Greek Culture in Hellenistic Egypt

Persistence and Evolutions

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The Fayum: A Changing Landscape

Abstract: In the last years several articles and volumes have been published on Fayum's history, archaeology, and geo-morphology, with an increasing interest for the impact of climate-changes on the landscape evolution, in a multi-disciplinary perspective. The region has proved to be an interesting case-study, for its environmental characteristics and for the possibility of comparing them with a large number of literary and documentary sources. This paper will put together the available evidence and the results of recent researches to offer an overview of the eventual changes in the Fayum landscape, which in the past was quite different from what we may see today.

Keywords: Fayum landscape, climate change, geo-morphology, landscape archaeology.

1 Introduction

Landscape and environment are topics much discussed today, with good reasons, and as a consequence there is much interest also for studies on climate change in the ancient world. The present contribution aims to be a critical overview, albeit short and partial, of some studies and projects carried out on such topics during last decades, all focused on Fayum. The purpose is to bring to the attention of historians and papyrologists some crucial characteristics of the region, whose geomorphological evolution has been long debated, with conflicting results and not fully proven outcomes.

The geomorphological situation of the region and the evolution of its lakes, and therefore of the landscape, are topics of great interest to specialists of different disciplines and have been addressed in numerous publications since the *Description de l'Égypte*.[1] This is a complex subject, since many factors have contributed to its natural and artificial evolution. Attempts by research groups or individual scholars to establish a narrative of these changes have often led to contradicting conclusions. Recently, physicochemical studies on soil, water, and water microorganisms, possible indicators of changes in climate and vegetation, have also proliferated. However, until now, the study has been approached in a sectorial and not multidisciplinary manner.

1 For a geological overview Embabi 2018, 153–162.

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Reading through the vast bibliography, one realizes that the arguments are often circular. Geologists and sedimentologists base the interpretation of the core samples on the syntheses of historians, who often make use of the geologists' conclusions, without there being a real interaction and a cross-over of secure data. In this way, we continue to consider as certain data that are not certain at all.[2]

Knowledge of the region's current situation is essential to understand the complexity of the agricultural and hydrological dynamics at work today and in the past. Still, it must be remembered that the current landscape differs from the ancient one and can mislead us. The main changes in the Fayum landscape over time are due to the extent of the lake, which has changed many times by shrinking and widening with pulsations of different magnitude and duration, to the consequent extension of the cultivated and inhabited areas, as well as to the natural and artificial hydrographic system. Establishing these dynamics and dating them with a fair margin of certainty is essential to understanding the actions taken by the rulers in the various periods.

The study of the Fayum landscape should be approached in a multidisciplinary way, with new data collection campaigns in the area. A similar study, in which historical sources were examined compared to sedimentological, geological, and archaeological analyses, was recently undertaken to reconstruct the evolution of the lakes in the Mareotis, with good results (Crépy/Boussac 2021). The topic is also of particular interest for papyrological studies if the information handed down to us by written sources is to be given substance. Wide-ranging ground investigation would be indispensable, and as James Cook (2011, 20, 144–146) wrote in his interesting doctoral dissertation on the canals at Karanis, there are still few archaeological excavations of canals and hydrographic structures. Recent archaeological excavations have brought to light a complex hydrographic system in Philoteris, composed of dikes, locks, basins, canals, and wells (Kopp 2019, 343–355).

That the Fayum landscape is subject to changes even in recent times, is evident even if one limits oneself to reading the accounts of travelers from the 17th century onwards: Vansleb and Lucas (1672, 1699–1717: Davoli 2001, 354) report of a lake whose shores lapped Sanhur (-5 m). P.D Martin, an engineer who contributed to the survey of the Fayum with E. Jomard, saw dried forests at the eastern and western

2 Hassan/Tassie 2006 is often mentioned as a source of data derived from scientific investigations. This is a short and informative article in which the dynamics of the lake are reconstructed starting from data which are only stated, such as the analysis of some core samples that have never been scientifically published; nonetheless, it gave rise to reconstructions of the lake that are now widely accepted. In subsequent articles by the same authors the narrative changed, but the data was not made public for verification.

ends of the lake during the circumnavigation of the Birket Qarun carried out in early 1801; moreover, he attests that the water of the lake was brackish and still drinkable (Martin 1813, 212–213; *Description de l'Égypte*, Atlas F.lle 19–20; Fig. 28). Jomard, for his part, describes the region as one of the most fertile in Egypt, but with a cultivable area equal to about half of the current one, a sparse population and an inefficient canal system. The area to the west was completely abandoned and covered by sand dunes; El-Gharaq was deserted, as it was the southern shore of the lake and other areas. Jomard attests to the presence of only 60 villages (Jomard 1809, 80–81).

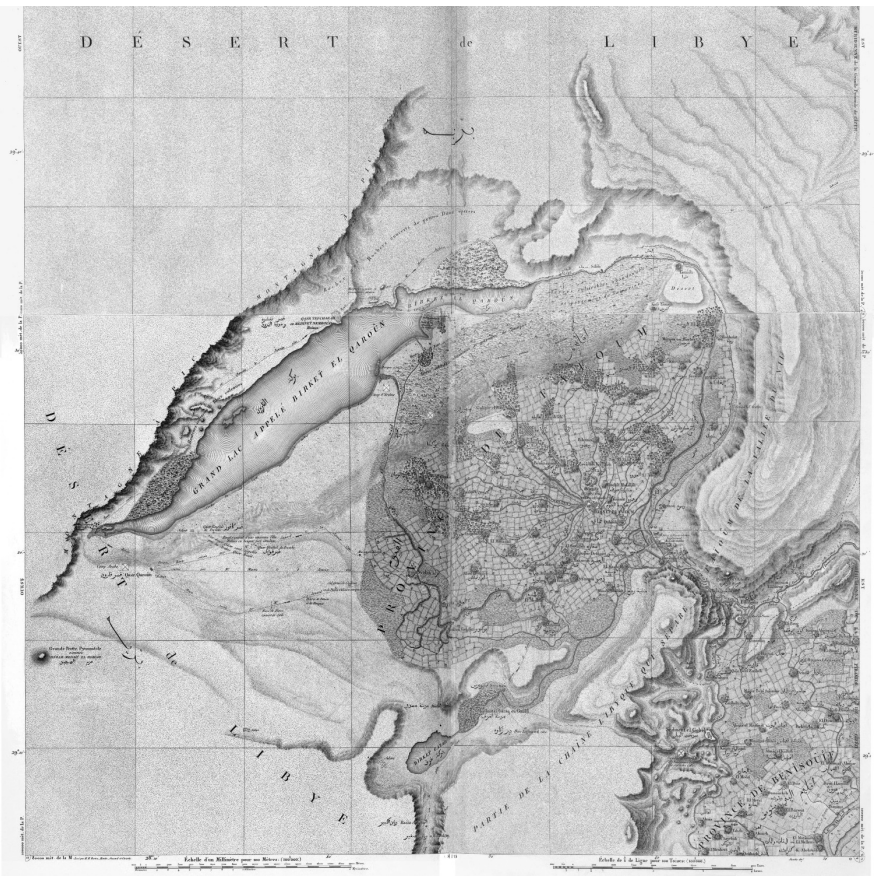

Fig. 28: *Description de l'Égypte*, Fayoum, Atlas F.lle 19+20.

