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## Coastal cities Resilience for Climate Change

Case study: Egyptian North coast cities

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### Abstract

Climate change is one of the most important threats facing the Mediterranean basin, and the Mediterranean coastal cities will suffer from several risks. Studies predict that these cities are threatened with drowning by 2070-2050. Intervention policies for the conservation of coastal cities are among the most important concerns for Europe and North Africa. The concept of Resilient cities is one of the recent ways to deal with natural disasters and climate change that could threaten cities in the future. The northern coastal cities are of great importance in Egyptian urbanization, Where the second capital of Egypt (Alexandria). Northern cities have about 12% of Egypt's population. These cities represent economic and social power as well as historical and humanitarian value. Despite these risks, there has been a trend towards urban expansion in the northern coastal region since the end of the last century.

This paper aims at studying the impacts of climate change on Egyptian northern coastal zones and exploring the urban resilience to the effects of climate change. In this regard, the current paper discusses the concept of resilience and describes the city resilience framework. Then the research focuses on coastal cities and surveys coastal vulnerabilities to the risks of climate change. The paper addresses climate change resilience strategies by exploring various techniques applied in three international case studies. Then it surveys Egypt's coastal zones vulnerabilities to the impacts of climate change and Egyptian adaptation and mitigation attempts to climate change risks. Finally, the paper addresses challenges and opportunities of the resilience of Egyptian northern coastal zones to the impacts of climate change and suggests some recommendations.

**Keywords:** Climate change, Coastal, Urban, Resilience, Egypt

### 1. Introduction

Urbanization, environmental degradation, climate change, and development-related process and planning shape and configure hazards. While building and developing our cities, there is always a concern about the impact of development and climate change on such complex systems that influence our ability to understand and manage risks (Jha, Miner, & Stanton-Geddes, 2013).

Coastlines are shaped by tides, waves, winds and storms so; they are considering one of the most dynamic environments on the planet. From the beginning of history, humanity was attracted to the coastal areas to harvest the benefits of food resources, transportation routes and building materials despite the risks of storms and immersion.

In the recent day, the coastal zones also represent a disproportionate population growth due to the immigration, causing a rapid expansion of coastal settlements, that consequently led to expansions in agriculture and aquaculture. These reasons made the inhabitants of coastal areas fragile and increased disproportionately (Beatley, 2012). So, there is an urge for Coastal to become more resilient.

## 2. The concept of Resilience

In the 1970s, the term “resilience” emerged in ecology to express the ability of a system to preserve or improve functionality in case of disturbance or disruption. Then the term applied to cities because of their complexity that is always adapting to changing conditions (The Rockefeller Foundation & ARUP, 2015).

In case of the exposure of a certain community system or society to a risk, Resilience is defined as its resisting, accommodating and recovering capability from risk effects in a timely and efficient manner.

In cities’ planning context it's introduced as a new model for urbanization and effects the way of our understanding and the management of urban planning and hazards on the urban level as well.

The term Resilience in cities is acknowledged both explicitly and implicitly in the United Nations’ 2030 Agenda for Sustainable Development Goals (SDGs). Target 1.5 aims, by 2030, “to build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.” Target 9.1 emphasizes building resilient infrastructure while target 11 aims “to make cities and human settlements inclusive, safe, resilient, and sustainable,” and target 13.1 aims “to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters.”

The Urban Crisis Charter of the Global Alliance for Urban Crises, presented at the World Humanitarian Summit, instantly categorizes resilience as an essential goal for the New Urban Agenda of the United Nations (Patel & Nosal, 2016).

## 3. City Resilience Framework

It provides a framework guided with rules that could be applied to influence stakeholders' decisions making process leading to merging the management of climate and disaster risks into investments on the urban level. In the practice field, the process of resilience operationalization is a rather challenging one. *fig(1)* City Resilience Framework.



**Fig (1)** "City Resilience Framework."

Source: United Nations University Centre for Policy Research 2016

Twelve indicators on which communities depend to determine the framework of City Resilience. These indicators fall under four main sectors: Health and wellbeing, Economy and society, Infrastructure and environment, Leadership and strategy. These four sectors reflect the key values of the resilient policy. The value of each indicator varies according to the economic, social and urban status of the city. Other sub-indicators appear under these indicators and each city develops sub-indicators to suit their circumstances and their socioeconomic structures and environmental risks that may have been experienced in the past or may suffer from in the future (The Rockefeller Foundation & ARUP, 2015).

