SYLVIE FANCHETTE*

DELTA VULNERABILITY LINKED TO CLIMATE AND ENVIRONMENTAL CHANGES: METROPOLIZATION CHALLENGES IN ASIAN AND NILE DELTAS

Deltas are low-lying social, political and environmental systems (SPES) characterized by the interplay between rivers, land and oceans and influenced by a combination of riverine and oceanic processes. They are shaped by human intervention in the form of strong water control management policies implemented by the state (Biggs et al. 2009; Fanchette 2006). The political dimension of SPES is central to understanding their dynamics and the settlement of a dense population in a vulnerable environment. They can have a population density ten times higher than the world average, as they offer a wide variety of natural resources (Wong et al. 2014), such as fertile land and water for irrigated and intensive agriculture, fisheries, abundant biodiversity and non-farm activities (Vorosmarty, Syvitski, and Paola 2009). Deltas and coastal areas are among the most dynamic places on earth in terms of urbanization and economic change (Government Office for Science 2011). They benefit from being strategic places for global trade and having high population densities that encourage industry development focusing on export. National economic reforms have restructured economies and increased international and domestic capital inflows to

* **Sylvie Fanchette** is a geographer and Director of Research at IRD (Institute of Research for Sustainable Development) in France.

delta areas, resulting in the development of world coastal zones. Delta megacities can be found in Asia – Shanghai, Guangdong, Jakarta, Bangkok, Ho Chi Minh City, Kolkata and Dhaka – and in Africa, including Cairo and Alexandria. Two-thirds of metropolises with more than five million inhabitants are located on the coast or in deltas. Approximately 500 million people live in delta areas, despite them representing less than 1 per cent of the earth's surface.

However, deltas are one of the most vulnerable coastal environments. They face a range of threats that climate change is exacerbating, and sea-level rise puts their coastal areas at stake. With sea-level rise and changes in river flows, deltaic cities are exposed to new challenges related to climate change as well as inadequate and short-term urban and hydraulic planning policies. There are contradictions between the growing awareness of the risks of climate-induced flooding in resilient-city plans and the continuation of development practices widely acknowledged to exacerbate those risks (Weinstein, Rumbach, and Sinha 2019). Thus, cities in deltas face a double danger in terms of adverse impacts of climate change: they are a uniquely vulnerable environment and are affected by urban-led development driven by the coastalization of the economy and the increase in population due to migration. Projections warn of dramatic increases in populations prone to chronic flooding and of the potential permanent inundation of densely populated urban areas (Hanson et al. 2011).

In this chapter, I will investigate the contradiction between the growing awareness of risks induced by climate change and the unsustainability of urban management and development policies driven by land and global capital accumulation. I will also highlight the unsuitability of the majority of adaptation policies implemented at global and national levels to mitigate the impact of flooding, increasing the vulnerability of deltaic cities.

DELTAS ARE LARGE ECONOMIC HUBS AND RICE BOWLS

Deltas are among the most populated plains in the Global South, especially in monsoon Asia and Egypt. Asia is home to the world's largest and most populated deltas, created by the sediment deposited by mighty rivers descending from the Himalayas. They are considered the 'rice bowls' of monsoon Asia: the Mekong Delta, for example,

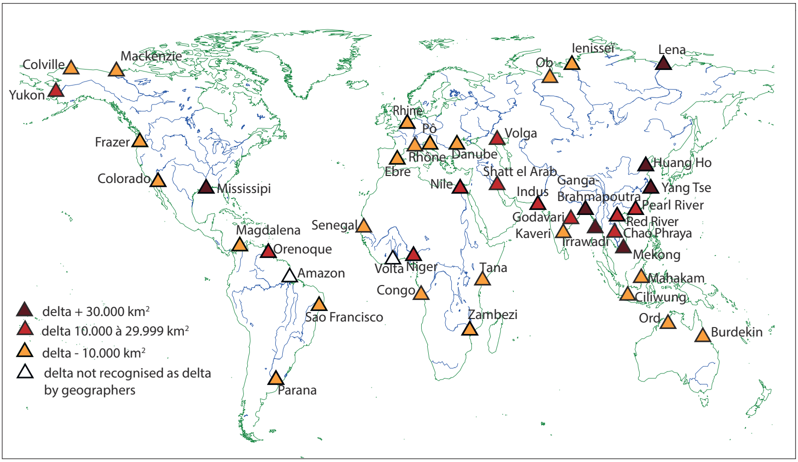


Figure 1. Locations of large and medium deltas in the world. Source: Figure by Sylvie Fanchette.

produces over 50 per cent of Vietnam's food resources. The Ganges Brahmaputra Meghna Delta, commonly called the Bengal Delta, is the largest in the world, shared between Bangladesh and West Bengal in India and hosting 250 million people. Egypt's Nile Delta is medium-sized, although the Nile is the longest river in the world. The population densities in this delta amount to more than 1,600 inhabitants per square kilometre, while the Asian deltas have a density of between 500 and 1,000 inhabitants per square kilometre.

Deltas have played an essential role in human history, serving as cradles of civilization, testing grounds for early agriculture and the birthplace of hydraulic engineering. They therefore offer many opportunities for settlement and economic development. The alluvial deposits brought by their rivers nourish their flat lands, and irrigation is largely developed thanks to a dense hydraulic network and a nearby groundwater table. These lands can bear three cereal crops annually. These outstanding agronomic qualities continually shape these regions, renewing the fertility of the soil each year. The contact between the fresh water of the river, rich in nutritious elements, and the salt water of the sea leads to an abundance of fish and seafood. Deltas have many advantages for artificial irrigation by gravity, thanks to their flat topography, and thus for agricultural intensification, especially in arid regions like the Nile Delta. Similarly, the shallow water table prevents the clay soil from drying out and allows easy access to groundwater for human consumption and irrigation.

