, communities received financial and technical support to develop sustainable livelihoods by boosting aquaculture productivity and developing eco-tourism.

The program was a partial success. Mangroves were not successfully restored behind the permeable structures because rates of subsidence proved to be too high. Erosion was halted, however, and mangroves recovered where communities made space for them by giving up part of degraded aquaculture ponds. The socio-economic interventions were highly successful: a cost-benefit analysis showed that breakeven could be met after about five years on the basis of higher incomes from aquaculture alone.

COASTAL EROSION DUE TO AQUACULTURE AND SUBSIDENCE

Demak is situated in the north of Central Java, the most densely populated of Indonesia's 15,000 islands and home to 60 percent of the country's total population of almost 290 million. It has a per capita GDP of around US$ 4,000[61]. The Indonesian archipelago is rich in natural resources and has one of the world's most bio-diverse ecosystems.

Northern Java faces the shallow Java Sea, where the tidal range does not exceed one meter and waves rarely top 0.5 meters. The climate is tropical, with most coastal erosion occurring during the monsoon season between November and February. The coastal plain is alluvial, with thick deposits of mud—primarily clay, with some sand. It was once

Demak, Indonesia

covered with a wide, dense mangrove belt, but more than 80 percent of it has disappeared.

Around 44 percent of Java's total 1,690-kilometer northern coastline is now eroding, in some locations by more than 50 meters per year, causing annual economic losses estimated at US$ 2.2 billion[62]. Without interventions, on average a six-kilometer-wide stretch of the entire north coast will become prone to regular flooding by 2030[63]. Traditional protection measures—dikes, levees and seawalls—have proved both expensive and ineffective. They fail to deliver the many economic, environmental, and social services which the mangrove belt can provide. The ecosystem services provided by mangrove forests, including coastal protection, have been valued at US$ 70,000 per hectare per year[64].

Java's mangroves have been destroyed to create space for aquaculture ponds since large-scale aquaculture started in the 1970s. The productivity of these ponds was always low, and became even lower over time due to poor practices and salinization. Rural poverty is widespread.

Land subsidence is a second major driver of mangrove destruction and coastal erosion in Java, causing further deterioration in conditions for local communities. Subsidence is caused by excessive extraction of groundwater to meet the demands of industrialization and the growing urban population. In some cases, significant land subsidence can occur as far as 20 kilometers away from the extraction site.

Other contributory causes of coastal erosion include the construction of coastal infrastructure, disturbing sediment build-up from offshore, and sand mining in rivers—along with damming and channelization—reducing sediment input into the coastal system. The impacts of climate change and sea-level rise are so far relatively small in comparison, but likely to become increasingly important as time goes by.

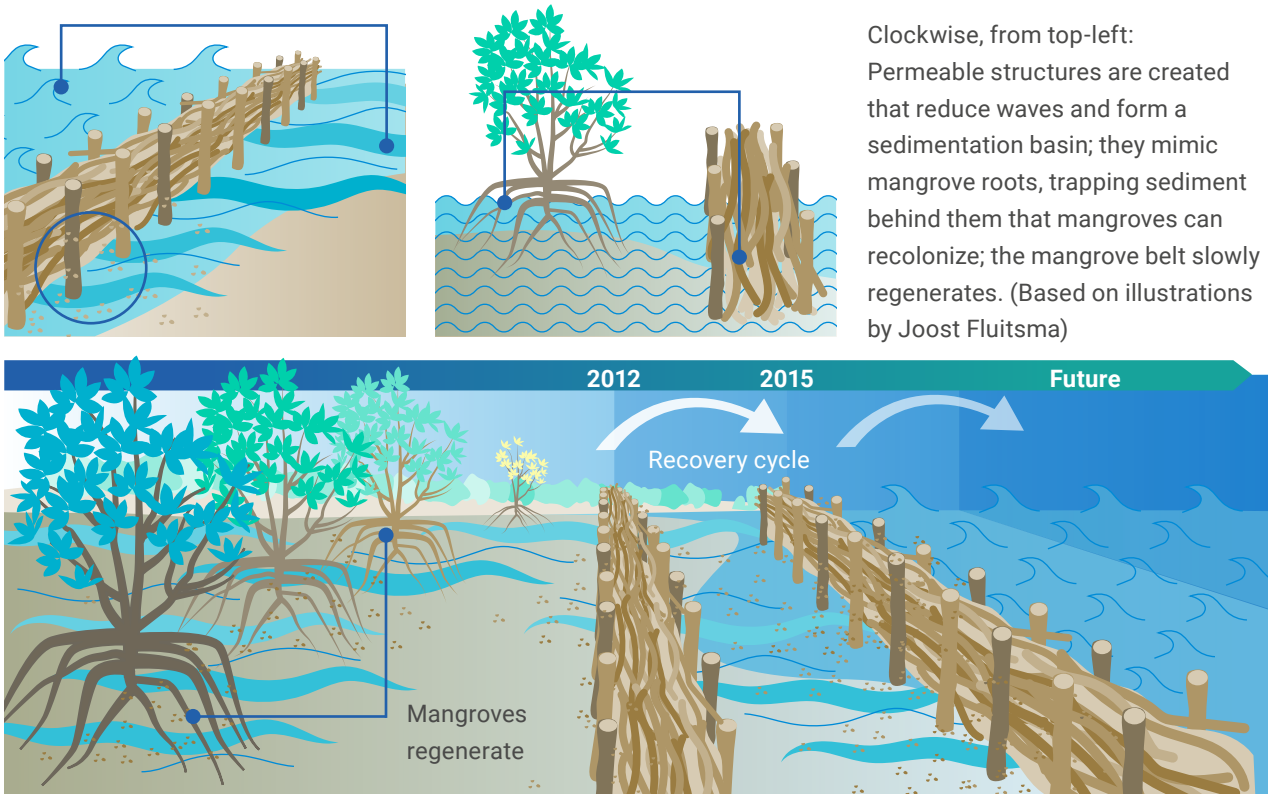
THE INTERVENTION: RESTORING MANGROVES AND IMPROVING LIVELIHOODS

A team led by the NGO Wetlands International, in collaboration with the Indonesian government and local community, tested a BwN approach through a small-scale pilot in 2013 in Timbulsloko, a village in Demak. This led in 2015 to the development of a district-scale BwN initiative along 20 kilometers of coastline, led by local authorities, the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) and the Ministry of Public Works and Housing (MPWH), and supported by Wetlands International and Ecoshape Foundation.

BwN is a design philosophy, covering a wide range of problems and systems[65]. In the U.S. this approach is known as Engineering with Nature[66]. The BwN approach in Demak had two main aims.

The first was restoring natural sediment dynamics conducive to mangrove forests. This involved constructing permeable structures to form sedimentation basins of a few hundred square meters. The structures should dampen waves, enabling new sediment accretion behind them where mangroves can settle. The structures are made of relatively cheap natural materials such as bamboo. They are designed in collaboration with local communities, and

Figure E: Permeable dam structure in Demak



Clockwise, from top-left: Permeable structures are created that reduce waves and form a sedimentation basin; they mimic mangrove roots, trapping sediment behind them that mangroves can recolonize; the mangrove belt slowly regenerates. (Based on illustrations by Joost Fluitsma)

are easy to construct and maintain using local materials and manual labor.

Figure E shows a permeable structure and illustrates how the approach can gradually reclaim land lost to erosion: when mangrove forest colonizes the newly accreted sediment, new structures can be erected further out to sea. These low-tech permeable structures speed up the natural sedimentation and accretion processes which would, when left alone, eventually restore a degraded coast, though this may take decades or centuries.

In areas where erosion was less severe, degraded fishponds were converted into sedimentation basins that can be recolonized by mangroves—a managed retreat of the coastline, rather than an attempt to reclaim land already lost. Along rivers, pond bunds were moved back to allow mangroves to recolonize the riverbank.

The second aim was improving living standards for local communities through a long-term (five to 10-year) program linked to their involvement in, and ownership of, maintaining the mangrove greenbelt. The intervention approached this in two main ways: bio-rights and a coastal field school.

BIO-RIGHTS

Bio-rights are a financial incentive mechanism that aims to reconcile economic productivity with environmental conservation and restoration[67]. In return for their engagement in conservation and restoration measures, communities receive financial and technical support to develop sustainable livelihoods.

