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Climate Change in the Coastal Areas: Consequences, Adaptations, and Projections for the Northern Coastal Area, Egypt

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Abstract

Coastal and estuarine ecosystems provide a diverse range of products and services, such as water quality management, carbon storage, food supply, some natural disaster protection, and to name a few. However, these areas are the most vulnerable to climate change. In this study, we look into climate change consequences and the potential regional adaptation methods to them, with an emphasis on coastal risks. We evaluated their efficacy in terms of both the coastal management methods for which they were designed as well as the climate change in the long term. Because the assessment is not reliant on the local environment only, it is applicable to most coastal locations. We undertook a literature analysis to identify measures that may be applied to the coastal area of Damietta. The EMA (Egyptian Meteorological Authority), the Egyptian Environmental Affairs Agency (EEAA), the Climate Change Performance Index (CCPI), and the Intergovernmental Panel on Climate Change's (IPCC) classification of adaptation measures based on institutional characteristics, socioeconomic characteristics, or physical-environmental characteristics are used to categorize these metrics in these two integrated methodologies. Parallel to this, a number of standards were developed to evaluate the measure's present and potential efficacy, regardless of the context. At last, this strategy enabled objective and straightforward comparisons between measurements by assessing the adaptation strategies according to these standards and predictions of the challenges we will face in the future. The study proposed several extension strategies to raise awareness about the expected consequences of climate change.

Keywords: Coastal area; Climatic change; Consequences; Adaptation; Awareness; Risk assessment; COP27.

Introduction

Egyptian coasts stretch over 3000 kilometres along the Mediterranean and Red Seas. The Mediterranean coastline (1200 km) varies from the Red Sea coast due to its geology, geomorphologic, and geographic context. Deltaic deposits, sand dunes, lagoons and lakes, mud flats, salt marshes, and stony beaches make up the Mediterranean Sea's coasts, which are rather lengthy, (**Omran and Negm, 2020).**

The northern coast is a climate change hotspot. In recent years, the climate on the northern coast has changed significantly. The summers have been hotter and drier, while the winters have become colder and wetter. As this region is currently experiencing some of the fastest climate change anywhere on the planet, future climate changes are anticipated to be significant. Since these communities have infrastructure constructed on sandy, muddy soil, have economies based on natural resources, heavily rely on land-based harvesting activities, and are situated on low-lying coasts, they are highly vulnerable to the effects of climate change. Rock and cliffy beaches are more resistant to erosion and sea-level rise than muddy and sandy beaches, which are sensitive to it. **(Guiot *et al*., 2020)**.

Flat coastal regions are much more prone to seawater intrusion than steeply sloping shores. Furthermore, strong waves carry more energy and have a greater impact on beaches than low waves. Egypt's coastal region faces a number of challenges, including coastline erosion, lagoon degradation, excessive resource use, transportation and oil industry pollution, and the anticipated sea level rise, **(Bramante *et al*., 2020)**. Coastal erosion and the degeneration of coastal lagoons have been directly impacted by the hydrologic regime shifts in the Nile Delta brought about by the construction of the High Dam in the 1960s and the prevention of sediments and flood water from reaching the Mediterranean Sea. Sand beaches with fine to very fine sand make up the Nile Delta, which stretches from Alexandria to Port Said. The majority of the population resides there, and it also serves as the nation's breadbasket. The North Coast, a 550 km long calcareous rocky plateau west of Alexandria with limestone hills and rocky headlands of marine origin, borders the Nile Delta on the west. To the east of the Nile Delta, in North Sinai, a 200 km long field of coastal sand dunes is broken up by a tiny lake called El-Bardawil Lagoon. The most populated and developed cities along this coast are Matrouh, Alexandria, Rosetta, Damietta, El-Arish, and Port Said. Sea-level rise was a significant problem in the delta because of its mountainous topography, especially along its 250-kilometer-long shoreline, (**Omran and Negm, 2018)**. 31% of the Nile Delta will reportedly be submerged if sea levels rise by 100 cm above their current level. Millions of people will be displaced southward to the current shoreline, water supplies would be contaminated, and agricultural land will be lost. In the northern half of the Nile Delta, delta subsidence, which is anticipated to be 4.5 mm/yr, will be combined with sea level rise to cause the impact, **(Ibáñez and Caiola, 2021).**

Given the dangers that climate change poses to Egypt's coastline, it is critical to review and study the current level of knowledge about climate change's impacts on ecosystems, communities, and economic sectors, as well as related vulnerabilities and adaptation strategies. In Egypt, adaptation is increasingly seen as a crucial facet of climate policy, encompassing various measures to increase the resilience of people, households, and entire economic sectors to climate change. **(Elliott *et al*., 2019)**.

