EGYPT

Source: esri

General

Egypt - officially the Arab Republic of Egypt - is a transcontinental country spanning the northeast corner of Africa and southwest corner of Asia by a land bridge formed by the Sinai Peninsula. Egypt is a Mediterranean country bordered by the Gaza Strip and Israel in the Northeast, the Gulf of Aqaba in the East, the Red Sea in the East and South, Sudan in the South, and Libya in the West. With a population in 2022 of 111 million, Egypt is the third-most populous country in Africa (after Nigeria and Ethiopia). The great majority of its people live near the banks of the Nile River, an area of about 4.0 Mha (million hectares), which implies 28 persons per ha. However, counted over the whole area of the country it is 1.1 person per ha (Wikipedia and United Nations, 2022).

Climate and geography

Egypt is the driest and the sunniest country in the world. The country has an unusually hot, sunny and dry climate. Average high temperatures are high in the North but very to extremely high in the rest of the country during summer. The cooler Mediterranean winds consistently blow over the northern sea coast, which helps to get more moderate temperatures, especially at the height of the summertime. Most of Egypt's rain falls in the winter months. South of Cairo, rainfall averages only around 2 to 5 mm per year and at intervals of many years. On a very thin strip of the northern coast the rainfall can be as high as 410 mm, mostly between October and March (source: Wikipedia).

Apart from the Nile Valley, the majority of Egypt's landscape is desert, with a few scattered oases. Winds create sand dunes that peak at more than 30 m high. Egypt includes parts of the Sahara Desert and of the Libyan Desert. Prior to the construction of the Aswan Dam, the Nile River flooded annually replenishing the soil. This gave Egypt a consistent harvest throughout the years (source: Wikipedia).

Historic polder development

Biswas (1972) stated that the reclamation works of King Men (or Menes) form an example of ancient impoldering activities. He describes that King Men ruled Egypt around 3400 BC, was the founder of the Egyptian dynasties and can be considered the first Pharaoh. He united Upper and Lower Egypt, which resulted in a large increase in prosperity. He built his new capital at Memphis on the old fertile riverbed, for which, according to the historian Herodotus, he constructed a dam in the Nile River some 20 km south of Memphis at Kosheish. The course of the river was diverted to a canal, which was excavated between two hills. The dam is supposed to have had a maximum height of 15 m and a length of some 450 m. In a later stage King Men excavated a lake northwest of the new town and dug a canal to connect it with the Nile River. The system of watercourses, viz. the lake, the canal, and the river, served as a moat to protect him from his enemies. The dam had to be guarded and maintained carefully, because in case of a breach the entire city of Memphis would have been flooded. When Herodotus visited Egypt some 2500 years later, the dam was still guarded with greatest care by the Persians (Biswas, 1972).

Wolters *et al.* (1986) state that large scale basin irrigation first started under King Men and that the basins of this type of irrigation are regarded as the first polders of the world. However, they also state that it may be debatable whether this indeed were polders in the true sense.

In the Ptolematic and Roman periods lowlands in the North of the Nile Delta were cultivated. The British Engineer Sir William Willcocks (1913) stated that the presence of Pharaonic summer canals and dikes suggests that these lands were once covered with vineyards and enormous basins planted with wheat, maintaining a dense population. It also can be supposed that basin irrigation in these coastal areas was combined with a rudimentary form of aquaculture. Although it later became barren lands the many mounds, strewn with bricks and pottery', also called 'turtle backs', observed by Willcocks testify of a rich history. There are several archeological sites in this area, with villages located on mounds (*kom*), such as: Kom Khazm, Kom Om Ghafer, Kom El-Khanzera, Kom El-Khaloulid and Kom Zabaa.

Basin irrigation, using the low flow and high flow of the Nile River, was for millennia the dominant irrigation method in Egypt. With the introduction around 1820 of cotton and sugarcane, perennial irrigation was established and, from 1826 onwards, under the rule of Mohammed Ali, Egypt developed a system of canals for the irrigation of Lower Egypt. As a result, the discharge entering the lakes decreased and some land fell out of cultivation. Later on, the government constructed a series of Delta barrages in the Rosetta and Damietta branches of the Nile River (constructed in 1861, renovated in 1890), diversion dams like Zifta Barrage (completed in 1902, renovated in 1952), and the Mohammed Ali Barrage at the apex of the delta (1939). In addition, the Aswan Dam was constructed in 1902, and further raised in 1912 and 1933.

Burullus Lake is located along the Mediterranean Coast in the northern part of the Nile Delta, in between the Rosetta and Damietta Nile branches. Figure 1 (left) shows the extension of Burullus Lake in 1859 as well as the vast seasonally flooded area, that almost reached Daqalt, meaning that most of the Meet Yazid Canal area was at the time under semi-flooded conditions (the *kom* are also appearing on this map). In 1902 the delta was only cultivated in its core part and the central section - between the two branches - received most of its waters through the feeder canals that branched off from the delta barrage. Figure 1 (right) indicates the three major canals that reached Burullus Lake though what is now Meet Yazid irrigated area, namely (from left to right): the Ruwena Canal, the Al Qased Canal, and the Gaafaria Canal, all branching from a feeder canal north of Shibin el Kom.

