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THE MOST EFFICIENT COASTAL PROTECTION AND DEVELOPMENT METHODS THROUGH A COMPARATIVE STUDY BETWEEN THE COAST OF HOLLAND AND LOWER MANHATTAN

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ABSTRACT

Coastal zones are increasingly dynamic areas where terrestrial and marine processes interact. Over the past 100 years, coastline changes are one of the global problems in both natural ecosystems and urban communities. In all cultures, Waterfront is a fundamental attraction. Each city must have an identity that can be used as a main development attraction. In recent decades, Alexandria, like many third-world cities, suffers from many aspects of environmental and urban decline due to rapid, unplanned, and uncontrolled urban expansion which usually creates a bad environment affecting all parts of the city. In the face of climate change and urban growth, the influence of shoreline alterations on city waterfronts is a critical issue. Based on comparisons of analytical examples of coastline changes and the protection, development methods used to meet future urban requirements and raise the level of the current urban elements. They were selected upon criteria responding to the aim of the study, which is relied on the impact of coastal changes due to environmental threats and urban challenges as same as Alexandria City. Finally, this paper intends to identify the key reasons for coastline changes, establish a guideline and recommend a practical approach for coastal conservation and development.

KEYWORDS: Coastline, Coastal Zones, Climate Change, Environment Threats, Urban Challenges, Coastal Protection.

1. INTRODUCTION

Environmental concerns and urban difficulties provide a direct and indirect threat to millions of people living in low and middle-income countries. Unexpectedly, it could contribute to forced migration, war, poverty, and the destruction of infrastructure all around the planet. People have long been drawn to coastal cities because of their abundance of resources. Today, because of the cities' increased susceptibility to frequent and severe windstorms, floods, and sea level rise (SLR), this geographical

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region is no longer advantageous. According to the World Bank (2010), 360 million people reside in coastal regions that are fewer than 10 meters above sea level, making them extremely susceptible to extreme events that endanger their lives[1].

2. PROBLEM STATEMENT

The coastal cities and specialy Alexandria, suffer from many aspects of environmental threats (Coastline change, sea level rise and coastal erosion) and urban decline due to rapid, unplanned, and uncontrolled urban expansion which usually creates a bad environment affecting all parts of the city. The Problem of the Research and its Rebill Effect:

2.1 Environmental Threats

- Climate Changes are of the major global problem (weather of natural causes or manmade), it affects the Coastline changes resulting due to two main factors (natural and human activities) that affect the cities' waterfront respectively.
- Increasing sea levels because of climate change, resulting in the progressive submergence of most coastal cities.

2.2 Urban Challenges

The rapid urban growth on the coastline due to population growth, which leads to the lack of green, tourist and recreational areas.

3. METHODOLOGIES

The research technique is divided into three parts: descriptive, comparative, and analytical. This paper's study technique aimed to identify Coastal Areas, its components and the major changes and their impacts and then comparisons of analytical examples of coastline changes and the protection, development methods used to meet future urban requirements and raise the level of the current urban elements. They were selected upon criteria responding to the aim of the study, which is relied on the impact of coastal changes due to environmental threats (sea level rise and coastal erosion), urban challenges (rapid uncplanned urban expansion), climate condition and coast type (low-lying coast) as same as Alexandria City. Finally, it suggests an Effective method of coastal protection viable in urban development to be applied to Alexandria Coastal City.

4. THEORETICAL APPROACH

4.1 Coastal Areas

4.1.1 Coasts and coastline: The keywords coast and coastline refer to the vast boundary between the terrain and the water. The coast is a thin strip of land that extends inland from the sea to a regional break in topographical features. The coastline is the boundary dividing the terrain from the water. The term coastline refers to the boundaries between the ocean and land that range from regional to global in scope. Changes in boundary forms and positions are used to define continents, oceans, and their margins at global scales. Coastlines are used to characterize the forms and orientations of estuaries, bays, deltas, barriers, and islands at small regional sizes. It can be directly depicted on global or regional-sized maps, but the spans of lines created at these scales are too broad to identify the actual physical location of the sheared border between land and sea[2].