In addition, deltas' position on the great maritime routes integrated them into world trade networks early on (Kaida 2000), which has boosted the economic development of many cities. The dense water system canals facilitated exchanges between cities and the countryside and relationships with the upstream valley. From the beginning, Alexandria was envisioned to be the largest harbour in the Mediterranean region. Delta cities are therefore in a favourable position for sea and river trade, despite the difficulty of developing the sites and protecting their extensions from flooding risks. Indeed, many cities were created on levees, such as Phnom Penh, or rocky spurs, such as Alexandria, and require the construction of polders to expand, which are created by building dykes and filling in low-lying land (Pierdet 2012).

INCREASING VULNERABILITY LINKED TO CLIMATE CHANGE AND UNSUSTAINABLE POLICIES

Deltas are recognized as one of the most vulnerable coastal environments. They face a range of threats operating at multiple scales, from global climate change and sea-level rise to various hazards (floods, erosion, salinization, subsidence), local anthropogenic activities and land-use change. Twenty-four out of thirty-three deltas studied globally are sinking, and 85 per cent have experienced severe flooding during the last decade (Syvitski et al. 2009). They are sinking in part because they are sedimentarily unstable but primarily because pumping groundwater for agriculture, fish farming and urban and industrial areas creates a vacuum. With climate change, the frequency and intensity of these hazards are increasing and are less and less predictable. More than ten million people annually experience flooding due to storm surges alone, and most of these people live in Asian deltas.

MARITIME FLOODING

Maritime flooding has multiple combined causes: the adverse secondary effects of hydraulic developments (dams, dykes, water control) on the reduction of sedimentation, the variation of floods in low-lying

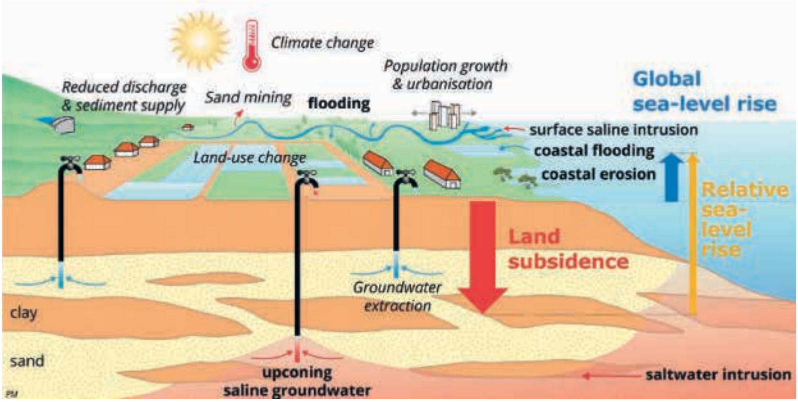


Figure 2. Changes (italic) and consequences (bold) in modern urbanizing deltas. Relative sea-level rise is the combined effect of global sea-level rise and land subsidence. Source: Minderhoud (2019). © CC BY-NC-ND 4.0, no changes made.

areas and the subsidence of deltas. In addition to trapping alluvial deposits, dams reduce riverine inputs to the oceans, weaken deltas in the face of maritime dynamics, jeopardize the fragile alluvial balance at the scale of the plain and the deltaic front and increase coastal and river erosion in addition to saline water intrusion. Soil and water salinization puts agriculture development in the lower deltas at risk. Deltas of extensively dammed rivers are shrinking.

In cities, flooding problems are exacerbated by the paving of land and industrial sprawl at the expense of agricultural areas. This affects the permeability of the soil and its capacity to store and drain water. Similarly, mangroves, site of rich biodiversity where marine and river waters meet, protect coastlines from maritime erosion and form a natural barrier against the effects of swells and storms. With the development of aquaculture and shrimp farming for export as well as beach tourism and deforestation, mangroves are disappearing, threatening the biodiversity of coastal areas. The 2004 tsunami in Thailand caused severe damage mainly because mangroves had disappeared to make way for mass beach tourism.

COASTAL NILE DELTA AT RISK BECAUSE OF SEA-LEVEL RISE AND URBAN MANAGEMENT POLICIES

Egypt is predicted to be one of the top five countries most impacted by climate change. The coastal zone of the Nile Delta is undergoing severe erosion caused by human intervention and non-adapted management. The construction of the Aswan High Dam in 1964 seriously impacted the Nile Delta due to the changed load of water and sediment flow. Today, it is experiencing a high rate of erosion and saline water intrusion. The water mass of the coastal area lagoons has significantly decreased, with a loss of approximately 4,883 square kilometres over twenty-five years, mainly because of the excessive enlargement of fish farms and other aquaculture activities. Other areas were drained and reclaimed for agricultural development. Shoreline erosion along the Nile Delta ranges from ten to twenty-one metres per year, depending on location, time and methodology. The rate of erosion in Alexandria is nearly thirteen metres per year (Ali and El-Magd 2016). This coastal instability is not new. In the seventh and eighth centuries, several cities surrounding the western Nile's Canopic branch – including Canope, Menouthis, Thônis and Heraklion – played an essential role in trade, religious events and leisure. They disappeared beneath the sea due to a series of earthquakes and tidal waves (Goddio and Fabre 2007).