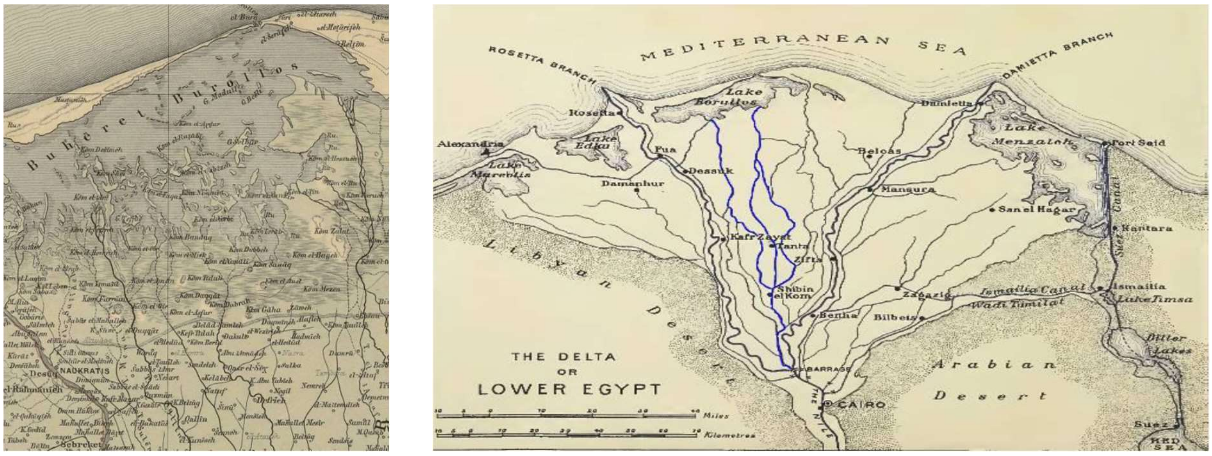

Figure 1. Nile Delta in 1859 (left) (Kiepert, 1859) and Sketch of the Nile Delta in 1902 (right) (after Brown, 1902)

In a publication by Diab (1983) it is stated that the northern extremities of the Nile Delta are dominated by lowlands, previously covered by lakes and marshes known under the local name *Barary* and that the reclaimed area amounts to 25,000 ha.

Drainage started shortly after the introduction of perennial irrigation during the 19th century and has been developed ever since. Drains constructed at that time were of the gravity type. However, the relatively flat nature of the delta required, at places, to install drainage pumping stations. The Centre for Civil Engineering Research and Codes (CUR) and Ministry of Transport, Public Works and Water Management (1993) describe that the surface in some parts of the Nile Delta were at 5.0 m-MSL.

In late 19th and early 20th century, private companies and individuals undertook land reclamation in the Nile Delta. For example, in the early 20th century the State initially conferred rights for reclamation of land in the Daqalt Area to the European *Societé Anonyme du Béhéra*. These were land reclamation efforts for large-scale foreign and national land development schemes. The total reclaimed area in Egypt from 1932 to 1952 reached about 84,000 ha (200,000 feddan) (AusAID *et al.*, 2013).

Following the 1952 Revolution, the Egyptian Government under President Nasser became more involved in reclamation (Hanna and Osman, 1995). The government gave priority to improving the conditions of the rural poor (Voll, 1980) and distribution of the reclaimed lands among landless groups (2.1 ha (5 feddan) for each rural household), while maintaining certain reclaimed areas under State management. The Ministry of Land Reform and Land Reclamation reclaimed land according to 5 year plans with varying degrees of success: ambitious programs but haphazard implementation until 1959, increasingly rapid expansion after 1960, which consolidated after the 1967 war and became marked by retrenchment (Voll, 1980). Between 1960 and 1965, the State leased the reclaimed lands to small farmers. In the 1980s, the government distributed reclaimed lands to new graduates from the university. In the Meet Yazid irrigated area, for example, there are six graduate (*kharigeen*) villages, which were settled around 1989 along the Halafy and Ghabat canals. The graduates received between 1.7 to 2.1 ha (4 to 5 feddan) of land.

Most of the lands in the northern part of the Nile Delta were probably reclaimed in the 1940s or 1950s. The Moheet Drain was dug to mark the limit of the cultivated area and to drain the excess water from the tail of the Meet Yazid irrigated area. Subsequently, in a second phase the northern areas of Meet Yazid irrigated area were reclaimed. The districts of El Riyad and Sidi Salim were developed during the Nasser regime (1956-1970), while the Sidi Ghazi District (in the East) was developed in the 1970s with Yugoslavian cooperation (Figure 2). Most of these areas were reclaimed with the idea of developing a Soviet style state or collective farms and large-scale pumping stations were constructed to irrigate large tracks of land. However, this idea was dropped during the 1970s, after Nasser's death, after which these farms disaggregated into different forms of land holding. In the 1980s in Sidi Ghazi district, some land was offered to potential reclaimers: they had to form a 'cooperative' of at least 100 persons to which a track of land was sold (in one instance 105 farmers received 2,940 ha (7000 feddan) and each received a plot of about 29.4 ha (70 feddan) allocated through a 'lucky draw'). This partly explains the existence of quite large fish farms in the area.

