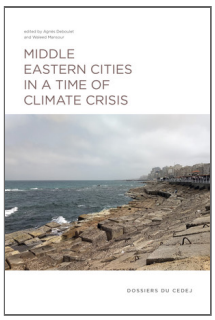

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Adapting to Climate Change: For a Social Approach to Coastal Defence Structures in the Nile Delta

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FLORIAN BONNEFOI*

ADAPTING TO CLIMATE CHANGE: FOR A SOCIAL APPROACH TO COASTAL DEFENCE STRUCTURES IN THE NILE DELTA

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) identified deltas as being among the areas most vulnerable to climate change (IPCC 2022). Indeed, low-lying deltaic coasts are particularly vulnerable to flooding. The coast of the Nile Delta in Egypt extends over 225 kilometres between Port Said and Alexandria. It is bordered by four lakes, 'the four sisters', which form lagoons: Lake Manzala, Lake Borollus, Lake Edku and Lake Mariout. Since the construction of the Aswan High Dam in the 1970s, the risk of river flooding has been under control. However, in the context of global climate change, concern has shifted to a potential increase in sea level. According to estimates, between 15 and 25 per cent of the Delta could be submerged if the Mediterranean rises between half a metre and a metre by 2100. The risk of submergence is reinforced by the natural dynamics of subsidence and coastal erosion linked to a lack of sediment supply, which remains blocked by the Aswan Dam. Only 9 per cent of deltas in the world are in a regression phase.

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This is the case for the Nile Delta as well (Nienhuis et al. 2020), although it is not homogeneously vulnerable to climate change. A distinction must be made between global and relative sea-level rises, which depend on the characteristics of each coastal region. In Egypt, the eastern part of the Delta is more vulnerable because it is subject to more pronounced subsidence. The governorates most at risk are Port Said, Damietta and Kafr el-Sheikh. More locally, the two promontories of Damietta and Rosetta are particularly at risk (Frihy and Lawrence 2004). Generally though, the entire coast is vulnerable and appears to be a hotspot of climate change in Egypt and in the Mediterranean basin.

Risks result from a meeting between a hazard and human vulnerability (Pigeon 2005). The Nile Delta is characterized by an uncommon demography. Indeed, half of Egypt's population – nearly 50 million people – lives in the region in high-density conditions, which differentiates this delta from other deltas in the world (Fanchette 2014). The northern Egyptian coast represents a strategic territory occupied by several ports and large cities, foremost among which is Alexandria. Continued urbanization not only increases vulnerability but is also a driver of global climate change. Fishing villages are also scattered along the coast and bear the full brunt of the ongoing environmental

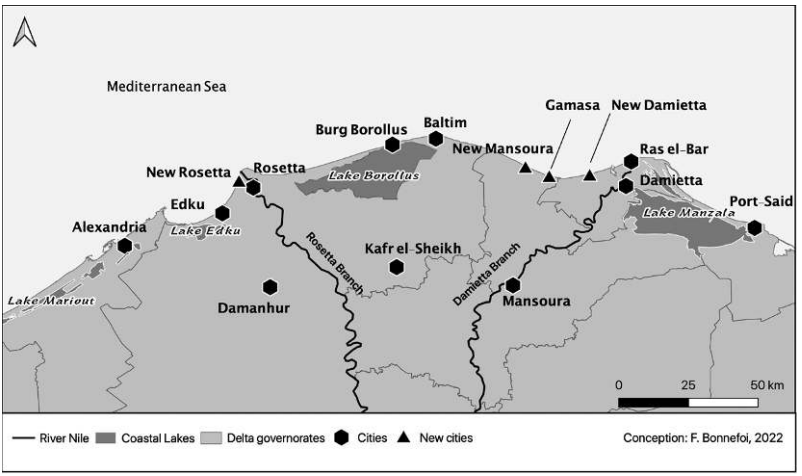

Figure 1. The Nile Delta: A very urbanized area. Source: Florian Bonnefoi, 2022.

degradation (Malm and Esmailian 2012). Authorities have focused on adaptation more than mitigation. Since the 1990s, successive governments have made the political and social choice of adaptation through hard structures: jetties, dykes, breakwaters and concrete blocks have gradually colonized the northern Egyptian coast. They have imposed themselves on the landscape but also on the daily practices of coastal areas and are the symbol and embodiment of environmental and climatic risks. At the same time, they are a reminder of human responsibility for and vulnerability to these risks. However, they are gradually being appropriated by political and economic actors as well as city dwellers to the point that we are witnessing a departure from their initial function of protection.

