THE EFFECT OF THE CURRENT NILE CRISIS ON GREATER CAIRO WATERFRONT

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ABSTRACT

The Nile is the backbone of urban development in Egypt. Besides, it plays an essential role in the urban development of the Greater Cairo. Unfortunately, regional threats have arisen recently from the upstream states where the Nile flows. The individual plans of these states to establish projects on the Nile without coordination with downstream states will result in catastrophic consequences. Many research works have been undertaken to identify the impacts of such projects. They have mainly focused on the future availability of water, the impacts on hydroelectric power and the socioeconomic consequences. Despite its importance, no research work highlights the impacts on the urban development in Egypt. Therefore, this research addresses the important question of how the Greater Cairo Metropolitan Core will be affected by the Nile crisis. Specifically, it discusses the effect of the current crisis on the waterfront in Greater Cairo. It predicts the impacts that can be expected as a result of the various scenarios of the crisis. Putting aside any political issues, this paper highlights the future of urban development in the Greater Cairo and its ability to thrive in the era of a Nile water crisis that seems likely to persist for a long time.

Keywords: River Nile; Nile crisis; Greater Cairo Metropolitan Core; waterfront; riverbanks.

1- INTRODUCTION

Waterfronts offer a great opportunity for city planning. As an attractive zone in a city, it plays important environmental, economic, and urban roles. The loss of such a waterbody to a city is regarded as a very significant challenge that threatens the life of that city. The Greater Cairo Region (GCR), which is one of the world's most famous metropolitan areas, was developed on the banks of the Nile. Throughout history, the Nile has played an essential role in the development of the urban fabric of the region. Many important land uses are located at the waterfront (Mouad 2006). Riverine social and sports clubs, hotels, restaurants and gardens are all important recreational land uses in the city and the region. In addition, the water-body of the Nile that exists within the region is considered to be the largest open area in a very dense urban fabric. Its effect as a lung of the region is very important in generating fresh air. Unfortunately, these important roles are endangered and the disappearance of the entire existing waterfront is threatened. Recently, some of the upstream countries have decided to take unilateral actions and have started to establish projects on the Nile, regardless of the effects on other riparian countries, especially the downstream ones. The current Nile crisis started when Ethiopia, one such upstream country, adopted a plan to build four dams on the Nile. It has already started to build the largest one, the Grand Ethiopian Renaissance Dame (GERD). All this has been done without any form of coordination or reassurance about its risks or negative impacts or a guarantee of other countries' rights to the Nile. Given that Egypt has no other real fresh water resource besides the Nile (Abd-elhaleem and Helal 2015 - Bottoms 2014), this is a great challenge to the life of Egyptians. All governmental, academic and other related parties are principally focused on studying the impacts of such dam projects on the availability of fresh water, the future of the agricultural sector, the

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efficiency of hydroelectric power generation from the Aswan High Dam and, of course, the economic consequences. Unfortunately, these studies have disregarded the impacts on the urban development of Cairo, the nation's capital, important metropolis of the Middle East and Africa, and one of the main regional centers. To understand the importance of this issue, it is sufficient to imagine how Cairo would be without the river Nile running through it.

The present research is mainly focused on addressing the possible impacts on the urban development of the Greater Cairo Metropolitan Region (GCMC) of the individual projects on the Nile in the countries upstream. To achieve this, two objectives are addressed. The first is the identification of the possible scenarios of change in the flow characteristics of the Nile as a result of the construction of river projects in upstream countries. The second objective is to analyses the consequences of these scenarios on the waterfront of the GCMC.

It is worth highlighting that the scarcity of technical data regarding the upstream countries' projects has resulted in a situation of considerable uncertainty. This vagueness allows an almost unlimited number of scenarios for the flow of the Nile during the construction and subsequent operation of these projects. Thus, to achieve the first target of this research both quantitative and qualitative approaches are required. The quantitative approach is crucial for the numerical estimation of impacts on the Nile's water levels, flow speed and water quality. In this respect, the research uses the results of research work in the hydrology field. The qualitative approach is important in identifying the possible changes to the waterfront zone that arise in consequence.

The research starts with a literature review that introduces the essential role of the Nile in the urban development of the GCR, before discussing the emerging Nile crisis. After this, the expected scenarios for altered Nile flow are presented. The third part of the research analyses the impacts of these scenarios. In addition, it discusses the consequences of these impacts on the waterfront zone of GCMC. Finally, the research proposes a preliminary framework for regeneration plans for the Nile waterfront in the GCMC during this era of Nile crisis.

2- LITERATURE REVIEW

In the 5th century BC, Herodotus, a famous Greek historian, described Egypt as the gift of the Nile (Zahran and Willis 2009). The great role of the river Nile in both civilizing and developing Egypt throughout its history is well acknowledged. Despite its relatively limited water volume, this river is considered the most important in the world (Simonett 2012). Since the dawn of history, the Nile has nurtured the civilization and the development of human community in Egypt.

2-1- The backbone of urban development in Egypt

Egyptian life has always relied on the flooding cycle of the Nile (Echols and Nassar 2006). That is why most Egyptian cities, especially the largest ones, are located in the Nile Valley. As of 2006, Egypt had 201 cities in which a total of 31.1 million urban inhabitants lived (City Population 2006). Of these cities, 157 are located within the Nile valley and delta, with a total of 27.7 million inhabitants, and 57 of these cities (including the state capital and the capitals of many Egyptian governorates) are located on the banks of the Nile and have Nile waterfronts. These cities have 20.9 million inhabitants. As a result, the Nile could be described as the backbone of urban life in Egypt.

2-2- GCR waterfront evolution

Historically, the city of Cairo did not overlook the River Nile until the period of Khedive Said Pasha in the second half of the 19th century (Salheen and Attia 2003). In 1876, inspired by Baron Haussmann's work in Paris, Khedive Ismail decided to reconsider the urban planning of the city of Cairo (Paraskevas 2011). He commissioned Ali Pasha Mubarak to develop the city's urban fabric (Serag 2013) and hired Pierre Grand, a French civil engineer, to create the plan (Al-Sayyad 2011). This was the first time an urban plan had been made for Cairo. This plan was called 'Oriental Paris' and targeted 750,000 inhabitants (Soliman and Shraf El-Din 2000). The plan was mainly focused on developing a new city quarter on the lands between the existing urban fabric and the Nile waterfront (Arnaud 1993). It was called the Ismailiyya Quarter and imitated European urban fabric for the first time. As a result, Cairo became known as 'Paris on the Nile' or 'the Paris of the Middle East' (Argaman 2014). By analysing the original Pierre Grand plan of 1874, it is clear that this urban

development granted the city of Cairo for the first time a Nile waterfront on the eastern bank of the river, two kilometers in length.

