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An integrated framework for urban resilience to climate change – Case study: Sea level rise impacts on the Nile Delta coastal urban areas

M.A. Abdrabo*, Mahmoud A. Hassaan

Alexandria Research Center for Adaptation to Climate Change (ARCA), Institute of Graduate Studies and Research – Alexandria University, 163 Horreya Avenue, Chatby, Alexandria, Egypt

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ABSTRACT

The Nile Delta is one of the most vulnerable areas in the world to sea level rise (SLR). Urban areas, located in the coastal area of the Nile Delta have been experiencing, over the past five decades, mostly unplanned rapid growth. Existing research work on the Nile Delta coastal urban areas focused only on their vulnerability to SLR inundation, with no work on the resilience of these urban areas. This paper, accordingly, intends on one hand to propose an integrated resilience framework for urban areas in general and to develop and apply an urban resilience index, incorporating relevant variables and inundation by SLR hazard aspect on the Nile Delta urban coastal areas. The application of this resilience index reveals that 11 out of the 18 urban areas are projected to be vulnerable to inundation under different SLR scenarios. Additionally, it was found that urban resilience is influenced on one hand the differences in scale of area and population vulnerable to inundation by SLR in each of these areas. Resilience is also influenced by their socioeconomic characteristics, environmental quality and scale of infrastructure and services provision, on the other.

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1. Introduction

Egypt in general and the Nile Delta in Particular, had during the past five decades experienced rapid population growth, from about 19 to 72 million. Urban population have increased, during the same period, from 6.4 to 31 million people, representing 34–42.6% of Egypt's total population (CAPMAS, 1978, 1988, 1998; CAPMAS, 2008). Such urbanization, in absolute number, was dominated by growth in Greater Cairo and Alexandria as well as small-to-medium size cities, mostly located in the Nile Delta that increased in size and number.¹

The Nile Delta coastal zone hosts 18 urban centers located in six different governorates namely Port Said, Damietta, Dakahlyia, Kafr El-Sheikh, Behaira, and Alexandria (Table 1). These urban centers cover total area of about 2879 km², of which 631.74 km² is built-up area (Fig. 1). These urban centers that had by 2006, an overall population of 6.4 million persons (CAPMAS, 2008) are creating, like most coastal urban areas worldwide, significant pressure on coastal environments and ecosystems through pollution and over-exploitation of natural resources (Grenon and Batisse, 1989; di Castri et al., 1990).

The Nile Delta is considered to be one of the most vulnerable areas to climate change and associated sea level rise (SLR) impacts. It was argued that the Nile Delta coastal cities, with the concentration of population, economic activities and

* Corresponding author.

E-mail addresses: mabdrabo@arca-eg.org (M.A. Abdrabo), mhassaan@arca-eg.org (M.A. Hassaan).

URL: <http://www.arca-eg.org> (M.A. Abdrabo).

¹ Generally, the designation of urban areas in Egypt is more about administrative decisions rather than any urban-related characteristics of the area.

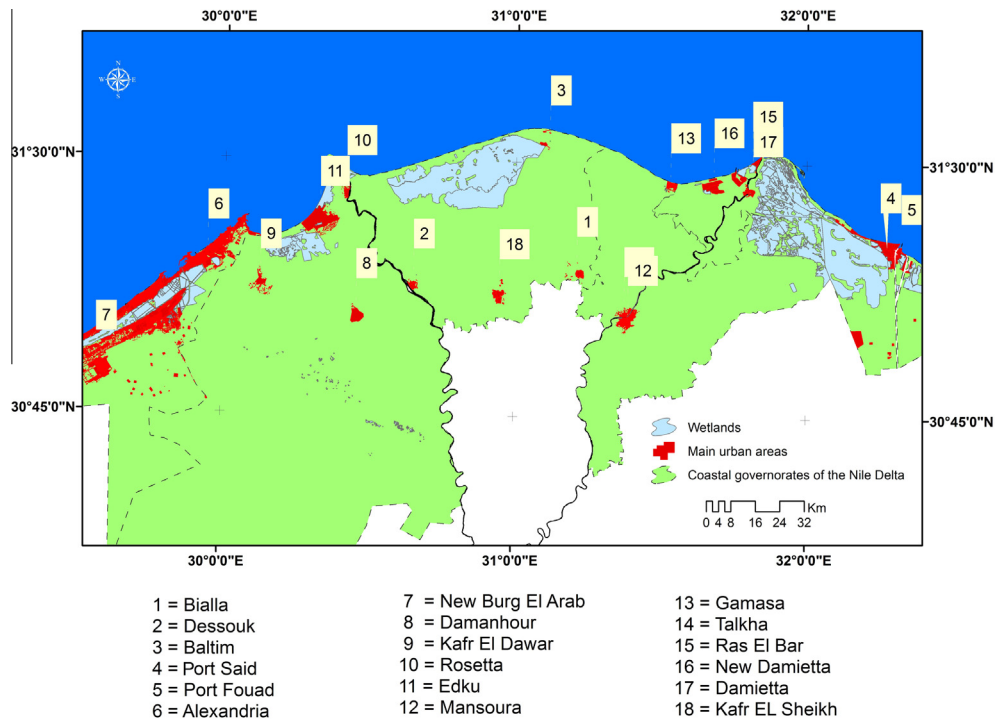


Fig. 1. The built-up area of main urban centers in the Nile Delta coastal governorates. *Source:* Prepared based on the developed GIS.

Table 1

Total and built-areas of the Nile Delta coastal urban centers. *Source:* Calculated from the developed GIS.

Governorate	City	Total area (km ²)	Total built-up Area (km ²)
Alexandria	Alexandria	1491.97	353.06
	New Burg EL Arab City	122.95	35.63
Behaira	Damanhour	16.31	13.66
	Edku	89.02	52.85
	Kafr El Dawar	28.87	7.33
	Rosetta	49.68	4.62
Dakahlyia	Gamasa	14.02	5.84
	Mansoura	27.47	13.85
	Talkha	11.23	4.24
Damietta	Damietta	14.94	7.45
	New Damietta	58.87	30.48
	Ras El Barr	21.11	4.76
Kafr El Sheikh	Baltim	32.75	2.39
	Bialla	39.78	4.68
	Dessouk	7.89	4.68
	Kafr EL Sheikh	19.83	10.26
Port Said	Port Said	832.23	59.65
	Port Fouad	560.69	16.32
Total		2878.91	631.74

infrastructure and services, are hotspots to such exposure (Milliman et al., 1989; El Raey et al., 1995, 1997, 1999; El Raey, 1997; Frihy, 2003; El Nahry and Doluschitz, 2010; Hassaan and Abdrabo, 2013). However, none of these previous studies have attempted to study resilience of these urban areas.

This paper intends on one hand to propose an integrated resilience framework for urban areas in general and to develop an index to assess resilience of urban coastal centers in the Nile Delta to inundation by SLR impacts, on the other. For this purpose, the paper begins with a discussion of the concept of urban resilience, in an attempt to develop a conceptual framework of such resilience. This is followed by developing an index for assessing urban resilience that thereafter applied to the Nile Delta coastal urban areas expected to be susceptible to the risk of inundation by SLR. Then, the results of the assessment is presented and discussed.

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