AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Urban Planning

Urban Climate Change Resilience:
A Study of Sea Level Rise Impacts on Nile Delta Northern Region

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Architectural Engineering

(Urban Planning)

by

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Architectural Engineering Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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بسم الله الرحمن الرحيم

" قالوا سبحانك لا علم لنا إلا ما علمتنا

إنك أنت العليم الحكيم"

صدق الله العظيم

سورة البقرة - الآية (٣٢)

SUMMARY

Summary

This thesis aims at studying the impacts of the Sea Level Rise (SLR) and measuring the level of urban community resilience on the region of Northern Nile Delta , with special reference to Alexandria (Egypt) as one of the cities subject to the impacts of SLR resulted from climate change. Additionally, the research compares Alexandria to a similar region; namely the Northern Coast of Java Island, with particular focus on Jakarta (Indonesia) as one of the most threatened cities by SLR in terms of exposed population.

In this regard, the current thesis addresses two main problems and suggests suitable recommendations for them. **Firstly**, the lack of resilience strategies in urban planning development in the Northern Coast of Nile Delta, which is considered a highly threatened zone by SLR impacts, specifically floods. Hence, increasing the vulnerability of the inhabitants of this areas. **Secondly**, the undetermined stakeholders and their responsibilities regarding the reduction of the impacts of SLR on this affected zone and lack of coordination, which lead to the incapability of identifying their role in increasing the resilience of the affected community by SLR. Specifically that the severity of floods is expected to increase in the 2070- according to the recent studies of the Organization for Economic Cooperation Development (OECD) , hence, these two problems are expected to increase the vulnerability of the Northern Coast of the Nile Delta region.

This thesis addresses the first problem by exploring various techniques applied in two mega coastal cities: Alexandria (Abo-Qeer zone) in Egypt and Jakarta (Pademangan zone) in Indonesia. This selection is mainly due to their naturally low topography below the sea level and the rank of the two cities in terms of population exposed to coastal flooding by 2070 as the 11th and the 20th respectively among 20 cities according to the OECD. Lately these ranks have been modified into the 1st and the 11th respectively according to recent researches.

Moreover, an index has been developed to measure the level of communities' resilience in these mega coastal cities using a Flood Disaster Resilience Index (FDRI). This index is developed on five resilience-based capitals: Governance, Economic, Natural, Physical and Social. Different methods have been employed to measure these capitals using the FDRI; these include literature review, questionnaires, and in-depth interviews held by the researcher.

Furthermore, statistical analysis is carried out using Microsoft Office Excel. This analysis indicated that higher values of resilience are correlated with higher preparedness to cope with flood-related disasters and vice versa. It also shows that there are various types of vulnerability characteristic of each city. Based on this analysis , recommendations are presented to enhance the community resilience against flood-related disasters. In the overall, FDRI performance for both cities showed that the highest performance is achieved in the Governance Capital. However, as for the Natural Capital, Alexandria city has a higher preparedness than Jakarta. Regarding the Social Capital: Jakarta's performance is higher than Alexandria's. In general, results showed strength and weaknesses in one capital or another.

This thesis addresses the second problem which is the overlapping and lack of coordination in the responsibilities of possible stakeholders regarding the reduction of the impacts of SLR on this affected zone by literature review, the in-depth interviews and the questionnaires. The findings of this thesis showed clear determination for the concerned stakeholders and their responsibilities for both cities. Moreover, these findings shown that the availability of cooperation efforts between theses stakeholders are high in Jakarta than Alexandria , especially between the government and academic representatives and between the academic representatives and NGOs. This is resulted from the increase of social awareness of flood disaster in Jakarta which leads to the effective participating between the community individuals, government, NGOs and academics to enhance the community resilience of the affected community by floods.

Key words: climate change, sea level rise, Alexandria, Jakarta, Flood Disaster Resilience Index, community resilient

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December 2015

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List of Abbreviations

ACCCRN	Asian Cities Climate Change Resilience Network
AIFDR	Australian Indonesian Facility for Disaster Reduction
APBD	Revenue and Expenditure Budget
APCO	Association of Public-safety Communications Officials
ARC	Agriculture Research Center
BNPB	Indonesian Disaster Management Agency
CoRI	Center of Research Institute
DANIDA	Danish International Development Agency
EC	European Commission
EEAA	Egyptian Environmental Affairs Agency
EWB UK	Engineers Without Borders- United Kingdom
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
GFDRR	Global Facility for Disaster Risk and Recovery
GIF	Global International Finance
IDRS	International Development Research Center
IDSC	Information and Decision Support Center
IIED	International Institute for Environment and Development
IPCC	Intergovernmental Panel on Climate Change
ISET	Institute for Social and Environment Transition
MVT	Motorized Vehicles Taxes
MWRI	Ministry of Water Resources and Irrigation
OECD	Organization for Economic Cooperation Development
SEC	Supreme Energy Council
SLRDI	Sea Level Rise Disaster Index
SPA	Shore Protection Authority
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children Emergency Fund
UNISDR	United Nations International Strategy for Disaster Reduction
WB	World Bank
WHO	World Health Organization

CHAPTER 1
INTRODUCTION

Chapter 1: Introduction

Climate change is expected to continue over the next century in spite of the international effort to reduce greenhouse gas emissions ,which are considered to be the main causes of climate change (UNFCC, 2004; Hare, 2009). This change is expected to exacerbate the already existing environmental problems in many areas. In particular, coastal areas all over the world are expected to suffer from the impacts of Sea Level Rise (SLR), such as: intense floods, coastal erosion, subsidence, salt-water intrusion and deterioration of ecosystems (Asian Disaster Preparedness Center, 2004). Floods alone cause global deaths of approximately 195,843 people yearly and affect 96,878,672 people yearly (UNISDR, 2014; University Corporation for Atmospheric Research, 2014). A key to protect communities from the impacts of SLR, specifically floods, is to enhance mitigation, adaptation and resilience measures and to consider them as high priorities for coastal cities, particularly in developing countries where urbanization is happening at a fast speed (AG Urban Climate and Health, 2014; The World Bank , 2011).

Current literature is concerned about the challenges facing the enhancement of community resilience and how it can be translated into measurable indicators to absorb, recover from and bounce back from current SLR trends. Within the context of this research community resilience is addressed as a guiding concept to protect coastal communities from floods by assessing their current resilient situation. Climate change community resilience indicators are widely considered the way forward to measure progress toward the resilience. They can be a useful and possibly vital element in furthering the concept of urban resilience (The World Bank, 2013; Chandra, et al., 2011). However, such indicators are lacking for specific focus on flood disasters.

Therefore, this research aims to investigate in depth the process of developing and applying the Flood Disaster Resilience Index (FDRI), together with the role it can play in assessing either the progress or the decline of coastal communities on the path of community resilience in Egypt.

Back in 2005, the top eleven cities in terms of exposed population were estimated to be Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Kolkata, Greater New York, Osaka-Kobe, **Alexandria**, New Orleans and **Jakarta**. By 2070, the total population exposed could grow more to reach about 150 million people, due to the combined effects of climate change such as SLR, in-

creased subsidence, population growth and urbanization (Nichollas, et al., 2007).

This thesis deals with community resilience indicators which are considered to be a crucial guiding tool for decision-making in a variety of ways. Their main purposes are to translate physical and social science knowledge into manageable units of information, and to reduce the volume of information to a workable level for decision-makers. These indicators can highlight problems, which need urgent policy actions and help to measure and calibrate progress towards community resilience goals and objectives. Moreover, they can provide an early warning, sounding the alarm in time to prevent economic, social and environmental damage (Khalifa, 2007; UNCSD, 2001).

Although measuring community resilience is a complex process − due to the dynamic interactions of people, community, societies, and the environment− there are currently many conceptual frameworks proposed to measure this concept (Kyoto University , 2011; The World Bank, 2013). Most of these frameworks conceptualize community resilience in the same way in which they all focus on similar factors that could reduce vulnerability and increase community resilience. However, what is suitable for a general concept, such as "climate change" may not work for a specific impact such as: floods.

Besides that, narrowing down the scope of community resilience to long-term economic, social and environmental concerns serves the purpose at hand. It reduces the range of issues covered so as it becomes possible to define with clarity what community resilience is about and what it is not about. This is the first step towards realizing the potential of community resilience. Hence, this research aims at filling this gap by integrating an index to combine these generalized indices into a sole index that can assess community resilience against floods through five capitals: Governance, Economic, Natural, Physical and Social, as will be explained in Chapter 3.

The following sections illustrate different items considered to be the keystone of this thesis.

1.1.Research Problem

Northern Coast of Nile Delta is considered to be a highly threatened area by SLR. Urban development plans in this zone face a lack of proper strategies to deal with the impacts of SLR, specifically floods ,which increase the vulnerability of the population living there. Furthermore, the undetermined of stake-

holders and their responsibilities regarding the reduction of the impacts of SLR and the lack of coordination between them cause incapability of identifying their role in the current or future strategies and plans.

1.2.Research Aim and Objectives

This research aims to study the impacts of SLR and measuring the urban community resilience on the Nile Delta Northern region, with particular focus on (Alexandria) as one of the most vulnerable cities subject to the impacts of climate change. Additionally, the researcher conducts a comparative study between Alexandria and another region that has similar conditions; namely the Northern coast of Java island, with particular focus on (Jakarta) as one of the most threatened cities in terms of population. The research investigates the role of collective actions in building community resilience and in assessing whether such adapted measures and climate change resilience are being included and implemented on coastal urban development strategies in these two cities. Furthermore, it determines stakeholders who are concerned with enhancing community resilience to overcome impacts of SLR.

The research has four objectives:

1. To investigate physical, social, and economic vulnerability both globally and in Egyptian coastal zones as caused by climate change.

2. To explore measures used to reduce the exposed population and assets threatened by SLR for coastal zones, both globally and in Egypt.

3. To assess current community resilience situation in Alexandria and Jakarta in order to reduce the impact of floods on exposed population and assets.

4. To determine stakeholders who are concerned with enhancing the community resilience in Alexandria and Jakarta with the aim to overcome the impacts of SLR.

1.3.Research Questions

The research questions are as follows:

1. What are the impacts of SLR as one of the most significant impacts of climate change both globally and on Egypt?

2. What are the measures used to reduce the exposed population and assets threatened by SLR in the coastal zones both globally and in Egypt?

3. What are the appropriate indicators that measure community resilience against SLR in mega coastal cities?

4. What are the differences between the performance in Alexandria and Jakarta, due to their consideration as mega-coastal cities, through the characteristics of resilient communities?

5. Who are the stakeholders who target the enhancement of community resilience against floods among the two cities ?

1.4.Research Methodology

In order to address these questions a proper research methodology is used mainly relaying on literature review, comparative analysis for the two +case studies together with different supporting methods. These are discussed as follows in three steps:

Firstly, investigating literature review that discussing the impacts of climate change and SLR globally and on Egypt and further exploring for the applied measures in the field of reduction their impacts, especially the newest approach in this field which is "urban community resilience".

Secondly, in order to build the rationale for using the suggested FDRI, investigations have been held thorough out literature review related to various frameworks used in assessing the current situation of community resilience against climate change impacts.

Finally, based on the suggested FDRI; a comparative analysis between both cities: Alexandria(Egypt) and Jakarta (Indonesia) have been held in order to measure the current situation of their community resilience. Moreover, to enhance the community resilience in these cities, determination of stakeholders and their responsibilities have been developed.

1.5.Research Structure

This thesis is divided into two parts; 'Literature Review' and 'Application'. Each part includes a number of chapters as shown in Fig. 1-1.

Part (1): Literature Review

This part reviews literature about two issues: firstly, key issues related to climate change, SLR and floods through Chapter 2, and secondly, an overview of issues related to mitigation, adaptation and resilience as these are considered

to be the main measurements applied by both the governments and the communities against the impacts of SLR, specifically floods through Chapter 3.

Chapter (2): Causes and Impacts of Climate Change and Sea Level Rise

This chapter provides in its first part a detailed explanation of the concept of climate change linguistically and scientifically, followed by exploring causes and impacts of climate change globally and on Egypt through seven sectors: ecosystems, food, coast, industry, infrastructure and human settlements, health and water. The second part of this chapter focuses on the impacts of SLR and its expected scenarios globally and on four Egyptian cities: Alexandria, Port Said, Rosetta and Damietta as considered to be the most threatened cities by SLR in Egypt.

Chapter(3): Responding to Climate Change with Focus on Sea Level Rise

This chapter begins with a discussion about the definitions and techniques uses as global approaches in order to respond to climate change and SLR , as well as clarifies the efforts applied by the Egyptian government in dealing with climate change and SLR in various fields and sectors. Then this chapter discusses the "National Strategy for Adaptation to Climate Change and Disaster Risk Reduction" developed by the Information and Decision Support Center under the supervision of Egyptian Cabinet Office as it is considered to be the first Egyptian attempt to address the impacts of climate change.

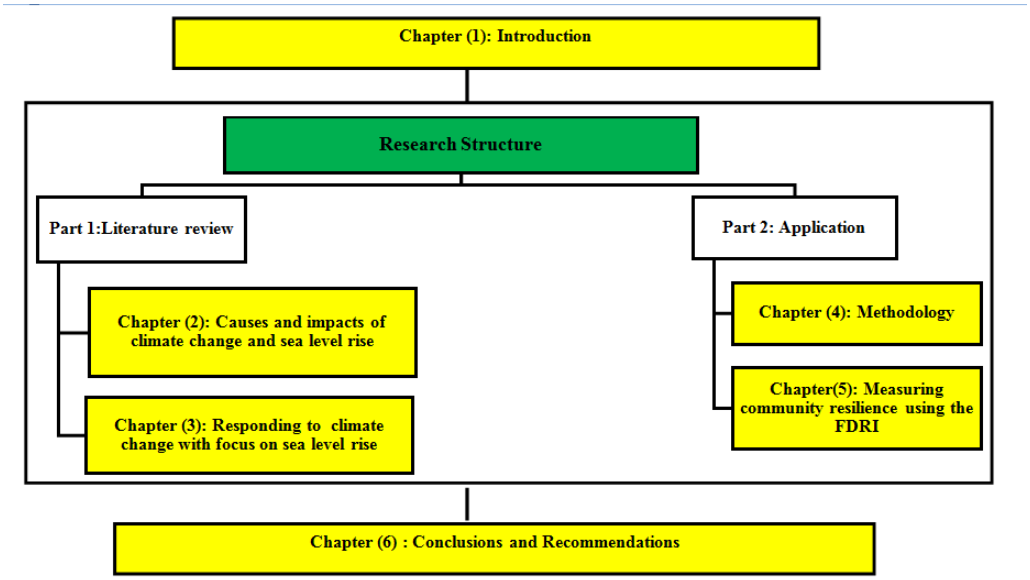


Figure 1-1: Thesis structure

Part (2): Application

The application part encompasses two chapters: Chapters 4 and 5. Chapter 4 expounds the development of the adopted methodology and explains the procedure for developing the FDRI appropriates to the mega-coastal city. Lastly, Chapter 5 examines the applicability of the developed FDRI.

Chapter(4): Methodology

This chapter explains the rationale for selecting the theoretical approach as well as its application to develop the FDRI appropriate to the mega-coastal cities. The research methods are then explained, with a clarification of how and why incorporation between quantitative and qualitative methods takes place to carry out the selected process.

Moreover, this chapter explains the process implemented to establish an index, which assesses the current preparedness of a typical mega-coastal city and addresses the interrelationships between the components of community resilience in terms of Governance, Economic, Environmental, Physical and Social Capitals.

Chapter (5): Measuring Community Resilience Using the FDRI

This chapter examines the applicability of the proposed FDRI. It aims at investigating the impact of using the FDRI in providing a wide perspective for the current community resilience performance in two particular cities: Alexandria (Egypt) and Jakarta (Indonesia). Moreover, it aims at determining the stakeholders who are concerned with enhancing the resilience of the community in the selected two coastal cities. The outputs and findings of these analyses indicate similarity in some capitals and differences in the others. Besides that, they approved that there isn't clear overlapping between the responsibilities of the concerned stakeholders for the selected two coastal cities. However, the cooperation efforts between the concerned stakeholders are higher in Jakarta than Alexandria.

Chapter (6): Conclusions and Recommendations

This chapter draws together the conclusions from the research and explores to what extent the research findings fulfilled its own aim and objectives as well as answered the research questions, then suggesting recommendations for stakeholders concerned with SLR and floods. It ends with suggested future work.

CHAPTER 2

CAUSES AND IMPACTS OF CLIMATE CHANGE AND SEA LEVEL RISE

Chapter 2: Causes and Impacts of Climate Change and Sea Level Rise

Different approaches are being implemented on a global level to reduce the impacts of climate change on communities and affected sectors in cities. The same approaches, but with different measures, have been implemented on coastal zones in order to reduce the impacts of SLR on coastal communities, particularly in developing countries where urbanization is taking place at a fast pace. This chapter addresses these approaches, with their various measures, both globally and in Egypt. It further illustrates the Egyptian efforts in implementing each approach.

2.1. Definitions of Climate Change

Definitions of climate change are divided into two types; linguistic definitions and scientific definitions. As for the linguistic definition, The Oxford Dictionary defined it as "*Changes in the earth's weather, including changes in temperature, wind patterns and rainfall, especially the increase in the temperature of the earth's atmosphere that is caused by the increase of particular gases, especially Carbon Dioxide*" (Oxford, 2012).

Regarding the scientific definitions, the United Nations Framework Convention on Climate Change (UNFCCC) has defined climate change as "*A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods*" (UNFCCC, 2013).

Moreover, the Intergovernmental Panel on Climate Change (IPCC) has defined it as" *A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity*" (IPCC, 2014).

2.2. Causes and Impacts of Climate Change

Causes of climate change can be classified into various types, such as: external versus internal factors, processes, according to the duration of influence and forcing versus feedbacks (Pidwirny, et al., 2010).

Moreover, the impacts of climate change can be classified into many types according to the threatened sectors and the natural phenomena. The following section states drivers and impacts of climate change according to the classifications of the IPCC.

3.1.1. Drivers of climate change according to IPCC classifications

According to the classification of the IPCC, there are natural and anthropogenic drivers of climate change, including the chain of Green House Gases (GHG) emissions, atmospheric concentrations and radiative forcing to climate responses and effects as shown in Fig. 2-1.

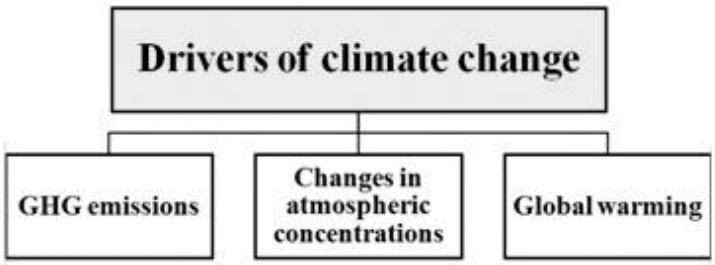


Figure 2-1: Classification of climate change drivers according to IPCC
Source: Researcher based on data available in (IPCC, 2014)

2.2.1.1. Chain of Greenhouse Gases emissions

Green House Gases (GHG) "are those gaseous components of the atmosphere, both natural and anthropogenic gases making parts of the atmosphere work as a blanket with right thickness, which absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself and by clouds" (University Corporation for Atmospheric Research, 2012) as shown in Fig. 2-2. It's consists of natural gases, such as: Water Vapor (H_2O), Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Ozone (O_3) and man-made gases, such as: Halo Carbons and other Chlorine and Bromine containing substances and Hydro Fluoro Carbons (HFCs) (IPCC, 2007; NASA, 2015).

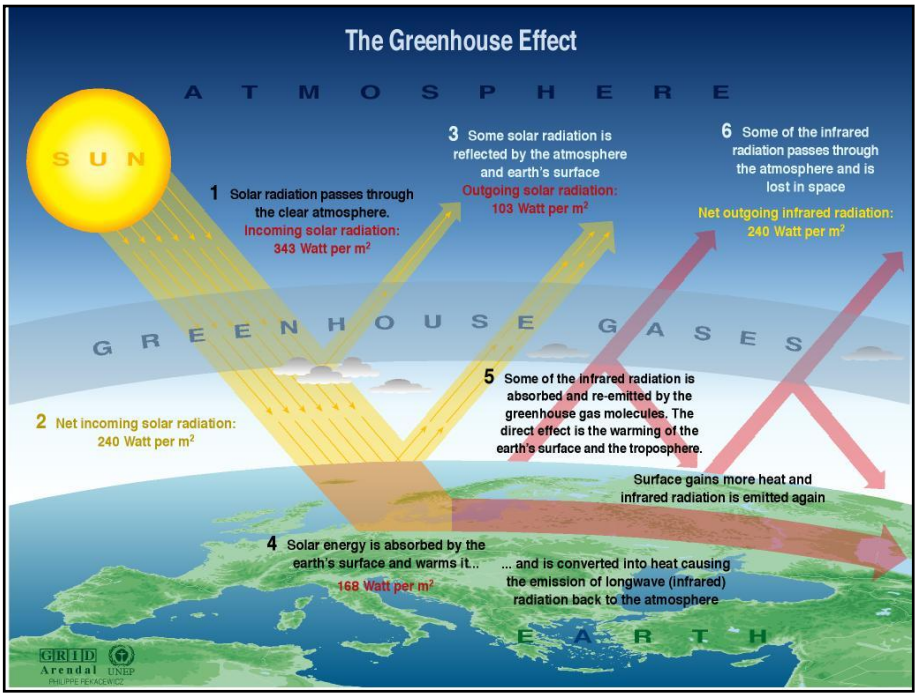


Figure 2-2: Mechanism of GHG
Source:http://www.dnrec.delaware.gov/ClimateChange/Pages/Greenhouse%20Effect.aspx

The sources of GHG emissions produced by human activities are broken down into 7 sectors. The largest portion is the energy supply followed by the industry as shown in Fig. 2-3.

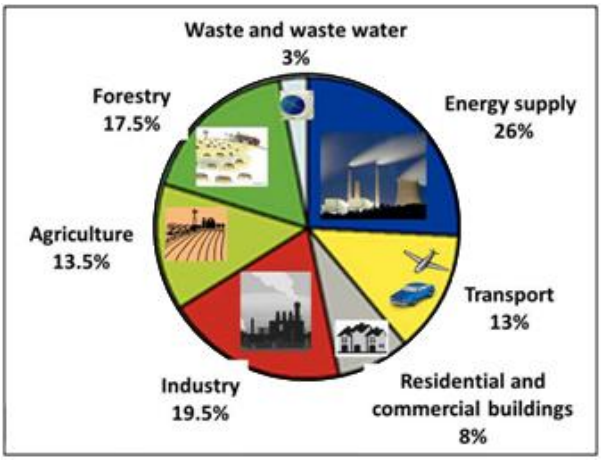


Figure 2-3: Global human resources for GHGs emissions
Source: http://www.climate-change-knowledge.org/ghg_sources.html

2.2.1.2. Atmospheric concentrations

Changes in the atmospheric concentrations of GHGs -such as: CO_2, CH_4 , N_2O, O_3- Aerosols, land cover and solar radiation affect the energy balance of the climate system and are drivers of climate change. They increase when the emissions of these gases are larger than the removal processes of radiation within the atmosphere and at the surface of the Earth (IPCC, 2014). Measurements shown in Fig. 2-4 illustrate the activity of three specific gases which form the GHGs; these are: CO_2, CH_4 and N_2O. These measurements are taken from samples extracted from ice cores due to the fact that they contain information about climate (Alley, 2000; IPCC, 2007). Different colors resemble different studies. The graphs show that the concentrations of CO_2, CH_4 and N_2O are increasing through the passage of time; hence, climate change occurs.

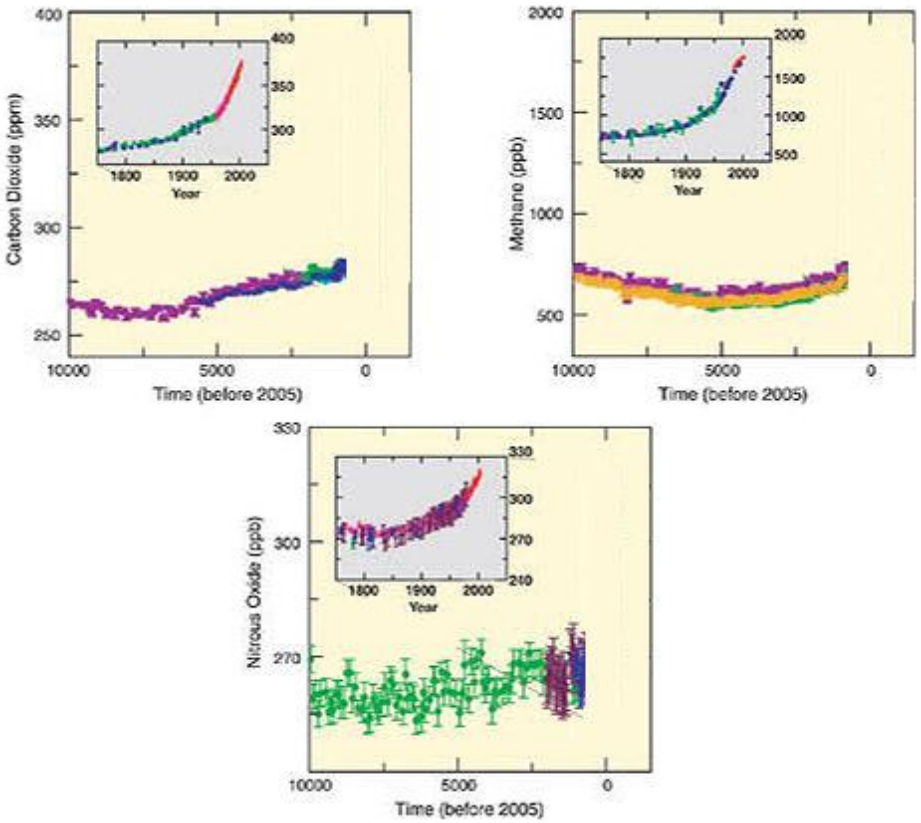


Figure 2-4: Atmospheric concentrations of CO_2, CH_4 and N_2O
Source:http://www.hko.gov.hk/climate_change/atmospheric_concentrations_of_greenhouse_gases_e.jpg

2.2.1.3. Global warming

The observed widespread warming of the atmosphere and the ocean, together with the loss of ice mass , support the conclusion that it is extremely unlikely that global climate change of the past 50 years can be explained without external forcing (IPCC, 2014; Nature Conservancy, 2014). Fig. 2-5 illustrates information from decadal averages of observations about global land and ocean for the period 1900-2000 as represented by black line. Information produced by several climate models are represented by blue and red shadows.

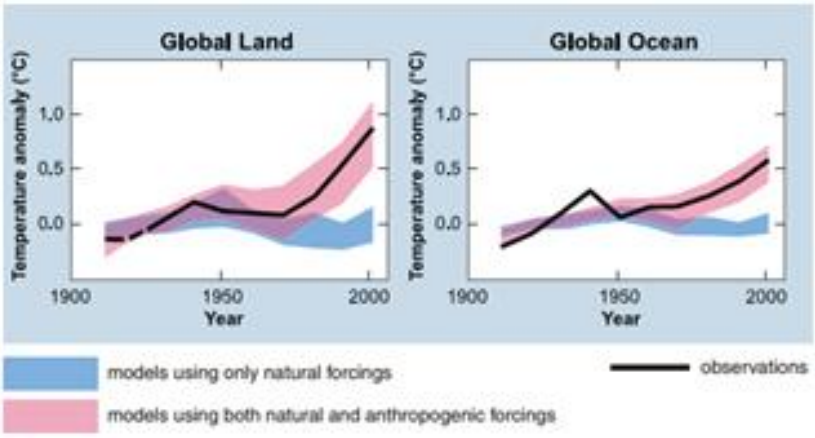


Figure 2-5: Comparison of observed simulated results by climate models
Source: (IPCC, 2007), P.40

2.2.2 Classifications of the impacts of climate change

According to the IPCC (2007; 2014), the global impacts of climate change can be classified in various types as shown in Fig. 2-6 (IPCC-WGII, 2007). The black-highlighted classification is the chosen type in the following comparative study for the impacts of climate change, both on a global realm and on Egypt. Tables 2-1 & 2-2 illustrate phenomena appeared in each sector and its relation to climate change. Table 2-1 illustrates the global impacts of climate change whereas Table 2-2 shows the impacts on Egypt only.