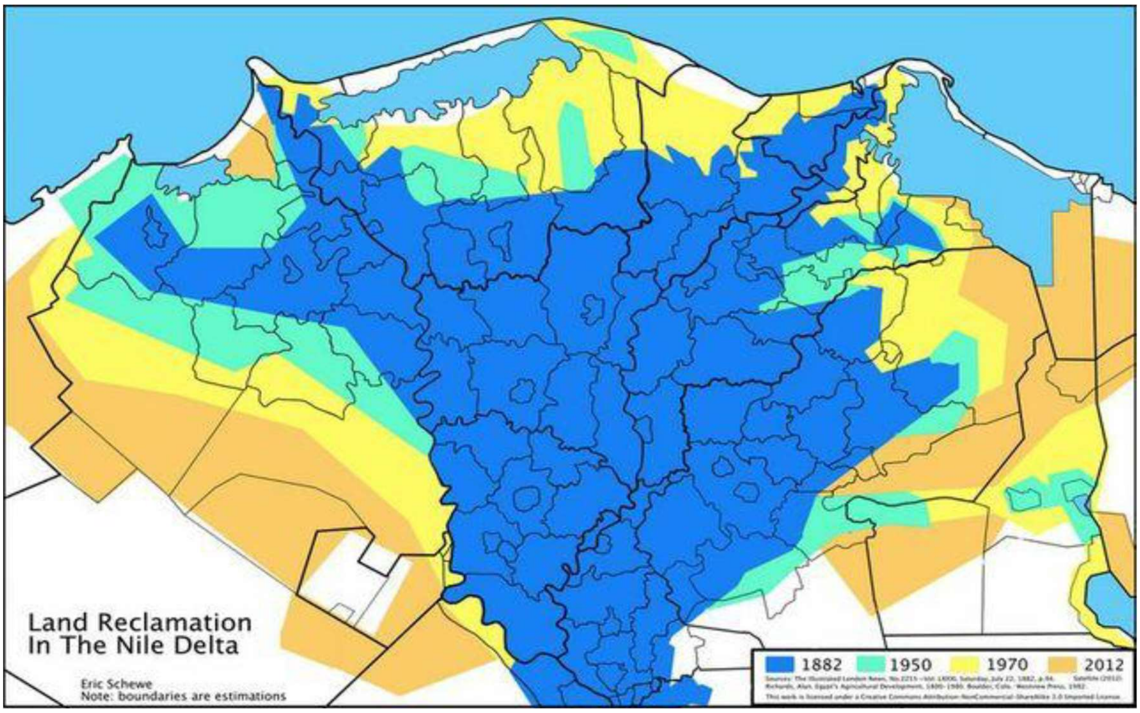

Figure 2. Agricultural land expansion in the Nile Delta
(Australian Agency for International Development (AusAID) et al., 2013)

With the raising of the Aswan dam, 85% of the agricultural lands in Egypt at that time came to be cultivable under perennial irrigation. The conversion of the remaining lands was achieved after the closure of the High Aswan Dam in 1964 and its inauguration in 1970. The construction and adaptation of a complex canal network in the Nile Delta enabled the expansion of agriculture towards the coastal zone and year-round irrigation (Ayache *et al*., 2009). These infrastructural interventions changed the regime of the river from a seasonally variable discharge to a much more constant and controlled flow containing a negligible sediment load.

After the construction and extension of irrigation canals and partial reclamation during the 1960s, agriculture was not possible at the onset because of the high salinity of the coastal soils, the unreliability of water supply and lack of drains. Because of the long process of annual inundations and the leaching of saline soils, land owners were aware of the beneficial aspects of applying water on land. During the first years land plots were flooded with canal water in order to leach the salts. Farmers realized that they could also use fish ponds and mullet farming for this (Radwan, 2008). So, the advance of the agricultural frontier benefited from aquaculture to develop the land. For example, along the Daramally and Halafy branch canals in the Sidi Ghazi Irrigation District, the former graduate settlers, (*kharigeen*) farmers, acknowledge that *in the beginning you needed three years of intensive soil-washing before being able to cultivate rice or cotton; fish farming was therefore widespread*. This fish farming continued to be practised until a ministerial decree prohibited the *kharigeen* farmers to continue with it, with the sanction of losing the land that the government had allotted to them. Also along the Ghabat Canal, the land has improved under the fish farming and the originally saline soils became suitable to cultivate wheat. In contrast, on Mares El Gamal Canal (as in other parts), some farmers started fish farming later, because of the salinity of the soil and the poor yields. Twenty five years of fish farming improved the soil, thereafter they could use it for agriculture. Aquaculture thus enhanced the conversion of these reclaimed lands to agricultural exploitation and, hence, contributed to the advance of irrigated agriculture (Australian Agency for International Development (AusAID) *et al*., 2013).

One of the most important productive areas for aquaculture lies on the northern coastline, in the Kafr El Sheikh Governorate (Macfadyen, 2011). The fast majority (86%) of aquaculture production depends on brackish rather than fresh water (Sacchi, 2011). Aquaculture benefits in this area from two main sources of brackish water: the brackish water of the Burullus Lake and the reuse of agricultural drainage water from the Meet Yazid irrigated area and the Nile Delta. These two sources of brackish water enabled the expansion of aquaculture in the region.

The Group Polder Development (1982) describes that the Northern Fringe of the Nile Delta is partly below mean sea level (1 to 2 m-MSL). Some dikes have been constructed to protect these low-lying areas against flooding from the see and the riverbranches (Figure 1).

Wolters *et al.* (1986) describe that the Nile Delta contains many polders, with a total area of 1.14 Mha and mention that the Nile Delta can be divided in 70 drainage basins. They also mention that the drainage water of lower lying areas is pumped into free flowing main drains, mostly with an outfall in a coastal lake (Figure 3).