In this study, the North Coast phase is used to review current knowledge on the effects, adaptation, and vulnerability of climate change, update it with recently published research, and identify and describe important research needs. We begin by providing some background information on the features of Egypt's north shore. The remaining sections summarise key findings on climate change impacts, vulnerability, and adaptability, as well as the research needed in each area in the future. The authors' research needs are based on an examination of current knowledge in the context of recognised knowledge required for identifying and characterising climate change impacts, adaptation, and vulnerability; and provide documented needs identified by decision-makers, communities, and researchers; and the authors' insights and experience as researchers.

Egyptian Northern Coastal Area

Egypt is geographically located in Northeastern Africa between 22° and 32° latitudes as well as 24° and 37° longitudes, with a total area of roughly 1x106 km^2 and a population of 109 million as of March 1, 2023, according to the central office for public mobilisation and statistics. **(CAPMS, 2020).** With an average elevation of 306 meters, the elevation ranges from Qattara Depression, at 133 meters above sea level, to Mount Catherine, in South Sinai, at 2629 meters above sea level. **(Gado, 2022)**. In the north, Egypt's coastlines follow the Mediterranean Sea. Three geomorphologic regions can be found along Egypt's 1200 km of Mediterranean coastline. **(Figure 1)**: The Nile Delta coast, which is 250 kilometers long, the middle region, which includes 550 kilometers of coastal sand of the Western Desert known as the North Coast, and the eastern region, which includes 200 kilometers of North Sinai., **(Hereher, 2016).**

The North Coast runs approximately 550 kilometers from Alexandria to El-Salloum (the Libyan border). Except for a few tiny towns like Matrouh and El-Salloum, and the recently built resort communities, it is deserted. This shore is a stony coastline with sloping vertical cliffs made out of Pleistocene calcareous rocks. The shoreline is mostly low cliffy along the approximately 100 km between Alexandria and El-Alamine. A sizeable portion of the eastern Mediterranean coast is made up of the Nile Delta beach, which is supported by sabkhas, coastal flats, and sand sheets and is composed of flat deltaic sediments, and the North Sinai coast, **(Fouda, 2021)**.

In the northern coastal regions, the temperature ranges from 14 °C in the winter to 30 °C in the summer. In the south, summertime temperatures can range from 7 °C at night to more than 43 °C during the day, particularly in the desert. Although there is less variation in the wintertime temperatures, they can still decrease to 0°C at night and soar to 18°C during the day. **(E MA, 2022)**. In some areas of the country, especially close to the coasts, there may be strong winds; around the Mediterranean coast, annual average wind speeds range from 6.0 to 6.5 m/s. The island's annual rainfall ranges from 200 mm on the northern shore to virtually none in the upper reaches.

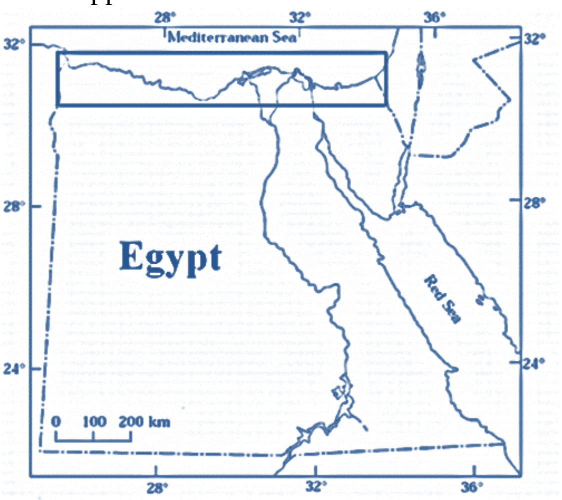

Figure 1. The location of the Northern Egyptian Mediterranean Coastal Area

Climate change impacts on Northern Coastal Area

The main cause of global warming is the excessive increase in greenhouse gases (GHGs) brought on by human activity such as the burning of coal and oil. Rising temperatures influence wind speed, water vapour percent, precipitation, humidity, snowfall, soil moisture, evapotranspiration rates, cloud features, and snowmelt regimes. These changes have an impact on the rate of groundwater recharge, the frequency and intensity of droughts and floods, and sea level rise. As a consequence, both environmental and human systems are negatively impacted by climate change, **(Letcher, 2022).**