Recent surveys show that the northern delta region is subsiding at a rate ranging from about two millimetres per year in Alexandria to about two-and-a-half millimetres per year in Port Said. The Bay of Aboukir is sinking five to seven millimetres per year. Between 1974 and 2006, the mean sea level in Alexandria increased by 8.09 centimetres, which means a sea-level rise of 2.45 millimetres per year. Coastal flooding will occur with increasing frequency. Thus, urban coastal structures are at considerable risk (Hendy et al. 2021). In absolute terms, Alexandria, Port Said and Edku have the largest built-up areas susceptible to inundation by sea-level rise (Abdrabo and Hassaan 2015).

The proposed extreme Intergovernmental Panel on Climate Change (IPCC) sea-level rise scenario of fifty-nine centimetres coupled with the estimated land subsidence of an average of twenty-five centimetres by this century leads to an estimated sea-level rise of eighty-four centimetres by the year 2100. In this scenario, a large area of the Nile Delta (approximately 2,671 square kilometres) would be inundated, which means that 10 per cent of the entire area would be directly vulnerable to inundation and saltwater intrusion. This would affect the coastal Nile Delta environment and marine life and force millions of inhabitants to migrate from their homes to save their livelihoods (Ali and El-Magd 2016).

RIVER FLOODING: METROPOLISES AT RISK

Since the early 2000s, natural disasters related to river flooding have intensified in low-lying coastal areas. River flooding combined with cyclones and tide-induced sea flooding severely affects deltas. During monsoon rains in tropical valleys, the flow of river water to the sea slows down and the river overflows. The draining of rainwater is challenging because of the many obstacles erected in its way (roads, buildings and so on). Changes in land use, from flooded or irrigated rice fields to paved and impermeable land, limits the natural drainage of rainwater.

These trends will only increase, placing more people and assets at risk as sea levels rise in large metropolises and their precarious neighbourhoods are located in flood-prone areas. Some deltas, such as the Indus Delta in Pakistan, have reached a tipping point. Tipping points are defined as reaching the Anthropocene 'collapse', in which society is no longer capable of protecting (part of) a delta because of uncontrolled or unmitigated forces, including the social, political and ecological forces which are part of the SPES (Renaud et al. 2013).

UNSUSTAINABLE DEVELOPMENT OF DELTAIC CITIES AND ENVIRONMENTALLY DESTRUCTIVE PRACTICES

Until the colonial era, the great old port cities of Europe and Asia were protected from the open sea by bays, estuaries or deltaic river systems. 'It is as if, before the early modern era, there had existed a general acceptance that provision had to be made for the unpredictable furies of the ocean – tsunamis, storm surges, and the like' (Ghosh 2016, 37). After the seventeenth century, colonial cities were erected on seafronts around the world. These cities, all brought into being by colonization, are now among those most directly threatened by climate change (Ghosh 2016, 37).

Export-led industries are developing near large harbours, increasing the process of coastalization of the economies and fuelling the migration of workers from remote areas. Thus, the number of people and assets affected by floods related to globalization and climate change is increasing, as is their exposure to these risks.

Deltaic metropolises expand rapidly, taking environmentally unsustainable land-use planning paths. They represent an extraordinary and unique 'concentration of risk' (Ghosh 2016). The floods in Thailand's Chao Phraya Delta in 2011 showed the fragility of the country's economy, which is concentrated in the Bangkok metropolitan area that at the time housed 75 per cent of the country's urban population and produced 50 per cent of its GDP (Pierdet 2012). The impacts of climate change are likely to be more harmful in urban areas, since the latter are exposed to additional risks linked to increasing socio-economic disparities (social and spatial fragmentation, growing inequality, land pressure in the city centre, urban sprawl, multiplication of informal neighbourhoods relegated to the outskirts or areas at risk, etc.). These factors certainly increase the physical but above all the social vulnerability of delta regions, which is likely to be further exacerbated by climate change (Quenault 2013).

The expansion of cities into their low-lying margins adds to the risk of flooding and poses many problems:

- A dense hydraulic network for field irrigation criss-crosses cities' peripheries. Urban expansion necessitates a redesign of this hydraulic system as agricultural land becomes building land: polders have to be created, which are dammed and filled in with a drainage system made of canals, locks and pumping stations.
- Towns and villages extend into fields and rural outskirts, and the construction of large motorways is carried out with a great deal of embankment but at the cost of flooding the villages. These constructions constitute obstacles to water flow when the basin is exposed to flooding, and the water stagnates for weeks (Bravard 2019).
- The risk of floods increases in 'sinking' deltaic cities.

Delta cities are subject to many development challenges, and subsidence is one of the most pressing. Land subsidence has several causes, including natural compaction of soil and compaction caused by buildings and infrastructure. However, the main driver in many cities is groundwater extraction for use by households and industry (Ward et al. 2011).

Competition for water between industries and growing household demand is intense, and groundwater supply appears to be an easy solution. The water distribution system is sometimes old and not well adapted to the growing demand of new neighbourhoods. Installing pipe-water distribution systems is expensive and raises the question of the fate/destiny of unregistered land that local governments do not want to develop.[1] In parts of Bangkok, land subsidence rates have reached up to ten centimetres annually, while in Jakarta, figures as high as twenty-six centimetres per year were recorded in parts of the city (Abidin et al. 2011). The adverse effects of coastal cities' subsidence are numerous: faster relative sea-level rise due to the sinking of the coast, difficulty in evacuating drainage water, damage of distribution and traffic networks and the destruction of buildings and assets.