Lake Qarun itself is described as brackish and not yet salty by G.B. Belzoni in 1819 (Davoli 2001, 357). Belzoni himself attests to the presence of ruins on the southern shore of the lake, which have now completely disappeared, while a group of artists following the orientalist painter Jean-Léon Gérôme, who went to the Fayum three times on hunting trips between 1856 and 1868, describe a natural environment rich in fauna that has now disappeared, including wild boars and pelicans, and a wilder countryside than today (Lenoir 1872, 87–95).

Landscape changes from antiquity to the 19th century are well illustrated by Claire Malleson, in *The Fayum Landscape,* published in 2019 (Malleson 2019). The author effectively summarizes the narrative of classical and medieval writers, travelers and scientists and highlights the perception they had of the landscape, having visited the region but also reinterpreted it in the light of previous narratives, as well as local traditions. Herodotus often strongly influenced travelers who visited the Fayum. On the other hand, Malleson's volume does not address the topic from a geoarchaeological or climatic point of view.

Today the population of the Fayum is close to 4 million, and the reclamation of desert lands has reached a scale never seen before. The fields, sometimes organized on terraces, are carefully measured, and leveled with the aid of advanced technology and efficient, invasive tools. The land is intensively cultivated and urbanized. The recent constructions of military areas, roads, quarries, and landfills have obliterated and often destroyed archaeological evidence and significantly changed the landscape. Desert tourism has also altered the surface of the desert on the fringes of the region, sometimes causing very serious damage.

Lake Qarun has reached a high level of salinity (34 g per kg) in recent years with artificially introduced marine fauna. Salinity increased rapidly during the 20th century and not only due to evaporation: in 1929 it was 21 g per kg.[3]

3 Today Birket Qarun occupies ca. 240 km^2 (40 × 6 km, depth 5–8.5 m), with a surface at -43–45 m below sea level. The lake water is currently salty mainly due to the fact that the lake does not have an emissary and the salts precipitate by evaporation remaining in the basin. The increasing salinization in the last decades is also due to perennial irrigation, intensive agriculture, and increased population. Drainage waters bring with them, as demonstrated by a recent study, salts that contribute to the constant increase in the salinity of the lake: Mahmoud et al. 2014. The lake was defined as "lagune saumâtre" in 1929 when the salt was 21 gr/kg: Hug 1929a, 66. Azadian/Hug 1931, 242 determined that the lake was a "chloro-sulfate-magnésien" type and that the salinity varied according to the seasons. According to Schweinfurth in 1884 it was "ziemlich trinkbar" (Schweinfurth 1886, 127). Salinity measurements started in 1901: Keatings et al. 2007, 263.

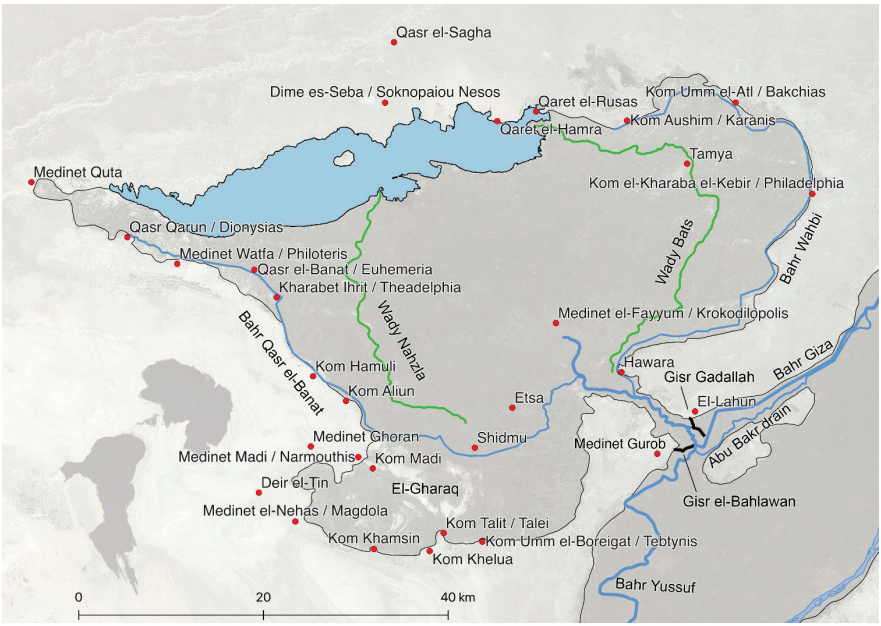

Fig. 29: Satellite image of the Fayum with the main sites and features mentioned (by B. Bazzani).

2 Geomorphological and Water Characteristics of the Fayum

The Fayum is a natural depression in the western desert, closed and fed by a single source of water, the Nile, which enters the region through its natural arm called Bahr Yussuf (Fig. 29). Today there are two incoming canals: in addition to the Bahr Yussuf, an artificial canal, the Bahr Wasef, was built in 1905.[4] It is well known that not all the water brought by the two canals enters the Fayum: a certain quantity is blocked at upstream of the locks at El-Lahun and diverted into a spillway channel, the Bahr Giza, which continues north. A second spillway channel (Abu Bakr drain), which returns the waters to the Nile, was active when basin floods were in use during the nineteenth century. This canal was reactivated in 1973 to divert excess winter water.

4 Ibrahimiya canal was realized to feed the agricultural lands of Khedive Ismail during summer months: Brown 1892, 9–11; Linant de Bellefonds 1872/1873, 548–554.

The amount of incoming water is today, and since 1885, calculated on the basis of the needs of the population and crops. An excess of water would cause a rise in the level of Lake Qarun, which occupies the lowest part of the depression. It should be remembered that the deepest point of the lake is -53 meters below sea level, while the Bahr Yussuf at the entrance to the so-called El-Lahun corridor is located at +25 m. A second lake, which was present in ancient times in El-Gharaq depression, disappeared in the last century.[5]

More attention has been paid to the history of Birket Qarun, which, moreover, is still not entirely clear. Less investigated but not less important was the role of Lake Gharaq in historical times, albeit of very limited size since the depression is much shallower: the bottom is about 2 m a.s.l.

The Fayum, with its lakes, constitutes a closed environment surrounded by the desert, comparable to that of the oases, but fed by Nilotic water and not by groundwater. Like the oasis environment, the Fayum also suffers from critical issues due to its proximity to the Saharan desert, with self-propelled dunes and strong winds blowing mainly from the north. Unlike the oases, life in the region depends on Nilotic water and silt, therefore sharing sedimentological characteristics with the Valley and the Delta. Thanks to recent sedimentological studies carried out in various locations in the Delta and the Valley, it has become clear how much the Egyptian landscape has changed over the centuries and millennia. The Fayum, like the Nile Delta, is characterized by a thick sediment of Nilotic clays covering the geological floor of the depression. This sediment was deposited on the bottom of the ancient Holocene lake, which, according to recent sedimentological studies, covered the entire depression up to an altitude of 40–44 m (Marks et al. 2016). A furthermore recent deposit was formed by the input of the Bahr Yussuf and spreads in the shape of a fan from the terrace on which the capital Shedet/Krokodilopolis/Medinet el-Fayum is located (+18 m) down to 0 m a.s.l. According to Beadnell (1905, 12), a British geologist of the Geological Survey of Egypt, the so-called Ptolemaic land reclamation was able to use this fertile soil — extending up to 40 m a.s.l. — for the new agricultural fields.

