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Socio-Economic Dimension of Mariout Lake as an Ecological Approach for Sustainable Development in Alexandria, Egypt

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Abstract:

The global warning released by Boris Johnson during the United Nations climate conference 2021 sounded the alarm about the environmental danger posed to the city of Alexandria- Egypt. Alexandria is an inherited valuable legacy as one of the oldest cities in known history; since its origin, Mariout lake represents the ecological key factor in raising its urban formation. This study targeted to highlight the influential role of Mariout lake in regenerating Alexandria city ecologically; it argued that the keystone for this process is a dual urban regeneration process for both regions based on the dual impact of ecological issues between the lake and city regions across history. This approach follows a sophisticated process to analyze the inherited social and economic urban formation for the lake's range as a key to rehabilitating the ecological issues for the Alexandria City region. the outcomes recommended an urban scenario for a sustainable redevelopment process for the city and the lake. Optimally, the paper seeks to present an academic approach to developing an urban regeneration process based on the origin of the urban environment for the lake range and the city region.

Keywords: urban environmental; socioeconomic dimension; ecological sustainability; climate change Alexandria, Egypt.

Introduction:

Climate change is a severe issue on the scene that threatens cities' security and stability (Zhang et al., 2021). During United Nations Climate Change Conference, British Prime Minister Boris Johnson sounded an alarm about Alexandria City (PM Address at COP26 World Leaders Summit Opening Ceremony - GOV.UK, 2021). He presented the issues as a cause and effect; if the temperature is raised by 2℃ degrees, then the crops for hundreds of millions of people are subject to wilting and locusts swarms; if the temperature is raised by 3℃ degrees, then wildfires and cyclones doubled, droughts increased fivefold, and the number of heat waves increased 36 times; if the temperature is raised by 4℃ degrees, then entire cities such as Miami, Alexandria, Shanghai are at risk of disappearing (Belcher & Kossivi, 2021; PM Address at COP26 World Leaders Summit Opening Ceremony - GOV.UK, 2021). This statement summarized the ecological danger facing cities in general and Alexandria city in particular.

Alexandria is one of the ancient cities in the world, existing back to circa 6000 BC as a flourishing urban center called Rakotis (Stanley et al., 2007); it was a destination for mariners, attributes, and different races from the Mediterranean basin (Stanley et al., 2007). Nevertheless, its known origin dates back to its founding by Alexander the Macedonian in 331 BC. Mariout Lake was the keystone for raising the city; it was the primary factor that tempted Alexander to establish the city as it was a primary source of drinking water. Alexandria became Egypt’s capital for about a thousand years throughout the Ptolemies, Romans, and Byzantines eras until the Arab conquest in 640 AD. Across history, the lake was a southern coastal board for the city, a flourishing spot for maritime trade, a source for fisheries, besides a drinking source. In the twentieth century, the lake became over-polluted, and the Alexandria governorate considered filling it up. Soon, as the government took action of backfilling, some districts in Alexandria city, 10 km away from the lake, started to collapse and drown, which alerted another value to the lake as a source of the city's ecological and geological balance. This brief origin points to Mariout Lake as a critical factor for the ecological balance in Alexandria city.

In response to the severe impact of global climate changes on Alexandria City, the study attempted to propose an academic approach to cope with the ecological issues based on regenerating the origins of urban formations' potential for the Alexandria City region and Mariout Lake range, based on the related ecological history of both; the study also argued that rehabilitating Mariout Lake is the keystone for sustaining the ecological dimension of the Alexandria urban formation. Restructuring Alexandria city ecologically by exploiting the area of Lake Mariout for hosting the urban density of Alexandria City requires a scientific approach based on academic disciplines; so as not to be repeated the experience of Burg Al-Arab City, which did not achieve the desired goal since its founding in 1986, where the city of Burg Al-Arab was founded to accommodate the overcrowding and urbanization in Alexandria city with an excepted population 570,000 inhabitants (Home - New Borg El Arab, 2015), nevertheless, the city has not achieved this goal yet for mostly societal structure reasons, with 129,364 inhabitants (Burj Al-'Arap (Population Statistics), 2021). Urban Generation and are accreditable terms for the meant objectives; both terms serve scientific approaches for achieving optimal sustainable development for redistributing the urban density and restructuring its environment.

The study followed a comparative analysis across history to characterize the dual impact; many studies referred to the ecological balance or environmental stability between the lake range and the city region. The optimal goal is to propose an approach based on academic disciplines to characterize the potential of the lake range that serves to rehabilitate the city's ecological issues; it aims to impose an intervention and comprehensive method for sustainable development for the city region and the lake range.

2. Abstracted principles and followed methods:

The study alternately followed the inductive and deductive methods to support the abovementioned argument.

The inductive approach included a historical brief of the dual impact between the Mariout lake range and the Alexandria city region; this brief grounded the ecological interaction between the lake and the city.

The history of Mariout lake is teeming with economic and social dimensions that impact the city's region. The meant approach aims to characterize the entity of the socioeconomic dimension as a substantial factor in regenerating the urban form of the lake range in furtherance of rehabilitating the urban formation ecologically of Alexandrina City region. The stander of Environmental Quality (EQ) in urban spaces is a required term in this approach, referring to the ecological dimension of Alexandria city, climatic conditions, and the effect of urban mass formation on the EQ standards; as a necessity to characterize the city's environmental issues in the open spaces. EQ concerns public human health, increasing productivity, and community wellness; therefore, it is an accreditable term for sustainable urban development. Urban sustainable development concerns achieving EQ standards naturally by controlling the urban mass formation, such as the open spaces to built-up ratios, their building specifications, and the design order in the space, all those factors in the shed of the climate data condition (Yoseph, 2019). Optimal EQ parameters in urban spaces are as the following; for the temperature, the comfort zone falls in the range of 17-23°c in winter and 19-25°c in summer. For the relative humidity, the comfort zone is conditioned to the temperature; the acceptable RH level for the range of 40-70% is 22.5-27°C, while above 70%, the range is 20- 24°C, but under 40%, the range is 22.5-26°C. For wind movement or the air circulation provided by a sufficient fresh air flow for urban formation in urban spaces, the reasonable rate of air velocities should generally be in the range of 0.9-28 Kilometers per Hour. Less than that is stagnant, more than is windy annoying states. The required amount of wind flow to keep the outdoor atmosphere comfortable should be 16 liters per second per person in open spaces.

The deductive approach included a comparative analysis across modern history for the dual impact of the related ecological issues between the lake range and the city region; this analysis aims to exemplify the importance of the lake water body for the city's ecological stability. The grounding data, as mentioned above, for the ecological interaction between the lake and the city guides the possibilities of urban economic and social regeneration for both regions and comprehensively ratiocinate the principle of urban regeneration ecologically.

Urban regeneration is an accreditable term in this approach; it is a concept that depends on the base of variety for redevelopment. The concept covers various rehabilitating strategies that support maintaining the environment ecologically based on economic strength and social diversity. Here, the methods propose a restructuring process for the existing urban formation based on the entity of the socioeconomic dimension. Urban regeneration is the science of characterizing the space's potential behind the existing distortion (Yoseph, 2017); this concept aims to resolve urban defects by defining the origin of the space's configuration's social, economic, and ecological dimensions. Here, urban regeneration concerns those dimensions' origin as rehabilitation factors for the restructuring process. Urban regeneration requires applicable principles for the redevelopment process (Delivering Quality Places: Urban Design Compendium 2, 2007; Llewelyn-Davies, 2002) offers some principles based on the process's inherent or original potential. Those principles are, first, "Places for People," designing a vibrant place by offering opportunities to meet people's demands. Second, "Enrich the Existing" (Llewelyn-Davies, 2002); concerns enriching the qualities of existing urban formation by response concluded from the space setting or complementing them. Third, "work with the Landscape" (Llewelyn-Davies, 2002) regards the balance between the natural and urban environment in reciprocal utilizing between both to present eco-friendly solutions. Fourth, "Mix Uses and Forms" (Llewelyn-Davies, 2002); is an adoptive place that meets various demands, presenting a mixed land use in a balanced representation. Fifth, "Manage the Investment" (Llewelyn-Davies, 2002); concerns the viable economic potential of the urban spaces according to the market considerations of developers; it also concerns the economic vision of the community and the local Authority, which defines deliveries and applying mechanisms in the urban design development. Sixth, "Design for Change" (Llewelyn-Davies, 2002); concerns are responding to future change with enough flexibility in design for uses; it requires maintaining energy and resource efficiency besides the flexibility in the use. Those principles shape adaptive and resilient concepts to fit various urban design redevelopment and regeneration cases.

3. Urban Material: The historical dual impact of the city and the lake:

3.1 Mariout Lake natural history and the inherit Socioeconomic dimension:

Anciently and originally, Mariout Lake had been a freshwater source with an area of approximately 700 km^2, fed from the south by the waters of the Nile River through the Canopic branch; It drains into the Mediterranean through the Naucratis Canal. In 1770, a storm breached the sea wall at Abu Qir; it created a seawater lake known as Abu Qir Lake, separated from Mariout Lake by a sea wall. A canal separated the salt water from Lake Mariout, which allowed fresh water to move from the Nile to Alexandria. On March 13, 1801, during the French -British conflict over the land of Egypt, as part of the Siege of Alexandria, the British cut off the canal, allowing an enormous seawater rush from Abu Qir Lake to Mariout Lake, Abu Qir Lake no longer exists, 150 villages in the lake range had vanished, and Mariout Lake has become brackish rather than fresh (Mackesy, 2013). In the early twentieth century, the lake area was 200 km^2 (Close et al., 2012); a sequential backfilling process took place in the twentieth century for constructing some national projects, where 500 acres were deducted for the construction of Mubarak Sports City, 200 acres were deducted to construct the seventh sector of the northern coastal international road (the reconstruction axis), 130 acres were deducted for the establishment of the international park, and 40 acres were deducted for the expansions of the sewage project in Alexandria (Qamar et al., 2018). By the beginning of the twenty-first century, the lake became 50 km^2 due to those encroachments. In addition, the lake became over-polluted due to misuse of the lake water body (Figure 1).

