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Suitability of Egyptian Deserts for Sustainable Urban Development

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Abstract

Egypt has limited cultivable land, its water resources are limited and its population is growing, which in turn is destroying the cultivable land. If these issues are not dealt effectively, Egypt will have a large scale food crisis in its hands. This study aims to identify the resources provided by the uninhabited Egyptian deserts, their potential and how they can be utilized. Most of the research has been undertaken online, including in-depth study of the characteristics of Egyptian soil and how their composition changes over time. The country will require undergoing massive amounts of change, especially when it comes to conserving water, as this will be the main source of development. Underwater aquifers need to be found and dug up, and recycling and modern irrigation techniques will need to be adapted. A number of developmental projects have been put forward and some were initiated as well, however, due to mismanagement, these projects either failed or were not initiated. The government must learn from its previous mistakes and undertake the development of the Egyptian desert in stages, with proper quality assurance criteria.

Keywords: Urban Development, Egyptian Deserts, Urban Planning, Sustainable Development.

1. Introduction

Because of the intensively increasing population rates of the Nile Valley and the Delta, the Egyptian government is looking into extending the population growth towards the eastern and western parts of the Egyptian desert. Currently, Egypt's population is confined to a fine strip of arable land along the Nile River, while deserts account for around 96% of Egyptian land (EEAA 2007). Around 99 %of the Egyptian population resides on only 4 percent of land, which is the only piece of fertile land. Majority of the Egyptian population is settled in Cairo, a city which is crumbling under urban development pressure, some areas of the city have a population density of over 100,000 persons per square kilometer. Some parts of the city lack basic services such as water, electricity and sewerage, since the population has greatly exceeded the city's design capacity.

A number of satellite towns have been created since the launch of the "Greater Cairo Master Scheme" by Egyptian ex-presidentGamal Nasser. He proposed creating four satellite towns by 1990 around Cairo's deserts. Development corridors were built to link the new towns with the main city, and eventually three of the four proposed satellite towns were developed around Cairo, and four other towns were developed further from Cairo and Alexandria.

Although the cities did fulfill the requirement of dispersing the population, they didn't however improve the lives of the settlers. The three towns suffer from problems in providing basic services such as water, electricity, transport and communications. These satellite towns suffer from recurrent electric failures, water stoppages and telephone service interruptions. These towns were unable to develop further because of these problems and the difficulties associated with attracting manufacturers and workers alike to reside in those areas.

Taking into account the nature of the desert land and the lack of transport, water and electrical facilities, it is evident that a considerable amount of infrastructure development work will have to take place before developing new satellite towns or cities. Moreover, it is important to identify the suitability of the desert region for sustaining urban development. This study will investigate the desert regions that are suitable for urban development, and will address the concerns those regions may face, the prime concern being the availability of water and agricultural land. Another key factor for ensuring the sustainability of these developments is the creation of road and train networks from these cities to the rest of the country. Electricity and power issues will also be investigated in this study.

The development of agricultural land is imperative for sustainability, as Egypt was the world's largest wheat importer in 2012, importing around 11.5 million tons of wheat. Water shortages and scarcity of arable land are to blame for the decline in wheat production. If part of the Egyptian desert is used for cultivating wheat, it is possible to satisfy the total Egyptian demand for wheat and perhaps enable Egypt to export wheat to other

countries. The main obstacle to address would be water, since the Nile Delta is responsible for around one third of total agricultural production in Egypt. However, the intrusion of salt into the Delta water, caused by the rising of the Mediterranean Sea, has decreased the availability of arable water. The fact that Egypt suffers a shortfall of seven billion cubic meters is also another of concern, and alternative sources of fresh water must be investigated. This study addresses this issue and suggests alternative methods of obtaining fresh water, which include tapping into unclaimed water reservoirs.

In the mid 1990's ex-president Hosni Mubarak launched the "Toshka" project which aimed cultivating around 202,347 hectares of land in Egypt's western desert by using Lake Nasser, a manmade lake, for irrigation. However, this project was never developed due to political and funding reasons. Currently another scientist, Farouk Al-Baz proposed the launch of another similar mega-project titled "the Corridor of Development" which targets at building a 1200 km superhighway along the Nile in the Western Desert which is connected with railroad networks, water and electric pipelines. Critics of this project state that the Western Desert's soil is comprised of limestone, basalt and sandstone all of which make it difficult to use for cultivation purposes. Moreover the critics state that the Western Desert is a plateau which rises 500 meters above sea level in one area and drops to 200 meters in another area, making it difficult to develop a sustainable water pumping and sewerage disposal project. These concerns will also be addressed in this study.