The sea-level rise

According to the Intergovernmental Panel on Climate Change (IPCC), the heat capacity of ocean waters carried on by melting glaciers as a consequence of increasing emissions of greenhouse gases is the main cause of rise in sea levels (IPCC 1990). The 20th century saw an average global sea level rise of 1-2.5 mm/year, with 1.8 mm/year between 1950 and 2000. Between 1993 and 2000, data from oceanography satellites (Topex/ Poseid) indicated a mean worldwide sea level rise of 2.5 0.2 mm/year. Global sea level rise averaged 1.8 millimeters per year between 1961 and 2003, with a higher rate of 3.1 millimeters per year between 1993 and 2003, according to IPCC (2007). The Mediterranean Sea level rise during the 20th century was continuous with the global sea level rise of 0.5-2.5 mm/year. However, this pattern does not last during the duration, and it alternates between two orientations. While it is in accordance with the overall pattern from 1961 to the end of the 20th century, it exhibits higher values than the global pattern from the end of the 19th century to 1960. Sea level rise is the main manifestation of climate change that poses a threat to the northern Nile Delta region, **(Abutaleb, *et al*., 2018).**

Many studies have documented sea-level increase along Egypt's Mediterranean coast, varying between 1.8 mm per year in Alexandria and 2.8 mm in Port Said. In **El-Nahry and Doluschitz (2010)** study, there were representations of rising sea levels in 2100 in three possibilities. (1, 1.5 and 2 meter). Figure 2 shows how an additional 6.39 to 50.78 percent of the Nile Delta's total area would be added to the areas that would be flooded.

In the **(Hereher, 2015)** study, the CVI was calculated by giving the area between the El-Salloum and Port Said, where sea level rise is 1.8 mm/yr, a value of 2.0 in the CVI equation. On the other hand, a large portion of the coast east of Port Said is going to experience a 2.8 mm/yr increase in sea level. He also confirmed, The Nile Delta would be severely harmed by even a one-meter increase in the Mediterranean Sea. The already deteriorated offshore sand dune belt would be completely destroyed by rising sea levels.

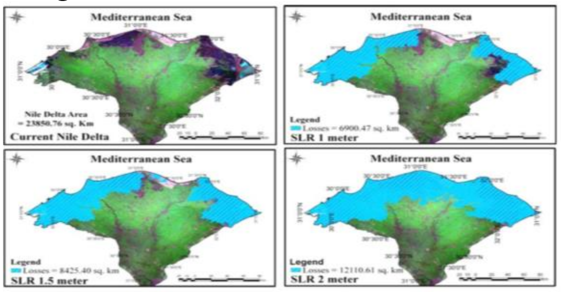

Figure 2: Sea level rise senarios by the year 2100, (El-Nahry and Doluschitz, 2010)

Sharaan and Udo (2020) predicted future shoreline decline along Egypt's Mediterranean coast as a result of rising sea levels. The Mediterranean shoreline was expected to experience coastal retreats ranging from 12.6 to 29.0 metres (m), 11.3 kilometres (km2), and rates (percent) for the lowest rise in sea levels scenario (RCP2.6), and from 1.3 to 41.9 metres (m), 19.2 kilometres (km2), and 36.3 percent for the highest rise in sea levels scenario (RCP2.6). Local land subsidence in combination with rise in sea level scenarios suggested an increase in shoreline retreat along the Nile Delta region in response to spatial variation of local subsidence, as well as changing the layout of heavily retreating areas that was based solely on RCP rising sea levels.

The shoreline retreat was projected to be from 34.1 to 61.3 meters for the lowest rise in sea level scenario (RCP2.6) and up to 81.2 meters for the highest rise in sea level scenario after local ground subsidence was taken into consideration (RCP8.5). In the Nile Delta region, the similar expected beach decline ranged between 8.4 and 13.3 km2 and 14.2 to 19.0 km2. The annual coastal retract was predicted to be 0.36 to 0.65 m/yr for RCP2.6, 0.39 to 0.71 m/yr for RCP4.5 and RCP6.0, and 0.48 to 0.85 m/yr for RCP8.5 when landfall was taken into consideration.