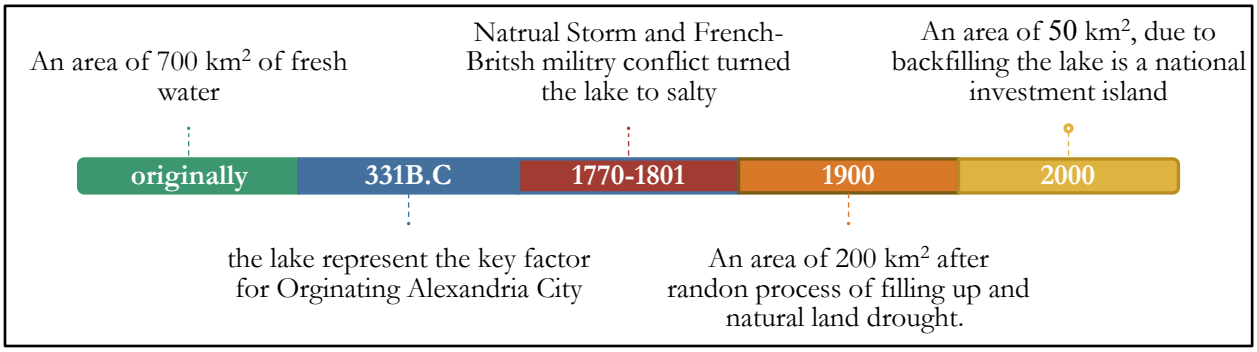


Figure 1 A timeline illustrates Mariout lake's history.

3.1.1 The inherited socioeconomic dimension

over time, the shrunk process in the lake's surface, whether by backfilling or natural drought factors, decreased the number of people living on Mariout Lake to minimum levels. While across history, the lake represented a flourished southern board for Alexandria city, as the following (Figure 2):

- Till 1801 the lake was a strategic point for maritime trade in Egypt; it connected the outboard maritime trade through the Naucratis Canal that reaches the Mediterranean to the inboard maritime trade through the Canopic branch that connects to the Nile.
- Throughout history, the lake has represented a source for fisheries; it harbored types of fish since it was fresh and until it became salty, noting that the current pollution of Mariout Lake has caused a severe decline in fishing wealth and activities.
- Since 1801, after becoming brackish, the lake became salinas and a source of salt refining in its western sector, resulting in another economic dimension to its natural ingredients.
- Since the mid of the twentieth century, the approach was to turn the lake’s range into an industrial area; it has caused substantial ecological problems and immense pollution; the lake has suffered both air pollution due to factory smoke and water pollution due to the continuous dumping of huge and ongoing quantities of industrial drainage, agricultural drainage, livestock barns, and untreated sewage, which causes a loss of biological balance. The aquatic environment has become saturated by Hydrogen sulfide (H2S); it is a chemical, colorless chalcogen-hydride gas, toxic, caustic, and combustible compound; tiny levels in the ambient environment, it emits a distinct rotten egg stench, which requires chemical solutions.
- By The beginning of the twenty-first century, the government had attempted to purify and treat the water of the lake; as a result, the lake range has been populated by 63,493 inhabitants, which is about 555.2 km², resulting in a Population Density of being14.4/km² according to 2021 data records (Al-Iskandariyah (Governorate, Egypt) - Population Statistics, Charts, Map, and Location, 2020).

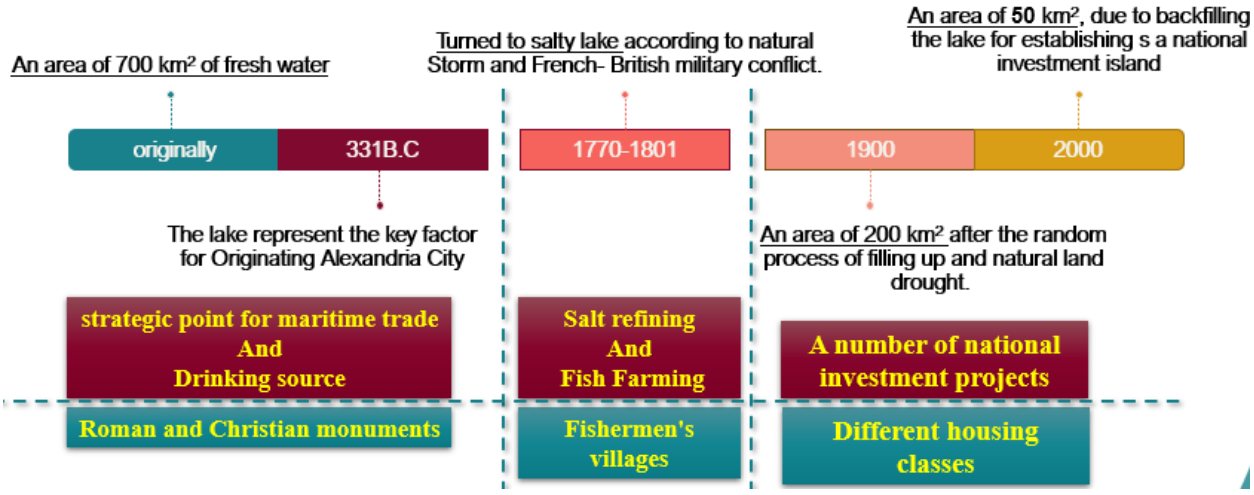


Figure 2: A timeline illustrates the socioeconomic dimensions of Mariout lake across history.

3.1.2 The lake's modern environmental degradation

Mariout Lake was ranked in 2009 among Egypt's most polluted areas with industrial waste. Mariout lake suffers severe aquatic environmental deterioration according to the encroachments mentioned earlier; those encroachments caused a significant decrease in fish wealth, a decrease in the biological diversity of its organisms, an increase in the concentration of heavy metals, a reduced the percentage of dissolved oxygen, and an emitted foul odor for lake surface. They noted that the pollution had infected the fish's wealth due to depending on their diet on plant residues that contain a high percentage of these elements (Figure 3).

The water body became formed of about 12 million cubic meters of drainage that drains into the lake daily, of which 60% is agricultural drainage, 22% is another agricultural drainage from the Nubariya Canal, and 10% is untreated industrial sewage. Primary treated sewage from the Qalaa Drain (Eastern Purification Plant) and 3% of primary treated sewage through the Western Purification Plant. However, the proportion of sewage water represents about 0.5% of the total inflow of the lake compared to agricultural drainage, which amounts to about 91% of the incoming water.

Notably, pumps of this mix raise the water level in the lake to preserve some nearby neighborhoods from landslides and collapse. Still, the water level declined significantly, not allowing the fish wealth to multiply; this water level in the lake threats the natural aquatic environment.

By the end of the twentieth century, there was a proposal to drain the lake by removing its waterbody and shores to use its large area for urban expansion. People interested in environmental affairs warned of this action as a natural environmental catastrophe; the environmental problems in this region will further become complicated as one of the essential city's features of nature will vanish. They demanded the urban preservation of the lake as an environmental, economic, and social formation. This vision calls for an urban expansion towards the west "Northern Coast" and linking those areas with the city's public roads and transportation networks. Also, it calls for the reclamation and cultivation of desert lands in the lake region, which leads to the preservation and economic development of surrounding communities around the lake shores.

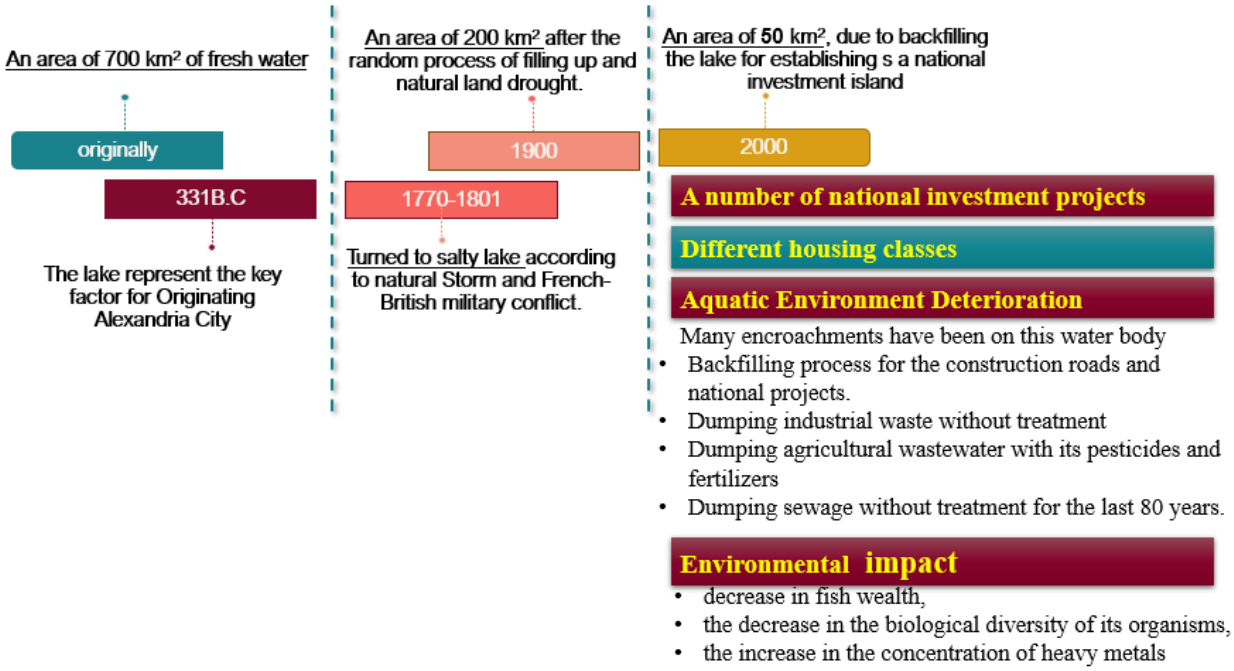


Figure 3: The gained aquatic environmental deterioration of Mariout lake across history.