Several disasters have struck in this century as a result of these issues: in 2011, catastrophic floods occurred in and around Bangkok following five to six months of intense rainfall. In Jakarta, floods caused by heavy rains and the destruction of dykes in 2007 displaced more than half a million people and closed many roads, railways, motorways, telephone lines and the international airport, paralysing the region (Texier, Lavigne, and Fort 2010).

URBAN RISK ASSESSMENT PLANS AND THEIR IMPLEMENTATION

Numerous coastal metropolises have implemented plans to better respond and adapt to hazards, including those induced by climate change. The World Bank and other international organization help governments implement urban risk assessments and climate-friendly city plans (Dickson et al. 2022). The 100 Resilient Cities project, pioneered by the Rockefeller Foundation, 'help[s] more cities build resilience to the physical, social, and economic challenges that are a growing part of the 21st century' (Rockefeller Foundation n.d.). However, while these plans acknowledge a city's climate-induced challenges, they still focus on development-driven economic growth. These practices exacerbate floods and flood losses, facilitated by increasing land consumption

1. In Jakarta, more than 3,700 deep wells have been drilled by residents in most low- and moderate-income settlements (Shatkin 2019).

(Weinstein, Rumbach, and Sinha 2019). Thus, as mentioned in the introduction, there are contradictions between the growing awareness of climate-induced flooding risks in resilience plans and the continuation of development practices widely acknowledged to exacerbate those risks (Weinstein, Rumbach, and Sinha 2019).

In Kolkata's Bengal Delta region, the city and regional governments have produced several plans aimed at helping the city mitigate flooding and adapt to future environmental change. Despite their acknowledgement of the ecologically harmful impacts of current development practices in low-lying and ecologically sensitive areas, these governments demonstrate continued support for real estate-led development. Weinstein, Rumbach and Sinha (2019) highlight three factors:

- Most new construction happens outside of official planning documents, for elites as well as for the poor, and laws are routinely suspended to further elite interests.
- City officials appear more focused on 'less fancy' but 'more urgent' issues than flood risk reduction, such as housing and real estate development.
- Cities may adopt the language of 'resilience' in high-level plans and strategy statements, but their own approach to climate resilience is deeply invested in and directed by a real-estate-driven economic growth model.

Finally, large development projects such as fish farms are not sustainable, neither environmentally nor socially. However, aquaculture has strongly developed in Nile Delta coast to meet the growing demand for seafood and animal protein. Between 1990 and 2014, the region's fish farming area expanded from 81 square kilometres to 937 square kilometres, at the expense of water bodies and coastal dunes. The Nile Delta coast was initially occupied by a strip of dunes and land forms that separated the Mediterranean Sea from the inland of the Nile Delta. They played a role in maintaining the ecological balance and worked as an intermediate shelter zone between marine and terrestrial environments (Ali and El-Magd 2016). Moreover, large projects and highly industrialized farms are managed by foreign companies and provide few jobs locally, leading to the emigration of the local population due to a lack of jobs. These projects are also unsustainable because they erase very fertile land and pump up groundwater (depleting the table); thus, they increase the subsidence of coastal areas.

HOW DELTAIC CITIES CAN ADAPT OR MALADAPT TO ENVIRONMENTAL CHANGES LINKED TO CLIMATE CHANGE

Deltas are dynamic systems where communities have a long record of adapting to natural hazards, living with floods and becoming accustomed to being highly exposed to environmental risks. In Asia, states and international agencies have strongly invested in water management to protect the population and territory from multiple dangers (floods and storm surges) by building hard technological infrastructure (dams, dykes, polders) and setting up early warning systems. For centuries these populations have developed a range of strategies and practices.

Cities currently face the double challenge of mitigating their high greenhouse gas (GHG) emissions and developing adaptive measures. Deltaic societies and their systems of governance and organization have extensive experience in anticipating risks such as floods and cyclones and coping with and adapting to risk. Nevertheless, climate change, along with other drivers of global economic change, poses novel risks often beyond their range of experience (Klein et al. 2014). Moreover, their resilience to ongoing environmental climate change is challenged by increased socio-economic inequalities, the asymmetry of power in these societies and their inability to respond to external stresses (Adger, Safra de Campos, and Mortreux 2018).

Potential measures to help deltaic communities and their environments adapt to the impacts of climate change, especially in cities, are multiple and can be technical and physical, social and organizational. They essentially depend on states' wealth and their modes of governance (democratic or authoritarian), the role and power of their civil society and their historical experience and assessment of risk. Various types of adaptation strategies are implemented at several levels and can be combined. They highlight the importance of local governance and community involvement and participation.

- Hard-engineering protective measures are most commonly used to reduce coastal flooding and erosion, as seen with the construction of sea walls on the Nile Delta coastline, projects to dam up bays in Jakarta's great Garuda Project or polders, as used in Dhaka and Phnom Penh. These measures have raised contentious questions about their high cost, effectiveness, ecological effects and social impacts on communities residing along the coast. Also, hard protection is not an affordable long-term solution for most countries in the Global South (Haasnoot, Lawrence, and Magnan 2021). Many experts are sceptical about attempts to reduce risk by hazard control alone (Tabet and Fanning 2012; Weinstein, Rumbach, and Sinha 2019; Du et al. 2020). Dykes give a false sense of control and security and increase the potential exposure of the many people living nearby. In the Nile Delta, despite the availability of a wide range of alternatives to deal with the retreating shoreline, only 'hard' adaptation options – such as the construction of breakwaters, dykes and jetties – have been used to control shoreline erosion (Abdrabo and Hassaan 2015). Even though the coastal erosion of the Nile Delta persisted with this infrastructure in place (Ali and El-Magd 2016), the Green Climate Fund (GCF) continues to implement hard-engineering options. Sixty-nine kilometres of sand dune dykes will be installed in five vulnerable hotspots within the Nile Delta.