The last decade of the 19th century witnessed the start of the urbanization of the Nile islands. Urban development started to take place on the islands of Zamalek and Rowda (considered as western extensions of Cairo) and this required the establishment of three new bridges besides the Kasr-Elneil Bridge that already existed (Herzog et al. 2010). At the turn of the 20th century, three further extensions of Cairo took place. Two of these extensions were towards the river: the Garden city district to the south and the Bulaq-Abulela district to the north (The Aga Khan program for Islamic Architecture 1984). Urban extensions on the western bank of the Nile started in the second quarter of the 20th century when parts of the Giza and Dokki quarters were developed. These created the western waterfront of the GCR (Salheen and Attia 2003).

The third quarter of the 20th century witnessed the development of three more important extensions: Helwan to the south, Shubra-El-Kheima to the north and Imbaba to the north-west (The Aga Khan program for Islamic Architecture 1984). These extensions added long stretches of Nile waterfront to the city, giving Greater Cairo its complete waterfront of today. In addition, the eastern waterfront witnessed notable modern-ization work. This involved establishing modern buildings and towers that are overlooking the Nile. As a result, Cairo was described as 'Manhattan on the Nile's (Abeck 1967). At the turn of the fourth quarter, urban development was directed to the east–west corridor on desert lands (Soliman and Shraf El-Din 1999 - Abdel-Kader and Ettouney 2009) as part of a new cities programme, instead of the north–south corridor that already extended on the Nile banks for a length of more than 30 kilometers.

2-3- Current status of the GCMC waterfront

Within the boundaries of the GCMC, the river Nile extends for 45 kilometers (Sami 2011). It creates a natural boundary between the Cairo and Shubra-El-Kheima cities to the east and Giza city to the west. The river course includes seven main islands with large areas, in addition to a group of other smaller islands. The gross width of the river course varies between 250 meters, at Tora district, and 2300 meters at Dahab Island. Including both mainland and island waterfronts, 105 kilometers of Nile waterfront can be identified. This includes both west and east banks in addition to the islands fronts. Nine main bridges span both sides of the river and play a crucial role in urban mobility in the GCMC. A group of main roads run parallel to the Nile's edge, either on the mainland or the islands. As a result, the waterfront zone can be divided into two main longitudinal parallel bands. Band one is the river floodplain. This is a strip of land that is located directly on the riverbank and is bounded by the parallel road which forms the other side. It is a low, wide strip of land, which is higher than the water level by around two meters (Kondolf et al. 2012). Band two is the strip of land that is located beyond the road. Bandone's width varies between two meters, where the road directly adjoins the river, to approximately 500 meters. The urban use of each band is clearly differentiated according to the width and elevation of its lands (Hammam 2014).

2-3-1- Land use

In terms of the waterfront of the mainland and the urbanized islands, a wide range of land use exists (El-Hosieny, Hassan and AbdElrahman 2010), which includes commercial, educational, religious, administrative, entertainment, cultural, open space, plant nursery and residential uses. In addition, other land uses are also existed such as industries, logistics, and utilities (Sami 2011). Residential land use exists for a range of income levels. As a result, the GCMC waterfront has strategic roles to play in Cairene life that are not limited to entertainment and touristic activities, but extend to daily life activities for many of differing income levels. Important hospitals, famous hotels and restaurants, banks, embassies, office buildings, many riverine social clubs and key governmental offices are all located along the waterfront. This makes the waterfront one of the most important destinations for both the local community and visitors. The waterfront has many berths that service boats, yachts and ferries in both leisure and passenger transport activities(Sami A. 2006), and docks also exist for the transport of freight and ship maintenance. In addition, a variety of floating structures and tethered ships are located on the Nile banks to provide, in the main, entertainment

activities (Sweidan 1997). There is no coherence in existing land use between the two opposite waterfronts of the Nile in the GCMC (Hammam 2014). However, it could be argued that most hotels, clubs, office buildings, and governmental activities are concentrated at the centre of the riverfront and decrease to the north and south. Finally, it is noteworthy that the current GCMC waterfront has both planned and unplanned areas (Kondolf and Pinto 2016), although some islands, such as Dahab and El-Warraq, have still not been urbanized or else have only limited, informal urban areas.

2-3-2- Accessibility

In GCMC, three main types of river access can be identified. These are free access, access via charges, and private access. The first type, free access, offers public access to the Nile's banks without any financial or categorical restrictions (Kondolf et al. 2011). This type exists in limited, small locations in the GCMC, accounting for only 15% of the riverbanks (Herzog et al. 2010). The second type, which is access via a charge, is the most common one along the river. A lot of river-based social clubs, boat clubs, and restaurants occupy large areas on the riverbanks.

They offer public or graded access through charges that vary widely by amount. These charges may take the form of a membership, an entry fee or patronage. The third type is the private access that restricts access to the Nile's banks to particular groups (Mouad 2006). Some residential, administrative and entertainment activities also effectively restrict access to the Nile.

2-3-3- Connectivity

Visual connectivity to the river represents an important benefit of the Nile. Sometimes, it is a substitute for limited physical access to it. In general, visual connectivity is only available along some sectors of the waterfront (Mouad 2006). Bridges and flyovers play a very important role in offering this connectivity (Nassar, Fathy and Saleh 2013). Other sectors of the waterfront are visually disconnected due to the existence of visual barriers that range from high-rise buildings to dense plantations (Kondolf and Pinto 2016 -Aly 2008). Permanently moored ships and floating structures that are used as restaurants, cafes and social clubs also prevent visual connectivity with the river.