Bio-rights agreements are conditional: payments are provided to communities subject to their participation in restoration measures. Small funds were made available to community groups in return for performing 'ecosystem services': constructing, guarding, inspecting, and maintaining permeable structures and sedimentation basins; converting degraded fishponds into sedimentation basins; and setting back the pond bunds along rivers. It was previously deemed impossible to persuade farmers to give up even degraded ponds for mangrove restoration, so this part of the intervention shows that intensive stakeholder engagement really can achieve a paradigm shift. The funds must be used for set purposes to boost livelihoods, including heightening the pond bunds, adjusting pond layouts, and buying equipment such as a machine to make fish food and probiotics from organic waste.

COASTAL FIELD SCHOOLS

Coastal field schools were set up to give practical training, in improving livelihoods as well as restoring mangroves. This included improving the chemical conditions in aquaculture ponds, selecting species and food, protecting from predators, and using natural resources sustainably. Beyond technical knowledge, the schools developed farmers' critical thinking to adapt by developing, testing and implementing new practices in an ecologically sound way. Communities trained through coastal field schools became committed to BwN measures and leaders in developing and implementing local coastal-zone management plans. The schools pioneered an alternative practice known as associated mangrove aquaculture (AMA), in which part of an aquaculture pond is given up to make space for mangroves. These act as water filters, so higher-quality water

enters the pond, together with nutrients, and introducing aquaculture best practices enables higher productivity. AMA uses mangrove ecosystem services to increase aquaculture production sustainably.

The bio-rights and coastal field school programs are executed by 10 community groups in nine villages along the Demak coast, supported by Indonesian staff from the NGOs Wetlands International and Blue Forests, who resided in Demak district throughout the project lifetime. Local communities appoint individuals to participate in the programs, and community members are in general positive about the initiative.

While funding came initially from donors, the approach has since been adopted by the Indonesian government. All layers of government are involved: the national government MMAF has placed permeable structures at many other locations in Indonesia; PUSAIR (the research department of the Indonesian Ministry of Public Works and Housing) has developed guidelines for hybrid engineering; and Menkomar (the Indonesia Coordinating Ministry for Maritime & Investment Affairs) has launched a roadmap to address land subsidence, which the provincial government is now translating into a local one. District and village governments have allocated budget for mangrove restoration and aquaculture revitalization implementation and maintenance, and at village level stakeholders are involved in planning, execution, and maintenance.

UNDIP, a university in Semarang, was involved in monitoring and research into issues such as sedimentation rates behind the permeable structures, resilience of mangroves to subsidence and plastic contamination, and innovations in sustainable aquaculture[68].

The results in Demak can be considered a partial success. Erosion was halted, as the permeable structures reduced wave conditions and accreted sediment. Mangrove ecosystems were restored in areas with lower rates of subsidence, but not where subsidence was more severe: young trees initially emerged, but soon died. Analysis[69] of the project alongside similar initiatives in Vietnam, Thailand, Suriname, and Guyana concludes that this BwN solution can cope with subsidence rates up to an estimated 10 centimeters per year, though this will vary depending on local conditions. This is not a problem with the BwN approach only: this degree of subsidence would similarly undermine more traditional approaches, requiring costly large-scale polders with drainage by pumping.

The experience in Demak shows that coastal restoration in Java should be accompanied by a program to resolve the subsidence problems. So far, however, all levels of government in Indonesia have found it difficult to address groundwater withdrawal. Partners in the Demak project managed to put this topic on the national agenda, leading to the creation of a presidential task force and the adoption in 2019 of a national roadmap to mitigate subsidence. The initiative is working with Central Java Province to translate this into a provincial roadmap.

The project has demonstrated that the bio-rights and coastal field school approach can build local communities' ownership and involvement in coastal restoration projects and empower them to express their needs in policy dialogues, while contributing to livelihoods that increase income sustainably beyond the project's lifetime.

Success factors: long time horizons, system understanding, stakeholder involvement

The analysis found three conditions are necessary for success.

Long time horizons. Mangrove-mud coasts take decades to degrade[70], so it would be naive to expect rehabilitation within a few years. As the natural timescale to restore mangroves extends beyond political horizons, continued financing and support for conservation and management is an issue. This necessitates a long-term vision that has scope for adaptation through learning by doing and to accommodate initial failures, alongside a supportive policy framework and sufficient institutional capacity. The bio-rights and coastal field school programs and policy dialogues facilitate patience, persistence and continuation beyond a project's lifetime.

System understanding. The long-term vision should be based on a robust understanding of both the biotic and abiotic coastal system, and of the socio-economic system. This is key to anticipate setbacks and minimize the scope for early disappointments to undermine patience and persistence.

Stakeholder involvement. Jointly designing, learning by doing and capacity building are needed to build trust, maintain motivation, gain insights, and find solutions that otherwise would not have been considered. Community members must be engaged to establish a vision, design and implement measures, and enable adaptive management. For example, the design of the permeable structures was discussed and agreed with villagers to ensure it was something they could do without the need for additional equipment.

Stakeholder involvement implies both short-term incentives and long-term socio-economic prospects: the bio-rights and coastal field school programs successfully catalyzed intra- and inter-community dialogues and collaboration.

Political support has been key to success, at national and regional levels. The central government provides funds and designs for permeable structures, contracting with local communities and resolving questions over land ownership, which can be difficult. Involving all levels—central, provincial, regency, district, and village—may slow down decision-making, but increases the prospect of gaining the confidence of local stakeholders and building local ownership over time.

SCALABILITY AND REPLICABILITY

The problems in Demak—including demographic and economic developments, subsidence, and climate change—are typical of those found along the coast elsewhere in Java and around the world, so the BwN approach may also be applicable in other areas and at larger scale. Mangrove-mud coasts, which are especially sensitive to subsidence, are found mainly in rural East and South Asia, Africa, Australia, and Latin and South America. Mangrove areas are being lost globally at an average rate of 0.2-0.6 percent per year[71]. Without interventions, an estimated 30 million people on Java alone will suffer from frequent flooding by 2030.

In technical terms, there are four main conditions for considering this approach:

- A mangrove greenbelt can be restored only in locations where mangroves have grown in the past.

- Water should not be too deep, or sustainable mangrove habitat will not develop—one meter water depth at mean sea level was found in Demak to be the likely maximum, though elsewhere it may be less.

- The BwN approach needs space for natural processes

to do their work, so it is generally not suitable for urban coastlines.

• Sufficient sediment should be available to be trapped—this depends on local conditions such as tidal range, wave climate, and erosion rates.

The Demak case study covered about 20 kilometers of coastline. Application at a larger scale—for example, the hundreds of kilometers of degrading coastline in Java—raises the possibility of interactions among local interventions, affecting patterns of tidal and wind-driven flows, wave conditions, and the availability of sediment and propagules. A system-wide, integrated analysis is needed to set priorities. This requires a proper understanding of the integrated biotic and abiotic system, using numerical models to quantify complex effects and interactions.

The socio-economic context should be conducive to commitment and patience from all stakeholders, in particular from local communities. Bio-rights and coastal field school programs can be instrumental in this.

Scalability also requires proper political support. In Indonesia it took time to persuade various ministries and provincial and district-level governments, but the approach is now becoming embedded. A research department of the MPWH has developed national guidelines for permeable structure designs, and since 2015 MMAF has erected many structures at other locations, facilitated by a capacity-building program using a training-of-trainers approach. Eight Indonesian knowledge institutes and universities have included BwN in their curriculum, reaching over 2,000 students annually.

Scaling up requires sufficient budget allocation and a cost-benefit analysis that takes into account long-term benefits. Data from Indonesia, Vietnam, and Thailand suggest that the permeable structures cost between around US$ 50 to 150 per meter to construct, and maintenance costs between US$ 30 to 80 per meter per year[72]. These costs must be weighed against the benefits of the BwN approach in comparison with a business-as-usual scenario, which assumes that most threatened land is lost and incomes from aquaculture stop entirely.

In Demak, the initial costs of the entire program were around €8 million, and revitalization of 300 hectares of aquaculture ponds was projected to yield a net profit of

€5,000 per hectare per year, implying breakeven would be attained after about five years. This calculation does not include other potential societal benefits, including mangrove forest products such as fruits and timber, near-shore fisheries, potential carbon values, avoided damage and costs of relocating people.

CONCLUSION

The BwN approach as applied in Demak is feasible, replicable and scalable given the right conditions: involved and committed stakeholders from different sectors and disciplines who are willing to exercise patience and persistence; favorable bio-physical conditions and good understanding of the bio-physical system; and limited subsidence rates. Stakeholder involvement and capacity can be built through training and short-term incentives, as shown by the bio-rights and coastal field school training programs.