Although detailed studies have not been conducted into Egyptian deserts, this study will try to conduct an in-depth analysis of the viability of Egyptian deserts and their viability to sustain urban development. Alternative courses of action will be investigated in this study, to overcome the obstacles that may arise during the transformation of these deserts.

2. Desert Area

The Egyptian desert is divided into four primary sections; The Nile Valley and Delta, the Western Desert, the Eastern Desert and the Sinai peninsula. Each of these subdivisions has their own characteristics and geological lay out, some of these subdivisions are further divided into a subset of divisions. Figure 1 provides an overview of Egypt's geography.

The Nile valley is around 10 km in width and runs from Lake Nasser in the south to the top of the delta around Cairo in the north, whereas the Delta is 250 Km wide and 166 km long ending in the Mediterranean coast (Image House 2000) This subdivision of the desert is blessed with fertile soil and water resources, and nurtures a range of fruits and vegetables. Because of the abundance of food and water resources, the Nile Valley and the Delta have attracted a number of inhabitants both humans and animals alike. One can witness a range of animal species in this area, in contrast to the other areas of the Country. Water, Electricity and Waste disposal resources are also abundant in this area. Figure 2 shows the concentration of canals in the Nile Valley and Delta region and figure 3 shows the concentration of electricity and power lines in the region. The main power lines are concentrated in the Nile Valley and Delta region with extensions towards the south and east; the developmental corridors.

The Western Desert has two subdivisions; the northern and the southern section, it spans across 700,000 square kilometers and counts for two third of total Egyptian land area, it is mostly comprised of rocky highland and is covered by eolian sand (Food and Agricultural Organization of the UN 2009). The desert is comprised of sand dunes; the north is covered by longitudinal sand dunes, whereas the southern section is covered with crescent shaped dunes (Image House 2000). The Western Desert has numerous depressions that are scattered from the northern section to the southern section. The biggest depression is Qattara Depression which consists of lakes, salt marshes and salt flats. This depression represents the second lowest point in the continent; it is 133 meters below sea level (Bayne Fisher 1978). There are a number of oasis lined together in this region that are collectively called the New Valley (Hanna & Osman 2009*)* which used to have a flourishing agricultural landscape in the past but presently comprises of date palms, grains and citrus trees, as its major crop(s).

The Eastern Desert covers around 22 % of Egyptian territory (Darwish & Wahba 2010) and constitutes of mountain ranges that peak around 3000 feet above sea level and is in total contrast to the Western Desert. This region experiences rainfall of less than 50 mm per annum, thus has no permanent water resources; it does have Wadis (dried stream beds in a desert), however, running on the side of the mountains. The Eastern desert is known for its inhabitability and is very distinct from the rest of the Country, however it is an important area as this regions provides around 20 percent of the Country's oil output (Mongabay 1990). This region is also known for its gold and coal deposits. One of the major gold projects; the Sukari gold project is currently under development and is said to be "Egypt's first large-scale gold mine", total reserves are estimated to be 7.1 million

ounces (Mining Technology Projects 2008)

The Sinai Peninsula is divided into three subsections namely; the southern section, the central section and the northern section. The southern section is comprised of mountains and is home to Egypt's largest mountain: Gebel Katherine. These mountains are surrounded by Wadis that drain rainwater and snow towards the Gulf of Aqaba and to the Gulf of Suez. Because of the availability of water, the northern section is abundant with plant and animal species and can be great for agricultural cultivation. The Central section is comprised of limestone plateau whereas the Southern Section is surrounded by At-Teeh plateau that is abundant in water resources (Bishay 1993)

Egyptian deserts have great developmental potential as they are abundant with a number of natural resources. Figure 4 shows the topography of Egypt and figure 5 shows the abundance of mineral resources throughout the Country.

3. Characteristics of Soil

The Egyptian peninsula is comprised of mainly rocky plateau that provides minimal probability for plant growth (Kassas, 1952). As a result of the mountainous terrain of the country, the desert is covered with a number of Wadis that contains water borne material and silt.

Egyptian soil is created mainly through the process of erosion, sedimentary deposits from the Wadis, and flooding, therefore the characteristics of soil vary according to the desert region and its surrounding areas.