- Combining hard-engineering measures with nature-based solutions, spatial planning and early-warning systems can help contain residual risk (Du et al. 2020). Nevertheless, there are limits to this strategy in terms of its environmental impacts and costs and the availability of potential and permitted sand reserves, which may be unable to keep up with higher rates of sea-level rise.
- Which adjustments communities implement is determined in part by their ability to act collectively, their social capital, their knowledge of the risks involved, their vulnerability (social, economic, environmental) and the policy of adaptation implemented by local or national authorities. In deltas, famers adapt their cropping pattern to floods and salinity intrusion by diversifying, mixing aquaculture and rice. This is done in parallel with water management and disaster risk management. With the help of NGOs and associations, communities and local authorities have initiated early-warning systems as well as micro-credit and micro-insurance systems.

Environmental migration is one of the structuring elements of deltaic SPES. Given that the delta settlement process has involved land reclamation and water control for thousands of years, combined with the population's high vulnerability to various types of floods and hazards, mobility has become systematic for many delta residents. Migration can be considered one of many interrelated adaptation strategies for affected populations. However, the latter rely on translocal networks and practices across multiple places within and beyond deltas.

- Accommodation measures include the elevation or flood-proofing of houses and other infrastructure, spatial planning, amphibious building designs following a *sponge city* pattern, increasing water storage or drainage capacity and slum upgrading. Raising land or buildings (on stilts) could avert flooding and be accomplished artificially. At a medium scale, a government may implement nature-based interventions through river diversion (Haasnoot, Lawrence, and Magnan 2021).
- Among the many adverse impacts of climate change in the most vulnerable countries, climate-change-induced displacement caused by extreme weather events is an increasingly serious concern, particularly in densely populated Asian countries (Alam et al. 2018). Bangladesh is the most vulnerable: 4.1 million people were displaced as a result of climate disasters in 2019 (2.5 per cent of the population) (Khan et al. 2021). Retreat is a strategy to reduce exposure and eventually the risks facing coastal cities by moving people, assets and activities out of coastal hazard zones. It includes adaptive migration, involuntary displacement and the planned relocation of populations and assets from the coast. However, implementing a managed retreat constitutes a multidecadal sequence of actions, including community engagement, a vulnerability assessment, land-use planning, active retreat, compensation and repurposing (Haasnoot, Lawrence, and Magnan 2021). Building climate-resilient, migrant-friendly cities and towns in Bangladesh has become an urgent need to tackle the adverse effects of climate change. Infrastructure which can not only absorb shocks but also attract rural populations by providing services and livelihood opportunities will ease the population pressure on major cities (Khan et al. 2021).

ADAPTATION GOVERNANCE CHANGES: THE CASE OF EGYPT

'An array of climatic and non-climatic perils … present coastal communities and their governing authorities with immense governance and institutional challenges that will become progressively more difficult as sea level rises [sic]' (Glavovic et al. 2022, 2177). In order to overcome these challenges, various countries highly impacted by climate change have been implementing projects and plans with the support of international agencies for the last one or two decades. The GCF collects USD 100 billion a year from Western countries with a high historical level of GHG emissions. In Egypt, this fund is co-financing a project with the United Nations Development Programme (UNDP) called 'Enhancing climate change adaptation in the North Coast and Nile Delta Regions in Egypt 2018–2025'. The USD 100 million project aims to reduce coastal flooding risks on Egypt's north coast and finance hard-engineering defences. An integrated coastal zone management (ICZM) plan has been developed for the entire north coast to manage long-term climate change risks and provide Egypt with adaptability to impending flood risks (Green Climate Fund n.d.). However, the institutional context of the Nile Delta's coastal urban areas suffers from several shortcomings. A lack of vertical and horizontal integration reveals gaps between and conflicting positions of governing bodies and affects the proper development of the plan. The mode of governance of these government bodies is characterized by centralization and limited participatory practices (Tabet and Fanning 2012).

In addition, the government developed a National Strategy for Adaptation to Climate Change and Disaster Risk Reduction in 2015, which proposes actions to increase the population's resilience and enhancing community participation at all levels. However, the plan does not propose any specific measures to be adopted. The current institutional setting and coastal zone governance mechanisms involve limited institutional contributions to urban resilience in the Nile Delta (Abdrabo and Hassaan 2015). According to the last IPCC report (Glavovic et al. 2022), few infrastructural or adaptation plans for urban areas are being developed through consultation and co-production with diverse and marginalized urban communities.

Finally, unlike monsoon cities, Alexandria does not suffer from regular floods. However, in 2015, severe rainfall events caused flooding in the city and its neighbouring region, leading to casualties. Activities stopped for two weeks, leading to EUR 25 million in damages (IHE 2017). A project called Anticipatory Flood Risk Management (AFMA) was set up with the help of the Netherlands in order to understand the flood risk facing Egyptian cities and the possibility of an increase in the frequency of events. It aims to better prepare the region for extreme rainfall events, creating a design for the exceedance of urban drainage systems (IHE 2017).