4.1.2 Coastal area: The land that connects the land with the ocean, this area is where land uses are established and affect the ocean area and vice versa, and therefore it is not specified in length, depth,

and width[3], the coast is the meeting between the sea and the land, and divided the coastal areas into five consecutive parts as shown in fig.1. and divided into two boundaries, as shown in fig.2

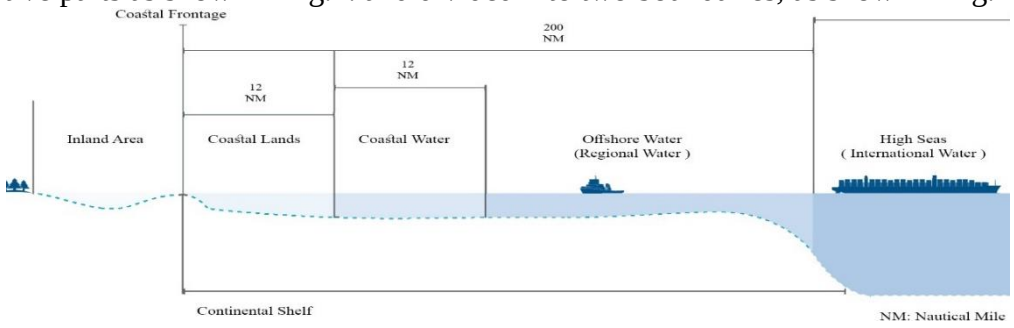

Fig. 1. The Zones of Coastal Areas (Source: [4-6],Researcher)

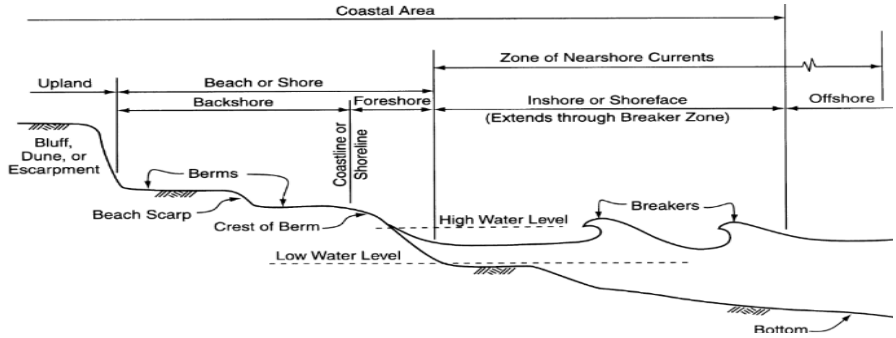

Fig. 2. The Boundaries of Coastal Areas (Source: [7])

4.2 Environmental Threats

4.2.1 Coastline changes: (Associated with tidal cycles, meteorological events, earthquakes, or tsunamis) evolve depending on short-term processes that are constantly happening, as well as long-term processes that take millions of years[8]. The reasons for coastline changes may be divided into two categories: natural processes such as waves, soil erosion, and accretion, and human actions such as land reclamation for development[9].

4.2.2 Sea level rise: (SLR) is an ongoing coastal flooding caused by the impact of climate change on the rising global mean sea level. Ocean thermal expansion, ice sheet and glacier melting, and changes in terrestrial waterways are the main causes of SLR. One of the most important and expensive repercussions of global warming is SLR. flooding, faster erosion, saltwater intrusion, and land subsidence are some of the possible negative effects of SLR [10], as shown in fig.3.

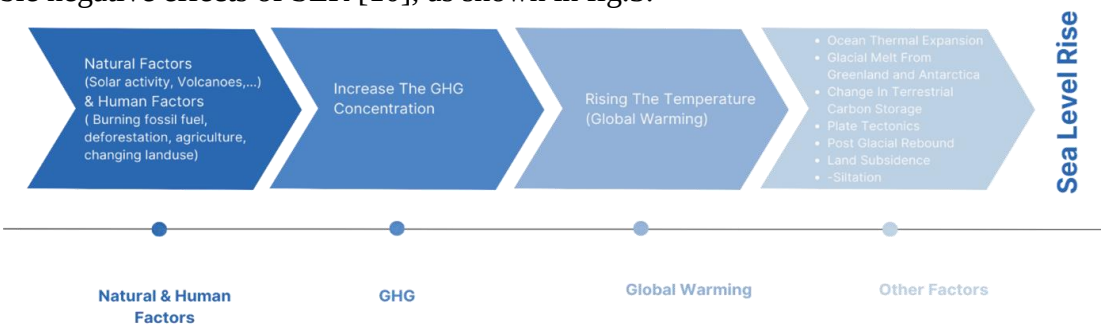

Fig. 3. The Causes of Sea Level Rise (Source: Researcher)

4.2.3 Coastal erosion: Natural forces and, to a minor extent, long-term human activity destroys coastal regions swiftly. A consistent decline in area size may be impacted by a consistent rise in sea level as well

as the existence of sub-delta plains[11]. Main causes are due to fewer human actions over a long duration and/or coastal hydrodynamics[12], as shown in fig.4.