Soil in the Nile Valley and Delta can be described as Alluvial Soils. This type of soil is formed from mountain sediments that flow down by waters and rivers into a valley. This type of soil is very fine and favorable for cultivation as it contains organic and natural elements. . The soil in the Delta region is sunder threat because of a number of reasons, the main one being urbanization; studies indicate the annual loss of 60,750 hectares of fertile land. The other problems of the soil include: salinization, use if soil for brick making, pollution, sand encroachment, and wind and water erosion (Hamdi & Abdel Hafez, 1999)

The Western, and parts of the Eastern Desert's soil are made of Calicosols and Gypsisols; Calicosols are rich in calcium and are not saline whereas Gypsisols contain Calcium Sulphate, which is more commonly known as gypsum. These soils have low concentration of clay and other organic material; therefore they are not suitable for cultivation purposes since they have low water holding capacity (Asia Pacific Network, 2010). The Calcium content in the soil makes it difficult to manage, since they become hardened and make it difficult for plant roots to penetrate through the soil and are especially problematic if they are on the surface. This problem can be partly overcome by adding manure or fertilizers and properly irrigating the area, however a lot of effort will need to be made in order to make this type of soil fit for cultivation.

Solonchaks are found in the major oasis and depressions in the Western Desert, they have a high soluble salt content and are very difficult to manage. Their salinity content alters the osmotic balance of the soil, making it difficult for plants to extract nutrient from the soil, which inhibits their growth levels and decreases the overall yield. One way to combat this problem is by irrigating the soil, to take out most of its salinity, or by adding less saline content to the soil. Irrigation of the soil is difficult especially in the Western Desert unless a fresh water source is found.

Another type of soil, called Lethic Leptosols are also found in the Eastern Desert and parts of the Western Desert. This type of soil does not run very deep and does not develop over time; it is mainly constituted of consolidated rock. Cultivation is difficult in this type of soil due to the low content of nutrients, low water holding capacity and their shallowness. This soil can only be used for local land use (Asia Pacific Network 2010).

The Sinai Peninsula consists of a number of different types of soil that can be classified according to specific areas in the peninsula. Soil in the El-Tina plain mainly consists of alluvium deposits along with Aeolian sand deposits. There is little of no vegetation in the area due to their low water content and poor drainage system. The soil's characteristics vary within the area, from a sandy to a clay texture and are extremely saline. The soil contains elements of gypsum crystals, salt crystals and a few shells.

Soil in the Rabaa and South El-Kantara Shark area is good for vegetation, and is covered with patches of palm tree vegetation, the reason being that the soil has low calcium carbonate content and possess no saline characteristics (Abd El-Aziz 2002)

Soil profile of Wadi Al Arish region is made of calcareous and sand deposits, and they have a proper drainage

system. The soil texture varies from grainy to sandy to loamy and has a varying degree of calcium carbonate content and no saline content.

The type of soil deposits around the Suez Canal are completely different when compared to the ones around the Nile Valley (Hafez, 2005), they have high quantity of sodium and iron oxide and minimal organic matters.

The Sinai Peninsula is home to a large number of limestone deposits especially in the Al Tih plateau, whereas southern Sinai is home to mineral rocks such as granite and basalt. This region has three distinct types of land; land comprised of limestone, land comprised of Nubian Sandstone, and land formed of ancient sediments. All these tree types of land can be of great use in the construction industry, both locally and internationally (Dunsay 2012).The area also has a fresh water source from the numerous wells, allowing for more urban development in the area. A fresh water source means potential for cultivation and development.

4. Water Solutions

Water supply is a major problem in Egypt, where agriculture consumes around 80 % of the river Nile's water (El-Kady & El-Shibini 2000) and where most of the other water resources have been exhausted. The Nile river is surrounded by dams that control the flow of the river, Lake Nasser, and artificially created lake, is the main water source (El-Kady & El-Shibini 2000) Around 85% percent of total available water is used for agricultural purposes where 6% is used for domestic needs and the remaining used for industrial needs. The current water per capita is 900 cubic meters per person annually, and is expected to drop to 600 meters cube unless a reliable water source is not found.

It is imperative that the government launch a water conservation and exploration strategy that initiates the discovery of water and which educated the public about the importance of conserving water.

There are deep groundwater aquifers in the country, for example in the Western Desert the ground aquifer contains 200,000 BCM of fresh water however pumping costs represent a financial (El-Kady & El-Shibini 2000).

Rain Water provides 1 to 1.3 billion cubic meters of water annually and represents a substantial proportion of total available water resource.