Abou Samra *et al* (2021) also reported, according to the findings, if sea levels rise one metre, the submerged region will cover roughly 254 km2 of governorate territory, or 16% of the entire area. In a 2-m SLR scenario, the submerged area would grow to 661 km2, accounting for 64% of Damietta's land area. Damietta Governorate will be flooded, with 37.4 to 76 percent of Damietta's people being forced to from their houses and economic damages ranging from $84 to $288.5 million in the residential sector.

Even minor increases in sea-level rise might have a major impact on the Egyptian coastal zone, causing the nearshore area's erosion activity to increase due to an increase in wave energy (strength and frequency in sharp occurrences), Flooding of marshes and other low-lying terrain, as well as eroding coastlines, an increase in the chance of floods, increasing the salinity of the Nile River, its groundwater tables and bays; accelerating coastal retract; cliff and dune erosion; inlet instability; breaking of coastal barriers; and salty water intrusion into coastal freshwater aquifers, **(Nazarnia, 2020)**

Erosion and accretion pattern

Previous studies on shoreline changes in the central Nile Delta between 1971 and 1992 reported that the west jetty's structure on the Burullus lagoon intrance caused the greatest accumulation along the western barrier to be 4.9 metres per year, while the maximum erosion was 5.5 metres per year about 3 kilometres east of the Burullus intrance and predominated along the unprotected sector of the eastern barrier. On the western shore of the Nile Delta, the Rosetta clifftop has been significantly degraded, **(Sheeja and Vishnu (2015); Hzami *et al*., (2021)).**

El-Nahry and Doluschitz (2010) investigated erosion and accretion along Northern Coastal Area**.** They used multi-date satellite TM and ETM+ images (1980 and 2003) covering multiple the coastal area of the Nile Delta to monitor erosion and accretion. The coastal zone's delta promontories are the areas that have been affected the most. Figure (3) shows the soil loss of 3.93 and 6.04 km2 on the two promontories of the Nile Delta (Rosetta and

Damietta apexes).

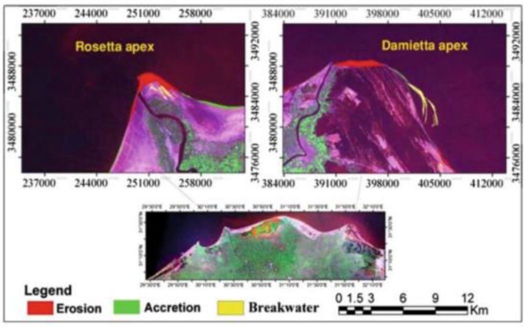

Figure 3: Erosion and accretion along the northern coast **(El-Nahry and Doluschitz 2010)**

likewise, **Hereher (2015),** studied the Mediterranean coast of Egypt's coastal erosion pattern. He reported, because of the rocky nature of some area of shore, the bulk of it has stable coastlines. This can be seen from Alexandria to El-Salloum (the Libyan border) all the way up to the North Coast. Another 40-kilometer stretch of steady beachfront runs from El-Arish to Sinai (Rafah), in which satellite images show no changes to the position of the coastal line. Low-erosion shores could be found for 100 kilometres in the North Sinai, from the western edges of El-Bardawil Lagoon to the west of El-Arish. Moreover, a small piece of land (25 kilometres) east of Alexandria falls under this group. Moderate-erosion shores were found at four different areas along the coast, totaling around 190 kilometres. The terminal portions of the Nile River branches (Rosetta, Damietta, and the now-defunct Sebenetic branch together across Lake Burullus) and the downdrift sides of the major coastal structural engineering, such like harbours, were found to be the five spots that were the most hazardous and defenceless to coastal erosion. According to satellite observations, the 180 km of these severely degraded beaches experience erosion at a rate of more than 2 m per year. In satellite pictures, the headland of Damietta promontory has visibly migrated southward.