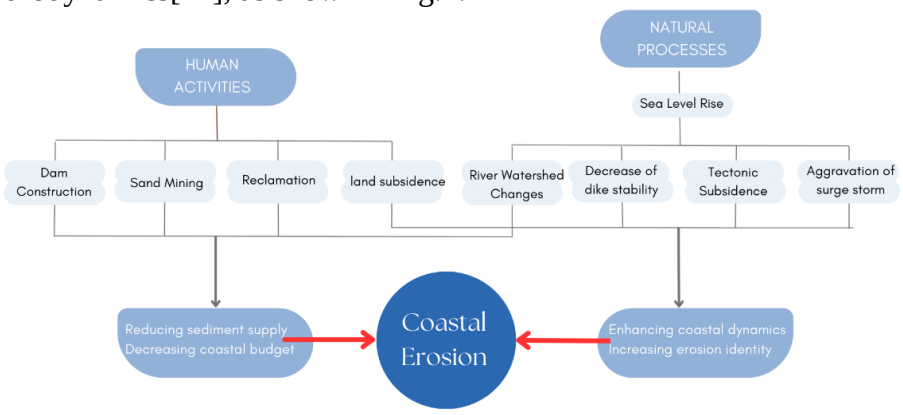

Fig. 4. The Main Causes of Coastal Erosion (Source: Researcher)

4.3 Urban Challenges

4.3.1 Urban sprawl: Sprawl is considered an unsustainable kind of urban growth. The Oxford Advanced Learners Dictionary (2005) defines sprawl as "a big region filled with buildings that expand from the city towards the countryside in an unsightly manner." It is an unattractive kind of development because of the negative externalities that it entails[13]. Population migration to coastal areas is associated with the growth of tourism, recreation, housing, and industry. While the ground is rapidly eroding, the population in the area is growing steadily. As a result, a sizable portion of the country's Coastal vulnerable zones with high concentrations of population and housing stock[11].

4.3.2 Human activities: There are many different human pressures on coastal areas lead to the exploitation of marine resources, including industrial, urban and residential development, tourism and recreational activities, transportation, fisheries/aquaculture and agriculture The magnitude of each pressure and the impact of these activities on coastal areas and communities will depend on the nature of the activity and local conditions[14, 15].

4.4 Coastal Protection Methods

4.4.1 Hard defenses: Hard-engineered Buildings are designed to slow or stop the coastal retreat, sea level rise, and erosion. Local scales are where they succeed. Hard-engineered structures, on the other hand, prevent sand from moving towards the coast. Another issue is that stiff structures, which can be costly to create and support, might prevent people from using beaches for recreational purposes. It is necessary to weigh these expenses and advantages. Many kinds of hard structures exist such as (seawalls, revetments, bulkhead, dikes, levees, groins, breakwaters and jetties) [12].

4.4.2 Soft defenses: Growing knowledge of the advantages of soft defenses such as (beach fills, dredging or sand bypassing and sand dunes stabilization) and the adaptation techniques of accommodate and retreat have resulted from increased awareness of the detrimental impacts of hard constructions on erosion and sedimentation patterns[12].

4.4.3 Combined protection methods: Such as (Submerged breakwaters, perched beaches, artificial headlands, and islands. Recent inventions have taken use of developments in particular fields of engineering related to erosion prevention[12].

4.4.4 Innovative methods: Recent inventions have taken use of developments in particular fields of engineering related to erosion prevention.

These are a few of these methods (geotextile structures, beach drainage systems, ecological engineering, and biotechnical concepts)[12].

5. CASE STUDIES TOWARDS ACHIEVING THE MOST EFFICIENT COASTAL PROTECTION METHODS

It outlines guidelines for coastal protection and development based on comparisons of analytical examples of coastline changes and to protect them from the major changes to meet future urban requirements and raise the level of the current urban elements. The selection has been divided according to the characteristics of coastal cities and the major changes and their impacts. The examples were selected upon criteria responding to the aim of the study, which is relied on the coastal city function, role, type of coast, also the impact of coastal changes due to environmental threats and urban challenges as same as Alexandria city, Egypt. Finally, the method of protection used to be applied to alexandria city.

5.1 Holland Coast, Netherlands, Europe

5.1.1 Review: The Netherlands is located between Germany in the northeast and Belgium in the southwest, which is in Europe's north-west. The Netherlands has a coastline that stretches for more than 400 km along the North Sea's southeast coast. for nearly 120 km without any tidal flats, estuaries, or islands and it displays a slightly concave shape as the sand moves towards the shore. During low tide, the beach expands from 100 to 200m. The Delta Coast located in the south, the Holland Coast located in the middle, and the Wadden Sea region located in the north make up the three distinct sections of the Dutch coastline[16]. The majority of the country is located less than 1m above mean sea level, and 30% of it is below sea level[17, 18]. The coast of the Netherlands is a low-lying sandy region. The coast of Holland is composed of sand and barred beaches, approximately 290 km, while around 60 km of the coast is safeguarded by man-made structures has been divided into three sections and is categorized as a wave-dominated coast based on morphological variations[17],such as: The Delta coast: on The Netherlands' south-western coast, consists of a series of former islands that are divided by an estuary, inlets, and tidal basins. Most of the four tidal basins were blocked or partially closed after the great flood tragedy of 1953 due to extensive building activity. The Holland coast: a continuous stretch of shoreline with coastal cities in the middle of The Netherlands. The Wadden coast: a barrier island coastline on the landward side that alternate with tidal inlets and the associated ebb-tidal deltas in the Netherlands north.

