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Delta Urbanism: New Challenges for Planning and Design in Urbanized Deltas

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The Nile Delta: Urbanizing on Diminishing Resources

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The Nile Delta is one of the world's largest river deltas shaped by the interplay of urbanization, agricultural and industrial land uses with an increasing state of urgency defined by water scarcity and pollution, sea-level rise and population increase. For Egypt, it remains the most important source of ecological goods and services, as well as an economic, agricultural and tourism hub. The Delta mirrors the consequences of past and present climate change, anthropogenic transformations, and the socio-ecological dimensions associated with each. Rapidly spreading informal urbanization has taken on an unprecedented dynamic in the absence of enforcement, while projected sea-level rise is turning the Nile Delta into a highly vulnerable coastal region. Dams upriver, most prominently the Renaissance Dam in Ethiopia, will put additional pressure on the territory in terms of sediment transport and actual discharge. In response to rising sea level and diminishing sediment discharge, the Nile Delta will naturally decrease in size. Engineering efforts may delay these processes, but are unlikely to prevent the destruction of the Nile Delta in the coming decades. How should we react to this assumption? What short and long-term strategies are available?

The Nile Delta is one of the world's largest river deltas. From Alexandria in the west to Port Said in the east, it covers 240 km of Mediterranean coastline. From north to south the delta is approximately 160 km in length starting 20 km downriver from Cairo. As a region it is shaped by an interplay of urbanization processes, agricultural and industrial land uses coupled with an increasing state of urgency defined by water scarcity and pollution, sea-level rise, desertification and population increase. For Egypt, the Nile Delta remains the most important source of ecosystem goods and services. It is also a site of amazing cultural heritage and the north coast is one of Egypt's major national and international tourist destinations.

The Nile Delta testifies to the consequences of past and, more urgently, present climate change, anthropogenic transformations, and the socio-ecological dimensions associated with each. About 95 per cent of the Egyptian population (84 million in 2012) live on the scarce agricultural land in the Nile Valley and Delta in a country that is otherwise a desert (see figure1). With a population density of 1,500 inhabitants per square kilometre, it is already the most densely populated delta in the world.[1]After Cairo, the delta is Egypt's main economic region with industry, agricultural production, natural resources and tourism. While shrinking in size, an estimated population increase from 48 million in 2010 to 75 million by 2050 will require more jobs, housing and food production. Unprecedented rapid informal urbanization in the absence of enforcement, following the 2011 revolution and the exposure to projected sea-level rise, is turning the Nile Delta into a highly vulnerable coastal

Figure 1. The Nile. (*Source*: NASA Jeff Schmaltz, MODIS Rapid Response Team; NASA/GSFChttp://eoimages.gsfc.nasa.gov/images/imagerecords/68000/68269/Egypt.A2003235.0845.250m.jpg)

region. An assessment of the vulnerability of Alexandria alone suggests that a rise of only 50 cm would demand the evacuation of more than 2 million people (see GOPP and UNDP, 2009).

As a result of dams, impoundments, dikes, and canal construction the delta is already suffering from decreased sediment and flow supply resulting in enhanced subsidence and reduced accretion (Kantoush and Sumi, 2013). The Nile is completely controlled by the Aswan High Dam and a series of barrages along its course to the Mediterranean Sea. Dams in Ethiopia, Sudan and South Sudan are currently being planned or are already under construction. These dams, most prominently the Renaissance Dam in Ethiopia, will put additional pressure on the territory in terms of reduced sediment transport and freshwater supply (Kantoush, 2013). Local water and mineral extraction further aggravate the natural rates of subsidence and increase salt-water intrusion into wetlands and reservoirs. The destruction of wetland habitat has diminished water quality, decreased biological production, and reduced biodiversity. A landward migration of coastal wetland zones is no longer possible due to urbanization.

Climate change is likely to increase the current stress on resources, especially in the developing world. Most systems are sensitive to both the magnitude and the rate of climate change (e.g. Gleick, 1998). The vulnerability of a system to the expected change depends on the overall resilience to cope with different risks. Most developing countries, such as Egypt, are generally more vulnerable and less able to adapt (Nour El-Din, 2013). Engineering efforts may delay, but are unlikely to prevent the destruction of the Nile Delta in the coming decades. How should we react to this assumption? Between eco-engineering, adaptation and resettlement what short- or long-term intervention strategies are available?