3.2 Alexandria City's urban formation:

A Sequel to the aforementioned historical summary of Alexandria city's inherited legacy, it represents Egypt's second-largest city and the second capital, with strategic value at the political, economic, and commercial levels.

3.2.1 The direction of urban growth:

Across history, the city has been extended eastward along the Mediterranean coast for about 40 km as an urban strip formation (Figure 4). The city is located at 31.2 latitudes and 29.9 longitudes, bordered by the Mediterranean Sea on the north, Mariout Lake on the south and west, an agricultural region as a natural Green built on the south, and Abu Qir Bay on the east.

The city's area is up to 2,900 km2, distributed in nine contiguous districts (Table 1). The population is about 4,439,869 inhabitants, representing a density of 2,366 inhabitants/ km2 (Al-Iskandariyah (Governorate, Egypt) - Population Statistics, Charts, Map, and Location, 2020). The Annual Population Change is 1.1%. as recorded from 2017 to 2021 (Al-Iskandariyah (Governorate, Egypt) - Population Statistics, Charts, Map, and Location, 2020). The city's urban growth followed the Hippodamian planning as a crisscross grid along with the urban growth (Figure 5). The gird is perpendicular to the coastline, resulting in a precise formation of streets parallel to the coast. The urban mass is highly dense; according to the rate, the urban built-up area is about 75%, with a highly urban extending average of 3% annually (Atlas of Urban Expansion, 2020). The built-up area is about 68%, the suburban area is 10%, the rural areas 1%, and the urbanization open spaces are 22% (Atlas of Urban Expansion, 2020). In addition, the details of urban land use are listed in Table 2

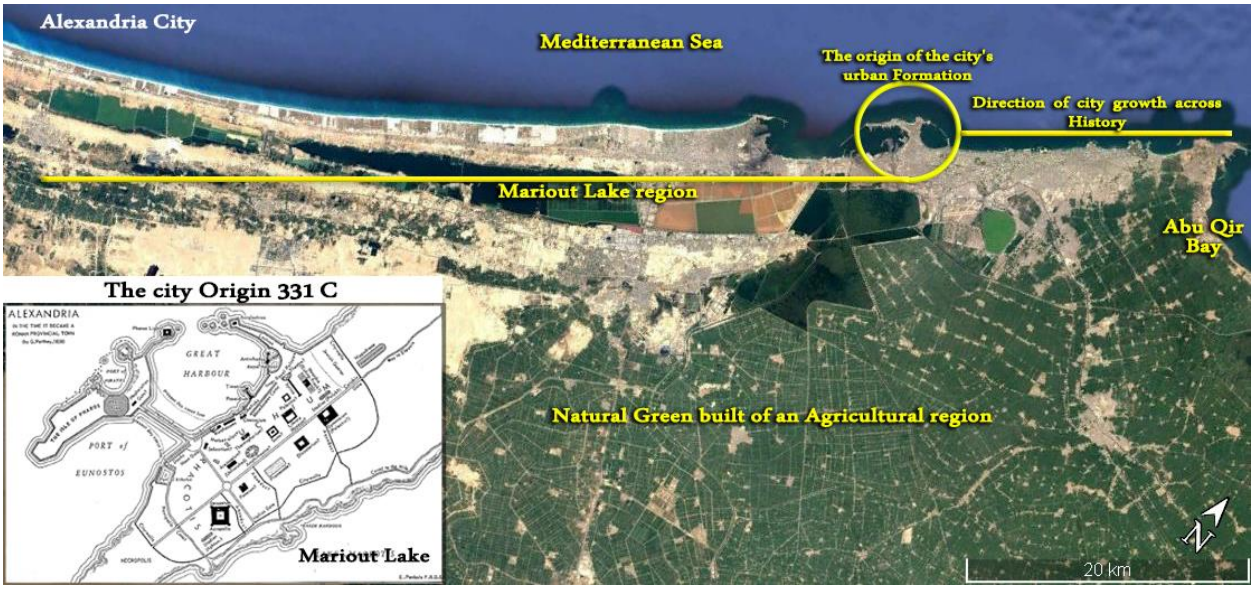


Figure 4: The existing urban formation gained across the history of Alexandria City.

Table 1.The population of Alexandria city districts (*Al-Iskandariyah (Governorate, Egypt) - Population Statistics, Charts, Map, and Location*, 2020)

DISTRICT	POPULATION	AREA KM2	DENSITY (PERSON/ KM2)
AL-MONTAZA	1,660,073	72	23,057
SHARQ	949,960	35	27,142
WASAT	793,741	31	25,604
AL-GOMROK	526,696	5	31,960
GHARB	910,444	39	23,345
AL-AMREYA AND AL-AGAMY (MARIOUT LAKE RANGE IS INCLUDED)	526,696	1249	422
BORG AL-ARAB (MARIOUT LAKE RANGE IS INCLUDED)	178,324	743	420
TOTAL	5,441,866	2,300	2,366

Figure 5: The urban density in the direction of city growth.

Table 2.Urban land uses across the Alexandria region (AASTMT & Egis BCEOM International, 2011)

CLASSIFICATION	AREA (HECTARE)	PERCENTAGE
RESIDENTIAL ARTIFICIAL TERRITORIES	18041.69	7.65%
INDUSTRIAL AND COMMERCIAL AREAS	4875.95	2.07%
HANGAR AND WAREHOUSE	558.33	0.24%
AIRPORTS	4146.97	1.76%
PORT AREAS	544.43	0.23%
FACILITIES	2285.1	0.97%
CEMETERY	74.71	0.03%
MINES, LANDFILLS, AND WORKSITES	4654.92	1.97%
URBAN GREEN AREAS	154.45	0.07%
SPORTS AND LEISURE FACILITIES	405.72	0.17%
AGRICULTURAL TERRITORIES	94886.01	40.22%
ORCHARDS AND SMALL FRUIT	2024.99	0.86%
OPEN SPACES WITHOUT OR WITH LITTLE VEGETATION	9549.83	4.05%
BEACHES, DUNES, AND SAND	72150.81	30.59%
SABKHA	647.89	0.27%
RIVERS AND WATERWAYS	17861.46	7.57%
FISH FARM	3031.13	1.28%
TOTAL	235894.4	100.00%

3.2.2 The city's prevailing climate and recent change:

Due to the city's location, the prevailing climate has good potential, located at Latitude 31.5 N, Longitude 29.6 E, and Altitude: 7, suited in a moderately hot, humid region, as shown in Table 3, which characterizes the climate data as the following:

For temperature, in winter, the lowest temperature record was 0°C, with a monthly average of 11.2°C; the coolest month is February. In summer, the highest temperature record was 43.8°C, with a monthly average of 32.9°C; the warmest month is August. The monthly average is 19.6 °C in autumn and 21.3°C in spring.

For the relative humidity RH%, the average annual relative humidity is 67.2%, and average monthly relative humidity ranges from 65% in April "as the least humid month" to 78 % in August "as the most humid." The lowest humidity record was 61%, and the highest record was 96%.

Daylight intensity has high rates, especially at noon. On average, it is sunny for 82% of daylight hours; the shortest day is 10:39 hr./day in December, and the longest is 14.1 hr./day in August. Other daylight hours are low sun intensity, cloudy, or hazed hours. The sun altitude at noon is intense, with an average of 59.2° above the horizon; the highest angle is 82.2° in august, and the lowest is 47.9° in December. The city is exposed to high solar radiance intensity for long hours or the sun's angle (Figure 6).

The prevailing wind direction is the northwest wind, the wind with rain, primarily seen in January. While "Khamsin" is the gusting wind, its direction is southwest as a dusty, hot, and dry wind. This unlikely wind lasts fifty days during those months, starting from late February but does not extend until early June; its maximum speed is 140 km/h. Notably, according to the city population, the outdoor atmosphere comfortable may be less than 16 liters per second per person in some open spaces.

Table 3. Shows the average data climate during 2022average data climate (Alexandria - Wikipedia, 2022; Temperature - Alexandria - Climate Robot Egypt, 2022)

		Winter			Spring			Summer			Fall			Year
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
Record high Temperature °C		31.0	33.3	32.9	40.0	41.0	45.0	43.8	43.0	38.6	41.4	38.2	35.7	45.0
Average high temperature °C		20.1	20.4	20.1	21.0	26.0	29.5	29.2	32.1	32.9	31.1	28.7	26.0	24.6
Average low temperature °C		12.2	11.4	11.2	11.9	14.5	18.6	21.4	25.0	25.6	23.6	20.1	17.6	17.8
Record low Temperature °C		1.2	0.0	0.0	2.3	3.6	7.0	11.6	17.0	17.7	14	10.7	1.0	0.0
Average RH%		68	69	67	67	65	66	68	73	78	69	68	68	67.2
Highest RH%		79	78	71	76	79	84	88	89	96	80	74	70	80.3
Average Day length (hr.: min)		10:39	10:14	10:24	11:01	11:56	12:53	13:22	13:54	14:1	13:16	12:23	11:26	12:15
Sunny Daylight		73 %	69 %	73 %	78%	81 %	86%	87 %	90%	92%	89 %	77 %	70 %	82%
Sun Altitude at noon on the 21st day		47.9°	35.4°	38.9°	47.9°	48.2°	59.1°	70.7°	79°	82.2°	79.2°	70.9°	59.4°	59.2°
Average Wind	Prevailing Km/h	12.7	13.2	12.7	15.6	14.5	13.6	14.9	15.5	13.7	15.1	13.0	10.1	13.7
	Dir.	WSW	WSW	NW	NNW	NW	NW	NW	NW	NW	NNW	NNW	NNW	NW
	Guest Km/h	-	-	5.6	11.2	45.3	12.2	4.3	-	-	-	-	-	6.7
	Dir.	-	-	SE	SE	SE	SE	SE	-	-	-	-	-	SE