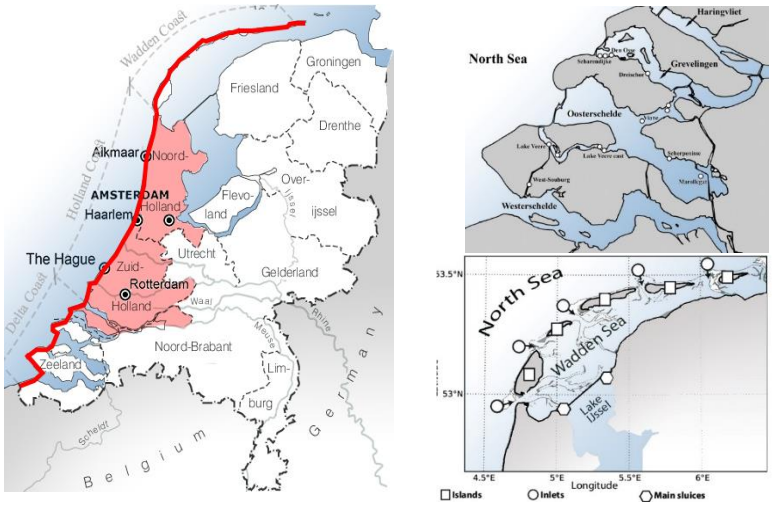

Fig. 5. (a) Map of the Netherlands, (b) Map of The Delta Coast, (c) Map of Wadden Coast (Source: [19-21], Researcher), Researcher)

The function and role of the Netherlands coast are[22]:

Agriculture and horticulture: The primary agricultural are bulbs and indoor farming. The Netherlands remains a major exporter of agricultural products.

Fisheries and aquaculture: The North Sea is the primary region for offshore fishing, which is more productive and has a stronger export position than the EU.

Industry: The Dutch industrial sector is both varied and highly technological. The Netherlands is the headquarters for almost all industries. Two industries predominate in terms of production: food and chemicals.

Transport: The biggest port in the world, every year. The fourth-largest airport in Europe for both cargo and passengers is Schiphol Airport.

Energy: Europe relies on it for energy, and it plays a vital role in the transfer of petroleum products. It is renowned as a pioneer in promoting sustainable energy practices.

Tourism and Leisure: One of the most popular tourist sites in the Netherlands.

5.1.2 Environmental threats

A. Impact of the Sea Level Rise: The coastline of the Netherlands is increasingly threatened by the possibility of sea level rise brought on by climate change[23]. The Intergovernmental Panel on Climate Change (IPCC) assessments are the foundation of the third coastal policy document's selection of three scenarios that are linked to the projected rise in relative sea level:

- "Low" Scenario: 20cm/Century. This decision-making for projects requiring flexible solutions, like sand replenishment, but with limited funding and a short design period (5 yr.).
- "Medium" scenario: 60 cm/Century. The decision-making process for projects with longer design durations (50–100 yr.), such as the dam contractions and barriers of the storm surge, which demand substantial investments and limited flexibility.
- "High" scenario: Wind speed increases between 10% and 85 cm/strength. This situation is utilized to set aside land for flood defense[18].

B. Impact of Erosion: The sand loss has averaged 1 million m3 per year over the past 30 years. On most of the northern coast, erosion occurs in deep water and coastal areas. In southern regions, sedimentation happens in coastal areas and erosion occurs at depth. Structural erosion is occurring in some areas due to rising sea levels and the construction of port dams[4].

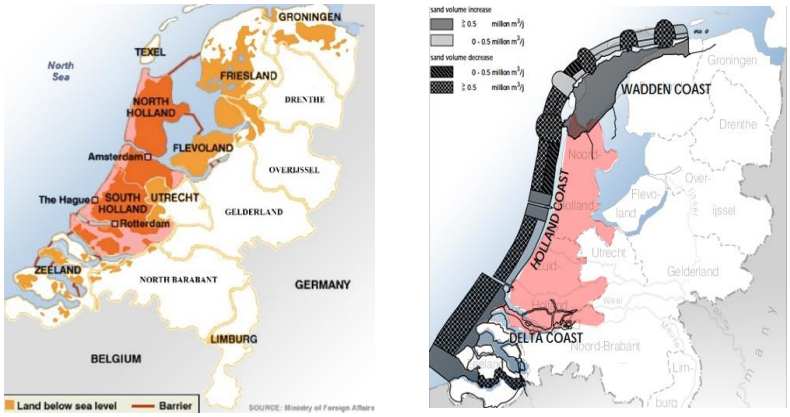

Fig. 6. (a)The Area below mean sea level in the Netherlands, (b) The Dutch Coastline with annual fluctuation in sand volume (Source: [24, 25], Researcher)

5.1.3 Urban challenges

A. Urban Sprawl: is still increasing and thus the use of space in the Dutch coastal areas is becoming more intense. Demand for quality urban locations with quality housing is increasing, and coastal areas can provide this[26].

