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ASSESSMENT OF URBAN COMMUNITY RESILIENCE TO SEA LEVEL RISE USING INTEGRATED REMOTE SENSING AND GIS TECHNIQUES

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ABSTRACT

Sea level rise (SLR) is closely linked to increasing global temperatures. Rising temperatures are warming ocean waters, which expand as the temperature increases. This thermal expansion was the main driver of global sea level rise for 75 - 100 years after the start of the Industrial Revolution, though its relative contribution has declined as the shrinking of land ice has accelerated. Alexandria is vulnerable to sea level rise risks, especially with its current high-density coastal communities and the rapidly increasing population rates. Most of the 's inhabitants are living in low-lying land and some are even below sea level. Moreover, Alexandria has been identified as one of the 'Mediterranean vulnerable cites'. This paper assessed the resilience of Alexandria to sea level rise risk, focusing on hazard assessment (inundation) as one of the most significant physical impacts. Resilience index to SLR for the ten-urban district in the study area is developed using vulnerable built-up areas, vulnerable population and socioeconomic conditions (represented in unemployment rate, annual population growth and Human Development Index (HDI). The results revealed that the resilience index ranged from "0" for low resilience and "1" for high resilience. The calculated resilience index indicated that urban districts in Alexandria had different levels of resilience to SLR impacts. Sharq district had the highest resilience that may be attributed to the relatively high HDI, availability of high levels of infrastructure and services in addition to the improved environmental and demographic conditions.

Keywords: ***Sea level rise (SLR); Urban; Resilience; Socioeconomic Conditions; Human Development Index (HDI).***

1. INTRODUCTION

Rising sea levels are expected to increase the risk of flooding, storm surges, and property damage in coastal cities and regions. Egypt is considered one of the top five countries expected to be mostly impacted with SLR due to low elevation in the Nile delta region (Sestini, 1989; El-Raey, 2010; Frihy, 2003; Batisha, 2015). Alexandria as the second capital of Egypt is built on a narrow and partially elevated coastal ridge facing the sea and is exposed to many environmental problems such as SLR, tsunami, earthquake and other hazards (El-Raey, 2010). Moreover, informal areas, which house one third of Alexandria's total population had a

deteriorating infrastructure in the old parts of the (Soliman, 1996). Fast urbanization over the reclaimed wetlands and other low-lying areas made the extremely vulnerable to these hazards. Furthermore, previous studies proved that Alexandria is one of the most vulnerable s to SLR because of its natural topography of flat and low land (El-Raey, 1995, 1999 and 2015). In addition to the rapid urbanization process and the increasing population growth in Alexandria that limit resilience and the capacity to cope SLR and put pressure on infrastructure and services.

IPCC, in its third assessment report defined resilience as the "amount of change or amount of pressure a system can undergo without changing state" (IPCC, 2007). A more detailed definition, provided by the AR5 of the IPCC defined resilience as "the capacity of a social-ecological system to cope with a hazardous event or disturbance, responding or reorganizing in ways that maintain its essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation" (Arctic Council, 2013). Onneshan (2013) defined resilience as the capacity of an individual or community to cope stress, overcome adversity or adapt positively to change. Dickson et al., (2012) and Mebarki et al., (2016) defined resilience as "the ability of a system to withstand or accommodate stresses and shocks such as climate impacts, while still maintaining its function". Onneshan (2013) defined resilience as a measure of how much disturbance an ecosystem can handle without shifting qualitatively into a different state and then classified resilience into ecological and social. Others defined resilience as the capacity of a system to both withstand shocks and to rebuild itself after damage. While, community resilience is the ability of human communities to withstand and recover from stresses such as environmental change, social and economic or political upheaval. Noy and Yonson (2016) refereed to resilience as what enables the exposed elements to withstand, cope and recover from disaster impacts

UKaid (2015) expressed risk as a function of hazard exposure, vulnerability and coping capacity (Risk = Hazard x Vulnerability / Resilience). According to Modica and Zoboli (2016), the logical sequence of pre-event, disaster and post-event situation are vulnerability, resilience as a pre-event, hazard، risk as a disaster. While, damage, and loss are considered post-event. In terms of disaster risk reduction priorities, vulnerability is typically linked to prevention, preparedness, and mitigation; while resilience, to rehabilitation, reconstruction, and recovery.

2. STUDY AREA

Alexandria is the second main in Egypt, located approximately between 30°50' to 31°40' north and 29°40' to 32°35' east. It lies northwest of the Nile delta and occupies a T-shaped peninsula with a waterfront that extends for 60 km from Abu-Qir Bay in the east to Sidi Krier in the west. Alexandria is bounded by the Mediterranean Sea in the north, Behira in the east and the south and Matrouh in the west as shown in Figure (1).