2-4- Future development plans

Due to its strategic importance, the Nile waterfront is included in many future plans for urban development that are proposed by either governmental agencies or research bodies. One of these plans is the Greater Cairo Urban Development Strategy (Cairo2032). It is an urban development strategy that is proposed by the Ministry of Housing, Utilities and Urban Communities and the United Nations Human Settlements Programme. The strategy addresses the waterfront as one of the urban sectors of the GCMC, where it mainly targets the development of hotels, and administrative and recreational land use on the vacant sectors of the waterfront, in addition to upgrades of the other waterfront sectors (Ministry of Housing, Utilities and Urban Communities and United Nations Human Settlements Programme 2012). River transport facilities are also proposed in this plan.

Another plan is Vision of Cairo 2050, which was based on the participation of various stakeholders. This plan devoted the Nile waterfront to administrative, services and touristic land uses. Many skyscrapers were proposed to create a new skyline for the waterfront. In addition, the issues of non-motorized transport, the alleviation of traffic congestion along the Nile and the expansion of green areas were all addressed (General Organization of Physical Planning 2010). In terms of the undeveloped islands, the 2050 vision described the establishment of mixed-use (entertainment, residential and services) districts on them. It is notable that this vision did not adopt river transport as one of the mobility modes for the city’s future.

The Ministry of Tourism, in collaboration with Cairo University, proposed a comprehensive master plan for the Nile waterfront in the GCMC in 2005. This mainly involved a plan for the GCMC waterfront that depended on retaining the current urban land use, preventing new services and government activities, upgrading the river transport network, upgrading the motorized transport network, and creating recreational green longitudinal corridors (Urban Research and Studies Consultation Center 2005). On the other hand, a partnership in 2011 between Cairo University, the American University in Cairo and the University of California proposed a development plan for the central sector of the Nile waterfront in the GCMC.

The plan was entitled Connecting Cairo to the Nile: Renewing Life and Heritage on the River. It recommended the establishment of a longitudinal, non-motorized (cycling and walking) corridor along the waterfront, improving cross-connections between the waterfront and the surrounding districts, and developing the undeveloped islands for recreational and mixed uses (Kondolf et al. 2011). In addition, it emphasized the importance of river transport.

It is notable that none of the future plans for the Nile waterfront gave any consideration to the risks that Egypt in general and the GCMC in particular would face as a result of a major change in the Nile, such as the current crisis that may threaten not only the waterfront but also the entire surrounding urban settlement. Most of these plans focused on how to utilize the waterfront for touristic and entertainment activities ignoring any possibility of losing the value of the Nile.

3- NILE WATER CRISIS

The crisis of Nile water that blew up recently is a complicated, multifaceted, and multilateral affair. Many regional and international parties are involved and have roles to play. In order to engender a better understanding of the potential consequences of this crisis, some pertinent facts about the region should first be established.

3-1- Background to the Nile basin region

The following are some important facts about the Nile basin region:

* As the world's longest river, the Nile is an international river and crosses the borders of more states than any other river in the world (Tadesse 2007). The Nile basin is a region that extends into eleven nations: Burundi, DR Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania and Uganda. This means that all of these countries have rights to Nile waters and this requires efficient management of Nile waters that is based on both coordination and cooperation between these states (Hassan and Al-Rasheedy 2007 - Veilleux 2015).

* The configuration of the Nile basin is unique because it is characterized by alatitudinal wetness gradient (Camberlin 2009). There is a clear gap between upstream and downstream states in terms of precipitation rates. These range between 435 and 1449 mm/year in upstream countries, while in downstream countries the range is just 19 to 487 mm/year (Food and Agriculture Organization 2011). In addition, Nile water-dependency ratios range between 77.3 and 96.6% in downstream countries, versus 0 to 68.2% for upstream countries (Karyabwite 2000). This means that upstream countries typically have other sources of fresh water but the downstream ones have far fewer, if any, alternatives to the Nile. Finally, water availability also demonstrates a clear gap as some Nile countries are now below the water poverty line: per capita water availability scores for Rwanda, Egypt and Kenya are 610, 790 and 930 m3/person/year, respectively. In contrast, other Nile countries' water availability scores range between 1470 and 23,580 m3/person/year (Abtew 2013).

* There is a clear disparity between the riparian states in terms of socioeconomic characteristics. Distribution of people along the Nile is unequal. Egyptians alone account for 34% of the Nile basins population. Some other states, such as DR Congo and Eritrea, each account for only 1% (Nile Basin Initiative 2012). The Human Development Index ranges from a maximum of 0.690 (Egypt) to a minimum of 0.391 (Eritrea) (United Nations Development Programme 2015). Similarly, gross domestic product (GDP) also bears witness to great disparity. Egypt records the highest GDP at US$10,733, while DR Congo records a GDP of less than US$500(Nile Basin Initiative 2016).

3-2- Start of the crisis

Two principal events that took place in 2011 have sparked the current crisis on the Nile. The first was the signing of a new quota agreement by one group of the riparian states without the approval of the others. This was the Antibi (or Entebbe) agreement (Bakr 2012). The second and more important event was the unexpected declaration by Ethiopia that described the start of construction of a mega-dam on the Blue Nile (N?ss 2015). This is called the Grand Ethiopian Renaissance Dam (GERD) and its pronounced purpose is solely the generation of hydroelectric power (Bayeh 2015). However, GERD is only one in a group of four dams that Ethiopia proposes to construction the Blue Nile (Tawfik 2015).

It is noteworthy that the timing of these two events was concurrent with a very critical period in Egypt, the Arab Spring revolution (Kılıç 2014).

Furthermore, these two events effectively overrode already existing agreements and treaties relating to the Nile basin (Yihdego 2013), as well as overriding the cooperation and coordination principles of international river management. As this article is being written, the construction of GERD is almost complete and the reservoir filling process has already started, without the emerging crisis having been resolved.

3-3- Main framework of the crisis

Three main issues characterize the current Nile crisis. These issues are unilateral decision-making, lack of information and foreign interventions. These issues create a very unclear situation that is full of uncertainties, especially for downstream countries. The first issue appears in the unilateral decisions taken by one or more of the upstream countries concerning the Nile's flow (Tadesse 2007). This behaviour is totally at odds with the international principle of cooperation and coordination between riparian countries. Unilateral decisions can result in sudden and unexpected impacts on other riparian countries, significantly affecting life in those countries.