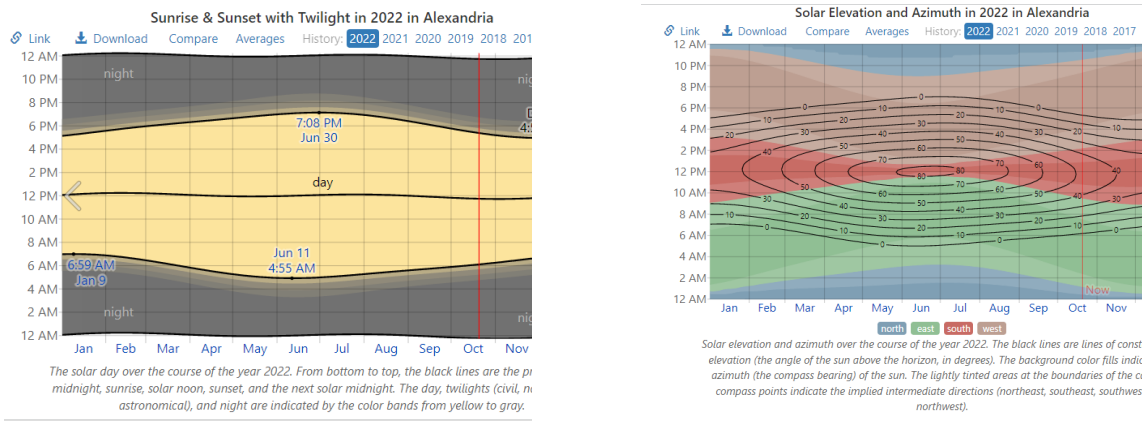


Figure 6: shows the prevailing shiny hours and solar elevation; the charts show high radiance exposed to urban spaces in Alexandria.

4. Urban Analysis: the city's ecological issues.

The city's prevailing climate data reveals a potential that meets the EQ Standards. Table 4 shows the ranges of city data climate compared to EQ Standards, where the averages meet the EQ data in urban spaces; mainly, the temperature is likely as hot in summer as warm in winter. The humidity is reasonable in the winter but severe in the summer, according to the hot temperatures. The wind is reasonable all over the year, except for the guest wind in spring, which is unlikable and dusty.

Table 4. The EQ standards and local climate statistics recorded

		EQ Stander Levels	Alexandria City prevailing climate (Suit the EQ Standers)									
			Average			Highest record			Lowest record			
Temperature	Winter	19°C to 21°C	15.3			29			5			Warm winter, hot summer, as a city suited in a hot, humid region.
	Summer	20°C to 22°C	24.9			43.8			16			
Daylight	Winter		11.3hr.	72.1%	57.9°	12:30hr.	81.3%	80.1°	9:58hr.	63.2%	34.2°	Intensive radiance rate and high hour rates
	Summer		12.9hr.	85.6%	71.6°	15.48hr.	94.1%	85.1°	11.3hr.	75.1%	61.6°	
Humidity	Winter	Above 40% (20.5-25.5°C). Above 70 % (20-24°C).	65% (15.3)			87%			59%			Moderate rate of humidity
	Summer	Above 40% (24.5-28°C). Above 70 % (23-25.5°C).	67% (24.9).			89%			43%			high rate of humidity
Wind Movement	Winter	0.72 to 1.44 k/h.	17.1 k/h			94 k/h			4.9 k/h			Reasonable wind movement around the year

Still, the up-to-date data climate results from a state of climate data ascension (Table 5); it shows the average temperature in the last ten years, which indicates a rise in the averages; it implies that the average data climate in table 3 is higher than typical region rates.

Table 5.The ascension of average temperature around the last ten years (Temperature - Alexandria - Climate Robot Egypt, 2022)

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
°C	12.9	13.7	15.0	13.9	13.8	11.9	14.7	12.8	13.9	16.0

4.1 Turning from maritime climates to continental:

According to its location, Alexandria city has enjoyed that maritime climate; nevertheless, the average data climate in Table 3 shows a continental climate, where the difference between the average day and night temperatures and the average differences between the summer and winter temperatures is getting higher. Table 5 proves the average temperature ascension over the last ten years. Figures 7 show the recent climate monitoring in 2022 till October; Figures 8 and 9 show the climate change throughout the last forty years; there is a severe escalation in climate data averages according to many factors, which is out of the research scope. Briefly, there is an elevated summertime temperature, malfunction of rainwater annually, and less windy days; it is a severe climate condition regarding the privilege of a maritime climate.

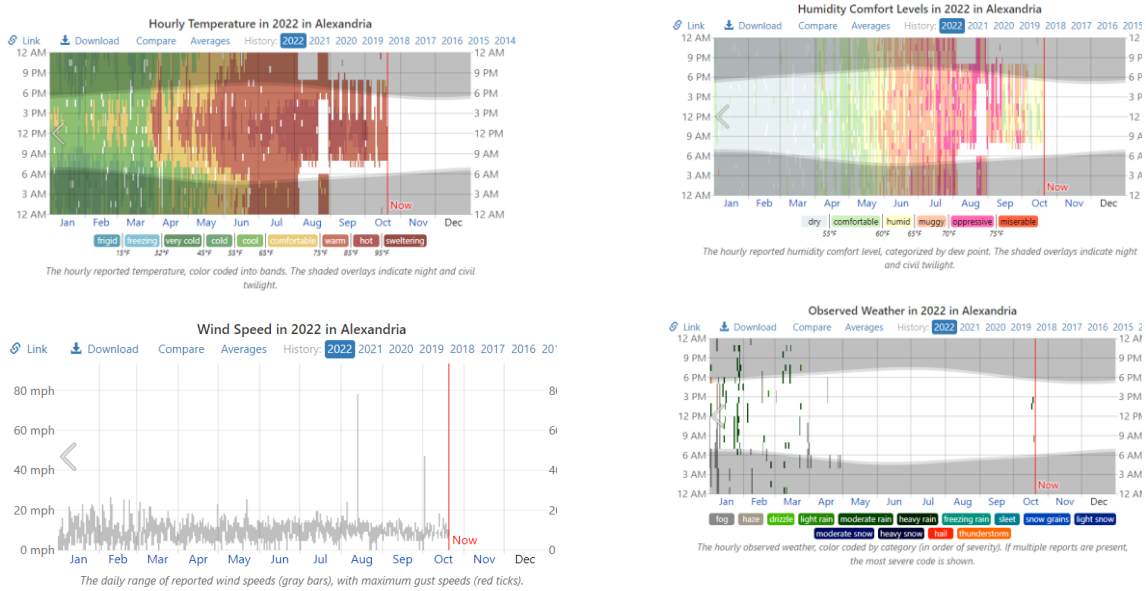
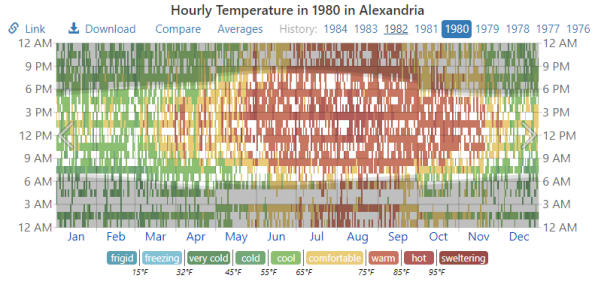
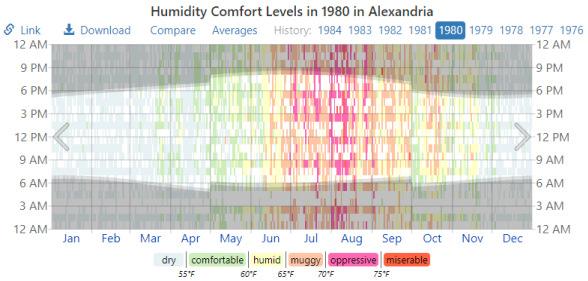


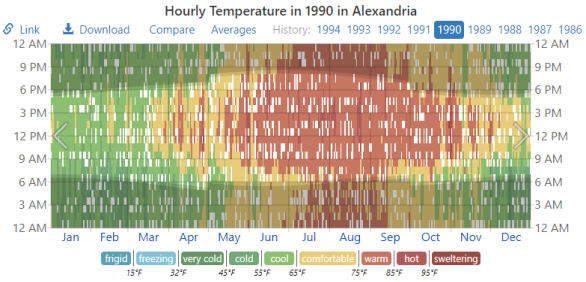
Figure 7: Different charts show the current status of climate data from 2022 till October.



The hourly reported temperature, color coded into bands. The shaded overlays indicate night and civil twilight.



The hourly reported humidity comfort level, categorized by dew point. The shaded overlays indicate night and civil twilight.



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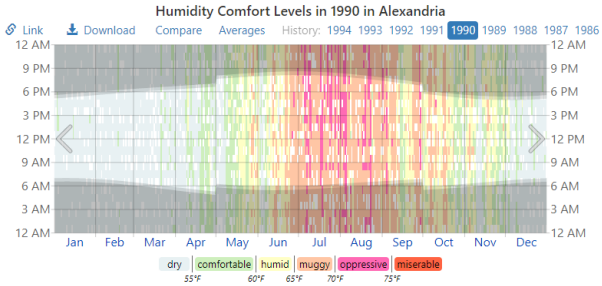
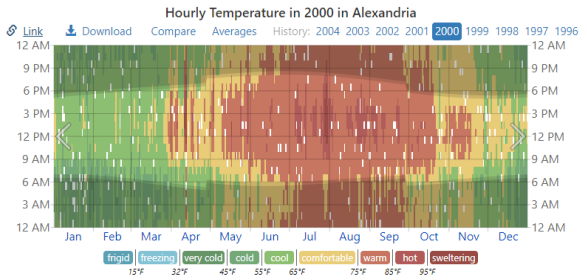
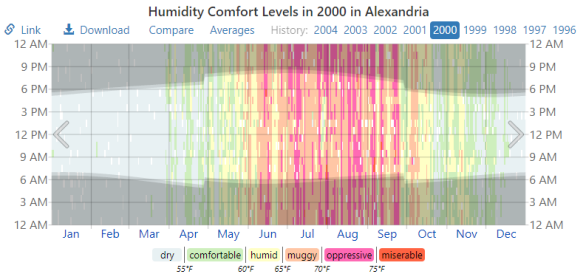


The hourly reported humidity comfort level, categorized by dew point. The shaded overlays indicate night and civil twilight.