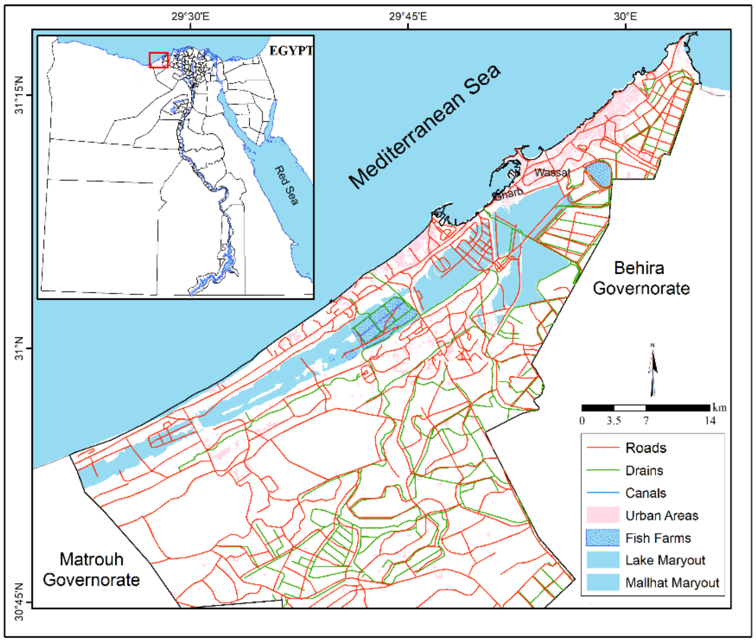


Figure (1). Location of Alexandria

Alexandria is extended in the longitudinal direction to accommodate the growth in population between the Mediterranean coast and Lake Maryout that gave the a semi rectangle shape with more than 30 km length and around 6 km width. Alexandria is an urban that includes Alexandria city, the new industrial town and Burg El-Arab district (GOPP, 2011). The current boundary of the urban agglomeration of Alexandria consists of ten districts including Al-Montazah-1, Al-Montazah-2, Sharq (East), Wassat (Middle), Gharb (West), Al-Gomrok, Al-Agami and Al-Amereya-1, Al-Amereya-2 and Burg Al-Arab. See Figure (2).

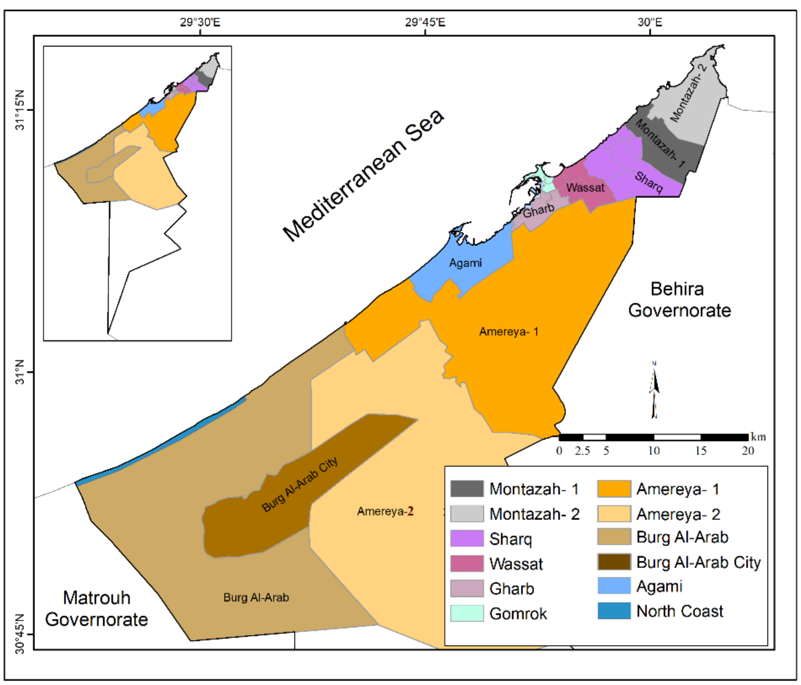


Figure (2). Alexandria urban centers and districts

Population census in Alexandria in 2017 was 4,989,756 according to CAPMAS (2017). The spatial distribution of the population was found to be rather uneven between the different districts of Alexandria, reaching its saturation level in many urban centers. The average rate of increase in the whole was 1.36%, the last census in each district of Alexandria population according to CAPMAS (2017) are given in Table (1).

Table (1). Census population (2015) and its distribution in Alexandria

District	Population	Rate of increase	Density (Capita/Feddan)
Montazah-1, Montazah-2	1,350,967	1.37	116
Sharq	1,131,604	1.26	578
Wassat	598,568	0.94	337
Gomrok	165,664	1.17	305
Gharb	439,876	1.54	278
Amereya-1, 2, Agami	968,771	2.23	9
Burg Al-Arab	85,144	2.77	25

Built-up areas of Alexandria are obtained from Soha (2017) and presented in Table (2) and Figure (3).