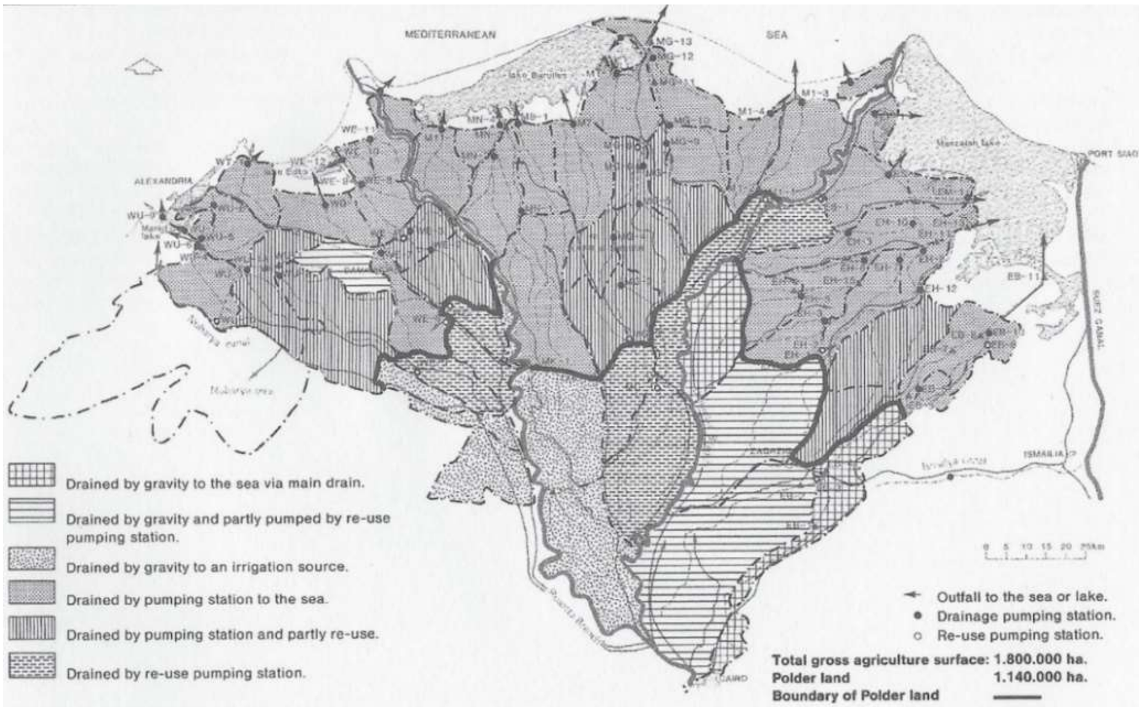

Figure 3. Polders in the Nile Delta and the drainage basins of the delta with their drainage system (Wolters et al., 1986)

The Centre for Civil Engineering Research and Codes (CUR) and Ministry of Transport, Public Works and Water Management (1993) gave an overview of the development of the Nile Delta. From this overview it can be derived that the total net irrigated area is 1.61 Mha (total gross area of the delta is 1.98 Mha). They stated that because of the required drainage the Nile Delta has been subdivided into a few hundred drainage basins. With respect to this it has to be noticed that the 70 drainage basins as mentioned by Wolters *et al*. (1986) seems to be a more accurate figure. The drainage water has to be lifted between 1 to 3 m from the open drains to an outfall drain. The outfall drain conveys the water to one of the four lakes near the Mediterranean, or directly to the sea either as a freely flowing drain or via a pumping station. The outfall drains also receive water from upstream higher areas in the South where the open drains can discharge by gravity into the outfall drains.

The Centre for Civil Engineering Research and Codes (CUR) and Ministry of Transport, Public Works and Water Management (1993) also mention that in 1988, the pump-lift system consisted of 70 pumping stations with a total capacity of 1,300 m^3/s corresponding to an average drainage capacity of 8 mm/day. This figure seems to be in line with the 70 drainage basins as mentioned by Wolters *et al.* (1986). In the files of Prof. Adriaan Volker there are three relevant maps of the Nile Delta. These maps are: topographic map of the Nile Delta with the elevation in feet (Figure 4), drainage units in the Nile Delta (Figure 5) and drains in the Nile Delta (Figure 6).

