Conference EastGIS 2023

The potential of using GIS for regional development

Climate change in the context of historical trend analysis and forecasting the shoreline changes at the Nile Delta using RS data and GIS with the DSAS tool

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Presentation outline

1. Introduction to climate change
2. Impacts of climate change
3. Study area
4. Methodology
5. Results
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1. Introduction to climate change

Climate change refers to any distinct change in measures of climate lasting for a long period of time. It includes major changes in **temperature**, **precipitation**, snow, or **wind patterns** lasting for decades or longer.

If **no actions** are done to adjust to these changes, the world may face extensive impacts in the long run

Adaptation measures should be taken to address climate change consequences

1. Introduction to climate change

Climate change mainly result from

- **Natural processes** (e.g, volcanoes, sun energy…… etc.)
- **Human activities** (e.g, burning fossil fuels, deforest, urban developments…… etc.)

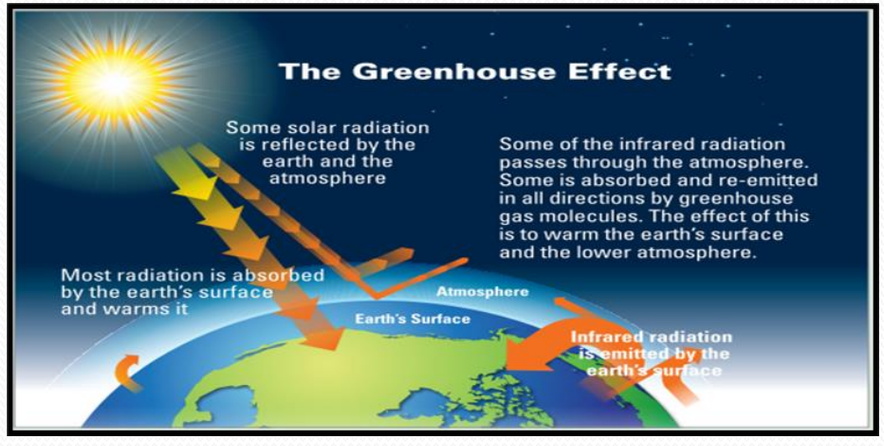
1. Introduction to climate change

Global warming

Is the average increase in temperatures near the Earth's surface and in the lowest layer of the atmosphere

Greenhouse gases are increasing due to human activities

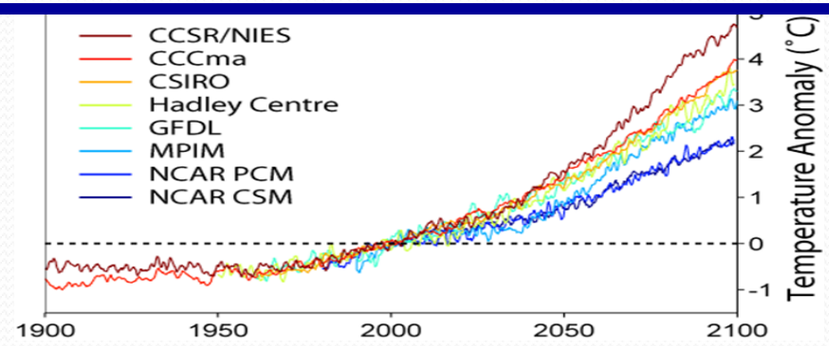
- Burning coal, oil, and gas are increasing production of carbon dioxide
- Destruction of forests (deforestation) that absorbing CO_2 from atmosphere
- Nitrous oxide emissions produced by using nitrogen fertilizers
- Fluorinated gases emitted by fluorinated gas-using equipment and goods

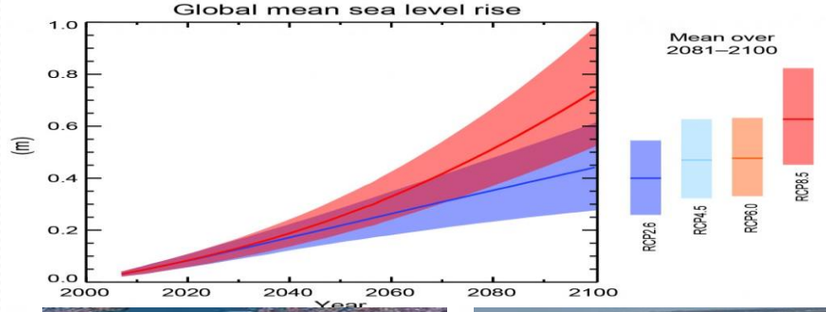


1. Introduction to climate change

Increased greenhouse gas concentrations led to

- Increase the global average temperature
- Change in precipitation patterns and possibly droughts/floods
- Reduce ice and snow cover, as well as permafrost
- Increase oceans acidity
- Rising sea levels
- **Coastal erosion increase**
- Wetlands loss increase
- Seawater intrusion increase into coastal aquifers
- Extreme events frequency, severity, and duration will increase
- Changes in ecosystem characteristics
- Pose a greater risk to human health





2. Impacts of climate change

Climate change will affect different sectors

Economy

2. Impacts of climate change

Impact of climate change on coastal areas

Climate change could have a wide range of effects on coastal areas

- Sea level rise
- Coastal flooding
- **Coastal erosion**
- Land subsidence
- Changes in storm surge frequency
- Increased precipitation intensity
- Rising ocean temperatures will affect coastal ecosystems

2. Impacts of climate change

The impact of climate change on Europe

- **Northern Europe** is getting significantly wetter, and winter floods could become common.
- **Southern and central Europe** are seeing more frequent heat waves, forest fires and droughts.
- **Mediterranean area** is becoming drier, making it even more vulnerable to drought and wildfires.