Being a closed depression, water entering the region stays there and can only leave by evaporation. It is therefore clear how important the control of incoming water was in historical times for the agricultural exploitation of the region and for the containment of the size of the lakes. The study of the history of Lake Qarun, its variations and whether it can be identified with Lake Moeris described by classical authors, has produced a vast bibliography which, however, as mentioned above, has not reached unambiguous and certain conclusions.

5 According to Grenfell and Hunt, at the end of the 19th century, there were still small lakes at the western end of the depression: Grenfell/Hunt/Hogarth 1900, 1.

Since the Napoleonic expedition, studies have been based on empirical observation and the analysis of written sources, in particular the accounts of Herodotus, Diodorus Siculus, and Strabo. The breakthrough in studies occurred only in the 1920s, when the well-known Gertrude Caton-Thompson and Elinor Gardner began to employ geological and archaeological investigation methodologies. More recently, deep core drilling has been carried out at different places in the region, the study and analysis of which have helped to define different types of issues, such as the causes of the lake's salinity increase, microfauna changes, and soil permeability. A much-studied aspect is also the diatoms (unicellular algae) embedded in clay sediments, which can be dated with the ^{14}C technique. They can also be identified in different types corresponding to different climatic and environmental conditions. Teams of Polish and English scientists have analyzed the Fayum lake deposits using core samples, one of which was 26 meters deep. These analyses suggest numerous environmental climate changes due to different water availability (rain and Nilotic), increasing/decreasing temperatures, and salt concentration. Five major climate changes have been identified during the Holocene (from approximately 11,000 years ago to the present),[6] in which water was alternately fresh and brackish. Unfortunately, these cores have not contributed definitively to providing a clear and well-dated history of the pulsations of the lake, in particular of the period that interests us most, from the 4th century BC to the 4th century AD, since the ^{14}C dates are not considered reliable for such a short period of time by the scholars themselves.

El-Gharaq lake has not been specifically investigated until now, nor have the two natural wadis, El-Bats (or Bahr bela-ma) to the east and El-Wadi drain (or Wadi Nazla) to the west, which convey the waters towards the lake. The history of the formation of the two wadis would be of great interest in understanding the changes in the territory since they constitute deep cracks in the Nilotic clay deposit that are difficult to cross and characterized by steep slopes that convey water rapidly towards the bottom of the depression. These wadis are 200 m to 2 km wide and 8 to 12 m deep, being real barriers in the canal network. Their nature suggests a formation caused by short and periodic alluvial activations, but no systematic geoarchaeological study has ever been conducted that could clarify the period of their formation (Butzer 2014/2015, 66).

6 Project funded by the Polish National Science Center in 2012: Zalat et al. 2017; Marks et al. 2016; 2018.

3 Nilotic Studies

The continuous mobility of the course of the Nile is now well established: it moved eastward and westward, creating islands or incorporating existing ones at the shore, as in the case of the Karnak area as well as Memphis.[7] In the Delta, the landscape has changed even more drastically over the centuries with extensive marshes that have gradually shrunk due to the constant input of sediments, the same ones that have buried natural and artificial channels. This phenomenon is particularly clear when we look at the present Delta, in which there are two arms of the Nile, and no longer seven as Herodotus describes. Even the present location of the ruins of the ancient capital Memphis, once at the apex of the Delta, has decidedly changed: the Delta's apex has moved away towards the north for several tens of km. Because of this same phenomenon, the coastline of the Delta must have been quite different from what it is today.

The Egyptian landscape in its broad outlines has certainly not changed from antiquity to the present, but if we take a closer look at individual areas and places, we notice strong changes due to natural phenomena of erosion and accumulation. Also, human action contributes to the changing landscape: the more incisive factors are the greater population density and the adoption of more sophisticated technologies.

The most dramatic and recent change in the landscape can be attributed to the conversion of the country's hydrographic system, from a hydrography based on the annual cyclicality of the Nile to a perennial one, made possible by the construction of the Aswan High Dam and the creation of Lake Nasser. Since 1971, the Egyptian territory has no longer been flooded once a year, with direct and evident consequences on the land, which lacks silt deposition (at least approximately 1 mm per year, i.e. 1 m in 1000 years), and the removal of salts from the soil. The consequences of this drastic change are also reflected in the agricultural rhythms, food production, a decrease in widespread plagues during the flood, and a complete change in the distribution of settlements in the country and the network of canals.

The process of hydrographic transformation that ended with the construction of the Aswan High Dam began with Mohammed Ali and featured Egyptian, French, and English engineers, whose technical solutions were not always successful. The land and the hydrographic system were completely modified with the excavation

7 See at least Bunbury/Rowe 2021; Bunbury et al. 2023. The evolution of the Nile and the changing landscape in Medieval Egypt is well described in Cooper 2014.

of new canals and drainage channels, and with the creation of extensive chains of irrigation basins bordered by dams or embankments.[8]

4 Perennial Irrigation

The Fayum has benefited from perennial irrigation since 1886 (Brown 1892, 96) thanks to the construction of the Assyut Dam and the Ibrahimyia Canal. According to Linant de Bellefonds (1872/1873, 57) the surface of the Birket Qarun was at -29 m in 1840, while by 1890 it had dropped to -43.30 m. This rapid change was explained by R.H. Brown, engineer of the Irrigation Department, with the fact that following the introduction of perennial irrigation the surface of the lake decreased due to intensive agriculture which since then allowed three harvests a year (Brown 1892, 7, 96).

Irrigation in this depression without an emissary works by gravity starting from +25 m above sea level, the altitude of the El-Lahun locks. This system is and was very sensitive to inaccuracies (Hopkins 1999, 375–376). The numerous inefficiencies of the Egyptian and Fayum hydraulic system are well described by the engineers who dealt with the country's hydrographic conversion such as Linant de Bellefonds (1872/1873) and Sir C.C. Scott-Moncrieff (1910), who headed the Hydrographic Department. It is clear from the Ottoman documents, from the cadastral reports, and from the studies carried out in the region prior to the creation of the perennial irrigation system, that the territory and the canal network have undergone drastic changes, with continuous modifications.[9] In fact, the dams built to retain water on the fields during flooding also had the effect of retaining Nilotic sediments, which over time raised the level of the soil. The change in slopes due to natural deposits is a constant in reclamation systems and they result in continuous changes in the location and depth of distributary and drainage canals. The archaeological investigation recently carried out by J. Cook (2011, 147–148) of the ancient canal near Karanis also found the continuous change of its route.

The 1878–1888 cadastral map of the Fayum shows a very small agricultural region, limited within the bounds of natural channels.[10] According to C. Audebeau (1918, 186, 191), the works carried out by the Irrigation Survey between 1885 and 1917

8 Anthropic activity has profoundly affected the use of the different areas of Egypt and the Fayum: the changes caused by the new irrigation system can be appreciated from the cadastral maps, from the geographical maps created during the 19th and 20th centuries, and from the publications of the Irrigation Department.