The hourly reported temperature, color coded into bands. The shaded overlays indicate night and civil twilight.



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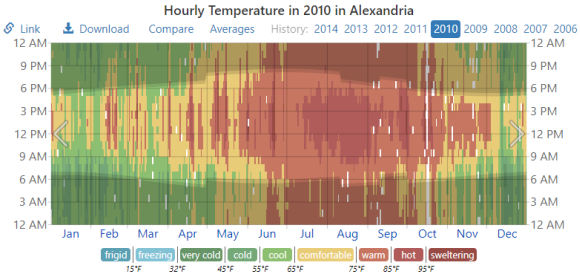

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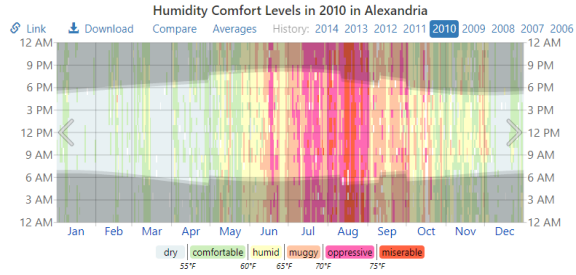

The hourly reported humidity comfort level, categorized by dew point. The shaded overlays indicate night and civil twilight.

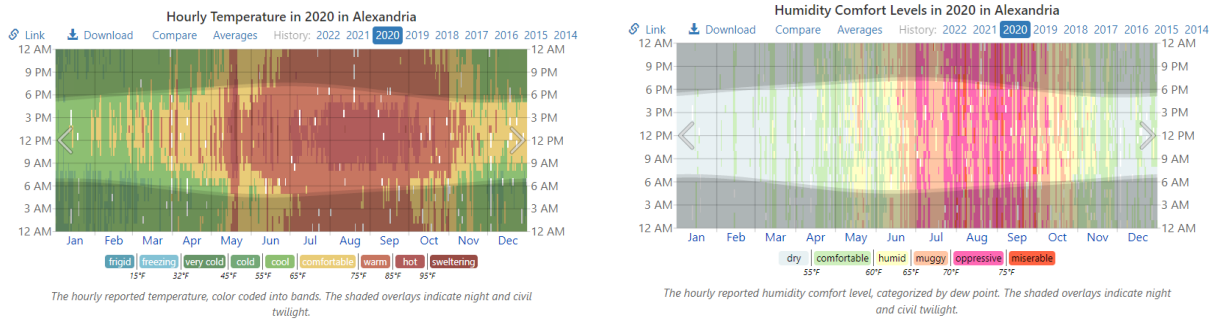

Figure 8: The ascension in temperature and humidity data over the past forty years shows the data within every ten years.

Figure 9: Sever escalation of Climate data over the past forty years; charts show the ascension every ten years.

4.2 Formed Urban Heat Island

Based on the data comparison in Table 4, the climate data suits the optimal EQ standards in urban areas. Nevertheless, the city is exposed to the urban heat islands according to; first, the gained urban formation in the direction of urban growth with the urban density (Figure5), the massive built-up area, and the high record of the city population; second, the shiny hours, sun altitude, the daylight intense, the range of radiance hours (Figure 6); third, the escalation of Climate data over the past forty years (Figures 8, 9). All these factors cause a difference in climate data between the measured in urban spaces and the monitored by meteorologists. An urban heat island is an exposed area to differences in temperature according to the urban density and population. For a million inhabitants in a city, the annual mean air temperature is in the range of 1 to 3°C warmer than the surrounding areas, five times in Alexandria city according to its population rates. In addition, global climate change increases the situation (Figure 10).

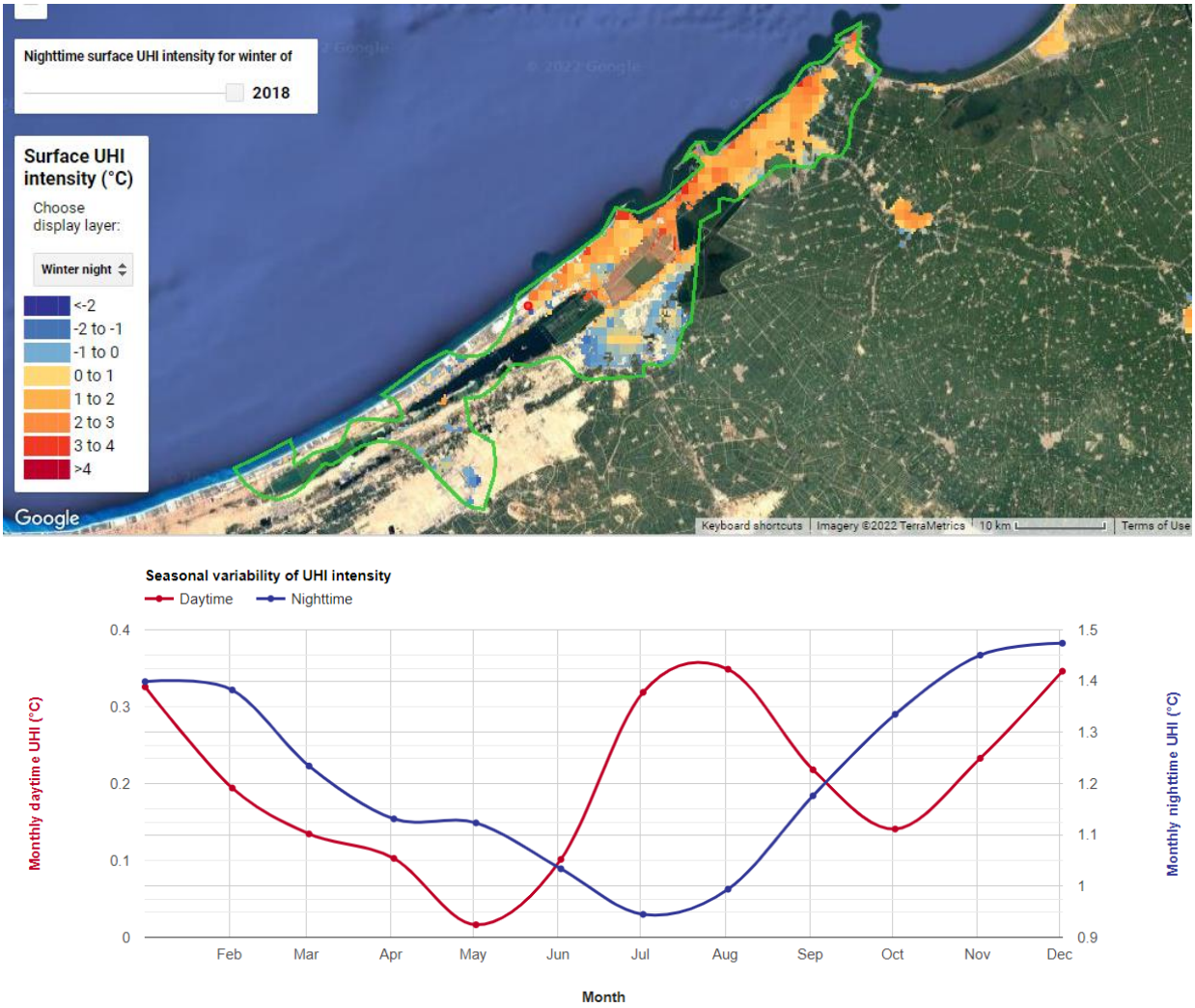

Figure 10: Monitoring urban heat islands on the urban mass in the province of Alexandria, Maroiut lake act as a lug for the areas. (Global_Surface_UHI_Explorer, 2022).

4.3 Marine Submersion Risk of the city coastline:

The significant environmental risk facing Alexandria city in light of global climate change is exposure to Marine Submersion Risk. It is worth noting that the fear of the city's sinking is taken seriously, as it has been repeated throughout history more than once. The most recent incident of the sinking of the city of Alexandria was in the fourth century AD, which led to the city being completely buried under the streets of the current city. This confirms that the city's geographic location and geological structure are vulnerable to drowning, affected by environmental and climatic factors.

The predicable drowning issue is connected to the city region ranges between -5 and 57 meters above sea level (Figure 11); the elevation of the dense urban area along the direction of urban growth ranges between zero and 18 meters above sea level, in contrast to the Mariout lake range, which ranges between 18 and 57 meters above sea level. Many projects took place to evaluate the extent of the environmental damage to the city. Figure 12 displays projections of areas exposed to flooding or erosions by 2030 (AASTMT et al., 2011)

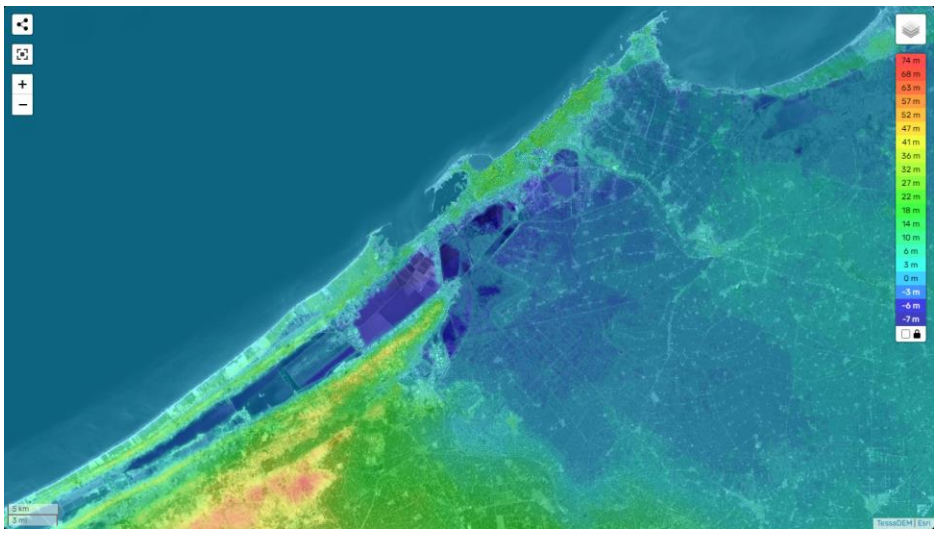

Figure 11: A map illustrating the elevation of the Alexandria City region land above sea level (Egypt Topographic Map, Elevation, Terrain, 2022).