The second issue, lack of information, is similarly crucial. In this instance, the unilateral actions have been accompanied by the withholding of related information. This has resulted in a very serious situation as it prevents other riparian countries from accurately assessing and responding to these unilateral decisions, and much important data has still not been made available (International Panel of Experts 2013). Furthermore, the technical data relating to GERD has not only been made available to downstream countries, but has also been withheld from the specialist panel formed upon agreement between Egypt, Ethiopia, and Sudan (Abdelhady et al. 2015). The reason for the information scarcity may either be a decision by the Ethiopian government to withhold information, or be that this data really is unavailable due to insufficient analysis. Either way, the result is potentially disastrous. Withholding information is likely to mean that the project has negative impacts, while poor analysis and consultation indicates the neglect of other riparian countries' rights.

The third issue, foreign interventions, has further increased the complexity of the crisis. Many regional and international countries are playing either passive or active roles in the crisis to achieve their own ends, regardless of the rights of the local riparian countries affected (Whittington, Waterbury, and Jeuland 2014). Overall, the future of downstream countries, especially Egypt, can be correctly described as under an ill-defined but very serious threat that may radically affect their lives, not least because GERD does not represent sustainable development (Swanson 2014).

4- EXPECTED SCENARIOS OF NILE WATER FLOW

In order to discuss the effects of the Nile crisis on the GCMC waterfront zone, it is important to identify the possible consequences on the Nile flow that might result from GERD's construction, the filling of its reservoir and its ongoing operation. Unfortunately, as a result of unilateral action accompanied by a lack of information, and the already well-known complexity of the Nile basin, it is hard, and perhaps impossible, to settle on a list of certain consequences. Instead, there are a group of expected scenarios that vary in their base information, use of modelling tools and consequent results. This part of the research will briefly introduce the principal scenarios expected for the Nile flow as a result of the Nile crisis.

Three main factors relating to GERD will affect the flow of Nile water. These factors are:

1- The operational framework. If the dam's function is only to generate hydropower, as declared, then the Nile's flow will be reduced but will at least flow at a consistent rate in order to drive the power-generating turbines. On the other hand, if the dam is used for irrigation purposes, as predicted by some research (Tawfik 2015 - Hammond 2013 - Zeydan 2006), then the flow will be highly reduced as larger amounts of water, which may also vary according to agricultural season, are extracted throughout the year.

2- The filling process. This is the most important and complicated factor. As a result of the large volume of the GERD reservoir, a rapid filling process may lead to huge reductions in Nile flow, especially in the drought seasons (Schoeters 2013 - Ramadan, Negm, Smanny and Helmy 2013 - Attalla 2015).

3- The structural safety of the dam. It is noteworthy that some research has confirmed the possibility of the dam's collapse due to either

earthquakes (N?ss 2015) or landslides (Batisha 2013). Such collapse would result in a sudden huge rise in Nile flow, with river levels increasing by up to three meters (Ahmed and Elsanabary 2015), which would inundate lands in downstream countries. It might also threaten the safety of other dams such as the Aswan High Dam and some in Sudan.

Different scenarios of Nile water flow have been proposed by specialists. These scenarios vary according to filling rates, initial baselines and the modelling and simulation tools used. According to these scenarios, the minimum expected discharge rate at GERD will fluctuate between 28.9 and 44.4 billion cubic meters (BCM) per year (Mulat and Moges 2014 - Abdelhaleem and Helal 2015). Given that the average historical discharge rate at the GERD location is 56 BCM/year (Mulat and Moges 2014), these minimum discharge rates represent only 52% and 79% of current Nile flow, respectively.

This decrease in discharge rates will mainly result in a lowering of water levels (Schoeters 2013) and a reduction in the velocity of water flow (Ahmed and Elsanabary 2015). The highest minimum GERD discharge rate of 44.4 BCM/year would decrease the Nile river level by between approximately 0.1 and 1.1 metres (Abdelhaleem and Helal 2015). Applying the same percentage suggests that the lowest predicted discharge rate of 28.9BCM/year would reduce river levels by up to 1.7 meters. In terms of water flow velocity, the median discharge rate of 36 BCM/year would reduce flow velocity by 42% (Ahmed and Elsanabary 2015).

In general, such downstream reductions in water level and flow velocity would result in many adverse impacts. The most important of these are a decrease in the production of hydropower (Tesfaye, Mersha and Wheeler 2016), a deficit in irrigation systems(International Panel of Experts 2013 - Ismail 2013 - Wu, Jeuland and Whittington 2016), an increase in the salinization of agricultural lands (The International Non-partisan Eastern Nile Working Group 2014), the disturbance and possible blocking of river navigation routes (Radwan and Hussin 2015), a reduction in the operational efficiency of other river infrastructure, changes to the physical properties of the water and increased pollution of water streams (Ahmed and Elsanabary 2015),and disruption of current sedimentation rates (Abdelhaleem and Helal 2015).

5- CONSEQUENCES FOR URBAN DEVELOPMENTOF THE GCMC

The reductions in fresh water volume and flow deriving from the Nile crisis will result in four main interrelated consequences for the GCMC. These are:

* Decreased water levels. This is the most important and obvious consequence as users would easily identify the receding of the river's waters from its banks. It would have major adverse impacts on the local community (Radwan and Hussin 2015).

* Increased sedimentation rates. As an alluvial river system, there are various sources (natural and artificial, regional and local) of sediments in the Nile (Ahmed, Sersawy, Vanacker and Ismail 2005). A decrease in flow velocity results in an acceleration of the sedimentation process. This principally affects the morphology of the river basin (both the riverbed and the riverbanks).

* Decreased water flow speeds. This is another impact of the decrease of water velocity. As well as enhancing the rate of sedimentation, it affects river navigation.

* Changed water quality. Because there are many man-made discharges (agriculture, municipal and industrial) into the Nile (Dumont 2009 - El-Sheekh 2016), reduced amounts of fresh water with the same volumes of these discharges will increase the relative concentrations of their components in the river and will result in a decrease in water quality as the percentage of pollutants increases.