Table (2). Total and built-up area of Alexandria

Total Area (km^2)	Total Built-up Area (km^2)
1459.6	307

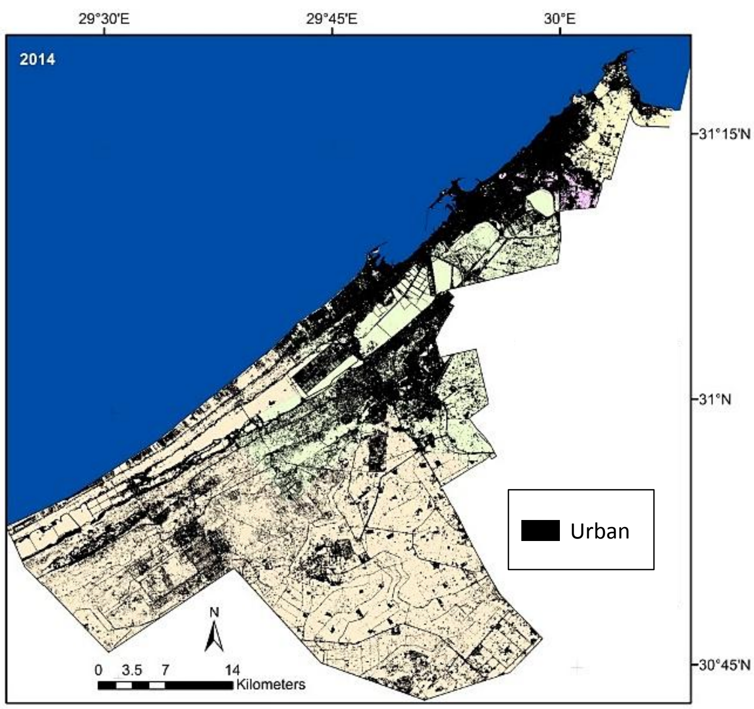


Figure (3). The built-up area of urban districts in Alexandria (2014)

The unemployment rate is ranged between 0.85% in Burg Al-Arab and 3.75% in Wassat (CAPMAS, 2017) as seen in Table (3).

Table (3). Socioeconomic conditions in Alexandria

District	Unemployment rate (%)	Population density (Person/km2)	Population annual growth rate (%)
Montazah-1,	3.3%	15453.6	1.7
Sharq	3.5%	26273.6	1.4
Wassat	3.7%	13897.5	1
Gharb	3.4%	10213	1.7
Gomrok	3.3%	3846.3	1.2
Amereya-1, 2, Agami	2.2%	22492.9	2.7
Burg Al-Arab	0.8%	1976.8	2.7

3. METHODS

Assessing of community resilience of Alexandria to SLR impacts was performed in four steps:

(1) Identify and calculate the required variables for determining urban resilience in Alexandria according to Table (4).

Table (4). Required variables to determining urban resilience in Alexandria

Characteristic	Variable
Physical Vulnerability	1. Built-up areas vulnerable to SLR proposed scenarios, 2. Vulnerable population to SLR proposed scenarios.
Socio-economic Conditions	1. Unemployment rate, 2. Population growth rates, 3. Human development index (HDI).

(2) The ASTER GDEM imagery was used to generate contour lines which were used as the elevation data. The elevation data was prepared in WGS 1984 (UTM Zone 35) coordinate system.

(3) Vulnerability of urban districts of Alexandria is assessed by the identification of the spatial extent of SLR impacts inundations using four proposed scenarios of SLR (0.5 m, 1 m ,1.5 m and 2 m) in addition to land subsidence.

(4) The inundation maps are overlaid on the population map of the Alexandria using GIS overlay analysis to estimate the vulnerable population.

(5) All variable (vulnerable built-up areas, vulnerable population, unemployment rate, annual population growth and human development index (HDI) are normalized using Equation (1) to obtain values ranging from 0 to 1.

$$Nx = \frac{(X - X_{min})}{(X_{max} - X_{min})} \quad (1)$$

Source: FAO (2016)

Where, Nx = Normalized variable

X = absolute value of the variable being normalized

Xmin = Minimum variable value

Xmax = Maximum variable value

(6) Calculate the resilience index to quantify community resilience of the Alexandria and integrate the different variables that determine resilience to SLR impacts. Six variables are integrated in the proposed composite index including proportions of built-up area vulnerable to SLR, vulnerable population and socioeconomic conditions (represented in unemployment rate, annual population growth and human development index (HDI) which reflecting health, education, income levels in the community).