One may then ask to what extent the multiplication of coastal defence structures on the Delta seashore tends to alert us to current and future dangers and at the same time, tend to trivializes the environmental and climatic risk. This chapter will first review this highly urbanized deltaic coast's vulnerability to environmental and climate change. It will then discuss these adaptations that have taken the form of hard structures, leading to a concrete landscape that has become an interface between the sea and human society. Finally, it will look at the daily practices of these spaces and question their impact on the social vulnerability of the Nile Delta coast.

A PARTICULARLY VULNERABLE URBANIZED COASTLINE

A DENSELY POPULATED STRATEGIC AREA

With 104 million inhabitants in 2022, Egypt is a demographic giant in the Mediterranean basin and in the Arab world. The Delta region is home to half of its national population and has extremely high densities of up to 1,600 people per square kilometre in rural areas. It is far removed from the image of the eternal countryside as it is home to several large cities, especially on the coast. Indeed, the region is now home to five of Egypt's ten most populous cities: Alexandria, Port Said, Tanta, Mansoura and El-Mahalla el-Kubra. The dynamics of urbanization, which began in the post-war era, continue to intensify, making the Delta an emblematic territory of 'planetary urbanization' (Ruddick et al. 2017) and of the Anthropocene. Researchers have

called it an 'Ecoumenopolis' (Denis 2007). More and more land is being nibbled away by urbanization every year, challenging one of the planetary limits (Steffen et al. 2015), namely land-use change. Of the Delta's fertile land, 74,600 hectares were lost between 1992 and 2015. Over this period, the built-up area increased from 755 to 1,890 square kilometres, with an average annual growth of 47 square kilometres (Radwan et al. 2019). To put this into perspective, this increase represents an area equivalent to the city of Berlin. The coast is not spared. In fact, urbanization is coupled with strong littoralization dynamics, following the worldwide preference of people to settle in coastal areas, which are attractive in terms of economy and living environment.

Regarding the Egyptian Nile Delta, this urbanization is very ancient and dates back to the Pharaonic era. Alexandria was founded in 331 BC by Alexander the Great. Today, the urbanization process continues with two concomitant dynamics. On the one hand, existing cities are extending through urban sprawl, via either government-led development projects or informal settlements. On the other hand, new cities are being created directly on the coast. One recent example is New Mansoura, which was started in 2017. It is being built in the dunes, on the international road between Lake Manzala and Lake Borollus. Images that the government and real estate developers posted on social media show the construction boom this area has undergone since the beginning of the project.

Urbanization is leading to the increased artificialization of land and the coast, which has a double disadvantage. On the one hand, the disappearance of the vegetation cover accelerates temperature increases. Thus, the transition from agricultural to urbanized land likely produced a temperature increase of 1.7 °C in the areas concerned (Hereher 2017). In cities, the phenomenon of heat islands is particularly important and leads to a vicious circle: air conditioning is used to lower temperatures inside buildings, consuming large quantities of energy and leading to a rise in outside temperatures. In Alexandria, for example, electricity consumption, which has been steadily increasing over the past ten years, could increase exponentially by 2050. It is estimated that 50 per cent of the city's electricity consumption comes from residential areas, and it has grown 6.7 per cent annually between 2010 and 2016. Population growth alone is not

responsible for this increase. This consumption is subject to strong seasonal variations and, since summer temperatures could significantly increase by 2050, we can expect another surge in the coming years. In this sense, global warming represents an additional pressure on energy demand and consumption (Abdrabo, Hassaan, and Abdelraouf 2018). Another disadvantage of the increased artificialization of the coast is that increasing numbers of people and activities are exposed to risks. Their settlement in these areas seems counter-intuitive, although it is a worldwide dynamic.

COASTAL CITIES PARTICULARLY VULNERABLE TO CLIMATE CHANGE

Cities play the role of drivers and amplifiers of climate change but are also very vulnerable. Cities of the Delta, first and foremost the coastal cities, are exposed to climate risk in its different forms, whether an increase in sea level or storms (Abdeldayem et al. 2020). The extreme littoralization of people and activities accentuates the magnitude of losses in case of floods. For instance, in Alexandria, average annual economic losses due to flooding between 2005 and 2050 will be the highest worldwide. They could increase by 154 per cent between these two dates (Hallegatte et al. 2013). Alexandria is the second largest city in the country, with almost 5.1 million official inhabitants according to the 2017 census. The city is densely built and highly vulnerable to sea-level rise, as 37 per cent of its buildings are located less than one kilometre from the shore (El-Hattab, Mohamed, and El Raey 2018). Without protection, a fifty-centimetre sea-level rise would be enough to displace two million people and threaten 214,000 jobs (Redeker and Kantoush 2014). Furthermore, the city is home to 40 per cent of the country's industries, which, in addition to the economic implications, could lead to an industrial disaster in case of flooding.