9 Linant de Bellefonds 1872/1873; Lyons 1908; Brown 1908; Scott-Moncrieff 1910; Mikhail 2010.

10 Lyons 1908, Plan XVII; on the beginning of the cadastral surveys cf. *ibid*.

improved water management and expanded the cultivated area. The Bahr Qasr el-Banat on the west side of the depression was dug in 1900, and since then new settlements have been built near the ancient ones, abandoned in Late Antiquity (Davoli 2015, 101). The same occurred along the eastern perimeter of the region, where the new Bahr Wahbi was excavated between 1900 and 1907, partly following the old Bahr Wardan. The latter, described by Al-Nabulsi (governor of the Fayum in 1245) as a silted canal,[11] appears to have been active in the Hellenistic-Roman period.

In the 1960s, the government began researches on soils and water to improve cultivated land and food production.[12] In 1963, the soil maps made in collaboration with the F.A.O. were published. In the Fayum, investigations focused on desert territories to understand in which direction artificial irrigation and reclamation could be expanded. An example of new reclaimed lands is the so-called Kom Aushim Shooting Club area, north-east of the Fayum, with three artificially created lakes (Hussein et al. 2013). In the 1963 map (El-Fayum-Cairo Sheet VI) the area was classified as "III medium suitable". In this area Caton-Thompson and Gardner found a system of canals and buildings from the Ptolemaic and Roman periods which suggested the presence of an artificially reclaimed area.[13]

Important hydrographic changes were carried out in the 1970s. The creation of the Wadi Rayan lakes in 1973 introduced new irrigation parameters: by means of an artificial connection with the hydrographic system of the southern Fayum, it made it possible to increase the water entering the region and to dispose of around 30% of the water drainage, which flowed into Lake Qarun through Wadi Nazla, into the new Rayan lakes (Wolters et al. 1989, 106). In 1984, further drainage was activated towards Wadi Rayan (Wolters et al. 1987, 161), and a new Egyptian-Dutch project started with the aim of improving water distribution for a more uniform supply in the region.

It is therefore clear that the territory has undergone heavy changes until very recent years, due to natural causes and anthropogenic intervention. Lake Qarun has changed, widening, and shrinking: the progressive reduction of its extension assumed by Caton-Thompson and Gardner (1934) has long been outdated. It is extremely difficult to establish the reasons for ancient pulsations, whether of natural or artificial origin. Therefore, studies on the Nile's water flow in various periods are of extreme interest and theoretically can help us understanding the extent of

11 Rapoport/Shahar 2018, 47.

12 Achthoven et al. 2004. Maps 1:100,000 July 1963, UAR High Dam Soil Survey Project, in cooperation with United Nations Special Fund (FAO).

13 This and the surrounding areas were re-investigated by Cook 2011 as part of the URU Fayum Project of the University of Los Angeles directed by W. Wendrich.

the artificial interventions implemented during the 12th dynasty and the Hellenistic and Roman periods. Here we enter the scientific field of those who study the African lakes from which the Nile originates. Ancient sources on the Nile floods are not numerous until the Islamic era. The Nile's water flow is due to rainfall and is therefore affected by climate variations, which are periodic but also long-lasting. Climate change's influence on ancient civilizations is still too underestimated, especially when studying areas in precarious ecological balance, such as the oases. The comprehension of the activity of the primary source of water in the Fayum, the Bahr Yussuf — its accessibility by the Nilotic water at its starting point, and at the entrance at El-Lahun — would also be crucial for our understanding of the regional hydrographic dynamics.

Sedimentological studies in various areas of Egypt and the Near East seem to agree that a major climatic shift toward greater aridity occurred around 2100 BC (the end of the Old Kingdom) and would have led to the crisis of entire civilizations in North Africa and Asia.[14] This would have been produced by the change in the North Atlantic circulation, and therefore, the monsoons became weaker over these areas. Some scholars believe that there was a lowering of the water of Lake Qarun during the Late Predynastic and Early Dynastic (Butzer 1976, 36; Hassan 1986), and a further decrease around 2100–2000 BC (First Intermediate Period) in which different sources attest to a strong political and economic crisis. Recovery in the Middle Kingdom appears to be linked to high levels of flooding of the Nile as evidenced by rock inscriptions near Semna (Bell 1975). The so-called first reclamation of the Fayum is ascribed to the 12th dynasty, but what this project consisted of is not yet known. The presence in the region of imposing monuments erected by the rulers of this dynasty, as well as two of their pyramids significantly at the entrance to the region in El-Lahun and Hawara, suggested an artificial intervention, which some scholars today define as "valorization" of the region,[15] rather than a reclamation: an elegant way to express our complete ignorance on the methods of intervention on the territory implemented in this period.

14 It is commonly accepted that among the reasons of the collapse of the Old Kingdom state there were years of low Nile floods. In that period (ca. 4200 BP) famines and climate crises also occurred in the Eastern Mediterranean. Around 3000 BP the vegetation in the Nile Delta testify to aridity (which also coincides with the fall of the kingdom of Ugarit and famines in the kingdoms of Syria and Babylon). Bernhardt et al. 2012 state that between 4200 and 2000 calibrated BP the Nile was characterized by moderate but not constant floods. Stanley et al. 2003, 395–402 argue on the base of analysis of some core samples from the Delta that the fall of the Old Kingdom was due to climate change. A gradual desiccation of Egypt occurred from 6000 BP (Predynastic) to 4300 BP (Old Kingdom).
15 Veymiers 2016, 141. Also C. Malleson 2019 argues our complete ignorance of what type of intervention was carried out by the Pharaohs of the 12th dynasty in the region.

According to an interesting and well-documented article on the changing hydrographic landscape of the Bahr Yussuf valley published by Harco Willems and collaborators, there are no direct sources testifying the nature of the activities occurred in the 12th dynasty in the region. However, the toponymy and few remains suggest which kind of activities may have been carried out.[16] The presence of the two pyramids of Sesostris II and Amenemhat III near the dam Gisr Gadallah is significant, according to the authors, as is the toponym Ra-Henet, or "mouth of the canal" which identifies El-Lahun since the Middle Kingdom. These would be the only evidence attesting hydraulic works in the Middle Kingdom, in which two large dams were built, the Gisr Gadallah to the north and the Gisr el-Bahlawan south of the canal near El-Lahun. These were probably equipped with locks, later also controlled from the site of Gurob in the New Kingdom. Hawara is a toponym deriving from the Egyptian *Hwt-wret*, already known to designate a legal institution in the Old Kingdom. Hawaret el-Maqta and Hawaret el-Adlan are two settlements closely connected to the El-Lahun dams and can suggest, according to the authors, the presence of settlements or institutions controlling the locks (Willems et al. 2017, 332). This study does not address the topic of the lake's width and the problems relating to the altimetry of the region. If the construction of the locks at El-Lahun by the rulers of the Middle Kingdom can be accepted on an inductive basis, it remains to be ascertained what the condition of the lake was: it is generally taken for granted that the reclamation action undertaken in the Middle Kingdom and then early Ptolemaic times intended to decrease the size of the lake and drain the waters that formed swamps and marshes.[17]

In this context, the term reclamation means agricultural reclamation, or a set of operations aimed at making a territory productive. These actions are not necessarily limited to the drainage of water and marshes but can consist of infrastructure works of a different type, such as water regulation and distribution systems. In fact, if the Fayum had been an arid region at the end of the First Intermediate Period, with a reduced or even absent lake, the work of the rulers of the Twelfth Dynasty would have been centred on the artificially regulated use of the newly available water and aimed at preventing the depression once again became an immense lake leaving no room for agricultural use. The commonly accepted opinion, which however should still be scientifically demonstrated, sees the creation of a new lake whose shores were at +14 m, which therefore also entirely covered El-Gharaq. On the

16 Willems et al. 2017, 332.

17 Butzer (2020, 106), a well-known expert on the hydrography of Egypt, puts forward the hypothesis that the lake of the Middle Kingdom reached +15 m and had a smaller size compared to previous eras. However, Butzer does not explain how it was possible to lower the lake level.

shores of such a lake are the monuments and settlements known until now and dated to the Middle Kingdom. The largest agricultural area would thus have been limited to the highest step, on which the capital is located, to the El-Lahun corridor and to the south-eastern end of the region.