(7) All previous variables are integrated into the resilience composite index using an using GIS weighted overlay analysis using Equation (2).

$$R = \sum_{Nx=1}^{Nx=n} \left(Nx \, \frac{1}{n} \right) \quad (2)$$

Source: Abdrabo and Hassaan (2014)

Where, R = Resilience index

Nx = Normalized variable value; n = Number of variables

(8) Resilience index is ranged between 0 and 1 reflecting lowest and highest level of resilience, respectively.

4. RESULTS AND DISCUSSION

The results are composed of three sections, the first section presented the results of the physical vulnerability to SLR inundation. In the second section the calculation of the human development index is discussed. The final section introduced the resilience index.

4.1. PHYSICAL VULNERABILITY

Physical vulnerability combined many factors including both of vulnerable built-up area and vulnerable population to SLR under four proposed scenarios.

4.1.1. VULNERABLE BUILT-UP AREA

For identifying susceptible areas to SLR, four scenarios are proposed 0.5, 1, 1.5 and 2 m. ASTER images with spatial resolution 30 m with elevation points collected from topographic maps in addition to ground measurements were combined together and used to carry out the analyses by extracting the areas that could be vulnerable to inundation. DEM were created using inverse distance weighted (IDW) interpolation technique as seen in Figure (4). The elevation of the study area is ranged from -4 m in Lake Maryout and 50 m above sea level in Burg Al-Arab.

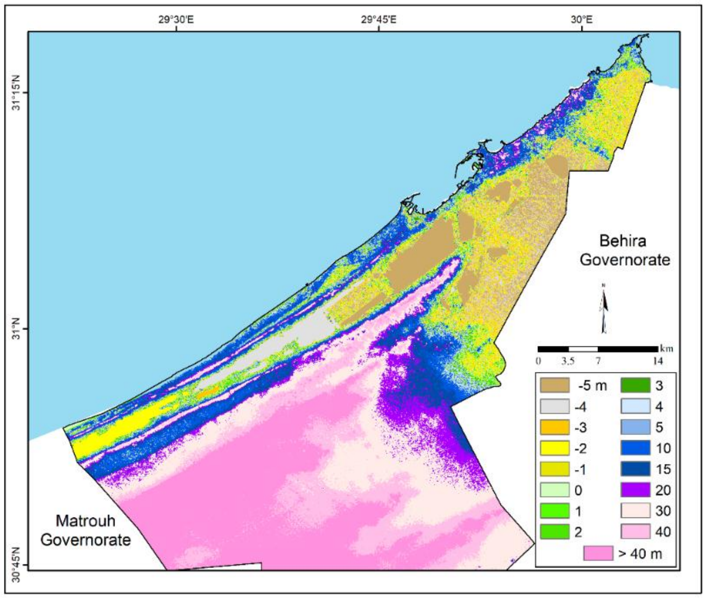


Figure (4). DEM for Alexandria City using ASTER data and IDW technique

Vulnerable built-up areas to SLR inundation are presented in Table (5), the spatial extent of inundation under different inundation scenarios are showed in Figure (5). The total area of these ten-urban districts is 2553.8 km^2. The total built-up areas susceptible to inundation by SLR in these districts ranged between 257.7 and 336.3 km^2, representing 21.5% and 28.2% of their total built-up areas. The spatial extent of SLR impacts differs widely among these urban districts. For instance, the proportions of inundated built-up areas in urban districts are found to be highest in the case of Amereya-1, Amereya-2 and Agami districts ranging between 11.2% and 14.1% of its total built-up area under the 0.5 m and the 2 m scenarios, respectively.

Table (5). Built-up area vulnerable to inundation by SLR under different scenarios

District	Built-up Area (%) susceptible to inundation by SLR			
	SLR Scenario			
	0.5 m	1 m	1.5 m	2 m
Montazah-1, Montazah-2	2.9%	3.5%	3.8%	4.2%
Sharq	1.8%	2.02%	2.1%	2.3%
Wassat	1.5%	1.7%	1.9%	2%
Gomrok	1.9%	2.1%	2.3%	2.5%
Gharb	1.3%	1.44%	1.64%	1.85%
Amereya-1, Amereya-2, Agami	11.2%	12.61%	13.6%	14.1%
Burg Al-Arab	0.90%	1.03%	1.17%	1.25%
Total	21.5%	24.4%	26.51%	28.2%

The lowest built-up area susceptible to inundation was found to be in Burg Al-Arab district, ranged between 0.9% and 1.3% of its total built-up area under the 0.5 m and 1 m scenarios respectively.