The Agricultural drainage system is composed of a network of drains to avoid water logging and salinization. This drainage system was constructed in the 20th century that involved developing deep drains, construction of pumping stations and installation of drainage systems.

A number of water reuse options are investigated in this study, the first one being reusing the agricultural drainage water. Currently the drainage water coming from Upper Egypt is pumped back into the Nile, where this water is further discharged into a network of open drains. Three options of water reuse can be investigated; natural re-usage, official re-usage and non official re-usage. Natural re-usage is done by natural canals or rivers, where the irrigated water runs from the land into the Nile Delta, this method of re-usage is uncontrollable, except by modifying the amount of recharge that flows. Official re-usage involves inserting drainage water into the irrigation water through the irrigation system, whereas non-official re-usage is practiced by farmers who decide on the quantity and quality of drainage water usage for irrigation.

There are a number of official projects that are dependent on re-used drainage water including the Al Salam Canal Project, the Omoum Drain Project, and Drain No.1 & 2. The potential riskiness of drainage water cannot be underestimated; however a number of measures can be undertaken to mitigate those risks. One method would be the immediate re-sue of drainage water, where the water supply is diverted right before it reaches the main bacterial contamination point. This can be achieved through developing a new drainage system which is concentrated in metropolitan and industrial areas. Another method of mitigating drainage water risks is through using treatment technology; however this is costly and should only be used as a last resort. Table 1 below shows the current and potential levels of drainage water usage.

Another method of re-using water is though desalination, this is relatively new to Egypt but is currently becoming a popular method reusing water. Gas turbine exhaust is used for desalinating water in the Suez Canal in the Sinai Peninsula and it has around 125 turbines units working (El-Kady & El-Shibini 2000). Studies suggest that production of desalinated water could reach up to 59,000 cubic meters if the current production methods are maintained. Solar energy can be used to power these wind turbines, this will enable considerably reduce desalination costs and will enable desalination plants to be setup in remote areas.

Treatment of Municipal Waste Water can be another method of reusing water, especially in Egypt where water is

scarce. Generally, Municipal Waste water is not toxic; therefore it can be treated at low cost and is economically advantageous. Municipal waste water can be used to irrigate crops, since they already contain some nutrients, they may eliminate the need to use fertilizers.

5. Linkages

In order to disperse the population to other cities in Egypt, it is imperative that the government create developmental corridors. These corridors will be the source of migration from the main city to the outskirts of Egypt.

Basically, the country needs to construct land and or sea links with the main city, to enhance the development of the desert areas. A proper transportation link should be developed between the Nile Valley to the Eastern and Western Deserts and the Sinai Peninsula. Water transportation arrangements should be made, either through digging canals from the Nile to the other parts of the country or by linking a drainage system.

Fresh water sources could be discovered in the Western Desert and the reservoir can be used to provide fresh water to the surrounding areas. With the massive need for development, the government should ensure that there is enough electricity and power in the region to sustain the development.

Previous attempts of creating growth corridors have been unsuccessful because the government did not take into account the electricity and water needs. A more important area of consideration is the development of road links throughout the country. The first step the government should take is creating travelable roads through the desert; this will greatly reduce the cost of transportation of materials and speed up development.

The new cities must be attractive to the populations, they must be habitable, and the residents should not feel left out and isolated, by creating an efficient transportation network, this fear can be eliminated. Another important mode of transport that should be developed is the rail system, not only will this come into use when handling large construction materials but it will also be a cheap transport options for the inhabitants.

The desert areas of Egypt have great developmental potential, the limiting factor that they faced was transport links, as travelling in the desert is not easy, especially with elevations and other obstacles. The developers can plan road links based on the ancient transportation links, as they were quite effective in developing the country. Ancient road maps could be used as a starting base, and superhighways could be built on those roads. An extensive transportation network should be created, where travellers can have the option of travelling by car, bus or rail. This is imperative in developing desert communities as inhabitants may choose to live in the desert due to the low cost of living but work in the city. If this continues, large companies may start basing their offices in these desert communities, and this in turn would further propel the development of these cities.

5. Discussion and Conclusion

Developing the Deserts of Egypt for urban settlement will not be an easy task because of the nature of the desert, the scarcity of water and the financial constraints. During the course of the development, the government may face a number of setbacks; one prime example is the development of the Toshka Project by ex-president Husni Mubarak.