Continued climate change could led to:

- 400,000 premature deaths per year due to air pollution
- 90,000 annual deaths as a result of heat waves
- 40% less available water in southern regions of the EU
- 2.2 million people exposed to coastal inundation each year
- €190 billion in annual economic losses

3. Study area

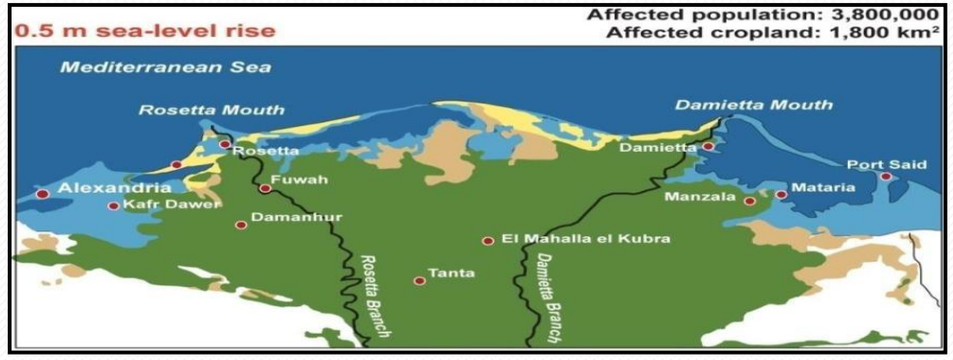
The Nile Delta, Egypt

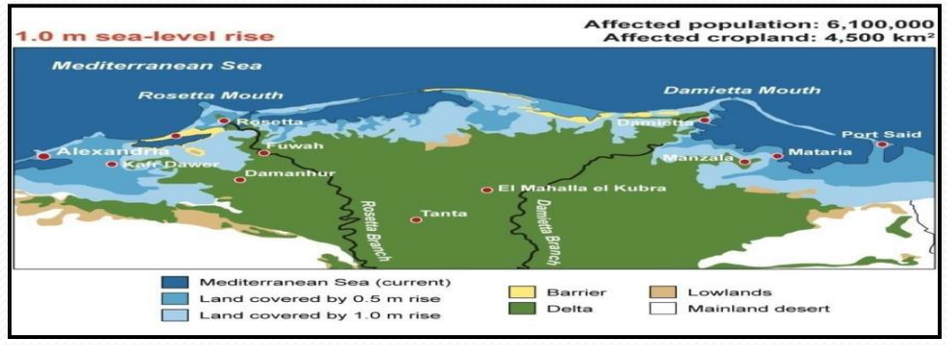
- Latitudes 30° 25′ and 31° 30′ North,
- Longitudes 29° 50′ and 30° 15′ East
- Area of about 25,000 km²
- Coast length of 240 km
- 160 km from South to the North
- Population 40 million

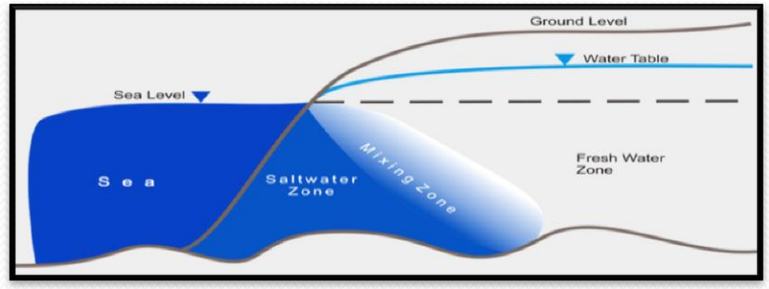
3. Study area

The impact of climate change and sea level rise on the Nile Delta

- **Coastal erosion**
- Coastal flooding
- Land subsidence
- Inundation of lands
- Sea water intrusion
- Soil and groundwater salinization
- Evaporation increase
- Crops water demands increase
- Shortage of water resources
- Loss of agriculture lands
- Socio-economic
- Tourism
- Others



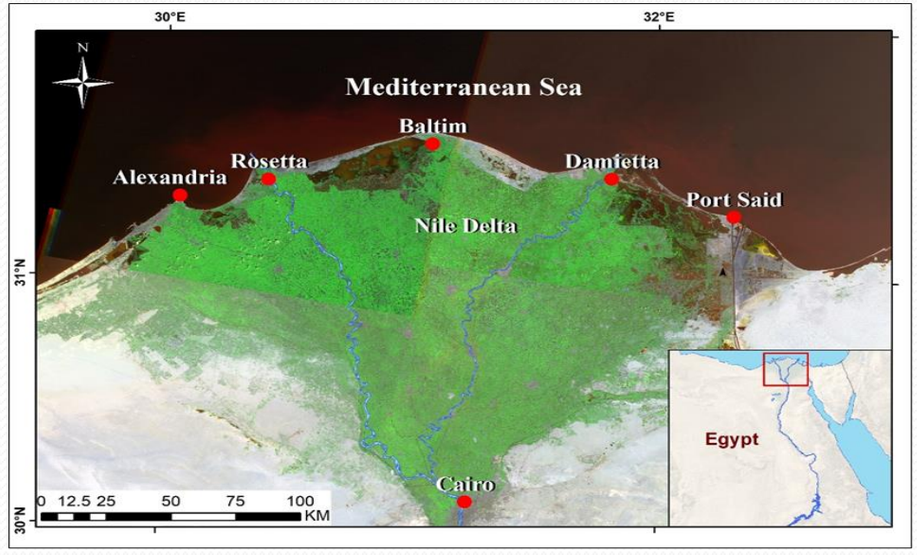




3. Study area

Aims of the study

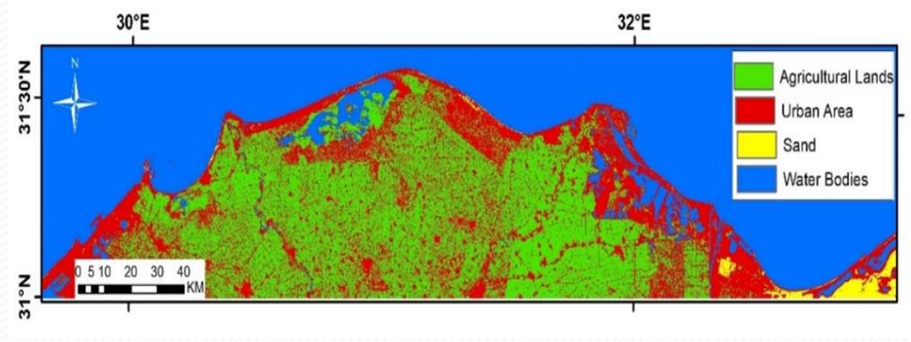
Coastal areas are increasingly endangered by climate change and associated sea level rise [expected sea level rise (0.20–0.88 m) by the end of the 21st century, which could have serious consequences, that could affect the inhabitants, economy, buildings, roads, railways and ports.