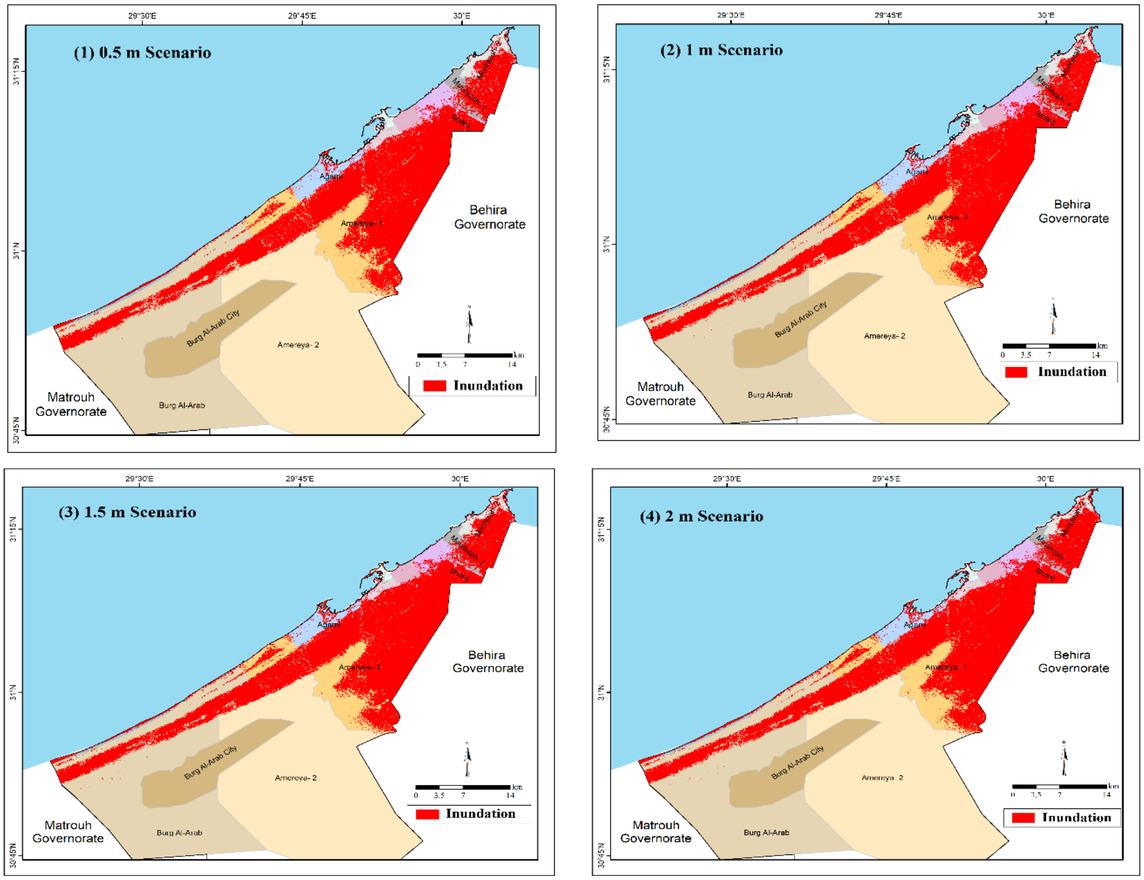


Figure (5). Vulnerable areas to inundation by SLR under four proposed SLR scenarios

5.1.2. VULNERABLE POPULATION

In order to estimate the population vulnerable to inundation by SLR, it was assumed that populations were evenly distributed over the built-up area of these urban areas. Table (6) showed that the total vulnerable population in the ten-urban districts ranged between 21.5% and 28.2% of total population under 0.5 m and 2 m respectively. It was found that Montazah-1 and Montazah-2 districts has the largest vulnerable population size of all districts studied as seen in Table (6). In meanwhile, Burg Al–Arab had the smallest vulnerable population size under all SLR proposed scenarios.

Table (6). Vulnerable population to inundation by SLR under different proposed scenarios

District	Vulnerable population (%)			
	SLR Scenario			
	0.5 m	1 m	1.5 m	2 m
Montazah-1, Montazah-2	15.3%	16.9%	18.2%	20.4%
Sharq	14.3%	16.4%	16.8%	17.2%
Wassat	2.6%	2.8%	3%	3.2%
Gomrok	3.8%	4.9%	5.1%	5.5%
Gharb	3.7%	4.3%	4.6%	4.9%
Amereya-1, Amereya-2 and Agami	7.5%	8.4%	9.1%	9.4%
Burg Al-Arab	0.03%	0.04%	0.05%	0.05%

5.2. SOCIO-ECONOMIC CONDITIONS

Socio-economic term compromised two parts, "socio" comes from social and refers to any number of demographic and social conditions such as the age structure. Economic refers to the economic conditions, such as income, unemployment rates. Socio-economic is used as an umbrella term to cover a wide variety of interrelated social and economic factors. Socio-economic conditions in this study included unemployment rate, population growth rate and HDI.