Yet we do not have certain data to establish what the width of the lake was during the periods that preceded the Hellenistic era: according to some scholars, a certain stability around +14 m is probable, which also needs to be demonstrated given that it is known how the flow of the Nile was not constant. The existence of a high lake for ca. 1500 years would have resulted in a continuous deposit of lake sediments, to which an input of aeolian sand coming from the north must be added. In these lake conditions — at +14 m above sea level — it is difficult to imagine that the two natural wadis (Wadi Nazla and Wadi Bats) could have been formed before the Middle Kingdom, since they would have been eroded and leveled again by the high lake. Geologists believe that (Embabi 2004, 179) these deep ravines originated on the surface of the clay deposit (the Fayum delta) after a recession of the lake. The wadis cut through the Nilotic sediments and reach the Eocene limestone in some places. The soil eroded by this or these events must have formed fan-shaped accumulations in the southern part of the lake. Great damage and washing away of the soil certainly occurred during the extraordinary floods of the Nile: in the last two centuries some of these events have been recorded as catastrophic (for example the breaking of the El-Lahun dam in 1819).

Determining when these wadis were formed is important for our understanding of the natural and artificial hydrographic system in use during the Hellenistic and Roman periods, since they constitute real barriers in the canal system, but they are also formidable collectors of water due to their depth and slope. For this reason, dams were built to prevent the water from draining rapidly into the two wadis: these are massive walls of stone and fired bricks built near Tamya and Miniet el-Heit (or Etza-Shidmu). Ottoman documents from the 18th century also mention a dam protecting El-Gharaq and numerous works carried out to repair and maintain the dam system (Mikhail 2010, 6–10), including those at the entrance to the Fayum (Gisr el-Bahlawan and Gisr Gadallah). It is therefore also important to establish the dating of the construction of the dams, which is not easy due to numerous renovations and restorations that took place until recent times.

The history of Wadi Bats and its Tamya Dam also affects understanding the northern route of the ancient perimeter canal that preceded the Bahr Wahbi. This canal passes west of the Hawara pyramid cutting through the labyrinth, a Roman settlement, and a 6th century church, following the route of another canal already present in the K.R. Lepsius' cartography (1843) and called Bahr Sharkhiya. Bryan Kraemer (2007; 2010), who has studied the history of this canal in detail, believes

that the Ptolemaic canal, the Kleon Canal, must have passed for orographic reasons even further west of the pyramid, very close to the Wadi Bats, which constitutes a danger for the capture of water towards the lake. Precisely because of this wadi, the Bahr Sharkyia was excavated, perhaps between the 8th century and 1240, further east, cutting through the labyrinth. As I underlined at the beginning, there is a lack of studies that allow us to date the formation of the deep Fayum wadis, which were certainly created due to a very shallow lake and one or more violent Nilotic floods. The history of the Bahr Sharkyia may therefore suggest that the Wadi Bats did not exist in Ptolemaic period, and this would have allowed the ancient Kleon canal to pass much further west of the pyramid and the present canal. If so, we would have to admit one or more catastrophic floods before the inspection of Al-Naboulsi (1240), but after the construction of the so-called Kleon Canal. According to Willems (Willems et al. 2017, 332) the dam near Hawaret el-Maqta, which closed the entrance to Wadi Bats, was built in Roman times.

5 The Hellenistic Period

After these premises, let us turn to the Hellenistic period, in which we know that the Fayum became one of the most productive agricultural regions in the country. The impressive papyrus documentation mentions numerous settlements and canals, of which we have archaeological evidence for only a few of them. According to Katja Müller, there were 147 settlements in the 3rd c. BC; 118 in the 2nd c. BC and 61 in the 1st c. BC (Müller 2005, 114). These data seem to testify to a change in the population distribution and therefore in the agricultural landscape during the Hellenistic period. Papyri attest to low floods of the Nile in the reign of Cleopatra VII (Casanova 1984, 192), which seem to be proved by levels of abandonment, at least in some Fayum settlements, and perhaps by the interruption of public works, such as the construction of temples whose decoration remained unfinished. A new flourishing period occurred during the principate of Octavian Augustus, in which the settlements were repopulated and public works resumed. The canal works carried out in this period throughout Egypt are generally interpreted as a necessity caused by state negligence in the previous period. More likely, however, they became necessary due to a series of low Nile years. Whatever the cause, the result does not change and we can agree with J. Cook that in Egypt, and in particular in the Fayum, the development of the irrigation system was not a single event, but a continuous process in which not only annual maintenance was needed (attested by papyri), but sometimes a variation of their course was necessary, to adapt the flow of the water to changes in the orography (Cook 2011, 79).

In Bart Van Beek's important volume (2017) on the archive of Kleon and Theodoros little space is dedicated to the geographical context. The study of the archive is particularly interesting and points to a series of activities under the responsibility of the two engineers, such as those at the stone quarries,[18] in addition to the works connected with the hydrographic system.[19] In the introduction the author briefly traces the history of the lake which occupied the Fayum depression from 7500 BC to the beginning of the Ptolemaic period. However, he does not specify the sources that he has used to draw data on the height/width of the lake over very long periods. The result is a sort of summary of a history of the territory, which now seems to be well established and free of uncertainties. According to Van Beek, the lake would have reduced in size very quickly at the beginning of the Hellenistic period due to natural evaporation, and following the construction of a dam which blocked the incoming water at El-Lahun. According to this narrative, the water level dropped to -2 m, and therefore the lake assumed its current size.[20] Needless to say that the shores of the present lake are at -45 m, so well below -2 m.

On these bases Van Beek then moves on to the study of Ptolemaic land reclamation which intended to expand agricultural areas for well-known needs. He suggests that the reclamation — the drainage and water distribution works — were carried out by Greek engineers. As D. Thompson already noted,[21] Greek engineers had extensive and consolidated experience in Boeotia (Lake Kopais) and in Macedonia (Philippi and Pella areas).[22] Unfortunately, the papyrus documents from the archive of the two Greek engineers Kleon and Theodoros dates back to a time when the reclamation works had already been carried out (256–237 BC) and therefore does not explain what the reclamation actually consisted of. The narrative that

18 Van Beek 2017, 26 claims no stone quarries in the Fayum exist. However, it is well known that the plateau around the depression was used as a calcareous sandstone quarry to build temples and tombs: see at least Minaya 2012, 104 and Fig. 37.