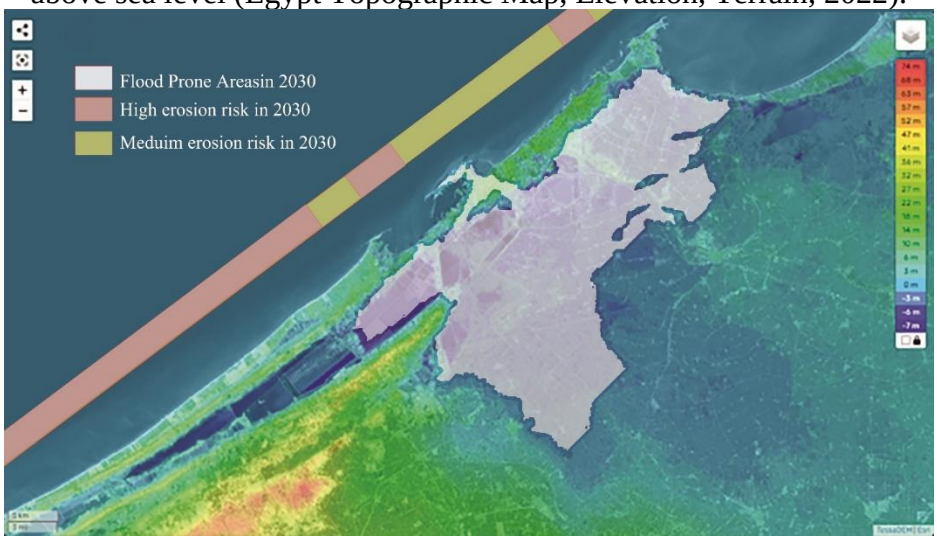

Figure 12: Areas exposed to marine submersion risk in 2030, edited by the author (AASTMT et al., 2011; Egypt Topographic Map, Elevation, Terrain, 2022)

According to the official measurements of the water level of the Mediterranean on the coasts of the city of Alexandria, the sea level has increased by 3.4:8 mm/yr. (AASTMT et al., 2011). Over the last 14 to 60 years. The coastal area is at risk of submersion, which is evident from the effects of storms in the winter season. Usually, water levels rise 60 cm above average, which can submerge the city's shoreline; however natural ridges or sea walls protect low-lying locations near Mariout Lake.

Consequently, Coastal Erosion is a risk that faces the city's coastline; some parts are seriously eroding areas, some are occasionally eroding areas in times of tsunamis or coastal storms, and some are safe according to their land elevations. In addition, the land elevations and the rains during the winter cause possibilities of a low risk of floods due to where most of the urbanized areas are below sea level. Noted that those floods usually do not exceed a few hours, still, a risk faces most of the urbanized areas of Alexandria city, which causes temporary traffic disturbed (AASTMT et al., 2011).

5. Results and Discussion:

The research sought to rely on Lake Mariout as an approach to achieving the ecological balance for the Alexandria City region based on their reciprocal environmental history. Throughout history, Mariout Lake has had an essential role as a supply of drinking water, providing agricultural investment, fishing, antiquity maritime trade, and supporting Alexandria city’s geological balance; besides, the lake’s area and nature represent a natural lung for the city according to monitoring maps of urban heat islands (Figure 10).

5.1 Resulted Ecological Issues and Socioeconomic Potential:

Alexandria City’s current environmental issues are summarized in urban heat islands, increasing climate measurements, rising sea levels, and a marine submersion risk on the city coastline. In addition to environmental solutions from other disciplines, reducing population and urban density is essential to reducing carbon emissions in the atmosphere and the intensity of climate conditions. Moreover, reducing the population and urban densities makes it easier to deal with in times of emergencies such as tsunamis and sea level rise. The idea of redistributing the city’s density is authentic, even if it is a prelude to protecting it from the environmental dangers mentioned above.

Considering Lake Mariout as a solution to evacuate Alexandria city of population and urban density is a theoretically acceptable solution (Table 1), as the district's density varies between half to one million inhabitants, with an average density of 20 to 30 thousand inhabitants /km^2, Table 6 shows the dens of common land use for each district based on Tables 1 and 2. In comparison, the Mariout lake range's area has an average density of 0.40 thousand inhabitants/km^2. This case represents a misdistribution of densities, which can be dealt with by studying the origins of the urban formation for both the city region and the lake range to study the possibility of reconstructing the lake area to achieve environmental harmony in the city. Due to the dual historical impact, increasing the depth of Alexandria city's urban extension towards the south is axiomatic. There have been reciprocal urban diversity, whether residential, agricultural, commercial, or industrial, especially when the region's origin was fresh water, not salt. There, the Lake's range was densely occupied during Greco-Roman times (Flaux et al., 2021); initially, before this era (Stanley et al., 2007), it was a flourished urban center as part of the related town. This range was a flourishing commercial, agricultural, maritime, and residential center. This inherited socioeconomic dimension defines the layers of activities accumulated over time (Table 7).

Table 6.Alexandria city's urban formation issues. Overpopulation related to districts 'Social And Economic Factors

District	Population	Density (Person/Km^2)	Social And Economic Factors	Ecological issues		Required Density Adjustment
				UHI Intensity ℃	Flooding, Erosion Risk 2030	
Al-Montaza	1,660,073	23,057	Residential Artificial Territories Industrial And Commercial Areas Hangar And Warehouse Facilities Cemetery Mines, Landfills, and Worksites Urban Green Areas Sports And Leisure Facilities Agricultural Territories Orchards And Small Fruit Beaches, Dunes, and Sand.	3:4	Flooding Risk High Erosion	Reduce
Sharq	949,960	27,142	Residential Artificial Territories Industrial And Commercial Areas Facilities Sports And Leisure Facilities. Beaches, Dunes, and Sand.	2:3	Flooding Risk Medium Erosion	Reduce
Waste	793,741	25,604	Residential Artificial Territories Airports Facilities Cemetery	2:3	Flooding Risk Medium Erosion	Reduce

			Urban Green Areas Sports And Leisure Facilities Beaches, Dunes, and Sand Fish Farm			
Al-Gomrok	526,696	31,960	Residential Artificial Territories Port Areas Facilities Sports And Leisure Facilities Beaches, Dunes, and Sand Rivers And Waterways Fish Farm	3:4	Flooding Risk High Erosion	Reduce
Gharb	910,444	23,345	Residential Artificial Territories Industrial And Commercial Areas Hangar And Warehouse Port Areas Facilities Cemetery Beaches, Dunes, and Sand Fish Farm	2:3	High Erosion	Reduce
Al-Amreya, Al-Agamy (Mariout Lake range is included)	526,696	422	Residential Artificial Territories Industrial And Commercial Areas Hangar And Warehouse Facilities Cemetery Mines, Landfills, and Worksites Agricultural Territories Open Spaces Without or With Little Vegetation Rivers And Waterways Fish Farm	-1:0		Raise
Borg Al-Arab (Mariout Lake range is included)	178,324	420	Residential Artificial Territories Industrial And Commercial Areas Hangar And Warehouse Facilities Cemetery Urban Green Areas Sports And Leisure Facilities Open Spaces Without or With Little Vegetation Rivers And Waterways Fish Farm	-1:0		Raise
Total	5,441,866	2,366				

Table 7.The inherited socioeconomic formation of the Mariout Lake region.

Origin	*Potential*		*Regenerating the existing*	*Expected land use*
A source of fresh water	The geological origins of the region are freshwater		Reclamation of agricultural lands.	Agricultural Territories.
Fishery activities	Requires chemical and physical purification	Fish farming.	Fishery activities settlements.	Fishing Territories.
Trading harbor	No recent impact	A closed lagoon now.	Recreational harbor in the closed water body, and seasonal trips.	Recreational Territories.
Migratory birds	Seasonal			
Salt refining	An existing activity.	Factories.	Industrial sectors.	Residential Artificial Territories.
Natural ambiance	Available shores.	Corniche.	Touristic communities.	Recreational communities.
				Service sector: desalination for sewage, agricultural, and industrial drainage.

Table 7 shows the inherent urban economic and social factors that originated in the lake's rage; they represent the potential that facilities attract urban expansion from Alexandria city to the lake shores according to the recent economic activities among the social formation of each district in Table 6.

5.2. Discussing the Urban Regeneration Possibilities for the Lake's Range to support the City's Region Ecologically:

5.2.1 Urban Environmental Regeneration

Regeneration is an area-based concept, focusing on land areas' characteristics to rehabilitate the land uses through environmental improvement. The process mainly aims to restore the origin of the environmental formation of the spaces by developing eco-friendly solutions (Maciej Serda et al., 2013), such as green spaces, enriching green belts, redeveloping brownfield sites, and managing sufficient water bodies, if it is necessary, in cityscapes.

Based on the principle of "**work with the Landscape**," the recent Mariout Lake basin is 50 km^2 and is a part of the original 700 km^2 on the one hand. The digital elevation maps show that approximately 900 km^2 are likely exposed to flooding and marine submersion by 2030 (Figure 11, 12). On the other hand, restoring the Mariout Lake's drought areas as standby basins to absorb and store the inundation water that threatens the areas concerned is an ecological approach to revive the urban environmental dimension (Figure 13).

Applying the mentioned principle is to recover the balance between the natural origins as an eco-friendly solution. Moreover, considering the drought area of the lake as a standby space to absorb expected flood water of the city is compatible with the principle of "**Enrich the Existing**"; it enriches the qualities of existing lake urban formation by restoring the ecological balance of the entire region, as is based on the response the space setting and complementing with the current situations.