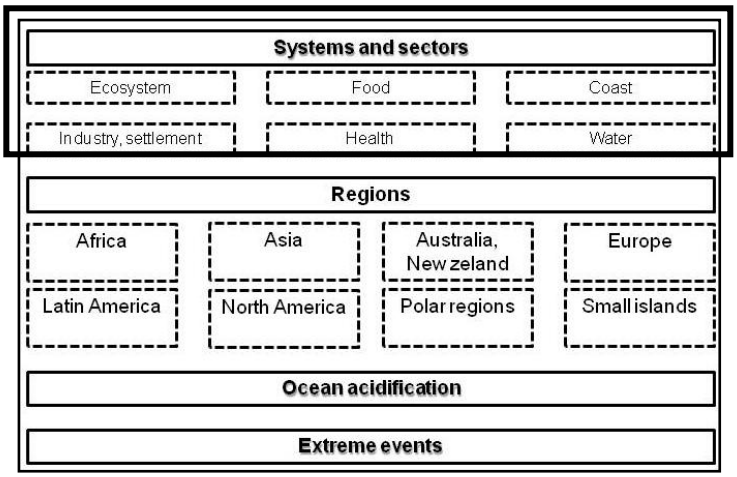


Figure 2-6: Climate change impacts according to IPCC's classification
Source: Researcher based on data available in (IPCC-WGII, 2007)

Table 2-1: Climate change impacts globally
Source: Researcher based on data available in (IPCC-WGII, 2007; United Stated Environmental Protection Agency , 2010; National Center for Ecological Analysis and Synthesis, 2013; Lerner, et al., 2014; Agrawla, et al., 2004)

Sector	Phenomena	Reasons related to climate change and human activities
1-Ecosystem	Risk of species' extinction	Global warming, precipitation, flooding, drought, wildfire, ocean acidification and human made: land-use change, pollution, over exploitation of resources
	Negative consequences for ecosystem goods and biodiversity (Fig. 2-7)	
	The migration of species in order to survive.	SLR, global warming, human made: land-use change, pollution, fragmentation of nature
	Isolated patches of ecosystem habitat	
	Negative effects on the fertility of marines species	Global warming, ocean/lakes acidification
2-Food	Uncertain future supply of fishmeal and oils from capturing fisheries	Global warming, increased acidity, extreme weather events, loss in ice cover
	Uncertain future water supply	
	Frequency of diseases and toxic events	Run-off precipitation, global warming, SLR
	Negatively affects the growth rates and food conversion efficiencies	
	Difficulty in growing crops, raising animals and catching fish	Changes in the frequency and severity of droughts and floods

Table 2-1 :Climate change impacts globally (continued)

Sector		Phenomena	Reasons related to climate change and human activities
3-Coast		Coastal erosion	Natural: SLR , human-made: pressures on coastal areas
		Floods affecting heavenly the densely populated and low-lying megadeltas of Asia and Africa (Fig. 2-8)	Heavier rainfall , precipitation, SLR
		Migration of coastal sensitive species	Global warming, extreme weather events, SLR
		Coral bleaching	Sea acidification
		Salt water intrusion	SLR, human made: land-use change
4-Industry, infrastructure and settlements	Industry	Negatively affects the sensitive inputs for raw materials used in food processing	Significant changes in temperature and precipitation changes
		Weather-related transportation accidents (Appendix A)	
		Shift in conditions favorable to many forms of tourism (Appendix A)	Significant changes in temperature and tropical storms, SLR
		Negatively affecting tourist infrastructure and activities (Appendix A)	
		Limited access to resources (financial, human and institutional) (Appendix A)	Floods, droughts, SLR
	Infrastructure	Excessive expansion in bridge joints and pavement surfaces (Appendix A)	Increasing the frequency and intensity of very hot days and heat waves
		Increase in the cost of construction (Appendix A)	Extreme weather occurrence
		Inundation of coastal transportation elements (Appendix A)	SLR, extreme weather occurrence
		Posing hazards to passengers of coastal airports (Appendix A)	
		Costly adjustment in harbor and port facilities to accommodate tidal increases (Appendix A)	

Table 2-1 :Climate change impacts globally (continued)

Sector		Phenomena	Reasons related to climate change and human activities
4- Industry, infrastructure and settlements (continued)	Human settlements	Negatively affecting assets and populations in coastal areas, slopes and other risk-prone regions	Storms, floods and sustained droughts ,SLR
		Negatively affecting productive sectors in urban and rural settlements	
		Migration of people	Extreme weather occurrences , SLR
		Poverty, negatively affecting shelters specially in developing countries	Global warming , SLR
		Negatively affecting sources of energy(wood fuel) in most developing countries	Drought, extreme weather occurrences
5-Health		Execrating the ranges of disease vectors (e.g.: mosquitoes)	Storms, floods, and heat waves, extreme weather events, SLR
		Concentrations of unhealthy air and water pollutants	Increased salinisation of groundwater supplies
		Number of heat-related illnesses and deaths	Changes in temperature, precipitation patterns, SLR
		Enhancing the spread of some diseases	
		Direct damage of health	Extreme weather occurrences
6-Water		Negatively affect physical, chemical and biological properties of freshwater lakes and rivers	Extreme weather occurrences, SLR, salt water intrusion
		Melting glaciers (the only freshwater source in some areas)	Global warming, floods, droughts
		Water insecurity	
		Reduction of snow cover and frozen ground	
		Creating dead zones in deep lakes	Ocean acidification

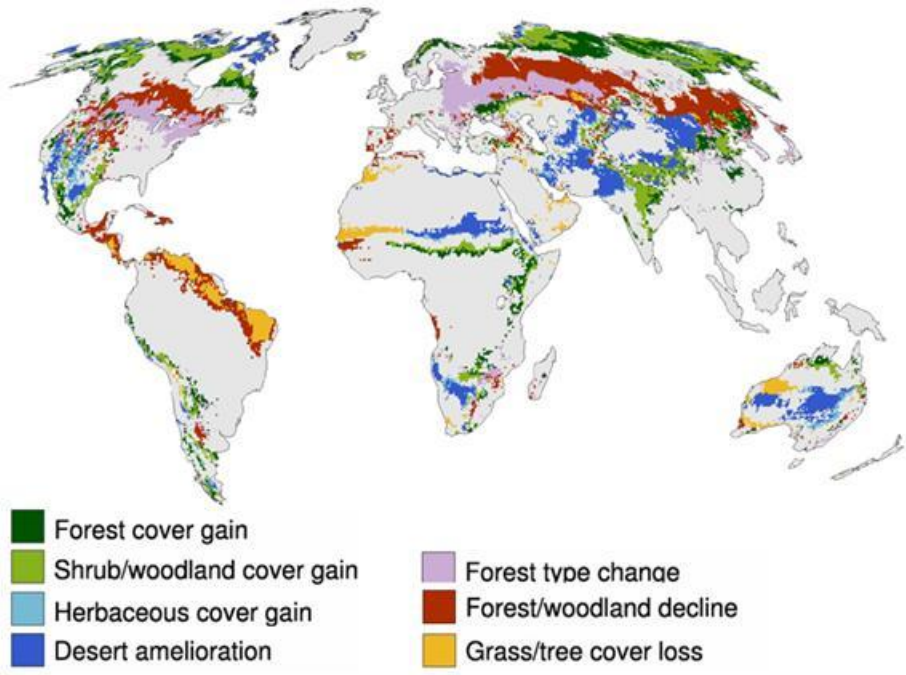


Figure 2-7: Negative consequences for ecosystem caused by climate change
Source: https://www.pik potsdam.de/aktuelles/pressemitteilungen/archiv/2008/klimaschutz-ist-artenschutz

Figure 2-8: Relative vulnerability of coastal deltas as shown by indicative population potentially displaced by current sea level trends to 2050
Source: (IPCC-WGII, 2007)-P.327

Table 2-2:Climate change impacts on Egypt
Source: Researcher based on data available in (National Center for Ecological Analysis and Synthesis, 2013; Lerner, et al., 2014; Agrawla, et al., 2004)

Sector		Phenomena	Reasons related to climate change and human activities
1-Ecosystem		Increasing threatened species	Extreme weather occurrences
		Negatively affecting adjacent habitat to the Egyptian Northern lakes, Eastern desert habitats, marine habitats, marginal pasture in Sinai	
		Negatively affecting mangrove vegetation (Red Sea)	Global warming
		Unprecedented reproductive failure in species	
		Wild Fish mortality diseases	
		Loss of habitats (birds-animals-plants)	SLR , land subsidence, floods , salt water intrusion ,extreme occurrences of dust storms
		Loss of biodiversity (birds-animals-plants)	
		Negatively affecting birds and animals migration pattern	SLR , floods ,extreme occurrences of dust storms
		Negatively affecting nesting of marine turtle	Soil warming
2-Food	Agriculture	Increase in the desertification phenomenon	Global warming ,soil and water salinity ,SLR
		Decrease in the overall agriculture productivity and increasing competition over the natural resources	
		Affect the grain filling periods	SLR
	Livestock	Coasts of the Nile Delta: reduction of the area under cultivation and likely reducing production.	Global warming, extreme weather occurrences
		Negatively affecting the health and productivity of animals	
		Severity and spread of animal's diseases	
	Fisheries	Negatively affecting fodders	Salt water intrusion in coastal lakes

Table 2-2: Climate change impacts on Egypt (continued)

Sector		Phenomena	Reasons related to climate change and human activities
3-Coast		Changes in lakes ecosystems	Increase in water temperature, SLR
		Increasing rates of submerging for low elevated areas (Fig. 2-9 &2-10)	SLR
		Negatively affecting shoreline (Fig. 2-11)	SLR, salt water intrusion
		Increasing the severity of "El-Nuwa't " pattern	Extreme storm occurrences, SLR
		Changes in fisheries catch, coastal recreation areas, and coastal navigation	SLR, extreme storm occurrences
		Coral bleaching	Sea acidification, increase in water temperature
		Salinity of inland lakes (Nasser and Qarun in Fayyoum)	Salt water intrusion
4-Industry, infrastructure and settlements	Industry	Deterioration of coastal tourism	SLR, increase in temperature
		Negatively affecting employing movement	
		Implications for the fisheries industry	SLR, saltwater intrusion, droughts
		Negatively affecting the energy sector industry	SLR , extreme weather occurrences
		Deterioration of food industry	
		Changing the economic base in various zones	Droughts , SLR
	Infrastructure	Increase the risk of transportation accidents and health risks in the coastal zone	SLR, flash floods, extreme weather occurrences
		Deterioration of roads	Extremely hot days, sandstorms, thunderstorms and dusty and windy conditions, sea surges
		Softening of asphalt	
		Excessive expansion of bridge components	Heat waves, SLR
		Deformation of metal components such as rail truck	
		Negatively affecting wastewater treatment infrastructure	SLR
		Increasing the peak volume and sediment loading into wastewater treatments plants	

Table 2-2: Climate change impacts on Egypt (continued)

Sector		Phenomena	Reasons related to climate change and human activities
4- Industry, infrastructure and settlements	Human settlements	Increasing demographic displacements and migration	Extreme weather occurrences, SLR
		Inadequate in low-income urban centers	SLR, flash floods, extreme weather occurrences
		Increased unemployment inducing political and civil unrest	
		Negatively affecting cultural and natural heritage	
		Increasing of poverty rates	Extreme weather occurrences, SLR
		Negatively affecting the population pyramid	
		High population density	
5-Health		Skin cancer, eye cataracts, deaths and injuries from cardiovascular and respiratory illness	Increase in temperature, decrease of rain fall, SLR, dust storms
		Increased prevalence of asthma and infectious diseases	
		Vector borne diseases, diarrhea and dysenteric infections	
		Decrease in children mortality rates and malnutrition	
		Respiratory disease	Extreme weather occurrences, SLR
		Negatively affecting mortality rate	
		Increasing the number of deaths	
6- Water		Contamination of fresh water lakes	SLR, salt water intrusion
		Increase in soil and water salinity	Increasing temperature and SLR
		Shortage in the storage capacity of water systems	Precipitation changes
		Increasing the gap between water supply and water demand	Increase in temperature, SLR, salt water intrusion
		Negatively affecting ground water sources	SLR, salt water intrusion
		Increase in the cost of water	

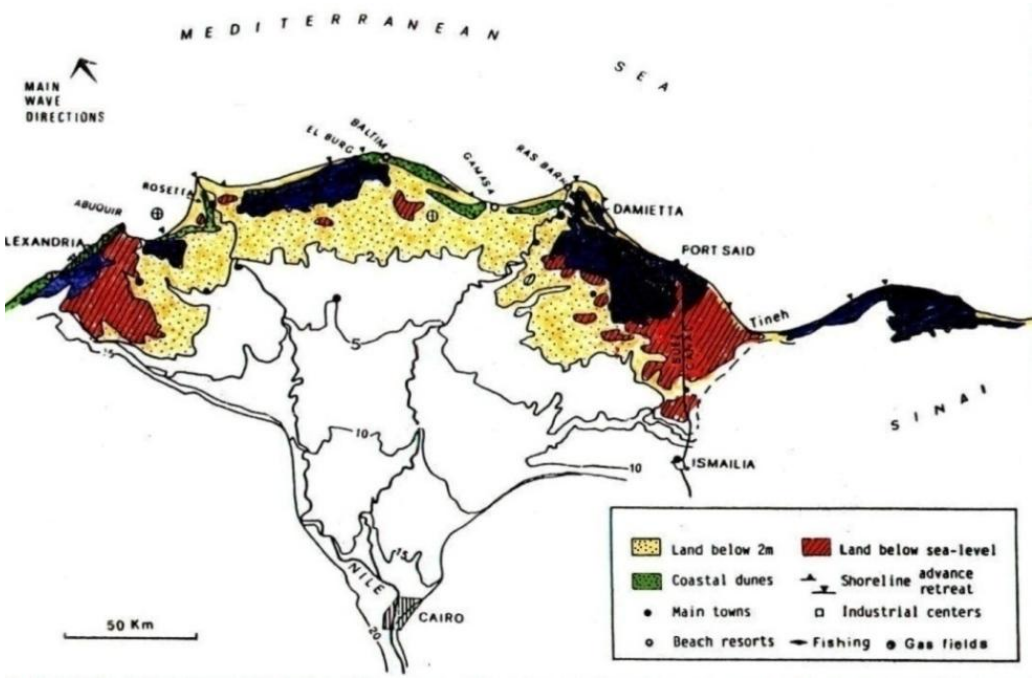


Figure 2-9: General topography of the Nile Delta region indicating areas below mean sea level
Source: (Egyptian Environmental Affairs Agency, 2013)- p.85

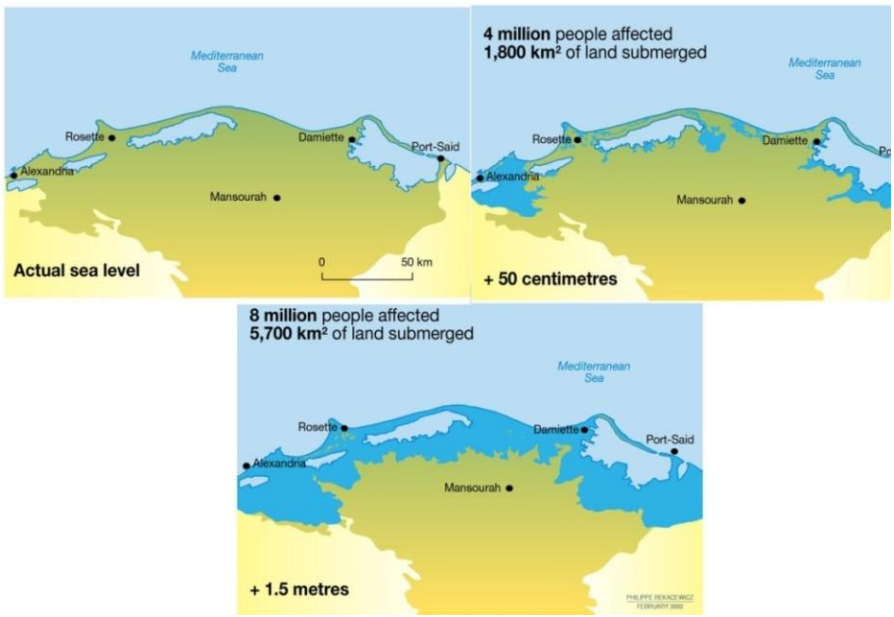


Figure 2-10: Nile Delta regions affected by SLR by 2050
Source: http://www.unep.org/dewa/vitalwater/jpg/0405-Nil-EN.jpg

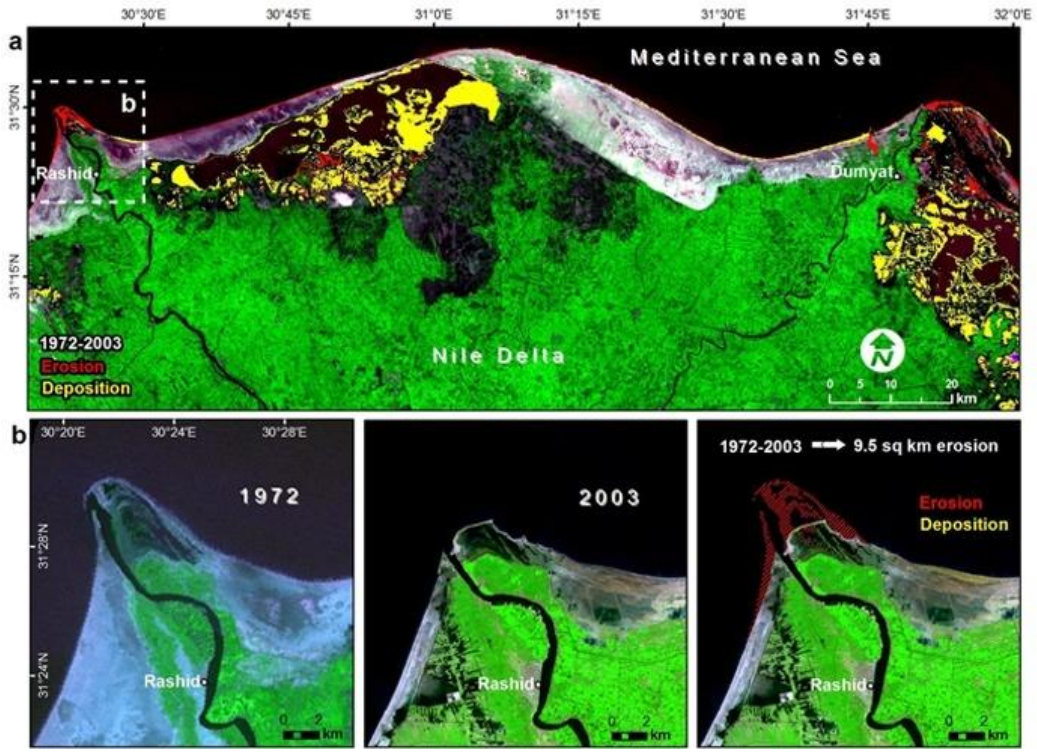


Figure 2-11: Coastal erosion changes as observed for Rashid zone
Source: http://people.uncw.edu/ghoneime/rsl/research/coastal/nile_delta_erosion.jpg

It can be summarized form Table 2-2 that SLR, salt water intrusion, extreme storm occurrences ,change of acidity, increase of water temperature are considered to be main reasons related to climate change that affect Egyptian coastal zones, as shown in Table 2-3. It can be observed from this table that SLR affects all the natural and socio-economic issues. Hence, all the SLR's column is colored with black. Following the SLR - in affecting a larger amount of aspects - is the extreme storm occurrences .

Table 2-3: Impacts of climate change on Egyptian coastal zones
Source: Researcher based on data available in (Agrawla, et al., 2004; Brown, et al., 2011)

Aspects		Impacts of climate change on coastal zones				
		SLR	Salt water intrusion	Extreme storm occur-rences	Increase wa-ter tempera-ture	Change of acidity
Nature	Land subsidence	■				
	Soil salinization	■	■		■	■
	Endangered eco systems	■	■	■	■	■
	Erosion	■		■		
Socio-economic activities	Agriculture	■	■	■	■	■
	Fisheries	■	■	■	■	■
	Livestock	■	■	■		■
	Industry	■		■		
	Trading	■		■		
	Tourism	■		■		■
	Land use	■	■		■	■
	Infrastructure	■		■		
	Socio-economic tiers	■	■			
	Health	■	■	■	■	

2.3.Sea Level Rise and its Impacts

The change in the sea level nowadays is one of considerable interest because of its potential impacts on human populations living in coastal regions. Scientists have shown that in the past there have been periods of significant sea level change due to natural factors (UNISDR, 2012). However; current measurements indicate that human activity is the main driving force. This section discusses the main causes and impacts of sea level rise both on a global level and on Egyptian Northern coast .

2.3.1 Causes of sea level rise

Sea level changes are caused mainly by rising global temperature which, in its turn, is accelerated by various factors; both natural and man-made as shown in Fig. 2-12. Global warming leads to ocean thermal expansions, glacial melt from Greenland and Antarctica and change in terrestrial carbon storage

(National Oceanic and Atmospheric Administration, 2013; Bromfield, et al., 2011; Sarwar, 2005).

In addition, the main human factors that are responsible for raising temperature are: the burning of fossil fuels and deforestation. Therefore, the variability of relative sea level rise and its impacts and consequences will vary according to location as shown in Fig. 2-13. Other factors which cause SLR and aren't caused by global warming are: plate tectonics, post glacial rebound, land subsidence and siltation.

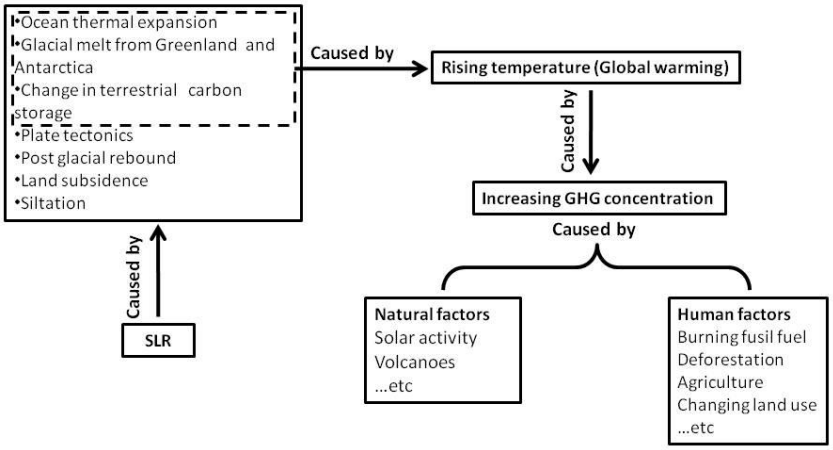


Figure 2-12: Causes of sea level rise and rising temperature
Source: Researcher based on data available in (Bromfield, et al., 2011; Sarwar, 2005)

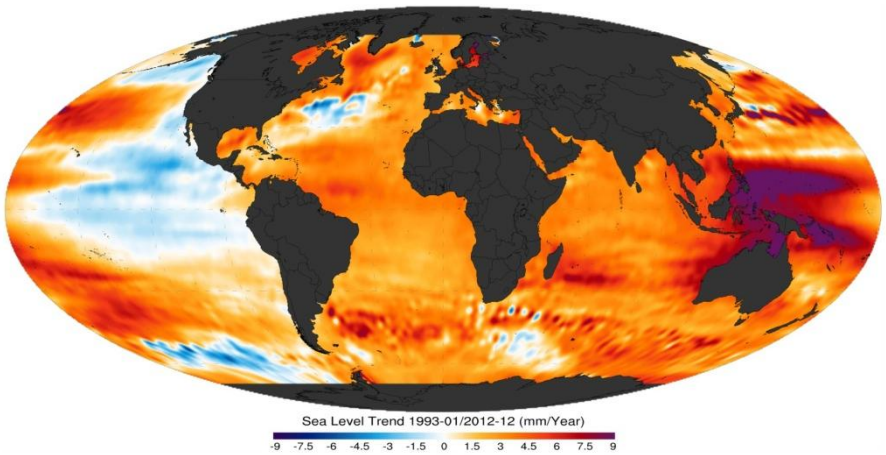


Figure 2-13: Variability of sea level rise process by location
Source:http://upload.wikimedia.org/wikipedia/commons/6/69/NOAA_sea_level_trend_1993_2010

2.3.2 Scenarios of sea level rise

Sea level rise scenarios –globally and on Egypt- vary depending on the thermal expansion and ice melt measurments as mentioned in Special Report of Emissions Scenarios (SRES) produced by IPCC (2007) as will be explained below.

2.3.2.1. Global scenarios of sea level rise

According to IPCC (2007), global sea level rose by about 120 m during the several millennia that followed the end of the last ice age. However, records and measurements show that the sea level has been steadily rising at a rate of 1 to 2.5 mm, per year since 1900 (National Oceanic and Atmospheric Administration, 2013). It's projected for SLR to increase by the end of the 21st century to levels estimated between 18-58 cm (AFED, 2009) (Fig. 2-14) .

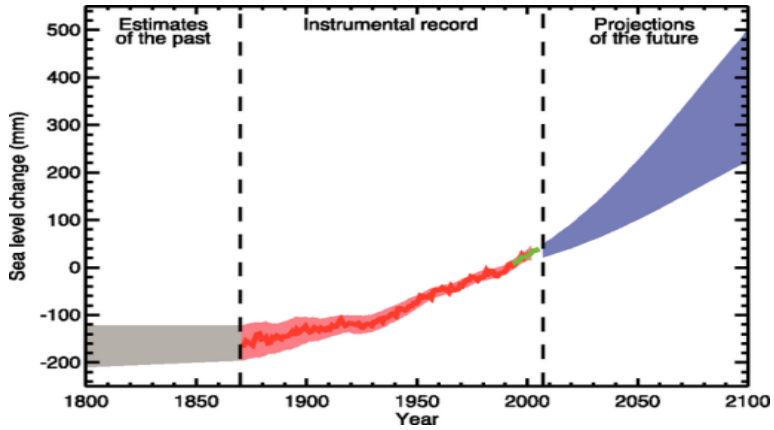


Figure 2-14: Past, present and predicted sea level trends in A1B scenario
Source: (IPCC-WGII, 2007) –P.409

The IPCC team defined four narrative storylines (Fig. 2-15), labeled A1, A2, B1 and B2, and describing the relationships between the forces driving GHG and aerosol emissions − considered to be the main factors for the impacts of climate change, and hence of SLR,− and their evolution during the 21st century on a global level. Each storyline represents different demographic, social, economic, technological, and environmental developments that diverge in increasingly irreversible ways.

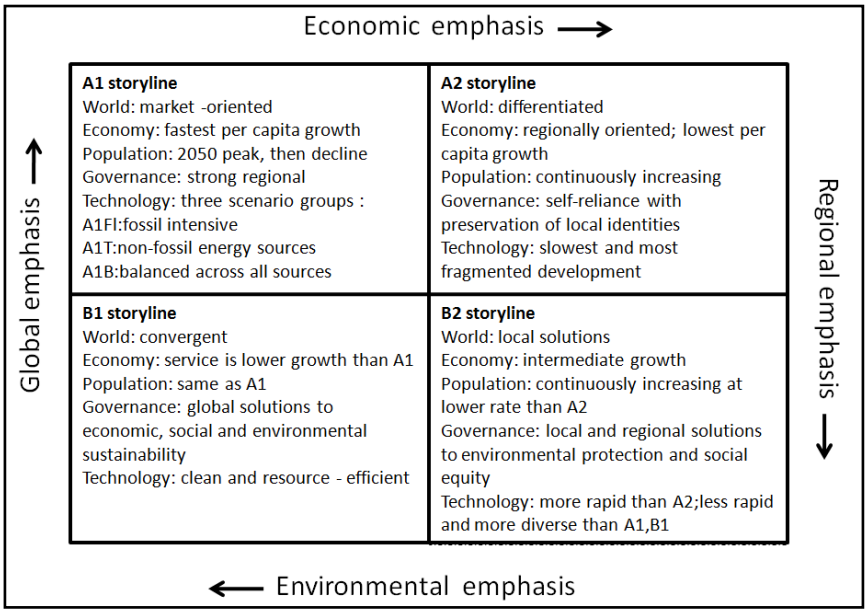


Figure 2-15: Summary for characteristics of the four main SRES families
Source: (IPCC-WGII, 2007)-p.147

Given this huge range of future emissions and their driving forces, there is an infinite number of possible alternatives to explore. The SRES scenarios cover a finite; albeit a very wide range, of future emissions. The set of scenarios consists of 40 SRES scenarios which are constructed from six main scenario groups drawn from the four families: one group in each of A2, B1, B2, and three groups within the A1 family, characterizing alternative developments in technologies of energy: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel) as shown in Fig. 2-16 (IPCC, 2015).

Within each family and group of scenarios, some share "harmonized" assumptions on global population, gross world production, and total energy. These are marked as "HS" for Harmonized Scenarios. Other Scenarios "OS" denotes scenarios that explore uncertainties in driving forces beyond those of the harmonized scenarios. The number of scenarios developed within each category is shown (IPCC, 2015).

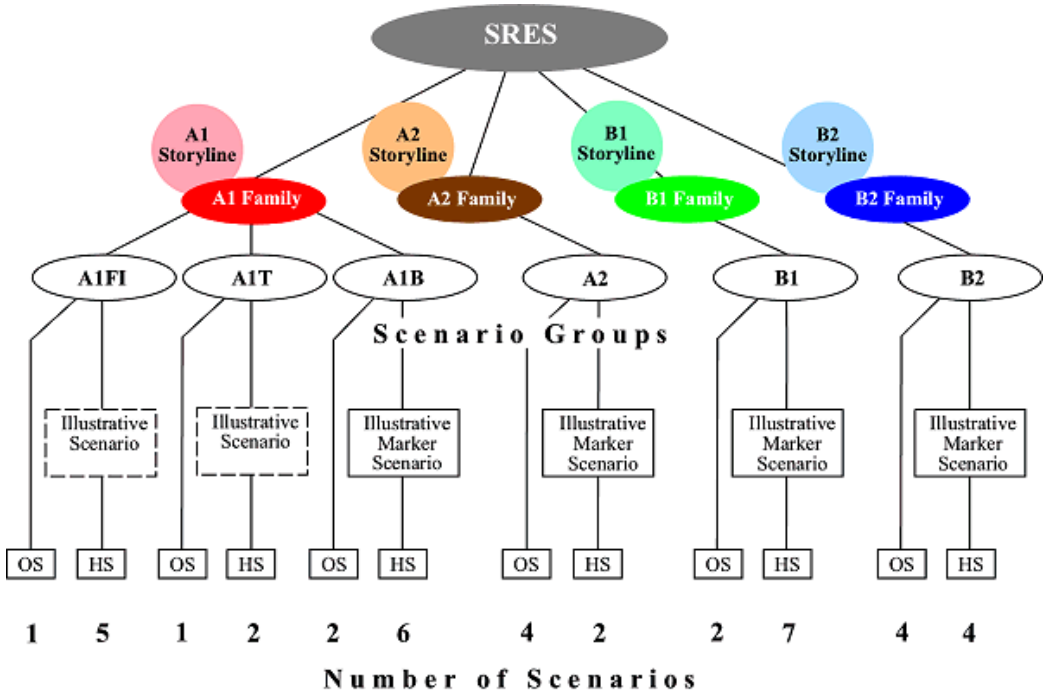


Figure 2-16: Schematic illustration of SRES scenarios
Source: http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=3

Therefore, Table 2-4 represents adjacent projections of SLR and temperature changes for the previously mentioned scenarios according to the IPCC (2015). According to this table, even for the most optimistic scenario − B1 scenario − it is projected for sea level to rise approximately 0.38 cm which can badly affect the previously mentioned sectors.