Together, these consequences give rise to adverse impacts on three main levels: environmental, infrastructure operations and urban development. Figure (1) presents a flowchart illustrating the potential effects of the current Nile crisis.

5-1- Environment

Unfortunately, many agricultural, industrial, and municipal wastes are being discharged into the Nile (Bottoms 2014), either formally or informally. If accompanied by the same amounts of waste discharge, especially industrial discharge in urban centers (Abdel-Satar 2005), a reduction in the amounts of fresh water that arrive in Egypt in

general and the GCMC, in particular, will result in increasing the already high percentages of pollutants (Evans 2007) and lead to even more degradation of water quality (Wahaab and Badawy 2004). In addition, the slowdown in Nile flow will cause these pollutants to concentrate in the discharge zones. Thus, changes in the quality of the Nile's water (color, smell, etc.) can be expected. Figure 2 illustrates comparable cases of Nile pollution due to flash floods in Upper Egypt in 2016, which discharged soil, waste and other pollutants into the Nile. As a result, the Nile's color changed to brown for many days.

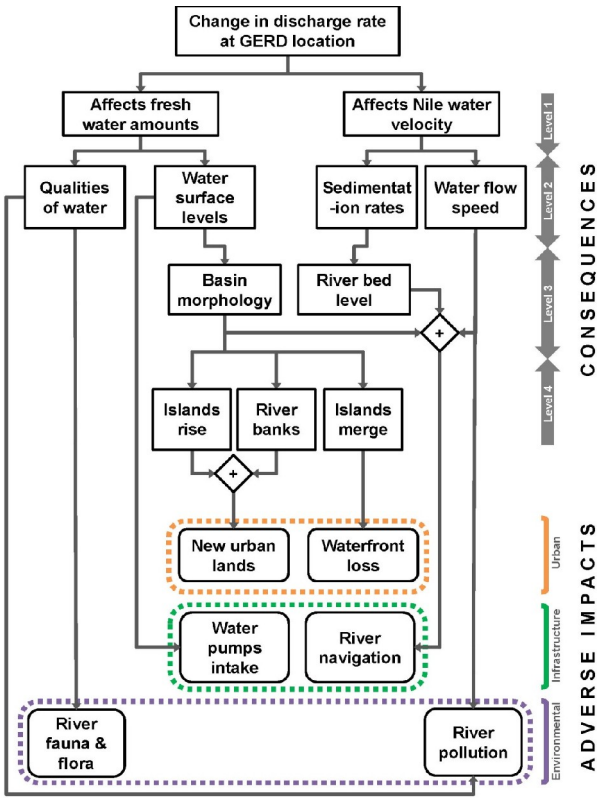

Figure 1: Chart of the expected consequences of GERD on the GCMC waterfront. Source: Researcher

In terms of aquatic life, decreases in water quality and changes to riverbed levels as a result of increased sedimentation will cause disturbance to the current status of aquatic fauna and flora. For instance, the water hyacinth plant, which grows readily in shallow waters, is likely to spread out and may obstruct river navigation (Elgohary 2012). Similarly, some species of fish may multiply while others will be forced to migrate to more suitable environments elsewhere (El-Sheekh 2009 - EL-Nemaki, Ali, Zeinhom and Radwan 2008).

Figure 2: The brown-coloured Nile resulting from flash flood discharges. Source: Researcher from Internet

5-2- Infrastructure operations

Two main municipal networks in the GCMC will be affected by the Nile crisis. The first is the river transportation network. This is due to both the reduction in water surface levels and the increase in sedimentation rates that raises the level of the riverbed. It is expected that the Nile riverbed will rise between 0.1 and 3.0metres in some zones due to disruption of the water flow(Sadek and Hekal 2008), meaning that the depth required for navigation will not be available in some sectors of the Nile basin(Ismail and Samuel 2011 - Raslan and Abdelbary 2001). Some existing facilities such as docks and berths will become too vertically or horizontally remote from a body of water sufficient for navigation. Furthermore, water levels will be lower than the inlet levels of the pumping stations that extract water from the Nile for the municipal water stations that feed the GCMC with fresh water (Radwan and Hussin 2015), and increased sedimentation will also result in deeper intakes becoming clogged (Elgohary 2012). In combination, these effects would render the operation of these stations insufficient for the fresh water needs of Cairenes in the GCMC.

5-3- Urban development

The impacts on urban development are more complex and multifaceted than those on environment and infrastructure. A reduction in water levels accompanied by changes in sedimentation

rates would change the morphology of the river basin and profoundly affect the urban development of the GCMC (Herzog et al. 2010). The vulnerability of the basin morphology results from the alluvial nature of the Nile (Raslan and Salama 2015). Three possible changes are expected to take place: the emergence of new islands, the merging into the mainland of some islands, and the expansion of riverbanks. The following section offers a brief discussion that illustrates how the river basin may change.

5-3-1- New islands

There are five main types of islands in the Nile valley in Egypt. These are permanent islands, principally bank-attached islands, under forming islands, seasonal islands and submerged islands (Sadek 2013). The GCMC sector of the Nile has both permanent and seasonal islands. In addition, some submerged islands also exist. With decreased water surface levels, these latter islands will rise above the surface, a process further exacerbated by sedimentation increases. Figure (3) illustrates the rise of such islands.

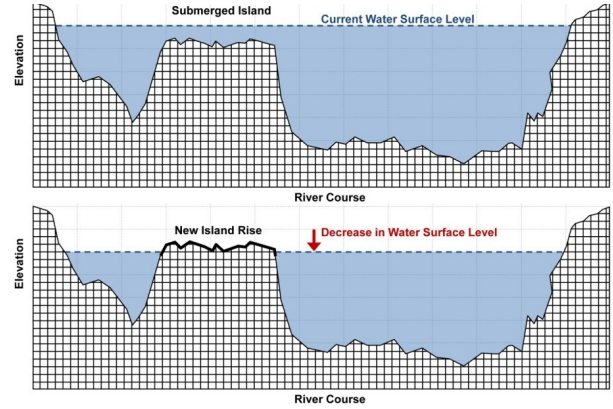

Figure 3: Schematic sectional views of the emergence of new islands in the course of the Nile. Source: Researcher

It deserves mention that Egypt has already witnessed the appearance of new islands as a result of constructing the Aswan High Dam (Radwan and Hussin 2015). In addition, the GCMC in particular has already experienced similar situations of submerged islands emerging during more extreme drought seasons. Figure (4) illustrates one such case that took place in the Nile in the heart of the GCMC.