For more explanation, initially, the lake was fed from the south by a Canopic branch and linked to the Mediterranean Sea by Naucratis Canal from the north. Nowadays, the lake is more likely defined as a lagoon as it is a closed water body with no linked channels to revive or filter its nutrition to manage the degree of contamination. Applying the expected flooding water to the current aqueous composition of agricultural drains, industrial drains, sewage, and rainwater drainage may be a natural filtration for the lake water body.

As a previous experience of this approach, Mariout Lake saved the city of Alexandria from the famous flood crisis in 2015 and absorbed the amount of water from the drains and rainwater drainage in the city and the neighboring agricultural lands (Ahmed Hassan, 2019). Besides, restoring the lake enhances the medicinal environment of migratory birds and some rare birds that live in the surrounding, increasing the amount of dissolved oxygen and reducing the number of heavy metals in the water, which restores the biological balance. Back to applying the principle of "**Work with the Landscape,**" the approach promotes establishing recreational territories where the lake shoreline enjoys an ambiance of recreational activities, such as fishing, visiting salt refinery sites, and watching migratory birds in hunting seasons.

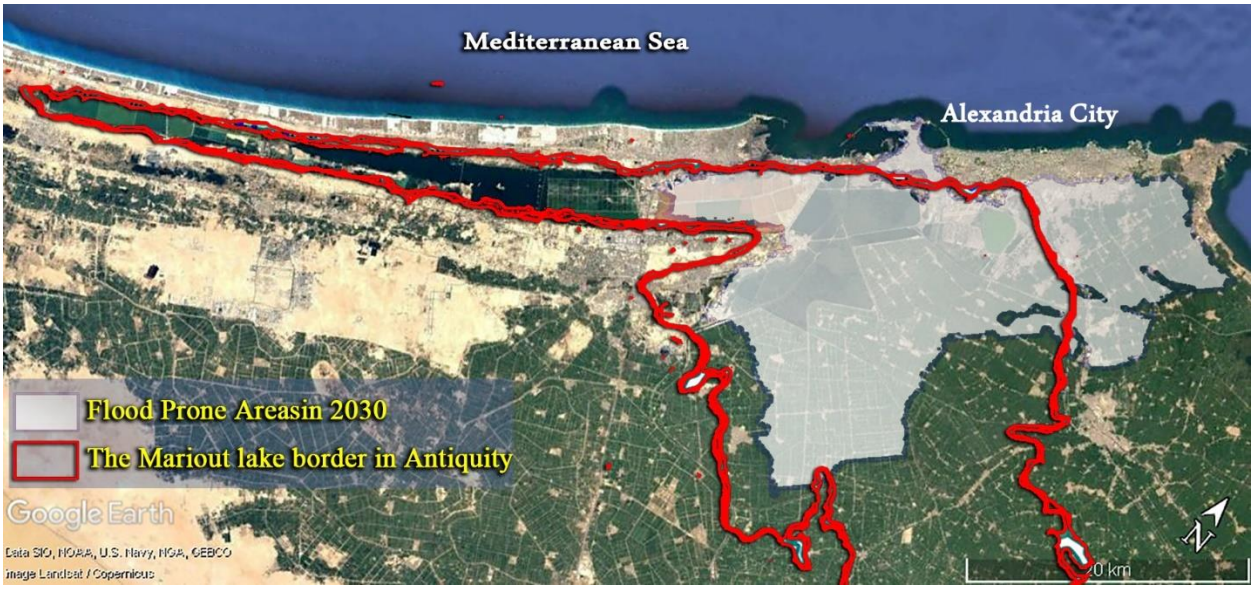

Figure 13: The map illustrates a current representation of the city based primarily on satellite imagery, an approximate depiction of the Mariout lake boundaries, and the monitoring of expected flood areas in 2030.

Applying the abovementioned principles may cause a deduction from the urban and agricultural areas in the city (Figure 13). However, it gives two advantages other than absorbing the inundation water expected by 2030, which are: First, a large sector of the land expected to be inundated by 2030 will be prepared to be part of the lake basin, the second is the lake shoreline will be increased by about 70 km, which provides a more waterfront for economic and social redevelopment.

5.2.2 Urban socioeconomic regeneration:

Urban socioeconomic regeneration is an approach to restructuring urban distortions by providing radical deliverables based on the origins of urban formations' potential, considering that economic regeneration targets reinvigorating local economies through inward investment and relocating businesses and households in neglected areas. In the case of relocating the economic activities outside Alexandria city, similar cases found tremendous success as vibrant destinations for the central sector of the city's inhabitants by the two regional city's entrances (Yoseph, 2017); the investors and stakeholders sought new sanctuary for to start businesses in open cheaper land than expensive ones inside the city. Table 6 shows the wide variety of economic activity types for each residential district, which might be the cause of the relocation process's success.

Accordingly, the meant regenerating process relies on the inherited socioeconomic formation of the Mariout lake range (Table 7) as its server relocating the economic activities in overpopulated districts in Alexandria city (Table 6). Here, the regeneration process target users that settle in Alexandria city and seek to practice their economy in new areas. The process also relies on community contexts. Therefore, the reliable principle for the process is "**Manage the Investment**"; the inherited economic dimension (Table 7) is the viable economic potential that suits the market considerations of developers in the city (Table 6). That inherent potential fits the economic situation for the Alexandria city community, which are fish farming, agricultural territories, commercial areas, industrial territories, salt refining factories, residential artificial territories, mines, landfills, and worksites based on desalination plants for drain and sewage water (Table 4, 6). Notably, applying those deliverables concerns land owners around the Mariout lake ranges, such as ministries, institutional entities, individuals, and majorly owners under squatter law. Meanwhile, managing the investment targets the land owners to plan a map road based on the viable economic potential they can provide or adopt that suit the future developers' market considerations in the city region.

This starting point for an adaptive and resilient economic regeneration also applies the other principle, "**Design for Change**"; this principle manages the flexibility in designing uses, which could be established by pairing projects with suitable variety. For example, constructing orchards and small fruit is related to agricultural activities; residential artificial territories and hangars and warehouses are related to industrial activities; sports, beaches, and leisure facilities are a service for accommodating resident territories. The optimal target of applying this principle is reducing consumerism at many levels by connecting similar uses in the same area with the same services facilities, which sustain the resource and decrease consumption in the urban context. Moreover, responding to future requirements in a flexible application requires considering urban context formation.

In the case of lake Mariout regeneration, the recent natural formation of the lake border allows extending the original gridiron planning originated in Alexandria city while applying the proposed approach by restoring the original border in antiquity allows more spontaneous urban solutions around the lake shores; this application concerns managing the required permeability in urban spaces use. Agricultural and industrial activities are more likely to be in gridiron planning for applying the irrigation and sewage systems, while other activities could be applied in a spontaneous grid in planning. This sequenced process is based on the uses' flexibility in the urban context, which supports resource efficiency and decreases energy consumption.

Holistically, the economic regeneration activities open the door for the social dimension in designing the urban context; here, the process requires applying the principle "**Places for People**," where the mentioned diversity of land uses supports creating a vibrant place by offering opportunities to meet people's demands comprehensively. For example, the mentioned economic activities earlier impose establishing facilities, cemeteries, and urban green areas as a must; accordingly, briefly, the holistic activities promote compatible and integrated uses inside the same districts for enhancing city life.

Simultaneously, applying the principle "**Mix Uses and Forms**" regenerates integrated and comprehensive land uses in the available space lands in the lake range, where the inherited socioeconomic and natural formation of the lake range support achieving all types of land uses such as agricultural, residential, industrial, mining, and recreational uses. On the other hand, the related land uses as integrated and comprehensive activities support adopting various demands that meet people's needs. For example, the fishery and salt refining activities support raising villages for fishing and small industrial villages; reclamation of agricultural land is a stand-alone activity representing a specified settlement; constructing recreational harbors in a closed water body, and tourist communities are compatible with leisure projects; creating specialized industrial sectors by constructing industrial activities and service facilities of desalination for sewage, agricultural, and industrial drainage form. The point is to present an integrated and compatible community within each settlement.

6. Conclusion and Recommendations:

The marine submersion risk threatens Alexandria City within the next ten years; Alexandria City has also suffered over the past forty years from the impact of climate change, such as the serve rise of heat intensity in summer, air movement stagnation in winter, forming urban heat islands, and the increase in the difference between the temperatures of the night, day, summer, and winter, although Alexandria enjoys a maritime climate. This change negatively affected the environmental quality (EQ) in urban spaces according to other urban reasons, such city's building density in light of its prevailing climate, the encroachments on the southern agricultural region that shapes a natural green belt bordering the city, besides the current environmental degradation of Mariout Lake that has a reciprocal ecological history within Alexandria.

The study does not admit that the lake's current environmental degradation is the only reason for the city's ecological issues, as mentioned earlier; it is a critical reason, among others. Still, the research points to the Mariout lake range as an evolutionary approach for a sustainable redevelopment to solving the environmental issues within Alexandria city's region. The mutual history between the lake and the city, proved by a history of scientific research, dictates this view.

An urban socioeconomic regeneration process for the lake range based on its valuable inherits proposed a comprehensive and holistic redevelopment process that can sustain the ecological dimension of the city region. The study followed a sophisticated analytical process to characterize the lake range potential and the optimal way for a holistic regeneration process to serve the city region ecologically, socially, and economically. Optimally the proposed scientific approach mitigates the impact of climate change, facilitates dealing with the destructive consequences in expected crisis times, and supports the decision-making for future urbanization processes regarding sustainable redevelopment.