The Nile Delta, Egypt

There is a need for:

- Detecting and monitoring changes in the shoreline
- Forecasting future changes in the shoreline for the next 10 and 20 years
- An integrated coastal management and adaptation plans for the region

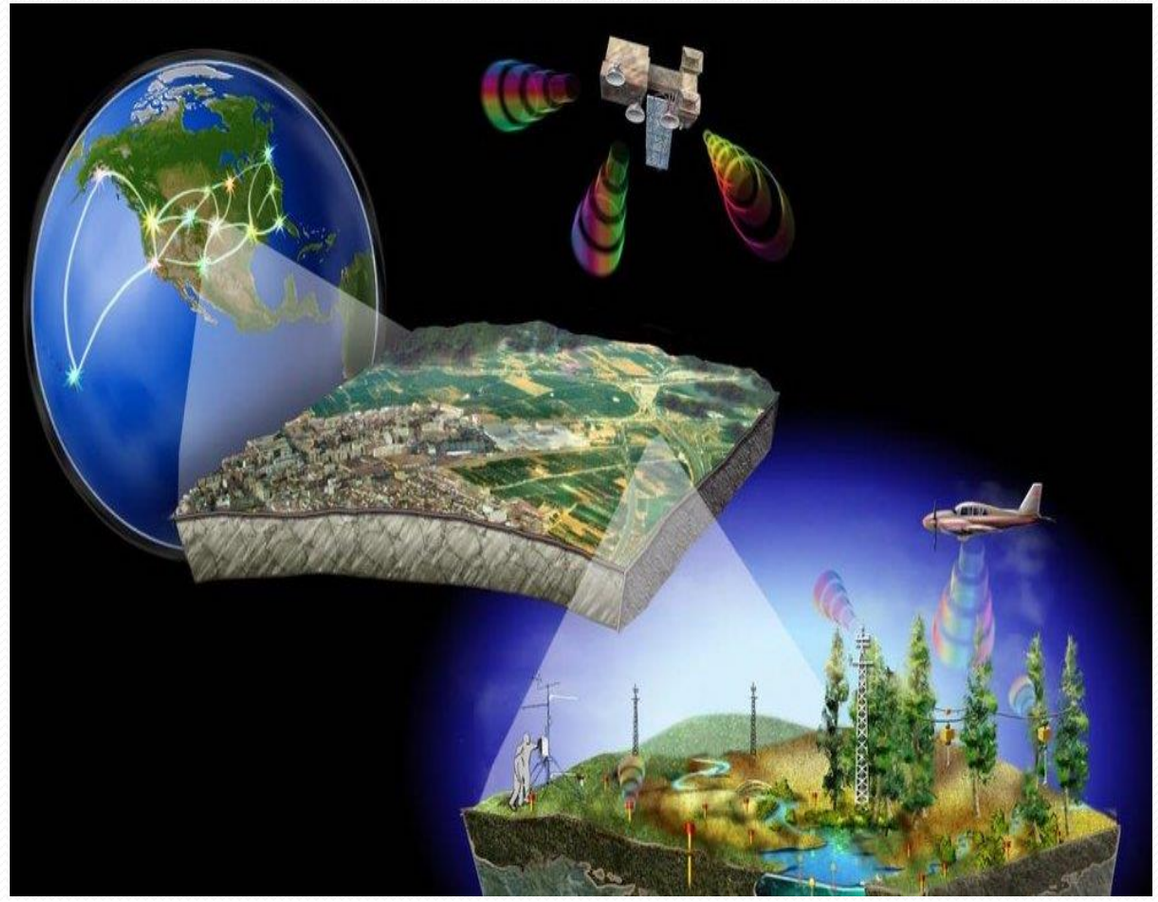


4. Methodology

- Remote Sensing (**RS**) and Geographic Information System (**GIS**) are among the advanced tools that link climate data with its spatial-temporal framework to demonstrate changes that may occur due to climate change.

- The Digital Shoreline Analysis System (**DSAS**) is an important tool that can be used for monitoring and forecasting shoreline changes.

- In this study, RS and GIS with the DSAS tool are used to monitor changes in the Nile Delta shoreline during the period (**1974–2022**).