While the pilot project in Demak was financed by the Indonesian government and foreign donors, a quick-scan cost-benefit analysis shows that such a project can pay for itself if up-front investments can be financed, for instance via mild-conditioned loans.

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CASE STUDY

A PATIENT, PROCESS-ORIENTED APPROACH IN BEIRA, MOZAMBIQUE

Beira's municipal government and the Netherlands have worked together since 2012 in a long-term partnership to support urban resilience. The partners made a conscious decision to focus on process, allowing strategies to emerge and adapt to changing contexts, rather than setting concrete objectives up front.

Two initiatives are especially relevant. The partners used the process of developing an urban master plan to bring together multiple stakeholders and leverage investment from international development finance institutions in drainage, coastal protection, and sanitation infrastructure. And Beira set up an urban land-development company to invest and create opportunities for affordable, flood-resilient housing for the urban poor as well as catalyze the development of commercial and industrial areas to create jobs and facilitate private-sector investment.

Beira's challenges, including lack of budget to operate and maintain physical infrastructure, insufficient institutional capacity, and political sensitivities, are shared by many low-lying coastal cities. A patient, process-oriented approach with a committed development partner can produce tangible results over time.

THE CONTEXT: URBAN SPRAWL, CYCLONE RISKS, AND DECAYING INFRASTRUCTURE

Beira is Mozambique's fourth-largest city, with approximately 530,000 inhabitants[73]. Like all the country's cities, it is growing quickly—Mozambique's urban population has more than doubled in the last 20 years[74]. Mozambique is, as per the World Bank, a low-income country, with around three-fifths of its 30 million people living below the US$ 1.90 per day poverty line[75]. It is among the African countries most vulnerable to climate change[76].

Beira was founded in 1890 as a station for trade and exploitation of natural resources and both its port and a railway line to Zimbabwe were established around then[77]. Today the port is Mozambique's second-largest, behind only the capital Maputo, and it handles international trade for Zimbabwe, Malawi, Zambia, Botswana, and DRC[78].

Much of the city of Beira—including the center—is built on the low-lying alluvium of the Pungue river, and is prone to flooding due to rainfall and invasion from the sea. Some of the lowest parts of the city are regularly inundated during spring tides. A dune strip of varying height offers coastal protection to other parts of the city, but only some small

patches of mangrove remain along the coast—most disappeared decades ago.

Parts of the city are built on a higher plateau, with an elevation difference of at least five meters. However, the plateau is also flood-prone during high-rainfall events due to the low permeability of soils and the absence of effective drainage.

Alongside more intense rainfall and rising sea levels, climate change is threatening Beira by shifting the trajectory of tropical cyclones southwards[79]. In March 2019, Cyclone Idai hit the city. High winds destroyed 70 percent of houses either partially or fully[80], roads and other infrastructure were damaged, and intense rainfall caused widespread flooding. Despite this, Idai was a narrow escape for Beira because it coincided with a neap tide—had it hit during a spring tide, when sea levels are 2.3 meters higher, the resulting storm surge would have almost totally inundated the city.

Population pressure has increasingly led to urban sprawl. Many urban poor have no alternative than to settle in low-lying, flood-prone areas; much of the land that people have informally settled in Beira in recent years is marshy lowland previously used for rice agriculture. This kind of land is not suitable for human habitation because it is a breeding ground for malaria and other diseases, and the public health hazards are known to be especially serious for children.

Economic activity is also increasing demands on land for industrial and commercial use. Expansion of the port's activities has created pressure on roads, with frequent traffic jams of trucks. After decades of neglect, the railway is functioning only partly.

At the time of publication, Beira's municipal government is in the hands of a different political party than the national government. FRELIMO has governed Mozambique since independence in 1975; Daviz Simango has been the Mayor of Beira since 2003, and now helms national opposition party MDM. Democratic cross-party co-operation is not yet well established in Mozambique, and this complex governance environment exacerbates challenges in service delivery and infrastructure investment, which is mostly funded by donors and channeled through central government.

The port and railway are under the control of Mozambique's

Beira, Mozambique

central government[81], as is the water supply: the port is largely operated by a private firm of mixed national and foreign capital[82], while the water supply and electricity services are in the hands of a national parastatal[83]. Roads are the responsibility of the municipality, along with the drainage and sewage networks, and an important element of coastal protection.

However, the municipality has insufficient budget even to operate and maintain this decaying infrastructure, much of which dates from the pre-independence era, let alone repair or improve it[84]. Its annual income from municipal taxes and central government endowments together amounts to approximately €15 million—less than 1 percent of the budget of a city of a similar number of inhabitants and physical challenges in Europe.

THE INTERVENTION: A LONG-TERM DEVELOPMENT PARTNERSHIP

Beira's municipal government and the Netherlands have worked together in an equal partnership since 2012 on a program to support urban resilience—that is, the capacity of a city to absorb shocks, continue to function, and recover

quickly. The partnership's broad aims include improving awareness of climate-change vulnerability and adaptation, the sustainability of development interventions, and coordination across institutions and levels of government to achieve and promote positive development outcomes for vulnerable Beira citizens.

The partnership is long-term—intended to last for 15 years, with a mid-term review currently underway. It is wide-ranging and deliberately open-ended: both Beira and the Netherlands made a conscious choice to avoid setting concrete goals upfront, in an environment that is prone to constant and rapid change. Instead, they wanted to maintain maximum flexibility to respond to events and pursue priorities as they are identified by the municipality. In line with this, the partners started by developing an urban master plan that aimed to set out a vision of Beira's future to 2035, though not a detailed blueprint.

Two elements of this partnership are most relevant to this study.

Facilitating investment in urban drainage, coastal protection, and sanitation The process of developing the urban master plan created space for dialogue between the mayor and international financiers. This helped them to understand Beira's particular needs—not only for social development, but also for creating an enabling environment for private-sector development.

As a result of this dialogue, Beira benefited from around US$ 60 million-worth of investment as part of the World Bank-financed Mozambique Cities and Climate Change Project. It rehabilitated 11 kilometers of drainage canals, installed flood control stations, and constructed a large water-retention basin[85]. The project was completed by 2018 and during Cyclone Idai, the project demonstrated its effectiveness: areas with rehabilitated drainage experienced relatively less flooding.

Nonetheless, Idai also made starkly clear that the project would not be sufficient to safeguard the city against future cyclones—indeed, without further investment, disaster is only a matter of time. Because the partners had already analyzed Beira's disaster risk exposure and preparedness, plans for additional adaptation measures and investments could be drawn up quickly.

In consequence, around another US$ 225 million of investment is now planned in drainage, sanitation and coastal protection, addressing various aspects of urban resilience. The Beira Urban Recovery and Resilience Plan was developed with the support of the Dutch Government, UNDP and UN-Habitat, and the funding comprises grants from the World Bank, the Netherlands, German co-operation through KfW and the European Union, coordinated at national level by the Ministry of Public Works and Housing.

Creating an enabling environment for affordable, flood-resilient residential housing. While this international funding is improving the climate resilience of flood-prone areas which have already been developed, for the future it is critical to change incentives to shift new development onto more suitable terrain, in alignment with Beira's urban development plans.

In 2018, the municipality set up an urban land-development company, SDU Beira. It aims to create the space for new, affordable, flood-resilient residential housing close to the city center: 20,000 people are expected to live on the 400-hectare Maraza development, three hectares of which have been set aside for a fast-track pilot project.

In Mozambique, the state owns all land and people apply for rights to use it. The land assigned to SDU Beira had

previously been used for subsistence agriculture. Several hundred smallholders have so far been resettled and have benefited from programs to restore families' livelihoods in ways that aim to improve on international best practice on acquiring consent and providing compensation.

SDU Beira[86], with financial support from the Netherlands, is pre-investing in infrastructure such as drainage, roads, sewage, and landfill to raise the terrain level of the Maraza development. The overall goal is to offer plots or pre-constructed houses at prices that will be affordable even at the bottom of the pyramid. This will depend on achieving scale through a combination of efforts including:

• **Cross-subsidization from commercial development.** SDU Beira is working to establish 900 hectares of land for industrial and commercial development in connection with the port and the Beira corridor. Development is still in the planning stage. As well as attracting investors, enhancing economic activity and creating jobs—all goals in themselves—this should create funds to cross-subsidize the residential development.

• **Working with banks to improve access to financing.** It is effectively impossible for an ordinary person to get a mortgage in Mozambique, where the banking sector is traditional and risk-averse and interest rates are high; in a country of 30 million people, only 600 have a mortgage[87]. Meanwhile, real-estate developers struggle to access finance to build affordable housing as local banks lack experience and development banks focus on larger-scale projects. By working to improve access to affordable finance for both developers and buyers, the partners aim to bring down prices significantly in the longer term.