Table 2-4: Projected global warming and SLR at the end of the 21st century
Source: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html

Case	Temperature Change (°C)		Sea Level Rise (cm)
	Best estimate	Likely estimate	
B1	1.8	1.1-2.9	0.18-0.38
A1T	2.4	1.4-3.8	0.20-0.45
B2	2.4	1.4-3.8	0.20-0.43
A1B	2.8	1.7- 4.	0.21-0.48
A2	3.4	2.0- 5.4	0.23-0.51
A1F1	4	2.4- 6.4	0.26-0.59

2.3.2.2. Scenarios for sea level rise in the Northern coast of Nile Delta region

Since early studies by Sesteni (1993), various analyses have evaluated the impacts of climate change on the Nile Delta using two SLR scenarios : 0.5 m and 1m (Fig. 2-10), concluding that a large percentage of the Northern Coast of the Nile Delta is totally vulnerable to inundation and saltwater intrusion that could drive millions from their homes in both scenarios (ElGanzori, 2012; Raey, 2010). Furthermore, the optimistic 0.5 m scenario −Thesis scope − projected that 3800000 people and 1800 km^2 of the cropland will be endanger while the 1.0m scenario projected that 6.100000 people and 4500 km^2 of the cropland will be endanger.

2.3.3 Impacts of sea level rise on the Northern coast of the Nile Delta region

The Nile Delta region in the Mediterranean coastal zone represents the major industrial, agricultural, and economic resource of the country. Its shoreline extends from Alexandria in the west to Port Said in the east, with a total length of about 240 km. The four main coastal cities located at this area are: Alexadnria, Rosetta, Damietta and Port Said. Its coastline has two promontories: Rosetta and Damietta and three lakes: Idku, Burullus, and Manzala (Raey, 2010; Agrawla, et al., 2004) (Fig. 2-17).

Previous studies have concluded that the region is characterized by relatively low land elevation as shown in Fig. 2-9, which leaves it severely exposed to rising sea levels, local land subsidence, especially in Alexandria, Rosetta, Damietta and Port Said which are considered to be highly vulnerable coastal cities (Raey, 2010; ElGanzori, 2012; El-Sharkawy, et al., 2009; Agrawla, et al., 2004).

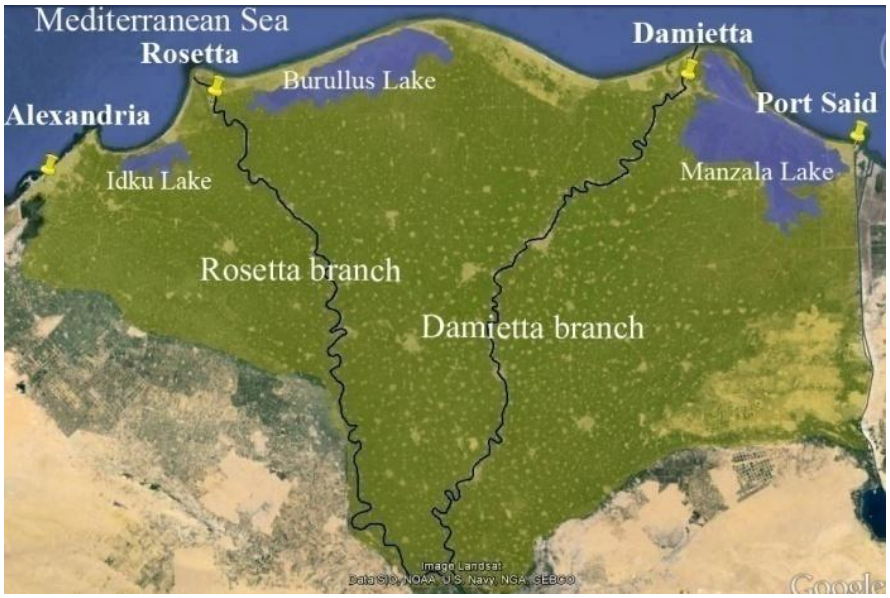


Figure 2-17: Nile Delta Northern Region
Source: Researcher based on Google Earth

2.3.3.1. Alexandria

The city of Alexandria, the second largest city after Cairo, is located in Alexandria Governorate to the west of the Rosetta branch of the Nile (Fig. 2-17) and is famous for its beaches, historic and archeological sites. It has a population of about four millions and hosts the largest harbor in the country as well as roughly 40% of the Egyptian industrial activities (Raey, 2010; Agrawla, et al., 2004).

According to the analysis of OECD, Alexandria is considered to be one of the top 10 cities in terms of exposed population due to SLR (Nicholls, et al., 2008)**.** About 51% of the city area is projected to be lost due to inundation (Table 2-4) (Elasha, 2010; Raey, 2010; Agrawla, et al., 2004).

The recent coastal flooding in Alexandria on December 12, 2010 on the Nile Delta Coastline is a striking example for the severity of more progressive global phenomena. Egypt was hit by strong winds, exacerbated by heavy precipitation, up to 60 km/hr with a surge of over 1.0m (Ismail, et al., 2012). Although reported values of storm-surge on the Nile delta coast are typically from 40 to 50cm, a preliminary analysis, based on the equations developed by the Dutch-Engineers on storm-surge in Zuider-Zee (Wiegel, 2005), yielded a storm-surge 0.7 to 1.5m (Ismail, 2011) . This range coincides with the maximum reported value of 1.2m provided by Egypt-Navy (Ismail, et al., 2012).

In addition, the salinity in Lake Manzala may increase because of the stronger influence of tidal flows penetrating the lake. Accelerated SLR will enhance the increase of insalinity in the lake which will eventually affect its ecology and fisheries (El-Sharkawy, et al., 2009; El-Raey, 1999).

Table 2-5: Potential loss at risk by 0.5 m SLR in Alexandria Governorate
Source: http//www.ess.co.at/GAIA/CASES/EGY/impact.html

Potential loss	2050 (0.5 m)
Area (km^2)	
Area at risk	317
Affected people (people)	
Population to be displaced	1512000
Loss of employment in Agriculture sector	8812
Loss of employment in Tourism sector	33919
Loss of employment in Industry sector	151200

2.3.3.2. Rosetta

Rosetta city is located at the north-eastern tip of Behira Governorate, on the west bank of Rosetta branch of the river Nile (Fig. 2-17).It forms its estuary 12 km to the north, the area surrounding the city extends towards the west to the borders of Lake Idku, which is located on the eastern zone of Alexandria Governorate (El-Raey, et al., 2000; Agrawla, et al., 2004).

One study concludes that a 0.5- meter rise would cost over 2 billion dollars and would eliminate over one third of the jobs located in Rosetta (Sterman, 2009; Agrawla, et al., 2004). Besides , excessive erosion rates have been observed near the Rosetta promontory (Fig. 2-11) due to the cessation of sediments following the building of the High Dam on the River Nile about 1000 km to the south. The region surrounding the city is well known for its water-logging and water-bogging problems (El-Raey, 2011; Agrawla, et al., 2004).

As a result, erosion problems are expected to be exacerbated by SLR. So far, the Government has built a massive sea wall near the tip of the promontory as a protective measure against the already-existing erosion problems (Brown, et al., 2011; El-Sharkawy, et al., 2009; Agrawla, et al., 2004).

2.3.3.3. Damietta

The city of Damietta is the capital of the governorate that holds the same name. Damietta is famous for being the location where the Eastern Branch of the River Nile (Fig. 2-17) pours into the Mediterranean Sea at the popular local resort of Ras El Barr. What is more,, the Port of Damietta is one of the most ac-

tive and vital trading points in Egypt (El-Raey, 2011; El-Sharkawy, et al., 2009; Raey, 2010; Brown, et al., 2011).

Due to its location at the northern low-lying Delta region (Fig.2-9). It's projected that Damietta will face population growth, land subsidence in the Delta region, excessive erosion rates ,saltwater intrusion, soil salinization, land use interference (Raey, 2010; ElGanzori, 2012; El-Sharkawy, et al., 2009).At present, erosion is a significant environmental problem affecting the coastal zone of Damietta city, which has retreated more than 50 cm in over 10 years (El-Sharkawy, et al., 2009; Brown, et al., 2011; EEAA, 1999) .

However, a number of protective structures have been constructed along this projection to reduce shoaling in the river entrance. Continuous SLR is expected to enhance the rates of erosion of the northern coast and Nile delta (EEAA, 1999; El-Sharkawy, et al., 2009).

2.3.3.4. Port Said

Port-Said is located on the Mediterranean Sea east of the Damietta branch of the River Nile at the entrance/exit of the Suez Canal (Fig. 2-17). The vulnerability of Port Said to SLR is particularly high due to the fact that it has one of the highest rates of local land subsidence in the Nile Delta which amplifies the effects of climate change induced SLR (El-Sharkawy, et al., 2009; EEAA, 1999; Agrawla, et al., 2004).

SLR is expected to cause a landward shift of the salt wedge and to increase the rate of saline seepage in the top soil, which may have potentially serious implications for agriculture and drainage conditions as well as for the available groundwater resources in the upper Nile Delta (El-Raey, 2011; Agrawla, et al., 2004). As shown inTable2-6, the most severely affected sectors are expected to be industry (12.5%) and transportation (11.7%). In case of a SLR of 0.5m, a loss of 6,700 jobs (5.3%) is expected. In terms of economic losses, the loss of beaches is likely to outweigh losses in other areas, given their high value for tourism (EEAA, 1999; El-Sharkawy, et al., 2009; MWRI, 2009).

Table 2-6: Physical and socio-economic losses for a SLR of 0.5 m in the Port Said Governorate
Source: (Agrawla, et al., 2004), p.30

Potential loss	Total
Area (km^2)	
Beach area	21.26
Urban area	0.46
Industrial area	0.05
Aqua-cultural area	0.024
Length (km)	
Transportation network	23
Affected People (people)	
Population	28191
Employment	6700

2.4.Floods and their Impacts

Flash floods are considered one of the worst weather-related natural disasters. They are highly dangerous because they are sudden, and because they are highly unpredictable; usually following brief spells of heavy rain. Flood hazard seems to be increasing as climate change takes effect and according to UN (2014) . They cause half of the disasters worldwide and 84% of all disastrous deaths. Floods in dense, poorly-serviced settlements can lead to diseases such as diarrhea, typhoid, scabies, cholera and malaria. Furthermore, floods can cause contamination of water supplies, as pipes in slum areas are often damaged and often leak. Many of the world's cities are located on coasts and are accordingly vulnerable to floods area (El-Sayad, et al., 2013).

2.4.1 Definitions of Floods

According to the European Union (EU), flood means "*the temporary covering by water of land not normally covered by water*". This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses, floods from the sea in coasts and flash floods (EU, 2007). Moreover, according to the American Psychological Association (2013), the word "flood" is usually applied to an "*over flow of a great body of water as, for example: a river, although it may refer to any water that overflows an area*".

2.4.2 Characteristics of floods

A number of criteria determine the dangers of a flood (Millet, et al., 2014) , such as :

- High velocities of flow create erosive forces and can do things like destroy foundations
- Rate of Rise: it is the rate at which the water level increases
- Seasonal: it means the effects on agriculture production

2.4.3 Causes and impacts of floods and flash floods

Tidal cycles, behaviors of the storm, river or stream runoff, no offshore reefs or other barriers, high winds and soil conditions are considered to be responsible for increasing the effects of floods (Mclean, et al., 2001; Nicholls, 2002).

Although sometimes flood is a good thing to occur for fisheries, wetlands, and irrigation, it also makes a mess for the environment, such as: increasing the salination of the soil, decreasing the growing season especially to woody plants and crops. Moreover, on the scale of human settlements, the amount of people affected by floods from 1999-2000 is reported to be approximately 1.5 billion (Millet, et al., 2014).

Nonetheless, for flash floods − which could be defined as runoff of intense rain that results in high flood waves− are responsible for the failure of dams and more. They are threats in steep land, high runoff rates, and narrow streams (Nicholls, 2002).

2.4.4 Floods and sea level rise

SLR can exacerbate all of the causes of coastal flooding, according to various studies (EPA, 2014; Nicholls, 2002; Mclean, et al., 2001). Fig. 2-18 illustrates that the impacts of SLR on the coastal zones always cause floods.

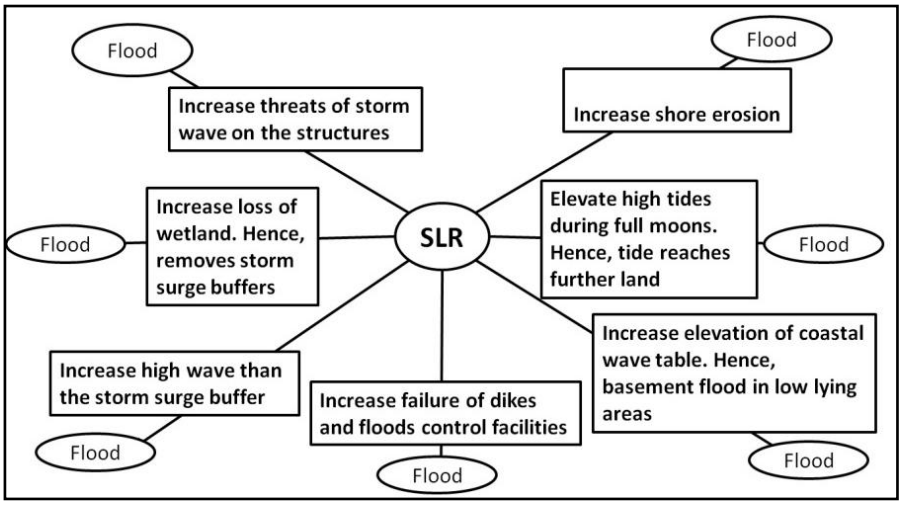


Figure 2-18: Causes of coastal flooding
Source: Researcher based on data available in (EPA, 2014; Nicholls, 2002; Mclean, et al., 2001)

Nowadays, scores of coastal communities are witnessing more frequent flooding during high tides. As sea level rises higher over the next 15 to 30 years, tidal flooding is expected to occur more often, causing more disruption.

However, most countries still lack the capability to observe, evaluate and predict flash flooding, flood warnings, and coordinate response. Accordingly,, the least developed countries and the developing countries suffer the greatest loss of lives and livelihoods due to the lack of resources that might help to detect imminent flash floods and to warn the population at risk (IPCC, 2012; Union of Concerned Scientists , 2014; Sakr, 2010).

2.4.5 Egypt and flash floods

Flash floods are common in some areas of the Egyptian coastal zone and Upper Egypt. They normally prevail when the intensity of rainfall exceeds 1 millimeter per minute and the duration exceeds 10 minutes. In Port Said, on the eastern coast, the number of thunderstorm days rose from 0 to 18 to 41 days in the last 10 years. The Mediterranean coast of Egypt experienced a successive increase in the amount of annual rainfall during the last three decades. The mean trend over the area is 0.76 millimeters per year. Rainfall has increased over the western coast of Egypt by up to 3 millimeters per year. Their negative socioeconomic impacts occur in almost all sectors, including agricultural productivity, livestock, public health, environment, and tourism (El-Raey, 2010).

According to the Egyptian Government (2005), Alexandria was affected by heavy rainy storms in 1993 which caused severe damage to people and infrastructure. Nevertheless, in the current days rainstorm (Nawa't) often drawn the streets of the city and affect people. Furthermore, 1330 people are currently affected by coastal floods and it is expected for that number to increase by 2070 to reach over 4 million people (Reuters, 2010; Nassar, 2013).

Additionally, according to the Egyptian Red Cross (2010), on 21 January 2010, severe floods have occurred and caused the following: houses have been swept away, 57 electrical towers have collapsed in cities and villages. Main roads were closed throughout the country and telephone and power lines were cut. Heavy flooding has seriously affected several communities in the Sinai Peninsula and in Aswan. The resorts of Taba, Nuweiba and Sharm El Sheikh on the Red Sea had temporary blackouts (Egyptian Red Cross, 2010; Nicholls, 2003).

2.5. Concluding Remarks

The previous discussion investigated the causes and impacts of climate change and SLR. It can be concluded from the previous discussion that there are key human activities which play a leading role in exaggerating climate change drivers; hence, leading to major threats as shown in Fig. 2-19.

As shown in this figure, there are main human activities -sorted in orange-colored rectangle- that can be sorted under two main groups, which are: land use changes and fuel burning activities. Both activities are mainly responsible for increasing the intensity of atmospheric concentrations, GHGs and global warming ,which are mentioned in the middle part under the name of climate change drivers -sorted in a purple-colored rectangle.

In the "climate change drivers" part, each component leads to the other. This relationship is represented by arrows with two heads-arrows colored in brown. Atmospheric concentrations and GHGs are sorted in one group surrounded by dotted ellipse due to the fact that they are both components of climate change. By contrast, global warming is a factor caused by these climate change components, being not a component of climate change itself.

The climate change drivers cause the climate change impacts − sorted in blue-colored rectangle. Changes in Atmospheric concentrations and GHGs directly cause the salination of soil and water, precipitation, extreme weather events and ocean acidification. However, global warming directly causes ocean

acidification. Soil and water temperature, ocean thermal expansion, glaciers melt and ice cap melting are sorted in one dotted rectangle due to the fact that they play a role model in causing SLR, and that they are caused by all the climate change drivers. Hence, they are sorted in one group. In this part, each impact lead to another. This relationship is represented by arrows with two heads-arrows colored in brown as previously shown.

Climate change impacts cause main major threats and disasters − sorted in red-colored rectangle. SLR , which is the focus of this thesis , is mainly caused by increasing the temperature of the soil and water, ocean thermal expansion, glaciers melt and ice cap melting. SLR cause floods, biodiversity loss, famines and other types of disaster mentioned in this figure. Likewise, every disaster might be the cause for another. This relationship is represented by arrows with two heads-arrows colored in brown as previously shown.

Furthermore , as discussed briefly in this chapter, Egypt is more likely to face unbalanced economic and health situation, food and water scarcity, problems in coasts, a decrease in supply in infrastructure and ecosystems (as a result of severe climate changes) and an increase in demand (as a result of the increasing population). Hence, the ability to face these impacts is a pressing issue. For Alexandria city, it is severely impacted by SLR, which is especially represented by coastal floods. Hence, more measures should be applied to protect this city and reduce the impacts of flash floods (Nuwa't) on the city.

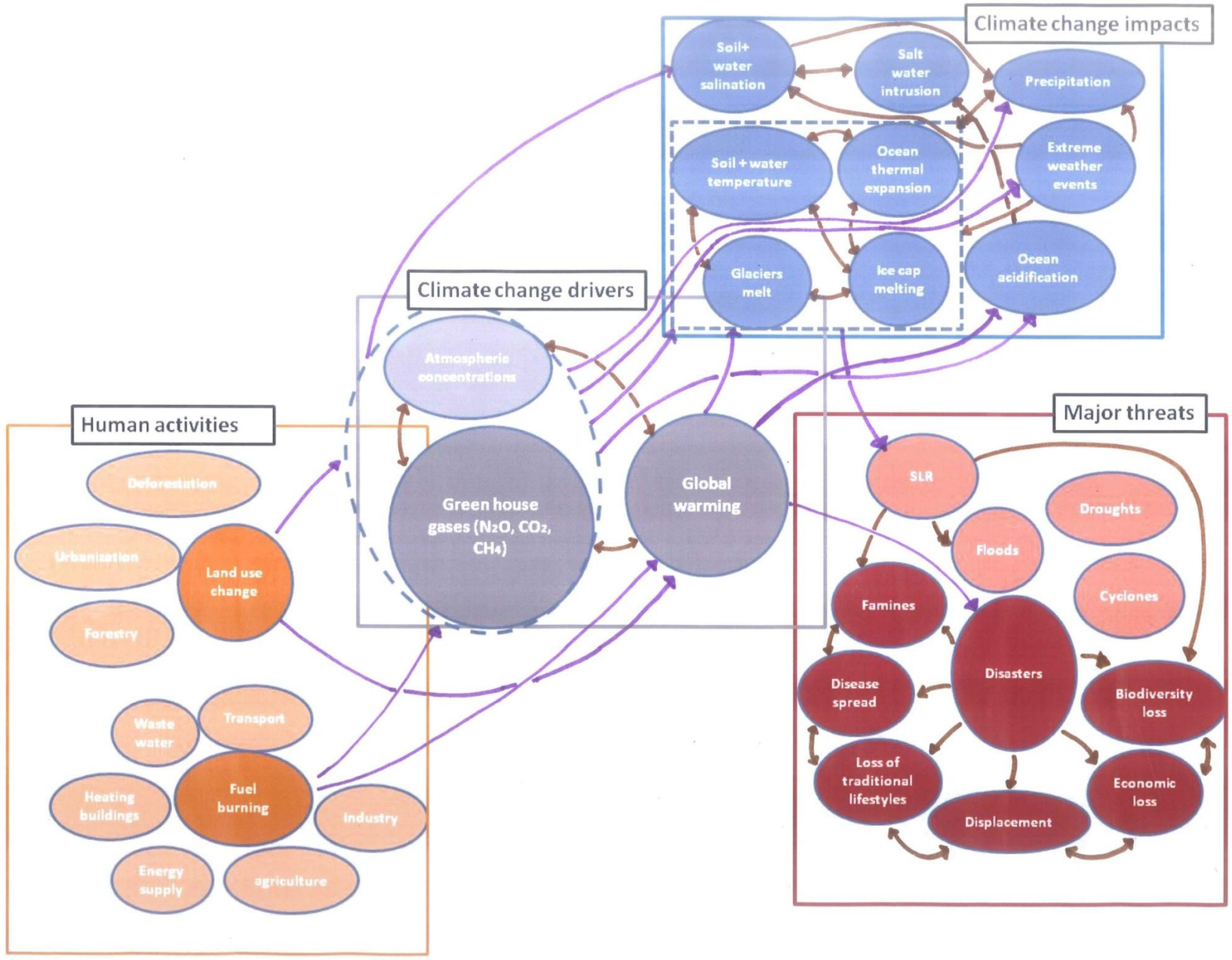


Figure 2-19: Direct causes and impacts for climate change and SLR

CHAPTER 3

RESPONDING TO CLIMATE CHANGE WITH FOCUS ON SEA LEVEL RISE

Chapter 3: Responding to Climate Change with Focus on Sea Level Rise

Different approaches are being implemented globally to reduce the impacts of climate change on the communities and the vulnerable sectors in cities. Similar approaches, though with different measures, have been implemented in the coastal zones to reduce the impacts of SLR on coastal communities, particularly in developing countries where urbanization is taking place at a fast speed. These approaches with their various measures are discussed in this chapter using an in-depth comparative method both in Egypt and on a global realm.

3.1. Global Approaches to Climate Change

According to the IPCC (2007), the mitigation approach is defined as "*an anthropogenic intervention to reduce the sources or enhance the sinks of GHG*" (Glenn, 2010)**.** The adaptation approach, on the other hand, can be defined as "*Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects*". Raising river and the substitution of more temperature-shock resistant plants for sensitive ones are considered common adaptation measures for SLR (Rashid, et al., 2009; Carraro, et al., 2008). However, there are various definitions of "resilience" that can be found in the literature based on their domains as shown in Table 3-1.

Table 3-1: Definitions of "resilience" according to chosen domains
Source: (Norris, et al., 2008; Community and Regional Resilience Institute, 2003)

Domain	Definition
Physical	The speed with which a system returns to equilibrium after displacement irrespective of how many oscillations are required.
Ecological	The ability to persist through future disturbances
Community	The capability to retain similar structures and functioning after disturbances for continuous development

Nevertheless, from the point of view of urban communities, it's mainly focused on: capacity to absorb stress or destructive forces through resistance or adaptation, capacity to manage or maintain certain basic functions and structures during disastrous events, and capacity to recover or 'bounce back' after an event (Kyoto University , 2011). For that reason , various options that can be applied to cover the broad aspects of resilience against SLR and floods, which is the focus of this thesis, have occurred (Wardekker, et al., 2010; Bagdonavicius, et al., 2014) (Table 3-2). It can be observed from this table that for a definition

of "Omnivory" and "Redundancy" , there is a similarity in the method of application.

Table 3-2: Options to be considered within the resilience approach
Source: Researcher based on data available in (Wardekker, et al., 2010; Kaklauskas, et al., 2014; Bagdonavicius, et al., 2014)

Option	Definition	Example
Homeostasis	Incorporating feedback loops that stabilize the system to external disorders	Social cohesion structure could turn the response to disturbances into a more collective effort.
Omnivory	Having several ways of fulfilling one's needs; when one becomes unavailable, other ways can be used	In case of floods: functions could easily be relocated to other buildings in other parts of the area
High flux	Allowing quick responses to threats and changes and having power to resist attack	Using quick notification of high tides to allow residents to take measures early on.
Flatness	Preventing the system from becoming top-heavy	The individuals and NGOs should be more self-reliant in facing risks
Buffering	Increasing the ability to absorb disturbances to a certain extent.	Leaving plenty of open spaces that could change function relatively rapidly during floods
Redundancy	Overlapping functions; if one fails, others can take over	Having multiple roads into and out of the area.

Although mitigation, adaptation and resilience measures are targeting the reduction of the impacts of climate change; and hence SLR, they differ from each other as shown in Table 3-3.

Table 3-3: Comparison between mitigation, adaptation and resilience according to their definitions
Source: Researcher based on data available in (Wardekker, et al., 2010; The World Bank, 2013)

	Mitigation	Adaptation	Resilience
Type of role	Only active	Active and proactive	
Way of thinking about climate change	Top-bottom way	Top- bottom and bottom-top method	
Type of actions applied	Actions whereby GHGs emissions are reduced	Actions whereby impacts of unavoidable global warming are managed	Actions for preparedness and increasing the capacity of the community
Type of SLR preventation	Indirect	Direct and indirect	

3.2.Definitions of Urban Resilience

In the “resilient” literature, there are many definitions for the notion of “urban resilience” according to the type of dealing with this notion. For example: in disaster studies, urban resilience is often defined as “the capacity of a city to rebound from destruction” with the focus often being on whether the city has recovered, in quantitative terms, its economy, population or built form. However, in Psychology, where resilience theory has made major inroads, the equilibrium model of resilience to trauma is defined as “the ability of adults who are exposed to an isolated and potentially highly disruptive event to maintain relatively stable, healthy levels of psychological and physical functioning" (Bonanno, 2004) as stated in (Davoudi, 2012). Selected further definitions are presented in Table 3-4.

Table 3-4: Selected definitions for "urban resilience"
Source: Researcher based on data available in (Wilbanks, 2009; Mortimer, 2013)

Aspect	Definition
Adaptation	A measure of how well an urban settlement, its residents and its subsystems can adapt to shocks and persistent change in a complex, dynamic and interdependent world
Absorption	The ability of a city or urban system to absorb disturbance while retaining identity, structure and key processes
Phases of dealing with a disaster	Capability to prepare for, respond to and recover from significant multi-hazard threats (climate change, natural disasters and terrorism) with minimum damage to public safety and health and security of a given urban area

According to Wikstorm (2013), urban resilience can be viewed as "*having the concept of resilience applied to that of cities*". This means viewing cities and urban space as ‘systems’ that are constantly exposed to both internal and external types of change ((Vale, et al., 2005) as stated in (Davoudi, 2012)) . Hence, urban planners and other involved actors such as policymakers and local governments play an important role in the shaping of resilient cities (Wikstrom, 2013).

However, for a wider perspective, it can be defined as "capability to prepare for, respond to, and recover from significant multi-hazard threats −SLR threats in this thesis− with minimum damage to public safety and health, the economy, and security" (Kates, et al., 2010; Atkinson, 2014).

It can be observed from these variety of urban resilience definitions that its main goal is: increasing the resilience of the community by assessing measures

of preparing for, responding to and recovering from any impact of the climate change −SLR as in this thesis. Hence, further explanation for the concept of "community resilience" is provided in the following section.

3.3.Community resilience: definitions and components

Since the adoption of the Hyogo Framework for Action 2005-2015: *Building the resilience of nations and communities to disasters*, the main goal of hazard planning has focused more on building community resilience rather than on merely reducing vulnerability (UNISDR, 2013). Thus, various campaigns and competitions are supported by international sponsors in order to promote the concept of urban resilience as shown in Table 3-5.

In general terms, according to the Oxford Dictionary (2015), communities are defined as "*group of people living in the same place or having a particular characteristic in common*", and according to Rifkin (1988) as stated in (Brieger, 2006), it's defined as" *a group of people living in the same defined area sharing the same basic values, organization and interests*".