19 Van Beek 2017, 17 agrees with G. Garbrecht and H. Jaritz (1990) in believing that Lake Moeris was a seasonal (from October to February), artificial lake located in the Hodd el-Tuyur or el-Mala'a basin, artificially created with retaining walls equipped with locks. Lake Garaq was connected to this reservoir and served in case of excess water. The Etsa-Shidmu stone wall, dated by Garbrecht and Jaritz to the 1st–2nd c. AD, probably replaced a Hellenistic earth dam, similar to the Gisr el-Bahlawan and Gisr Gadallah, both of the Ptolemaic period. According to the two German authors, the earth dam was broken by high water in the reign of Claudius (41–54 AD) or Nero (54–68 AD) although there are no sources that can attest to the event. See also Erbich 2020, 68.

20 A lake at 0 and -2 m is hypothesized by Hug, Ball, and Schwartz (1927, 1939, 1950): cf. Davoli 1998, 356.

21 Thompson 1996, 43–59; 1999, 107.

22 On the reclamations carried out by Philip and mentioned by Theophrastus, *De causis plantarum* 5.14.4–6, cf. Hammond 1989, 152–154.

emerges from the archive in question concerns the maintenance of water infrastructure, the organization of work and administration. Very significant is the fact that these papyri were reused in the cartonnages of the Gurob necropolis, that is at the entrance to the Fayum and near El-Lahun locks. The papyri mention four locks (*thurai*) at El-Lahun, and locks on other canals, on whose opening and closing the flow of water and the irrigation of the fields depended (Van Beek 2017, 26). Such sluices, it is said in the texts, could be raised vertically to let water pass through. This is a very important acquisition, since the presence of a lock necessarily implies control of the water which can be diverted into different channels. A dam without locks, on the other hand, involves the creation of a reservoir upstream of the dam itself, something that never seems to have occurred upstream of El-Lahun.

As Van Beek points out, in addition to canals, great importance is played by dykes, to hold back water during flooding, and sluices. The careful study of the Greek vocabulary of the archive reveals the use of several terms that point to dams having different functions, as *choma*, used to retain water, or *gephyra*, a raised bank that acted as a passage at the time of flooding. Also mentioned are "new dams", an "old dam", and "common dams", perhaps built by locals as opposed to government ones.

To understand the extent and type of works carried out at the beginning of the Ptolemaic period, it is necessary to know the conditions of the lake at that time, but I am not aware of any studies or data on the 30th dynasty lake. Recent discoveries of structures dating back to the 26th dynasty in Bakchias and north-west of Soknopaiou Nesos (Marchand 2012), would seem to indicate the presence of a high lake on whose banks there were settlements, or the presence, already hypothesized by Cook, of an eastern perimeter canal that passed through Bakchias. So far, no canals have been identified that could reach Soknopaiou Nesos. Herodotus's testimony also seems to refer to a large lake. However, this evidence and account date back to the 7th and 5th centuries BC, and cannot be considered representative of the situation existing at the end of the 4th century BC.

According to Fekri Hassan (Hassan 1986, 495) the lake naturally shrank at the beginning of the Ptolemaic period due to a low level of the Nile, attested by a lowering of the water level of Lake Rudolf. If this were the case, the land reclamation project would have benefited from a natural reduction of the lake. The intervention therefore may have been concentrated at the entrance to the Fayum on the Bahr Yussuf, to control the incoming water and convey it through artificial canals to increase the agricultural area. Such a hypothesis seems more realistic than the artificial reduction of the lake in a short time, as is commonly stated.[23] An artificial

23 The recurring idea that the lake was artificially reduced is not based on any evidence: Cook 2011, 65 ff.

reduction of the lake can only have occurred through the closure of the Bahr Yussuf, that is the diversion of the water northwards, so that the lake would not be continuously fed and would have been reduced by evaporation over a long period of time. There is no doubt that Greek engineers were capable of great reclamation works, such as that, above mentioned, of Lake Kopais in Boeotia. In that plain, scholars have identified artificial works dating back to the Mycenaean era (13th c. BC), as well as to Hellenistic and Roman times. However, the reduction of Lake Kopais made use of the possibility of draining water through cracks in the rock to the subsoil. As with the Fayum, Lake Kopais was the subject of repeated interventions until very recently, and scholars find it difficult to date the individual works and understand their efficiency. Other impressive hydraulic works were also carried out in Greece, such as the excavation of the Khephalari underground canal (resembling a *qanat*), attributed to Crates, Alexander the Great's engineer.[24] The Fayum, however, is a closed environment that is difficult to drain from the inside, although we may be reminded of Herodotus, who believed there was an underground canal that conveyed water from the lake into the gulf of Sirti. Such a drain has never been found, and its existence appears very unlikely; but it certainly resembles the system implemented in Lake Kopais and at Khephalari.

In 2003 a project was launched by University College London: "Environmental Change and History of Water Management in the Faiyum Depression during the Holocene", directed by F. Hassan and R. Flower (Hassan/Tassie 2006). Drill cores were carried out in several places, and articles examining their contents were published by different teams, focusing on different fields, as limnology, salt concentration, diatoms, and more.[25] However, as we have already mentioned, the geoarchaeological and historical results are presented but not discussed and fully published (Hassan/Tassie 2006; Hassan et al. 2011).[26] According to Hassan, the lake would have been at a height of +10 m in the MR, then at +22 m in the New Kingdom, at -5m in the Ptolemaic period, to reach -20 m in the Roman era. However, these conclusions, as already noted, have never been demonstrated but only announced. On the contrary,

24 A recent multidisciplinary project focuses on the dynamics and history of Lake Kopais: Kountouri et al. 2013. See also Mamassis et al. 2015. On hydrographic works in the Pella area cf. Greenwalt 1999, 168.

25 See e.g. Flower et al. 2006; Keatings et al. 2010; Abu-Zied et al. 2011; Flower 2016. Here I mention only the articles that can give clues to the historians about the topic.

26 Hassan et al. 2011 should be used with cautions: some data are not correct, and several assumptions are not demonstrated by evidence. The mentioned results of the geological analysis in Hassan 1986 are not from drill cores. In the web site of the project there is no detailed information nor an effective scientific publication of the research results: https://www.geog.ucl.ac.uk/people/emeritus/roger-flower/research/qarun (last visit August 2020).

the sedimentologists who are part of the same project have concluded that the certain dating of the core deposits is only possible up to the 18th century of our era. Another project obtained different data from the analysis of a 26 m deep stratigraphic core. According to these analyses, the lake in the Ptolemaic period would have been at 0 m (Marks et al. 2016 and 2018).

These hypotheses do not consider the altitudes at which the Greco-Roman settlements known to us would be located compared to the hypothesized lakes. On the other hand, other scholars have theorized lakes of different sizes depending on the periods, due to the presence or absence of dated ruins. In both cases these are method errors, as I have already demonstrated (Davoli 2001). In fact, the ruins of the ancient settlements have undergone different modes of destruction over time and for different causes, not least the growth of the lake's water level at different periods and up to 1840.