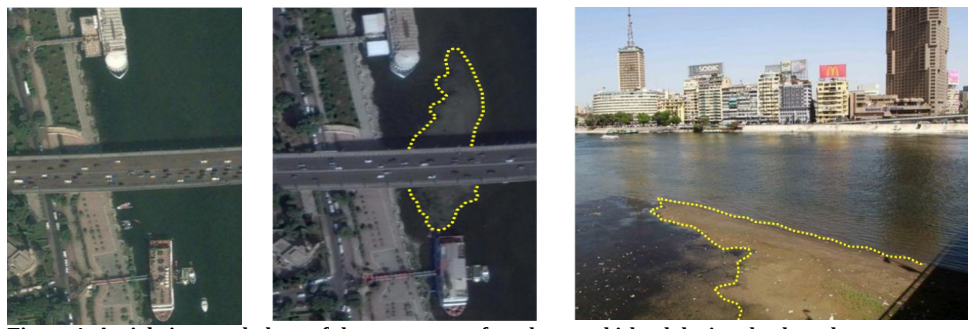

Figure 4: Aerial views and photo of the emergence of a submerged island during the drought season. Source: Researcher from Google Earth and Internet

Furthermore, the seasonal islands that typically only appear in certain periods during the year will be turned into permanent islands. Figure (5) presents an aerial view of one such case called Shubra-El-Kheima island, which is located in the northern part of the GCMC (between the districts of El-Warraq and Shubra-El-Kheima). These new islands will decrease the waterbody area in addition to creating new vacant lands in the densely urban fabric of the GCMC.

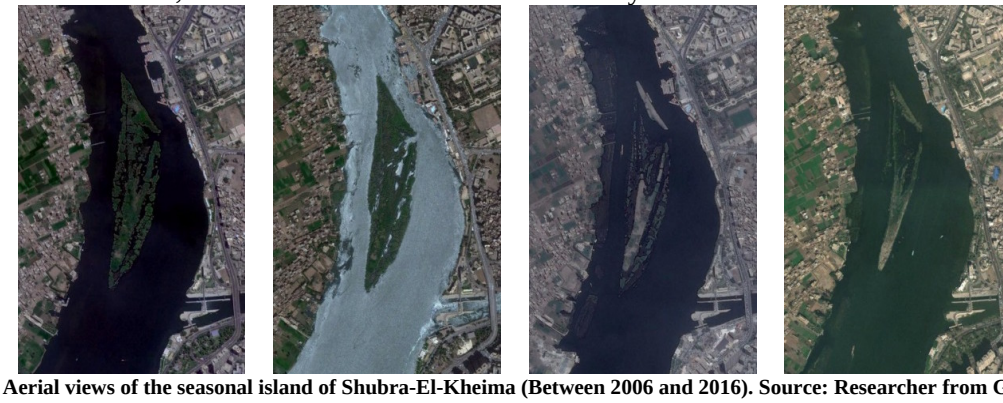

Figure 5: Aerial views of the seasonal island of Shubra-El-Kheima (Between 2006 and 2016). Source: Researcher from Google Earth

5-3-2- Merging of river islands

The increased sedimentation rates that will accompany a decrease in water flow speed will mainly affect the anabranches, narrow water bodies that divert from the main stream and separate existing islands from the riverbanks. Over time, these anabranches will fill with sediments, vegetation, and other solid particles, resulting in a reduction in their width (Raslan 2009) and eventually causing the islands to merge with the adjacent floodplain (Osterkamp 1998 - Ham and Church 2002). Again, it is noteworthy that many islands in the Nile merged with riverbanks as a result of decreased water flow following the construction of the Aswan High Dam (AHD) (Raslan and Salama 2015).Within the boundaries of the GCMC, three existing anabranches are vulnerable to such changes, currently creating the islands of Rowda, Athar-Ennabi and Qursaya. This will result in the loss of areas of waterbodyas well as significant lengths of waterfront on both the islands and the main riverbanks. Figure (6) illustrates the locations and forms of these anabranches.

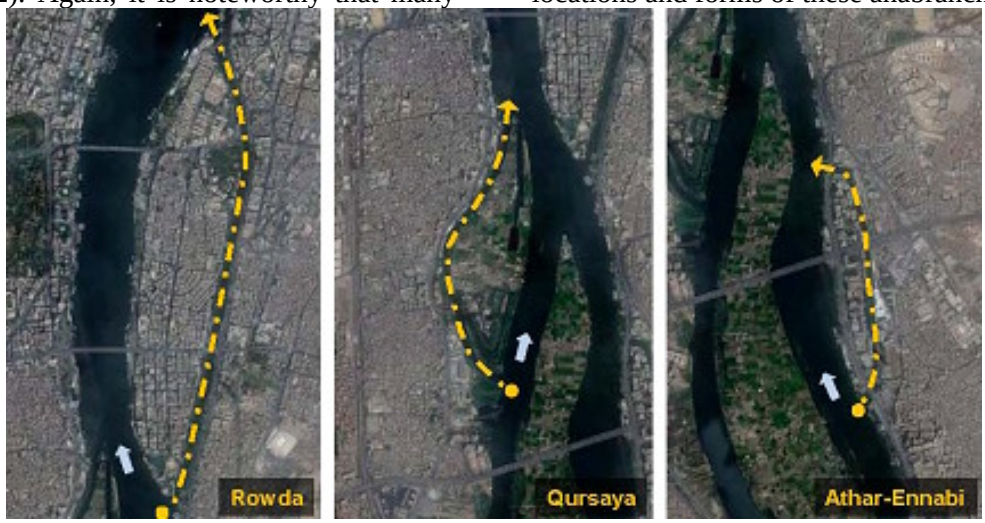

Figure 6: GCMC anabranches vulnerable to in filling by sedimentation and vegetation due to reduced Nile water levels/flows. Source: Researcher from Google Earth

5-3-3- River floodplain expansion

The impacts on the Nile's floodplains vary according to type: the Nile has many types of floodplain that are distinct in their form, slope, and components. However, two principal types can be identified: gently sloping floodplains and steeply sloping floodplains. Figure (7) presents a typical sectional view of each type.