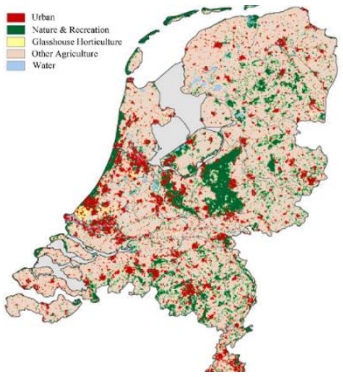

Fig. 7. The Urban Sprawl in the Netherlands (Source: [24])

B. Human Activities:

- Agriculture: Agricultural production, such as livestock farming and monoculture crop production, can increase soil erosion rates and decrease plant cover, resulting higher coastal erosion rates.
- Industrial: Mining, dredging, and sand and gravel extraction may all disrupt the natural equilibrium of sediment in coastal regions, resulting in erosion and the loss of beaches.
- Tourism and recreation: Increasing tourism and recreation can result in the construction of infrastructure such as marinas and beach amenities, which can change natural coastal processes and cause erosion[25].

5.1.4 Coastal protection: The Dutch have had success with "Building with Nature," a concept that combines hard and soft protection. Working with natural to preserve the coastline, such as restoring natural ecosystems and using natural materials for infrastructure projects. It has successfully restored eroding beaches and dunes while also increasing the environmental health of coastal ecosystems[27].

A. Hard Defenses: seawalls, dikes, dams and breakwaters that are meant to keep waves and storm surges from reaching the coast[18]. The Delta Works project is one of the most successful strategies employed by the Dutch to defend their coasts built of a succession of dams, floodgates, and coastal flooding barriers across the Rhine-Meuse-Scheldt delta that was finished in the 1980s.

Fig. 8. The Dutch Hard Defenses (Source : (a)[28] -(b)[29])

B. Soft Defenses: Only sand nourishments complement the Netherlands' coastal defense efforts. The sand-feeding approach was chosen because it is a low-cost method that corresponds to the natural features of the Dutch shore and is more sustainable and environmentally friendly. Sand is mined from the seafloor at depths more than 20m to avoid disruption to seafloor life and to prevent coastal erosion[18]. The project has proven to be extremely effective in defending the

Netherlands against flooding and storm surges, and it is now regarded as a global model for coastal protection[27].

Fig.9. The Dutch Urban Protection (Source : [30])

5.2 Lower Manhattan, Newyork, North America

5.2.1 Review: When the Wisconsin ice sheet crushed up rock and carried sand, gravel, and pebbles. This rock debris, which created the city's mountainous terrain between Staten Island and Central Brooklyn, when it began to melt. The low-lying areas of the city in South Brooklyn and the East Shore of Staten Island, were formed by sand, silt, and clay deposits carried by streams from the melting glacier. This is related to the susceptibility of coastal regions to risks since low-lying places are more vulnerable to surges and sluggish sea level rise. Because of the presence of bedrock closer to the earth's surface, some regions of the city, notably those in Northern Manhattan and the Bronx, are usually higher in elevation. Because of their elevation, these areas are less vulnerable to flooding and sea level rise. As shown in fig.10 [31].

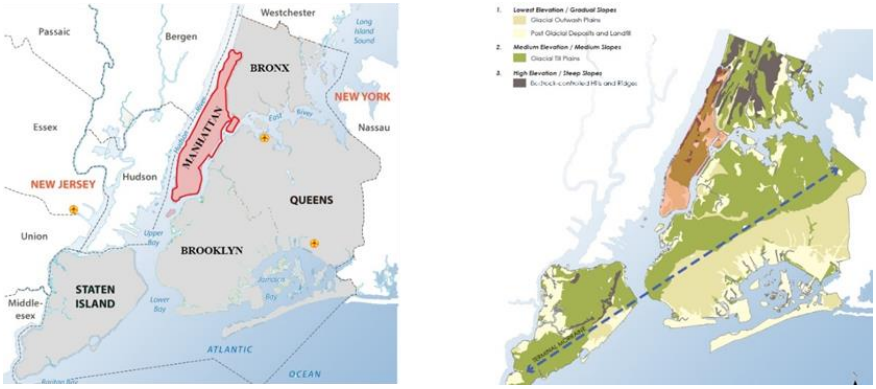

Fig.10. (a) The Map of New York City.(b) The Map of Soil and Elevation Study for New York City (Source: [31], Researcher)