• **Improving the functioning of the municipal land registry.** Clarifying the existence of land-use rights that could be used as collateral should help to create a better market for lending, contributing to a more enabling environment for private-sector development.

A consequence of the wide-ranging, open-ended nature of the partnership between Beira and the Netherlands is that many individual interventions serve multiple aims: the work to improve the land registry, for example, is also intended to make it easier to collect municipal property taxes, boosting budgets for sustainable operation and maintenance of critical infrastructure, such as the drainage and sewage infrastructure and coastal protection.

Four key learnings

The journey toward higher awareness of climate-change vulnerability, more sustainable development interventions, and better coordination at all institutional levels is challenging. The achievements of the partners so far—notably increased international investment in infrastructure and incremental improvements in the enabling environment—have inevitably come amid setbacks. That said, we can identify four key learnings from the intervention.

1. Building a long-lasting partnership means focusing on the journey, not the destination. The partners took the conscious, explicit decision from the start that the best chance of success came from a long-term commitment with a focus on process, rather than 'big bang' projects with concrete objectives set up front. They both aimed to create an equal partnership, with mutual inspiration and co-creation as key aspects.

In particular, the process of developing the urban master plan in 2013-14 was just as important as the resulting document, which was approved in 2015 by the Municipal Assemblée. Developing a vision and articulating priorities jointly with stakeholders helped the city to engage people and institutions in a coherent framework of interventions. Annual thematic round tables brought together finance partners and national and municipal government entities. Investment conferences involved the private sector. These have become an important platform for dialogue and exchange, helping to coordinate and maintain momentum.

Taking a long-term perspective means there is scope to adapt when contexts change or new insights emerge—an important element in building urban resilience. This process of 'strategy emergence' involves the mayor taking leadership in the change process, the Netherlands Embassy playing the role of convener, a flexible budget for interventions, and a willingness to take risks.

SDU Beira is an example of strategy emergence: setting up an urban-development company was a stated wish of the municipality, but might not have happened without the partnership and its focus on building an enabling environment. The potential for synergy between SDU Beira and other efforts—such as to improve the land registry—also requires long-term vision and analytical work that goes beyond simple project interventions.

Cyclone Idai showed how the existence of a strong partnership can lead to a flexible response when contexts change: Beira acted rapidly and involved multiple international partners to draw up a municipal recovery and resilience plan, and contribute to the national post-disaster needs assessment, thus building on their accumulated joint knowledge of the city. The convening role of the Netherlands Embassy helped to support other financiers to make substantial funds available.

2. Aiming for sustainable social inclusion at scale. The partnership between Beira and the Netherlands is rooted in the conviction that urban development can be successful only when it is equitable and creates sustainable improvements for people in the lower socio-economic strata.

Engaging people from such strata has proved to be a challenge. During the master-planning process in 2013 and 2014, it became clear that civil society is not well organized in Beira: grassroots organizations are few and they are often politicized. Moreover, people frequently have the experience that participation in such processes will not translate into positive change in their lives and access to services. In many low-income countries, the social contract between citizens and state is not strong; Mozambique is no exception.

In response to these challenges, it is critical to implement environmental and social-impact assessments professionally and independently, to promote the well-being of vulnerable people. When resettling smallholder farmers from the land assigned to SDU Beira, the

partners not only secured their consent and provided compensation, but also enrolled the farmers or their relatives in vocational training courses to enable them to learn an alternative livelihood. People who have been resettled so far are mostly positive about their personal outcomes[88].

Ultimately, the only way to prevent urban sprawl into low-lying swamp areas is to create alternative settlement options that are affordable and more attractive—and the only way to do this sustainably and at scale is by developing initiatives that use the market economy to engage low-income people as customers, offering them socially beneficial products at prices they can afford. This sounds simple, but it will require systemic change to achieve.

The cheapest houses in Mozambique currently sell for upwards of US$ 40,000—well beyond the average person's reach. SDU Beira has set itself the initial target of offering affordable, flood-secure residential units at around a quarter of this price: cross-subsidization, improved financing for both developers and buyers, new models such as rent-to-buy and economies of scale should all help to force prices lower over time.

3. Improving the capacity of municipal institutions. While international finance partners are funding the development of new flood-protection infrastructure—bringing immediate benefits for the urban poor, who have already settled on unsuitable marshland—the municipality will be able to maintain it only if it has well-functioning institutions with adequate budgets and sufficient, well-motivated professionals.

The partnership between Beira and the Netherlands is working hard to put the foundations in place. Improving the land-registry database, for example, aims in part to make it easier to levy property taxes—a sustainable and substantial source of municipal income. Property owners perceive these taxes to be legitimate when they visibly fund improved drainage and flood protection. Similarly, the municipality is working with the national water company to look at recovering sanitation costs through the fees paid as part of water bills.

The partners have implemented various interventions to improve the professionalism of personnel, including as part of their work to build capacity in the land registry and urban planning department. Programs are being developed that focus on personal motivation of staff through the 'field level leadership' approach[89] of the World Bank.

Other interventions focus on physical reorganization of departments, digitalization of land administration, and improving work processes and communication with civilians, all with the aim of improving the municipality's performance toward its citizens.

4. Structuring for the best chance of political sustainability. Mayor Simango is widely recognized as a charismatic leader with the capacity to work across political dividing lines. Nonetheless, the political sustainability of interventions has needed as much careful thought as their economic sustainability.

SDU Beira was purposefully set up to be a politically neutral entity because the partners believe this gives it the best chance of helping to foster a more business-like environment for co-operation on development objectives which are shared by the municipality and central government. The aim was to find the right distance from the municipal government for SDU Beira to operate: a publicly owned company rather than a municipal department, with the municipality as sole shareholder; and the municipality setting the strategic direction, with SDU Beira responsible for operations.

Legally this is not a novelty, but it is the first time in Mozambique that such a set-up has been applied to address the challenges of equitable land development for affordable housing and job creation by attracting business to well-organized industrial and commercial parks.

SCALABILITY AND REPLICABILITY

Beira is characteristic of many low-lying coastal cities in terms of the challenges—and benefits—of its physical geography. It is typical also of many municipalities in low-income countries (LICs) in the insufficiency of its budgets to operate and maintain its physical infrastructure; its dependency on international financiers for investment projects; and its complexity of power dynamics and politics at various levels of the administrative system.

All this speaks to the potential replicability of the overall process approach toward the transition from unsustainable to sustainable, and from climate vulnerability toward climate resilience. Beira shows how a long-term partnership between a municipality and a development partner can create space for greater imagination, flexibility and commitment than the typical time horizon and terms of reference of project interventions and project cycles. Such a partnership enables a series of different hard and soft interventions, rather than a single intervention, while building institutional capacity.

Also potentially replicable is using the process of developing an urban master plan to bring together national institutions and international financiers with municipal leaders to align their efforts. Many other cities share Beira's experience of political and administrative barriers between municipal and national levels, complicated by silos within and between international financial institutions. Donors and citizens often speak completely different languages and local government leaders are well-positioned to bridge the gap with long-term process support, delivering significant benefits for all involved.

The replicability of the urban land-development company—SDU Beira—is more uncertain. Land-development companies are common in developed countries, but their potential in low-income countries such as Mozambique is not yet proven. The structure of SDU Beira was informed by a similar institution in Amsterdam[90] and best practices in land-development companies from around the world[91].

Land-development companies use their public mandate to organize the market, capturing part of the increase in land value that would otherwise accrue to the private sector. In this way they not only help to implement spatial plans, but improve equity—for example, by using profits to subsidize affordable city-center housing. If the experiment of SDU Beira succeeds in attracting businesses to commercial areas and generating investment in affordable housing, it could be a model to guide and promote equitable spatial development in similar cities.

CONCLUSION: PROCESS-ORIENTED APPROACH ACHIEVES TANGIBLE RESULTS

Cities like Beira face enormous challenges to address climate-change adaptation: lack of investment budgets; lack of institutional capacity and sustainable funding for operations and maintenance; lack of well-functioning institutions; and the need to navigate the complex environments of national government and international financiers, who all have their own agendas.

The Beira case shows how an equal partnership between a municipality and a development partner can help low-lying coastal cities in LICs to increase urban resilience and adapt to climate change. A patient, process-oriented approach can bring imaginative solutions that facilitate systemic change processes and facilitate networking with national institutions and financiers on more long-term and integrated investments.