El-Qara el-Hamra and Qaret el-Rusas are two settlements submerged by the waters of the lake, that have been recently studied by Hans Barnard and the team from the University of Los Angeles (Barnard et al. 2015): the first is located on the north shore of Birket Qarun at -39 m, while the second, which was already known, is on a limestone promontory at the eastern end of the lake at -41 m. According to Barnard, the two settlements were abandoned after a catastrophic rise of the lake which occurred during the 4th century, as the pottery found seems to testify. The inhabitants probably moved to Karanis, which saw considerable expansion southwest of the kom in the 4th century AD. The excavation of this area of Karanis involved some very degraded buildings with ceramics dating from the 4th to the 6th century AD. According to this study, in the Ptolemaic era the lake must have been at -37 m and in the Roman era at -44 m (Barnard et al. 2015, 67). The rise of the lake in the 4th century AD may have been caused by a strong flood that broke the dams and poured into the lake, rapidly raising its level. C. Römer, who studied the western area of the Fayum, hypothesized that the 4th century crisis recorded in that area was due to the breaking of the Etza dam caused by an anomalous flood. The water would have flowed rapidly towards the lake through the Wadi Nazla and since then it would no longer have reached the canals of the western area of the region, leading to the abandonment of the settlements. Particularly attractive is the hypothesis that it was the same catastrophic event that led to the breaking of the El-Lahun and Etza dams, with the consequent increase in the lake level and the submergence of the two settlements of El-Qara el-Hamra and Qaret el-Rusas during the 4th century. However, upon closer archaeological examination, the ceramics found in the recent excavations carried out in El-Qara el-Hamra have been dated between the 2nd c. BC and 2nd c. AD (Ringheim 2019): the abandonment of the site would appear to precede the supposed flood of the 4th century AD. According to

Ringheim, the settlement was a Hellenistic foundation, dating back to the 2nd century BC, and thus testifies to a low lake (at least -39 m) already in this historical period.

6 The Bahr Yussuf

The study of the hydrographic system of the Fayum cannot be separated from that of the Bahr Yussuf, in Antiquity the only source of water in the region.

An important multidisciplinary study, directed by Harco Willems, of the course of the Bahr Yussuf up to the Fayum found that the water from the Nile flood which poured into the Bahr Yussuf valley did not all flow into the Nile at the end of the flood period. Part of it descended towards the north, following the natural slope of the Bahr Yussuf valley up to the Fayum, which therefore received both the flood of the Nile and the water from the outflow of the areas located south of the Fayum (Willems et al. 2017, 323). This project also studied the dam system in El-Lahun (Gisr el-Bahlawan and Gisr Gadallah), considering it essential to understand the ancient hydrographic situation of the region. In addition to the two above mentioned dams, the existence of a third dam, no longer preserved, was assumed, which blocked the flow of runoff waters between El-Lahun and Gebel Abu Sir. The surviving dams are embankments (sometimes covered in stone), 28 m wide at the base and 8 m at the top, approx. 3.25 m height (reaching +29.25 m). In this area the land towards the Fayum is approx. one meter lower than that of the other side of the dams. The system of double locks currently active in El-Lahun, which dates back to the beginning of the 19th century, is already attested in documents from the 11th century, but must have also been present in ancient times. According to the authors, in Greco-Roman times there must have been multiple locks in the Hawara area, which had the function of diverting excess water from the Bahr Yussuf. Without a system of locks the artificial hydrography of the Fayum could not be operational (Willems et al. 2017, 135). The canals branching off the Bahr Yussuf and fanning out towards the region had to be already equipped with locks in more ancient times. A lock still exists, southwest of Hawara: it controlled the water flowing into the Hodd el-Tuyur (Mala'a basin, a plain north of Tebtunis), as found by Garbrecht and Jaritz while investigating the function of the Itza-Shidmu wall.[27]

27 According to Garbrecht, the wall allowed the formation of a lake, a reservoir that could allow a second harvest a year in this area, and which the author identifies with Lake Moeris: Garbrecht 1987.

The Lahun system of dams and locks was therefore meant to convey the water into the main Bahr Yussuf canal and then from this into branch canals with different directions. This complex system also had the function of controlling the amount of water entering the region and avoiding excessive flooding: a spillway channel was needed for this purpose from the moment of their construction.

Such a canal is present in the cartography of Egypt by Ibn Hawqal (943–988 AD) (Fig. 30),[28] and according to G. Goyon (1971, 148–253) it was created at the beginning of the 1st dynasty (at the time of Menes). This would be the canal called *Iter-aa* in Egyptian texts, the "Great Canal", and then the Memphis Canal, created when the hydrography of the Memphite area was organized. It served, according to Goyon, to irrigate the extreme western side of the Delta, but also as a waterway to reach the ports of the Giza pyramids. It started from Bahr Yussuf near El-Lahun and reached Lake Mareotis. Goyon's hypothesis is well supported by ancient, medieval and modern sources. The existence of such a spillway since the 1st dynasty implies that well before the Middle Kingdom there was a way to control the waters that flowed inside the depression. In his work on the canals of the north-eastern area of the Fayum, J. Cook believes that there was no drainage of the lake in the Ptolemaic period, and that the engineers Kleon and Theodoros were only administrators of a pre-existing system, in continuous evolution and maintenance; this system could date back to the Old Kingdom, as Caton-Thompson and Gardner (1937, 268 ss.) already hypothesized, after having found the remains of a canal dated to that period near Bakchias (Cook 2011). Unfortunately, the changing landscape in this area due to recent land reclamation works prevents any further investigation.

Finally, we cannot trust the account of Herodotus, and others after him, who claim that the water accumulated in the lake after the flood, flowed from the Fayum towards the Nile for six months of the year: this account is unrealistic, as the depression is closed. The story, however, takes on a less fanciful aspect, as it considers the existence of a spillway canal already before the Hellenistic period, the above mentioned *Iter-aa* of the Egyptian texts, which conveyed the post-flood runoff waters, captured by the Bahr Yussuf valley, towards the north.

28 Ibn Hawqal, *Manuel de géographie* (end of 10th century; copies of two 16th century maps after a manuscript of 1443–1444), manuscript BnF Arabe 2214, f. 11v–12; https://archivesetmanuscrits.bnf.fr/ark:/12148/cc12992d, last viewed 8/30/2023. See also Ducène 2004.