On the other hand, **Sharaan and Udo (2020)** investigate future beach loss projections along Egypt's Mediterranean coast. The predicted coastal retreats and associated average beach loss for the years 2081-2100 for the ensemble-mean SLR RCP2.6 and RCP8.5 ranged from 12.6 metres and 11.3 kilometres to 41.9 metres and 19.2 kilometres, respectively. Along the Alexandria shoreline to the Port Said beaches, very sensitive areas to shoreline recession for SLR and local ground subsidence were discovered (the Abo Qir bay, the Damietta Rosetta to promontories, and so on). As a result, coastline retreat and accompanying beach consequently, loss climate change and rising sea levels make this a critical issue that Egypt's integrated coastal zone management policies should address and strategic environmental monitoring programmes, combined with long-term considerations, are required, **(Gallina *et al*., (2019); El-Zeiny *et al*., 2022)).**

Temperature

The mean rise in the global temperature over the early 20th century was roughly 1.0 °C, then by 2100, it is predicted to vary between 1.3 to 5.1 °C. This is according to the most recent comprehensive emission projections.

Goda (2021) investigates the expected changes in temperature for Egypt in the latter half of the 21st century (2071-2100) for three sample concentration scenarios (RCP8.5, RCP4.5, and RCP2.6) by adjusting the forecasts of the mean, highest, and lowest daily temperatures made by regional climate models (RCMs). All temperature indexes for all stations will increase significantly under all possible scenarios, peaking at the end of the 21st century when the predicted increases in mean, highest, and lowest temperatures are between 4.08 and 7.41 degrees Celsius, 4.5 to 7.89 degrees Celsius, and 3.88 to 7.23 degrees Celsius, respectively. In comparison to 1850–1900, the IPCC's 6th evaluation report expected that Egypt's average temperature would rise by 1-6 degrees Celsius between 2081 and 2100, **(IPCC 2021).**

As a result, Egypt's average temperature would rise significantly quicker than the world average, with disastrous effects for natural resources and hydrological systems. Furthermore, the maximum temperature is growing at a faster rate than the lowest, suggesting that Egypt's daily temperature range (DTR) will continue to increase in the future., (Fig 4) However, he reported that Egypt's northern region is the least affected **(Goda, 2021).**

Limiting all future GHG pollution to the same amount as seven years' worth of emissions at current rates would be necessary to maintain a two-thirds chance of staying below 1.5 °C. It is impossible to accomplish that short of a global catastrophe that stops the majority of societal activities that produce GHGs. According to the UN Environment Programme, there is "no credible pathway to 1.5C in place" at the moment. Warming is likely to be in the range of 2.5 C even if all current national pledges to reduce emissions are implemented, which history strongly suggests will not happen. **(UNEP, (2022); UNFCCC, (2022)).**

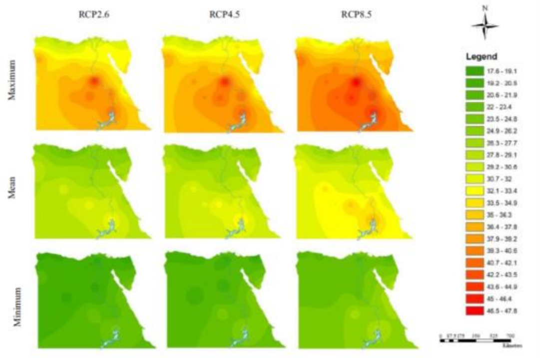

Figure 4: Spatial distribution of the projected average of temperature (ºC) by 2071-2100 (Gado, 2021)

Precipitations

Temperature variations impact rainfall, and forecasts indicate that climate change will manifest itself as swings in precipitation amounts, resulting in temperature shifts. As a result, the Nile flow will experience mild to dramatic oscillations, In the long run, the latter scenario is more probable. Second, due to climate change, the Nile Delta is particularly susceptible to the effects of storm surges and SLR, Especially in the relatively low altitude delta regions, **(Abutaleb, *et al*., 2018).**

On the other hand, **Nashwan and Shahid, (2022)** invistigated in their study, CMIP6 multimodel ensemble simulation of future precipitation variations in Egypt under 2 and 1.5 degrees Celsius global warming goals. Two shared socioeconomic pathways (SSP) scenarios, SSP1-2.6 and SSP1-1.9, which represent 1.5 and 2.0 degrees Celsius of warming at the end of the 21st century, respectively, were used to project Egypt's precipitation and precipitation extremes at the end of the century (2081-2100). The results revealed that SSP1–2.6 and SSP1–1.9 precipitation increased by 54% and 37%, respectively, in the northern high precipitation zone.