For the notion of "community resilience", there have been several definitions according to the type of dealing with this notion. As stated in (Mayunga, 2007), Mcentire (2002) argues that one of the major challenges that limit the chances for an agreement on a common definition is that individuals, groups, and communities may have different degrees of resilience which significantly vary over time. Hence, it is difficult to reach a consensus or to share a common ground about the definition of resilience.

For example, it can be defined from the field of sustainability as "*a measure of the sustained ability of a community to utilize available resources to respond to, withstand, and recover from adverse situations*" (Rich, 2015), Whereas it could be defined from the perspective of the usage of resources as "*communities and individuals harnessing local resources and expertise to help themselves in an emergency, in a way that complements the response of the emergency services*" (UK Government, 2011). Selected definitions of community resilience are presented in Table 3-6. However, this thesis deals with the notion of "community resilience" as: *the capacity to absorb stress through resistance, capacity to manage certain basic functions and capacity to recover or bounce back after an event*" (Shaw, 2009; Twigg, 2007).

Table 3-5: Examples for selected international campaigns promoting the concept of "community resilient"
Source: Researcher data available in (Rockefeller Foundation, 2013; ACCCRN, 2012)

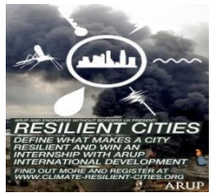
Sponsors and partnerships	Vision	Campaign's Goal	Time	Focus Area	Logo
The Making Cities Resilient Campaign: 'My City is getting ready!'					
-UNISDR &UN Habitat -International Institute for Environment and Development (IIED) -European Commission (EC) -Global Facility for Disaster Reduction and Recovery (GFDRR)	- The substantial reduction of disaster losses, in lives and in the social, economic and environmental assets of communities and countries - The social, political and economic imperatives for reducing disaster risk are acted upon'.	- Achieve resilient, sustainable urban communities, with a growing number of local governments that are taking actions to reduce the risks to disasters, based on common standards and tools.	**1st phase : 2010-2011** -No. of participants = 750 cities **2nd phase: 2012-2015** -No. of participants= 1276 cities	- Know more - Invest wiser - Build safer - Know more and commit - Invest wiser- build safer - Implementation - capacity building - Benchmarking and reporting	
Asian Cities Climate Change Resilience Network (ACCCRN)					
-The Rockefeller foundation - Institute for Social and Environmental Transition (ISET) - Association of Public-Safety Communications Officials (APCO) - International Council for Local Environmental Initiatives (ICLEI)	N/A	- Measurably enhancing the resilience of ACCCRN cities' institutions, systems and structures to current and future climate risks	Four phases started form 2008	- Capacity building of Cities Network for knowledge, learning and engagement - Expansion, deepening of experience, scaling up	
Resilient Cities 2012 competition					
-Engineers Without Borders (EWB UK)	N/A	- Increasing the engagement in the urban resilience debate - Determining different perspectives on urban resilience from the next generation of professionals who will play a key role in shaping our urban future	- Launch 2012 -No. of participants= 35 cities - Winning entry: Oaxaca City (Mexico)	- Determining multiple dimensions of the resilience	
100 Resilient Cities Centennial Challenge					
-Rockefeller Foundation	Building resilience by helping individuals and communities prepare for, withstand, and emerge stronger from acute shocks and chronic stresses.	- Enabling 100 cities to better address the increasing shocks and stresses of the 21st century	-Registration close on: 23/9/2013 - No. of participants= 100 cities	- Efforts to build urban resilience around the world.	

Table 3-6: Selected definitions of community resilience
Source: (Mayunga, 2007)

Aspect	Definition
Time duration	It is the one that resumes its previous growth trajectory quickly.
Adaptation	It is a social system that can reorganize itself to maintain essential structure and process within a coping and/ or adaptation process
Social	The ability of a community to not only deal with adversity but in doing so reach a high level of functioning

3.4. Measuring community resilience

Currently, there are various conceptual frameworks proposed to measure the concept of community resilience, although measuring community resilience is a complex process due to the dynamic interactions of people and environment The literature of resilience has various frameworks that measure the community resilience from the perspective of climate change both at national and sub-national levels (Heinz Center, 2002; Kaly, et al., 2004; Organization for Economic Cooperation and Development, 2001) as stated in (Cutter, et al., 2010). Lastly, composite indicators have been utilized to determine the physical and social vulnerability of coastal environments to sea level rise and its potential consequences (Boruff, 2005; Pethick, 2000) as stated in (Cutter, et al., 2010).

This section discusses three selected frameworks used for measuring community resilience against climate change and gives feedback for every framework. Such frameworks were selected due to their relevance to the issues discussed in this thesis.

3.3.1.1. Climate Disaster Resilience Index

Shaw and his team (2009) − under the supervision of Kyoto University, Japan− have proposed a framework called Climate Disaster Resilience Index (CDRI) and consisted of 25 variables, in order to measure the existing level of climate disaster resilience of targeted areas using CDRI, which is developed in relation to five resilience-based dimensions: natural, physical, social, economic and institutional as shown in Table 3-7. The main aim of the whole process of CDRI was to make city managers and practitioners aware of the existing and future risks of climate-related disasters. The study was limited to climate-induced disasters in general.

Nine cities were selected from different countries in Asia. The selection process was in a way to guarantee the representation of urban communities from large, medium and small cities. In this study, large, medium and small cities are

used to refer to those cities having a population of less than one million people, between one and five million and above 5 million inhabitants respectively.

Table 3-7: Proposed CDRI framework
Source: Researcher based on data available in (Shaw, 2009)

Dimension	Variable considered
Physical	Electricity, Water supply, Sanitation, Solid waste disposal, Internal road network, Housing and land use, Community assets, Warning system and evacuation
Social	Health status, Education and awareness, Social capital
Economic	Income, Employment, Households' assets, Access to financial service, Savings and insurance, Budget and subsidy
Institutional	Internal institutions and development plan, Effectiveness of internal institutions, External institutions and networks, Institutional collaboration and coordination
Natural	Hazard intensity, Hazard frequency

Questionnaire surveys were the prime means of data collection. They were filled in by the city officials and computed by Microsoft Excel. A rating scale for each variable has been constructed based on how the city officials perceive the vulnerability of each variable by comparing it to other variables.

It can be observed from Table 3-7 that there is a lack of attention that occurred in the process of decision-making and the process by which decisions are implemented by the governments. Decision-making processes can affect the resilience of the community . Risks endangering the community − due to environmental disasters − are worsened when integrated with poor decision- making strategies. By contrast,, good decision-making provides community resilience with, good connectivity between cities, improved efficiency, safety to communities and improved network reliability to all road users during disasters (Withanaarachchi, et al., 2014).

What is more, community individuals were not included in the surveys. Only governmental officials were consulted. Therefore, both the lack of attention given to the aspects of governance and the marginalization of other community individuals can be seen as gaps in this framework.

3.3.1.2. Disaster Resilience of Place Model

Cutter, Burton and Emrich (2010) have developed a Disaster Resilience of Place (DROP) model in order to monitor changes in resilience over time in particular places, and to compare one place to another through establishing baseline characteristics of communities that foster resilience. DROP Model consists of five main elements as shown in Table 3-8-colored with yellow-: social, econom-

ic, institutional, infrastructure and community. Each element consists of a number of categories which are measured by variables. The total number of variables is 36, which cover a wide range of aspects of community resilience. Each variable has an effect on the community resilience: either positive or negative. Higher value of the positive variable indicates higher the performance of the community resilience and vice versa. To the contrary the negative variable, higher value of this variable indicates lower performance of the community resilience and vice versa.

Table 3-8: Proposed DROP model
Source: Researcher based on data available in (Cutter, et al., 2010)

Category	Variable	Effect on resilience
Social Resilience		
Age	Percent of non-elderly population	Positive
Educational equity	Ratio of the population with college education to the population with no high school diploma	Negative
Transportation access	Percent of population with a vehicle	Positive
Communication capacity	Percent of population with a telephone	Positive
Language competency	Percent of population not speaking English as a second language	Positive
Health coverage	Percent of population with health insurance coverage	Positive
Special needs	Percent of population without physical, or mental disability	Positive
Economic Resilience		
Housing capital	Percent of homeownership	Positive
Employment	Percent of employed population	Positive
Income and equality	GINI coefficient	Positive
Single sector employment dependence	Percent of population not employed in farming, fishing, forestry, and extractive industries	Positive
Employment	Percent of participation of females in labor force	Positive
Business size	Ratio of large to small businesses	Positive
Health access	Number of physicians per 10,000 population	Positive
Institutional Resilience		
Mitigation	Percent of population covered by a recent hazard mitigation plan	Positive
	Percent of population participating in Community Rating System for Flood	Positive
Flood coverage	Percent of housing units covered by floods policies	Positive

Table 3-8: Proposed DROP model (continued)

Category	Variable	Effect on resilience
Institutional Resilience (continued)		
Municipal services	Percent of municipal expenditures for fire, police	Positive
Political fragmentation	Number of governments and special districts	Negative
Previous disaster experience	Number of paid disaster declarations	Positive
Social connectivity	Percent of population covered by Citizen Corps programs	Positive
Infrastructure Resilience		
Housing type	Percent of housing units that are not mobile homes	Positive
Shelter capacity	Percent of vacant rental units	Positive
Medical capacity	Number of hospital beds per 10,000 population	Positive
Housing age	Percent of housing units not built before 1970 and after 1994	Positive
Recovery	Number of public schools per square mile	Positive
Access to evacuation potential	Principle arterial miles per square mile	Positive
Sheltering needs	Number of hotels/motels per square mile	Positive
Community Capital		
Place attachment	Net international migration	Negative
	Percent of population born in a state who still resides in that state	Positive
Political engagement	Percent of the participation of voters in the elections	Positive
Religion	Number of religious adherents per 10,000 citizens	Positive
Civic involvement	Number of civic organizations per 10,000 citizens	Positive
Advocacy	Number of social advocacy organizations per 10,000 citizens	Positive
Innovation	Percent population employed in creative class occupations	Positive

It can be observed form the previous table that ecological (or natural systems) resilience was purposefully excluded. Besides , there are specific variables available in specific countries , hence, DROP cannot be applied by and large to any country. These variables are: percent of population not speaking English as a second language, percent of population working in creative jobs, number of paid disaster declarations, percent of housing units covered by floods policies and GINI coefficient. Besides that, the aspect of public participation has not

been discussed in this model. Various variables can be used to asses such an aspect, such as: percent population participating in community activities and the percentage of population who trust community representatives. All these issues are considered to be gaps in the DROP model. Although the DROP model has shown some gaps, it covered other community resilient aspects in a wider perspective.

3.3.1.3. Capital-Based Approach Framework

In 2007, a Capital-Based Approach was developed as a framework to assess the community disaster resilience by (Mayunga) . This framework is based on five major forms of capitals; Social, Economic, Physical, Human and Natural. According to Mayunga (2007), the notion of capital aligns very well with the concept of sustainability, which is often linked to the concept of resilience to disaster .The essence of using the capital approach is that, capital consists of components which are necessary for the development of a sustainable economy in the community. The wisdom here is that the more the economic opportunities the community has, the more potential it possesses for reducing the impacts of disaster ; hence the more resilient the community becomes.

The capital-based approach is not new to the fields of disaster and hazard management. The major forms of capital particularly social capital have been recognized as important and useful concepts in the fields of hazard and disaster (see for example (Dynes, 2002). Recent research suggests that the community development theory has demonstrated that success, sustainability and resilience depend on the ability of a community to appreciate, access, and utilize the major forms of capital (Beeton, 2006).

Table 3-9 demonstrates the five forms of capital-colored in yellow-. A definition for each capital, the indicators and variables related to it are also illustrated.

Table 3-9: Capital-Based Approach Framework
Source: Researcher based on data available in (Mayunga, 2007)

Definition	Indicators	Variables
Social Capital		
Features of social organization that reflect the quantity and quality of social cooperation	- Networks - Norms -Social trust	-Number of non-profit organizations , voluntary associations, religious organizations, sport and recreational clubs operating in the community - Percentage of voter participation and registration, newspaper readership
Economic Capital		
Financial resources that people use to achieve their livelihoods	- Savings - Income -Investment	- Household income - Property value -Employment
Human Capital		
The capabilities embodied in the working-age population that allow it to work productively to sustain the economic production	-Education -health skills -Information	Education attainment (years of schooling) -Health -Population density -Population growth -Demographic characteristics (racial and ethnicity) -Access to transportation services - Housing quality -Dependence ratio
Physical Capital		
- Built environment, which comprises residential housing, public buildings, dams and levees and shelters - Lifelines such as electricity, water, telephone, and critical infrastructure such as hospitals, schools, fire and police stations, and nursing homes	- Housing - Public facilities - Business/Industry	-Number, quality, and location of housing units, shelters, lifelines, and critical infrastructures
Natural Capital		
- Natural resources, such as water, minerals and oil, land providing space on which to live and work - Ecosystems that maintain clean water, air and a stable climate	- Resources stocks - Land and water - Ecosystem	-Water quality, air quality, soil quality, wetland, forests, and national and local parks

It can be observed from the previous table that it has the same gap found in the CDRI, which is discussed in section 3.3.1.1. There is a lack of attention giv-

en to the governance aspect. It can also be observed that there is a similarity between the Social and Human capitals.

3.4. Global Reduction of the Impacts of Sea level Rise

Urban residents are not just victims of climate change but are also part of the problem. In order to minimize the impacts of climate change and SLR (one of its ultimate results) on communities, some measurements are applied in coastal cities, especially coastal ones. There are various measures applied on a global level for mitigation, adaptation and resilience.

Table 3-10 illustrates selected measures for mitigation, adaptation and resilience applied in coastal cities around the world in order to reduce the impacts of SLR on these affected areas. As for mitigation measures, if atmospheric GHGs concentrations are stabilized by a mitigation effort, the rise in global sea level is only delayed at most for a few decades during the 21st Century. Thus, in the case of sea-level rise, mitigation has the slowest effects on the future of SLR changes (IPCC-WGIII, 2007) .

Table 3-10: Selected examples for mitigation, adaptation and resilience measures in coastal cities Source: Researcher based on data available in (Wardekker, et al., 2010; CSRCC, 2013)

	Mitigation	Adaptation	Resilience
Target	GHG emission reduction as a means of dealing with the global warming	Accommodate with the impacts	Absorb the stress, maintain basic functions during stress and bouncing back after stress
Method for SLR reduction	Only indirect	Equal effect: Direct and Indirect	Direct effect more that indirect effect
Affected community	Promoting green city: green roves, recycling, supporting public transit and love to walk and cycle	Relocation of human settlements	Informing new residents of the risks in the area and the measures they themselves can take to prevent risks.
		Increasing public awareness, understanding, and preparedness for tsunamis and other coastal hazards	
		Individuals and NGOs should be able to allocate the power to respond to the possible risks they live with	

Table 3-10: Selected examples for mitigation, adaptation and resilience measures in coastal cities (continued)

	Mitigation	Adaptation	Resilience
Role of affected government	Activate the policies of eliminating deforestation and boosting reforestation (Appendix B)	Leaving room and provide capacity for residents to modify the area in order to limit damage and problems	
	Developing green building standards that ensure new construction which incorporates green design and building techniques to conserve energy (Appendix C)	Planning certain low-lying places to serve as water retention areas until high water tides are reduced (Fig. 3-1-a).	
			Creating a National Disaster Resilience Strategy
Affected physical environment	Retrofitting of buildings	Dune and seawalls and natural barriers reinforcement (Fig. 3-1-b & c).	Careful selection of construction materials to reduce disturbances
	Renewal of transportation systems	Elevating house levels to be unreached by floods (Fig. 3-1-d).	Using materials that are resistant to water in buildings and infrastructure to help absorb disturbances
	Enabling clean, low-carbon infrastructure	Designing the road system to enhance the removal of water from the area in case of flooding (Fig. 3-1-e).	

a: low-lying places to serve as water retention areas
Source: Taken by the researcher in Jakarta, Indonesia, 2013
Figure 3-1: Selected examples for global adaptation measures

b: Dune reinforcement on the Dutch coast
Source:https://en.wikipedia.org/wiki/File:Waterway_opspuiten_zandsuppletie_355907s.jpg

c: Glavestone Seawall, Texas, USA,
Source: https://texasliberal.files.wordpress.com/2010/12/img_2661.jpg

Figure 3-1: Selected examples for global adaptation measures (continued)

d: Rain drainage system combined with elevated house
Source: Taken by the researcher in Jakarta, Indonesia, 2013

e: Rain water drainage system in Pademngan roads, Jakarta, Indonesia
Source: Taken by the researcher in Jakarta, Indonesia, 2013

Figure 3-1: Selected examples for global adaptation measures (continued)

Adaptation and resilience are sharing some measures, such as: applying early-warning and response mechanisms and designing the road system to enhance the removal of water from the area in the case of flooding. Hence, an overlapping between these two approaches occurs.

It can be observed from the previous table that there are various ways to classify or distinguish between adaptation measures. Firstly, they could be classified into retreat, accommodation and protection (Rashid, et al., 2009; Carraro, et al., 2008). In the retreat measure, the impacts of SLR are allowed to occur, and the human impacts are minimized by pulling back from the coast via land use planning, development control. Regarding accommodation, the impacts of SLR are allowed to occur and human impacts are minimized by adjusting the human use of the coastal zone to the hazard via increasing flood resilience , such as: raising homes on pilings, early warning and evacuation systems, changing location of recreational facilities. Finally,, protection is the adaptation measure in which the impacts of SLR are controlled by soft measures, such as: policies and regulations or hard engineering, such as: nourished beaches and dunes or seawalls

A second classification can be reactive or anticipatory (Klein, 2002; Government of Canada, 2015). Reactive adaptation occurs after the initial impacts of climate change have become manifest, whilst anticipatory (or proactive) adaptation takes place before impacts are apparent. A third classification can be based on the system in which the adaptation takes place: the natural system (in which adaptation is by definition re-active) or the human system (in which both reactive and anticipatory adaptation are observed).

Within the human system a fourth distinction can be based on whether the adaptation decision is motivated by private or public interests. Private decision-makers include both individual households and commercial companies, whilst public interests are served by governments at all levels. useful classification that is often made is the one between planned and autonomous adaptation (Smit, et al., 2000) as stated in (Klein, 2002). Planned adaptation is the result of a deliberate policy decision that is based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain or achieve a desired state. Autonomous adaptation involves the changes that natural and most human systems will undergo in response to changing conditions irrespective of any policy plan or decision.

3.5.Egyptian Response to Climate Change and Sea Level Rise

The Egyptian responses to climate change and SLR vary from one sector to another. However, they are generally classified into mitigation and adaptation. As for the resilience efforts, they are considered to be a means of adaptation to protect the community from the impacts of SLR and climate change.

3.4.1. Egyptian mitigation response

According to the Climate Investments Funds (2013) and Mckinsey (2010), Egypt is among the 11 fastest growing GHG emitting countries in the world; projections warn of a 300% increase in GHG emissions by 2017. The four top emitters sectors in 2005 are energy with a share of 45%, industry with a share of 35 %, agriculture and transportation with a share of 14% for each. Therefore, Egypt has carried out various projects that mainly aim to decrease GHG emissions in the country as shown in Table 3-11.

Table 3-11:Selected examples for Egyptian mitigation projects
Source: Researcher based on data available in (Azm, 2006; Energy Efficiency Council, 2013; Agrawla, et al., 2004; Croker, 2013)

Authority	Suggested Project	Applied project	Year of operating
Egyptian Environmental Affairs Agency (EEAA)	• Establishing the Egyptian Designated National Authority for Clean Development Mechanism (DNA-CDM)	Develop projects that support an energy efficient economy and the use of Egypt's renewable energy potential (Appendix D)	2009
	Creating a National Action Plan for Climate Change		2005
Ministry of Electricity and Energy (MOEE)	• Establishing several projects in the field of renewable energy (wind - solar - hydro)	Wind: Zaafarana wind farm	2000-2008
		Hydro: Aswan Dam	1968
		Solar : Kuraymat	2010
The Energy Efficiency Council (EEC)	Oversee the development of a national energy efficiency strategy to increase Egypt's efficient use of its natural resources		2000
Cairo Solid Waste Management Authority	Methane recovery from landfills which involves the recovery of methane generated in landfills	Sadat city(Cairo), Borg El Arab and El-Hammam (Alexandria)	2000
The New and Renewable Energy Authority (NREA)	Establishing a program for implementing a series of solar thermal power plants.	Kuraymat	2010

The responsibility for developing and monitoring the national policies −which are related to energy efficiency and renewable energy in all sectors− are held by the Supreme Energy Council (SEC). It was established in 1979 under the Prime Ministerial decree No. 1093 and comprises 11 ministries (Mahmoud, 2013; Azm, 2006). Table 3-12 illustrates selected mitigation polices adapted by the SEC and are currently applied for the four top emitters sectors.

Table 3-12:Selected mitigation polices adopted by the SEC
Source: Researcher based on data available in (Azm, 2006; Abdel-Gelil, 2009)

Sector	Policy
Energy	• Sustain the use of natural gas as the main available cleaner fossil fuel • Promote the usage of renewable energy alternatives • Enhance energy efficiency in the generation of power and the refining of oil
Industry	• Create a market for the climate and the environmental friendly technologies • Apply waste heat recovery • Improve combustion efficiency • Apply energy management systems
Agriculture	• Establish a national integrated network for the monitoring and assessment of the climatic and environmental hazards and their impact on agriculture • Introduce new varieties of rice to reduce the emissions of CH_4 • Rationalize the usage of fertilizers to reduce N_2O emissions • Reduce the burning of agricultural residues
Transportation	• Apply measures including provision of new vehicles, safety of public transportation and of non-motorized means of transportation • Mainstream policies aiming to remove old vehicles from the streets, promoting efficient public transportation, expansion of the underground Metro system and hybrid vehicles • Extend metro lines to newly developed cities and encourage private sector participation in financing and managing the new metro lines

3.4.2. Egyptian adaptation efforts

Regarding the Egyptian coastal cities, adaptation measures and projects are basically based on the "protection" type and its two concerns: hard -which imply the use of specific technologies and actions that involve goods-and soft-which focuses on information, policy and strategy development and institutional arrangements applying lows and strategies-.These measures and projects are

applied by several Egyptian authoities in order to reduce the SLR impacts on the Egyptian coasts as shown in Table 3-13. In this table; each governmnetal authoirty has its own roles played to reduce the impacts of SLR. Adaptation measures mentioned in this table are classified into soft and hard measures.

Table 3-13: Selected examples for Egyptian adaptation measures
Source: Researcher based on data available in (Egyptian Environmental Affairs Agency, 2013; Information and Decision Support Centre, 2011)

Role	Adaptation measures	
	Soft	Hard
Shore Protection Authority (SPA)		
Preparing a general plan for shore protection activities and projects	• Issuing environmental laws • Establishing a coastal zone management committee for the proper management and coordination	• Enhancing the Rashid protection wall, Mohammed Ali sea wall and coastal roads • Constructing hard structures(dam-sea walls-break waters) to protect coastal areas from erosion, beach reinforcing
Developing master plans for new development projects on the sea shores	• Accepting Environment Impact Assessment (EIA) reports for mega coastal projects • Preparing regulations such as: shoreline buffer	• Protecting the beaches of Alexandria, Port Said and Al-Arish, Damietta, Kafr E-Shikh, and El- Malaha • Regular enforcement for northern coastal cities beaches • Preparing a general plan for shore protection activities
Center of Research Institute (CoRI)		
Applying physical and numerical models to simulate future and present-day impacts of SLR	• Providing technical support and essential studies required for SPA • Providing technical consultations to decision makers and private clients on coastal issues	• Engineering design of the most efficient, low-cost and high-effective control works to protect urban and agricultural lands from sea attack.. • Develop master plans & prepare the technical designs for new development projects on the seashores
Agriculture Research Center (ARC)		
Coastal monitoring and assessment of morphological changes of the coastline configuration of the Mediterranean and Red sea coast of Egypt.	• Carrying out researches about the adaptation of more heat-tolerant cultivars	• Develop pilot projects which serve the authority's activities in cooperation with the different authorities, the Egyptian universities and the foreign universities.

Table 3-13: Selected examples for Egyptian adaptation measures (continued)

Role	Adaptation measures	
	Soft	Hard
Ministry of Water , Resources and Irrigation (MWRI)		
Measuring and analyzing coastal processes contributing to changes including wind, waves, currents and tidal variations.	Establishing research centers in cooperation with development partners and implementing projects for shore protection SPA	

In the context of reducing the SLR impacts on the Egyptian coastal cities, various projects have been applied and funded by Egyptian and international authorities. Selected examples of these projects are illustrated in Table 3-14.

Table 3-14: Selected examples for SLR reduction -cooperation projects
Source: Researcher based on data available in (Information and Decision Support Centre, 2011; El-Den, 2013; ALM, 2009)

Project	Aims to
World Health Organization (WHO), United Nations International Children Emergency Fund (UNICEF)	
Cooperate with members to exchange information	Provide technical support assisting in the provision of financial and technical support
EEAA, Alexandria Governorate, Arab Academy for Science, Technology and Maritime Transport, World Bank(WB)	
Prepare for natural disasters in the coastal cities of North Africa	Develop plans to improve the potential of adaptation to climate change and prepare for natural disasters.
Food and Agriculture Organization(FAO)	
Monitor the risks of climate change and sea level rise on agriculture in the Nile Delta	Develop the decision -making system for prediction and mitigation of the impact of climate change on agriculture and the environment along the Delta coast
EEAA- MWRI, Alexandria University, United Nation(UN)	
Develop strategy to address the impact of SLR on human migration in Egypt	• Include migration and human safety in the planning and development of policies • Provide technical aid from the most important governmental and non-governmental partners

Table 3-14: Selected examples for SLR reduction -cooperation projects (continued)

Project's name	Aims to
WB	
Developing regional guidelines for large scale water investment intervention	• Assist in the control of sea level rise • Create a mainstream of adaptation issues in national plans • Raise the awareness of policy for decision makers on adaptation measures
EEAA, Global Environment Facility (GEF)	
Initiative of Climate Change Capacity Building	Institutionalize climate change issues on a national level and assess the technology needed for adaptation measures
United Nation Development Program (UNDP), GEF	
Adaptation to climate change in the Nile Delta	• Promote coordination between water-related sectors • Raise public awareness of climate change

3.6. Egypt's National Strategy for Adaptation to Climate Change and Disaster Risk Reduction

According to the Infromation Decession Support Center (IDSC) (2011)− a governmental institution which was built in 1985 and acts as the Egyptian Cabinet Think Tank−, the Egyptian government has a deep concern for climate change. This concern has developed in creating a national strategy addressing the phenomenon of climate change according to the type of sectors affected and those affecting the issue of climate change.

This strategy is called: the "National Strategy for Adaptation to Climate Change and Disaster Risk Reduction". It is a strategy which addresses climate change and its potential impact at two levels, according to the type of sectors affected and those affecting the issue of climate change . Whereas the first level is concerned with adaptation to climate change, the second level is about the mitigation of its severity.

It was initiated by the National Committee for Crisis /Disaster Management and Disaster Risk Reduction affiliated to the IDSC in Egypt, in order to achieve its main objective which is increasing the flexibility of the Egyptian community while dealing with the disasters that might be caused by climate change and its impact on different sectors (Information and Decision Support Centre, 2011).

It further aims at strengthening the capacity to absorb, contain, and reduce the risks and disasters caused by climate change including SLR, hence accomplishing resilience. Regarding the issue of facing the danger of SLR in Egyptian coastal areas, several measures are specifically referred to as shown in Table 3-15.

Table 3-15: Brief illustration of SLR's adaptation measures in coastal zones as stated in the "National Strategy for Adaptation to Climate Change and Disaster Risk Reduction"
Source: Researcher based on data available in (Information and Decision Support Centre, 2011; Agrawla, et al., 2004)

Procedure	Include
Studies	Conducting detailed studies on the effectiveness of the proposed adaptation measures, in order to assess destructive factors, including high SLR.
Rules	• Allowing the establishment of viable and accommodated small beach construction • Including the Environmental Impact Assessment (EIA) in projects that would be established in coastal zones (with a special section on the impact of climate change)
Structural and architectural intervention	• Constructing and maintaining Maritime walls, submersible barriers, shore coating, soil fixation, and prevention methods for seawater intrusion into land including the implementation of covered and uncovered sanitary drainage projects • Protection of coastal buildings and constructions, electricity, water, and sanitation grids. • Establishing solid protection measures such as stone heads or submersible barriers, in order to protect the back shore from attacks by the sea and address the SLR. • Reinforcement of anti-flood protection structures and construction of new ones
Rehabilitation of installations	Strengthening the existing protection structures to act as wave breakers, in addition to their regular functions, including : International Coastal Road (Rafah to Salloum), Mohammad Ali sea wall, embankments of Al Salam Canal (from Damietta to Sinai)
Reinforcing natural protection	• Maintaining natural protection (sand dune stabilization through the cultivation of wild plants and wooden barriers). • Preserving natural defense lines against SLR, i.e. rocky coral reefs adjacent to the shores of the Red Sea or limestone barriers along the northwest coast from Alexandria to Salloum.

Although this strategy is specifically relevant to adaptation to climate change in different sectors, mitigation and few resilience measures are applied. As for the resilience approaches, they are classified as adaptation measures.

Basically, these adaptation measures are either soft or hard as shown in Table 3-16.