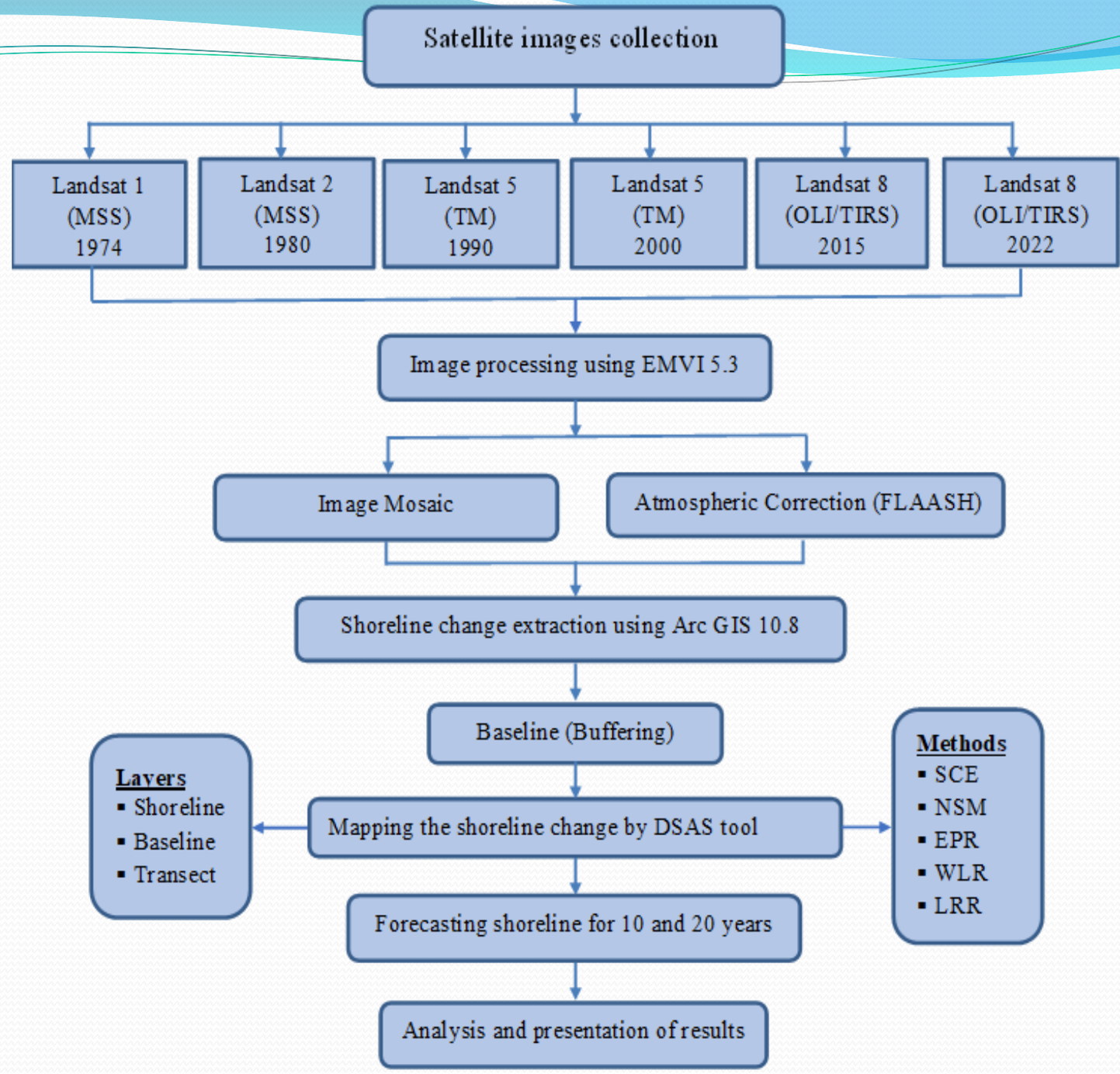
4. Methodology

Why DSAS?

DSAS is an effective tool that can be utilized in a variety of investigations, including [Temitope, Oyedotun; 2014]

- Monitoring the shoreline changes
- Mapping historic changes of shoreline position over a period of time
- Assessing the trends of a shoreline
- Evaluating coastal behavior and shoreline dynamics
- Evaluating time-series of changes at certain places of a shoreline
- Historical trend analysis, coastal system dynamics and cliff geometry modeling

4. Methodology



4. Methodology

4 steps

Step 1:

Data collection represents the assembly of satellite images for the Nile Delta from **1974** to **2022** for six periods (**1974–1980–1990–2000–2015–2022**). LAND-SAT satellite images with a resolution of 30 were downloaded from USGS using Landsat Collection.

Step 2:

Data processing represents mosaicking that involves combining multiple images into a single composite image for each period to cover the study area.

Step 3:

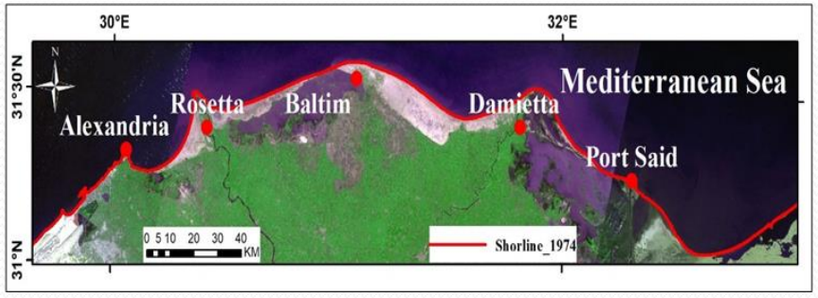
Mapping and forecasting of the shoreline change represents mapping the shoreline change from numerous historical shoreline positions and using it to forecast future shoreline features. DSAS is a free ArcGIS tool created by the USGS that can be applied for mapping and forecasting a shoreline in the long-term of **10** and **20** years.

Step 4:

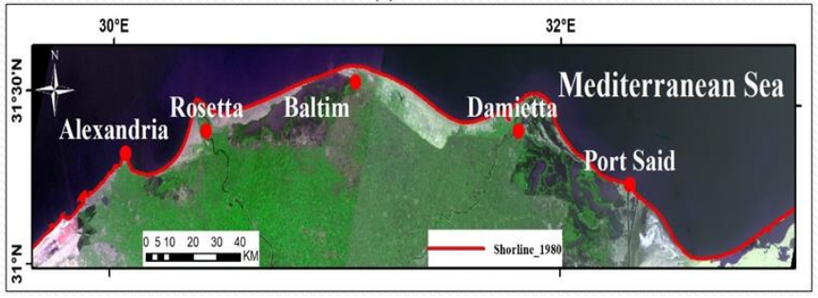
Data presentation is when the database is represented and given to decision-makers in the form of **maps, tables, graphs, photographs, and reports**.