The different adaptation strategies presented above can be combined in different contexts. However, they would benefit from citizen participation, drawing on local knowledge of adaptation to risk, from a socio-economic vulnerability assessment of the population exposed to these hazards and from an assessment of the population's and local stakeholders' perception of risk. 'Bottom-up' insights are more accurate than options that are deterministic and one-size-fits-all and encourage binary 'migrate or not' decisions (Horton et al. 2021). Thus, these strategies should not rely on climate risk assessments based on top-down approaches and international assumptions.

CONCLUSION

Most large metropolises built during the colonial era are located on coasts. As stated, deltas and coastal areas are among the most dynamic places on earth regarding urbanization and economic change. They benefit from strategically appealing locations in terms of global trade and high population densities for industry development. However, they are at the forefront of climate change and sea-level rise and represent an extraordinary and unique concentration of risk. They are increasingly exposed to floods linked to environmentally unsustainable land-use planning, urban sprawl on low-lying land and climate-change-related adverse impacts.

Thus, governments must overcome the double challenge of mitigating their GHG emissions and developing adaptive measures to deal with the adverse impacts of climate change. The implementation of these measures depends on states' wealth and their modes of governance, the role and power of civil society and their historical experience and assessment of risk.

In order to better adapt strategies to existing needs, countries are initiating climate risk assessments usually based on 'top-down' approaches. They privilege strategies based on physical sciences over understandings of local vulnerability and adaptive capacity informed by the social sciences. So far, adaptation solutions have been technical as opposed to nature- or accommodation-based. However, hard protection is not an affordable long-term solution for most countries of the Global South and it fails to address many technical, environmental and social problems affecting coastal communities. Governance adapted to the local and environmental context is a key solution.

REFERENCES

Abdrabo, Mohamed A., and Mahmoud A. Hassaan. 2015. 'An Integrated Framework for Urban Resilience to Climate Change – Case Study: Sea Level Rise Impacts on the Nile Delta Coastal Urban Areas'. *Urban Climate* 14, no. 4: 555–65.

Abidin, Hasanuddin Z., Andreas Heri, Irwan Gumilar, Yoichi Fukuda, Yusuf E. Pohan, and T. Deguchi. 2011. 'Land Subsidence of Jakarta (Indonesia) and Its Relation with Urban Development'. *Natural Hazards* 59, no. 3: 1753–71.

Adger, W. Neil, Ricardo Safra de Campos, and Colette Mortreux. 2018. 'Mobility, Displacement and Migration, and Their Interactions with Vulnerability and Adaptation to Environmental Risks'. In *Routledge Handbook of Environmental Displacement and Migration*, edited by Robert McLeman and François Gemenne, 29–41. London: Routledge.

Alam, Sarder S., Saleemul Huq, Faisal Bin Islam, and Hasan M. Hoque. 2018. *Building Climate-Resilient, Migrant-Friendly Cities and Towns. Policy brief*, International Centre for Climate Change and Development, July. https://www.icccad.net/wp-content/uploads/2018/10/Policy-Brief-on-Climate-Migration-and-Cities.pdf.

Ali, Elham M., and Islam A. El-Magd. 2016. 'Impact of Human Interventions and Coastal Processes along the Nile Delta Coast, Egypt during the Past Twenty-Five Years'. *Egyptian Journal of Aquatic Research* 42, no. 1: 1–10.

Biggs, David, Fiona Miller, Chu Thai Hoang, and François Molle. 2009. 'The Delta Machine: Water Management in the Vietnamese Mekong Delta in Historical and Contemporary Perspectives'. In *Contested Waterscapes in the Mekong Region. Hydropower, Livelihoods and Governance*, edited by François Molle, Tira Foran, and Mira Käkönen, 203–25. London: Earthscan.

Bravard, Jean-Paul 2019. *Crises sédimentaires du globe 2: Deltas, une crise environnementale majeure*. London: ISTE.

Dickson, Eric, Judy L. Baker, Daniel Hoornweg, and Asmita Tiwari. 2022. *Urban Risk Assessments: Understanding Disaster and Climate Risk in Cities.* Washington, DC: World Bank. https://documents1.worldbank.org/curated/en/659161468182066104/pdf/709820PUB0EPI0067926B09780821389621.pdf.

Du, Shiqiang, Paolo Scussolini, Philip J. Ward, Min Zhang, Jiahong Wen, Luyang Wang, Elco Koks, Andres Diaz-Loaiza, Jun Gao, Qian Ke, and Jeroen C. Aerts. 2020. 'Hard or Soft Flood Adaptation? Advantages of a Hybrid Strategy for Shanghai'. *Global Environmental Change* 61: 102037.

Fanchette Sylvie. 2006. 'De l'importance des liens géographie-physique/géographie humaine pour comprendre les risques de submersion des deltas très peuplés'. *Hérodote* 121: 6–18.

Ghosh, Amitav. 2016. *The Great Derangement. Climate Change and the Unthinkable*. Chicago: University of Chicago Press.

Glavovic, Bruce C., Richard Dawson, Winston Chow, Marjolijn Haasnoot, Chandni Singh, and Adelle Thomas. 2022. 'Cross-Chapter Paper 2: Cities and Settlements by the Sea'. In *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 2163–94. Cambridge: Cambridge University Press.

Goddio, Franck, and David Fabre, eds. 2007. *Trésors engloutis d'Égypte*. Paris: Seuil.