Lower Manhattan's shoreline is roughly 17.7028 km long, running from Battery Park to the Brooklyn Bridge. Coastlines are classified into two types: natural (margins is composed of components such as sand, mud, vegetation, and naturally existing rock) and hardened edge (bulkhead reinforcements edges to prevent erosion). Soft coastlines are especially vulnerable to erosion in the case of a strong storm, which might result in the loss of land directly inland of the coastline[31]. For over 400 years, New York's historical identity has been rooted in Lower Manhattan. Serving as a gateway for immigrants, the county has grown into a global economic and financial capital in recent decades. Accounting for more than 10 % of all New York City jobs

The region's growth is aided by good transportation linkages, with 19 of the 25 metro lines and 26 ferry routes passing through it. In certain places, the land is unusually low, descending below the deteriorating bulkheads of the coastline[26].

Fig.11. (a) Map of Lower Manhattan, (b). Map of The Coast of Manhattan (Source: [31][30], Researcher)

5.2.2 Environmental threats: The biggest danger currently facing New York is climate change. Hurricane Sandy struck New York City in October 2012, flooding 17% of the city and leaving 44 people dead. In Lower Manhattan alone, the effects of Hurricane Sandy were devastating. Because Lower Manhattan is an important economic, cultural and community center for New York and the region, the impacts of climate change on Lower Manhattan will extend far beyond the country[26].

A. Impact of Sea Level Rise: Stormwater and sewage runoff from the hurricane overwhelmed the city's wastewater treatment infrastructure. Significant damage was done to Lower Manhattan's transportation system, power supply, open space, and water and sewer infrastructure[26].

B. Impact of Erosion: Lower Manhattan is classed as Hardened Sheltered Bay Plains, which includes features such as glacial outwash plains, low fetch, low elevation / gentle slopes, Reinforced shorelines, and fine sediment. Where Erosion is Not the Biggest Threat to Lower Manhattan compared to other places in New York City[31].

Fig.12. (a) The map shows the hurricane's sandy inundation, (b) The Map Shows the case study area and Coastline Type (Source: [26, 31], Researcher)

5.2.3 Urban challenges:

A. Urban Sprawl: Since 2001, more than $20 billion in public and private investment has aided in the development of Lower Manhattan into a thriving live-work neighborhood open 24 hours a day. Lower Manhattan has had a meteoric rise in tourism because of hotel development. In addition to being a prosperous major business district, Lower Manhattan is also home to a burgeoning residential neighborhood. The number of people living below Chambers Street has increased by 129% [26].

B. Human Activities: The massive wetlands of Jamaica Bay and Long Island Sound, congested business areas, industrial hubs, beachside communities, and various other neighborhoods are all included in New York City's coastal zone[31].

Fig.13. the map shows land use of study area (Source : [31])

5.2.4 Coastal protection: Through Studying the Reach Strategies For coastal Adoption and Protection For case Study of Lower Manhattan Hardened Sheltered Bay Plains Coastline which is divided into hard and soft defenses each Classified into three Categories**[31]**.

Fig.14. The Big U Coastal Protection in Lower Manhattan (Source: [32])

Fig.15. The Urban Protection of Lower Manhattan (Source: [32])

A. **Hard Defenses:**

- Upland Approaches: Elevation of Land and Streets to safeguard against floods, elevate existing or new development sites and roadways above the projected storm level, and floodwalls are permanent or movable walls used to prevent floods along the shoreline or in the uplands [31].

Fig.16. The Upland Approaches – Hard Defenses (Source : [31])

- Coastline Approaches: Bulkheads are vertical retaining walls that are designed to keep soil in place and provide a secure coastline, revetments are coastal constructions constructed of stone rubble or concrete blocks that are often put on a sloping surface to protect the underlying soil from erosion and to lessen the effects of wave action, seawall is a big stone, rock, or concrete

barrier erected parallel to the beach to withstand the pressure of high storm waves and prevent coastal flooding of upland regions, levees or dikes are earthen embankments along the coast that guard against floods, and multi-purpose levees that integrate various services like transportation, roadways, buildings, or parks on top of or within a levee structure [31].