Figure 4. Topographic map of the Nile Delta - 1982 - with the elevation in feet

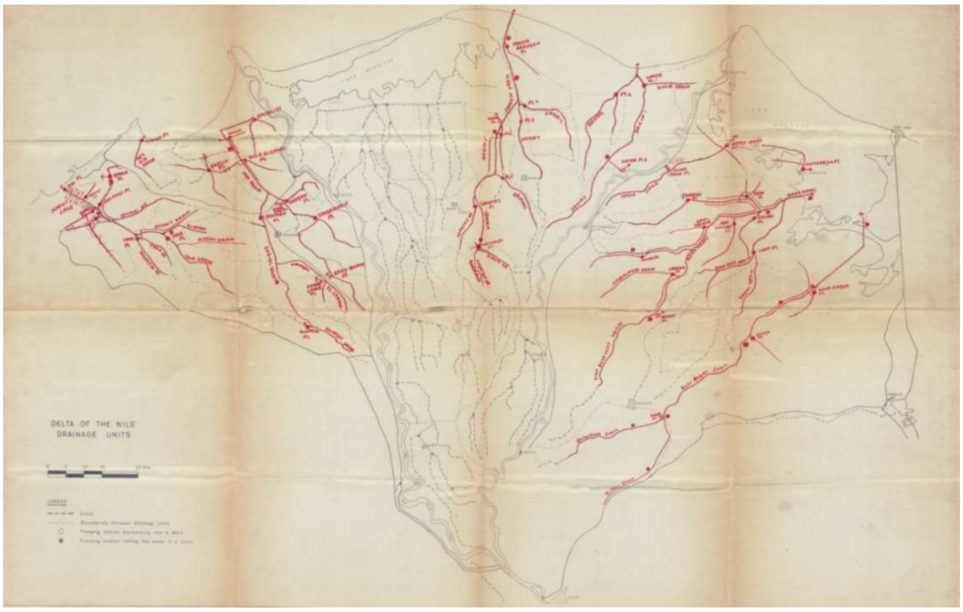

Figure 5. Drainage units in the Nile Delta

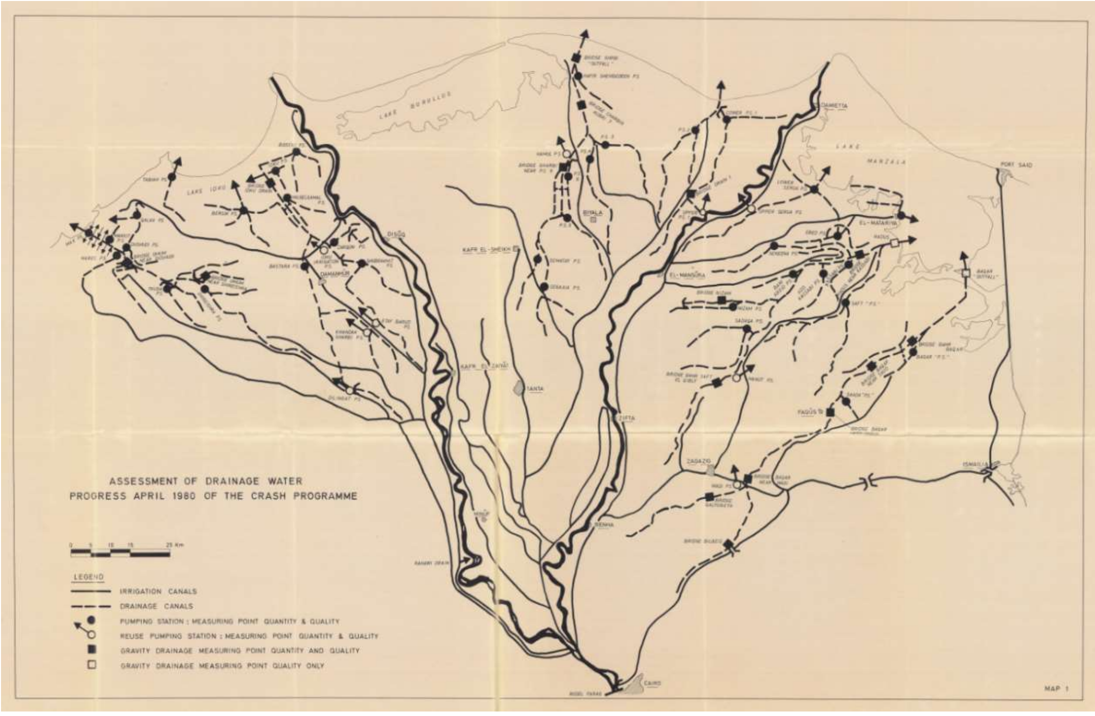

Figure 6. Drains in the Nile Delta – 1980

A map prepared by the Drainage Research Institute shows the main drainage pumping stations in the Nile Delta (Figure 7).

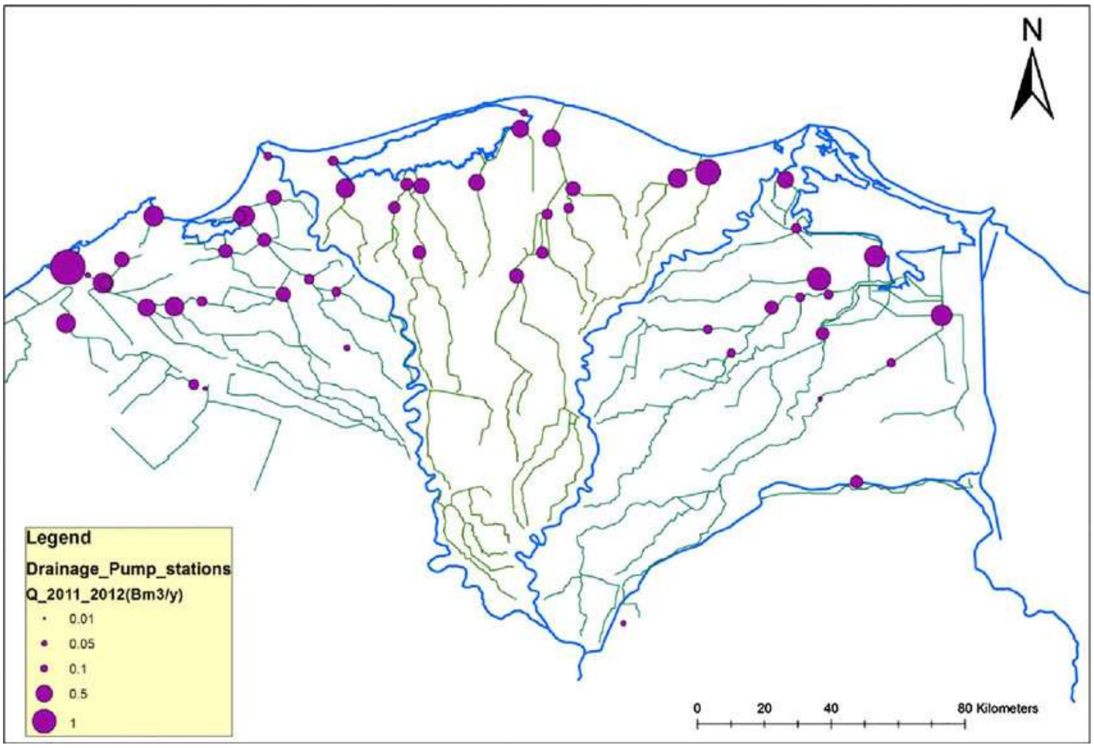

Figure 7. Main drainage pumping stations and their capacities in the Nile Delta (source: Drianage Research Institute)

Existing polders

In several publications references to specific polders were found. Information on these polders is given underneath.