#### **4. The resilience of Coastal cities**

Cities along coasts have even more severe Problems related to resiliency. The risk is constantly rising in the world's coastal cities, when there are 21 cities out of 33 coastal ones were expected to be overpopulated by eight million people by 2015, plus it's estimated that around 100 million people now are living only 1 meter (3.28 feet) above sea level. By the year 2050, the cost of the world flooded could reach \$60 billion a year. The cost of flooding in 2005 alone reached \$6 billion worth of damages. Even more, after the world's mega coastal cities seriously invest in risk mitigation, it predicted that the losses would double ten times by the year 2050. Comparing to that if we take no action at all the coast is estimated by \$1 trillion. The study not only handles cities that are expected to be suffering from maximum costs due to over flooding but also deals with cities that will be exposed to a significant increase in the average annual damages.

#### **5. Practical Lessons of resilient Coastal cities**

Coastal cities are cities of significant economic, social and cultural value to many countries. Therefore, three major coastal cities in three different countries were selected based on some factors. These factors are somewhat like the Egyptian case:

- Economic activities on which the city depends.
- Environmental risks to the city, particularly sea level rise.
- The cultural and historical value of the city. The three selected cities are among the oldest in the three countries.
- Selected cities are considered million cities, which is like the Egyptian case study.
- The diversity of policies for these cities to face risks in order to offer different approaches.

Based on these points, New York City in the USA, Melbourne in Australia and Thessaloniki in Greece were selected.

**Methodology of analysis of case studies:** Each case will be analyzed according to these key points:

- Recognizing the social, economic and urban context of the city.
- Identifying the factors and risks that led to resilient policies.
- Analyzing plans and strategies for the long, medium and short term
- Identifying the role of community participation
- Clarify the role of "infrastructure, buildings, community" in each city's resilient policy

### 5.1. New York, USA

New York City (NYC) is one of the main cities in the USA and most populated city by 8,622,698 inhabitants according to USA Population report 2017 (US Census Bureau, 2017). Located on East Coast of USA, Covering 784 Km<sup>2</sup>: NYC is one of the Economic leader cities in the world, touristic city 56 million tourists recorded in 2014 (The City of New York, 2014).

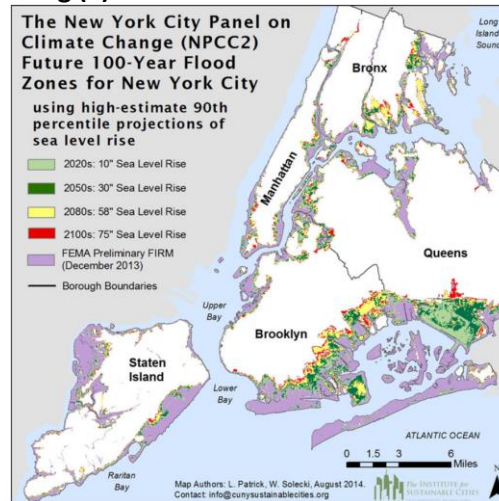
#### 5.1.1. Climate Change Risks:

In October 2012, NYC faced hurricane Sandy with unmatched force. It caused many damages on different levels. Economically, the city lost \$19 billion. Many neighborhoods suffered from floods. After Sandy NYC faced the new reality that the city must recover from Sandy results and must be for next Sandy with a broader range of climate change risks.

According to the new projections' sea level will be raised to 0.53 m by 2050, and 0.56:1.27 m by 2100. It will cost \$90 billion in 2050 if it is the same as Sandy events — *fig (2)*. All calculated damages and losses due to sea level rise alone. Many other effects will be releases like shortage of water, earthquakes, heavy winter weather, and pandemic disease (New York City Panel on Climate Change, 2015).

Since Sandy 2012, the main target /s of this vision build NYC stronger than before, ready for future risks, and reduce recovery time/cost after unexpected happens. When the city started making this new vision, they released that investments in the resiliency program will not only face inherent risks .it will be supportive of communities, increasing jobs. The right investments could repay if compared with future damages avoided .the 20\$billion cost plan for resilience program is a small amount if future benefits.

**Fig (2) " New York Future Flood Zones "**



Source: New York City Panel on Climate Change 2015 Report

#### 5.1.2. Resilience Alternatives and scenarios

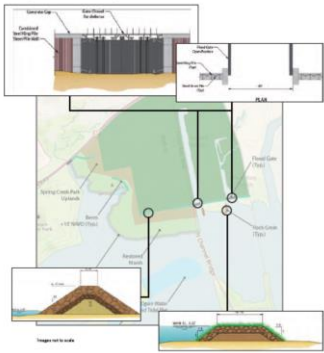

There were four main pillars established on NYC resilient vision (The City of New York, 2015):

- 5.1.2.1. *Neighborhoods*: every neighborhood within the city will be safer if there were a strong, resilient community, society, and the economy.
- 5.1.2.2. *Buildings*: city buildings will adapt and stand against the changing climate impacts.
- 5.1.2.3. *Infrastructure*: systems across the region will adapt to maintain a continuous flow of services.