Table 3-16: Applied selected approaches as mentioned in the IDSC
Source: Researcher based on data available in (Information and Decision Support Centre, 2011)

Sector targeted	Procedure	Approach achieved			
		Mitigation	Adaptation		Resilience
			Soft	Hard	
Water Resources and Irrigation	Improve the distribution network to reduce losses caused by leakage				
	Recycle treated wastewater				
	Launch a national campaign to raise water awareness among citizens				
Agriculture	Develop new varieties of crops with short growing seasons to reduce their water requirements				
	Educate farmers on all information related to climate change and the diseases that may be transmitted to them or their livestock, and the methods of prevention				
Health	Raise the awareness of citizens in health behavior that would limit any harm resulting from exposure to climate change				
	Develop weather and seasonal forecast and early warning systems				
	Establish an integrated database for diseases associated with climate change, and making it available to all concerned parties: government, private sector, NGOs				
Rural areas, housing and roads	**Buildings**: Transfer the latest technology in the generation of new and renewable energy				
	Roads: Construct dams to slow down the flow of floods				
	Housing: Renovate old houses in urban and rural areas, which are liable to collapse				

Table 3-16: Applied selected approaches as mentioned in the IDSC (continued)

Sector targeted	Procedure	Approach achieved			
		Mitigation	Adaptation		Resilience
			Soft	Hard	
Tourism	Orient the growth of tourism away from environmentally sensitive areas towards less sensitive and vulnerable ones				
	Encourage and support civil society organizations to participate in applying strategic operational policies				

3.7. Concluding Remarks

This chapter discussed various approaches which are supposed to be the global responses to climate change and SLR. It can be concluded from this chapter that: firstly; for SLR; the most suitable ways to reduce its impacts are adaptation and resilience according to what needs to be protected.

Secondly; this chapter discussed Egyptian governmental efforts as responses to climate change and SLR. In the field of reducing GHGs, one of these efforts is mainstreaming the usage of renewable energy and energy efficiency resources in all sectors that are held by SEC. However, for the adaptation approach, the Egyptian governmental efforts are basically based on the "protection type" and its two concerns: hard and soft. Their projects are held by various authorities and th-ey coperate with a number of internatinal organizations.

Finally, this chapter has invistigated the "Egyptian National Strategy for Adaptation to Climate Change And Disaster Risk Reduction and Sea Level Rise". A highlight of the main ideas of this strategy, comprising the three apporaches, is provided in Table 3-16. The above mentioned measures aim to allow effective cooperation among the state agencies, the private sector, the members of NGOs, the professional associations, trade and agricultural unions, research centers, media corporations, local and popular committees and cultural forums.

CHAPTER 4
METHODOLOGY

Chapter 4: Methodology

This chapter sets out the development of the research methodology; it expounds the research aim and objectives and attempts to answer the research questions . The chapter starts with a summary of the key findings of the literature review part. The rationale behind selecting the conceptual framework is then elucidated, followed by an explanation of the measurement techniques and the steps of developing FDRI .This includes the sources of information for the coastal communities within the limitation of the availability of data and the length of the research duration. The chapter ends with an explanation of the comparative analysis approach adopted in this research.

4.1.Summary of the Findings of Literature Review

Reviewing current literature shows that assessing community resilience is a complex process because of the dynamic interactions of people, community, societies, and the environment. Currently, there are many conceptual frameworks proposed to measure this concept, for example: (Brown, et al., 1996; Buckle, 2006; Foster, 2006) as stated in Mayunga (2007). Generally speaking, most of these frameworks conceptualize community disaster resilience in the same way, as they all focus on similar indicators that could reduce vulnerability and increase community resilience. Such factors include economic resources, assets and skills, information and knowledge, support and supportive networks, access to services and shared community values. However, the limitation of most of these frameworks is that they tend to only focus on some dimensions ,or even one dimension, of disaster resilience and do not adequately take into consideration the broader view of the concept as discussed in Section 3.3.1.

Those dimensions are of crucial importance particularly in relation to the Egyptian context . It can be recognized from the literature addressing the nature of Egypt that the real threat caused by climate change is SLR with all its impacts, which has to be placed as a first priority in policy intervention.

4.2.Justification of the Adopted Conceptual Framework

The adopted conceptual framework in this research is the Capital Approach, and it is grounded in the work of Mayunga (2007) as stated in the work of Smith (2008) , with modifications.

According to Mayunga and Smith; the notion of capital aligns very well with the concept of sustainability, which is related and often linked to the concept of disaster resilience (Brown, et al., 1996; Tobin, 1999; Mileti, 1999).The essence of using the capital approach is that, capital consists of Social, Economic, Human, Nature and Physical components, which are necessary for development of a sustainable community economy as shown in Table 4-1. The more economic opportunities the community has, the more potential it possesses for reducing the impacts of disaster; hence the more resilient the community becomes.

Table 4-1: Definitions of sustainable capitals
Source: Researcher based on data available in (Mayunga, 2007)

Capital	Definition
Social	Features of social organization: knowledge, norms, and social trust that facilitate cooperation for mutual benefit.
Human	Education , knowledge and skills that are accumulated through forms of education attainment, training, and experience
Natural	Refers to natural resources− water, minerals and oil, land...etc− which provides space on which to live and work and the ecosystems that maintain clean water, air and a stable climate
Economic	Financial resources− savings, income, investments and credit− that people use to achieve their livelihoods.
Physical	Refers to the built environment: residential housing, public buildings, industry, dams and shelters and infrastructures

The previous table shows that there are similarities between social and human capitals since they are both concerned with social assets. Therefore, in the adopted conceptual framework, they have been merged into one capital; classified as “Social” as shown in Fig. 4-1. In this Figure, the five upper blue ellipses represent the five original capitals used in assessing community resilience according to Mayunga, whereas the five lower modified ellipses represent the adopted framework in assessing community resilience facing floods in this thesis.

In this figure, a green-colored capital given the name “Governance” has been added to cover a wider perspective for assessing community resilience in facing floods as stated in (Atkinson, 2014; Briguglio, 2003). According to the United Nations (2012), it is defined as the "*exercise of political and administrative authority at all levels to manage a country’s affairs. It comprises the mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences*".

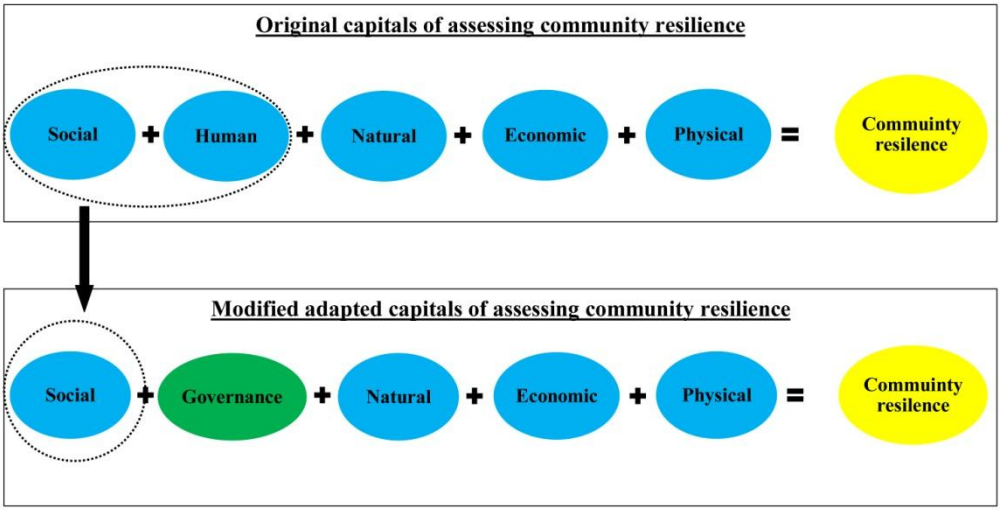


Figure 4-1: Original and modified adapted frameworks

4.3. Adopted Measurement Technique

The adopted measurement technique is the Social Multi Criteria Evaluation (SMCE) that is based on Munda's work (2004), as stated in the work of Abo-Elfetouh (2006). It provides guidelines for illustrating the theoretical variables of the adopted capital approach into quantitative statistical measures (Smith, 2008). It is the means by which policy makers will monitor the progression towards targets for specific variables, which are "capitals" in this thesis.

SMCE can be defined as a fundamental step of the rational decision-making process (Europian Union, 2013). According to Munda and Abo-Elfetouh; SMCE aims to foster transparency, reflection and learning in decision-making processes, simultaneously integrating political, socio-economic, as well as ecological, cultural and technological dimensions of a problem. It calls for a decision-making process using information coming from a multi/inter disciplinary work and participatory approaches. Moreover, integrating the researcher's skills in identifying, selecting, revising, testing and applying these indicators will guarantee the accuracy, sensitivity and reliability of indicators.

4.4.Steps for Developing the FDRI

This section explains the steps applied for developing the FDRI and the used quantitative and qualitative methods in order to apply FDRI on the two

cities. Each technique fits best in realizing the required purpose in order to make the best use of the data and information available.

The process of developing and applying the FDRI is divided into two steps:

1. Establishing the FDRI index
2. Testing the applicability of the FDRI

4.4.1. Establishing the FDRI index

Establishing the FDRI index basically depends on the researcher's skills and relative document analysis, such as: (Longstaff, et al., 2010; Wilson, 2012; Cutter, et al., 2008; Chandra, et al., 2011), which include practical examples of developing and applying the FDRI. However, special attention has been given to three main reports − which have been illustrated in Sections 3.3.1 and 4.3− Show and IEDM team (2011), Muynga (2007) and Munda (2005).

In order to collect data for the FDRI, two sources have been used. Firstly; qualitative information, have been collected through in-depth interviews with representatives from: government, public sector, private sector and NGOs (Appendix E). Throughout the interviews, interviewees are allowed to speak freely, no matter if their responses did not fit exactly with the order of questions. Secondly; quantitative information has been collected through questionnaires among the community (Appendix F).

4.4.2. Testing the applicability of the FDRI.

Testing the applicability of the FDRI is based on selecting a test sample of coastal cities and some appropriate mathematical techniques to assess the performance of coastal cities based on their indicator states. This is carried out through a **quantitative** and a **qualitative** analysis. A justification for the selected test sample will be elucidated in the following section.

4.4.2.1. Quantitative analysis: Individual indicators

The mathematical method aims at assessing a city's performance based on indicator states according to the values of **individual indicators**. The adopted mathematical method is proposed by Maunga and Shaw. More details of this proposed technique is explained in section 6.3. Although it seems that there are many methods in the literature that can be used to construct an index, the basic difference is in the summation of the components of the index (Briguglio (2003) as stated in Mayunga (2007)).

Hence, a straightforward summation method can't be possible unless these units are normalized in some ways into one standardized unit. Regarding the methods of normalization, there are various techniques which can be used to standardize or normalize the indicators to allow an addition or averaging to obtain a score or rank (Briguglio, 2003).Therefore, the chosen technique is selected because of its simplicity and ease of understanding. Consequently, coastal cities are evaluated using the new integrative index; the FDRI .

The results of the assessment are presented graphically by the so-called "radar diagram" to make the interpretation of the results easier. It proved to be vital to visualize changes and to enable relative comparisons in a number of cases. Radar diagrams can be established either manually or automatically, as they could be computerized. In this research, radar diagrams are created using Microsoft Excel.

4.4.2.2. Qualitative analysis: Stakeholders analysis

This qualitative analysis aims at determining the stakeholders whom are concerned with enhancing community resilience to overcome impacts of floods through classifying them into one of the following four groups: high power with high interest, high power with low interest, low power with high interest and low power with low interest.

4.5.Adopted Comparative Analysis Approach

Comparison is a fundamental tool of analysis, it plays a central role in concept-formation by bringing into focus suggestive similarities and contrast among cases (Colliier, 1993). It can contribute to the inductive discovery of new hypothesis and to theory-building and can be conducted across cases (countries, groups or individuals) at the same point in time (cross-sectional comparison) (Winters, 2015).

In this research, comparative analysis approach has been applied on two mega-coastal cities, which are: Alexandria and Jakarta in order to find out the strengths and weaknesses in each capital regarding community resilience performance, as well as to investigate possible methods for enhancing points of strength and reduce points of weakness in community resilience performance.

4.6. Selection of Test Sample

This section includes the justification for choosing the areas on three levels: city level, district level and zone level.

4.6.1. Selection of cities

Alexandria (Egypt) and Jakarta (Indonesia) are two coastal cities located in Africa and Asia respectively as shown in Fig. 4-2.

Figure 4-2: Location of Alexandria and Jakarta form the world

Alexandria city − which extends over an area of 300 km^2 and whose citizens are around 4110015 people− is considered the second largest metropolitan area after Greater Cairo and the largest Egyptian seaport that serves approximately 80% of Egypt's imports and exports. It is also an industrial center and an important tourist resort (Encyclopidia Britannica, 2014). It is located between the Mediterranean coast and Lake Mariout, at the western edge of the Nile River delta.

Jakarta city − The capital of the Republic of Indonesia that extends over an area of 730 km^2− is a huge, sprawling metropolis located on the northwest of the island of Java. It is known to be the country's economic, cultural and political

centre and the most populous city; not only in Indonesia but in Southeast Asia as a whole − home to 9 million people − (Ministry of Tourism, 2013).

Among the top 20 cities ranked in terms of population exposed to coastal flooding in the 2070, Alexandria and Jakarta cities are ranked as the 11th and the 20th respectively as shown in Fig. 4-3. Later, theses ranks have been modified to become the 1st and the 11th respectively according to recent researches (Dasgupta, et al., 2010). Moreover, they are ranked as the 17th and the 11th respectively in terms of exposed assets by 2070, and the highest exposed cities in 2005 as shown in Fig. 4-4 (Nicholls, et al., 2008).

Rank	Country	Urban Agglomeration	Exposed Population Current	Exposed Population Future
1	INDIA	Kolkata (Calcutta)	1,929,000	14,014,000
2	INDIA	Mumbai (Bombay)	2,787,000	11,418,000
3	BANGLADESH	Dhaka	844,000	11,135,000
4	CHINA	Guangzhou	2,718,000	10,333,000
5	VIETNAM	Ho Chi Minh City	1,931,000	9,216,000
6	CHINA	Shanghai	2,353,000	5,451,000
7	THAILAND	Bangkok	907,000	5,138,000
8	MYANMAR	Rangoon	510,000	4,965,000
9	USA	Miami	2,003,000	4,795,000
10	VIETNAM	Hai Phòng	794,000	4,711,000
11	EGYPT	Alexandria	1,330,000	4,375,000
12	CHINA	Tianjin	956,000	3,790,000
13	BANGLADESH	Khulna	441,000	3,641,000
14	CHINA	Ningbo	299,000	3,305,000
15	NIGERIA	Lagos	357,000	3,229,000
16	CÔTE D'IVOIRE	Abidjan	519,000	3,110,000
17	USA	New York-Newark	1,540,000	2,931,000
18	BANGLADESH	Chittagong	255,000	2,866,000
19	JAPAN	Tokyo	1,110,000	2,521,000
20	INDONESIA	Jakarta	513,000	2,248,000

Figure 4-3: Top 20 cities ranked in terms of population exposed to coastal flooding
Source: (Nichollas, et al., 2007)

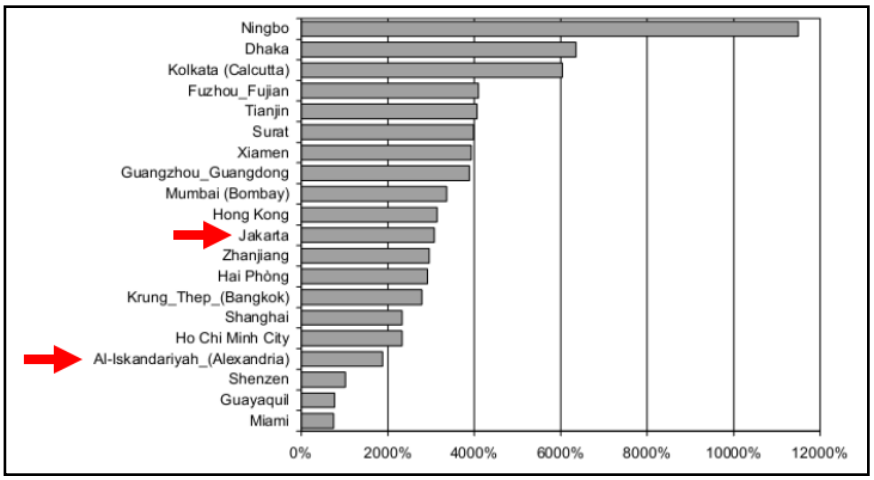


Figure 4-4:Top 20 cities with the highest proportional increase in exposed assets
Source: (Nichollas, et al., 2007)

4.6.2. Selection of districts

Much of the Abu Qir and Pademangan regions are below sea level as it can be seen in Fig. 4-5 & 4-6 ,respectively, and they include communities with a high population density. Therefore, they are particularly vulnerable to potential devastating impacts of SLR especially floods (El-Nawawi, 2014; Hadi, et al., 2011; Statistics Jakarta Utara Municipality, 2011).

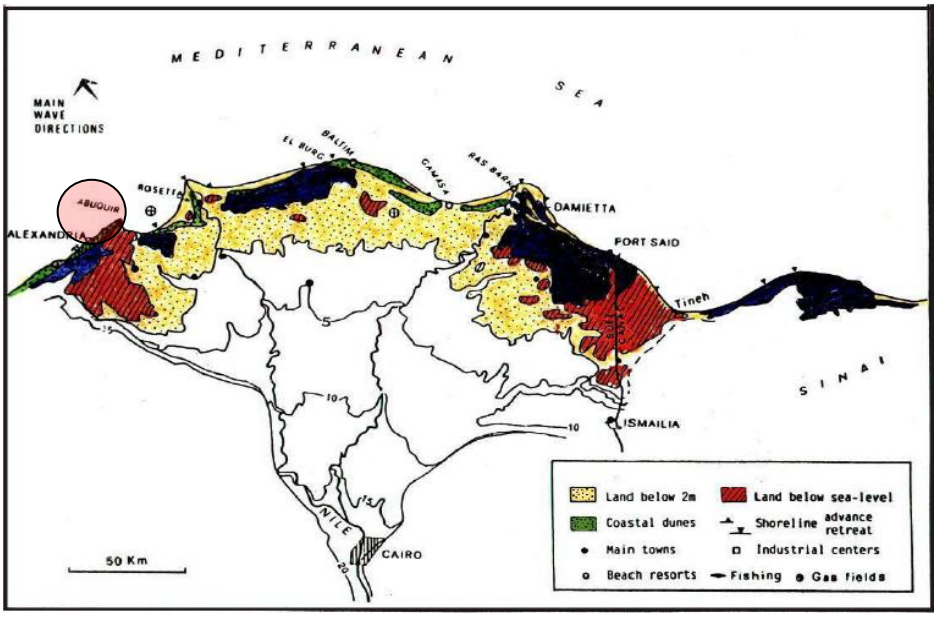


Figure 4-5: General topography of the Nile delta a selection on Abo-Qeer
Source: (Weekly Ahram, 2007)

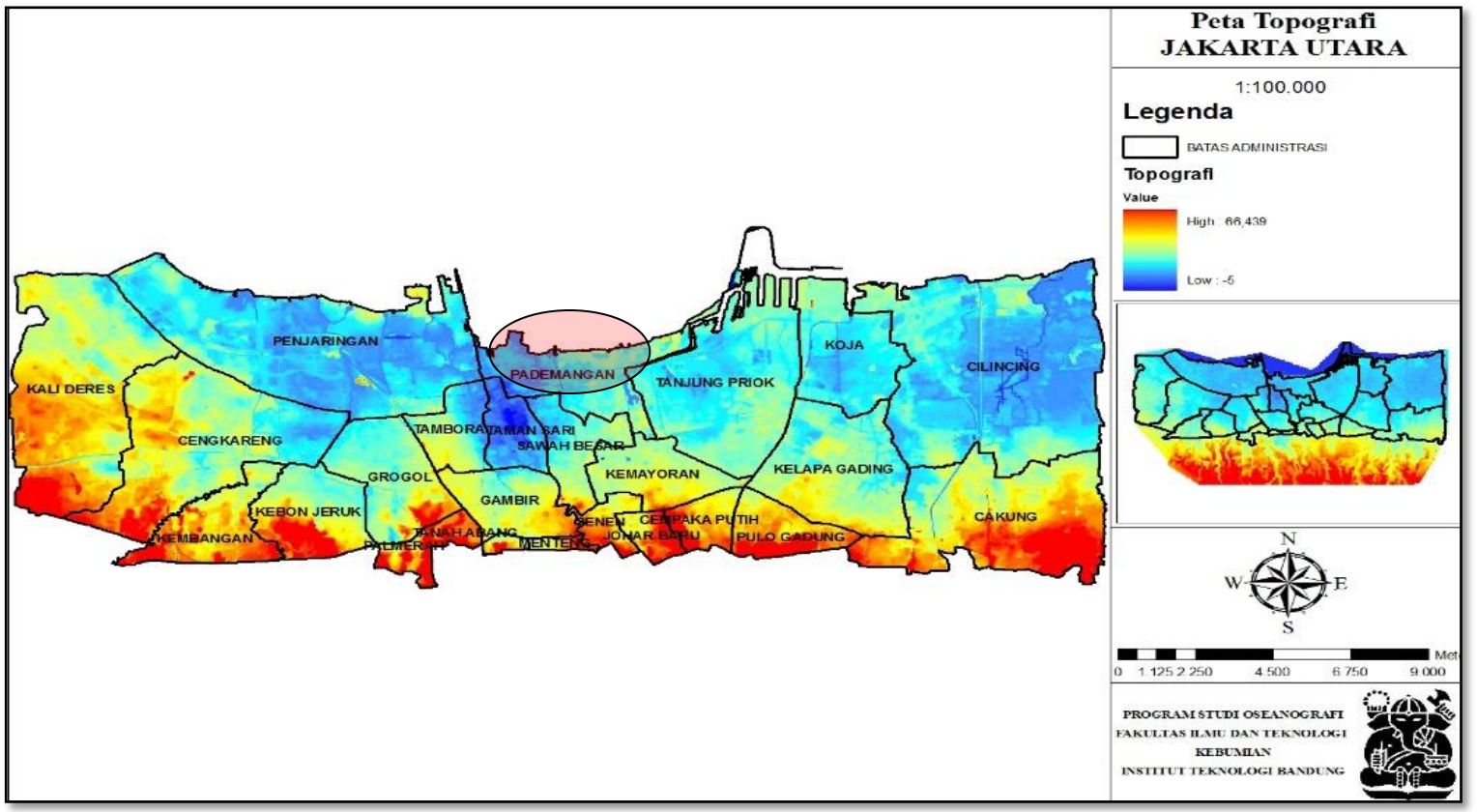


Figure 4-6: Topography of North Jakarta with a selection on Pademangan District
Source: (Hadi, et al., 2011)

4.6.3. Selection of zones

The selected zones were designated in a way to have a prespective of the community in the five capitals; taking into consideration the diverse classifications of age, gender, education and socio-economic tiers as shown in Fig. 4-7: a,b. In this figure, A-1 to A-4 in both cities represent high, middle and low housing available in the areas under examination, while B-1 to B-5 represent selected examples from the community individuals who have answered the questionnaires .

Figure 4-7: Diverse classification of socio-economic tiers, age and gender for the test sample- a: Abo-Qeer, Alexandri

Fig. 4-8 & 4-9 represent detailed illustrations for the study area in Egypt and Indonesia, respectively on four levels: country, city, district and study area. These selections were made based on the justifications mentioned above. Questionnaires have been distributed among the individuals and in-depth interviews have been conducted with academic, governmental officials, NGOs and private sector representitives in both cities.

Figure 4-7: Diverse classification of socio-economic tiers, age and gender for the test sample (continued)- b:Pademangan, Jakarta

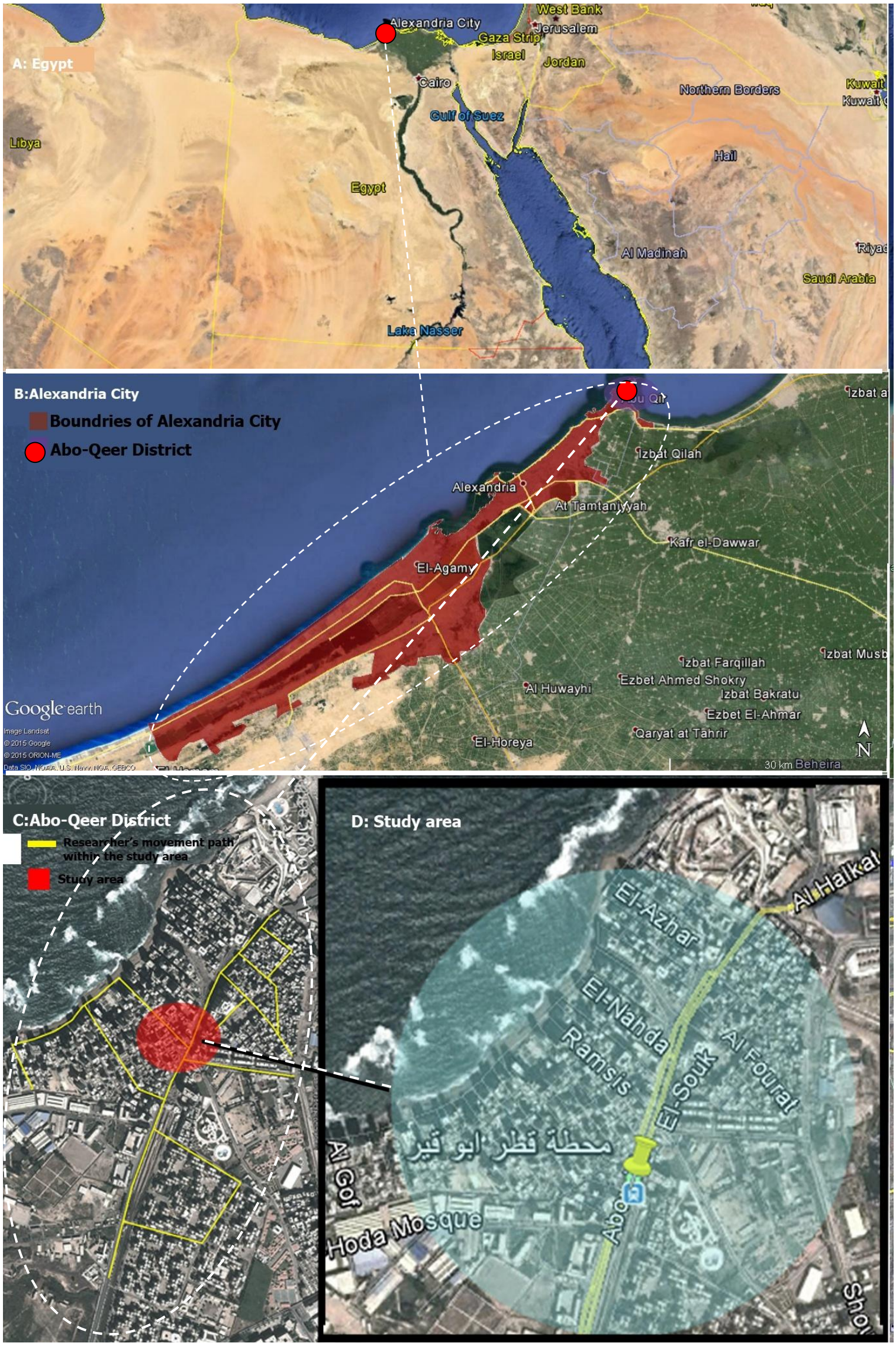


Figure 4-8: Illustration for the study area in Egypt on four levels: country- city- district- zone

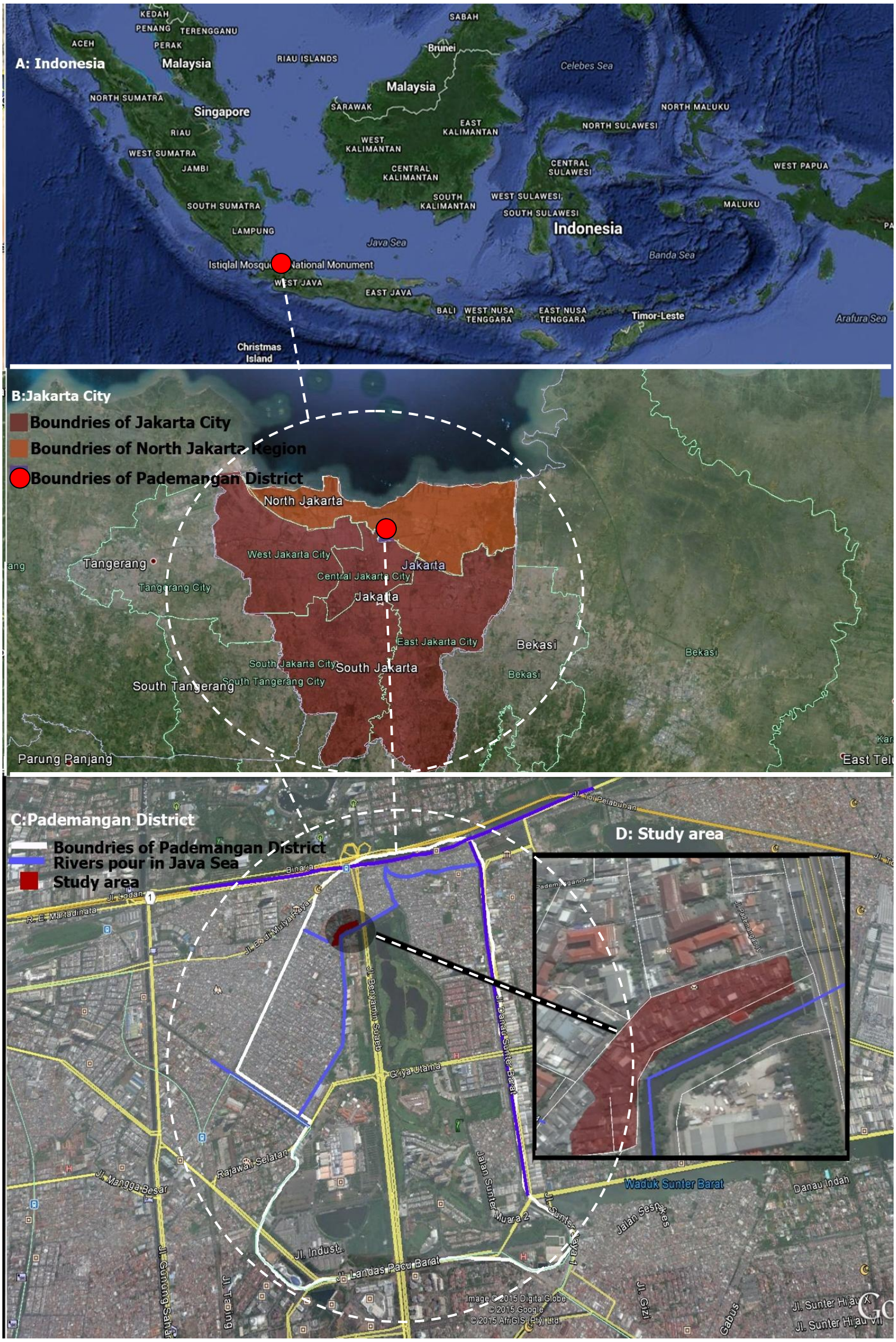


Figure 4-9: Illustration for the study area in Indonesia on four levels: country- city- district- zone

4.7. The Process of Developing the FDRI

This section explains the adopted process to establish an index to measure the current community resilience for a typical coastal city affected by floods, in terms of governance, economic, natural, physical and social variables in capitals. The process comprises four steps as follows:

- Identifying the purposes of developing the FDRI.
- Defining stakeholders.
- Identifying key issues of concern.
- Selecting a set of representative indicators for every capital.