One reason for the failure of the project was short sightedness of the planners and improper financing. Since the desert region is very underdevelopment, massive restoration needs to take place which could last for decades. And as a result of the political situation of the country it may be the case that different governments will have different plans, thereby halting the development of the desert regions.

One way to combat this issue is to undertake the development in short exclusive stages, so that even if the future government makes changes to the master plan, the current development area will not be affected.

In order to achieve sustainable development, the government must ensure a balance is reached between human development, economic development, environment protection and resource development. The government must keep in mind the constraints faced by the country that include:

- Scarcity of Water
- Scarcity of Energy
- Limited Funding

- Increase in Population Rates and
- Food Shortages

Funding is a major constraint when it comes to development, taking into account the political climate of the country. One method of raising finance will be the development of small scale projects, and using the income from these projects to finance the development of the Desert. There are a few areas in the desert which are readily suitable for further development, they include the following:

- The Coast around the Red Sea, these can used for tourism purposes.
- Development of the north-west coast for tourism.
- The Sinai coastal zone, which is ready for agricultural purposes and can be used as a tourist destination.
- Northern Desert that can be used for pumping underground water; this water can be used for irrigation purposes.

Egyptian deserts have huge developmental potential, they contain a number of mineral and water resources that can be used to finance the project, and however adequate management and constant improvements are needed in order to manage the development successfully.

Although new projects have sprung up, mainly outside the city of Cairo, the government needs to ensure that these developments cater to the upper as well as the lower class. Currently the satellite towns created either cater to the upper class or the lower class. The upper class residents do not suffer from the problems the poorer residents suffer, since they have access to more resources. They have cars which enable to commute between the main city and their satellite city, their housing companies have private contracts with the water company giving them complete access to running water, and they also have generators, giving them 24 hours of electricity, in contrast to the poorer residents. The poorer residents have no access to transport, water or electricity; since they are the minority their voices are not being heard. In order to ensure that these satellite cities are a success, the government must provide access to basic facilities to all the residents either rich or poor.

The first step in developing Egyptian deserts for urban development will require land reclamation, and this will pose many problems, particularly with water. This will require recycling water and applying modern irrigation techniques that will not only aid the reclamation process but will also help resolve Egypt's water supply problems.

Another issue facing the Egyptian government is the lack of financial resources. Given the current state of the economy and the political situation, Egypt cannot spend a lot on development projects without running a budget deficit; hence it has to rely on private investments from the local and international community. This problem can be solved if the government issues developmental bonds to its public, however this is risky especially if the development work is not successful or is delayed.

The Egyptian government must first strengthen its institutions, conduct thorough feasibility studies of each region and then undertake the developmental process in stages. Egyptian deserts have a lot to offer, and if their resources are used efficiently they can be a gold mine for the Egyptian community.

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Figure 1. An overview of Egypt's geography (Wordatlas http://www.worldatlas.com/webimage/countrys/africa/egnewzz.gif)

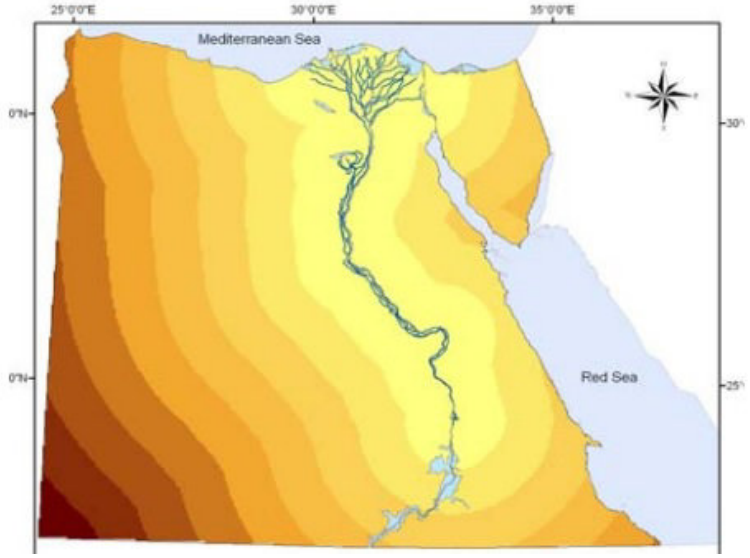

Figure 2. The concentration of canals in the Nile Valley and Delta region (Effat, H.A. & Hegazy, M.N. 2008)