Government Office for Science. 2011. *Foresight: Migration and Global Environmental Change*. Final Project Report. London: Government Office for Science.

Green Climate Fund. n.d. 'FP053: Enhancing Climate Change Adaptation in the North Coast and Nile Delta Regions in Egypt'. https://www.greenclimate.fund/project/fp053.

Haasnoot, Marjolijn, Judy Lawrence, and Alexandre K. Magnan. 2021. 'Pathways to Coastal Retreat. The Shrinking Solution Space for Adaptation Calls for Long-Term Dynamic Planning Starting Now'. *Science* 372, no. 6548: 1287–90.

Hanson, Susan, Robert Nicholls, N. Ranger, S. Hallegatte, J. Corfee-Morlot, C. Herweijer, and J. Chateau. 2011. 'A Global Ranking of Port Cities with High Exposure to Climate Extremes'. *Climatic Change* 104: 89–111.

Hendy, Dina M., Tarek M. El-Geziry, Mohamed El Raey, and Samir M. Nasr. 2021. 'Sea Level Characteristics and Extremes along Alexandria Coastal Zone'. *Arabian Journal of Geosciences* 14: 1273.

Horton, Radley M., Alex de Sherbini, David Wrathall, and Michael Oppenheimer. 2021. 'Assessing Human Habitability and Migration: Integrate Global Top-Down and Local Bottom-Up Analyses'. *Science* 372, no. 6548: 1279–83.

IHE. 2017. 'Improving Flood Resilience in Egypt'. Press release, July 11. https://www.un-ihe.org/news/improving-flood-resilience-alexandria-egypt.

Kaida, Yoshiro. 2000. 'Agrarian versus Mercantile Deltas: Characterizing the Chao Phraya Delta in the Six Great Deltas in Monsoon Asia'. In *Thailand's Rice Bowl: Perspectives on Agricultural and Social Change in the Chao Phraya Delta,* edited by François Molle and Thippawal Srijantr, Chapter 15. Bangkok: Kasetsart University.

Khan, Mizan R., Saleemul Huq, Adeeba N. Risha, and Sarder S. Alam. 2021. 'High-Density Population and Displacement in Bangladesh'. *Science* 372, no. 6548: 1290–93.

Klein, Richard J., Guy F. Midgley, Benjamin L. Preston, Mozaharul Alam, Frans G. Berkhout Kirstin Dow, and M. Rebecca Shaw. 2014. 'Adaptation Opportunities, Constraints, and Limits'. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 899–943. Cambridge: Cambridge University Press.

Minderhoud, Philip S. 2019. *The Sinking Mega-Delta: Present and Future Subsidence of the Vietnamese Mekong Delta*. PhD diss., Utrecht University. https://dspace.library.uu.nl/handle/1874/375843.

Pierdet, Cécile. 2012. 'La résilience comparée de Phnom Penh (Cambodge) et Bangkok (Thaïlande) face aux crises hydrauliques'. *Climatologie* 9: S83–S108.

Quenault, Béatrice. 2013. 'Retour critique sur la mobilisation du concept de résilience en lien avec l'adaptation des systèmes urbains au changement climatique'. *EchoGéo* 24: 1–22.

Renaud, Fabrice G., James P. Syvitski, Zita Sebesvari, Saskia E. Werners, Hartwig Kremer, Claudia Kuenzer, Ramachandran Ramesh, Ad Jeuken, and Jana Friedrich. 2013. 'Tipping from the Holocene to the Anthropocene: How Threatened Are Major World Deltas?', *Current Opinion in Environmental Sustainability* 5, no. 6: 644–54.

Rockefeller Foundation. n.d. '100 Resilient Cities'. https://www.rockefellerfoundation.org/100-resilient-cities/.

Shatkin, Gavin. 2019. 'Futures of Crisis, Futures of Urban Political Theory. Flooding in Asian Coastal Megacities'. *International Journal of Urban and Regional Research* 43, no. 2: 208–26.

Syvitski, James P., Albert J. Kettner, Irina Overeem, Eric W. Hutton, Mark T. Hannon, G. Robert Brakenridge, John Day, et al. 2009. 'Sinking Deltas due to Human Activities'. *Nature Geoscience* 2: 681–86.

Tabet, Laura, and Lucia Fanning. 2012. 'Integrated Coastal Zone Management under Authoritarian Rule: An Evaluation Framework of Coastal Governance in Egypt'. *Ocean and Coastal Management* 61: 1–9.

Texier, Pauline, Franck Lavigne, and Monique Fort. 2010. 'Réduction des risques d'inondation à Jakarta: De la nécessaire intégration d'une approche sociale et communautaire dans la réduction des risques de catastrophes'. *Bulletin de l'Association des géographes français* 87, no. 4: 551–70.

Vorosmarty, Charles, James Syvitski, and Chris Paola. 2009. 'Battling to Save the World's River Deltas'. *Bulletin of the Atomic Scientists* 65, no. 2: 31–43.