Throughout this section, an explanation of each of these steps will be provided.

4.7.1. Purposes of developing the FDRI

The main purposes of developing the FDRI set can be identified as follows:

- Assess either the progress or the decline of community resilience performance for floods in the two selected coastal cities
- Inform decision making, so that policy makers can draw policies and allocate resources to increase resilience on a solid basis.

4.7.2. Stakeholders

It is decided that the same set of indicators are to be applied to all the stakeholders who happen to share the same objectives of enhancing community resilience for floods. They are classified under main categories, as follows:

Governance Sector: local authority, administrative units ,utilities organizations.

Private sector: banks, economic enterprises, financial institutions, private utilities companies, private academic institutions.

Non-Governmental Organizations (NGOs): local service organizations, local religious groups, environmental groups, civil defense institutions.

Public sector: local leaders, informal sector groups, fisheries, divers, touristic societies, academic institutions.

4.7.3. Key issues of concern

Identifying the key issues of community resilience is the underpinning of this process, which will be built upon in the selection of the relevant capital. Based on the findings of the literature review (Kyoto University , 2011; The World Bank, 2013; Cutter, et al., 2008; Chandra, et al., 2011) , a number of key meanings and objectives are identified by the researcher under five main capitals as shown in Table 4-2. This table illustrates the five capitals− colored in yellow− in terms of components and objectives.

Table 4-2: Key capitals for measuring community resilience and their components and objectives

Source: Researcher based on data available in (Mayunga, 2007; Mcaslan, 2010)

Components	Objectives
Governance	
Providing the information needed to plan and prepare for, respond to and recover from flood disruptive event leading to make decisions	Enable the Physical and Economic capitals assets to be applied effectively and efficiently
Economic	
Financial resources to protect peoples' livelihoods (savings, income, investments and credit)	Increase the ability and capacity of individuals to absorb the impacts of the flood and to speed up the recovery process.
Natural	
- Natural resources, such as water and land, which provide space on which to live and work - Ecosystems that maintain clean water, air and a stable climate	Sustains all forms of life and increases protection from storms and floods
Physical	
- Built environment: buildings, dams and bridges and shelters -Electricity, water, telephone critical infrastructure	Physical infrastructure are essential for functioning of community, especially during evacuation time and provide the means to survive and recover
Social	
- Quantity and quality of social cooperation. - Knowledge and skills that are accumulated through forms of education	Citizens resolve collective problems more easily

4.7.4. The Representative Indicators of the FDRI

Selecting key representative indicators is not an easy task due to the wide perspective for the previous literature in trying to enhance community resilience

for the impacts of SLR and floods. Therefore, selection, modification and substitution for specific indicators have been applied to the previous frameworks mentioned in Section 3.3.1.

To select a set of representative indicators from the previously mentioned indicators in Section 3.3.1, the following criteria are taken into consideration:

- Each representative indicator is strongly related to community resilience objectives
- The representative indicators are practically measurable

Based on these criteria, a number of representative indicators are selected as shown in Table 4-3 to provide the FDRI. This table represents the five main keys of measuring community resilience for floods (colored in grey), variables (colored in yellow) and indicators (colored in white) composing the FDRI. The FDRI should be measurable and applicable to any coastal community.

Table 4-3: Key representative variables and indicators for the FDRI

1-Governance		
Symbol	**Indicator**	**Desired value**
G1- Mainstreaming of floods resilience		
G1.1	Existence of governmental institution that target the reduction of the floods impacts(Y/N)	Yes
G1.2	Existence of regulations organizing land use and building codes targeting the reduction of the impacts of floods(Y/N)	Yes
G1.3	Existence of city local strategies that target the reduction of floods impacts(Y/N)	Yes
G2- Good governance		---------
G2.1	% Effectiveness of government -community communication	High
G2.2	Existence of the ability to access the governmental information related to floods (Y/N)	Yes
G3- Effectiveness of a city's crisis management		---------
G3.1	Existence of governmental disaster management structure (Y/N)	Yes
G3.2	Existence of evacuation centers in the strategic plan (Y/N)	Yes
G3.3	Existence of financial resources for reduction of floods impacts(Y/N)	Yes
G3.4	Existence of flood early warning systems(Y/N)	Yes
G3.5	Percentage of trust in governmental data transferred through media	High
G4- Collaboration during floods with organizations		----------
G4.1	Existence of city's dependency on external supporters (Y/N)	Yes
G5- Knowledge dissemination and management		----------
G5.1	Availability of awareness campaigns for floods held by the government (Y/N)	Yes

Table 4-3: Key representative variables and indicators for the FDRI (continued)

2- Economic		
Symbol	**Indicator**	**Desired value**
E1- Employment		
E1.1	Dependency ratio	Low
E1.2	Percentage of Unemployment	Low
E2- Household assets		----------
E2.1	Percentage of owners for motorized vehicle	High
E2.2	Percentage of owned homes	High
E2.3	Percentage of house description	High
E3- Finance		----------
E3.1	Percentage of income range	High
E3.2	Percentage of total income range	High
E4-Subsidy		----------
E4.1	% Subsidy's to pass flood time	High
3- Natural		
N1- Ecosystem services		----------
N1.1	Percentage of quality of drinking water	High
N1.2	Percentage of quality of air	High
N1.3	Existence of drainage in channels (Y/N)	Yes
N1.4	Existence of improper disposal (Y/N)	Yes
4- Physical		
P1- Electricity		----------
P1.1	Percentage of accessibility	High
P1.2	Percentage of usage for alternative capacity	High
P2- Water		----------
P2.1	Percentage of accessibility	High
P2.2	Percentage of usage for alternative capacity	High
P3- Sanitation		----------
P3.1	Percentage of accessibility	High
P4- Accessibility during floods		----------
P4.1	Percentage of accessibility of roads during floods	High
P4.2	Percentage of efficiency of dams and bridges conditions	High
P4.3	Existence of any mechanism of rain water draining (Y/N)	Yes
P4.4	Percentage of accessibility to shelters in flood time	High
5-Social		
S1- Public participation in decision making		----------
S1.1	Percentage of population participating in community activities	High
S1.2	Percentage of trustfulness in the community representatives	High
S1.3	Percentage of effectiveness of the local elections	High
S1.4	Percentage of ability to express needs	High

Table 4-3: Key representative variables and indicators for the FDRI (continued)

5-Social (continued)		
Symbol	**Indicator**	**Desired value**
S2- Education and awareness		
S2.1	Percentage of high education level	High
S2.2	Percentage of population awareness about flood disaster	High
S2.3	Percentage of awareness efforts received from specialist	High
S3- Health		----------
S3.1	Percentage of accessibility to health facilities	High
S3.2	Percentage of existence of a medical alternative option	High
S4- Community preparedness		----------
S4.1	Percentage of people who obtain alternative food sources	High
S4.2	Percentage of people who regularly check emergency supply	High
S5- Population		----------
S5.1	Percentage of single families per home	High

4.8. Concluding Remarks

Based on the concept of "community resilience", an index has been established to assess the progress; or the decline, of community resilience to flood in typical coastal cities. This index aims at describing the key issues identified by previous literature review, and addressing their variables and indicators for each capital in details. A clarification of targeted stakeholders has been introduced in this chapter who share the same objective of enhancing community resilience for floods have been selected. The FDRI indicators aim at providing decision-makers with a comprehensive vision about the current status of a coastal city by covering all the system components in a wide perspective. The selection of the FDRI set is built upon the literature review about communities' resilience for climate change, this is due to its widely well-known frameworks as an assessment tool.

CHAPTER 5

MEASURING COMMUNITY RESILIENCE BY USING THE FDRI

Chapter 5: Measuring Community Resilience Using the FDRI

This chapter applies the proposed index of the FDRI. It aims at measuring the level of community resilience against flood disaster in the targeted cities using the FDRI which is developed in relation tothe previously mentioned five resilience-based capitals.

The scope of this thesis is limited to flood-induced disasters. This chapter starts with Section 5-1 entitled "why choosing the flood disaster" and illustrating reasons for selecting flood as one of the various impacts for SLR. Section 5-2 , bearing the title "descriptive analysis", illustrates the descriptive analysis for both cities. Then, Section 5-3 discusses the data sources used in assessing the data of the FDRI. Section 5-4 clarifies the adopted statistical approach to assess the resilient performance for both cities. Finally, section 5-5 provides graphical presentations for the results of the study with the aim of illustrating the interpretation with radar diagrams, followed by justifications of the findings.

5.1. Why Choosing the Flood Disaster?

A flood can be simply defined as: "*A general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters from the unusual and rapid accumulation or runoff of surface waters from any source*" (Australian Government Agency, 2013; UN, 2010). From this definition it could be induced that a flood can happen from increasing rain causing flash floods −as in Abo-Qeer − and tidal waters as well−as in Pademangan .

Although periodic flooding is an essential characteristic of coastal zones (Blankespoor, et al., 2012), it is responsible for causing half of the disasters worldwide and 84% of all disaster death according to many researches (Odufuwa , et al., 2012; Aon Benfield Americas, 2013). Hence, it was selected in this research as one of the catastrophic impacts of SLR.

5.2. Descriptive Analysis

The Number of population in Eastern Pademangan and Western Abo-Qeer districts are 44005 and 25784 inhabitant, respectively (Statistics Jakarta Utara Municipality, 2011; Information and Decisson Support Center, 2006). The sample size for the two zones are 449 and 267, respectively, which form 1% of

the population in each areas in both zones.Nine stakeholders have been interviewed in both citis as shown in Table 5-1.

Table 5-1: Stakeholders whom have been personally interviewed by the researcher

	Type of Stakeholder			
	Government	**Public sector**	**Private sector**	**NGO**
Alexandria	- Directorate of Utilities and Housing -Coastal Research Institute representative -Shore Protection Authority representative	- Alexandria University (Staff member) - Leader of fishermen	- Fish shops' retail -Owner of supermarkets -Owner of Restaurant	-Egyptian Red Crescent Society representative (Cairo and Alexandria branches)
Jakarta	-Urban Planning Department-Pademangan Sub-District Office representative -Post flood Department-Pademangan Sub-District Office representative	-Universtas Negeri Jakarta (Staff member) -Sub-community leader	- Owner of stationary - Owner of Restaurant	-Indonesian Red Cross society representative (Jakarta branch)

A descriptive analysis for both samples which include gender,age and income is presented in Fig. 5-1.

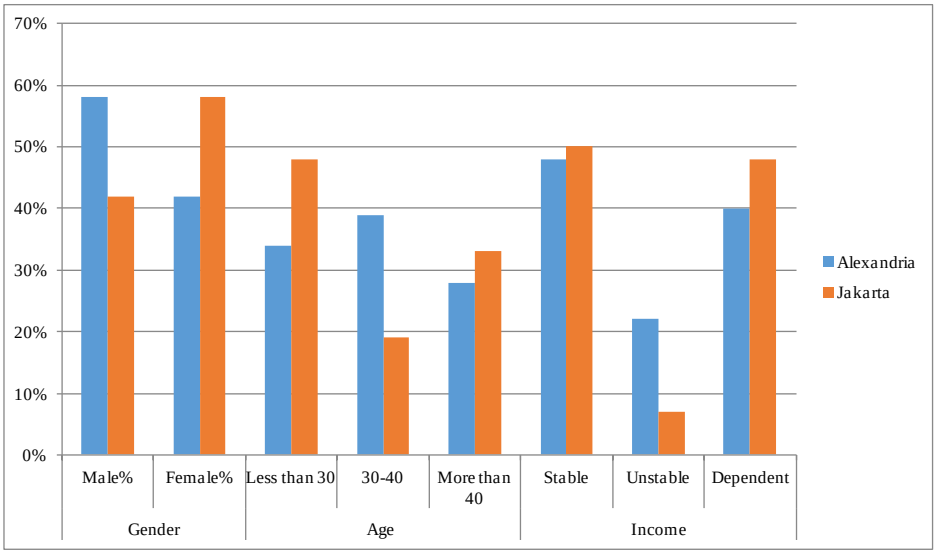


Figure 5-1: Descriptive analysis for samples of Pademangan and Abo-Qeer

5.3.Adopted Mathematical Techniques

Two different techniques are employed in this research to assess the resilience of coastal community using the FDRI based on indicator states; namely normalization method. Processing and analyzing the data proposed in this thesis is derived from the climate disaster resilience literatures, particularly the works of Show and IEDM team (2011) and Muynga (2007) .

According to Mayunga's work, there are many methods that can be used to construct an index, the basic difference is in the summation of the components of the developed index. A normalization method, which is commonly used, is the one which adjusts the observation to take a value from 0 to 1 ((Briguglio, 2003) cited in (Mayunga, 2007)). The results of this step are presented in Table 4-2: A&B.

Moreover, in order to make the calculations easier, an assumption was made that all the dimensions/indicators have the same weight, due to the following :firstly; according to the previously mentioned literatures all the dimensions/indicators are important; therefore, no dimension/indicator shall be favored in the final outcome of the FDRI; secondly; the calculation of the FDRI scores becomes more transparent and structured, and thirdly; to overcome having different types (yes/ no questions, usually/ sometimes/ rarely questions).

Therefore, by using this assumption in the formula proposed by Mayunga, which combines indicators to generate individual indices for each dimension is done (1). In this equation (Y_i) is the capital index, (X) is normalized indicator, (W) is the weight of each indicator and (n) is the number of indicators.

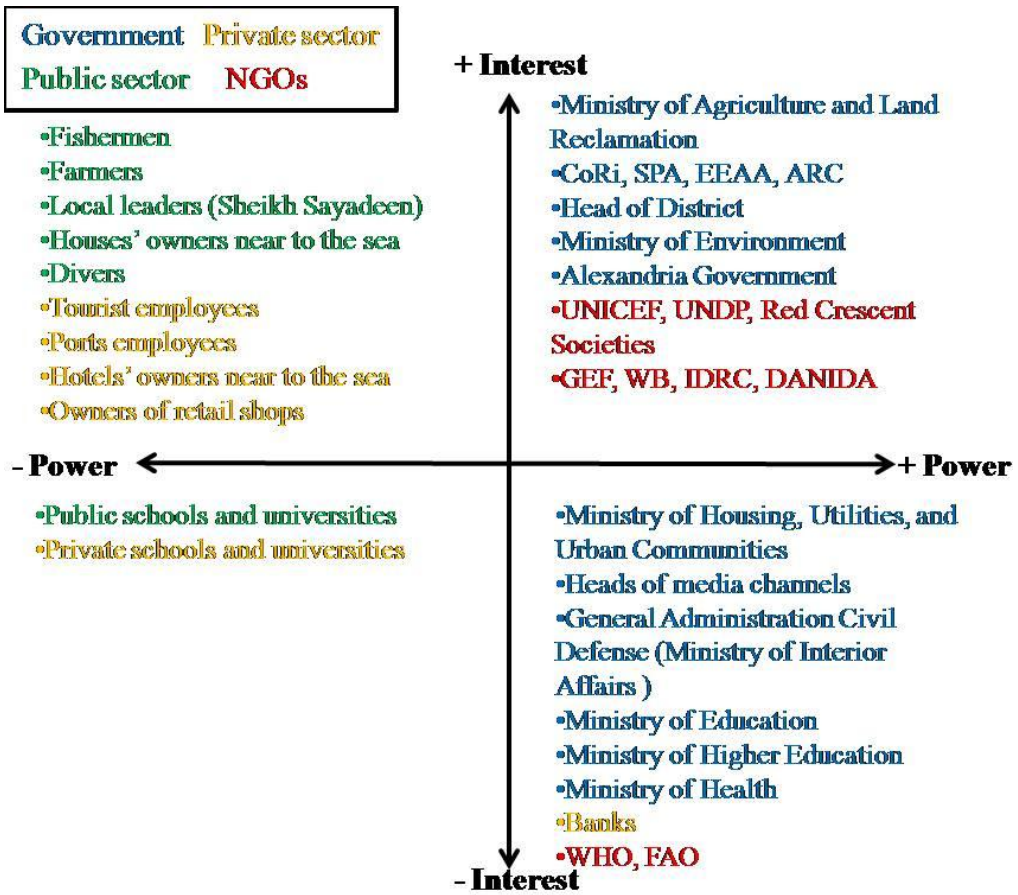
$$\mathbf{Y_i} = \sum(X_1 w_1 + X_2 w_2 + X_3 w_3 + \cdots \ldots\ldots\ldots\ldots\ldots X_n w_n) \quad \text{.....(1)}$$

Table 5-2: Raw and normalized(scoring) values

Capital	Variable	Indicator	A- Raw values		Capital	Variable	Indicator	B- Scoring	
			Alexandria	Jakarta				Alexandria	Jakarta
Governance	G1	G1.1	YES	YES	Governance	G1	G1.1	1.00	1.00
		G1.2	YES	YES			G1.2	1.00	1.00
		G1.3	YES	YES			G1.3	1.00	1.00
	G2	G2.1	20.5%	43.4%		G2	G2.1	0.21	0.43
		G2.2	YES	YES			G2.2	1.00	1.00
	G3	G3.1	YES	YES		G3	G3.1	1.00	1.00
		G3.2	NO	NO			G3.2	0.00	0.00
		G3.3	YES	YES			G3.3	1.00	1.00
		G3.4	YES	YES			G3.4	1.00	1.00
		G3.5	21.7%	30.5%			G3.5	0.22	0.31
	G4	G4.1	YES	YES		G4	G4.1	1.00	1.00
	G5	G5.1	NO	YES		G5	G5.1	0.00	1.00
Economic	E1	E1.1	58.5%	51.8%	Economic	E1	E1.1	0.59	0.52
		E1.2	8.9%	4.8%			E1.2	0.09	0.05
	E2	E2.1	41.1%	77.7%		E2	E2.1	0.41	0.78
		E2.2	52.7%	74.3%			E2.2	0.53	0.74
		E2.3	88.8%	83.9%			E2.3	0.89	0.84
	E3	E3.1	43.0%	27.7%		E3	E3.1	0.43	0.28
		E3.2	32.6%	35.7%			E3.2	0.33	0.36
	E4	E4.1	76.4%	74.1%		E4	E4.1	0.76	0.74
Natural	N1	N1.1	65.9%	3.2%	Natural	N1	N1.1	0.66	0.03
		N1.2	91.5%	13.2%			N1.2	0.92	0.13
		N1.3	NO	YES			N1.3	1.00	0.00
		N1.4	NO	NO			N1.4	1.00	1.00
Physical	P1	P1.1	100.0%	71.0%	Physical	P1	P1.1	1.00	0.71
		P1.2	50.0%	80.0%			P1.2	0.50	0.80
	P2	P2.1	100.0%	82.0%		P2	P2.1	1.00	0.82
		P2.2	36.0%	74.5%			P2.2	0.36	0.75
	P3	P3.1	95.9%	58.8%		P3	P3.1	0.96	0.59
	P4	P4.1	35.0%	53.6%		P4	P4.1	0.35	0.54
		P4.2	35.0%	40.0%			P4.2	0.35	0.40
		P4.3	NO	YES			P4.3	0.00	1.00
		P4.4	80.0%	60.0%			P4.4	0.80	0.60
Social	S1	S1.1	26.0%	63.0%	Social	S1	S1.1	0.26	0.63
		S1.2	16.0%	52.0%			S1.2	0.16	0.52
		S1.3	18.3%	46.8%			S1.3	0.18	0.47
		S1.4	36.4%	40.7%			S1.4	0.36	0.41
	S2	S2.1	95.2%	86.2%		S2	S2.1	0.95	0.86
		S2.2	20.0%	60.9%			S2.2	0.20	0.61
		S2.3	11.2%	14.5%			S2.3	0.11	0.15
	S3	S3.1	70.9%	60.8%		S3	S3.1	0.71	0.61
		S3.2	31.0%	25.7%			S3.2	0.31	0.26
	S4	S4.1	34.5%	43.4%		S4	S4.1	0.35	0.43
		S4.2	31.0%	15.9%			S4.2	0.31	0.16
	S5	S5.1	82.2%	67.0%		S5	S5.1	0.82	0.67

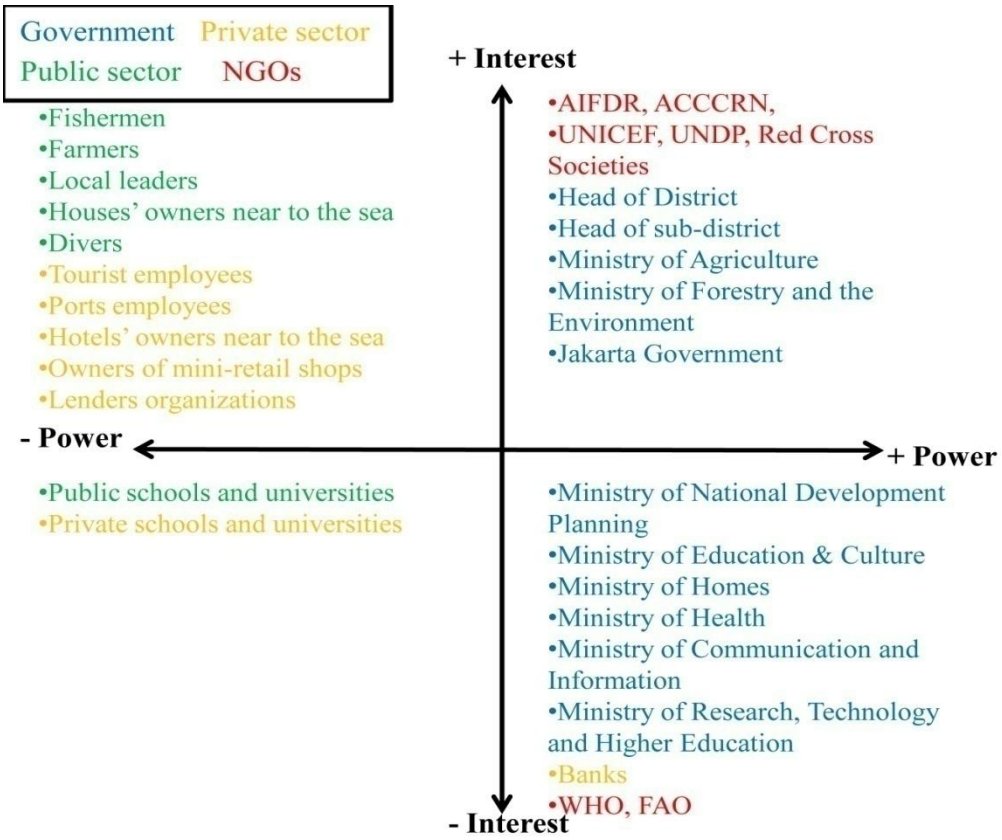
5.4.Stakeholders Analysis

Determining the stakeholders who are concerned with enhancing the resilience of the community in the two cities is a critical issue, as it is important to overcome the problem that resulted from unidentified stakeholders and responsibilities. Fig. 5-2 represents the analysis for stakeholders who share the goal of enhancing community resilience for floods in Alexandria and Jakarta, respectively. Stakeholders are grouped into four categories: government (colored in blue), private sector (colored in yellow), public sector (colored in green) and NGOs (colored in red) and then allocated in one of the four parts: high power and interest (upper-right), low power and interest (lower-left), high power and low interest (lower-right) and low power and high interest (upper-left).



a:Alexandria City

Figure 5-2: Stakeholder analysis for both cities: a:Alexandria, b:Jakarta



b: Jakarta

Figure 5-2: Stakeholder analysis for both cities: a:Alexandria, b:Jakarta (continued)

Justifications for selected stakeholders mentioned in Fig. 5-2 are illustrated in Table 5-3.

Table 5-3: Justifications for the views of stakeholders in the cities of Alexandria and Jakarta

Part	Type	City		Justifications
		Alexandria	Jakarta	
Upper- left	Public	Fishermen, farmers, local leaders, houses' owners near to the sea/river, divers		Their life style directly on the sea, hence, they would be severely impacted by floods in both on social and economic levels
	Private	Employees working in Tourism, employees working in ports, hotels owners near the sea/river		Economic loss occurs due to floods
		Owners of retail shops	----------	

Table 5-3 : Justifications for the views of stakeholders in the cities of Alexandria and Jakarta (continued)

Part	Type	City		Justifications
		Alexandria	Jakarta	
Upper-left	Public	----------	Lender organizations	Each time a flood crisis happens, many people borrow money from these organizations to repair the damages caused to their houses
Upper- right	Government	CoRi, SPA, EEAA	----------	Governmental entities responsible for either studying the impacts of SLR or applying policies that protect buildings, infrastructure and communities affected by floods
		Governor, head of district, head of sub-district		Responsible for allocating resources given by the country in order to reduce impacts of floods
		Ministry of Environment	Ministry of Forestry and Environment	Dealing with the environmental impacts of floods in the affected areas
	NGOs	Red Crescent and Cross Societies, UNICEF, UNDP		-International organizations responsible for relief. Hence, they play a role in: rescuing people during and post- flood crisis -Raise the environmental awareness through launching awareness campaigns in collaboration with schools, universities, and media about floods and how to deal with them and prepare for them
		International Development Research Center (IDRC), Danish International Development Agency (DANIDA)	Australian Indonesian Facility for Disaster Reduction (AIFDR), ACCCRN	International organizations who perform corporation projects with the governments in the affected areas with floods, such as: reinforcing sea walls and beaches, deepen the rivers streams to accommodate the increase in sea level
		GEF, WB		
Lower- left	Public	Public schools and universities		Launch flood awareness campaigns - with the help of academic institutions, media and ministries representatives , in order to enhance the capacity of the community during floods crisis, hence, rescuing the community individuals without relying on much external help.
	Private	Private schools and universities		

Table 5-3 : Justifications for the views of stakeholders in the cities of Alexandria and Jakarta (continued)

Part	Type	City		Justifications
		Alexandria	Jakarta	
Lower- right	Private	Banks		Supply affected people with financial aids (loans) to overcome impacts of floods on their lives and houses
	NGOs	WHO		Perform medical campaigns for diseases caused by floods
		FAO		Provide affected communities by floods with food during and after floods (spare food)
	Government	Ministry of Housing, Utilities and Urban Communities	Ministry of Homes	-Provide temporary houses in case of severe floods -Develop plans to protect existing infrastructure from floods
		Heads of media channels	Ministry of Communication and Information	Raise the awareness of media regarding the environmental impacts of SLR through cooperating with research and academic institutes.
		Ministry of Planning Follow-up Administrative	Ministry of National Development Planning	Develop intervention policies specific to existing high-density areas affected with floods
		Ministry of Health	Ministry of Health	launch medical campaigns for the diseases caused by floods
		Ministry of Education, Ministry of Higher Education	Ministry of Education and Culture, Ministry of Research , Technology and Higher Education	Launch awareness campaigns to raise awareness of floods − with the help of academics, media and political representatives − in order to enhance community capacity during the crisis of floods, . hence, help rescue community individuals without relying on external help
		General Administrative Civil Defense (Ministry of Interior Affairs)	----------	Responsible for applying human interventions during floods crisis to rescue affected people

5.5.Analyzing and Justification Results

Results of the above-mentioned mathematical analysis are presented by radar diagrams. Justifications of these results are then presented on two scales: An overall capitals scale and another scale for each variable/indicator. Presenting

the city performance in this manner draws attention to the capitals and the indicators which should be considered important policy priorities.

5.5.1. Overall performance

Overall, FDRI performance for both cities is represented in Fig. 5-3. The values in this diagram varies for the two cities and are ranged from 1.2 to 9.7. The blue lines are for Alexandria, while the orange lines are for Jakarta. As it can be observed from this figure: both cities show high tendency to reach the best performance in the governance capital. However, for the natural capitals: Alexandria city has higher preparedness than Jakarta.