Evolution of the Nile Delta before the Aswan High Dam

For the past 6,000 years,[2] migrating and decaying distributaries, tsunamis, earthquakes, inundation, sinking land, dune migration and severe coastal erosion – later to be complemented by large-scale anthropogenic interventions – have framed urban transformations in the delta (Shawkat, 2010*a*).

The Nile Valley consists of a broad flood plain between steep limestone and sandstone hills. The valley sediments from the deposits of sand, silt and clay formed when the Nile flooded. Similar alluvial sediments dominate much of the delta. As part of the African continental plate bordering the Mediterranean, the repeated submergence has left many layers of sedimentary rock in the Nile Delta. Over the past 10 million years it has been further shaped by sedimentation processes associated with its diverse branches only two of which, the Rosetta and Damietta River, since around 900 CE, have flowed into the Mediterranean. As sea levels rose, the river branches started to deposit silt also on the sand ridges in between the channels. The sand dunes evolved for two reasons: sand delivery to the coast terminated and by scouring and eroding beach sand that was transported eastwards by wave-driven longshore currents. Consequently the delta was transformed (Iskander, 2010). These sand ridges have produced silt layers 10–40 metres thick.

Along the coast there is a series of saline and freshwater lagoons and salt flats trapped behind coastal sand bars. These were at least partially formed by earthquakes in the Hellenic arc of the Mediterranean as their tsunamis flooded the lower lands behind the sand ridges (Sampsell, 2003). The risk of tsunamis has continued into the present. Over time offshore currents between the outlets of the distributaries resulted in sandbars emerging parallel to the coastline and leading to the enclosure of lagoons. These lagoons were partially disconnected and therefore became freshwater lakes as the northwest winds blew sands onto the shore. Over 25 per cent of all Mediterranean wetlands are found along the Mediterranean coast of Egypt. The Nile Delta was once known for large papyrus swamps, but these are now largely absent. The delta landscape is further defined by about fifty islands in the river branches (Ghobrial, 2007).

The cultivated area of farmland in Egypt remained more or less the same for centuries. With basin irrigation fields were compartmentalized by earth banks and flooded. On over two-thirds of the alluvial ground, annual flooding and draining of the floodplain enabled a single crop season. Karl Butzer (1976) estimated that in 150 BCE the delta had 16,000 km^2 of arable land. This remained more or less the same until the 1880s. Perennial irrigation was supported by Napoleon and driven by the viceroy Muhammad Ali's decision to plant cotton on a large scale. As a cash crop that needed water when Nile levels were low, basin irrigation was abandoned in favour of a system capable of producing two to three crops per year. In addition, a barrage was erected 20 km north of Cairo, not to protect against floods, but to supply feeder canals that were placed in former distributaries aligned with high levees. Water levels 4 m above average allowed for irrigation by gravity before letting the water flow back into the Rosetta and Damietta branches (Sampsell, 2003). This model was repeated at different locations along the Nile.

The Aswan High Dam and Sea-level rise

Until 1902 the amount of fluvial sediment that was transported was greater than the amount that eroded into the Mediterranean by wind, waves and current. Before the Aswan High Dam was constructed, the Nile delivered an average of 100 million tons of sediment each year to the Mediterranean with annual floods depositing 1 mm of fresh silt on the delta's surface (Bohannon, 2010). Constructed in 1968, at a distance of 7 km from the old Aswan Dam, the Aswan High Dam is 3.6 km long, with a maximum height of 111 metres. The current operating strategy is to keep the level of the lake as high as possible to secure sufficient release in case of consecutive dry years. The maximum amount of water that can be stored in Lake Nasser is 169 billion cubic metres – twice the annual flow of the River Nile at Aswan (ECIDSC and UNDP, 2011) – with a surface area of 5,250 km^2, a further source of evaporation. With the completion of the dam the Nile was freed from its annual floods, but also from its silt depositions. Since 1964, almost 5 billion cubic metres of sediments have been deposited in Lake Nasser. Studies indicate that up to 130 million cubic metres a year end up in the lake while only 4 million pass through the Aswan High Dam to the valley north of Aswan (Ghobrial, 2007). The erosion process along the Mediterranean coast is therefore no longer counter-balanced. Between 1964 and1982 the average retreat of the coastline amounted to 147 m to the west and 48 m to the east of the Rosetta land tongue. The reasons are a decrease in precipitation in eastern Africa leading to a decrease in discharge of up to 25 per cent, as well as the construction of dams and barrages leaving large amounts of sediment behind the Aswan High Dam and the delta without annual sediment influx. Today, the Rosetta branch carries 70–80 per cent of the water while the Damietta branch would silt up if not dredged. The dam has also largely cut-off floodwaters that would annually flush pollutants out of the Nile system and into the Mediterranean. Today, only 10 per cent of Nile waters actually reach the sea.