**5.1.2.4. Coastal Defense:** New York City coastal defenses will be reinforced against flooding and sea level rise.

One of the main actions is the integration between gray defenses and green defenses to achieve a comprehensive Coastal Defense system (The Nature Conservancy, 2015). For example, on Howard Beach, Queens The design alternatives identified the following elements to be used. *Table (1)*

**TABLE 1.** DESIGN ALTERNATIVES GREEN & GRAY COSTAL DEFENSE, SOURCE: AUTHOR

Natural infrastructure	Gray infrastructure elements
Berms.	Removable flood walls.
Marshes.	Permanent flood walls.
Edges hardened with ribbed mussel toes.	Floodgates.
rock groins and breakwaters	rock groins and breakwaters
Constructed islands and wetlands.	
	

In June 2013 New York City government announced a comprehensive climate resiliency plan for the city with several new concepts and focused areas, including:

- **Community Strengthening**

The focus of this plan is to strengthen communities by building a resilient neighborhood community, society, and the economy. It will emphasize on the deep inclusion of resident, business participation and non-profit in emergency planning. That strategy depends on social cohesion, including forming tasks for community institutions.

- **New Climate Projections**

In 2015 the New York City Panel on Climate Change (NPCC) launched Building the Knowledge Base for Climate Resiliency, which includes monitoring protocols, updated projections, and climate indicators. As this report also covered new topics like public health; focusing on extreme heat events, coastal storms and how to enhance dynamic coastal flood modelings, which incorporate the effects of sea level rise.

- **Focus on Heat**

Based on the NPCC's work, the City is putting a new goal to protect New Yorkers from acute and chronic heat; a group is working on the urban heat island to understand and determine the need for better ambient air temperature, analyzing the impact of the natural infrastructure on the urban heat island effect.

- **Land Use Policy**

The NYC climate resiliency plan in 2013 recommended further studies on the land use policy and its potential as a tool for resiliency. Ten neighborhoods across the city currently involved in future planning studies on both a local and citywide level to generate recommendations on land use changes resiliency, to reduce long-term vulnerability by the smart management of growth (The City of New York, 2013).

- **An Updated Federal Agenda**

After 2013(NFIP); the National Flood Insurance Program was reformed by the federal government leading to slow down the insurance premiums, but it failed to solve long-term insurance affordability problems. In 2017 NFIP was expected to be reauthorized, providing a unique opportunity to institute new reforms, at the same time the City continues to evaluate the policy changes and outcomes.

## 5.2. Melbourne, Australia

The city of Melbourne is a vibrant hub of 4.3 million residents from different cultures, with diverse backgrounds from over than 180 countries. It's called the 'city of cities' because of the 32 local governing (councils) that stretch to more than 10,000 sq. Km around Port Phillip Bay, consisting of mixed local Neighborhoods that are unique in their character, mixed ethnics and even with their issues. *Fig3 )*

**Fig (3) " Melbourne Map" SOURCE: THE CITY OF MELBOURNE**



### 5.2.1. Climate Change Risks

The climatic changes that Melbourne is exposed to could lead to four main hazards:

- Drought and declined rainfall: by 2030 the annual rate of rainy days will be decreased by 6% and by 10-19% in 2070 leading to decreased average stream flow by 3-11% in 2020 and 7-35% in 2050, by 2017 the percentage will accelerate to 50% less runoff feeding Yarra, Maribyrnong, Werribee, and Bunyip Rivers.
- High temperature: in 2020 the average annual temperature will jump by a rate of 0.3-1.0°C, and 0.6-2.5°C in 2050, days with temperature above 35°C be increased from 9 days a year to 10-13 days by 2030, 15-26 days by 2070, and 16-33 days by 2100.
- Heavy rainfall: the rainfall severity will rise to reach 0.9% by 2030 and 3.0-5.9% by 2070.
- Rising Sea level: the expected rise sea level will be 1.1 meters by 2100, causing inundation which endangers roughly 937,000 inhabitants by 2100. The risk of inundation and shoreline recession will threaten the state of Victoria, the most

affected will be the Local Government Areas' (LGAs) infrastructure and buildings (Wales, Khanjanasthiti, Savage, & Earl, 2012).

### **5.2.2. Resilience Alternatives and scenarios**

The long-term (30 years or more) strategy of Melbourne city to become more resilient set up four resilience objectives. All members of stockholders could take an important role, in partnership with other sectors. The main idea to be City truly resilient depended on four main pillars created to achieve this vision.