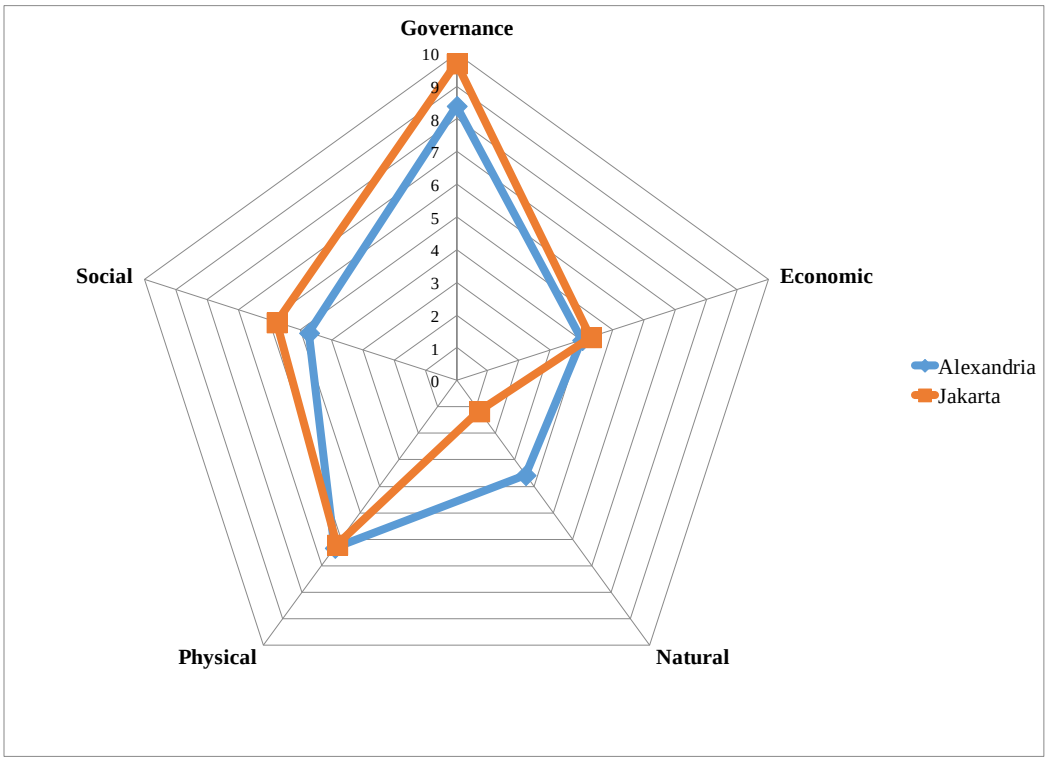


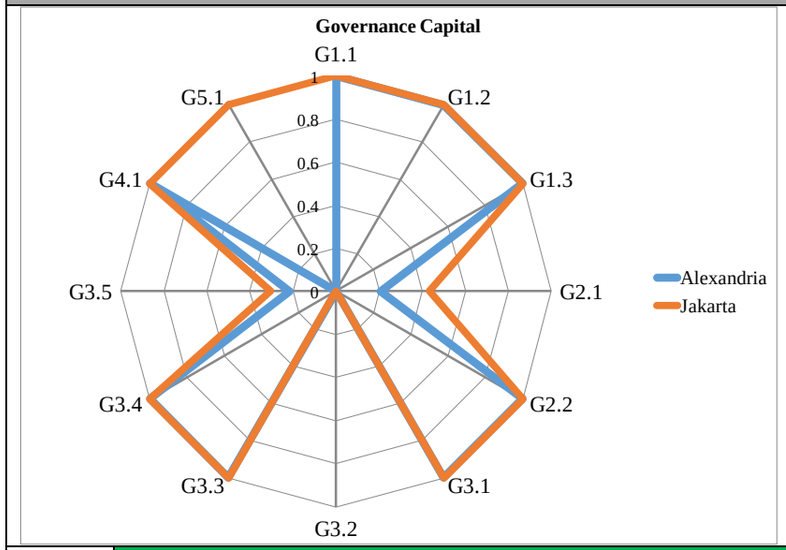
Figure 5-3: Overall FDRI performance among the five capitals for Alexandria and Jakarta cities

5.5.2. Overall performance by variables and indicators

The graphical presentation for the five capitals and their justifications in Alexandria and Jakarta are presented in Table 5-4. It consists of three parts: radar diagrams are located at the upper-left, while the meaning of symbols shown in these diagrams are located at the upper-right part, and the justifications for these results are colored in green and located at the lower part of the table.

Table 5-4: Graphical presenetations and justifications for the five capitals

1- Governance Capital

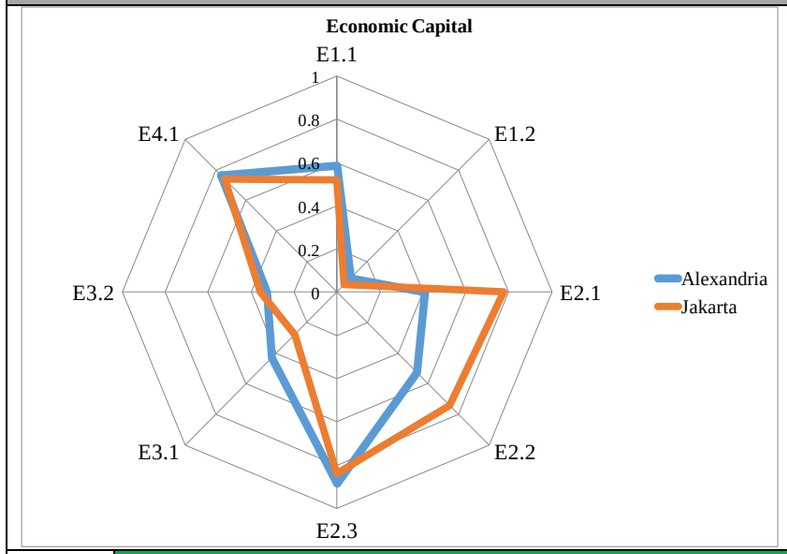


Symbol	Indicator
G1- Mainstreaming of floods resilience	
G1.1	Existence of governmental institution that target the reduction of floods' impacts (Y/N)
G1.2	Existence of regulations for land use and building codes target the reduction of floods' impacts (Y/N)
G1.3	Existence of city local strategies target the reduction of SLR impacts floods on people and city (Y/N)
G2- Good governance	
G2.1	Percentage of effectiveness of government -community communication
G2.2	Existence of the ability to access the governmental information related to floods (Y/N)
G3- Effectiveness of city's crisis management	
G3.1	Existence of governmental disaster management structure (Y/N)
G3.2	Existence of evacuation centers in the strategic plan (Y/N)
G3.3	Existence of financial resources for flood impacts' reduction (Y/N)
G3.4	Existence of flood early warning systems (Y/N)
G3.5	Percentage of trust in the governmental data transferred through the media
G4- Collaboration during floods with organizations	
G4.1	Existence of city's dependency on external supporters (Y/N)
G5- Knowledge dissemination and management	
G5.1	Existence of awareness campaigns for floods held by the government (Y/N)

Symbol	Justifications	
	Alexadnria	**Jakarta**
G1		
G1.1	Existence of institutions: SPA	Existence of institutions: Post flood department for Pademangan sub-district
G1.2	Respecting the beach buffer (Abo-Bakr, 2014)	Handling laws for evacuating settlements and turn these spaces into green belt (Waristo, 2013; Dharma, 2013)
G1.3	Periodic maintenance in Mohammed Ali Sea wall and raising level of sand ground (Salwa, 2014; Abo-Bakr, 2014)	Building three pumps to raise the excess water from Anchol river to the Java sea , increase its depth and apply periodic maintenance for its water gate (Dharma, 2013)
G2		
G2.1	There is no local leader for the whole community	Existence of successful local leader (Aten, 2014; Alamsyah, 2013)
G2.2	Transparency between the selected governmental institutions and the individuals	
G3		
G3.1	Existence of Egyptian National Committee for Disaster Management (Salwa, 2014)	Existence of Indonesian Disaster Management Agency (BNPB)
G3.2	Move to another safe house (Abo-Bakr, 2014)	Move to higher floors in the same house (Waristo, 2013)
G3.3	Existence of financial resources : from the Council of Ministries to SPA and CoRI.	Existence of financial resources: Revenue and Expenditure Budget (APBD) (Dharma, 2013)
G3.4	Existence of electronic sensors that keep recordings of the sea level (Salwa, 2014; Abo-Bakr, 2014; Dharma, 2013; Waristo, 2013)	
G3.5	Instability of the political situation	The governor did what he promised in his election's program according to individuals from the communnity
G4		
G4.1	Existence of city's dependency on external supporters: WB, Global International Finance (GIF) , Red Crescent Institution ,IDRC, DANIDA (Abo-Bakr, 2014; Ayyad, 2014; Salwa, 2014)	Existence of city's dependency on external supporters: AIFDR, UNICEF and Red Cross Institution (Hendra, 2013; Irma, 2013; Waristo, 2013)
G5		
G5.1	No awareness campaigns (Abo-Bakr, 2014; Ayyad, 2014; Mohi, 2015)	Awareness campaigns that resulted from the cooperation between the government and the Indonesian universities (Dharma, 2013; Irma, 2013)

Table 5-4: Graphical presenetations and justifications for the five capitals (continued)

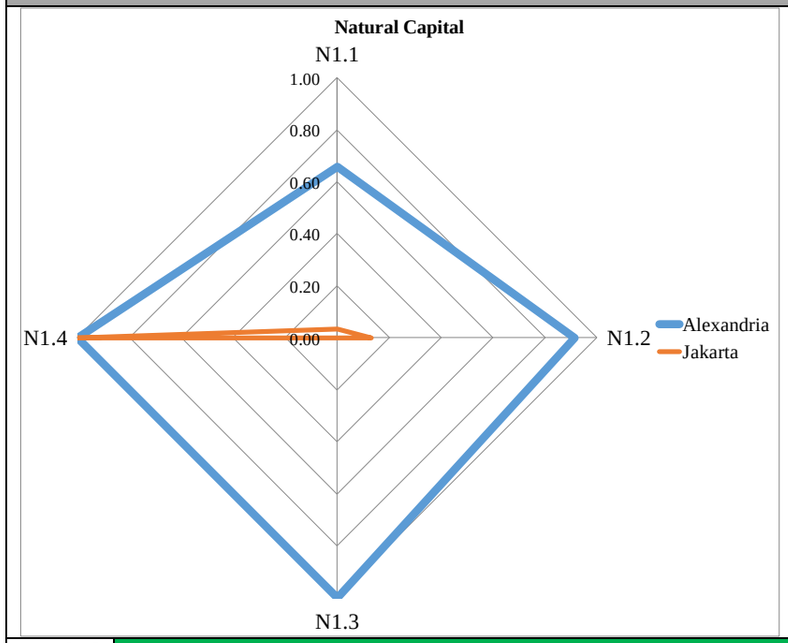
2- Economic Capital



Symbol	Indicator
E1- Employment	
E1.1	Dependency ratio
E1.2	Percentage of unemployment
E2- Household assets	
E2.1	Percentage of owners of motorized vehicles
E2.2	Percentage of owned homes
E2.3	Percentage of house description
E3- Finance	
E3.1	Percentage of Income range
E3.2	Percentage of Total income range
E4-Subsidy	
E4.1	Percentage of Subsidy's to pass flood time

Symbol	Justifications	
	Alexadnria	**Jakarta**
E1		
E1.1	Rapid population growth leads to insufficient number of available jobs (The World Bank, 2014; Trading Economics, 2014)	
E1.2	Job opportunities have grown at a slower rate compared to the growth rate of population (Indonesia Investments, 2014; Economy Watch, 2010)	
E2		
E2.1		Motorcycles are cheaper than cars
E2.2	The higher the percentage; the higher the ability to increase safe precautions for the house as the owner wants	
E2.3	The higher the type of house; the higher the income level. Hence, the higher the ability to reduce floods' impacts	
E3		
E3.1	The higher the income; the higher the ability to secure the home with vital preparations to reduce the impacts of floods	
E3.2	The higher the total income; the higher the ability to secure the home with vital preparations to reduce the impacts of floods	
E4		
E4.1	The higher the percentage; the higher the availability of side give subsidy to impacted houses	

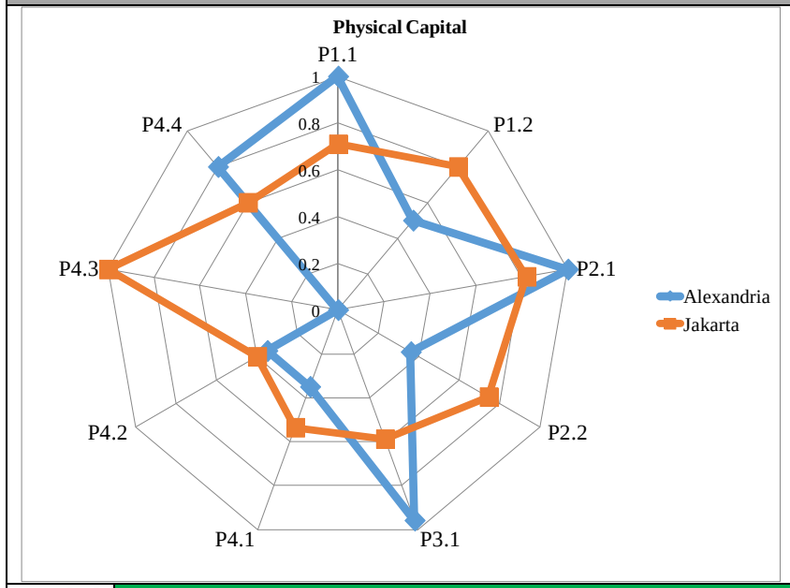
Table 5-4: Graphical presenetations and justifications for the five capitals (continued)

3- Natural Capital	
	**Symbol** / **Indicator** **N1- Ecosystem services** N1.1 Percentage of quality of drinking water N1.2 Percentage of quality of air N1.3 Existence of drainage in channels (Y/N) N1.4 Existence improper disposal (Y/N)

Symbol	Justifications	
	Alexadnria	**Jakarta**
N1		
N1.1	Filtered tape water or tap water due to lower pollution in water resources near district	Mineral water or transported by private companies to houses due to higher pollution in the rivers (Tjiptoherijanto, 2014)
N1.2		Big number of motorcycles which force people to wear muzzle (Sugiarto, 2014)
N1.3	Activation for laws that organize the drainage of the sea and rivers (Salwa, 2014)	Inactivation for laws that organize the drainage of the rivers (Waristo, 2013; Dharma, 2013)
N1.4	Inexistence of waste disposal in the soil affecting the selected zone (Salwa, 2014; Abo-Bakr, 2014)	Absence of waste disposal in the soil affecting the selected zone (Waristo, 2013; Dharma, 2013)

Table 5-4: Graphical presenetations and justifications for the five capitals (continued)

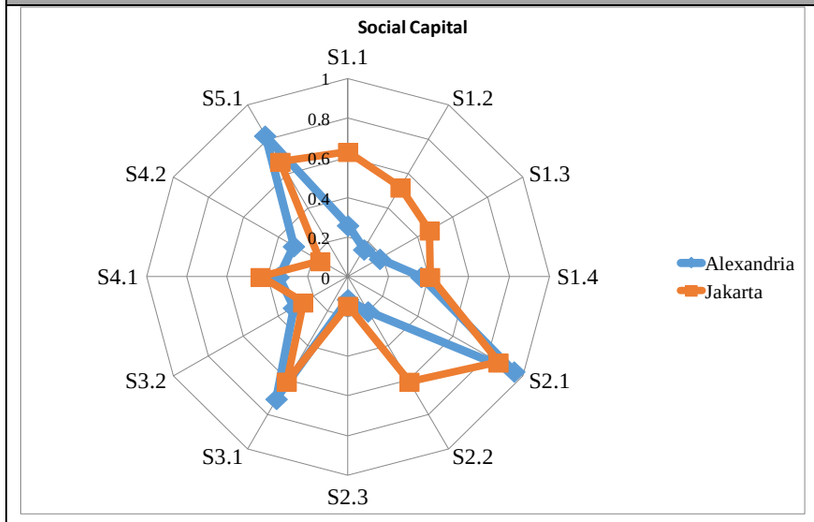
4- Physical Capital



Symbol	Indicator
P1- Electricity	
P1.1	Percentage of accessibility
P1.2	Percentage of existence of alternative capacity
P2- Water	
P2.1	Percentage of accessibility
P2.2	Percentage of existence of alternative capacity
P3- Sanitation	
P3.1	Percentage of accessibility
P4- Accessibility during floods	
P4.1	Percentage of accessibility of roads during floods
P4.2	Percentage of efficiency of dams and bridges conditions
P4.3	Existence of any mechanism of rain water draining (Y/N)
P4.4	Percentage of accessibility to shelters in flood time

Symbol	Justifications	
	Alexadnria	**Jakarta**
P1		
P1.1	Egypt: 96% (The World Bank, 2014)	Indonesia: 72.9 %
P1.2	Occasion electric cut off during floods .Hence, people aren't used to have alternative electric capacity	Frequent electric cut off during floods .Hence, people are used to have alternative electric capacity.
P2		
P2.1	Egypt : 99.3% (The World Bank, 2014)	Indonesia : 84.9% (The World Bank, 2014)
P2.2	Existence of occasional floods, hence, people aren't used to having alternative water capacity	Occurrence of frequent floods, hence, people are used to have alternative water capacity
P3		
P3.1	The existence of sanitation networks. Although they sometimes they don't work sufficiently during the floods	No sanitation networks in the selected zone. Therefore, people rely upon private septic tanks
P4		
P4.1	Insufficient sewage drainage network leading to inaccessible roads during floods	Sufficient rain drainage network leading to accessible roads during floods
P4.2	Equivalent score is taken from P4 4.1 due to that both indicators have a common target	Availability of some insufficient Wooden/ concrete due to humidity and time
P4.3	The absence of rain water drainage system in the area	The existence of some rain drainage canals, beside houses and in the streets
P4.4	The likeability of having accessible shelters is higher	The availability of accessible shelters is lower

Table 5-4: Graphical presenetations and justifications for the five capitals (continued)



5- Social Capital	
Symbol	**Indicator**
S1- Public participation in decision making	
S1.1	Percentage of population participating in community activities
S1.2	Percentage of trustfulness in the community representatives
S1.3	Percentage of effectiveness of the local elections
S1.4	Percentage of ability to express needs
S2- Education and awareness	
S2.1	Percentage of high Education level
S2.2	Percentage of population awareness about flood disaster
S2.3	Percentage of awareness efforts received from specialist
S3- Health	
S3.1	Percentage of accessibility to health facilities
S3.2	Percentage of existing medical alternative option
S4- Community preparedness	
S4.1	Percentage of people who obtained alternative food source
S4.2	Percentage of people who regularly check emergency supply
S5- Population	
S5.1	Percentage of single families per home

Symbol	**Justifications**	
	Alexadnria	**Jakarta**
S1		
S1.1	Existence of few community's activities	Existence of various community's activities : collecting donations, recycled materials.
S1.2	Low sense of cooperation among the individuals	Participating in improving the life standard of the community (Alamsyah, 2013)
S1.3	Low trust in the efficacy of the community representative, whenever there is one	Efficiency of local leader's communication with the government (Alamsyah, 2013; Hendra, 2013)
S1.4		Trustfulness in the Jakarta's governor and governmental officers
S2		
S2.1	Lower number of unemployed people and peddlers who are illiterate	Higher number of unemployed people and peddlers who are illiterate
S2.2	People's awareness is lower due to occasional floods	People's awareness is higher due to the high frequency of floods
S2.3	Lack of awareness campaigns (Abo-Bakr, 2014; Ayyad, 2014)	The launching of awareness campaigns (Waristo, 2013; Hendra, 2013; Irma, 2013)
S3		
S3.1	Higher percentage of people can access health facilities due to low severe floods	Lower percentage can't access health facilities due to high sever floods
S3.2	The tendency to keep a first aid kit and other medical alternatives is more favorable	Tendency to keep first aid kit and other medical alternatives is less favorable
S4		
S4.1	Mild, short-period floods do not motivate people enough to store food	Severe long-period floods force more people to keep food in their second floors
S4.2	Higher tendency to stay healthy force more people to regularly check their emergency supply	Seldom checking for the emergency supply
S5		
S5.1	Higher percentage of single families per home due to current condition of social fabric in Abo-Qeer.	Lowe percentage of single families per home due to current condition of social fabric in Pademangan.

From the above-mentioned comparative study between the two cities it can be concluded that although there are diffenrences in the severity and the reasons of floods between the two cities, the resileince among the five capitals proved that there is converge between performance of both cities for the Governance, Economic and Physical capitals. This resulted from the similarity between the policies which are adopted by the Egyptian governemnt and those adopted by the Indonesian governmement in enhacing community resielnce to floods.

However, the difference between the two cities in the Natural Capital reflects low reselience in this capital in Jakarta than in Alexandria.This result confirms what is known about Jakarta, that it ranks fifth among the most polluted cities in the world (Otto, 2012). Morover, low performance in Social Capital in Alexandria city reflects a disturbing situation after 25th January 2011 which enhanced the feeling of the absence for trustfulnes and effectiveness of communication between community and government. It also witnessed the absence of a local leader who has the ability to communicate effectively with the representitives of the government. This poor perfromance only reflects the absecene of social activities which increase the awareness of the community's awarness of its own problems and help people get empowered.

5.6. Concluding Remarks

In order to assess a city' performance, indicators are employed in this chapter. The adopted approach aimed at assessing the performance of the city according to the values of the individual indicators. It indicates city' performance based on the values of individual indicators. Thus, it can be easily used for policy purposes. The assessment results are presented graphically using the so-called radar diagrams, which has proved to be a valid tool for visualizing changes and enabling relative comparisons across a number of cases, to make the interpretation of the results easier. Presenting performance of the city in this manner highlighted the problems in each city clearly and drew attention to capitals, which should be considered important policy priorities.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Chapter 6: Conclusions and Recommendations

This chapter summarizes the conclusions from the research and explores to what extent the research findings fulfilled their aim and objectives, as well as, answered the research questions. Finally, the chapter provides recommendations and suggestions for future work.

6.1. Conclusions

To conclude, it is important at this stage to return to the main aim and objectives, as well as, the questions of this research, and investigate to what extent the research succeeded in fulfilling them. While setting out the research aim and objectives in the introductory chapter, research aim has been introduced first, followed by the research objectives. In this section, the order will be reversed, research findings will be presented in direct relation to the main research objectives. Fulfilling the main objectives should lead to realizing the research aim. Answers to the research questions fit in its appropriate positions to realize the research aim and objectives.

The **first objective** was " to investigate physical, social, and economic vulnerability both globally and in Egyptian coastal zones as caused by climate change". This objective was fulfilled in chapter (2), based on the identification of the key sectors affected by climate change globally and in Egyptian coastal zones, which are: ecosystems, food (agriculture-livestock-fisheries), coast, industry, infrastructure and settlements, health and water. In-depth analysis for the impacts of SLR on coastal zones globally and on the four main cities in Northern Coast of Nile Delta region (Alexandria-Rosetta-Damietta-Port Said) was provided. Table 6-1 summarized the common impacts of SLR globally and on Egypt. Then the relationship between floods and the impacts of SLR has been illustrated thought Chapter (2).

Table 6-1: Common impacts of SLR globally and on Egypt

Sector	Impact of SLR
Ecosystem	-Migration of species -Isolated patches of ecosystem habitat -Risk of species extinction
Food	-Negatively affecting the growth rates and food conversion efficiencies -Negatively affecting health and productivity of fisheries, livestock and agriculture

Table 6-1: Common impacts of SLR globally and on Egypt (continued)

Sector	Impact of SLR
Coast	-Existence of erosion, salt water intrusion -Submerging for low delta regions -Changes in fisheries catches, coastal recreation areas and coastal navigation
Industry, infrastructure and human settlements	-Increase demographic displacements, unemployment rate and poverty rate -Negatively affecting infrastructure (roads-electricity, water, gas...etc) -Negatively affecting cultural and natural heritage
Health	-Frequency occurrences of epidemic diseases -Increase the number of deaths -Decrease in children mortality
Water	-Contamination of fresh water lakes -Negatively affecting ground water sources -Increasing the gap between water supply and demand

This objective is directly connected to the first question of the five research questions, which was:

- What are the impacts of SLR as one of the most significant impacts of climate change globally and on Egypt?

The second objective was " *to explore measures used to reduce the exposure population and assets threatened by SLR for coastal zones, both globally and in Egypt*". This objective was fulfilled in Chapter (3) based on the identification of the main measures used to reduce the exposure population and assets threatened by climate change and SLR for coastal zones, both globally and in Egypt. It could be concluded that there are three approaches used globally to reduce the impacts of climate change and SLR , which are: mitigation , adaptation and resilience. Mitigation is the least powerful approach among these three approaches in facing SLR, while resilience is the most preferable due its concerns about empowering the community to increase the ability to "bounce back" from SLR.

Concerning the current case in Egypt, there are two approaches applied to reduce the impacts of climate change and SLR: mitigation and adaptation. Although few resilience measures were applied, however they were classified as adaptation measures. Generally, Egyptian adaptation measures for SLR can be classified into soft and hard measures. Soft measures include issuing laws which aim at respecting the back off-shore line and imposing punishments for people

who violate these laws, while hard measures include using sensors to measure sea level, sand nourishment and off-shore break water.

These conclusions addressed the first part in the research problem which was: "***Northern Coast of Nile Delta is considered to be a highly threatened area by SLR. Urban development plans in this zone face a lack of resilience strategies to deal with the impacts of SLR which increase the vulnerability of the population living there***".

Moreover, this objective was directly connected to the second question among five research questions, which was:

- What are the measures used to reduce the exposed population and the assets threatened by sea level rise for coastal zones globally and in Egypt?

The third and fourth objectives were: "*to assess current community resilience situation in Alexandria and Jakarta in order to reduce the impact of floods on population and assets*" and "*to determine stakeholders who are concerned with enhancing the community resilience in Alexandria and Jakarta with the aim to overcome the impacts of SLR*", respectively. These two objectives were fulfilled in Chapters (4&5) through selecting a set of community resilience indicators in order to form the FDRI. Applying the FDRI was illustrated in Chapter (5). The appropriate indicators that measure community resilience against SLR in mega coastal cities as well as the differences between the performance in Alexandria and Jakarta, due to their consideration as mega-coastal cities, through the characteristics of resilient communities were discussed and presented as radar diagrams with their justifications.

The third objective was directly connected to the third and fourth questions among five research questions which were:

- What are the appropriate indicators that measure community resilience against SLR in mega coastal cities?
- What are the differences between the performance in Alexandria and Jakarta, due to their consideration as mega-coastal cities, through the characteristics of resilient communities?

While the fourth objective was directly connected to the fifth question in the research questions which was:

- Who are the stakeholders that target enhancing community resilience against floods among the two cities ?

In order to address the second part of the research problem which was: "***Furthermore, the overlapping in the responsibilities and lack of cooperation of relevant stakeholders regarding the reduction of the impacts of SLR cause incapability of identifying their role in the current or future strategies and plans"*** stakeholder analysis has been applied and in-depth interviews with governments, academic, NGOs and private sector representatives for both cities have been held.

From the analysis and the in depth-interviews for Alexandria representatives, the following could be concluded:

Firstly; there wasn't clear overlap between the governmental institutions regarding their efforts applied to reduce the impacts of SLR. For example, CoRI and SPA are both governmental authorities whose specialty is to reduce the impacts of SLR. CoRI is responsible for the researches, studies and measurements conducted in order to get outputs with its own equipments. However, SPA is concerned with transforming and applying this data through technical solutions. This integration reflects the cooperation between governmental authorities regarding the reduction of the impacts of SLR. Moreover, the regular meeting for these parts reduces the time, money and efforts of those specialized in the reduction of SLR.

Secondly, existence of cooperation between the concerned government and international institutions in the research field in the way of financial grants and participating in studies. **However,** lack of cooperation between the concerned government representatives and universities were occurred , that was reflected by their lack participation in developing the future strategic plan regarding the reduction of SLR impacts. Morover, this lack of cooperation occured between the concerned NGOs and concerned government and academic representatives.

Recently, the current cooperation situation has been improved by taking advantage of research studies held by Egyptian academic institutions, such as: Arab Academy for Science and Technology and Maritime Transport and Alexandria University for reducing the impacts of SLR on Alexandria City. Moreover, choosing representatives from Faculty of Engineering -Alexandria University to cooperate with the government while developing the future strategic plan for Alexandria city (SUP Alexandria 2021).

For Alexandria and Jakarta, there are recomendtations that can be applied for both cities for enhancing the five capitals of community resilience, which are: Governance, Economic, Natural, Physical and Social and are shown in Table 6-2.