5.2.1. UNEMPLOYMENT RATE

The unemployment rate is the share of the labor force that is jobless, expressed as a percentage. When the economy is in poor shape and jobs are scarce, the unemployment rate can be expected to rise. When the economy is growing at a healthy rate and jobs are relatively plentiful, it can be expected to fall. The unemployment rate is seen in Table 3. The highest rate is found in Wassat district (3.7%) while, the lowest rate in Burg Al-Arab district (0.8%). Both of Montazah-1, Montazah-2 and Gomrok districts have the same unemployment rate.

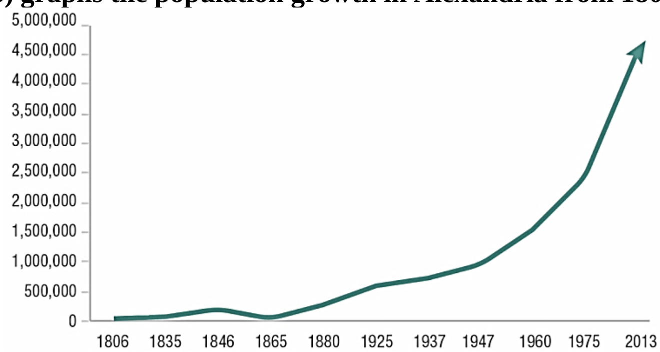
5.2.2. POPULATION GROWTH RATE

Egypt is the most populous arab country, with an estimated population of 92,115,689 million (CAPMAS, 2017). The population is currently growing at 1.6% per year (2013), producing obstructing economic growth. Euromonitor International's report, Global Economies and Consumers (2017), put Alexandria in its list for the fastest-growing cities in terms of population. Population grew to the extent that the number or rate of births exceeded the number or rate of deaths. The difference between these numbers (or rates) is termed "natural increase" (or "natural decrease" if deaths exceed births). Table (7) and Figure (6) show the number of births, deaths and natural increase in Alexandria.

Table (7). Number of births, deaths and natural increase Alexandria

	Births	Deaths	Natural Increase
2011	123194	39790	83404
2012	132732	38484	94248
2013	131287	36721	94566
2015	130624	40891	89733

Figure (6) graphs the population growth in Alexandria from 1806 to 2015



Source: Khafaji (2004) and Panzac (1978)

Figure (6). Population growth in Alexandria (1806 to 2015)

5.2.3. HUMAN DEVELOPMENT INDEX (HDI)

The Human Development Index (HDI) was developed by the United Nations as a metric to assess the social and economic development levels of countries. Four principal examination indicators are used to rank countries: mean years of schooling, expected years of schooling, life expectancy at birth and gross national income per capita.

A. LIFE EXPECTANCY INDEX (LEI)

Life expectancy at birth (LEI) is the number of years a newborn infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life (http://hdr.undp.org). According to UNDP (2015) Life expectancy index can be calculated from the next equation:

$$\text{LEI} = \frac{\text{Life Expectancy at Birth} - \text{Minimum value for Life Expectency}}{\text{Maximum value for Life Expectency} - \text{Minimum value for Life Expectency}} \quad (3)$$

Minimum value of life expectancy is 20 years; maximum value of life expectancy is 83.5 years (Japan, 2015). A LEI is 1 when Life expectancy at birth is 83.5 and 0 when Life expectancy at birth is 20. (http://hdr.undp.org/en/composite/HDI).

$$\text{LEI} = \frac{\text{Life Expectency at Birth} - 20}{83.5 - 20} \quad (4)$$

Life expectancy index in Alexandria in 2012 is 0.66; Table (8) presents the life expectancy for different districts in Alexandria.

Table (8): life expectancy in Alexandria districts

District	Life expectancy at birth (year)	Life expectancy Index (LEI)
Montazah-1, Montazah-2	60.84	0.64
Sharq	65.27	0.71
Wassat	51.44	0.50
Gharb	66.06	0.73
Gomrok	56.99	0.72
Amereya-1, Amereya-2 and Agami	63.9	0.69
Burg Al-Arab	63.78	0.69

B. EDUCATION INDEX (EI)

Education index (EI) consisted of two indices which were: Mean year of school (MSY) and the Expected school year (ESY) UNDP (2015). MSY is the number of years' person spent in school. The lower value was fixed and the maximum value for mean years of school is fixed at 15 according to UNDP (2015). Average number of completed years of education of a population is 25 years and older. ESY is a measure of the number of years of schooling a child at the start of education trajectory is expected to receive, if current rates of enrolment are maintained throughout the child life (UNDP, 2009). (Number of years a child of school entrance age can expect to spend in a given level of education). The ESY is calculated to be 18 years according to UNDP (2015).