Other major and secondary cities are located on the seashore and could suffer heavy losses. These include Port Said, Damietta, Gamasa, Baltim, Rosetta and Edku. Their inhabitants are experiencing increasingly frequent and intense sea storms that result in flooding. Coupled with run-off floods linked to the artificialization of the soil, these floods challenge the sewage systems, cause buildings to collapse and kill people. The storm of December 2010 was particularly violent: in Alexandria, four buildings collapsed within forty-eight

hours and about thirty people died. In October 2015, the city experienced heavy rainfall (thirty-two millimetres in a few hours). The city's drainage system was unable to redirect the rainwater to the sea. Many neighbourhoods were flooded – 30 per cent of the total urban area – transportation was stopped for several days, electricity was cut and seven people were electrocuted (Zevenbergen and Salinas Rodriguez 2017). Alexandria's vulnerability is heightened by its location: wedged between the Mediterranean Sea and Lake Mariout and stretching over some fifty kilometres. Coastal villages are also particularly vulnerable, especially since in their case, the environmental risk accentuates their pre-existing economic and social vulnerability.

A CONCRETE COAST: TOWARDS A NEW NATURE–SOCIETY INTERFACE?

BENEFITS AND DISADVANTAGES OF ENGINEERING STRUCTURES

Faced with these increased risks and vulnerabilities, the Egyptian government has implemented a variety of heavy infrastructure projects to protect the coast from the onslaught of waves and the rising sea. It has done so through the Egyptian General Authority for Beach Protection that is attached to the Ministry of Irrigation and Water Resources. Among these are structures perpendicular to the shoreline, such as *groin fields* used to maintain beaches and to limit longshore sediment transport and *jetties* that aim at minimizing sediment deposition, especially in harbours. Other are parallel to the shoreline, including *breakwaters* – offshore structures made of rock or concrete that break waves – *sea walls*, which reduce the impact of waves and thus of erosion, and *revetments made of concrete blocks*. These structures form a defensive front against erosion and the effects of climate change. They can be seen in many coastal cities, including in Alexandria, Burg Borollus, Baltim and Ras el-Bar. The implementation of these developments on the coast is not a novelty related to current climate change, but began as early as the nineteenth century during the reign of Mohammed Ali. The first dyke was built in Alexandria in 1830, and construction continued during the twentieth century with structures in Ras el-Bar in 1941, on the Rosetta promontory in 1989–1991, and elsewhere. These structures are therefore the result of a deliberate

Figures 2a. Coastal defence structures: offshore breakwaters in Ras el-Bar. Source: F. Bonnefoi, March and April 2021.

planning tradition, partly dictated by the fragile and unstable geography of the Delta.

Although they appear to be effective short- and mid-term defences against the effects of climate change, these defences are not a miracle solution and also have perverse effects. First of all, the construction of these structures is costly in terms of greenhouse gas (GHG) emissions. Indeed, the concrete that composes them is made from cement, the production of which requires the burning of fossil fuels. Cement production is responsible for 7 per cent of annual CO_2 emissions worldwide (Fennell, Davis, and Mohammed 2021). Moreover, they address only one facet of the problem. Indeed, while they are relatively effective in stopping waves and limiting the risk of marine submersion, they do not address the issue of saltwater intrusion. The latter extends several tens of kilometres inland. On the coast of Kafr el-Sheikh and Beheira for example, this intrusion suffocates palm trees and thus endangers the livelihood and living conditions of farmers. In addition, sea walls tend to accelerate erosion on adjacent beaches and at the toe

Figures 2b. Coastal defence structures: concrete blocks in Alexandria. Source: F. Bonnefoi, March and April 2021.

of the wall. These heavy structures also harm biodiversity. These disadvantages are why experts often promote nature-based solutions. Green buffers such as dunes are natural barriers against erosion and sea-level rise. Experiments with these are underway in Egypt. For example, a dune restoration programme is being carried out in New Damietta.