To produce tangible results takes time, especially for lower-income groups: even after eight years, Beira, with support from the government of the Netherlands, is still in the stage of putting building blocks in place to safeguard the sustainability and scalability of their work together. Nonetheless, results are appearing, from the improved drainage system to the leveraging of donor funds after Cyclone Idai. The partners have co-created an approach that enables mutual inspiration and adaptation to the changing circumstances and challenges around building urban resilience.

CASE STUDY

THE WADDEN SEA REGION: A TESTING GROUND FOR CLIMATE ADAPTATION

Dutch people have a long history of adapting to water-based risks. In the last 1,500 years, at least 25 major floods have been recorded, some of which had profound impacts on the Netherlands coastline.

Over the last few decades, Dutch thinking has evolved from a strong focus on controlling floods through 'gray-only solutions' toward living with water through solutions that are integrated or combined with natural systems and serve multiple functions for regional development. The nation is taking a proactive approach to climate adaptation, which is embedded in a long-term national policy framework. The country has developed a layer of governance organized along hydrological boundaries, and an approach of sub-sidiarity, which sees decisions taken at the lowest possible level. The OECD has recognized the excellent track record of Dutch water governance[92].

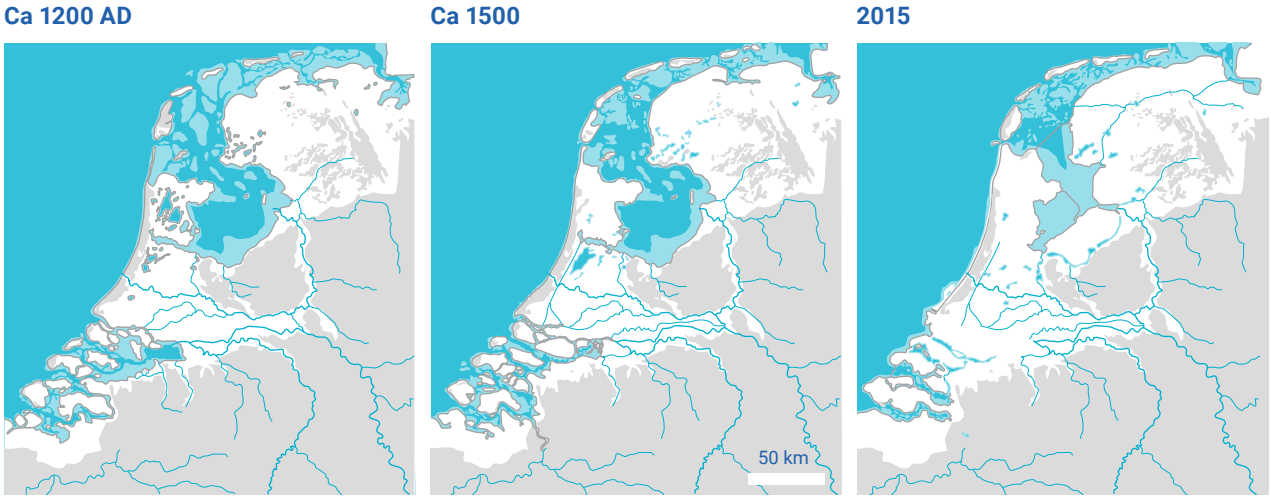
The Delta Programme, which plans to 2050 with an outlook up to 2100 and has funding assured until 2034, is characterized by the search for 'win-wins' across climate adaptation, nature, and economic and social development. Several experiments that could potentially inform climate-adaptation work elsewhere are underway in the Wadden Sea region of the north-eastern Netherlands.

A BRIEF HISTORY OF THE WADDEN SEA REGION

The Wadden Sea is an area of shallow water, wetlands, and mudflats that covers around 10,000 square kilometers along a 500-kilometer stretch of coast running from the north-western Netherlands into Germany and Denmark. Today its coastline is multi-functional. A Unesco World Heritage site, it is home to around 10,000 plant and animal species. It protects inland areas from coastal flooding and creates economic value for the region's farmers in particular.

Thousands of years ago this coastline had wide salt marshes. Attracted by the fertile soil in low-lying coastal areas, humans began to settle despite the risk of flooding. They built their dwellings on top of mounds of loam, manure and garbage, known as *terpen* or *wierden*, up to eight

Figure F: Land reclamation works in the Netherlands



Adopted from: Han Meyer 2017: The State of the Delta: Engineering, urban development and nation building in the Netherlands.

meters above sea level. These mounds—early examples of adaptation to water challenges—date back to around 500 BC. Similar structures were built in Danish and German parts of the Wadden Sea region.

As human activity reshaped the landscape, storm surges increasingly breached the marshes. The first dikes may have been built as early as the first century AD. The rate of construction increased around the 12th century, with the founding of new small monastic orders. The 126 kilometer *Westfriese omringdijk* was completed in 1250. Soon after, in 1287, St Lucia's Flood claimed tens of thousands of lives and carved out the Zuiderzee, a shallow inland sea that stretches to around 5,000 square kilometers[93]. The city of Amsterdam grew to its south-west.

Over the centuries, *kwelderwerken*—land reclamation works—saw continuous reclamation of land from the Wadden Sea. Wooden dams were built out to sea, calming the waters so sediment would settle; over time, the sediment formed highly fertile land. The north-eastern Netherlands became known for its wealth, built on large-scale grain farming. Farmers had strong economic incentives to collaborate on constructing and maintaining dikes and polders.

Various proposals were made to close off the Zuiderzee. This would require the highly ambitious construction of a dam over 30 kilometers long, but it would also create opportunities to reclaim more land around the hundreds of kilometers of Zuiderzee coast, and turn the Zuiderzee into a freshwater store for farmers. The idea was given impetus by the flooding of surrounding land during a storm in 1916, and plans were finally approved in 1918 through the Zuiderzee Act. It set out the key objectives of protecting the central Netherlands against flooding, increasing Dutch food supply and improving water management. A dedicated governmental body was set up, the *Dienst der Zuiderzeewerken* (Zuiderzee Works Department), in May 1919. The legal arrangements ensured political commitment and budget allocation over a long time horizon.

The Afsluitdijk was a water management intervention on a scale the world had never seen before. Over the next four decades, around 1,650 square kilometers of fertile land were reclaimed from the Zuiderzee, and, initially, mostly given over to agriculture[94]. The Afsluitdijk was also, however, an ecological disaster, cutting off routes to fish spawning areas. Other large-scale infrastructure to reclaim land followed through the mid-20th century. At the time, the thinking was predominantly about water management, safety, and civil engineering.

EVOLUTION IN DUTCH THINKING ON WATER MANAGEMENT

At national level, the Dutch government has a well-defined policy framework, governance structure, and predictable budget allocations for water-related infrastructure.

Water governance in the Netherlands has historically reflected the principle of subsidiarity—taking decisions at the lowest possible level. The Netherlands has a separate

layer of governance for the purpose of water management. Initially local 'water boards' were essentially associations of local stakeholders (farmers, landowners, politicians), but they gradually transformed during the 20th century into watershed-wide water management agencies with a board representing all stakeholders, including citizens, and their number decreased—for reasons of efficiency and governmental reform—from 3,500 in 1850 to 21 today. They form the fourth layer in the representative democracy of the Netherlands and have dedicated elections, as well as the right to levy local taxes. The *Bureau voor den Waterstaat* —the predecessor of the current Directorate-General for Public Works and Water Management (Rijkswaterstaat)—was established in 1798 to coordinate the implementation of national-level projects.

Dutch thinking on how to live with water has evolved over the years—from 'fighting against the sea' toward living with water, from controlling floods toward 'room for the river'—or, as so aptly put by the title of the Delta Commission's 2008 report, *Working Together with Water*[95].

This transformation was driven by the growing understanding that it was proving impossible to predict and control nature, and the necessity not to respond to challenges of the past, but instead to prepare for those of the future, in a strategic and adaptive manner. While safety remains a key concern, increasingly a systems approach is being adopted. For instance, primary flood defenses—dikes—are combined with secondary-level defenses, such as open spaces that can serve as emergency reservoirs in case the dikes fail. Under normal circumstances, these provide space for recreation, grazing areas for cattle, and so on[96].

The focus has broadened to include spatial planning, a growing awareness of ecosystem and sustainability considerations, and the embrace of a 'building with nature' approach. The concepts of adaptivity and resilience are increasingly part of the national (policy) conversation. As climate change began to penetrate public awareness, there was strong popular support for forward thinking and proactive measures—with their long history of water-related natural disasters, the Dutch are increasingly aware of the risks.