5. Results

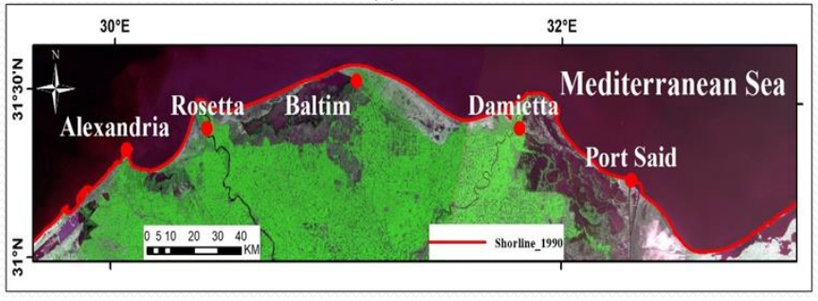
Historical Trend Analysis of the Nile Delta Shoreline for the Period 1974–2022



(a) 1974

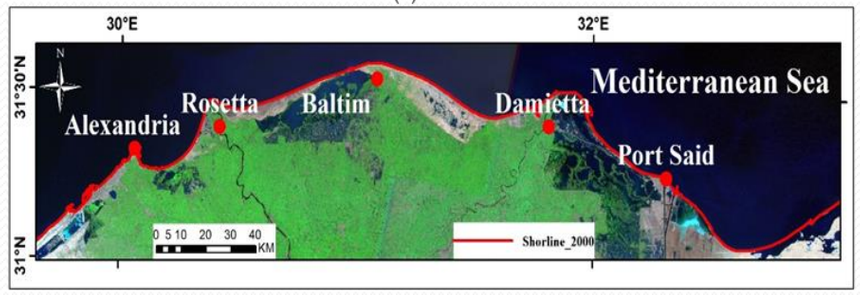


(b) 1980

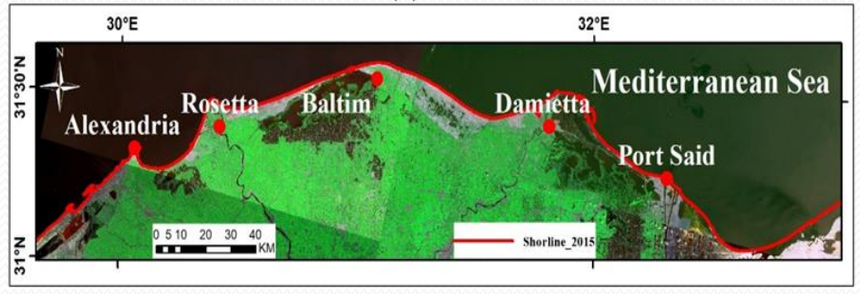


(c) 1990

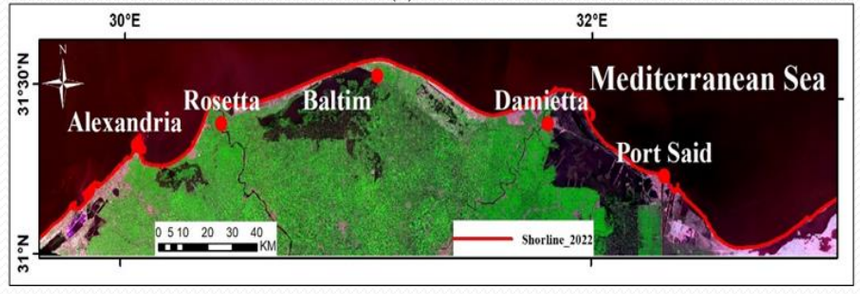
(c) 1990



(d) 2000



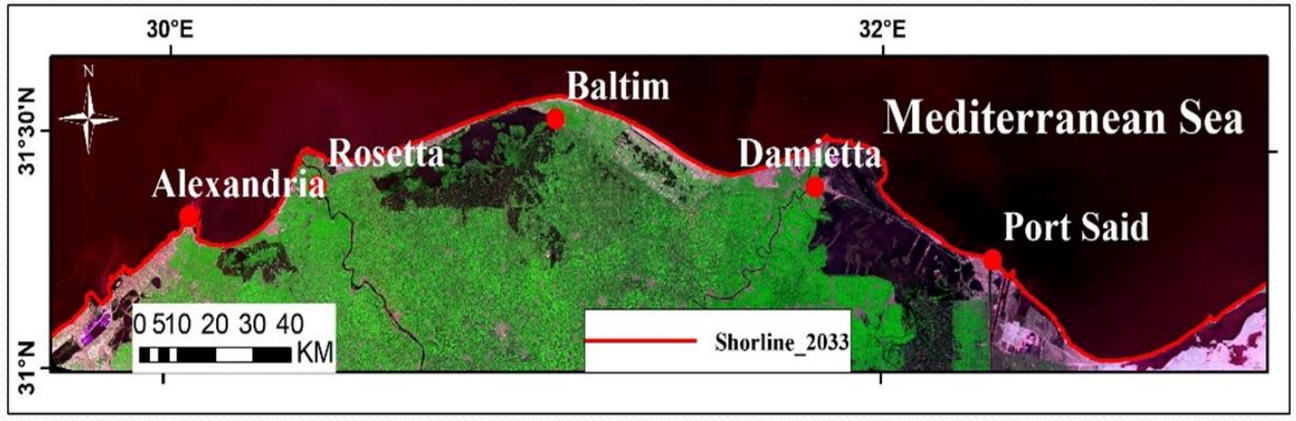
(e) 2 015