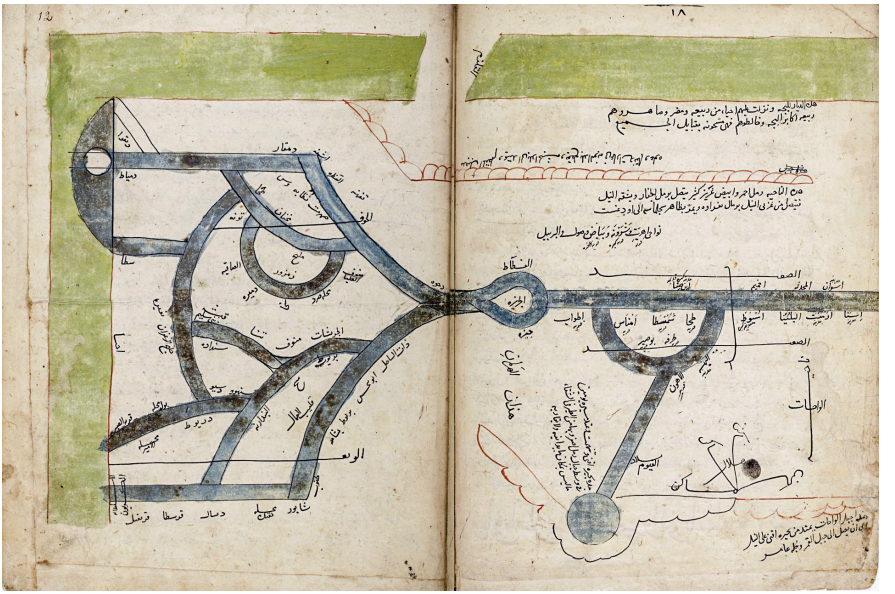

Fig. 30: Ibn Hawqal's map. Image of public domain: source gallica.bnf.fr / BnF (https://gallica.bnf.fr/ark:/12148/btv1b84061557, last access July 8th, 2024).

7 Final Remarks

As already stated, much remains to be done to achieve a scientifically based, historical picture of the changes in the Fayum landscape. The extensive bibliography on the topic reveals a varied picture of methodologies adopted, which have led to different results, demonstrating the importance of addressing complex phenomena through a multidisciplinary approach. Good examples are the works on Lake Mareotis and on the Bahr Yussuf valley which I have discussed.

Recent works have provided some reliable data, useful for targeted and multidisciplinary research, that can determine the width of the lake (Figs. 31–36): the identification of new settlements — such as those in the area of Soknopaiou Nesos and Bakchias, in Medinet Quta (Davoli 2018), the one in Qara el-Hamra, dated between the 2nd BC and the 2nd AD and located at -39 m, as well as the presence of Qaret el-Rusas at -41 m — may offer useful evidence for the presence/absence of the lake at certain altitudes that must be combined with other sources of information. It would be important to be able to have a certain dating for the foundation and abandonment of Qaret el-Rusas before venturing into hypotheses on the dating of

supposed catastrophic event that caused the lake to increase in level with the consequent rapid abandonment of the sites located at ca. -43 m on the shore. However, given the existence of these settlements, and perhaps others not yet identified, there can be no doubt that the lake in the Hellenistic and Roman periods had an extension like the current one, as already hypothesized by Caton-Thompson and Gardner. Therefore, I believe that the proposed reconstructions of lakes at different altitudes (0, -2, -5, -17 m) in the Greco-Roman period are not reasonable, unless we consider them short-lived pulsations.

As already underlined, the type and extent of the works carried out during the 12th dynasty and the Hellenistic era are not known, but they certainly concerned primarily the control systems of the water entering from El-Lahun. If, as now suggested by various scholars on mutually independent data, at the beginning of the Old Kingdom, or even during the 1st dynasty, there was already an albeit rudimentary and partial control of the waters of the Bahr Yussuf, with a spillway channel that allowed excess water to be diverted, we should reconsider many of the most deeply rooted beliefs relating to the reclamations of the subsequent eras.

In conclusion, the current Fayum region is the result of a stratification of natural and artificial actions: a sort of palimpsest. As demonstrated by the extensive bibliography, it is difficult to establish the natural causes and types of artificial interventions in various historical periods and how these have gradually changed the hydrographic structure and consequently the landscape and the settlement network.[29] The call for caution in assuming yet unproven solutions is a must.

29 On a methodological perspective cf. Butzer 2011.

The lake at different elevations based on the present geomorphology of the region (by B. Bazzani, based on ASTER GDEM 2, a product of Japan's Ministry of Economy, Trade, and Industry (METI) and NASA)

Fig. 31: Lake at 20 meters below sea level.

Fig. 32: Lake at 15 meters below sea level.

Fig. 33: Lake at 0 meter above sea level.

Fig. 34: Lake at 10 meters above sea level.

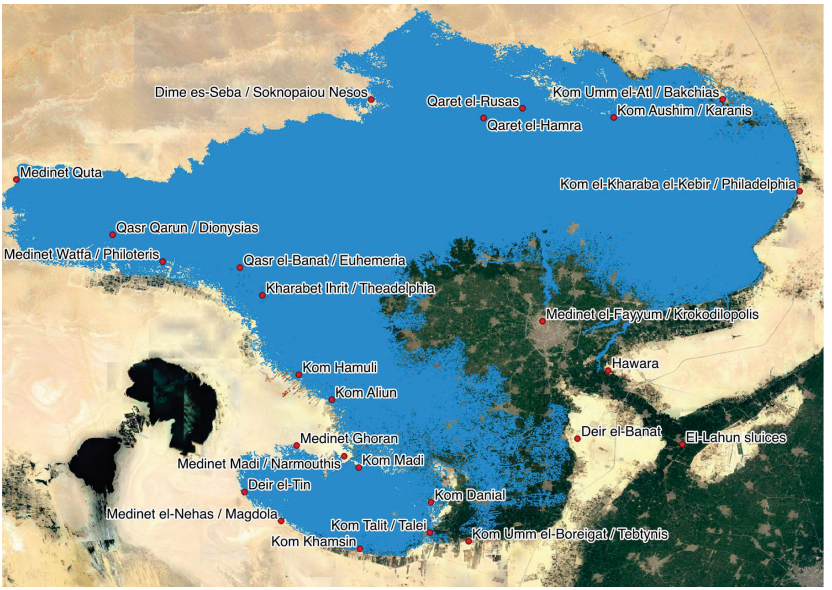

Fig. 35: Lake at 15 meters above sea level.

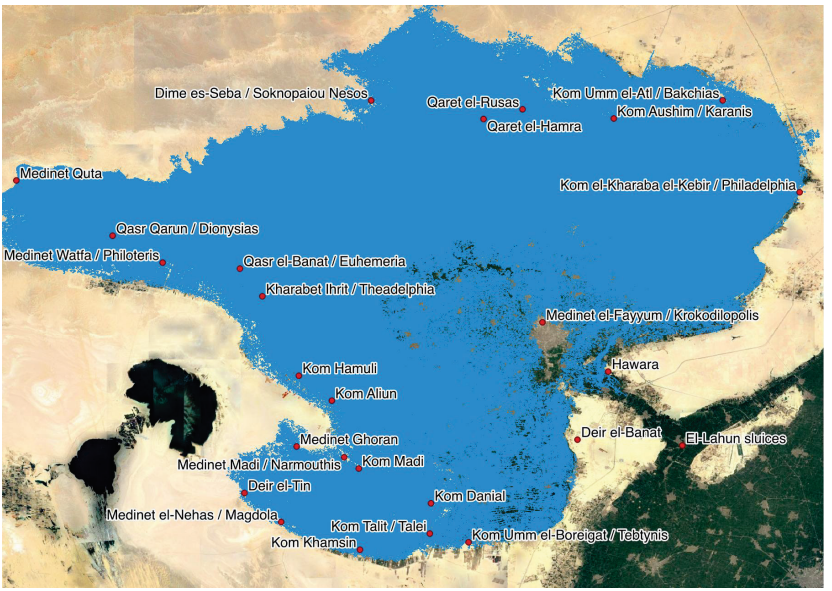

Fig. 36: Lake at 22 meters above sea level.

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