THE DELTA PROGRAMME

In 2012, the government passed the Delta Act, defined as a partnership between national, regional and local government and water authorities, based on the values of solidarity, flexibility, and sustainability. It created the position of Delta Programme Commissioner and a fixed, stand-alone Delta Fund. An average of €1.3 billion a year has been earmarked for this fund up to 2034, split around 50 percent for new investment and 50 percent for overheads, management and maintenance.

The Delta Programme Commissioner's role includes advising the government and promoting co-operation between national and regional branches of government and civil society. The Commissioner reports to the Minister of Infrastructure and Water Management, and participates in the Council for Financial Affairs, Economic Affairs, Infrastructure and Agriculture. Every year the Commissioner submits a proposal recommending new measures and reports on implementation, in consultation with a range of administrative bodies, private companies, and NGOs that are involved in designing, implementing, and maintaining infrastructure.

Water management is a long-term endeavor, so the program lays out plans until 2050, with a view to 2100. But it has not set out to give an immediate answer to the big question of the 21st century: given projected sea-level rises, should the Netherlands cease to invest in low-lying parts of the country, or invest whatever is necessary to keep those areas safe[97]?

Instead, it takes an adaptive approach: every six years it asks the question of whether there are new developments or insights that warrant policy adjustments. This approach of keeping long-term options open has so far proved successful in gaining political support. However, it remains to be seen whether the program will be able to switch to a transformational strategy if needed[98].

BUILDING WITH NATURE IN THE WADDEN SEA REGION

Managing sediment has become a major struggle in the Wadden Sea region. The reclamation of land has narrowed gullies, which have also been deepened to serve as shipping routes. With fewer salt marshes and mudflats for sediment to be deposited, waters have become more turbid, upsetting river and estuarine ecosystems. The imbalance between sediment and gullies also makes storm surges more of a problem: tidal and wind-driven flows can

enter deep into estuaries, causing water levels to rise quickly and requiring the building of ever higher dikes.

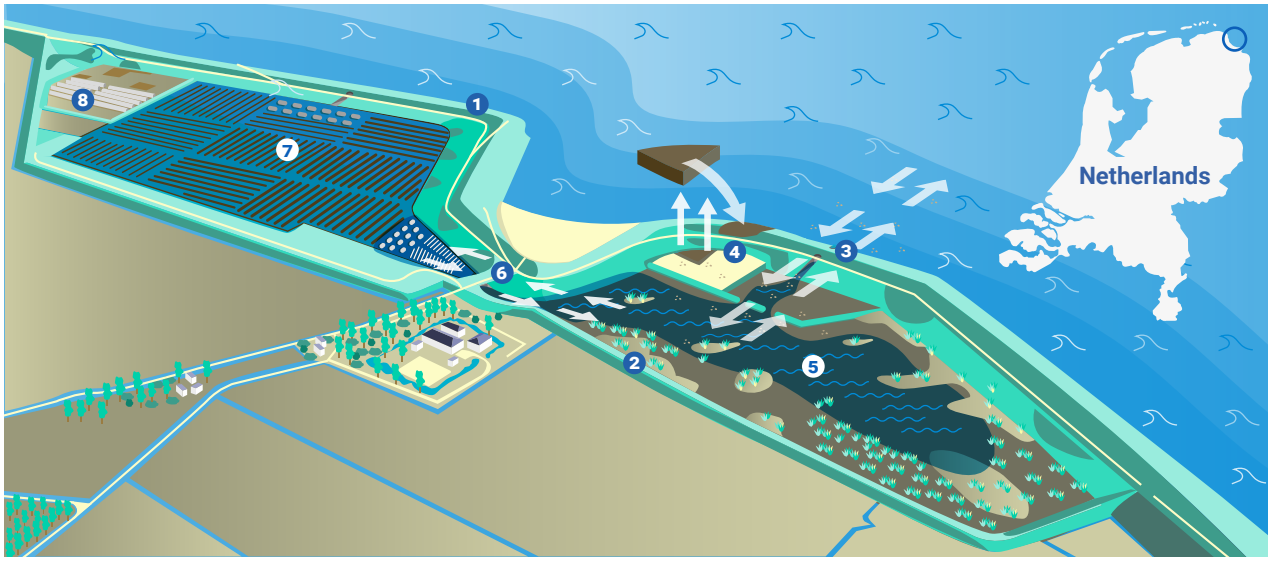
The Delta Programme includes strategies for seven regions in the Netherlands, including the Wadden Sea[99]. The strategies reflect negotiation between different government agencies, citizens' organizations, wilderness and nature conservation societies, industry and locals. The aim is to find win-win solutions that harness natural systems to improve coastal protection and deliver economic benefits.

The largest current project in the Wadden region is the reinforcement and renovation of the Afsluitdijk, which is scheduled to be completed in 2025. Since 1932, the Afsluitdijk has protected large parts of the Netherlands from flooding by the sea. The dam no longer satisfies current standards for water safety and so is due for renovation. In addition, greater amounts of water must be drained due to climate change. Rijkswaterstaat (the executive agency of the Ministry of Infrastructure and Water Management) and the building consortium Levvel are working on strengthening and renovating it to protect the Netherlands against water in the future.

The dike is being reinforced by, among other things, giving the dam new revetment with specially developed concrete blocks: Levvel-blocs. The hinterland will be protected with new floodgates. The sluices will be reinforced and expanded with eight new sluices near Den Oever. Two pumping stations containing six gigantic pumps will be built. The sluices and pumps are required to drain surplus water from the IJsselmeer (Lake IJssel) to the Wadden Sea. A regional partnership entitled De Nieuwe Afsluitdijk is constructing a fish migration river near Kornwerderzand, which will wind its way through the Afsluitdijk. Migratory fish will be able to use the river to go back and forth between the Ijsselmeer (freshwater) and the Wadden Sea (saltwater).

Between the Afsluitdijk and the Eems-Dollard estuary—which marks the border with Germany—the Wadden Sea region is hosting a range of experimental interventions aimed at restoring sediment balance. These include:

Figure G: Double dike in the Eems-Dollard estuary



❶ **Primary dike** allows water to wash over during storms, but is held back by a **second dike** ❷ further inland
❸ **Water inlet** controls water from Eems-Dollard estuary during ebb and flow of tides
❹ **Sedimentation basin** collects material used to increase height of primary dike
❺ **Brackish zone** forms natural filter for second basin, water flows into second basin via an **inlet** ❻
Second basin includes area for ❼ **fish and shellfish farming** and further along ❽ **agricultural produce** such as seaweed, saline potatoes and tomatoes

The 'mud motor' in Harlingen takes sediments dredged from the harbor and deposits them at sea, at a time and in a location where the tides will bring them back toward an area of coast where they can settle on salt marshes, bringing benefits for nature and coastal defenses[100].

The Brede Groene Dijk (Wide Green Dike) is taking naturally deposited mud from the harbor approach channel and a nature area and 'ripening' it into clay by drying and desalinating it, then using it as a building material to reinforce the dike. A one-kilometer stretch is expected to be completed in 2022[101].

The 'double dike' (see previous page) in the Eems-Dollard estuary involves constructing a second dike behind one that protects from the sea—a more cost-effective alternative to strengthening the sea-facing dike. A 27-hectare area between the two dikes will be used for farming crustaceans, shellfish, and salt-tolerant crops, as well as enabling sediments[102].

Conclusion: The importance of subsidiarity and broad-based public support

Changing estuarine dynamics is an expensive, multi-decade undertaking that requires budget predictability, a dedicated legal framework, and appropriate governance structures organized on water-based principles—the Netherlands' water boards being a case in point. In the Netherlands, long-term water management has risen above party politics and has broad-based public support. A proactive stance on climate-change adaptation—looking forward, rather than waiting for disaster to become imminent—has emerged as a non-partisan issue that commands support through the entire Dutch society.

Over recent decades, the Netherlands has seen a broadening from primarily focusing on prevention and control of floods toward living with water and deploying a combination of gray and green infrastructure. Combined with a deep understanding of the Dutch Deltas, this has allowed the Netherlands to look for innovative win-win solutions that benefit ecology, economic development, and human wellbeing.

The country's experience also shows that effective action is most likely when different levels of government work together effectively, following the principle of subsidiarity in decision-making—from local-level solutions owned by citizens to the involvement of national government when needed to finance innovations and scale. The restoration of the Afsluitdijk exemplifies how discussions between different stakeholders can lead to a consensus on necessary action.