Reclaimed land in the former Lake Abou Qir (or Aboukir), about 12,000 ha. The first mention of a polder in the true sense might have been the reclamation of almost the entire Lake Abou Qir in 1887 (Group Polder Development, 1982), located along the Mediterranian coast (Figure 8).

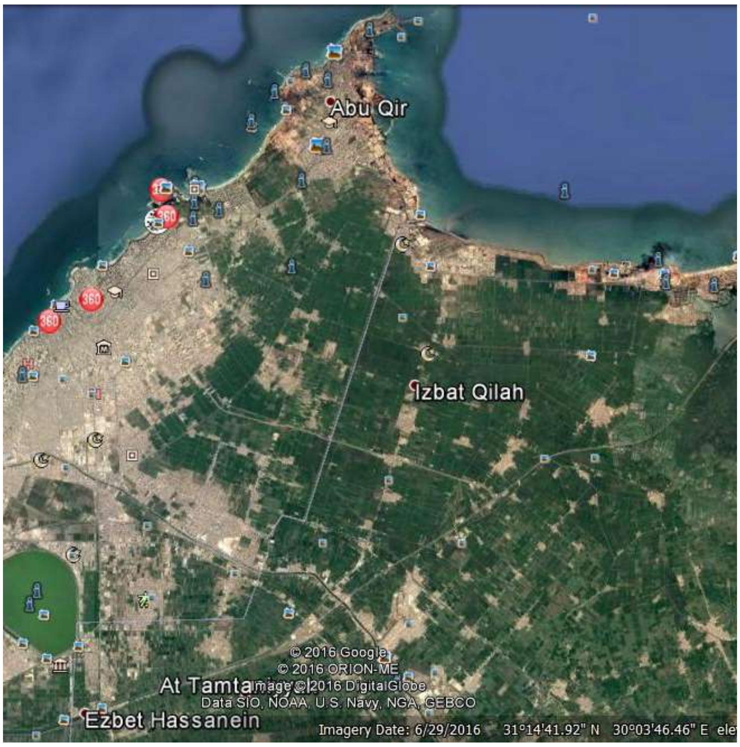

Figure 8. Reclaimed land (about 12,000 ha) in the former Lake Abou Qir (source: Google Earth)

El-Max area. In the publication by the Australian Agency for International Development (AusAID) *et al*. (2013) it is stated that the first drainage pumping station was constructed in 1898 in the El-Max area near Alexandria to drain about 89,000 ha (212,000 feddan).

Mansour and Zawia polders, 27,300 ha. These polders were reclaimed in the 1960s in the eastern part of Burullus Lake. Agriculture still suffered from high salinity (Group Polder Development, 1982) (Figure 9).

Figure 9. Area in which the Mansour and Zawia polders are located (in total 27,300 ha) (source: Google Earth)

Burullus Lake is one of Egypt's most important wetlands and its second largest lake, where the Meet Yazid irrigated area drains its waters to. The lake itself was separated from agricultural land by seasonally flooded marshlands that have now been reclaimed (Figure 10). This is a wetland of significance for fish habitats and migratory birds under the RAMSAR convention. The lake is a declared natural protectorate. Most of the water it receives is intensively used and reused agricultural, aquaculture and domestic water. In sum, this populated coastal zone constitutes a transition between highly productive agriculture and aquaculture with the lake area, which is acknowledged for its ecological value. This presents a number of water quantity, - quality and environmental issues and complexities.

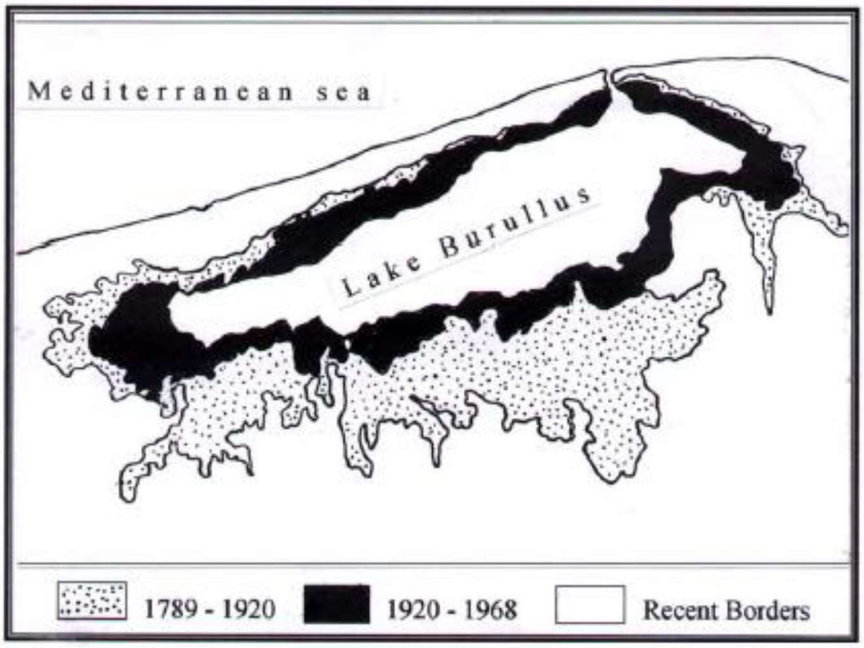

Figure 10. Changes in the size of Burullus Lake
(Australian Agency for International Development (AusAID) et al., 2013)

Reclaimed land in Lake Mariut, Aebis Project, 10,000 ha. Lake Mariut covers about 26,000 ha. Due to a fall of the water level by 3 metres large parts of the lake fell dry. A dike has been constructed and a drainage pumping station has been installed (Figure 11) (Group Polder Development, 1982).