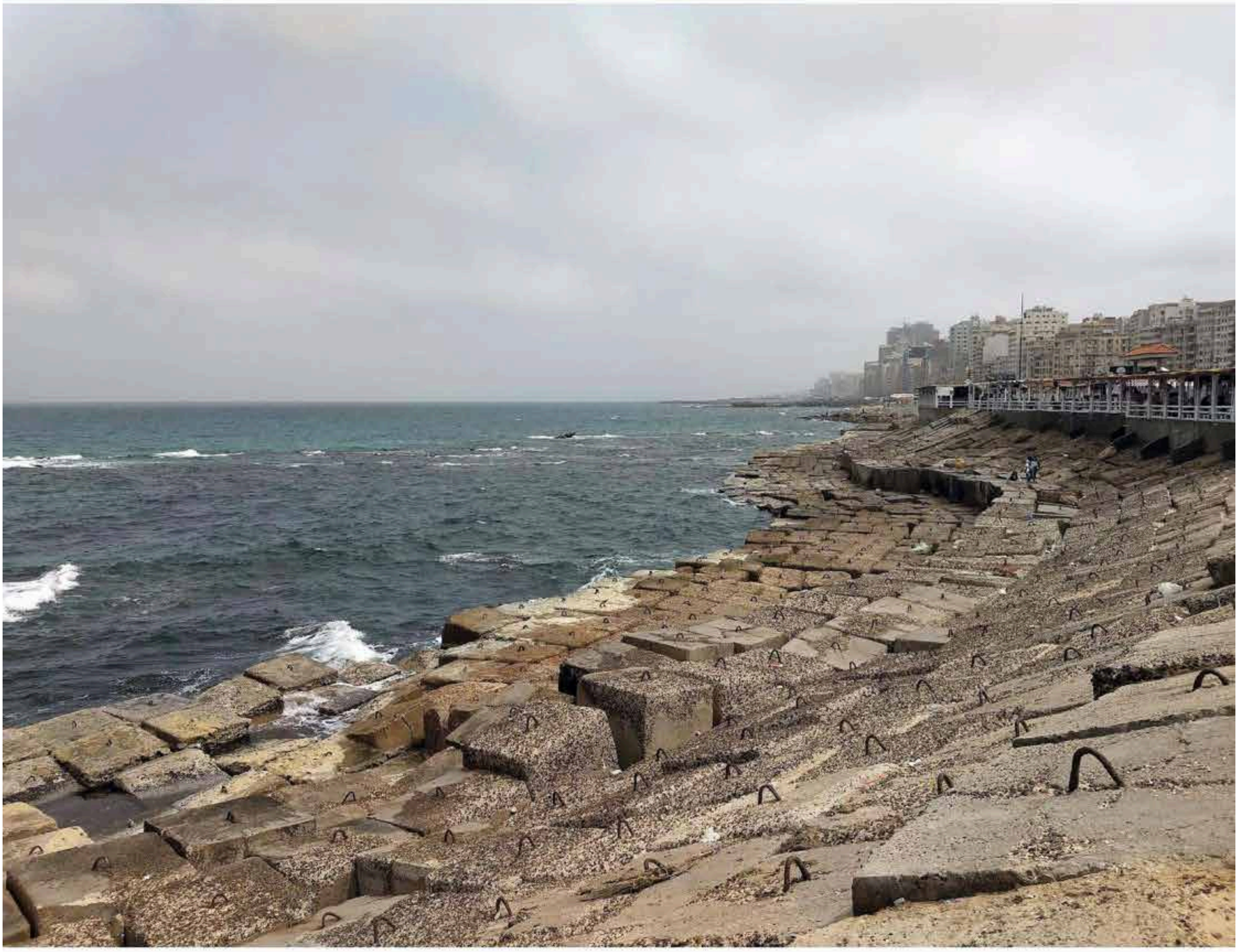
Ward, Philip J., Muh A. Marfai, Fajar Yulianto, Dyah Hizbaron, and J. C. Aerts. 2011. 'Coastal Inundation and Damage Exposure Estimation: A Case Study for Jakarta'. *Natural Hazards* 56, no. 3: 899–916.

Weinstein, Liza, Andrew Rumbach, and Saumitra Sinha. 2019. 'Resilient Growth: Fantasy Plans and Unplanned Developments in India's Flood-Prone Coastal Cities'. *International Journal of Urban and Regional Research* 43, no. 2: 273–91.

Wong, Poh Poh, Iñigo J. Losada, Jean-Pierre Gattuso, Jochen Hinkel, Abdellatif Khattabi, Kathleen L. McInnes, Yoshiki Saito, and Asbury Sallenger. 2014. 'Coastal Systems and Low-Lying Areas'. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, 361–409. Cambridge: Cambridge University Press.

edited by Agnès Deboulet
and Waleed Mansour

MIDDLE EASTERN CITIES IN A TIME OF CLIMATE CRISIS



DOSSIERS DU CEDEJ

DOSSIERS DU CEDEJ

MIDDLE EASTERN CITIES IN A TIME OF CLIMATE CRISIS

Edited by Agnès Deboulet
and Waleed Mansour

FRIEDRICH EBERT STIFTUNG

Book editors
Agnès Deboulet
Waleed Mansour

Copyediting
Marieke Krijnen
Taylor McConnell

Graphic design
Fatiha Bouzidi

Cover image
Florian Bonnefoi

Editors and supports
Friedrich-Ebert-Stiftung Egypt
CEDEJ

With the support of the Institut national des sciences humaines et sociales (InSHS) of the Centre national de la recherche scientifique (CNRS)

Publication directors
Pascal Menoret
Richard Probst

The Centre for Economic, Legal and Social Study and Documentation (CEDEJ) is a multidisciplinary research centre in social and human sciences whose works deal with contemporary Egypt and Sudan. The CEDEJ is under the administrative supervision of the CNRS (USR 3123) and the French Ministry for Europe and Foreign Affairs.

Dossiers du CEDEJ, Cairo, 2022
ISBN: 978-2-900956-08-3

www.cedej-eg.org