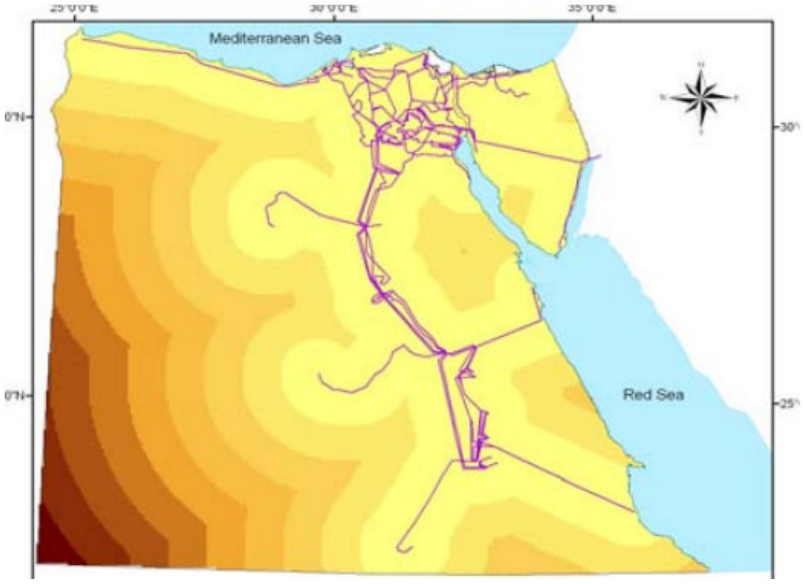

Figure 3. The concentration of electricity and power lines in the Nile Valley and Delta region (Effat, H.A. & Hegazy, M.N. 2008)

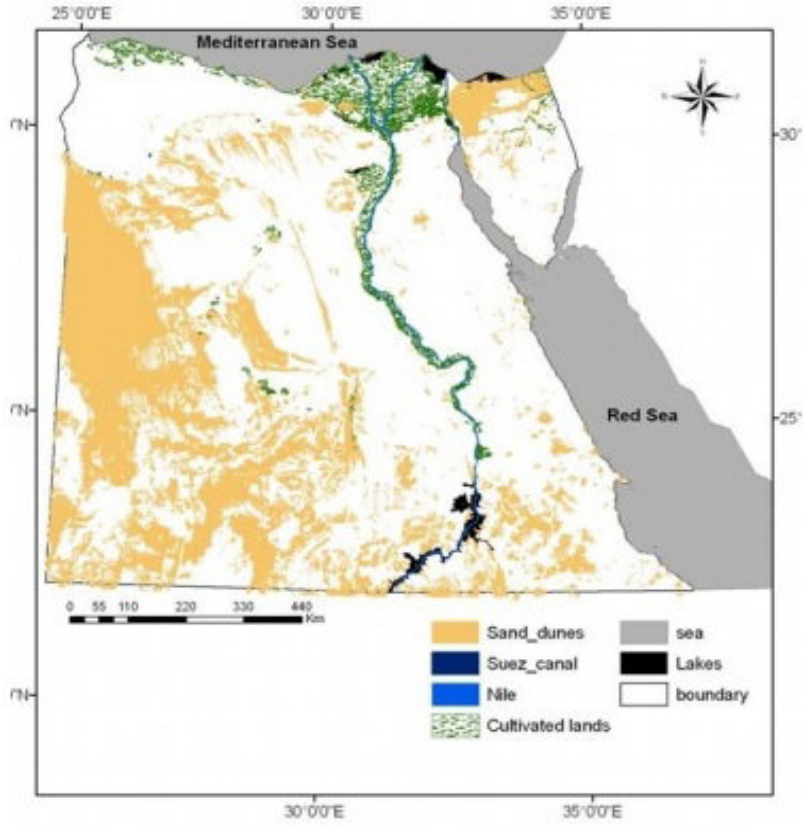

Figure 4. The topography of Egypt (Effat, H.A. & Hegazy, M.N. 2008)

Figure 5. Mineral resources in Egypt (Bassioni, H. A., El-Menchawy, A., & Farouk, A. 2012)

Table 1. Reuse of Low Quality Water in Egypt.

Region	**Available Drainage Water**	**Currently Re-used**	**Possible to be Re-used**
Eastern Delta	4083.65	2049.89	1519.02
Middle Delta	5849.14	2007.73	2881.06
Western Delta	3819.15	1123.56	2384.33
Total	13751.94	5181.18	6784.41