Figure 11. Reclaimed land (10,000 ha) in Lake Mariut, Aebis Project (source: Google Earth)

Reclamaimed land in Lake Idku (or Edko), 1,600 ha. According to the Group Polder Development (1982) an area of 18,000 ha can still be reclaimed (Figure 12).

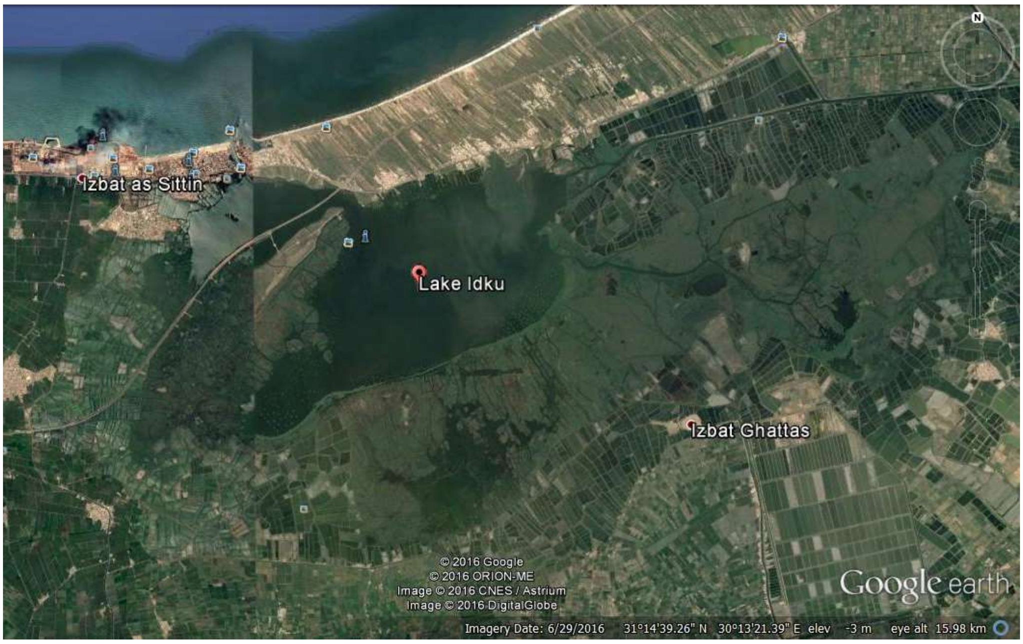

Figure 12. Reclaimed land (about 1,600 ha) in Lake Idku (source: Google Earth)

Reclaimed land around Lake Manzala, 100 ha. The 100 ha is a pilot polder near the western shore of Lake Manzala (Figure 13). According to the Group Polder Development (1982) a large area near Lake Manzala could still be impoldered.

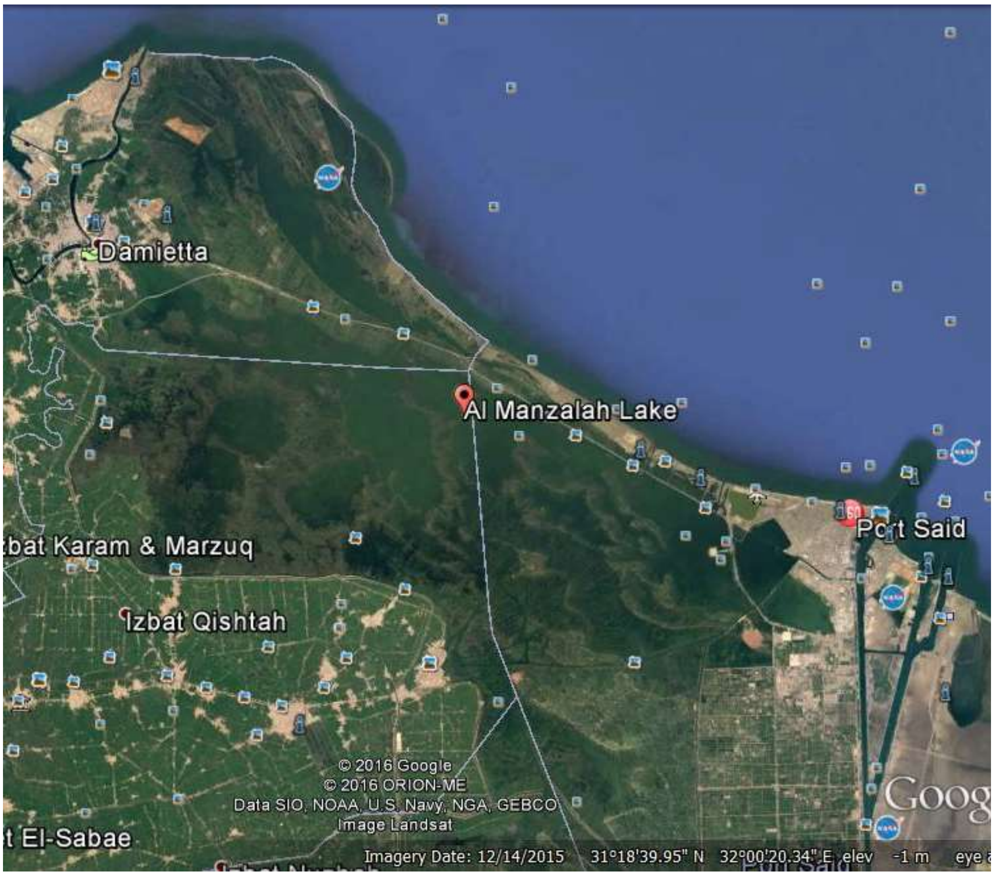

Figure 13. Reclaimed land (100 ha) around Lake Manzala (source: Google Earth)