TOWARDS A COASTAL LANDSCAPE OF CONCRETE

Coastal defence structures have profoundly modified coastal and urban landscapes. For example, in Alexandria, up to ten rows of concrete blocks sit in the sea, forming a buffer of about fifteen metres between the Corniche and the waves. This buffer extends along almost the entire Alexandrian coastline, from Manshiyet Bay in the city centre to Montazah Park twenty kilometres away. However, to think that the Alexandrian coastline was 'natural' before these blocks were put into place is an illusion. Instead, it has been constantly modified since the nineteenth century. For example, the Corniche along Manshiyet Bay was designed by Italian architect Pietro Avoscani in the 1870s.

Nearly 526,000 square metres of land were reclaimed from the sea. The Corniche was then extended to the north-east and widened several times during the twentieth century. Nevertheless, the protection measures currently implemented constitute a new stage in the anthropization of the coast. The landscape is losing its natural character and a new interface between the sea and the city, between nature and human society, is gradually being established. There is no more direct access to the sea. Concrete blocks have replaced the beach, which is reduced to a few minimal stretches that are accessible to paying guests only. The blocks play the role of mediators and are hybrid objects (Latour 2006) that crystallize the relations of the city with its natural environment and of its inhabitants with the risk of flooding.

However, one can wonder whether these engineered structures are more than a form of adaptation aimed at protecting human installations and whether they also have a performative dimension of making citizens aware of climate risks. They materialize the risk of flooding and submersion, making it more tangible. In brief, they are a constant reminder of danger and vulnerability. Thus, in a certain way, they could participate more or less latently in the diffusion of a culture of risk or at least of awareness. In the words of Bruno Latour (2006), dykes, blocks and jetties embody the end of the great division between nature and culture. They remind us of our vulnerability to the natural elements. They are also a reminder that the risks to which we are currently exposed are largely of our own making.

SOCIAL PRACTICES OF CONCRETE BLOCKS

A RENEWAL OF VALUES ASSOCIATED WITH RISK?

These coastal defence structures were conceived, designed and implemented according to a top-down logic. However, their location at the sea–city interface, i.e. at the heart of the economic activities of trade and fishing and of recreational practices, makes them an everyday space that economic private actors and city dwellers are gradually appropriating. They are the scene of new daily practices and social activities.

As spaces with amenities, particularly sea views, urban waterfronts attract investors. Different actors have hijacked them to turn them into spaces of leisure.

A striking example is the tip of the promontory where the Damietta branch of the Nile flows into the Mediterranean at Ras el-Bar. In June 2019, a new, 158-room luxury hotel from the Steigenberger brand opened in this location. It completely privatizes the left bank of the estuary, which is now occupied by a swimming pool, leaving room for only a narrow pier that leads to the lighthouse. Along the coast, the dykes are occupied by cafes and restaurants. This corresponds to a common dynamic of tertiarization of coastal areas linked to their touristic development. The same thing can be observed in Alexandria. In the San Stefano district, the Gleembay complex located on a dyke extends about 300 metres into the sea. Previously a place for walking, the pier is now colonized by big restaurant and cafe chains, emblematic of the generic places of globalization such as Costa or Starbucks. It has become a place of consumption where prices limit accessibility to the middle and upper classes. In these cases, the protective function of these structures loses visibility in the face of a new recreational function in line with the neoliberal city. More generally, this accompanies the privatization of the seafront, where the beaches, even the public ones, now almost all charge entry fees.

However, ordinary city dwellers are not passive and are also reclaiming and reappropriating these spaces (Berry-Chikhaoui and Deboulet 2000). Deprived of the beaches, which have been replaced by ledges, roads and protection structures, they reoccupy the concrete blocks. In Alexandria, people go there to stroll, meet friends, or eat ice cream facing the sea. Amateur fishermen take advantage of the blocks, which trap some fish. These 'infrastructure-interfaces' become new public spaces. Indeed, they compensate for the lack of urban public spaces that are accessible to all and free of charge. This lack has been emphasized repeatedly for the case of Cairo, but much less so for provincial cities. However, it is just as glaring in the latter. In Alexandria, places where one can stop and sit – such as Ahmed Ourabi Square or Saad Zaghloul Square – are a little more numerous than in the capital. However, parks charge an entry fee and are few in number. Residents tend to occupy any available space, even if it means diverting it from its initial function. This trend seems to be less pronounced in cities with more freely accessible public spaces. For

Figure 3. Occupation of the promontory of Damietta by a luxury hotel. Source: F. Bonnefoi, March 2021.

example, in Ras el-Bar, where the Nile River promenade and large sandy beaches are accessible, fewer people are seen sitting and relaxing on coastal defence structures.