Sediment deficit is not only an environmental problem, but also a socio-economic problem (e.g. Fan and Springer, 1993). Until now, the common engineering practice has been to design and operate reservoirs to fill with sediment. With such an approach, the consequences of sedimentation and project abandonment are left for future generations to cope with; for the Nile Delta this future has already arrived. Soft measures such as sediment augmentation through *wadis* during flash floods and artificial sediment supply through the drainage system near the estuary are being discussed as possible strategies. Also, a more flexible dam operation to change the flow regime putting the deposited sediment in suspension downstream of the dam and new sediment management techniques for the reservoir are studied (Sumi *et al*., 2013). Another proposal foresees the flooding of the Qattara Depression, the second lowest area in Africa 85 km from the coast, with water from the Mediterranean (see Remel Foundation, 2012).

Due to the diversion into a dense net of irrigation canals with a length of more than 10,000 km, excess water is redistributed to the Nile branches after watering the fields, but now polluted by fertilizers and industrial wastes. As groundwater tables rose to the root zone of cultivated crops with the operation of the High Dam, the need for drainage became apparent. In the mid 1970s, the government started a programme to install a system of drainage canals (Khurs) that will be completed in the coming years (ETH, 2009). The vast net of irrigation and drainage canals not only contributes to the consumption of scarce agricultural land: as a substitute for natural nutrients coming with floodplain sedimentation, farmers have been forced to use about a million tons of artificial fertilizer per year. With the discharge of irrigation waters back into the Nile from disperse sources, the overall water quality is diminishing and, because more water evaporates in irrigation systems, it also has higher saline levels.

The marine geologist Daniel Stanley coined the current period in Nile Delta evolution its destruction phase (see Bohannon, 2010). Presumed sea-level rise over the next nine decades, coupled with the accelerated erosion of the Nile Delta's coast as a result of 150 years of damming the Nile's flow, threaten the villages, towns and cities of up to 6 million people. A one-metre rise in sea level would endanger 8 million people, as well as possibly 4,500 km^2 of crop land, a fifth of the delta's area and, more importantly, almost 12 per cent of the nation's arable land (Simonett *et al*., 2005). Desertification and a continuous urbanization process paired with the absence of functioning governance and enforcement create a grim scenario for the Nile delta.

The cities of Alexandria, Rashid, Ras al-Bar and Port Said have only been preserved by concrete wave breakers that were set up along their coasts over the past few decades at huge expense. Sand dunes that once provided a natural defence system to the coastal erosion process now endanger the coastal villages with their migration (Shawkat, 2010*b*). Alexandria is protected through many coastal structures such as jetties, groins, seawalls and shore-parallel breakwaters. In the past the Mohamed Ali Seawall was constructed to protect the harbour complex. In addition, extensive shoaling exists along this sector of the coast and in general provides protection from the open sea waves (Iskander, 2010).

The impact of sea-level rise on a vulnerable population becomes evident when looking at Alexandria, home to 4.1 million with an expected 6.8 million inhabitants by the year 2030. The Alexandria agglomeration consists mainly of high-density settlements along two elevated ridges of 10 and 25 metres above sea level parallel with the sea, aligned by low-lying rural areas with a number of lakes and wetlands. Many of these areas are 2–3 metres below sea level and are therefore highly vulnerable to flooding. Today, pumping stations discharge the water back into the sea (World Bank, 2011). If, as projected, sea levels rise by 50 cm, in Alexandria alone 2 million people would have to abandon their homes, 214,000 jobs would be lost, and the cost in lost property value and tourism income would be over US$35 billion not to mention the loss of cultural heritage (GOPP and UNDP, 2009).