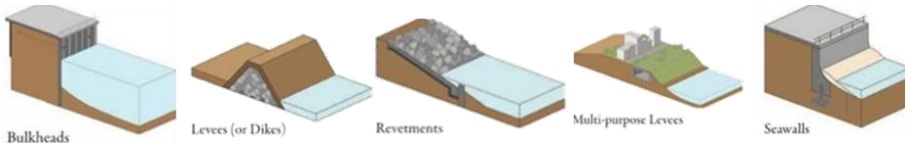

Fig.17. The Coastline Approaches – Hard Defenses (Source : [31])

- `In-Water Approaches: Constructed wetlands are new or rebuilt tidal wetland systems that employ plants and soils to hold and filter water while also providing wildlife habitat, breakwaters are offshore constructions built of rock or stone that are designed to break waves and reduce the force of wave action. Breakwaters can either float or be anchored to the ocean floor, artificial reefs are submerged or partially submerged constructions built of rock, concrete, or other materials that are intended to offer marine habitat for plants, animals, fish, and birds while also attenuating waves, floating island a plant-covered mat or structure that may lessen waves while also delivering environmental advantages such as habitat restoration and water quality improvement, built breakwater island are off-shore islands built with sand and rock fill, and surge barriers are permanent dams with water-stopping gates that can be opened and closed to keep coastal areas from being swamped by storm surges [31].

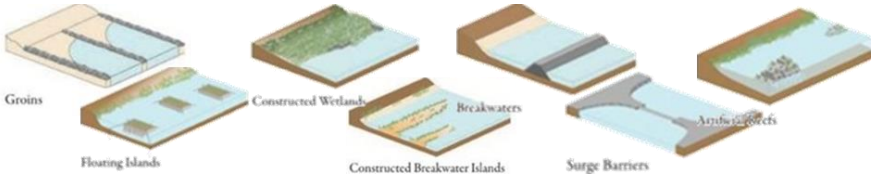

Fig.18. The In-Water Approaches – Hard Defenses (Source : [31])

B. Soft Defenses:

- Upland Strategies: Waterfront parks are open spaces planned with landscape elements such as floodable zones, elevated land masses, and other adaptive park design features that may swiftly rebound following storm events and help protect mountainous areas from coastal flooding, and strategic retreat is the process of withdrawing development from flood-prone areas and preventing future growth [31].

Fig.19. The Upland Strategies – Soft Defenses (Source : [31])

- Coastline Strategies: Living coastlines are a type of bank stabilization technology that uses plants, sand/soil, and a limited number of hard structures to offer coastline protection and preserve vital habitat, and sand nourishment [31]

Fig.20. The Coastline Strategies – Soft Defenses (Source : [31])

- In-Water Strategies: Changing the bathymetry of a body of water to allow for shallower seas can lessen the amount of storm surge, and polders are a low-lying area surrounded by levees that constitute an artificial hydrological entity. It might be used to temporarily deflect and hold flood flows [31]

Fig.21. The In-Water Strategies – Soft Defenses (Source: [31])

6. CONCLUSION

The Attached Table.1. Summarizes all the coastal protection methods that were discussed in the previous analytical examples (hard, soft and combined defenses) and qualify it depend on the efficiency of the erosion control and the sea level control.

Table 1. Coastal Defenses Efficiency (Source: Researcher).

Coastal Defenses Approach	Erosion Control	Sea Level Rise Control
Holland		
Hard Defenses		
Seawalls, dikes and dams	●	●
Breakwaters	⊖	○
Floodgates	○	●
Soft Defenses		
Sand nourishment	●	●
Combined Defenses		
Building with nature	●	●
Lower Manhattan		
Hard Defenses		
Elevation of land and street	○	○
Floodwalls	○	●
Bulkhead	○	○
Revetments	○	○
Seawalls	●	●
Levees or dikes	⊖	○
Multipurpose levees	⊖	○
Groins	○	●
Constructed wetland	○	●
Breakwater	○	●
Artificial reefs	○	●
Floating island	○	●
Breakwater islands	○	●
Surge barriers	●	●
Soft Defenses		
Waterfront parks	○	○
Strategic retreat	○	○
Living shoreline	○	○
Beaches and dunes	⊖	○
Coastal morphology alternation	●	●
Polders	●	●

● **High**	⊖ **Medium**	○ **Low**

Although The Attached Table.2. Summarizes all the points that were discussed in the previous analytical examples (location, coastal city shape, length, type , function, climate, population, environmental threats, urban challenges, coastal protection methods and the average of efficient method used) , then reached an approximate percentage of the average success of the protection methods used in each coastal city, because of what was studied and because of the similarity of erosion cases and sea level rise. At its end, depending on the approximate percentage of the immediate and long-run efficiency, it turns out that Lower Manhattan Examples used and applied the efficient urban protection methods at its coast.