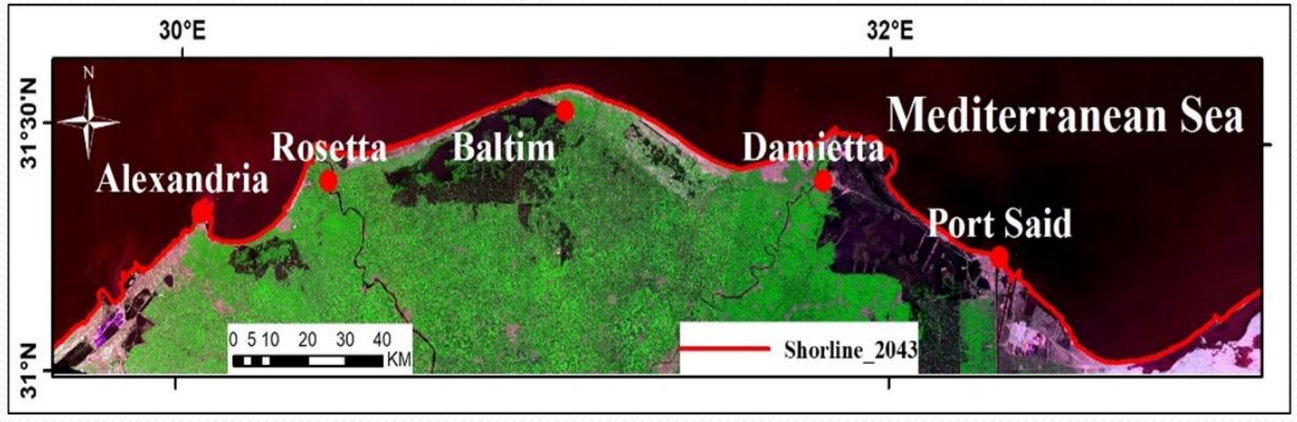
(f) 2022

5. Results

Prediction of Shoreline Changes in the Nile Delta for 10 and 20 Years



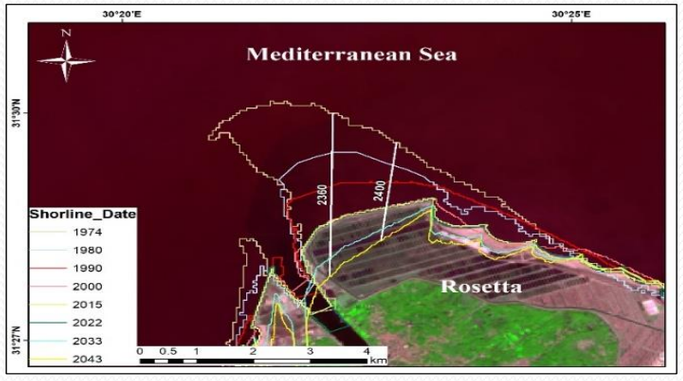
(a) 2033



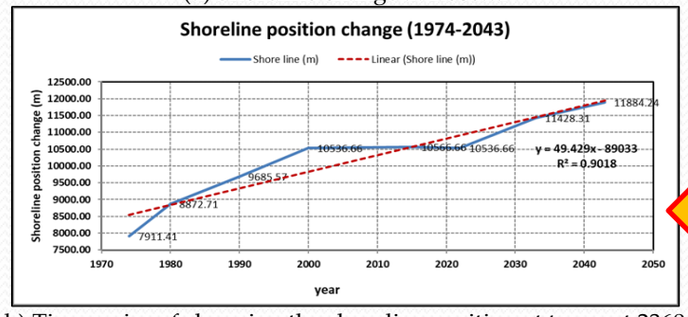
(b) 2043

5. Results

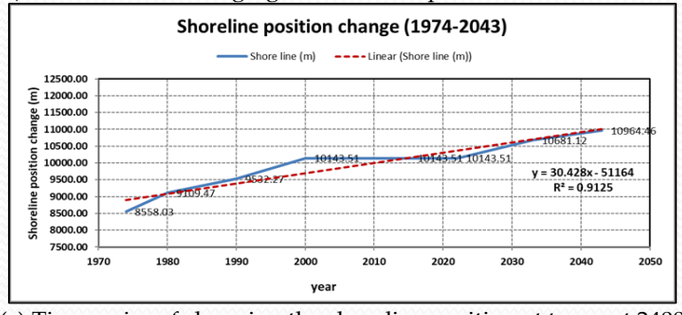
Analysis of Shoreline Changes in the Nile Delta at Critical Sections from 1974 to 2043