In 2011, the Egyptian Cabinet Information and Decision Support Center together with the United Nations Development Programme published a National Strategy for Adaptation to Climate Change and Disaster Risk Reduction (NSACC) with a strong focus on coastal protection as well as awareness and governance issues.

Four main risks induced by climate change in Egypt were defined: water scarcity (high risk); increased floods (low risk); high water consumption (high risk); and sea-level rise (high risk). The Nile Delta coast itself is divided into three sub-zones depending on the degree of exposure and vulnerability to the risk of erosion and sea-level rise. Figure 2 shows the naturally protected areas (accretion beaches, sand dunes, and long limestone ridges), the unprotected areas, and the artificially protected areas (protective sea walls and barriers). It also shows the more vulnerable areas requiring future measures of adaptation (areas indicated with the arrows) (ECIDSC and UNDP, 2011).

Currently, the Egyptian Shore Protection Authority (SPA) in cooperation with the Coastal Research Institute (CoRI) and several international agencies are launching an integrated coastal zone management plan to further secure and sustainably develop the coastal zones of Egypt taking into account expected sea-level rise. The 2012–2017 plan of the SPA with a total budget of about 770 million Egyptian pounds includes the following projects: enhancement of the Rashid protection

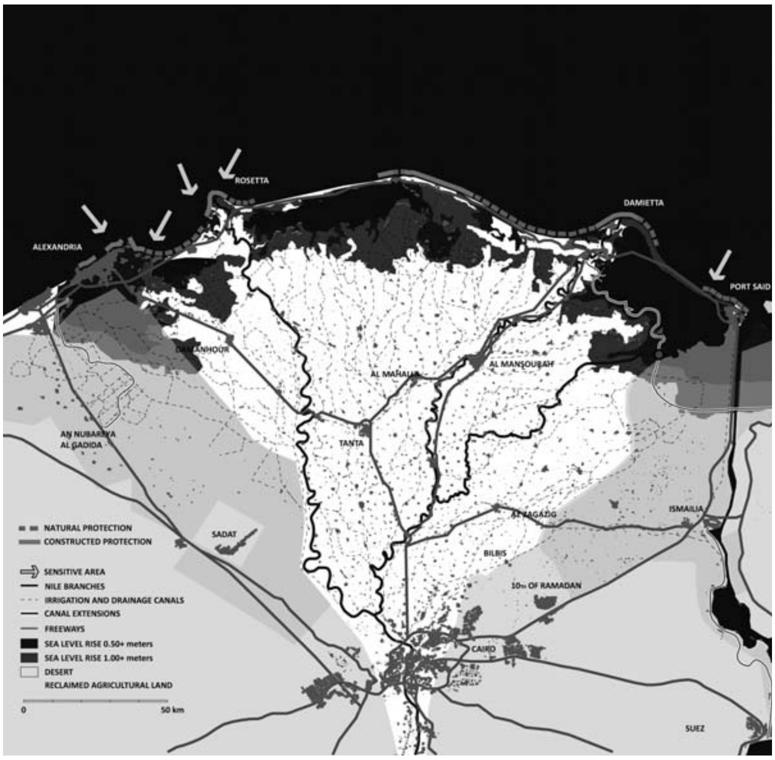

Figure 2. The Nile Delta. (*Source*: Map by Hassan El Ghayesh based on Simonett *et al*., 2005)

wall, protecting the beaches of Alexandria, Port Said and Al-Arish, Damietta, Kafr E-Shikh, and El-Malaha area east of Port Said.

With a paradigm shift from installing defensive measures which themselves produce adverse effects, currently softer measures such as the living-shorelines approach are proposed for the Egyptian Delta. These involve physical measures such as protecting and nourishing, constructing beaches and dunes, stabilizing dunes with fences and vegetation, coastal vegetative buffers to provide a vegetated transition zone between a waterway and developed land, creating and restoring wetlands and utilizing the coastal lakes as a mechanism for adaptive management protection. Beyond that, restrictions and community-based participation to trigger environmental awareness are urgently needed (UNDP and Government of Egypt, 2009). The adaptation strategy (total estimated budget for implementing the strategy is about 180 billion LE until 2050, unequally distributed over three 5-year plans and two 10-year plans) includes several infrastructural projects as well as technical and soft interventions including:

- desalination of brackish and sea water;
- increased ground water abstraction;
- water harvesting projects from rainfall and flash floods;
- water recycling from agricultural drainage water and treated waste water;
- modernizing water control and irrigation systems;
- upgrading municipal infrastructure;
- regional cooperation;
- sea water agriculture;
- capacity building, awareness raising, participatory management;
- scientific research and technology development;

The National Strategy for Adaptation to

Climate Changes faces several constraints to successfully applying integrated water resources management in Egypt. Apart from population increase, social and economic factors, fragmentation of agricultural tenure, a free crop structure, pollution and a lack of financial resources, the legal framework is considered one of the key limitations due to overlapping jurisdictions, weak penalties and fines related to water violations and slow litigation processes. Centralized laws and decision-making need to be amended to be suitable for the new variables in water resource management and also to give more space to the private sector to participate. At the same time, an institutional reform of the different state organizations is necessary to comply with the requirements of integrated water management. Since most of the measures used in formulating this strategy are of no-regret or low-regret nature, the allocated budget would target a sustainable development as well as adaptation to the future climate change impacts (Nour El-Din, 2013).

Water Scarcity and Productivity

The delta is fully reliant on water resources from Upper Egypt. Of the 55 million cubic metres discharge at Aswan per year (ECIDSC and UNDP, 2011) only 8 per cent reaches the delta (Ministry of Water and Irrigation, 2004). Eighty per cent of Egypt's water is used for irrigation (El Kateb and Mosandl, 2012) of which surface irrigation accounts for more than 85 per cent of the total volume of water used for irrigation in the Nile Delta. Today, farmland and water availability are decreasing while population increases, producing the opposite situation to 60 years ago when Egypt was more or less self-sufficient in almost all agricultural commodities with the exception of cereals, oils and sugar.

Water released from the dam is distributed throughout the valley and delta in a diverse network canals. This extensive irrigation network delivers water mainly by gravity diversion and pumping stations. The irrigation system distributes water among main canals and regions based on volumetric quota defined according to area served, soil and climate conditions and cropping patterns. Yet, control over branch canals is mainly by levels, which leads to mismatching allocated supplies from the upstream side with demands from the downstream resulting in unequal water distribution. This forces downstream users to lift water from the nearest drains to irrigate their lands.

Limited water reserves and poor water quality are the major challenges facing sustainable agricultural development in Egypt. Nearly 100 m thick, the porous Prenile River's sand and gravel layer serves as an excellent fresh water reservoir. As the second source, the Prenile aquifer with 300 billion cubic metres, or the equivalent of 3.5 years of total Nile flow is replenished by seepage from the Nile and irrigation channels. As the water passes through the sand, some pollutants are filtered. However, the reservoir has already been heavily tapped leading to seawater penetrating from the north and now extending at least 35 km inland (Sampsell, 2003). Today, changing perennial into drip irrigation is supposed to increase the efficiency of water use, as is the improved drainage of fields.

In the last three decades, Egypt has redeveloped a number of lagoons and lakes along the northeastern coast of the delta for fish production to compensate for the reduction in fish catches induced by land reclamation, industrial and nutrient pollution, and an overgrowth by water hyacinth (Ghobrial, 2007). A network of artificial structures, mainly short dikes enclosing hundreds of aquaculture ponds, occupies the Musalla lagoon shores directly south of Port Said almost entirely. The total area devoted to fish production in the lagoon is estimated to be 8,000 hectares – more than half of Egypt's aquaculture production. The intense aquaculture in the Nile Delta was born out of the impacts of the Aswan High Dam leading to such severe drops in nutrient supply that fishery in the lakes and lagoons in the mid-1960s came down to about 3 per cent of pre-dam values. The aquaculture programme throughout Egypt during the last 30 years has partially compensated for this loss, yet consumption has doubled in the meantime and export never fully recovered (see http://earthobservatory.nasa.gov/IOTD/view.php?id=7070).

Beyond agriculture and aquaculture, two further economic sectors will be severely affected by climate change: tourism and energy production (Cacouris and Cabot Venton, 2010). Reviving tourism after the revolution will require a reliable water supply, adequate wastewater treatment, safe and high-quality agricultural products, and good water quality for recreational uses. Thus climate-induced water shortages and pollution will severely affect tourism. Using concentrated solar power technology CSP technology, the MENA (Middle East and North Africa) region is capable of providing enough solar electricity to meet the regional as well as European electricity demands. Climate-induced water scarcity will also severely impact these plans.