The appropriation of protection infrastructure for leisure purposes leads to a reversal of the values and emotions linked to these spaces: whereas at first they evoked mistrust, even fear, regarding the future, they now take on a much more positive dimension linked to entertainment, relaxation and a carpe-diem type of enjoyment.

INCREASED VULNERABILITY?

Instead of alerting us to risks, these engineering structures can have the opposite effect and give the impression of safety. The use of hard structures seeks to (re)make people into the 'masters and possessors of nature', to quote *Discourse on the Method* by Descartes. It provides an illusion of control and spreads the idea that one could be free from the constraints of natural elements and the climate. One might then ask whether these structures, when implemented alone, lead to a form of

Figure 4. Appropriation of concrete blocks by city dwellers on the Corniche of Alexandria. Source: F. Bonnefoi, May 2022.

maladaptation (Magnan et al. 2016). The IPCC defines maladaptation as 'actions that lead to increased vulnerability or risk to climate impacts or [that] diminish welfare' (2022, 937) and as 'a consequence of failure to address root causes of vulnerabilities' (1189). In other words, it is an attempt to adapt that produces unwanted and undesirable effects.

Two main perverse effects of these defence structures can be identified. The first, mentioned above, is the diffusion of a feeling of security that leads to increased frequentation of the coastline and its development for settlement. These structures make vulnerable areas attractive. Low-lying coastal areas, particularly deltaic ones, will be the first to be affected by any increase in sea levels. Therefore, their continued anthropization and concrete development are dangerous.

On another note, these structures raise questions of equity and environmental justice. The construction of dykes requires technical know-how and financial resources. However, these resources are not equally distributed, and some populations and activities are privileged over others. Andreas Malm (2013) underlines the classist violence of

Figures 5a and 5b. Protection of the citadel of Qaitbay in Alexandria. Source: F. Bonnefoi, May 2022.

climate change, meaning that any intervention is neither politically nor socially neutral. The proposed solutions are very often based on the market economy and reinforce inequalities. Large cities are preferred, first and foremost Alexandria, but also resorts such as Ras el-Bar, where eight breakwaters were built 400 metres from the shore in the 1990s. The resort is better protected than the surrounding villages. In cities, the preferred sites seem to be those that can generate profits through tourism. Thus, in Alexandria, the citadel of Qaitbay has been the subject of a EGP 267 million protection programme. The project includes the construction of a jetty to recreate a beach through the accumulation of sediment, a bridge with Mameluke-style towers, stone blocks that will enclose the bay, and a marina.

Moreover, these structures address the consequences, not causes, of environmental degradation. While they are effective in the short term, their long-term efficiency is more uncertain. They also tend to displace the effects: by creating accretion zones, for example, jetties reinforce the erosion of adjacent coasts. Whereas the main cities and economically strategic places will be protected, secondary villages are increasingly vulnerable.

CONCLUSION

Although coastlines are increasingly vulnerable to the effects of climate change, the urbanization of the Egyptian deltaic coast continues at a steady pace. It accentuates ongoing environmental and climatic changes, causing various types of pollution and the appearance of heat islands as well as increasing soil sealing, increasing the risk of flooding by run-off. It also leads to population concentrations in areas at risk, especially in the face of rising seas. In this context, protective structures are increasingly transforming the coastal landscape of the Delta. The sand gradually gives way to concrete blocks that become an interface between the sea and the land, between the waves and inhabitants. They are a striking example of hybrid objects that reinterrogate the relationship between nature and culture in the era of global climate change. They question the capacity of authorities to implement sustainable solutions to climate risk. They have proven to be effective in the short term, stopping the erosion of the coastline and thus giving a sense of security. Nevertheless, they are only a stopgap measure that increases

vulnerability in the long term. They must be accompanied by other, less invasive measures such as nature-based solutions and, above all, by an in-depth reflection on land-use planning. The increasing anthropization of the coastline magnifies vulnerabilities and potential future losses. Without reflection on their social impacts, coastal defence structures lead to the marginalization and endangerment of the most disadvantaged. While coastal urbanization cannot be stopped easily, especially in a world that operates following a model of economic extraversion and globalization, the population's awareness of environmental issues must be increased in order to generate a real culture of risk and adaptation capacities at the individual and institutional levels. Protecting cities appears to be a priority, especially since climate change is pushing people towards urban centres on a global scale (Adger et al. 2020). This leads to a vicious circle in which vulnerable populations move to centres that are themselves exposed to climatic hazards, thus increasing the vulnerability of individuals and urban infrastructure.

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