In the case of steeply sloped floodplains, a decrease in water level will not result in any dramatic change to the floodplain width, but it will lead to increased visual separation between users and their view of the water. Figure (8) presents sectional views of the two different consequences expected as a result of the decrease of water level at the riverbanks.

It is also noteworthy that in some situations the familiar floating structures of the GCMC's Nile waterfront will be vulnerable to damage as a result of the large falls in water surface level in the gently sloped floodplains, as illustrated in Fig. (9 and 10).

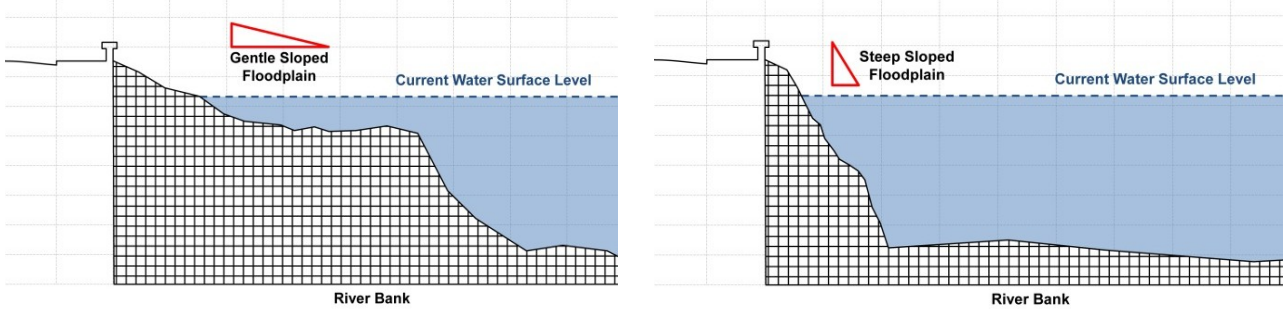

Figure 7: Sectional views of gently sloped (left)and steeply sloped (right) Nile banks. Source: Researcher

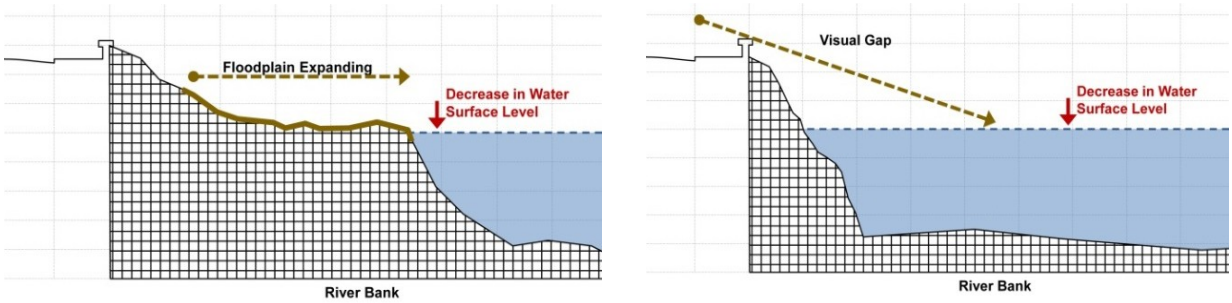

Figure 8: Sectional views of Nile floodplain expansion (left) and the increased visual gap between users and the Nile body (right) as water levels decrease. Source: Researcher

Figure 9: Hotel ship failure and sinking on the banks of the Nile. Source: Researcher from Internet

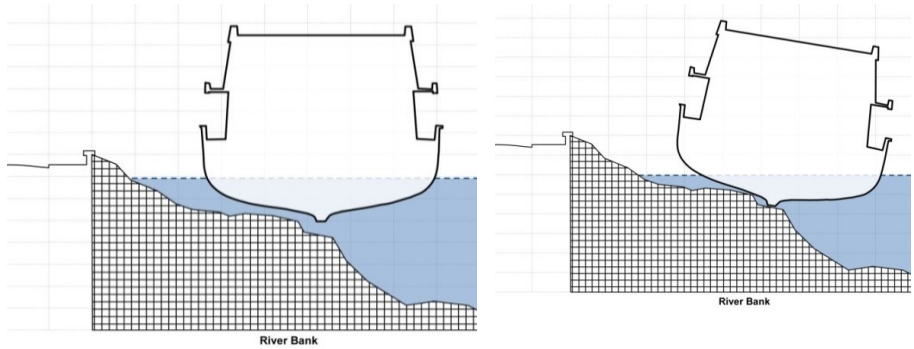

Figure 10: Sectional views of the current status of floating structures in some locations (left) and their potential capsizing due to reduction in Nile water level (right). Source: Researcher

6- EXPECTED THREATS

Based on all the potential changes described above, and dependent on the actual reduction in Nile flow rates associated with GERD, the GCMC waterfront is vulnerable to:

*** Unplanned urban growth** on the new reclaimed lands on the new islands and the expanded floodplains. The potential for direct physical and visual contact with the Nile is likely to encourage people to acquire plots and establish buildings on them as soon as possible.

*** Acceleration of urbanization** on the vacant areas of the undeveloped islands (such as Qursaya) due to the merger of the islands with the mainland, which facilitates their accessibility. This rapid urbanization would result in the loss of major green open areas in the heart of the GCMC.

*** Interference between informal and formal communities.** Currently, these communities are geographically adjacent but are separated by Nile anabranches (e.g. Imbaba and Zamalik). The disappearance of the anabranches would bring these communities into close proximity, with the likelihood of adverse impacts being experienced in the formal communities.

*** Deprivation of current waterfront lands of their direct visual and physical connection** with the waterbody, due to the rise of new reclaimed land at the riverbank.

*** Decline in the land value** of some current waterfront stretches as a result of their loss of visual connectivity with the Nile (i.e. no view).

*** Inefficiency for current water-dependent activities** (such as water sports centers and riverine clubs) and the need for relocation as a consequence of losing their direct water connection.