Informal Urbanization, Desertification and Informal Urbanization

Today, the dynamics of informal urban development are actually exceeding the expected area of lost agricultural land induced by sea-level rise due to population increase, perverse market incentives on agricultural products and, of course, the safety from floods for almost 50 consecutive years (Shawkat, 2010*c*). Due to sea-level rise, out of a total area of 25,000 km^2, between 1,800 and 4,500 km^2 of crop land may be lost by the year 2100. At the same time, urban expansion will claim between 12,500 to 25,000 km^2 of the delta. It is over five times more threatening to cultivable land than climate change, and threatens the entire delta. Almost 10 per cent of arable land in the Nile Valley and Delta has already been lost to largely informal urban development. If urban growth continues as it has for the last 20 years the arable delta will be lost in no more than 120 years (Al Gamily, see Shawkat, 2010*c*).

Since 2008 Egypt has adopted a multi-scalar strategic planning approach (Building Law 119/08) organized under the General Organization of Physical Planning (GOPP) at the Ministry of Housing and UN Habitat. So far, it has failed to tackle the challenges. Centralized structures and lack of budget reliability hinder true local empowerment, thus strategic planning fails to touch ground. Strategic planning was also set out as a tool to produce urgently needed databases, butthis is hindered by missing local capacity and database maintenance. In parallel, the plans are non-responsive to change and often out-dated by the time of implementation (Yousri, 2013).

The Informal Settlements Development Facility (ISDF) defines four grades of unplanned and unsafe areas according to the degree of risk exposure for the inhabitants. Immediate intervention through resettlement is only considered for unsafe areas that threaten lives, such as the exposure to floods (Algohary, 2010). Beyond resettlement, the integration of climate change and its consequences in informal urban areas is raised for the first time in Egypt since 2011 in the GIZ Participatory Development Program in Urban Areas aiming to raise awareness and to promote initiatives that improve the resilience of the urban poor in the Greater Cairo region. A pilot project to cope with encroachment along the Nile and the canals is also currently being conducted by the Ministry of Water Resources and Irrigation. The key hindrances to implementing innovative solutions are again the lack of institutional capacity and expertise to reform implementation procedures (Redeker *et al*., 2013).

Since the 1970s a network of highways connecting the major cities superimposes the evenly sprinkled pattern of small towns and villages across the delta. Until the 1950s, the Nile and its canals also served as a transport route: 25 per cent of goods were transported via the river. Today Nile transportation only makes up 1 per cent. As long as fuel is subsidized, the network of highways will remain the primary mode of transportation. This is also a key impairment for the growth of new desert cities as public transportation, a key to successful resettlement, is not being developed (see Sims, 2009).

While the delta fills with informal urban development, its fringes are suffering from desertification (ECIDSC and UNDP, 2011). According to the UN Convention to Combat Desertification, Egypt stands at the forefront of those countries threatened: the loss of 34 hectares per day is unique when looking at world statistics (Metawali, 2011). To reduce development pressure on the Nile Valley and Delta, the national strategy since the 1970s has been to reclaim land in the aligning eastern and western deserts for both agricultural land as well as for housing and industries. The extension of existing canals or the excavation of new ones brings water to the delta's edges The Nubaryia Canal to the west as far north as Lake Maryut, the extension of the existing Ismailiya Canal to irrigate 310 km^2 on the east side of the Suez Canal and a giant new canal known as El Salam Canal constructed eastwards from the Damietta branch over a length of 240 km will be combined with the discharge of the Bahr–Hadrus drain. This canal will eventually bring water to nearly 2,500 km^2 of land south of Lake Manzala and along the Mediterranean coast on the east side of the Suez Canal (see figure 2).

With the incentive of providing additional infrastructure and job opportunities, the national strategy for the delta continues to be expansion into the desert, which makes up 96 per cent of Egypt. The delta population is to be diverted to the existing desert cities Sadat City, Nubaraia Gedida, 10th of Ramadan, as well as the desert hinterland east of Bilbis (see figure 2). Existing new urban communities in the delta could host roughly two-thirds of the 10 million new inhabitants expected by 2020, while another 4 million can be accommodated in the northern delta and the coastal zone, which has some undeveloped areas (GOPP, 2008). Looking for alternative expansion sites, further capacity may be allocated in the market-driven vacation home developments along the northwestern coast where the revolution has left building skeletons and vacancies. These provide a potential yet untapped for development if adapted to sustain the projected sea-level rise.