Precipitation limits predict an increase in the amount of extreme precipitation ranging from 0% to 14% over the northern coast. The findings imply a significant rise in Egypt's sensitivity to hydrological hazards, even if global warming is confined to 2 degrees celsius through the end of the 21st century due to the Paris Agreement, **(Harris, 2023)**. Even if global warming is capped at 2.0 degrees Celsius, all of the earlier studies, Egypt may see increasing geographical precipitation variability. Extreme precipitation and protracted dry periods are anticipated to rise, thus increasing the risk of floods, droughts, and other hydrological hazards. As a result, flood protection measures must be planned, particularly over Sinai. **(Cramer *et al*., (2018); Li *et al*., (2019)).**

Impact on anthropogenic activities

Infrastructure

Because of the many soil types and sea dynamics along the northern shore, transportation infrastructure and networks are especially vulnerable to the effects of climate change. While extending the open-water season has advantages for maritime traffic or tourism, the drawbacks are mainly unfavourable, **(Ford *et al*., 2018)**. While many ports around the coast are projected to gain, significant dangers are associated with the port's single-track rail line, that is being weakened by severe precipitation events causing landslides, track washouts, flooding, as well as the melting of the discontinuous permafrost. In addition to the decline in the value of land and dwellings, Threats to key infrastructure (such as important harbours, coastal highways, trains, hospitals, and schools), tourism as well as important coastal industries and services like petrochemicals and oil production are in danger. Allocating funds for sea-level rise adaptation measures and raising protection costs, which could be prohibitively expensive for underdeveloped nations like Egypt unless considerable help is received, **(Siegel, (2019); Hayes, (2020)).**

Livelihoods and human health

Climate change has both direct and indirect health consequences for communities along the north coast. Key concerns have been highlighted, including water security, mental well-being, food security, and danger when participating in terrestrial pursuits, as well as the possibility for new and developing diseases (such as waterborne and food infections).

The implications of climate change on the health of the Northern Coastal Area are anticipated to be increased by underlying socioeconomic factors (food insecurity, high rates of poverty and housing), linked health-seeking behaviours, and healthcare system challenges, **(Lebel *et al*., 2022).**

Changes in temperature and rainfall patterns caused by climate change are damaging soils' physical structure. Particularly, organic matter is being damaged, and the nutritional balance of the soil depends on keeping it in balance, stability, water holding capacity, and population of soil organisms, **(Kulkarni, 2021).**

Due to climate change (reduced rainfall and increased evapotranspiration), fresh water supply is expected to decrease significantly (by 2–15% for 2 °C of warming), one of the largest declines in the world, with a significant increase in the length of climatic dry periods and droughts. In general, the flow of rivers will be reduced, particularly in the east and south where there is a shortage of water. The median runoff decline almost doubles at 2 °C, going from 9% with a probable range: of 4.5 to 15.5% at 1.5 °C to 17% at 2 °C. Water levels in lakes and reservoirs are likely to decrease., **(Cramer *et al*., 2018)**

Threats to the ability to produce food include declining coastal crop yields, deteriorating the quality of irrigation water, and the destruction or extinction of crucial ecosystems like coastal lagoons and coral reefs, which are responsible for one-third of Egypt's fish catches and serve as fish and shellfish nurseries all over the world. The decline in drinking water quality, threats to housing quality, increased health risks associated with resettlement, and disease barriers are all factors contributing to a decline in health and living standards, **(Corwin, 2021).**

Climate change adaptation

" The method of adapting towards the current or predicted climate as well as its effects in order to minimize or prevent harm or take advantage of favourable circumstances" is how climate change adaptation is defined. Adaptation refers to a set of techniques, activities, and behaviours which make families, societies, and communities more climate change resistant. It can be used to lessen vulnerability to the effects of climate change or to increase adaptability to manage and benefit from alteration. Personal and household actions, as well as community/local, national, and worldwide policy, all have adaptation possibilities, **(Janssens *et al*., 2020).**

As a result, a summary of some of the current international initiatives is appropriate. There are several comprehensive standards for planning, as well as awareness needs for adaption. Among these are **Shaw et al. (2007)** practical perspective for climate change, the International Council for Local Environmental Initiatives, which focuses specifically on coastal adaptations to climate change, and the UN Framework Convention on Climate Change **(UNFCCC 1999)** outline. In 2005 and 2008, the United Nations Framework Convention on Climate Change (UNFCCC) changed its recommendations for adaptation strategies.