- Stronger Together: that's created to cover social diminution by empowering communities to take responsibility for their own and each other's wellbeing, safety, and health.
- A Dynamic Economy: developing the city economy to be more diversity to create more jobs and stability in the future.
- Our Shared Places: Create and sustain buildings, infrastructure, and activities that promote social cohesion, equality of opportunity and health.
- A Healthier Environment: support natural assets and ecosystems, create new programs to maintain the environment (The City of Melbourne, 2016).

### **5.3. Thessaloniki, Greece**

Thessaloniki is a city with midsize located in northern Greece; it is a coastal city on Thermaikos Bay shoreline. It is the second largest city in Greece. Its port is the second largest export and transit port in the country. City population is 1.9 million inhabitants (2011 census). Thessaloniki has strong cultural and economic in history, Inhabited since 315 BC. The old center of the city has a mix of architectural styles including Byzantine, neoclassical, Art Nouveau and Art Deco.

Nowadays, Thessaloniki is a multicultural city that attracts young people, tourists, and international companies (Aristotle University of Thessaloniki, 2016).

#### **5.3.1. Climate Risks**

- Surface flooding:

In 2009 and 2014 happened significant flooding events in Thessaloniki and showed that despite the topography factor, the flood mitigation infrastructure needed interventions, seven streams running through Thessaloniki metropolitan center had been categorized as prone to flooding after the failure of infrastructure and the localized flooding. The problem was in the regulations of historic urban development; the infrastructure couldn't take in peak flows, plus The urban pressure that makes stormwater storage and retention insufficient.

- Fire at peri-urban forest:

Since 1997 a wildfire almost destroyed the suburban forest of Chortiatis by fire, the city has a plan to grown peri-urban forest areas. Now part of the city roads is on the limits of the woods, and some of the city's infrastructure is located within the forest area.

- Earthquakes:

One of the significant threat Earthquakes, in 1978, the city was an earthquake measuring 6.5 on the Richter scale. It cost the city deaths, infrastructure and property damages, and an economic loss 250 \$ million. Projections indicate that an earthquake of the same magnitude today would cause 4% of the city.

#### **5.3.2. Resilience Alternatives and scenarios**

There are four main pillars on Thessaloniki resilient vision:

- a) SHAPING A THRIVING AND SUSTAINABLE CITY with mobility and city systems that serve its people
- b) BUILDING A DYNAMIC URBAN ECONOMY AND RESPONSIVE CITY THROUGH EFFECTIVE AND NETWORKED GOVERNANCE
- c) CO-CREATING AN INCLUSIVE CITY THAT INVESTS IN ITS HUMAN TALENT
- d) RE-DISCOVERING THE CITY'S RELATIONSHIP WITH THE SEA – integrated thermaikos bay

Thessaloniki Goals, Objectives and Actions depending on strengthening Thessaloniki's resilience towards its population shifts, urban economy, open spaces and local governance, a new set of values are defining the City vision philosophy and shaping its future character (City of Thessaloniki, 2016).

- Goals are longer-term statements which address the vision statement and illustrate the overall impact.
- Objectives are mid- and long-term outcomes that are agreed by the city that they are the most important to achieving the vision and its goals.

**5.3.2.1.** Actions are the specific project level, including tactical activities to help accomplish the objectives; they can be policies, projects, and initiatives. They can be very simple or complex tasks, at the local or metropolitan scale.

**TABLE 2.** SHOWS THE COMPREHENSIVE VISION OF THESSALONIKI'S RESILIENCE. SOURCE: AUTHOR

	Goals	Objectives
<b>City Resilient Vision</b>	Shape a thriving and sustainable city with mobility and city systems that serve its people	A. Build an integrated resilient mobility system B. Adopt Transit Oriented Development (TOD) C. Develop smart urban logistics D. Move to clean power for transport E. Reduce air pollution and urban noise F. Reframe waste management G. Strengthen public environmental awareness for a stronger environmental policy.
	Co-create an inclusive city that invests in its human talent	A. Re-structure the role of Boroughs B. Establish Boroughs as social labs C. Welcoming Thessaloniki D. Foster youth participation E. Capitalize on Thessaloniki youth capital, invest in entrepreneurship and strengthen economic activity F. Invest in Intergenerational linkages in local communities G. Co-creation of inclusive, open spaces H. Nature-based solutions for green neighborhoods I. Child-friendly city
	Build a dynamic urban economy and responsive city through effective and network governance	A. Urban economy policy agenda B. Local cluster economic activities C. New cross-sector partnerships D. Metropolitan collaboration E. Performance-based management F. Financial resilience G. Municipal capital investment plan H. Local risk reduction and risk management systems I. Informed citizens and decision makers
	Re-discover the city's relationship with the sea - Integrated	A. Integrate economic and urban development of the Bay B. Environmental resilience monitoring. C. Restoration of the ecosystem. D. New governance system for the management of coastal activities on Thermaikos Bay.