Between now and 2050, using underground irrigation systems, 8,000 km^2 with an expected population of 15 million are to populate the desert (CAPMAS, 2006). But 'New Urban Communities' are not attracting the number of people expected. The lack of public transport, lacking densities that would enable low-income jobs and the failure to supply affordable housing for the majority of the population may be seen as the main reasons for poor results in the residential sector. Although large-scale public housing programmes have been launched in the past decades, inefficient distribution, missing financing models and the failure to include retail and commercial uses in housing developments means they have failed to meet the needs of a large part of the population. As of yet, desert cities target the automotive middle and upper class. For agricultural expansion into the desert, mechanized techniques such as piped irrigation systems are used in large-scale commercial farms. As capital-intensive corporate agricultural enterprises their only demand for labour is during harvest, making it a seasonal job that does not imply moving the family (see Sims, 2009).

Of the available 55.5 billion cubic metres of Nile water annually about 10 per cent is transformed into wastewater. Afforestation irrigated by sewerage treatment plants is being practiced on a large scale in the desert due to the availability of sufficient sewerage water and desert land. After basic treatment, sewerage water can be efficiently used as a resource for the production of wood, woody biomass and biofuel crops. Egypt produces over 6.3 billion m^3 of sewage water annually; 5.5 billion m^3 of this sewage water is sufficient to afforest over 650,000 hectares of desert land and to store over 25 million tons of CO_2 annually. Potentially, large-scale afforestation may also stimulate cloud formation, which might also result in rainfall that the country urgently needs (El Kateb and Mosandl, 2012).

Conclusions

Egypt is located in a semi-arid zone and its climate is characterized by hot dry summers and moderate winters with very little rainfall. Egypt relies on the Nile River as its main and almost exclusive resource of fresh water to meet the increasing demands of agricultural, industrial, and domestic sectors. With about 95 per cent of the population (84 million in 2012) living in the Nile Valley and Delta, any changes in water supply due to climate change, with the certainty of increased demographic pressure, will pose a serious national risk. Therefore adaptation measures need to be systematically incorporated into the design and implementation of national development plans, poverty reduction strategies, rural development plans, and sectoral policies and strategies. Yet, even when climate change is mentioned, operational guidance on how to take it into account is generally lacking (Nour El-Din, 2013).

Currently, Egypt is struggling with its political situation and future. The success of democratic development, a prerequisite to local empowerment, relies strongly on socioeconomic development, education and employment opportunities especially for young Egyptians, be it in the delta or in the desert. Local empowerment is also mandatory if conditions requiring urgent action are to trigger innovation enabling sustainable management of resources. Innovation regarding land use has not been a strategy of previous regimes (El Kateb and Mosandl, 2012). While adapting to climate change demands an iterative, long-term approach (e.g. ECIDSC and UNDP, 2011), current practice is lacking any substantial responsive capacity. Faced with urgently needed structural reform at a time of political instability and, consequently, lax enforcement, accumulative small-scale adaptation strategies could enable community-based developments. If government institutions supported by NGOs and the private sector were to tap into the capacity of the people, i.e. self-help, for which the Egyptian people have a proven track record, such developments could be achieved at the local scale.

While the threat of land loss in the delta due to urbanization exceeds the expected loss due to sea-level rise, both justify expansion strategies into the desert to spare fertile land. Urban expansion on the desert fringes will only provide alternative settlements for the delta inhabitants if they are capable of providing affordable housing and public transportation as well as adequate job opportunities. In the light of ecological development, with water scarcity as a prime parameter, the desert cities require concepts that capitalize on the specific landscape qualities instead of neglecting them. If social, economic and environmental conditions in need of urgent attention are really capable of triggering innovation – a statement that still awaits proof in this region – Egypt could become a frontrunner in many areas. Sustainable desert urbanism is such a field.

NOTES

1. Including Cairo, see Tamburelli and Thill (2013).

2. The oldest intact settlement found to date is present-day Merimde Beni Salama, about 50 km northwest of Cairo, which dates to 3800 BCE, almost six centuries before the legendary Menes unified Upper and Lower Egypt.

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