Table 6-2: Summarized recommendations for enhancing the five capitals of community resilience in Alexandria and Jakarta

Recommendations	Aim
Governance Capital	
Setting up community early warning and monitoring systems	Increasing the effectiveness of city's crisis management through providing alerts of flood threats
Applying laws that prohibit resettlement in the most impacted areas	Increasing the mainstreaming of flood resilience through the strategic plans
Supporting participatory decision- making (bottom-up planning)	Increasing the effectiveness of the good governance
Economic Capital	
Applying Motorized Vehicles Taxes (MVT) on their owners and improving the public transportations	Empowering the infrastructure with the finance of public transportation and improving the environment
Constructing subsidy's offices directed by the Head of the District and the local leader and funded by charity institutions, donations and MVT	Increasing the community resilience through increasing the sources of subsidies to pass the flood time
Developing projects with high intensive - labor (recycling projects)	Reducing the unemployment rate, hence, increasing the community resilience
Natural Capital	
Planting water resistant plants and trees	Improving the ecosystem through protecting it from floods
Activating laws concerning the reduction of GHG, produced by factories	Improving the air quality
Encouraging the traditional methods of waste disposal, such as: local garbage collector, by offering suitable salaries for them, paid by the Head of the District	Improve soil quality through collecting the garbage in a suitable way with periodical scheme
Physical Capital	
Raising foundations and reinforce access roads	Minimizing the intensity of water flows, hence, increasing the accessibility during floods
Placing transportation systems in safe locations	
Designing rain water drainage system to minimize the intensity of water flows	

Table 6-2: Summarized recommendations for enhancing the five capitals of community resilience in Alexandria and Jakarta (continued)

Recommendations	Aim
Social Capital	
Establishing community committees	Monitoring the construction quality and settlement planning as self monitoring group from the community itself
Increasing the ability to have political will within local government units	Increasing the abilities of public participation in the decision making process
Increasing the cooperation between government units, civil society organizations, public sector and private sector	

Additional recommendations specified for Alexandria City- Egyptian case study of this thesis- are presented in Table 6-3.

Table 6-3: Recommendations to enhance the FDRI's capitals for Alexandria City

Concerned stakeholder	Current situation	Recommendations
Governance Capital		
Ministry of information, EEAA, Ministry of Environment, Ministry of higher education	Inactivation of the role of the media in raising awareness of the impacts of SLR on coastal communities and how to increase their resilient	-Broadcasting interviews with governmental officers and academics who discuss the SLR issue, going in field trips and watching documentaries
Head of district	Absence	-Selection of a local leader by the community and being hired by the government with a stable salary
Ministry of Environment	Absence	Develop laws that encourage green roves and sustainable buildings in general
Ministry of Agriculture and Land Reclamation	Absence	-Omnivory: Relocating functions to other buildings in other parts of the area. -Buffering: Leaving open spaces that could change function during floods
Economic Capital		
CoRI, SPA	Instability of the financial resources allocated in the country's budget and the foreign grants	-Transform the institute into a self-financed entity

Table 6-3: Recommendations to enhance the FDRI's capitals for Alexandria City (continued)

Concerned stakeholder	Current situation	Recommendations
Natural Capital		
Ministry of Water Resources and Irrigation	Few number	Increasing the number of sea water desalination plants in order to improve quality of water for large sector of the community
Physical Capital		
Ministry of Housing, Utilities and Urban communities	Moderate	-Strengthen the efficiency of dams and bridges and the accessibility of roads during floods -Implying rain drainage system -Create places where flood waters can be stored and can be sued in the un-emergency times as recreational areas
Social Capital		
NGOs, local leaders, public universities and schools	Weak	-Directing the individuals and the NGOs to be more self-reliant in facing the floods(flatness measures) -Launching awareness campaigns for the impacts of floods,

6.2.Future work

The conclusions in the preceding sections suggested the need for further research in number of fields. There are significant areas couldn't be covered within the scope of this research, which are highly recommended for further research. They can be summarized in the following points:

- **Modifying the FDRI to accommodate the rest of SLR impacts.** For example, indicators used in measuring community resilience against floods cannot be applied as they are against increasing the soil slaination resulted from SLR. Therefore, further studies are needed to investigate the indicators that can be used to measure the community resilience against the whole impacts of SLR, as a way to form the Sea Level Rise Disaster Index (SLRDI). The general out-

comes of the SLDRI could be easily applied in the future strategic plans of the coastal cities instead of targeting each impact individually.

- **Applying the index on a larger fraction of the community.** Due to the limitations of time and human resources, the researcher couldn't apply the FDRI on larger sample with various socio-economic tires. However, for future work , the FDRI could be applied on larger fraction of participants using various methods of surveys, such as: online survey, cell phone application...etc, for obtaining more accurate outcomes.

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APPENDICES

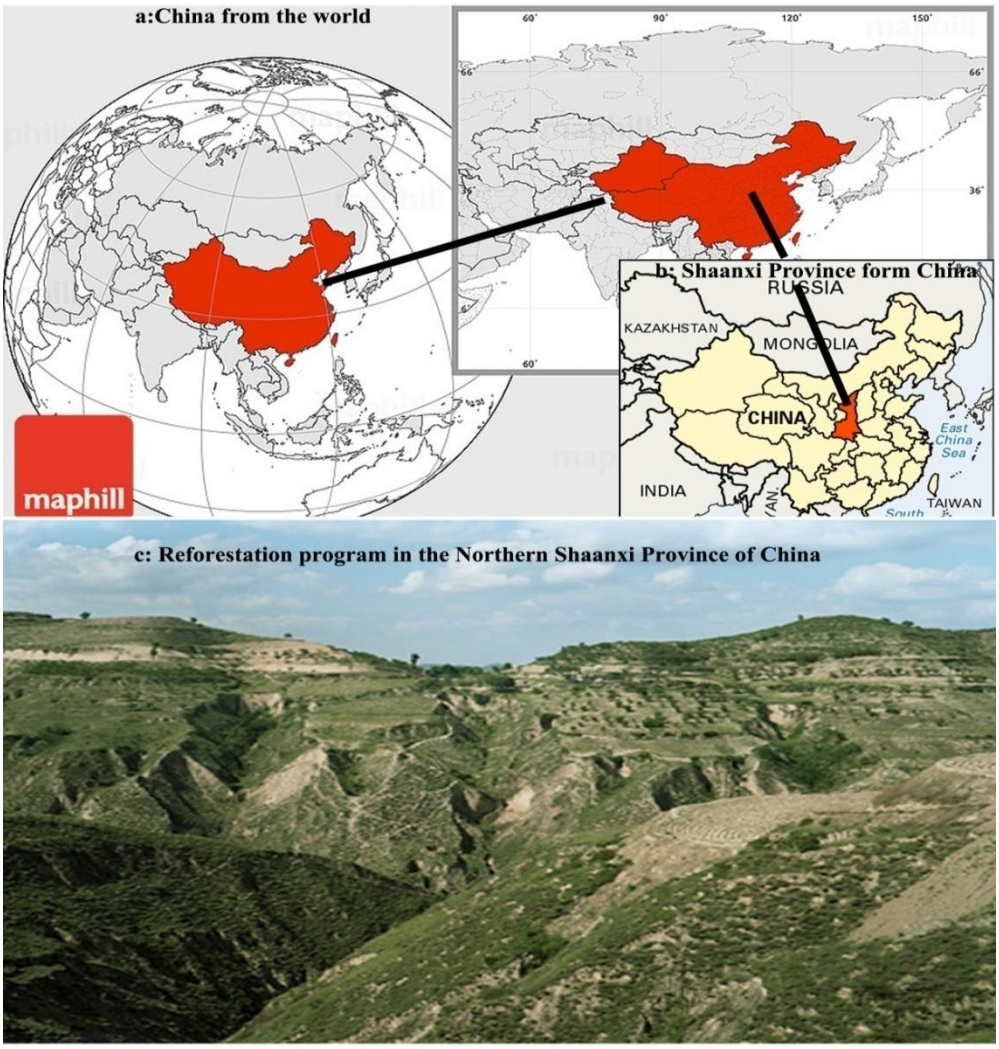
Appendix A: Selected global climate change impacts on industry and transportation

Source: (IPCC-WGII, 2007; AFED, 2009)

Sector	Impacts
Industry	-Energy costs -External fabric of buildings -Construction process -Changing consumer awareness and preferences -Operations and capacity -Control systems -Rising standards of service -Changing lifestyles influencing demand -Changing regional pattern of production
Transportation	-Limitation on the maximum load capacity of trucks and airplanes due to weakening of pavement -Frequent closure of coastal roads due to sea surges -Intense sandstorms in desert areas across the world would cause disruption of road traffic and increase frequency of closures and accidents -Deformities in metal components including rail-tracks, bridge steel elements -Inundation of coastal transportation elements including roads, bridges, airports -Costly adjustment in port facilities to accommodate tidal increases -Increased risk of mudslide and rockslide in mountainous regions

Appendix B: Activation the policies of boosting reforestation in China

China has long suffered from severe problems of soil erosion and flooding due to loss of forest cover. This has motivated the Chinese government to undertake the largest reforestation project in the world. China's Sloping Lands Conversion Program initiated in 1999, has the goal of converting14.67 million hectares of cropland to forests by 2010 (China Internet Information Center, 2015).



Reforestation Program in the Northern Shaanxi Province of China

Sources: a: http://maps.maphill.com/china/location-maps/blank-map/highlighted-continent/blank-location-map-of-china-highlighted-continent.jpg
b: http://media.web.britannica.com/eb-media/92/64392-004-1F1804A2.gif
c: http://canary-project.org/photo/photos_china_5.php

In the past two decades, volunteers participating in the national tree-planting movement throughout the country have planted over 35 billion trees. As a result, forest coverage in China has increased to 16.5 %. In the 1950s and 60s, China had one of the highest net forest carbon emission rates in world , this rate has now fallen to zero and could become negative the near future (Li, et al., 2011).

Appendix C: Relationship between green building codes and GHG emissions

Buildings have extensive direct and indirect impacts on the environment. During their construction, occupancy, renovation, repurposing, and demolition, buildings use energy, water, and raw materials, generate waste, and emit potentially harmful atmospheric emissions. These facts have prompted the creation of green building standards, certifications, and rating systems aimed at mitigating the impact of buildings on the natural environment through sustainable design (Vierra, 2014).

A variety of efforts to reduce energy consumption and GHG emissions from buildings have emerged in recent years, including the Leadership in Energy and Environmental Design (LEED) rating system, Architecture 2030's 2030 Challenge, and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers' (ASHRAE) goal to improve building codes by 30 % by 2010 (Center for Climate and Energy Solutions, 2015; United States Green Building Council, 2015).

Appendix D: Selected examples of the Egyptian CDM projects

Source: (Ernst & Young, 2013)

Project	Location	Operation Date
Reduction of N_2O emissions from the new Nitric Acid Plant of Egypt Hydrocarbon Corporation	Ain-Sokhna	2012
Zafarana 85 MegaWatt Wind Power Plant Project	Zafarana Zone	2011
N_2O and NOX Abatement Project at KIMA Fertilizer Plant	Aswan	2012
Emissions reduction through partial substitution of fossil fuels with renewable plantation biomass residues in CEMEX Assuit Cement Plant	Assuit	2011
Fuel Switching from Mazout to Natural Gas in Misr Fine Spinning and Weaving and Misr Beida Dyers	Kafr El Dawar	2011
Waste Gas based Cogeneration Project at Alexandria Carbon Black Co.	Alexandria	2008
Onyx Alexandria Landfill Gas Capture and Flaring Project	Alexandria	2006
Catalytic N_2O Destruction Project in the tail gas of the Nitric Acid Plant of Abu Qir Fertilizer Co.	Alexandria	2006

Appendix E: Question of the in-depth interviews

a: Governmental stakeholders

1. What are the local and national strategies dealing with floods and sea level rise?
2. How does the government communicate with the community before, during and after the flood (Nuwa't)? What is the most effective way?
3. Who are you representative in front of the community? (Local leader -officers…etc)
4. What are the kind of supporting efforts do the government present them to the NGOs?
5. What are the governmental disaster (sea level rise) management structures those asses the vulnerability and target helping communities in reducing impacts of sea level rise?
6. Where are the local and international financial resources for dealing with sea level rise come from?
7. What is the governmental structure from national to sub-community?
8. Is there any monitoring program of the health and stress facing ecosystems due to the floods?
9. What are the warning systems used to caution community about the floods?
10. What are the cooperation efforts between government and other international organizations(foriegn development projects)?

Put (Yes) or (No)

11. Existence of regulations for the land use and building codes targeting the reduction for impacts of sea level rise on city and community)	
12. Existence of the individual's ability to access the information of the way which the government deals with slr impacts	
13. Existence of Governmental disaster management structure across country	
14. Existence of evacuation centers	
15. Existence of awareness campaigns for climate change impacts on the city including sea level rise impacts	

b: NGOs stakeholders

1. How long have you been here?
2. What is your main activity?
3. How do you respond before, during and after the flood?
4. Where are your funds come from?
5. Does community participate in your activities?

Appendix E: Question of the in-depth interviews (continued)

b: NGOs stakeholders (continued)

6. Is there any cooperation between you and the government regarding building capacity of the community for the impacts of the flood? What kind of cooperation?
7. What are the common problems you face here?

c: Academic stakeholders

1. What is the role play of this university as one of the educational institutions in targeting climate change issues and impacts of sea level on the community?
2. Is there any cooperative effort between university and government regarding SLR impacts and floods?
3. Is there any cooperative effort between the university and NGOs regarding SLR impacts and floods
4. What is the expected scenario for the community here in Alexandria/ Jakarta under the curtained sea level rise and increased no. of floods?

Appendix F: Questionnaire form distributed among citizens

Dear citizen,

This study aims to measure community resilience through questions cover five capitals: Governance, Economic, Natural, Physical and Social.

Community resilience can be defined as a measuring method to its continuous ability for benefit from the resources to respond and adapted and recover from the negative impacts from natural hazards. one of these natural hazard is sea level rise(SLR) and floods which are expected to increase their severity due to the climate change which is the main field for the researcher's M.Sc..

First, questions of the **Governance Capital** measure to what extent does the governments of coastal communities deal efficiently with impacts of floods through preparedness with the necessary information in planning ,responding and recovering from its impacts. Second, questions of the **Economic Capital** measure to what extent does the financial resilience to prepare the coastal communities to floods.

Third , questions of **Physical Capital** measure to what extent can the built environment(residential housing, public buildings, business/ industry, dams and shelters) be resilient to the impacts of floods.

Fourth, **Natural Capital's** questions measure to what extent is the quality can the main natural elements (air-water-soil) achieve to know the current situation in the selected zones. Fifth, **Social Capital's** questions target the measuring of to what extent does the coastal community ready for adaptation to floods.

Note: Please be aware that all the information you provide me with is anonymous and I will only use this information to get better understand of resilience in your community

Thank you for your cooperation

Section 1: Personal information

1. What is your gender? (Tick only one)

1 ☐	Male	2 ☐	Female

2. Into which age bracket do you fall? (Tick only one)

1 ☐	Less than 30	2 ☐	30-40yrs	3 ☐	More than 40 yrs

3. What is your main occupation? (Tick only one)

☐ 1	Employed. What is your job?.....
☐ 2	Unemployed
☐ 3	Retired
☐ 4	House person
☐ 5	Student. What are you studying? .....
☐ 6	Worker by day. What do you work?.....
☐ 7	Other (Please specify):…….....…

Section 2: Governance Capital

In regard to your general feelings about living in this community, please describe the extent to which you agree or disagree with each statement (tick one answer)

	Usually	Sometimes	Rarely
4. Government communicates effectively through local leaders before, during and after flood	3 ☐	2 ☐	1 ☐
5. I trust the media (newspapers, TV, radio) to report fairly	3 ☐	2 ☐	1 ☐

Section 3: Economic Capital

6. What is your household's annual income?

1 ☐	Less than 996$	2 ☐	996 $– 1,992 $
3 ☐	1,992.1 $ -2,988 $	4 ☐	More than 2,988 $

7. What is your salary?

1 ☐	Less than 83 $	2 ☐	83 $ – 166 $
3 ☐	166.1 $ – 249 $	4 ☐	More than 249 $

8. What is best described you home?

1 ☐	Light structure	2 ☐	Studio
3 ☐	Apartment	4 ☐	Villa
5 ☐	Other. Please specify …….…….		

9. Do you have any motorized vehicle? (If yes, how many motorized vehicles do you have?

1 ☐	No	2 ☐	Yes. No. of motorized vehicles...

10. In the crisis time, where do you get money to pass through this crisis?

1 ☐	Loans from bank	2 ☐	Loans from relatives
3 ☐	Loans from NGOs	4 ☐	Other. Please specify ……

11. Is your home owned or rented? (Tick only one)

3 ☐	Owned
2 ☐	Rented
1 ☐	Other (Please specify):…….....

Section 4: Natural Capital

In regard to the environment surrounding you, please tick on what is close to reality

	Usually	Sometimes	Rarely
12. You drink directly from the tape	3 ☐	2 ☐	1 ☐
13. You suffer from any respiratory disease	3 ☐	2 ☐	1 ☐

Section 5: Physical Capital

In regard to your household location, please record whether you the accessibility for the following or not

	Usually	Sometimes	Rarely
14. While floods, you can go outside the inundated area	3 ☐	2 ☐	1 ☐
15. The bridges, dams, flood barriers near you are working efficiently	3 ☐	2 ☐	1 ☐
16. The shelters are accessed by you in the flood time	3 ☐	2 ☐	1 ☐
17. I have stock of drinking water in case of cutting off the water during the flood	3 ☐	2 ☐	1 ☐
18. I have an alternative electrical source in case of cutting off the electricity	3 ☐	2 ☐	1 ☐

Section 6: Social Capital

In regard to participating in life in this community, please describe how often you undertake each of the following.

	Usually	Sometimes	Rarely
19. I participate in local events or volunteering activities (festivals, fundraising…etc) to benefit my community	3 ☐	2 ☐	1 ☐
20. I trust my local council to meet the needs of its residents	3 ☐	2 ☐	1 ☐
21. Voting in local elections helps solve local problems	3 ☐	2 ☐	1 ☐

Section 6: Social Capital (continued)

In regard to what happens in your community, please describe the extent to which you agree or disagree with each of the following statements:

	Usually	Sometimes	Rarely
22. I think about floods impacts on my community	3 ☐	2 ☐	1 ☐
23. When people are needed to stand before a group of the stakeholders to tell them what this community needs, most people here could do it	3 ☐	2 ☐	1 ☐
24. I believe that there are awareness campaigns about sea level rise held by specialist	3 ☐	2 ☐	1 ☐

25. Which of the following describes your household now?(Tick only one)

1 ☐	One person household
2 ☐	Two parent family with one child or more
3 ☐	One parent family with one child or more
4 ☐	Other (Please specify)……

26. What is your highest educational qualification? (Tick only one)

1 ☐	Illiteracy
2 ☐	Mandatory education
3 ☐	Higher education

In regard to your household location, please record whether you the accessibility for the following or not

	Usually	Sometimes	Rarely
27. There is local emergency-medical service accessible by you in the flood time	3 ☐	2 ☐	1 ☐
28. I have obtained a supply of food that could be used in an emergency	3 ☐	2 ☐	1 ☐
29. I have purchased a first aid kit	3 ☐	2 ☐	1 ☐
30. I check the contents of my emergency supplies at least every six months	3 ☐	2 ☐	1 ☐

Section 6: Social Capital (continued)

In floods, what do you usually do to prevent floods from entering your house

……
……

الملخص

تهدف الرسالة إلى دراسة آثار إرتفاع منسوب سطح البحر وقياس مستوى مرونة المجتمعات العمرانية على الساحل الشمالي لدلتا النيل مع التركيز على مدينة الإسكندرية (مصر) بإعتبارها واحدة من المدن التي تخضع لتأثيرات إرتفاع منسوب سطح البحر الناتجة من التغير المناخي. إضافة إلى ذلك عمل دراسة مقارنة مع حالة مشابهة في الساحل الشمالي لجزيرة جافا (إندونيسيا) مع التركيز على مدينة جاكرتا كواحدة من المدن المهدد سكانها بظاهرة إرتفاع منسوب سطح البحر.

في هذا الصدد فقد تطرقت الرسالة إلى تحديد مشكلتين أساسيتين مع وضع الإقتراحات المناسبة لهما. **المشكلة الأولى** تكمن في نقص إستراتيجيات المرونة في مخططات التنمية العمرانية لمدن الساحل الشمالي لدلتا النيل بإعتبارها من المناطق عالية التهديد بآثار إرتفاع منسوب سطح البحر و تحديدا الفيضانات -مجال الدراسة- مما يزيد من قابلية تعرض سكانها لمخاطر هذا الإرتفاع. **المشكلة الثانية** تنحصر في قلة التعاون و عدم تحديد مسؤوليات شركاء التنمية المعنيين بالحد من آثار إرتفاع منسوب سطح البحر في تلك المناطق المتضررة مما أدى إلى عجز في تحديد أدوارهم للعمل على زيادة مرونة المجتمع المتأثر بكارثة إرتفاع منسوب سطح البحر. و حيث أنه وفقا لدراسات حديثة لمنظمة تنمية التعاون الإقتصادي (OECD) فإنه من المتوقع زيادة شدة الفيضانات في عام ٢٠٧٠، وبالتالي زيادة التهديدات لمنطقة الساحل الشمالي لدلتا النيل بسبب هاتين المشكلتين السابق ذكرهما.

تتناول الرسالة المشكلة الأولى من خلال دراسة مختلف التقنيات المستخدمة في مدينتين ساحليتين كبيرتا الحجم، وهما: الإسكندرية (منطقة أبو قير) في مصر وجاكرتا (منطقة باديمنجان) في إندونيسيا. ويرجع إختيار المدينتين إلى إنخفاض تضاريس المدينتين إلى ما دون مستوى سطح البحر وترتيب المدينتين في المركزي الحادي عشر والعشرين من عشرين مدينة من حيث عدد السكان المعرضين لخطر الفيضانات الساحلية بحلول عام ٢٠٧٠ تبعا للـOECD. وهو ما تم تعديله مؤخرا إلى الأول والحادي عشر وفقا للأبحاث الحديثة.

علاوة على ذلك، تم وضع هيكل عمل لقياس مستوى مرونة المجتمعات في هذه المدن الساحلية الكبيرة بإستخدام مؤشر مرونة كارثة الفيضان (FDRI). تم تطوير هذا المؤشر بناءا على خمسة أبعاد قائمة على المرونة، وهم: الحوكمة، الإقتصادية، البيئية، المادية و الإجتماعية. وقد تم إستخدام أساليب مختلفة لقياس هذه الأبعاد بإستخدام الـ FDRI، وتشمل الدراسات السابقة في هذا المجال، والإستبيانات، والمقابلات الشخصية التي تم إجراؤها من قبل الباحثة.

هذا وقد تم إجراء التحليل الإحصائي بإستخدام برنامج Microsoft Office Excel. أشارت نتائج هذا التحليل إلى إرتباط القيم الأعلى من المرونة بالإستعداد الأعلى للتعامل مع كوارث الفيضانات والعكس صحيح، بالإضافة إلى وجود أنواع مختلفة من نقاط الضعف والقوة لكل مدينة. بناءا على هذا التحليل تم عرض توصيات لتعزيز مرونة المجتمع ضد كوارث الفيضانات. بشكل عام حققت المدينتين أعلى أداء في البعد الحوكمي في الـ FDRI، وبالنسبة للأداء في البعد البيئي فقد أظهرت النتائج أن أداء

مدينة الإسكندرية أعلى من أداء مدينة جاكرتا. أما فيما يختص بالأداء في البعد الإجتماعي، فإن أداء مدينة جاكرتا أعلى من أداء مدينة الإسكندرية.

وتتناول الرسالة معالجة المشكلة الثانية وهي قلة التعاون والتداخل بين مسؤوليات شركاء التنمية المعنيين بالحد من آثار إرتفاع منسوب سطح البحر المحتملة في هذه المناطق المتضررة من خلال التحقيق في الدراسات السابقة والمقابلات الشخصية والاستبيانات. قدمت نتائج هذا التحقيق تحديد واضح لشركاء التنمية المعنيين ومسؤوليتهم بكلا من المدينتين، وأيضا أوضحت النتائج وجود جهود تعاونية بين هؤلاء الشركاء بقدر أعلى في جاكرتا عن الإسكندرية وخاصة بين ممثلي الحكومة و الأكاديميين من جهة وبين الأكاديمين والمنظمات الغير حكومية من جهة أخرى كنتيجة لزيادة الوعي المجتمعي بكارثة الفيضان في جاكرتا، مما نتج عنه مشاركة فعالة بين أفراد المجتمع والحكومة والمنظمات الغير حكومية والأكاديميين لتعزيز مرونة المجتمع المتأثر بالفيضان للحد من خسائره.

هذا وتحتوي الرسالة على سبعة فصول رئيسية يمكن إيجازها على النحو التالي:

الفصل الأول: المقدمة

إستعرض الجزء الأول من هذا الفصل مقدمة عامة عن الرسالة متضمنة نبذة مختصرة عن آثار التغير المناخي وإرتفاع منسوب سطح البحر عالميا -مجال دراسة الرسالة-، ويلي ذلك توضيح مختصر لمفهوم "مؤشرات مرونة المجتمع" والذي يعتبر مفهوم أساسي في هذه الرسالة. وتناول الجزء الثاني من هذا الفصل طرح لمشكلة البحث مع تحديد هدفه وغاياته، بالإضافة إلى الأسئلة البحثية المطلوب الإجابة عليها من خلال محتوى الرسالة. وإنتهى هذا الفصل بتوضيح لهيكل البحث.

الفصل الثاني: أسباب وآثار التغير المناخي وإرتفاع منسوب سطح البحر

تم تقديم شرح تفصيلي لمفهوم التغير المناخي لغويا وعلميا في هذا الفصل، ويلى ذلك دراسة لأسبابه وآثاره عالميا ثم على جمهورية مصر العربية من خلال سبعة قطاعات، وهم: النظام البيئي، الغذاء، الساحل، الصناعة والبنية التحتية والمستوطنات السكنية، الصحة، و الماء وذلك في جزئه الأول. وركز الجزء الثاني من هذا الفصل على توضيح تفصيلي لآثار إرتفاع منسوب سطح البحر والسيناريوهات المتوقع حدوثها عالميا وعلى أربع محافظات مصرية، وهم: الإسكندرية- دمياط- رشيد- الإسماعيلية وذلك نظرا لإعتبارهم أكثر المدن المصرية تهديدا بهذا الإرتفاع.

الفصل الثالث: الإستجابة للتغير المناخي مع التركيز على إرتفاع منسوب سطح البحر

بدأ هذا الفصل بمناقشة تعريفات وتقنيات النُهُج العالمية المطبقة للإستجابة لتغير المناخ وإرتفاع منسوب سطح البحر، بالإضافة إلى توضيح التقنيات التي نجحت الجهود المصرية في تطبيقها من هذه النُهُج في مختلف القطاعات للحد منهما. ثم يناقش هذا الفصل *" الإستراتيجية القومية للتأقلم مع التغير المناخي وتقليل مخاطر الكوارث*" التي وضعها مركز نظم المعلومات وإتخاذ القرار التابع لمجلس الوزراء المصري بصفتها أول إستراتيجية حكومية مصرية تستهدف تقليل مخاطر التغير المناخي.

الفصل الرابع: المنهجية

يقدم هذا الفصل شرحا وافيا للأساس المنطقي المستخدم في الرسالة لإختيار المدخل النظري وكذلك تطبيقه على تطوير مؤشرات الـ FDRI على المدن الساحلية الكبرى، ثم يشرح طرق البحث التي تم إستخدامها مع توضيح كيف ولماذا تم دمج الطرق الكمية مع النوعية اللذان تم استخدامها في الجزء العملي بالبحث للحصول على نتائج الرسالة.

الفصل الخامس: عملية تطوير الـFDRI

يشرح هذا الفصل عملية تطوير هيكل العمل الخاص بالـFDRI الذي يقوم بقياس الأداء الحالي لمرونة مجتمع المدينة الساحلية، ثم يتناول تعريفات للمكونات الخمسة المكونة للـFDRI وهم: الحوكمة والإقتصادية والطبيعية والمادية و الإجتماعية، و يلي ذلك توضيح تفصيلي للمؤشرات المستخدمة لقياس كل من هذه المكونات.

الفصل السادس: قياس مرونة المجتمع باستخدام الـFDRI

بحث هذا الفصل قابلية التطبيق العملي للـ FDRI، وذلك عن طريق التعرف على أثر إستخدامه في قياس الأداء الحالي لمرونة المجتمع من منظور واسع لمدينتين ساحليتين كبيرتين تم إختياهما وهما : الإسكندرية (مصر) وجاكرتا (إندونيسيا). علاوة على ذلك، فإن هذا الفصل استهدف تحديد شركاء التنمية الذين يهتمون بتعزيز المرونة المجتمعية بكلا من المدينتين المختارتين.

الفصل السابع: الإستنتاجات والتوصيات

تم في هذا الفصل تجميع الإستنتاجات من كل فصول الرسالة واستكشاف إلى أي مدى تم تحقيق هدفها وغاياتها، وكذلك الإجابة على الأسئلة البحثية السابق طرحها في الفصل الأول، وتلا ذلك تقديم مجموعة من التوصيات لشركاء التنمية المعنيين بتعزيز مرونة المجتمعات الساحلية للحد من آثار إرتفاع منسوب سطح البحر وخاصة الفيضانات لكلا المدينتين الساحليتين محل البحث. وينتهي هذا الفصل بعرض مقترحات تفيد إمكانية تطبيق البحث في مجالات مستقبلية أخرى.

كلمات المفتاح: التغير المناخي ، إرتفاع منسوب سطح البحر، الإسكندرية، جاكرتا، مؤشر مرونة كارثة الفيضان، مرونة المجتمع

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تاريخ المنح	: ٢٠١١
الوظيفة الحالية	: معيدة بالمعهد العالي للهندسة والتكنولوجيا- التجمع الخامس.

كليه الهندسة

قسم التخطيط العمرانى

مرونة العمران في مواجهة تغير المناخ: دراسة آثار ارتفاع منسوب سطح البحر على الساحل الشمالي لدلتا النيل

رسالة مقدمة للحصول على درجة ماجستير العلوم فى الهندسة

فى الهندسة المعمارية

(التخطيط العمرانى)

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