6.1 Recommendation for Regeneration Process:

The study proposed a theoretical framework for the urban regeneration process of the Mariout lake's range for the benefit of Alexandria city's region based on academic disciplines; it aimed to facilitate decision-making processes for the required sustainable development. The fruitful objectives could support an urban scenario of sequential procedural steps as a proposal for rehabilitating process as the followings:

6.1.1 Formulating phase: Legalization enforcement:

This phase concerns managing the environmental balance around the Mariout lake region; it targets enacting laws to set some corrective regulations to restore the biological balance for optimal urbanization process, such as the following:

A. Regulate land owing according to restoring process of the lake origin border, which better be gradual till 2030.

B. Regulate land allocation according to the required natural environmental management by allocating the required percentage of the residential, agricultural, recreation, transportation, and commercial land use around the expected lake shoreline. This action targets the land owners around the regions as ministries, Institutional Entities, and individuals; it also concerns urban decision-making by the involved pillars as planners, owners, stakeholders, and investors.

C. Establish several water purification plants around the lake shoreline for treating the incoming sewage, industrial, and agriculture drains because, like it or not, the lake will at least continue receiving the remnant of surrounding agricultural lands according to the nature of the lake range.

D. Manage the procedures for Alexandria's coastal zone sustainable development by redistributing the land use around the Lake range according to the allocation method.

This phase is based on the principles of "work with the Landscape" and "Enrich the Existing" for planning a road map for the ecological regeneration process mentioned before, by providing an urban context for expanding the natural lake's waterbody with proper land use, to mitigating the misuse of land use adverse effects.

6.1.2 Construction phase: Planning Strategy:

This phase follows an approach for enabling iterative, adaptive, and flexible actions to facilitate for urbanization process; it is a long-term plan of decision-taking with particular emphasis on high-level commitment from sound institutional structures. This phase offers investment opportunities based on redistributing population and urban density regarding ecological needs to reduce carbon emissions in the atmosphere and the intensity of climate conditions.

E. the first is flexibility in designing the urban context, to the extension of the natural urbanization of the city of Alexandria mixed with an urban renewal that is compatible with the shoreline of Lake Mariout to suit the desired diversity in the realization of economic activities.,

F. the second is holistic reviving for the economic project that originated within the lake rage

G. the third first is flexibility in designing economic activities, From the formation of packages of activities on one urban scale and within a diverse framework within each neighborhood

The principles of "Manage the Investment" and "Design for Change" are the basis of this phase; This stage is concerned with allocating lands for various economic activities by settling the original economic activities and attracting new economic activities, which works by those steps

6.1.3 Substitution phase: socioeconomic magnet:

This phase concerns control of the urban substitution, from the city region to the lake range; it is a management for sustaining communities and their being. The management includes the upcoming urban interventions to ensure the survival and continuity of new communities in the lake range and the equilibrium of communities whose density has been reduced in the city region. Here, the burden and responsibility fall on the New Urban Communities Authority to achieve the following:

H. To ensure, in a flexible method, the design of various community and economic services and activities within the districts.

I. To consider, in a comprehensive and compatible method, the uses within the residential neighborhoods according to the specific land uses types.

J. To manage the broader social, economic, and environmental implications of decisions-taking within old districts in the city and new districts in like range.

This phase follows “Place for People” and “Mix Uses and Form” rules to guarantee offering opportunities for achieving vibrant urban life; moreover, follow up emerging projects and investments to ensure the required diversity for the establishment of urban communities within districts, presenting a mixed land use in a balanced representation within the new ones in the lake range and the old ones in the city region that meets various demands.

6.1.4 Project monitoring: sustain the inherent and upcoming potential:

This sequenced process of applying the urban regeneration principles has a compatible reciprocal impact on urban redevelopment. the social regeneration by the principles of “Places for People” and “Mix Uses and Forms” support the impact of the principles of "Manage the Investment" and "Design for Change." the social development manages sustainable economic by monitoring the transient economic activities from the city region to the lake range and promoting social growth according to natural borders for the city region and lake range to create a vibrant settlement and desirable community for inhabitants. In the end, it is a sophisticated process that respects the natural green belt for Alexandria city and planning the urban context according to the lake shore; it is restoring the ecological aspect that enriches “Enrich the Existing” by concerning the existing urban formation and promotes “Work with the Landscape” by preserving the balance between the natural and urban environment, which control the negative impact of the redevelopment process and preserve the natural biodiversity of the city region and lake range.

7. References

1. AASTMT, & Egis BCEOM International. (2011). Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa Phase 1: Risk Assessment for the Present Situation and Horizon 2030-Alexandria Area.
2. AASTMT, Egis BCEOM International, IAU-IDF, & BRGM. (2011). Climate Change Adaptation and Natural Disasters Preparedness in the Coastal Cities of North Africa Phase 2 : Adaptation and Resilience Action Plan-Alexandria Area. http://www.egis-bceominternational.com/pbm/
3. Ahmed Hassan. (2019, June 1). Dr. Hossam Maghazi Writes: Lake Mariout, the Lung of Alexandria between Pollution and the Aspirations of the State. Agri2day. https://www.agri2day.com/2019/06/01/%D8%AF-%D8%AD%D8%B3%D8%A7%D9%85-%D9%85%D8%BA%D8%A7%D8%B2%D9%8A-%D9%8A%D9%83%D8%AA%D8%A8-%D8%A8%D8%AD%D9%8A%D8%B1%D8%A9-%D9%85%D8%B1%D9%8A%D9%88%D8%B7-%D8%B1%D8%A6%D8%A9-%D8%A7%D9%84%D8%A5%D8%B3%D9%83/
4. Alexandria - Wikipedia. (2022). https://en.wikipedia.org/wiki/Alexandria
5. Al-Iskandariyah (Governorate, Egypt) - Population Statistics, Charts, Map, and Location. (2020). https://www.citypopulation.de/en/egypt/admin/02__al_iskandariyah/
6. Atlas of Urban Expansion. (2020). http://atlasofurbanexpansion.org/cities/view/Alexandria
7. Belcher, E., & Kossivi, A. (2021, November 1). Day 1 - COP26 Update | GNDR News. https://www.gndr.org/cop26-update-day-1/
8. Burj Al-'Arap (Population Statistics). (2021).
9. Close, A. E., Schild, R., & Wendorf, F. (2012). Egypt During the Last Interglacial: The Middle Paleolithic of Bir Tarfawi and Bir Sahara East.

https://books.google.com.eg/books?id=IZXTBwAAQBAJ&pg=PA3&source=gbs_selected_pages&cad=3#v=onepage&q&f=false

10. Delivering Quality Places: Urban Design Compendium 2. (2007). www.urbandesigncompendium.co.uk

11. Egypt Topographic Map, Elevation, Terrain. (2022). https://en-gb.topographic-map.com/map-cbdnx/Egypt/?center=31.11703%2C29.8835&zoom=11&base=5

12. Flaux, C., Giaime, M., Pichot, V., Marriner, N., el-Assal, M., Guihou, A., Deschamps, P., Claude, C., & Morhange, C. (2021). The late Holocene record of Lake Mareotis, Nile Delta, Egypt. E&G Quaternary Science Journal, 70(1), 93–104. https://doi.org/10.5194/egqsj-70-93-2021

13. Global_Surface_UHI_Explorer. (2022). Earth Engine Apps. https://yceo.users.earthengine.app/view/uhimap

14. Home - New Borg El Arab. (2015). http://www.newcities.gov.eg/english/New_Communities/Borg_Arab/default.aspx

15. Llewelyn-Davies. (2002). Urban Design Compendium 1.

16. Maciej Serda, Becker, F. G., Cleary, M., Team, R. M., Holtermann, H., The, D., Agenda, N., Science, P., Sk, S. K., Hinnebusch, R., Hinnebusch A, R., Rabinovich, I., Olmert, Y., Uld, D. Q. G. L. Q., Ri, W. K. H. U., Lq, V., Frxqwu, W. K. H., Zklfk, E., Edvhg, L. v, … فاطمی, ح. (2013). Synteza i aktywność biologiczna nowych analogów tiosemikarbazonowych chelatorów żelaza. Uniwersytet Śląski, 7(1), 343–354. https://doi.org/10.2/JQUERY.MIN.JS

17. Mackesy, P. (2013). British Victory in Egypt, 1801: The End of Napoleon’s Conquest. https://books.google.com.eg/books?id=rsj8RStBgjwC&printsec=frontcover&dq=inauthor:%22Piers+Mackesy%22&hl=en&sa=X&redir_esc=y#v=onepage&q&f=false

18. PM address at COP26 World Leaders Summit Opening Ceremony - GOV.UK. (2021, November 1). https://www.gov.uk/government/speeches/pm-address-at-cop26-world-leaders-summit-opening-ceremony

19. Qamar, S. A. M., Jamila, A. A. F., & Hassan, G. S. (2018). Studying the Economic Effects of Lake Mariout Pollution on Egyptian Agricultural Production.
20. Stanley, J. D., Carslon, R. W., van Beek, G., Jorstad, T. F., & Landau, E. A. (2007). Alexandria, Egypt, before Alexander the Great: A multidisciplinary approach yields rich discoveries. GSA Today, 17(8), 4–10. https://doi.org/10.1130/GSAT01708A.1
21. Temperature - Alexandria - Climate Robot Egypt. (2022). https://www.weatheronline.co.uk/weather/maps/city?WMO=62318&FMM=1&LMM=12&FYY=1982&LYY=2021&LANG=en&R=0&LEVEL=162&MOD=MOA&ART=TEM&OFFSET=24
22. Yoseph, W. E. S. (2017). Urban Regeneration as an Approach for Rehabilitating the Two Entrance Region of Alexandria City. International Journal of Environmental Science & Sustainable Development., 2(1), 52. https://doi.org/10.21625/essd.v1i2.89
23. Yoseph, W. E. S. (2019). Parametric Assessment for Achieving Indoor Environmental Quality (IEQ) in Egypt's New Urban Communities: Considering New Borg El-Arab City Urban Morphology and Openings' Specifications. In Advances in Science, Technology, and Innovation (1st ed., pp. 87–100). Springer, Cham. https://doi.org/10.1007/978-3-030-17308-1_9
24. Zhang, Y., Yu, Z., & Zhang, J. (2021). Analysis of carbon emission performance and regional differences in China's eight economic regions: Based on the super-efficiency SBM model and the Theil index. PLoS ONE, 16(May 5). https://doi.org/10.1371/JOURNAL.PONE.0250994