$$\text{MSYI} = \frac{\text{MSY} - 0}{\text{Maximum value for mean school year} - \text{Minimum value for mean school year}} \quad (5)$$

$$\text{Mean Year of School (ESY)} = \frac{\text{MSY} - 0}{15 - 0} \quad (6)$$

$$\text{ESYI} = \frac{\text{ESY} - 0}{\text{Maximum value for expected school year} - \text{Minimum value for expected school year}} \quad (7)$$

$$\text{Expected Year of School (ESY)} = \frac{\text{ESY} - 0}{18 - 0} \quad (8)$$

$$\text{EI} = \sqrt{\frac{\text{Mean School Year} * \text{Expected School Year} - 0}{0.971 - 0}} \quad (9)$$

Education index in Alexandria C in 2012 is 0.71; Table (9) presents the education index for different districts in Alexandria.

Table (9). Education index for different districts in Alexandria

District	Education index (EI)	District	Education index (EI)
Montazah-1, Montazah-2	0.6	**Gharb**	0.6
Sharq	0.6	**Gomrok**	0.6
Wassat	0.8	**Amereya-1, 2 and Agami**	0.5
Burg Al-Arab	0.9		

c. INCOME INDEX (II)

According to UNDP (2015), the HDI index calculation for income is:

$$\text{II} = \frac{\text{In (Actual)} - \text{In (Min)}}{\text{In (Max)} - \text{In (Min)}} \quad (10)$$

The minimum value for gross national income (GNI) per capita is $100 UNDP (2015), the maximum value for gross national income (GNI) per capita is 123124 (UNDP, 2015). So, Equation 10 is modified to be:

$$\text{II} = \frac{\text{In (Actual)} - \text{In (100)}}{\text{In (123124)} - \text{In (100)}} \quad (11)$$

$$\text{II} = \frac{\text{In (Actual)} - 4.6051}{11.72095 - 4.6051} \quad (12)$$

Income index in Alexandria in 2012 is 0.7. Table (10) presents the income index for different districts in Alexandria.

Table (10). Income index in Alexandria and its districts

District	Income (II)	District	Income (II)
Montazah-1, Montazah-2	0.6	**Gharb**	0.7
Sharq	0.7	**Gomrok**	0.7
Wassat	0.7	**Amereya-1, 2 and Agami**	0.7
Burg Al-Arab	0.7		

Finally, Human Development Index (HDI) can be calculated using UNDP (2015) formula:

$$\sqrt[3]{\text{LEI} * \text{EI} * \text{II}} \quad (13)$$

Where,

LEL = Life Expectancy Index;

EI = Education Index;

II = Income Index.

From Equation 13, HDI for Alexandria urban districts can be calculated as presented in Table (11).

Table (11). HDI in Alexandria urban districts

District	HDI	District	HDI
Montazah-1, Montazah-2	0.6	Gharb	0.7
Sharq	0.7	Gomrok	0.7
Wassat	0.6	Amereya-1, 2 and Agami	0.6
Burg Al-Arab	0.7		

Thus, HDI for Alexandria is the average of the HDI in all districts (0.7). The estimated resilience index, derived for urban areas susceptible to inundation by SLR in the study area, is shown in Table (12). Ranking the ten-urban districts according to resilience index reveals that Burg Al-Arab district had the lowest resilience level with a resilience index value in the four SLR scenarios. Sharq district had the highest resilience value under the 0.5 m and 1 m SLR scenarios. Whereas, Montazah had the highest resilience value under both of 1.5 m and 2 m SLR scenarios respectively.

Table (12). Resilience index of various urban districts in Alexandria under SLR scenarios

District	Resilience index SLR Scenario			
	0.5 m	1 m	1.5 m	2 m
Montazah-1, Montazah-2	0.465	0.460	0.459	0.440
Sharq	0.479	0.470	0.455	0.434
Wassat	0.379	0.379	0.379	0.376
Gharb	0.294	0.293	0.293	0.293
Gomrok	0.363	0.363	0.361	0.360
Amereya-1, Amereya-2, Agami	0.421	0.421	0.419	0.413
Burg Al-Arab	0.77	0.75	0.72	0. 86

The resilience index ranges from 0 (low resilience) to 1 (high resilience). The lowest level of resilience in the case of Burg Al-Arab district can be attributed to the low proportion of population and built-up areas vulnerable to inundation by SLR and a relatively low coverage of infrastructure and services. The high resilience in Sharq district can be explained by the relatively high HDI, high levels of access to basic services and infrastructure, and improved environmental and demographic conditions.

The lack of resilience in urban to SLR may have far reaching implications to Egypt as a whole. Variation in resilience value in urban districts can be attributed to different area, population density, assets, socioeconomic conditions, capabilities and consequently different levels of resilience of urban districts to SLR impacts. Also, functionalities influence resilience value as urban districts of Alexandria are multi-functional, as they serve as tourist resorts host in addition to a number of economic activities such as industrial and commercial activities.