		E. Cultural and natural capital of the Bay as vehicles to social cohesion and improved city life.
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The previous three cities strategies showcased above revealed that there is diversity in the way of handling the challenges of climate change in coastal areas. The time frame of each strategy is linked to the city’s character and the managing authority’s vision in addition to the nature of risks and the time range.

## 6. Lessons learned from international experiences

It was clear to the research team that the process of developing resilient policies for each city should be consistent with the general vision of the community and the country.

This vision is based on cultural and social values and influenced by administrative and political factors. Policies vary according to this perspective and stem from the integration of this vision with the reality of the city and its future.

**6.1. In the US case,** the economic factor is one of the most important factors driving the New York City plan. This stems from the nature of the economic city, which is one of the most important cities of the economy in the world. It also stems from the American materialistic nature that respects and values the financial value of things. The second is the welfare rate of the society, as it appears from a New York City perspective to the economic indicator.

Yet the extent of innovation and diversity in the US experience is evident. Various policies and procedures have been adopted that combine green and gray infrastructure. To integrate infrastructure systems together. So that the city can face environmental risks as a one unit, that can absorb these risks and turn them into an element of strength.

This ambitious plan relies on different layers of procedures at the planning, design and executive level, and then moves to the monitoring and follow-up stages to the confrontation stage and to deal with the same danger .

The building system is integrated with the urban system in this case, where the new construction policies began to consider the future risks, and this has been translated into construction and implementation requirements that apply to buildings and neighborhoods that are being rebuilt. In addition to the rehabilitation of buildings at risk from floods and hurricanes.

The administrative and political factor is evident in this experience: the local politics of the city are combined with the broader plan of the country. The plan was developed based on complementarity between the central and regional methodology.

Effective community participation and stakeholder role was very evident in this experience, starting from the phase of ideas to planning and funding. The local community and companies as well as the city tool participated in the development of this plan and participation in its implementation. And for the clarity of vision and goal to all, especially after the hurricane 2012.

**6.2. In the Australian case,** there is another order of priorities for the Melbourne community. As a result, the city has not been exposed to risks in the past but is looking to prepare for future risks. Community participation is a top priority in this experience because society seeks prosperity and environmental awareness is an important part of the Australian personality. This is different from materiality in the American case.

Because risk indicators are still long-term. Building the generation that will face these risks was part of the strategy and building a society that can flexibly absorb them was the second priority in this experience. The strategy then begins with defensive thinking about the origin of climate problems and how to address them at source.

Australia's strategy is to reduce global warming and reduce pollution. In addition to increasing habitat, the dynamic movement reverses the trend of climate degradation. This philosophy is based on creating a new reality that fits with the target future and reduces the chances of future environmental risks.

These policies are long-term in themselves ambitious and do not depend on one country or city. Physical defense policies such as infrastructure development, rehabilitation of some sectors, and diversification of the economy will emerge at the end of the strategy.

7. In the **Greek case**, the cultural value of the city and the tourist activity appear as a major driver of politics and economy in addition to urbanization. In addition to the diversity of risks to the city, it is an important part of Greek history and geography. Therefore, a flexible policy has been developed to adapt to these different changes in the form of a set of scenarios that depend on the city's economic, urban and cultural dynamics and be multi-purpose and plans.

Mediterranean cities are among the most likely to be exposed to environmental risks, so the city's overall strategic plan is short-term by 2030 to counter any immediate threat, according to climate change experts. This may be closer to the Egyptian case, which may be exposed to some risks as the coastal cities of southern Europe. Egyptian cities may be more vulnerable due to geological and natural factors of the Egyptian coastline from the perspective of climate experts.

Thus, the process of resilience policy-making is a cumulative process where the economy meets with society with urbanism. Its layers are formed over the years and decades. In addition, it is a participatory process in which the private and the public sectors meet. They must be actively involved at all levels. This is primarily a local process that cannot be replicated from other experiences, but must be based on local values, concepts and circumstances. It is possible to benefit from different experiences but remains primarily dependent on the community and local administration of each city.

## 8. Case study: Egyptian North coast cities

Egypt is one of the most countries at risk from the effects of climate change, although it is one of the world's least countries contributing to greenhouse gas emissions worldwide, 0.6% of the world's total emissions (Ministry of Environment, n.d.).