CASE STUDY

WORKING WITH NATURE IN THE MEKONG DELTA

The Mekong Delta is the world's third-largest, accounting for 18 percent of Vietnam's GDP and population. Over the last half century, the delta has seen two fundamental shifts in approach. First, in the 1970s and 1980s, the government sought to exploit the economic potential of the delta through a 'rice first' policy of intensive agriculture, enabled by massive engineering projects to manage water flows. However, this proved to be ecologically unsustainable.

More recently, the government has moved to an approach of working with nature, embodied in a 'golden policy trio' for the development of the Mekong Delta, enacted in 2016-17: Prime Minister's Decision 593, the Planning Law, and Prime Minister's Resolution 120. They add up to a comprehensive approach to adaptation that spans provinces and involves living with annual flood events and salinization rather than trying to control them: floodwater brings valuable resources, such as fertile sediments and fish eggs that grow on flood plains.

The story of the changing approach to the Mekong Delta leads to four key lessons for delta management: think of the delta as a living organism; look beyond the economic rationale for the delta's development; ensure integrated planning and regional coordination; and apply the 'no-regrets' principle in planning for adaptation to climate change.

CLIMATE CHANGE AND ECONOMIC DEVELOPMENT

The Mekong River originates in the Himalayas and traverses China, Myanmar, Thailand, and Cambodia. At Phnom Penh, it divides into a main northern branch—called the Tien River after entering Vietnam—and a southern branch,

called the Bassac River in Cambodia and the Hau River in Vietnam. They divide into six and three main channels respectively, reaching the sea in southern Vietnam.

The delta's dense network of rivers and man-made canals covers 12 provinces and the municipality of Can Tho. Its total area of about 40,500 square kilometers represents 12 percent of Vietnam's territory. The delta is home to 20 million people, or 18 percent of the country's population, and accounts for 18 percent of its GDP. This includes 50 percent of the country's rice production—close to 95 percent of its rice exports—along with 65 percent of fruit production and 70 percent of fisheries, another key export sector.

The delta is divided into four hydro-ecological zones[103]:

Upper delta flood plain: Suitable for rice production, fruit horticulture, and freshwater aquaculture. During the wet season, floodwater levels regularly exceed two meters.

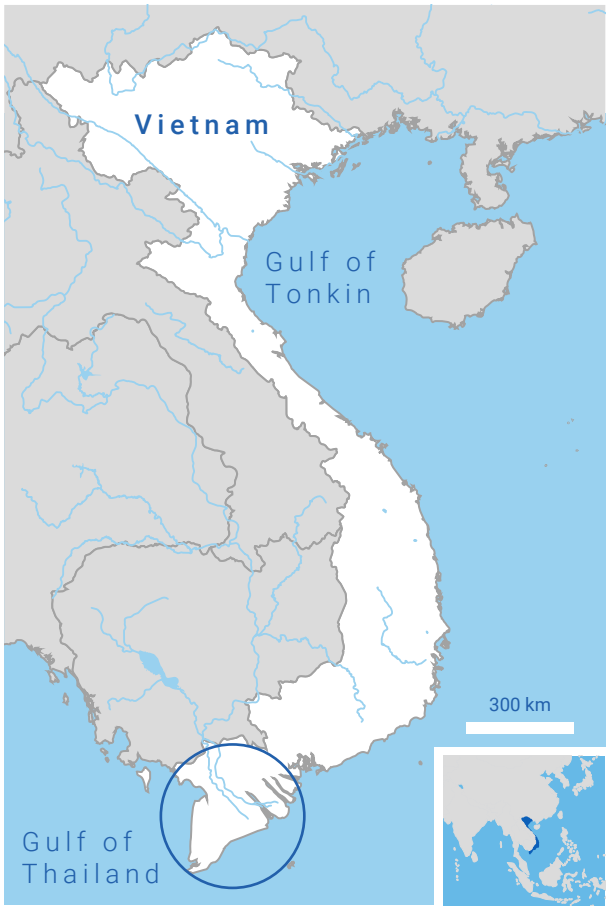
Middle delta: Characterized by industrialization, land use changes, and limited urban water supply and wastewater services.

Delta estuary: Rice cultivation and brackish aquaculture are important, but mangrove forests are being destroyed as farmers convert them into shrimp farms.

Delta peninsula: With limited freshwater sources, brackish aquaculture is the dominant land use.

Almost all the delta's rain falls between May and October. Flood dynamics are regulated through three natural reservoirs—the Tonle Sap (in Cambodia), the Long Xuyen Quadrangle, and the Plain of Reeds (both in Vietnam). The last two are vast flood plains, covering roughly 600,000 hectares and 700,000 hectares respectively, and holding water to a depth of three to four meters. They reduce the flooding impact downstream during the flood season, and balance salinity in the coastal zone during the dry season by releasing freshwater that supplements the Mekong flows.

The Mekong Delta, Vietnam



The Mekong Delta faces the sea on both its east and west coast, and its tides are a defining trait far inland: they cause the rivers and canals to flow back and forth, once a day on the west coast and twice a day on the east coast, with a weekly cycle of spring tides and neap tides. The 'flood pulse' of alternating inundation and drought means the rivers and canals can purify themselves, depending on the strength of currents that flush away contaminants and the amount of dissolved oxygen in the water to decompose organic matter and break down inorganic toxins into less-toxic compounds.

Climate change is increasing temperatures and making rainfall more variable, seriously affecting crop yields, human health, and the aquatic environment. Saltwater intrusion is projected to worsen with rising sea levels and land subsidence. Upstream, wetter wet seasons and drier dry seasons will result in more severe and frequent floods and droughts[104]. Peat swamp forests help with flood control, but overexploitation for timber and non-timber forest products has led to increased water loss and fire risks[105].

Climate change is not the only factor affecting the delta's development. In many areas, land subsidence is a major issue and reaches rates of between one and four centimeters a year, a ten-fold sea-level rise[106]. And even though subsidence is not a direct climate-related issue, it is accelerated due to the increasing extraction of groundwater to counter salt intrusion and combat increased droughts. Other influencing factors are: economic development (mainly rice cultivation, wild fisheries, aquaculture, and associated technological developments); demographic trends (aging populations and out-migration); urbanization; upstream activities (especially dam construction for hydropower); and weaknesses in governance and institutional capacity, particularly related to transport of goods and people, infrastructure, and financial capital.

Operation of the basin's hydropower reservoirs could exacerbate both floods and droughts: water is stored in the reservoirs during the dry season, potentially contributing to freshwater shortages, and released during storms, potentially making floods more dangerous. Another drawback of hydropower reservoirs is that the sediments transported by rivers get trapped by the dams. This deprives the delta of its natural fertilizers and building materials, resulting in soil degradation and erosion of coasts and riverbanks.

FLOODING: FROM BLESSING TO THREAT

Flooding in the delta was historically seen as a natural process that maintains productivity: fertile silt is transported downstream and deposited on the delta's flood plains, while the floodwaters also carry sand, fish eggs, and fingerlings bred upstream. The delta's population adapted their ways of life to avoid extensive damage and benefit from the valuable resources carried by the floodwater. Indeed, the term 'flood season' was not part of the vernacular and instead locals referred to a 'water rising season,' in which the water level would gradually and predictably rise.

After the reunification of Vietnam in 1975, however, this view changed. From being seen as a blessing, flooding started to be viewed as a threat to infrastructure and agriculture. At the end of the war, the country was starving. Consequently, the delta shouldered the role of providing food for the country and every effort was made in food production. The government pursed a self-sufficient food security strategy, the 'rice first' policy, to maximize rice production in the Mekong Delta—expanding the growing area, maximizing yields through chemical fertilizers and pesticides, and introducing 'triple cropping.' The third crop, planted during the flood season, requires high dikes to prevent sediment from entering the fields—but this also prevents the soils from naturally being replenished. Crop failures are common, especially in dry years.

This 'rice first' policy led to the construction of massive engineering infrastructure that disrupted the delta's natural systems: high dikes in the flood plains; canals that drain away floodwater; sea dikes and coastal sluice gates to prevent saltwater intrusion into the inner delta; and water regulation projects to bring freshwater for rice cultivation to areas that were naturally saline. These systems often proved to underestimate the complexity of the ecology in the delta. Among the impacts have been:

Displaced flooding and worsened salinity intrusion. Dikes to control floods in the upstream provinces increased inundation in the downstream provinces. They significantly raised the levels of the rivers, exacerbating the erosion of riverbanks and the coast[107]. Saltwater intrusion increased also during the dry season in the coastal provinces, for two reasons: (i) instead of entering the flood plains during the flood season for temporary storage, some floodwater is lost to the sea; and (ii) less freshwater is available during the dry season to supplement river flows and balance their salinity.