5. CONCLUSIONS

Alexandria is considered one of the most vulnerable areas to SLR. The resilience index of the ten-urban districts to SLR risk is assessed. the UCRA provides a snapshot of preparedness behaviors, risk perception and

the strength of neighborhood relationships. This research findings would enable individuals to identify context-specific adaptation actions and allow policymakers to engage community members in urban resilience planning. A resilience index was developed in this study to integrate various physical and socioeconomic variables that determine urban resilience. The index was calculated depending on the use of six variables (number of vulnerable population, inundated area, the unemployment rate, population density, the annual population increase the human development index and HDI). HDI (reflecting health, education, income levels in the community) of Alexandria and its districts was calculated. HDI is an indicator adopted by the United Nations Development Program since 1990 to determine the status of human development in a particular country. HDI is based on three indices: life expectancy at birth index, education index and income index. The human development index of Alexandria is 0.70.

The application of the resilience index showed that urban districts revealed different levels of resilience to SLR impacts. It was found that the level of resilience was varied in the ten-urban districts of Alexandria. Such varied resilience levels can be attributed to different magnitudes of physical vulnerability to inundation by SLR, which varied considerably among urban districts. The results indicated the highest resilience districts are Sharq, Montazah-1, Montazah-2, Amereya-1, Amereya-2, Agami, Wassat, Gomrok, Gharb and finally Burg Al-Arab district which has the minimum resilience. High resilience value didn't mean that a specific event will not affect the facility and will not cause severe consequences. Conversely, a low resilience value does not mean that a disruptive event will automatically lead to a failure of the critical infrastructure and to serious consequences. The resilience instead compares the level of resilience at critical infrastructures and guides prioritization of limited resources for improving resilience. The resilience also provides valuable information effective way for preventing problems and improving wellbeing. The results proved that the resilience does not necessarily mean that a community is invulnerable – a community can be resilient and vulnerable at the same time.

Socioeconomic aspects influence resilience as lack basic infrastructure and services, which is typically accompanied by overcrowded living conditions and poor housing quality. Also, environmental aspects adversely affect resilience such as the deteriorating quality of the urban environment, due to pollution, urban water and air quality and overexploitation of natural resources. The current coastal zone management strategies and the institutional settings involve limited contribution to urban resilience beside the overlap and conflict between these institutions. The governmental authorities are characterized by centralization in addition to the lack of vertical and horizontal integration that revealed gaps and conflicting positions between governing bodies.

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تقييم مرونة المجتمعات الحضرية لارتفاع مستوى سطح البحر باستخدام تطبيقات الاستشعار عن بعد ونظم المعلومات الجغرافية

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الملخص العربي :

محافظة الإسكندرية هى احدى المحافظات المصرية المعرضة لخطر ارتفاع مستوى سطح البحر، وتم تصنيف المحافظة على أنها واحدة من "أكثر المناطق المطلة على البحر المتوسط والمعرضة لخطر ارتفاع سطح البحر". ومما يزيد من خطر ارتفاع مستوى سطح البحر بالمحافظة هو ارتفاع الكثافة السكانية بالمتر المربع وكذلك معدل ارتفاع الزيادة السكانية بالاضافة ان المجتمع السكندري هو مجتمع ساحلى تتمركز فيه الانشطة اليوميه والحياتية فى منطقة الشريط الساحلي. هذا بخلاف وجود اراضي منخفضة أقل من مستوى سطح البحر يعيش فيها نسبة كبيرة من سكان المحافظة. تتناول هذه الدراسة تقييم مدى مرونة محافظة الإسكندرية لمخاطر ارتفاع مستوى سطح البحر من خلال حساب مؤشر المرونة باستخدام العديد من المتغيرات مثل المناطق المنخفضة المعرضة للغرق من ارتفاع سطح البحرعند اربع سيناريوهات مفترضة نصف متر، متر، مترونصف، واثنان متر بالاضافة الى العديد من المتغيرات الاخري ومنها معدل البطالة، معدل النمو السنوي للسكان، ومؤشر التنمية البشرية. أوضحت نتائج الدراسة أن مؤشر المرونة تتراوح قيمته بين الصفر الذى يعبر عن مرونة منخفضة والواحد الذى يعبر عن مرونة مرتفعة. ايضأ وجد من النتائج أن مؤشر المرونة تختلف قيمته بين أحياء محافظة الاسكندرية حيث ظهر حي شرق من أكثر الاحياء مرونة ويرجع ذلك لعدة أسباب منها ارتفاع قيمة مؤشر التنمية البشرية وكذلك ارتفاع مستويات البنية التحتية والخدمات والحالة البيئية والديموغرافية الجيدة.