Egypt's government is already taking steps to adapt, and there are numerous examples of leadership and adaptation in diverse sectors, dimensions, and areas. Local leadership and creativity, especially in the context of sustenance activities, are also the foundation for individual and family autonomous adaptations, and it has been shown that traditional knowledge systems and strong social networks confer significant adaptive potential., **(Mousa *et al*., 2019).**

A "national strategy study" on adaptation measures and tools was published by Egypt's Ministry of Environmental Affairs in 1997. It was presented as a ranking with a value ranging from zero to ten to indicate the most vulnerable areas, with 10 being the most resilient. **(Arab Republic of Egypt 1999)**. Egypt's essential adaptation strategies and activities for climate effects and vulnerabilities were addressed at first in the 1999 Initial National Communication, and then updated in the 2010 Second National Communication. The research conducted between 1995 and 1999 on the vulnerability of agricultural and water resources, adaptation to sea level rise, and assessment of the technologies used in the action plans served as the foundation for the Initial National Communication's content. 2010 saw the preparation of a Second National Communication to the United Nations Framework Convention on Climate Change that highlighted sectors that are vulnerable to change of climate. It also suggested cross-cutting policies and activities which may help with adaption efforts. This led to the publication of Egypt's National Environmental, Economic, and Development Study (NEEDS) for Climate Change, which covered adaptation and mitigation strategies, policies, and tactics as well as the associated socio-economic costs of such efforts. NEEDS has identified specific adaptation objectives, concentrating on agriculture and the management of coastal zone in particular. The national council for integrated coastal zone management was created to address the potential effects on coastal regions. Water quality, coastal alterations, and urbanisation were identified as three main issues for the Nile Delta. Also being developed is a national integrated coastal zone management strategy, which includes: (1) increasing adaptability by establishing institutional monitoring systems, creating a database, and awareness raising; (2) applying regulations for follow-up and adopting a "no regrets" stance while planning; (3) conducting the desalination process, halophytic plants, and research on sources of renewable energy; and (4) considering geo-engineering. Public awareness is also important. On both local and regional dimensions, the utilization of circulation models to foresee the effects of climate change on water supplies (i.e., within Egypt and the Nile Basin), building the skills of researchers across all fields studying climate change facilitating data and information exchange between nations in the Nile Basin; and The setup of advanced systems for early warning and upgrades to Egypt's and upstream countries' precipitation measurement networks are two things that support adaptation efforts, **(Abutaleb, *et al*., (2018); Dabaieh *et al*., (2021).**

Assessment and suggested protection measures

The IPCC recognised emerging hazards from the interplay of cross-sector effects, and the global repercussions of mitigation and adaptation activities. The direct effects of climate change on agriculture, water supplies, and fisheries are amplified by the impacts of the loss of biodiversity on ecosystem services (pollinators, nutrient cycling, water purification).

Direct human activity, such as inadequate management of marine resources land, and water, exacerbates a number of problems. Climate change exacerbates health effects, which are primarily brought on by vulnerability and exposure. Urban and low-lying coastal areas are more vulnerable than other populated areas due to the immediate effects of sea level rise as well as the potential for significant infrastructural and socioeconomic losses. Climate vulnerability is exacerbated by social and political instability, particularly among disadvantaged populations and in nations where the political and social framework places significant constraints on actions taken to mitigate the local effects of climate change and adapt to it. worldwide teleconnections could also have a major effect on the area's economy and climate (because of the instability of Antarctic glaciers, which causes sea levels to rise), **(Mohammed and Al-Amin, 2018).**

Natural infrastructure and hybrid approaches to coastal management give opportunity for risk reduction and collaboration around common socioeconomic and ecological goals. Climate resilience research has increased quickly in recent years, and it is increasingly being addressed in coastal protection, restoration, and management methods, **(Powell *et al*., 2019).**