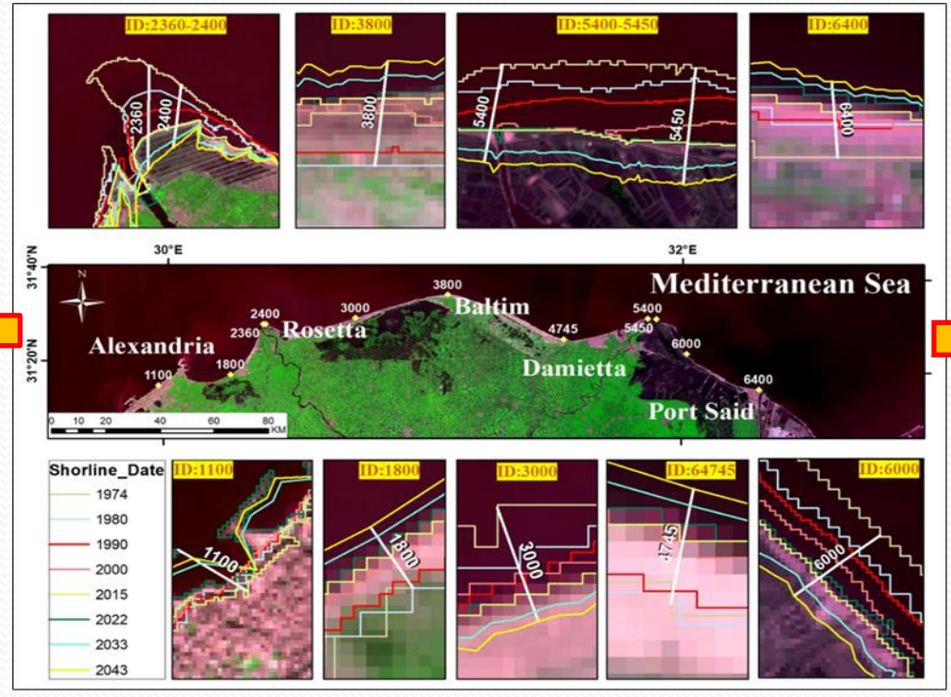
(a) Shoreline change at Rosetta

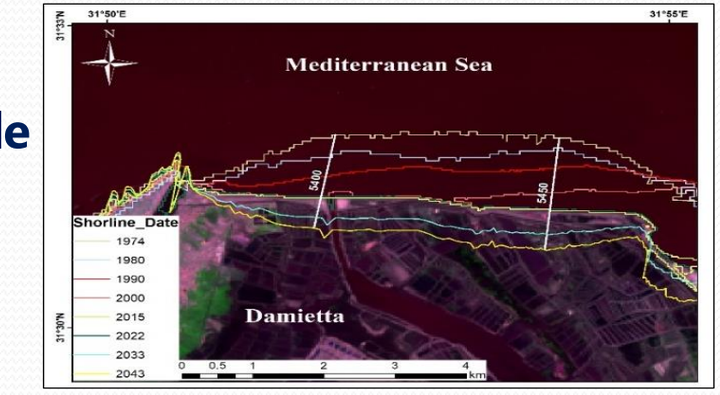


b) Time series of changing the shoreline position at transect 2360

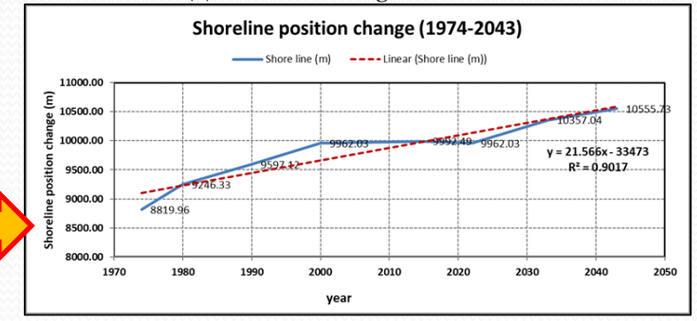


(c) Time series of changing the shoreline position at transect 2400

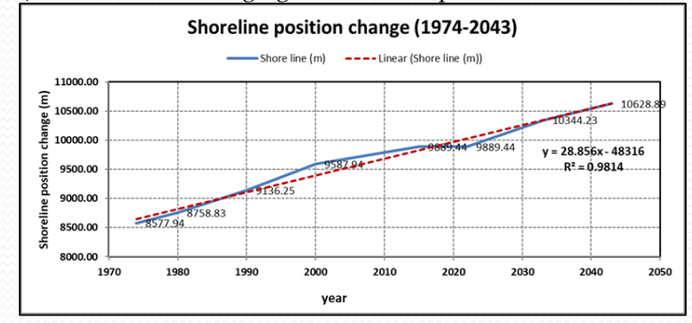




(a) Shoreline change at Damietta



b) Time series of changing the shoreline position at transect 5400



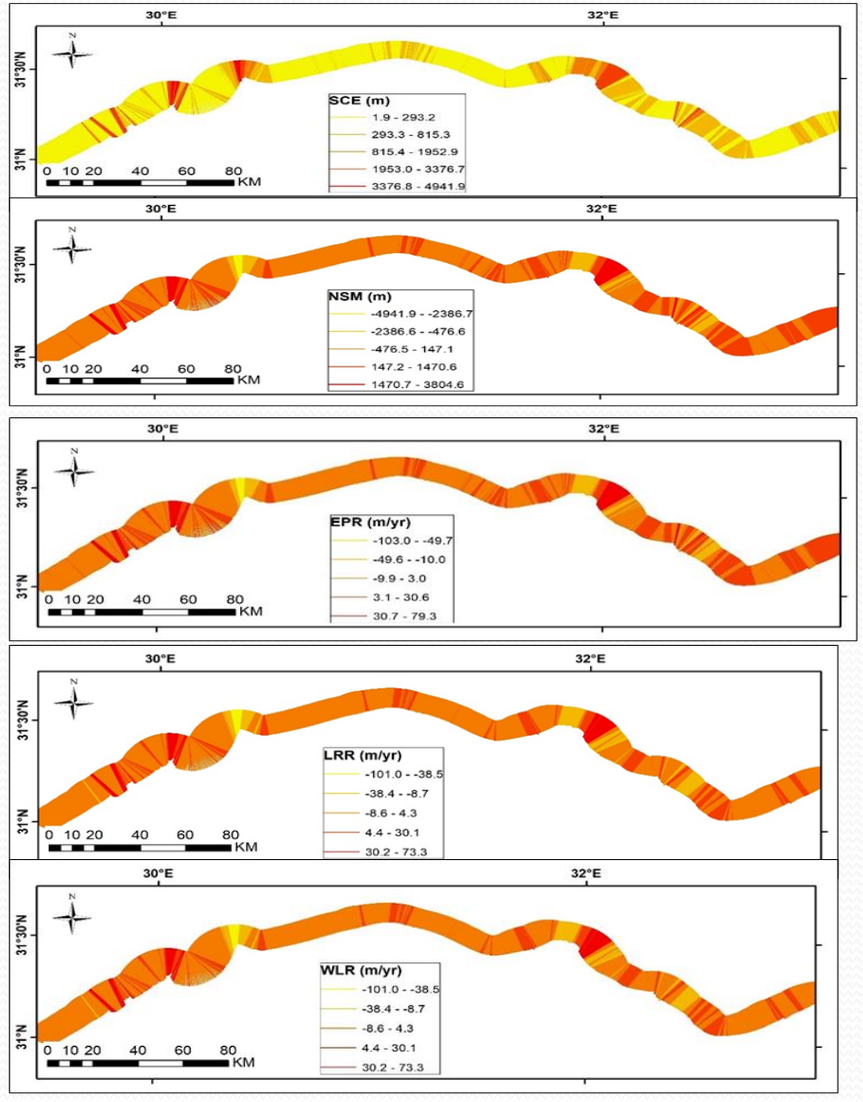
(c) Time series of changing the shoreline position at transect 5450

5. Results

Statistical Analysis of Parameters Using DSAS from 1974 to 2043

The results of statistical measures in the Nile Delta.