Declining fishery resources. The 'rice first' policy led to neglect of coastal fisheries, an important part of the delta's economy. The flood plains, where fish eggs and fingerlings have traditionally grown are taken up by rice cultivation, in areas protected from floodwater by high dikes. Tens of thousands of sluice gates—which are shut during dry season to prevent saline intrusion—have disconnected the sea from inland waterways, resulting in slow-moving rivers without enough dissolved oxygen to support riverine fish.

Increasing pressure on groundwater. The growing pollution of surface water has caused an increase in groundwater extraction, especially for household purposes. According to the Ministry of Agriculture and Rural Development (MARD), 70-80 percent of the rural population relied on groundwater in 2019. The water table in all aquifers

has dropped since 1995. This increasingly causes land subsidence, particularly in the coastal areas of Ca Mau and Bac Lieu. A study by Utrecht University found that between 1991 and 2016, the delta's annual subsidence due to groundwater extraction was between one and 4.7 centimeters per year.

Drought and salinity intrusion. Seasonal salinity of surface water affects about half of the delta, to varying degrees. During the wet season, much of its water becomes freshwater. During the dry season, it becomes saline again. Salinity penetrates inland up to 20-65 kilometers from the shore, varying from year to year, through the branches of the Mekong and the openings of smaller river mouths and canals. In extremely dry years, salinization can damage crops in areas usually not affected, resulting in drinking-water shortages, increased extraction of groundwater, and higher salinity levels in aquaculture ponds, which give rise to additional costs for farmers. Recent changes in salt-water intrusion and flooding in the delta have resulted from both climate change and damage to the delta's natural systems. Current counter-measures, such as closing the barriers, has had many ecological and socio-economic consequences due to declining water quality, depleting fish stock and restricted river navigation.

Poverty and loss of culture. Rice intensification has failed to help the delta's population escape poverty. According to MARD[108], per capita income in the delta over the last decade has risen by less than the national average. Rice intensification has also changed the culture of the delta. Today, most village children do not even know how to swim—rivers and canals have become too contaminated by agricultural chemicals to bathe in[109]. People fishing on rivers and canals is no longer a common sight because fish stocks have dropped sharply. According to MARD, the delta is the only region of Vietnam with net out-migration. Struggling to earn an income from agriculture, young people leave the area in search of employment in nearby cities or overseas.

THE 'GOLDEN POLICY TRIO' SHIFTING TO A NATURE-BASED APPROACH

After the turn of the century, the government of Vietnam gradually came to realize that the policy of intensive rice cultivation, requiring massive water regulation infrastructure, is unsustainable and a course correction was needed to develop the delta in a more sustainable, climate-resilient way. The government started to diversify land use in the delta and promote a 'living with floods' approach in the inland provinces, seeing both freshwater and brackish waters as valuable resources.

This fundamental change in approach was catalyzed and supported by development partners through analytical studies and policy documents—notably the Mekong Delta Plan 2013, with a budget of around US$ 10 million, prepared with Dutch support—and investments, such as the Mekong Delta Climate Resilience and Sustainable Livelihoods Project, financed by the World Bank with an ongoing investment of US$ 387 million. It culminated in 2016 and 2017 with the government passing a 'golden policy trio' for the development of the Mekong Delta.

First came Decision 593 on coordinating activities for regional development across the provinces. Next the National Assembly passed a new Planning Law, which mandates a multidisciplinary, integrated approach to planning—a clear departure from the traditional sectoral and community-based approach, which often led to conflicts, overlapping efforts, unhealthy competition among provinces and sectors, and the fragmentation of natural systems.

Finally, the adoption of Resolution 120 enshrined the aim of sustainable and climate-resilient development in the delta, based on a comprehensive approach to building a more diverse, modern, and high-quality agricultural economy, in harmony with nature and using the 'no-regrets' principle—selecting actions and investments that are cost-effective under a range of future climate scenarios, and do not involve hard trade-offs with other policy objectives.

Resolution 120 defines the long-term vision as: 'A sustainable, safe and prosperous Mekong Delta, based on suitable development of high-quality agriculture products, combined with services, ecotourism and industries, focusing on manufacturing industry, enhancing the competitiveness of agriculture products; infrastructure network is coordinately planned, developed, modern in an active, smart way and adapting to climate change; ensuring safety under disaster; reasonable use of natural resources; biodiversity and cultural tradition is conserved and enhanced; human lives and spirit are improved.'

The government has identified five main building blocks for its new approach:

(i) Establishing ecological sub-regions and developing land-use plans and population systems that reflect each sub-region's natural characteristics

(ii) Developing an integrated master plan to guide the socio-economic development of the entire delta region

(iii) Building an economic structure anchored in aquaculture-horticulture-agriculture, green industries, and ecotourism

(iv) Ensuring regional coordination, connectivity, and an infrastructure product chain

(v) Promoting innovative mechanisms and policies to attract nonbudgetary capital resources, especially from the private sector.

Implementing this trio of policies has so far brought some accomplishments, but also challenges. The need to embed land and water use and spatial planning in development policies is widely recognized, but sectors and provinces continue to be targeted separately. This is partly because of continuing lack of awareness of the new development policy approach among sectoral and provincial planners, and partly because there is no institution at regional level responsible for coordinating development.

KEY LESSONS FOR DELTA MANAGEMENT

The experience of the Mekong Delta over the last few decades offers four key lessons for deltas around the world.

1. Think of the delta as a living organism. Rivers, canals, and other water bodies are like its veins—the transportation channels for nutrients and energy. The tides, seasons, and flood pulse drive a circular system in which natural fluctuations of water levels provide alternating moist and dry conditions for soil organisms to respire and function. Higher levels of dissolved oxygen in the water of flowing rivers and canals gives them a natural capacity for self-purification, which is essential for maintaining the aquatic ecosystem: to some extent, rivers and canals need to flow freely to maintain the health of a delta.

2. Look beyond the economic rationale for the delta's development. Ironically, the loss of sediments as a natural fertilizer and material for the natural delta building process, for example, may in fact boost GDP growth as it necessitates more application and sale of fertilizers and more construction of expensive embankments to combat increasing erosions. So using GDP as a sole indicator of the development of a delta is very unhealthy. The short-term boost given to the Mekong Delta's GDP by intensive rice cultivation also came at the cost of long-term depletion of soils and waters. Development policies must look beyond benefits to identify costs, which are often hidden or not evident right away, and spatially and temporally far-reaching.

3. Ensure integrated planning and regional coordination. Natural systems do not respect administrative boundaries, and the interests of sectors and communities can conflict. For example, in the Mekong Delta, sand mining in upstream provinces leads to coastal and riverbank erosion in downstream provinces. The regional coordination mechanism provided by Decision 593 is intended to avoid such unhealthy competition, while pooling resources and creating synergies among provinces. Establishing a regional institution with the decision-making power to coordinate policies and actions—backed by sound scientific advice—is a precondition for regional coordination. The newly established (mid 2020) Mekong Delta Regional Coordination Council is expected to play this critical role.

4. Apply the 'no-regrets' principle in the planning for adaptation to climate change. No-regret actions are the opposite of 'high-regret' actions, which: (i) are expensive and irreversible; (ii) make other future options unfeasible; (iii) have adverse impacts on other geographic locations and/or sectors; and (iv) may be beneficial in the short term but detrimental in the long run. The no-regrets principle makes sense because of the many uncertainties inherent in climate change—the further into the future projections are made, the higher the margin of error—and the potential for adaptation actions to have adverse effects that may not be immediately clear.

ENDNOTES

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33 This Program was approved by Res.432/20, APN-MAD 27/11/2020.

34 Administración de Parques Nacionales (2020)

35 Administración de Parques Nacionales (2020)

36 Administración de Parques Nacionales (2020)

37 PADAS: Support Program for the Development of Sustainable Activities in Rural Populations linked to the National Parks Administration´s Protected

Areas. At present, there are two actions running, in the Ciervo de los Pantanos National Park and in San Antonio Reserve, involving civil organizations and inhabitants.

38 Jongman and Prungetti, 2004.

39 Badano et. al, 2012.

40 The Dutch term 'polder' is used to designate areas that are enclosed on all sides by dikes or embankments, separating them hydrologically from the main river system and offering protection against tidal floods, salinity intrusion, and sedimentation. Polders are equipped by in- and outlets to control the water inside the embanked area

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