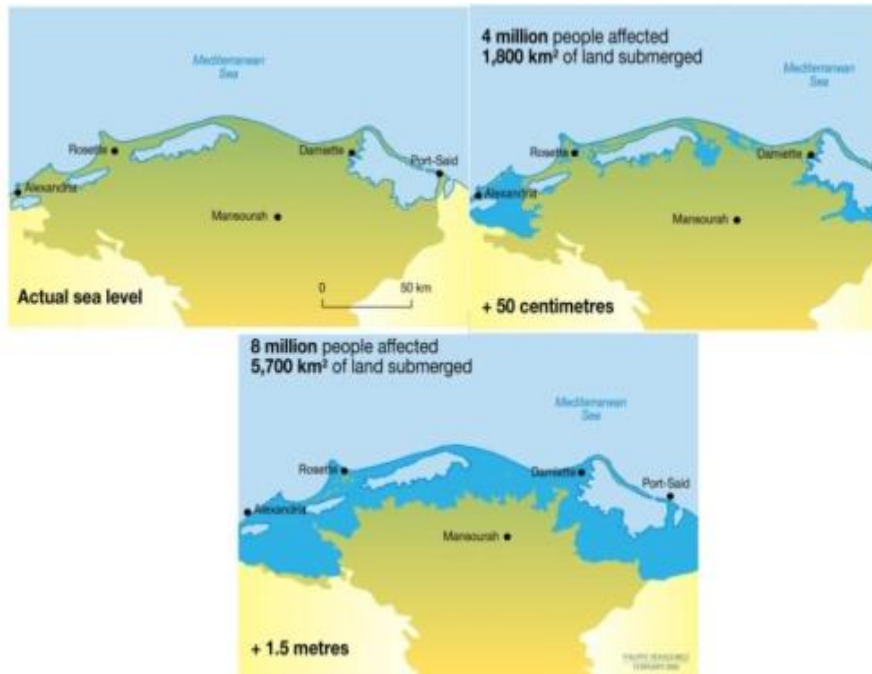
Most areas are expected to be affected by climate change are the Nile, Delta, and the coastal regions. The Mediterranean coast of Egypt is most vulnerable to the influences of climate change, not only for the effect of Sea Level Rise (SLR) but also on the impacts of water, agriculture and human settlements (Koraim, Heikal, & Zaid, 2011).

The coast of Egypt's Nile delta is about 300 km long and within it lies densely populated cities like Alexandria, Port-Said, Rosetta, and Damietta, they also are considered as hubs for economic and industrial and activities. The coastal areas are affected by many issues like the overpopulation, water pollution, conflicting land uses, water logging and at last the absence of institutional abilities to establish management integration (Agrawala et al., 2004).

### 8.1. Egypt coastal zones and climate change

The Nile delta in Egypt is considered one of the most fragile coastal to climate change in the Mediterranean. Aside from the sea rise level expected to happen; there are other inherent dangers like a saltwater intrusion in groundwater, decreased fisheries and shoreline erosion. Climate change also takes its damage on the North Egyptian lakes that are about 25% of the total Mediterranean wetlands and contributes to 60% of the fish production in the Mediterranean region. *Fig (4)* demonstrates the most vulnerable coastal Egyptian cities; Alexandria, Rosetta, and Port Said, in current conditions and after 0.5 and 1-meter sea level rise scenario.

**Fig (4)** Nile delta coastal zone affected by SLR by 2050



Source: <http://www.unep.org/dewa/vitalwater/jpg/0405-Nil-EN.jpg>

### 8.2. Climate change impacts on Egypt coastal zones

The effects of climate change produce stressful effects on water and agricultural resources, tourism and human settlements, as shown in *Table (3)*:

**TABLE 3.** CLIMATE CHANGE IMPACTS ON EGYPT COASTAL ZONES *SOURCE, (KAMH, 2015) WITH EDITING*

Effects	Climate change issues
Changes in lakes ecosystems	Increase in water temperature, SLR
Increasing rates of submerging for low elevated areas	SLR
Negatively affecting shoreline	SLR, saltwater 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
<b>- Food</b>	
Coasts of the Nile Delta: reduction of the area under cultivation and likely reducing production.	
Negatively affecting fodders	
<b>- Industry</b>	
Deterioration of coastal tourism	SLR, an 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 the food industry	
Changing the economic base in various zones	Droughts, SLR
<b>- Infrastructure</b>	
Increase the risk of transportation accidents and health risks in the coastal zone	SLR, flash floods, extreme weather occurrences
Deterioration of roads	Increase in temperature, sandstorms, dusty and windy conditions
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	
<b>• Human settlements</b>	
Increasing demographic displacements and migration	Extreme weather occurrences, SLR
Inadequate in low-income urban centers	SLR, flash floods, severe weather occurrences
Increased unemployment inducing political and civil unrest	
Negatively affecting cultural and natural heritage.	
Increasing poverty rates	Extreme weather occurrences, SLR
Negatively affecting the population pyramid	
High population density	
<b>• Health</b>	
Skin cancer, eye cataracts, deaths and injuries from cardiovascular and respiratory illness	Increase in temperature, a decrease of rainfall, SLR, dust storms
Increased prevalence of asthma and infectious diseases	
Vector-borne diseases, diarrhea and dysenteric infections	
A decrease in children mortality rates and malnutrition	
Respiratory disease	Extreme weather occurrences, SLR
Negatively affecting the mortality rate	
Increasing the number of deaths	
<b>• Water</b>	
Contamination of freshwater lakes	SLR, saltwater intrusion
Increase in soil and water salinity	Increasing temperature and SLR
Shortage in the storage capacity of water systems	Precipitation changes
Widening the gap between water supply and water demand	Increase in temp ., SLR, saltwater
Negatively affecting groundwater sources	SLR, saltwater intrusion
Growth in the cost of water	

It can be summarized from the Table that Sea Level Rise (SLR), saltwater intrusion, last storm occurrences, change of acidity, an increase of water temperature are considered to be primary reasons related to climate change that affect Egyptian coastal zones.

## 9. Egyptian Response to Climate Change

The Egyptian efforts against climate change effects classified into adaptation and mitigation.

### 9.1. Egyptian mitigation Attempts

Egypt is among the 11 fastest growing GHG emitting countries in the world (McKinsey & Company, 2020). Therefore, Egypt has carried out various projects that mainly aim to decrease GHG emissions:

- Develop projects that support an energy efficient economy and the use of Egypt's renewable energy potential:
- Establishing several projects in the field of renewable energy: wind (Zaafarana wind farm, 2000-2008), solar (Kuraymat, 2010), hydro (Aswan Dam, 1968).
- Creating a National Action Plan for Climate Change in 2005.
- Methane recovery from landfills which involves the recovery of methane generated in landfills: Sadat city (Cairo), Borg El Arab and El-Hammam(Alexandria) in 2000.
- The Supreme Energy Council (SEC) is developing and monitoring policies related to energy efficiency and renewable energy in all sectors.

### 9.2. Egyptian adaptation Attempts

Adaptation measures and projects are dealing with Egyptian coastal cities, are principally 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 laws and strategies.

There are some coastal protection activities already underway to improve resilience to Sea Level Rise(SLR) (Fanous, Khafagy, & Dean, 1995):

- The construction of a new drain at the western Nobariya drain outlet west of Alexandria; The new drain at western Nobariya drain outlet is about 20 km to the west of Alexandria. Two jetties of 65 m length were constructed in 1986 to protect the exit from siltation, and they are functioning effectively (El-Raey, Dewidar, & El-Hattab, 1999).
- Construction of a 180m extension of a breakwater in Alexandria's eastern harbor that would reduce wave heights at critical locations of the coast; A 180 m extension of the existing west breakwater would narrow the gap between the west and central breakwaters from its existing 300 m width to 100 m. This decrease in gap width would reduce wave heights along the critical area of the Cornish.
- Beach nourishment projects are undertaken in five beaches in Alexandria; Five beaches, El Shatby, Stanley, Sidi Bishr, El Asafra, and El Mandra, were nourished by medium to coarse sand transported from the desert near Cairo.
- The reinforcement of the Abu Quir Seawall that was originally constructed in 1780;
- construction of four breakwaters west of El Gamil;
- construction of two jetties on the western and eastern sides of the El Gamil outlet to protect it from siltation and migration.

**Egypt also has taken several actions to deal with the issue of climate change, including:**

- Ratify the United Nations Convention on Climate Change and the promulgation of Environment Law No. 4 in 1994 and participate in all international conferences and workshops related to climate change to avoid imposing any international obligations on developing countries, including Egypt.
- Ratification of the Kyoto Protocol and the formation of the Clean Development Mechanism (CDM) National Committee in 2005, including the Egyptian Bureau and the Egyptian Council for the Clean Development Mechanism.

- Issuance of the first national reporting report for 1999 on greenhouse gases and the development of the National Action Plan for Climate Change.
- Work on pilot projects to encourage the private sector to invest in clean energy projects, waste treatment, and tree forests.
- Restructuring the National Committee for Climate Change in 2007 to develop a vision of policies, strategies and implementation mechanisms
- Maximize Egypt's access to Kyoto Protocol mechanisms through the implementation of CDM (Clean Development Mechanism) projects, which has achieved significant successes in new and renewable energy sectors, industry, waste treatment, afforestation, energy efficiency improvement. These projects attract foreign investment, create new jobs and contribute to the implementation of the country's sustainable development plans.