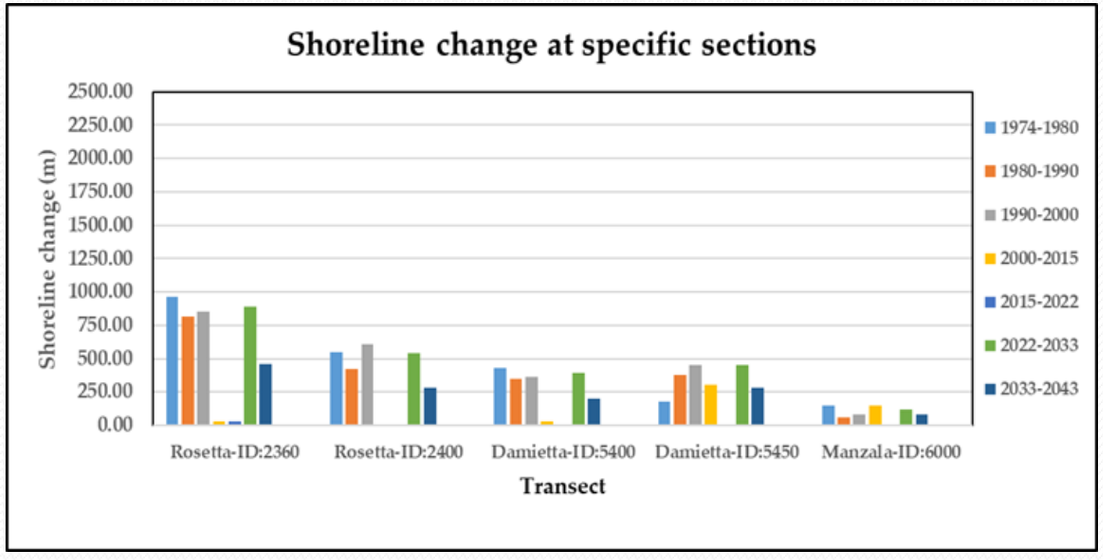
Transect ID	Location	SCE (m)	NSM (m)	EPR (m/year)	LRR (m/year)	WLR (m/year)
1100	Alexandria	585.21	495.96	10.33	5.98	5.98
1800	Idko	125.07	125.07	2.61	2.7	2.7
2360	Rosseta	2655.25	−2625.25	−54.69	−51.68	−51.68
2400		1585.48	−1585.48	−33.03	−31.67	−31.67
3000	Lake Burullus	260.34	−260.34	−5.42	−4	−4
3800	Baltim	365.18	105.69	2.2	5.42	5.42
4745	Gamasa	145.93	145.93	3.04	3.08	3.08
5400	Damietta	1172.52	−1142.07	−23.79	−22.56	−22.56
5450		1311.5	−1311.5	−27.32	−29.14	−29.14
6000	Lake Manzala	436.77	−431.76	−8.99	−8.64	−8.64
6400	Port Said	225.62	225.62	4.7	3.43	3.43

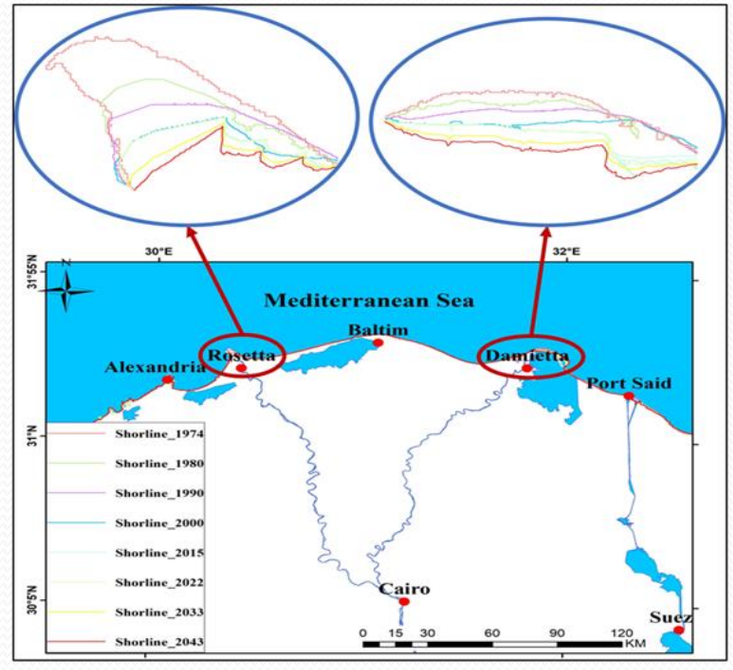


5. Results

Comparison between shoreline changes at critical sections in the period 1974–2043.

- The profiles at 5 critical sections were analyzed, and linear equations were developed for each profile that can be used to calculate the shoreline position in the future.
- Comparison between the shoreline at 5 critical sections.
- The maximum inland movement was observed at transect 2360 at Rosetta and the minimum was observed at transect 6000 at Lake Manzala.





6. Conclusion

- Increasingly climate change could have many effects on the coastal areas
- Egypt's Mediterranean coastline, especially the Nile Delta, is below the mean sea level that will be most affected by climate change and sea level rise
- The shoreline of the Nile Delta was extremely affected, and the predictions showed continuous erosion in 2033 and 2043, especially at the Rosetta and Damietta sites
- The calculated erosion rate ranged from 30–60 m/year at Rosetta, 10–25 m/year at Damietta and 8–15 m/year at Lake Manzala
- Continued erosion of the Nile Delta shoreline could have severe consequences on different segments, including ports, buildings, roads, railways, and inhabitants, which in turn affects the economy.
- Protection of coastal zones from erosion is essential

More information

Abd-Elhamid, H.F.; Zeleňáková, M.; Barańczuk, J.; Gergelova, M.B.; Mahdy, M. Historical Trend Analysis and Forecasting of Shoreline Change at the Nile Delta Using RS Data and GIS with the DSAS Tool. **Remote Sens. 2023, 15, 1737.**

https://doi.org/10.3390/rs15071737

score

About CCLLs Partners Contact

About SCORE

SCORE is a four-year EU-funded project aiming
to increase climate resilience in European coastal cities.

The project will tackle specific challenges related to sea levels, coastal erosion and extreme weather events using an integrated solution of smart technologies and nature-based solutions.

28	12	4	01.07.2021 31.06.2025	10M
partners	countries	years	start-end	euros

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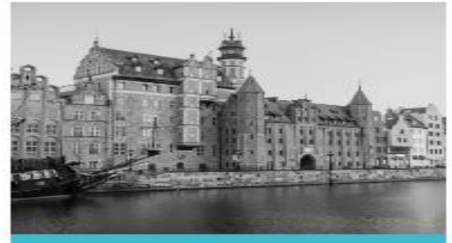

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- https://eos.org/research-spotlights/how-fast-is-the-nile-delta-sinking]
- https://en.wikipedia.org/wiki/Nile_Delta

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