Table 2. Analytical Examples Conclusion (Source: Researcher)

				HOLLAND	LOWER MANHATTAN
1	Location			North West Europe, Netherlands	North America, United State, New York
2	Coastal City		Coast Shape		
			Coast Length	120km long	17.7 km
			Type of coast	Low-Lying Coast - Sandy Coast	Low-Lying Coast - sand, mud, vegetation, naturally rock
			Function and role	Agriculture,Industrial-Recreational-Fisheries	the economic and cultural center and Residential
3	Climate			(C) Warm/Temperate Zone 	(D)-(C) Continental Warm/Temperate Zone 
4	Population			≈ 6.590 millions	≈ 1.630 millions
5	Enviromental Threats			Erosion - Sea Level Rise - Flooding	Sea Level Rise
6	Urban Challenges			Urban Sprawl	Urban Sprawl
7	Coastal Protection		Sea Level Rise	Seawall	Floodwalls Seawalls Groins Constructed wetland Breakwater Artificial reefs Floating island Constructed breakwater islands Surger barriers Coastal morphology alternation Polders
			Erosion	Seawall Sand Nourishment	Seawalls Surger barriers Coastal morphology alternation Polders
8	Coastal Protection Average	Sea Level Rise	Economically	65%	55%
			Environmentally	65%	75%
			Effectiveness Immediately	80%	85%
			Effectiveness in Long-Run	75%	85%
		Erosion	Economically	65%	55%
			Environmentally	65%	75%
			Effectiveness Immediately	90%	90%
			Effectiveness in Long-Run	75%	75%

7. RECOMMENDATION

- Use Nature-based solutions, such as dune restoration as they are effective natural barriers against storm surges, similar to those used in Holland.
- Use Engineering solutions, such as dikes and seawalls as seen in Dutch coastal protection, to defend against high tides and storm surges and storm surge barriers to protect against extreme weather events.
- Promoting innovative urban design, such as elevated structures and retrofit existing building with flood-proofing measures, includding vulnerable coastal areas similar to manhattan.
- Develop flexible coastal management policies that can adapt to changing environmental conditions and climate projections.
- Implement regular monitoring and assessment programs to track the effectiveness of coastal protection measures and adjust strategies as needed.
- Develop and restore wetlands to act as natural buffers, reducing wave energy and providing habitats for wildlife.
- Integrated Coastal Zone Management (ICZM), such as holistic approach that adopt a comprehensive approach to coastal management that integrates environmental, economic, and social objectives. Altough, stakeholder involvement that engage local communities, government agencies, and private stakeholders in the planning and implementation processes.
- Promoting sustainable development practices, such as infill development and public transportation, to reduce the impact of urban sprawl.
- Develop and regularly update emergency preparedness plans, ensuring that communities are ready to respond to coastal hazards.
- Ensure coordination between different levels of government and relevant agencies to streamline efforts and resources.
- Develop and enforce regulations that support sustainable coastal development and protect natural coastal environments.
- Increase public awareness and engagement on the impacts of climate change and the importance of coastal protection. This can be achieved through community outreach and education programs, public forums, and the use of social media.

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الطرق الأكثر فعالية لحماية السواحل وتطويرها
من خلال دراسة مقارنة بين ساحل هولندا ومانهاتن السفلى

دنيا نبيل[4]، سحر الارناؤطي[5]، احمد الزيات[6]

الملخص

المناطق الساحلية هي مناطق ديناميكية بشكل متزايد حيث تتفاعل العمليات الأرضية والبحرية. على مدار المائة عام الماضية، أصبحت التغيرات الساحلية إحدى المشكلات العالمية في كل من النظم البيئية الطبيعية والمجتمعات الحضرية. في جميع الثقافات، تعتبر الواجهة البحرية نقطة جذب أساسية. يجب أن يكون لكل مدينة هوية يمكن استخدامها كمنطقة جذب تنموية رئيسية. في العقود الأخيرة، تعاني الإسكندرية، مثل العديد من مدن العالم الثالث، من العديد من جوانب التدهور البيئي والحضري بسبب التوسع العمراني السريع وغير المخطط له وغير المنضبط والذي عادة ما يخلق بيئة سيئة تؤثر على جميع أنحاء المدينة. في مواجهة تغير المناخ والنمو الحضري، يعد تأثير تغييرات الخط الساحلي على الواجهات البحرية للمدينة قضية بالغة الأهمية. بناءً على مقارنات أمثلة تحليلية للتغيرات الساحلية وطرق الحماية والتطوير المستخدمة لتلبية المتطلبات الحضرية المستقبلية ورفع مستوى العناصر الحضرية الحالية. تم اختيارها وفقًا لمعايير تستجيب لهدف الدراسة، والذي يعتمد على تأثير التغيرات الساحلية بسبب التهديدات البيئية والتحديات الحضرية مثل مدينة الإسكندرية. أخيرًا، تهدف هذه الورقة إلى تحديد الأسباب الرئيسية لتغيرات الساحل، وإنشاء إرشادات والتوصية بنهج عملي للحفاظ على السواحل وتطويرها.

الكلمات الدالة: المدينة الساحلية، الخط الساحلي، تغير المناخ، التآكل، الواجهة البحرية، النسيج الحضري، التهديدات البيئية، التحديات الحضرية.

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