### 9.3. Egypt's National Strategy for Adaptation to Climate Change Risks

The Egyptian government concern for climate change 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. Whereas the first level is concerned with adaptation to climate change, the second level is about the mitigation of its severity.

**TABLE 4.** APPROACHES ACHIEVED ON EGYPT COASTAL ZONES, SOURCE: (IDSC, 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	<b>Buildings:</b> Transfer the latest technology in the generation of new and renewable energy				
	<b>Roads:</b> Construct dams to slow down the flow of floods				
	<b>Housing:</b> Renovate old houses in urban and rural areas, which are liable to collapse				
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				

It was initiated by the National Committee for Crisis /Disaster Management and Disaster Risk Reduction affiliated to the Information And Decision Support Centre (IDSC) in Egypt, in order to achieve its primary 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 (The Information and Decision Support Center of the Egyptian cabinet, 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.

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 (4)*

## **10. Conclusion: Towards the resilience of Egyptian north coastal cities: challenges and opportunities**

In the last ten years, the cities which faced eminent risks were more dynamic to work on setting up and initiating strategies comparing to other cities that haven't witnessed any major events

This analysis has focused on Egyptian northern coastal zones which were identified as the most vulnerable zones to climate change impacts. Egypt is one of the first developing countries to assess the vulnerability of coastal areasto climate change

In addition to that, some attempts have been conducted to protect the coastal areas and improve the resilience of these zones. Egypt undertakes these attempts mostly because of current development and environmental priorities however are synergistic with adaptation to climate change.

Nonetheless, attempts are mostly limited to "hard" adaptations, and– related to the significance of the obstacle – are still somewhat unsatisfactory in their coverage of vulnerable regions.

Moreover, while specific vulnerability studies have been carried for cities as Alexandria, Port-Said, and Rosetta, there is further an essential requirement to evaluate the vulnerability of various economic hubs in the Nile delta, as well as lakes and wetlands, coastal agriculture, and coastal archeological sites that are critical to sea level rise.

Partial solutions were successful in the past, but now there is an essential need for comprehensive plans to face climate change risks, what happened in New York on Sandy is proof of that. With the increasing risks and their diverse patterns and impacts in addition to the catastrophic losses that cities suffered from, the new strategies should be more enough.

The concluding resilient city vision is divided into three categories;

- Policies and plans to reduce environmental impacts starting from the reduction of fusel fuel consumption and ending with the life cycle of the city and its urban structure.
- Policies and plans on how to face crises when they take place that starts with monitoring systems, early warning systems and ending with grey infrastructure.

- Recovery plans after crises, and they depend on socio-economic foundations and its strength and the integration with urban and natural systems to achieve the maximum stability and reduce the recovery time.

Concluded from previous case studies, that most resilient city strategies have been developed from the setting of general goals by the community and stakeholders and translated by specialists into a set of objectives that resulted in the actual plans. This approach leads to the involvement of the local community at all stages of decision-making, leading to increase of community awareness of the importance of resilience for future risks and taking the necessary precautions.

The integration of urban resilience plans with regional plans is an important aspect. As proved by the European Union resilience plans. Thus, cooperation among Mediterranean cities in resilience plans increases the chances of success. Especially that the cities located in the North shore of Mediterranean have worked to create resilience policies, and work to develop these plans to achieve effective effects in the time frame 2030: 2050.

Successful mainstreaming also demands more emphasis on "softer" adaptations, which cover the implementation and enforcing of existing laws that diminish coastal vulnerability and the formulation of new legislation that correct misuses and other activities, which might increase coastal vulnerability to sea level rise and climate change. For instance, there is a law which requires Environmental impact assessments before the implementation of coastal projects, but its application has been uneven.

There is also a need to control land use, erosion patterns, and pollution from oil spills and land-based sources. There is also a necessity to reorient economic strategies that support the act of private agents.

Another set of adaptation strategy closely tied to development goals could revolve around promotion of alternate, "win-win" land use practices. Aquaculture or rice agriculture on vulnerable land on the Nile delta could, for example, available harness workforce, help enhance food security, and have useful results on the soil. While, the establishing of greenbelts on coastal hinterland based on the usage of treated wastewater from tourist resorts could support stabilize soil and dune movement and diminish dust influence on the Nile delta, increase carbon sequestration, decrease the influence of saline intrusion, harness rainwater, and afford employment to the local population.

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