*** Loss of their distinctive Nile views by touristic destinations** (river-based clubs, restaurants, and parks) on the waterfront as a result of increased pollution and changes in aquatic fauna and flora.

*** Loss of floating structures** (hotels, restaurants, and homes) that are located at the shallow riverbanks. The decrease in the Nile water level, accompanied by variations in the levels of the riverbed, will result in damage to their floats and may even cause structures to sink.

*** Disruption of river transport routes** due to the rise in riverbed levels and changes in the morphology of the Nile basin, such as the emergence of new islands and expansion of the floodplains.

* Breakdown of docks and berths due to the changes in river transport routes and the rise in the Nile riverbed, especially in the shallower zones of the riverbanks.

* Failure of municipal water supply stations due to ineffectiveness and/or inefficiency associated with the current locations of pump intakes as water levels fall and sedimentation increases.

* Decrease of the waterbody area as a result of emerging new islands and floodplain expansion. This open area is currently considered the GCMC's lung that provides fresh air, and some adverse environmental impacts can be expected.

7- PROPOSED FRAMEWORK FOR GCMC RIVERFRONT REGENERATION

The current unique status of GCMC riverfront calls for a quite different framework of waterfront regeneration. This framework is totally different than what is adopted worldwide and what is being used in Egypt till now. The reason of that difference is that Nile waterfront in GCMC is currently being affected by not only internal factors but also external ones. This is the result of the current Nile crisis. One of the main external factors is the unilateral decisions by the upstream countries. These decisions are out of Egypt control. For the first time since 1970, the flow of the Nile in Cairo is not fully managed by the Aswan high dam. Now, other dams and projects take a role in that. As a result, the Nile status is no longer could be estimated or predicted accurately. This is a great challenge to any future plan of regenerating the riverfront in GCMC because it is impossible to set goals and suggest proposals for something that is not well defined.

The aim of the new required framework is to maintain the GCMC riverfront as a sustainable, liveable and functional backbone of GCR. This framework should adopt two main approaches. The first one is the adaptation approach. It mainly focuses on the external factors such as the sudden decrease of Nile water discharge at the upstream countries. These out of control factors are affecting the nature and flow of the Nile water. This requires adapting the regenerating plans to cope with these emerged factors in order to prevent any conflicts, interference, or collisions between the goals and the reality. On the other hand, the second approach is the mitigation approach. It sheds the light on the internal factors that are affecting the Nile. Many of these factors are being neglected in the current plans of developing the Nile riverfront. Such a mitigation approach will help in reducing the adverse impacts that are resulted from local factors like severe consumption of Nile water, accelerated unplanned urbanization, inappropriate use of Nile and low community awareness.

The framework should address some important issues that are related to the current context of the Nile. These issues are:

* The seriousness of unilateral decisions that are being taken by upstream countries concerning the Nile flow.

* The vagueness and uncertainty of the Nile future due to the lack of the technical information of the unilateral projects.

* The various socio-economic characteristics and different needs, requirements and ambitions of all Cairenes who have their own rights to the Nile riverfront. All these should be considered in the regeneration plans.

* The multiple roles of the river Nile in Cairo life that includes environmental, entertainment, trans-

portation, sightseeing functions in addition to fresh water and fish sources.

* The Nile in GCR is only a small portion of the Egyptian basin of the Nile. The rights of other cities and regions to benefit from the Nile should be reflected in the regeneration plans of GCMC riverfront.

The following recommendations should be considered while proposing the future plans of regenerating the riverfront in GCR:

* Continuous monitoring of the Nile water status locally and regionally.

* Preparing detailed scenarios of the expected adverse impacts of decreased Nile River surface levels.

* A priority is to be given to preserving both the Nile's course and its water quality.

* Establishing a unified administrative body to manage the urban development of the waterfront in the relevant sectors of the three governorates concerned. This is crucial and should guarantee coherent development of the entire waterfront across the region.

* Founding a firm legislative framework to manage and inhibit any informal urban reactions to the consequences of the adverse impacts that can be expected.

* Raising the community awareness regarding the Nile crisis and its potential impacts on the GCMC waterfront.

8- CONCLUSION

The Nile basin is one of the most complicated regions in the world, due to the clear disparities in the natural, social, and economic characteristics of its states. At the turn of the second decade of the 21st century, a sudden crisis in the Nile regions has been brought about by the decision of some riparian countries to utilize Nile water regardless of existing treaties and the rights of other countries. The construction of GERD was the first such decision.

Due to the current lack of clarity about the precise status of the crisis, which is full of uncertainties, the expected consequences of establishing and operating GERD are far from clear. A lot of scenarios have been proposed to try and establish these consequences, and most of them have agreed on the likelihood of a reduction in the discharge rate of fresh Nile water from the GERD location. Such a reduction will result in decreasing both the amount and the flow velocity of fresh water in the countries downstream of GERD.

As a result, the expected consequences are at the levels of the natural environment, infrastructure, and urban development. Increased pollution rates are the main consequence at the level of the natural environment, which will have severe impacts on aquatic fauna and flora. A decline in the efficiency of networks such as river navigation and water supply is the most important threat at the infrastructure level. At the level of urban development, three main consequences are expected: the emergence of new islands, the merging of existing islands with the riverbanks, and the widening of existing riverbanks. As a result, some sectors of the waterfront will lose their connectivity with the river, some new lands will be reclaimed and, if not managed efficiently, will become unplanned urban areas, and floating structures will be rendered vulnerable to severe damage and possible sinking.

These threats are severe and may be harmful not just at the level of the waterfront bands but also at the level of the entire metropolitan core of Greater Cairo. It is crucial, therefore, that the approaches to Nile waterfront development in the GCMC are subjected to profound change. Traditional approaches have been primarily based on proposals for new luxury developments at the riverfront that target touristic and entertainment activities. Instead, the new approaches to Nile waterfront regeneration must address the threats of the current Nile crisis at all levels. In addition, they should propose a range of development alternatives, each of which acts to address a specific scenario of the changes expected in the Nile due to the crisis. It is also recommended that an independent administrative body be established that has representatives of all Nile-involved governmental parties so as to unify the efforts of GCMC regeneration, improve their efficiency, and ensure that the capital of the 'gift of the Nile' is not lost to history.

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