Despite the fact that several programmes have focused on Egypt's policy for adaptation, unfilled gaps still exist. These shortcomings relate to the application of various techniques, time constraints, and who is in charge of funding and implementation. These flaws include the lack of a clear implementation plan for the adaptation plan identified for health, an integrated multi-sector plan, a specific methodology for the plans' implementation, and a performance management component, despite the risk being scientifically identified in the National Strategy for Adaptation to Climate Change and Disaster Risk Reduction created in 2011and COP27 2022, **(Banwell *et al*., (2018): UNEP, (2022)).**

Conclusion and Recommendations

Egypt's research landscape is quickly changing. Concerns that are currently at the top of the political agenda on the north coast include addressing social and economic issues that many communities face, sustainable development, and combating climate change. Many of these concerns require research to be addressed. The northern coast is experiencing significant climate change, with hotter summers and drier winters. This region is experiencing some of the fastest climate change globally, with summer temperatures ranging from 14°C to 30°C. Winter temperatures can drop to 0°C at night and soar to 18°C during the day. Egypt's Mediterranean coast has stable coastlines from Alexandria to El-Salloum, with low-erosion shores in the North Sinai and moderate-erosion shores in four areas. The terminal portions of the Nile River branches and downdrift sides of coastal structural engineering are the most hazardous and defenseless to coastal erosion. Climate change is expected to significantly impact the health of the Northern Coastal Area, with socioeconomic factors like food insecurity, poverty, and housing affecting health. Changes in temperature and rainfall patterns are damaging soil structure, affecting its nutritional balance and stability. Fresh water supply is expected to decrease significantly, leading to longer dry periods and droughts. River flow will be reduced, and runoff declines are expected to double at 2°C.

However, previous (and present) research methodologies have not always met the requirements of northerners, typically reflecting the scientific community's priorities and worldviews. A new method is needed that respects the value of curiosity-driven or foundational science while also recognising the limitations of current approaches. Even though several programs have focused on Egypt's adaptation policy, there are still unfilled gaps. It is critical to apply various techniques, overcome time constraints in space-borne technology, and develop a clear implementation plan for the identified health adapting plan, an integrated multi-sector plan, a specific methodology for plan implementation, and a performance management component.

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الملخص العربي

عنوان البحث: تغير المناخ في المناطق الساحلية: التداعيات والتكيفات والتوقعات المستقبلية للمنطقة الساحلية الشمالية، مصر

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توفر النظم البيئية الساحلية ومصبات الأنهار مجموعة واسعة من المنتجات والخدمات، بما في ذلك إنتاج الغذاء، وإدارة جودة المياه، والحماية من العواصف، وتخزين الكربون، على سبيل المثال لا الحصر. ومع ذلك، فإن هذه المناطق هي الأكثر تضررا من تغير المناخ. في هذه الدراسة، نتحرى عواقب تغير المناخ وطرق التكيف الإقليمية المحتملة معها، مع التركيز على المخاطر الساحلية. قمنا بتقييم فعاليتها من حيث تغير المناخ على المدى الطويل وطرق الإدارة الساحلية التي تم إنشاؤها من أجلها. نظرًا لأن التقييم لا يعتمد على البيئة المحلية فقط، فإنه ينطبق على معظم المواقع الساحلية. قمنا بإجراء تحليل أدبي لتحديد الإجراءات التي يمكن تطبيقها على المنطقة الساحلية بدمياط. تصنف هاتان المنهجيتان المتكاملتان هذه المقاييس بناء على تقارير ممارسات الإدارة الإقليمية الهيئة الحكومية الدولية المعنية بتغير المناخ؛ الهيئة المصرية للأرصاد الجوية (EMA) وجهاز شؤون البيئة المصري (EEAA)، مؤشر أداء تغير المناخ (CCPI)، وتصنيف (IPCC) لتدابير التكيف القائمة على الخصائص الفيزيائية - البيئية أو الاجتماعية - الاقتصادية أو المؤسسية. بالتوازي مع ذلك، تم وضع عدة معايير لتقييم الكفاءة الحالية والمستقبلية للإجراءات المتبعة، بغض النظر عن الوضع المحلي. أخيرًا، سمحت هذه الاستراتيجية بإجراء مقارنات موضوعية وبسيطة بين القياسات من خلال تقديم تقييم لمقاييس التكيف باستخدام هذه المعايير وتقديم توقعات لما سنوجهه في المستقبل. اقترحت الدراسة أيضا بعض الاستراتيجيات الإرشادية لتحسين الوعي بالآثار المتوقعة لتغير المناخ.