Diab (1983) gives information on the dimensions of the drainage systems in the polder areas (Figure 14). These are:

- *field drains*. Spacing 25 m, depth 1 m;
- *secondary drains*. Perpendicular to field drains, depth 1.2 – 1.4 m;
- *collector drains*. Perpendicular to secondary drains, depth 1.6 – 1.8 m;
- *main drains*. Perpendicular to the collector drains. The water level in the main drains never exceeds the bottom of the collector drains.

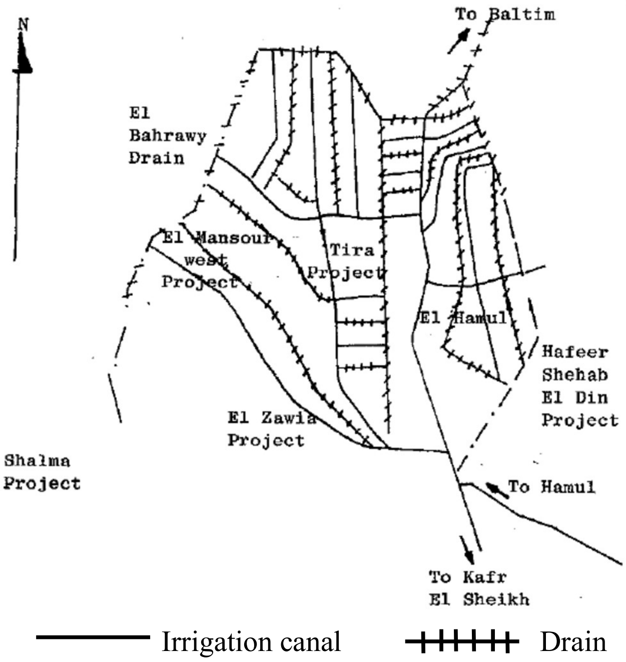

Figure 14. Irrigation canals and drains at polder localities in the North Delta (Diab, 1983)

General characteristics of the polders in Egypt are shown in Table I. Table II shows the characteristics of the water management and flood protection systems of the existing polders.

Proposed polders

No proposed polders have been identified.

Location of the polders in Egypt as shown on the World polder map

The location of the polders in Egypt is shown in Figure 15.

Figure 15. Location of the polders in Egypt (source: esri – Batavialand)

The pictures by Prof. Adriaan Volker are shown in Table III.

Acknowledgements

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Note: the Faiyum oasis is at 40 m-MSL. Baines and Malek (1980) mention that in the 12th Dynasty (1991-1783 BC) some 45,000 ha has been reclaimed for agriculture. This could have been polders. However, nowadays no polders could be identified here.

Bart Schultz

February 2023

Table I. General characteristics of the polders in Egypt

Name	Reclamation	Area in ha	Type *)	Latitudes	Longitudes	Elevation in m+MSL	Land use
Reclaimed land in Lake Abou Qir	1887	12,000	DL	31° 19' N	30 ° 04 ' E	0	Agriculture
El-Max area	1898	98,000	RLL				Agriculture
Several reclamations	1932 - 1952	84,000	RLL				Agriculture
Mansour and Zawia polders	1960's	27,300	DL	31°33' N	30 ° 01 ' E	-2	Agriculture
Reclaimed land in Lake Mariut		10,000	DL	31°09' N	29 ° 54 ' E	-2	Agriculture
Reclaimed land in Lake Idku		1,600	DL	31°19' N	30 ° 16 ' E	-1	Agriculture
Reclaimed area around Lake Manzala		100	RLL	31°20' N	32 ° 02 ' E	0	Agriculture
Other polders in the Nile Delta		907,000					
Total		1,140,000					

*) RLL = reclaimed low-lying land; LGS = land gained on the sea; DL = drained lake

Table II. Characteristics of the water management and flood protection system of existing polders in Egypt

Name	Design criteria in chance of occurrence/year							
	Water management						Flood protection	
	Drainage					Irrigation	Rural	Urban
	Type	Design criterion	Percentage of open water	Discharge capacity				
				m^3/s	mm/day			
Reclaimed land in Lake Abou Qir	DL					yes		
El-Max area	RLL							
Several reclamations	RLL							
Mansour and Zawia polders	DL					yes		
Reclaimed land in Lake Mariutt	DL					yes		
Reclaimed land in Lake Idku	DL					yes		
Reclaimed area around Lake Manzala	RLL					yes		
Other polders in the Nile Delta								
Total				1,300	8	yes		

Table III. Pictures by Prof. Adriaan Volker.

		
A3 000/XII.3.0 Prof. Adriaan Volker in a meeting	A3 001/XII.3.1 Prof. Adriaan Volker during a diner	A3 002/XII.3.2 Prof. Adriaan Volker, Prof. W.H. Van der Molen, Prof. L. Horst and Ir. Oosterbaan during a meeting
		
A4 001/XII.4.1 Group picture with Prof. Adriaan Volker at the Sad El Kafara Dam	B4 3 040/B.4.3.40 Draineer machine	