[Vicino Oriente XXVI (2022), pp. 77-97]

DIGITISING THE NAPOLEONIC MAP OF EGYPT. THE CREATION AND PUBLICATION OF AN OPEN DATA SET FOR THE RECONSTRUCTION OF THE ANCIENT EGYPTIAN LANDSCAPE

Julian Bogdani - Domizia D'Erasmo - Cecilia de Leone - Arianna Giordano
Sapienza University of Rome

The Carte topographique de l'Égypte, published in 1828 by the French engineer Pierre Jacotin, has always been considered a significant means for the reconstruction of the ancient Egyptian landscape. This cartographic series can be used as an informative bridge linking the present and the past, in the effort to understand the many changes that have determined the Egyptian landscape over the centuries. The production of digital geographical data from historical sources with the help of GIS (Geographic Information Systems) methodologies has been a goal of the Laboratorio di Archeologia Digitale (LAD) of Sapienza University of Rome for several years now. This paper presents the first significant results of the digitisation and analysis of the 47 plates of the Napoleonic Map of Egypt edited in the first years of the 19th Century, carried out by the LAD team and published online as open data.

Keywords: ancient Egyptian landscapes; historical cartography; ancient Egyptian waterways; ancient Egyptian toponymy; open data

1. INTRODUCTION

This paper has been conceived in the context of the activities of LAD: Laboratory for Digital Archaeology at Sapienza University of Rome (http://purl.org/lad) directed by Julian Bogdani, in tight collaboration with "PAThs: Tracking Papyrus and Parchment Paths", an ERC funded project directed by Paola Buzi, aimed at connecting in a single web-platform the archaeology, codicology, manuscript, and literary studies about Late Antique and Medieval Egypt.[1] Many historical maps regarding Egypt and eventually neighbouring areas, have been collected, digitised and georeferenced. When no legal barriers prevented, newly created data sets were published online in open access.[2] This service was built and is maintained with the double aim of providing a rich user experience for the Archaeological Atlas of Coptic Literature (https://atlas.paths-erc.eu) and to share structured and high-quality geographical data with a larger community of scholars. All available data sets that have been so far published are described with rich metadata and are listed for download in the PAThs' documentation and data portal (https://docs.paths-erc.eu/data).

Among these data sets, the 18th Century *Carte topographique de l'Égypt*,[3] called hereafter Napoleonic map, stands out as an exceptional historical document of great interest for the study of the Egyptian landscape. It is also an eloquent document of the very particular

1 ERC Advanced (2015) "PAThs - Tracking Papyrus and Parchment Paths: An Archaeological Atlas of Coptic Literature. Literary Texts in their Geographical Context. Production, Copying, Usage, Dissemination and Storage" directed by Paola Buzi and hosted by Sapienza University of Rome (project number 687567): Buzi - Berno - Bogdani 2017.

2 In particular, the Slippy Map Tilenames (also known as XYZ) protocol developed by OpenStreetMap (https://wiki.openstreetmap.org/wiki/Slippy_map_tilenames, accessed 23 July 2022) was used to deliver the data through the Web.

3 Jacotin 1818.

ISSN 0393-0300; 2724-587X
e-ISSN 2532-5159
doi: 10.53131/VO2724-587X2022_5

historical moment of the ill-fated Napoleonic campaign in Egypt. The publication of the fieldnotes and the methodology followed by the responsible of the survey, Pierre Jacotin,[4] provides a deep insight of the historical context when these activities were carried out. It is not the first time that this document attracts the attention of the modern scholarship, and a cornerstone study has been published by Anne Godlewska,[5] providing both historical and technical context.

We will not spend here many words on the methodology used to georeference the map, that has already been published (fig. 1).[6] Considering the great informative value of the document it was decided to further deepen our analysis and start what can be called a "backward engineering" effort aimed at acquiring in the vectorial domain and in a GIS environment many of its information layers.

From the early stages of this project, two themes have been receiving special focus: a natural one, i.e., the hydrographic network of 18th century Egypt, and a cultural one, i.e., the recording of locations and toponyms of the settlements. The hydrographic network of pre-modern Egypt is of great interest for the study of the historical landscapes of the country due to the radical changes that the course of the Nile has undergone in the last centuries, in the context of major land-reclamation programmes. As well-known, the main event that has radically changed the millenary landscape and economic system of Egypt is the construction of the Aswan High Dam between 1960 and 1970, and the creation of the lake Nasser, putting an end to the periodical floodings of the Nile, a natural event that has deeply determined the very birth of the Egyptian civilisation. Nevertheless, important land reclamation programmes put in place through water regimentation intervention, the construction of canals and embankments and the enhancement of communications infrastructure, such as road and railway networks can be dated back in the 19th Century, well before the action of Nasser.[7] Substantial changes in the landscape of the country are well-documented by the comparison of the Napoleonic cartography with maps dating to the very first years of the 20th Century, such as the 1:50.000 *Atlas of Egypt Compiled at the Offices of the Survey Department, Ministry of Finance, Egypt* published in 1914,[8] another fundamental document for the history of cartography of Egypt, georeferenced and published by LAD (fig. 2).[9]

Turning our attention to the cultural features of the Napoleonic map, the detailed documentation of populated places is by far its most important feature. It is a virtually georeferenced gazetteer of more than 3500 features dating before the end of the 18th Century that French cartographers mapped meticulously by reporting position, a symbolic representation of their dimensions, and toponyms written in most cases both in Arabic script and in a Romanised form following the French pronunciation.

The following paragraphs will focus mostly on the actual process of converting into structured data the hydrographic and population informative layers and will try to provide a

4 Jacotin 1822.
5 Godlewska 1988.
6 D'Erasmo 2019.
7 Linant de Bellefonds 1854.
8 This cartography was published by the Egyptian Ministry of Finance in collaboration with the British Ministry of War in two volumes (Lower and Upper Egypt): Ministry of Finance, Egypt - Al-Maliyah - Al-Misahah 1914 a-b.
9 Bogdani 2022b.

detailed report on the methodology employed. For this reason, it will be most important to report detailed explanations of the sometimes highly arbitrary solutions adopted, in the hope of a fully aware future usage of the data set.

This work would have never seen the light without the passionate, tireless, and extraordinarily accurate work of many students at Sapienza University of Rome, who day after day got acquainted with the interesting challenges of GIS technologies applied to historical data sets. [10]

This article does not put an end to the work on this map, since much more information is still waiting to be extracted, for example the road network and other connection facilities, such as bridges. Some initial steps have already been walked, also in the hope to connect this Historical Geographical Information System to other digital tools, such as the Late Antique Egyptian Road graph, another project of LAD.[11]

Finally, the Napoleonic map is the final stage of a long and complex project, as it will be outlined in the next paragraph, and it is fundamental for our work of encoding into digital format these information to keep track of this multi-stratified and multi-purposed endeavour and to try at least to bring back this complexity to the future users of our data sets.

Julian Bogdani

2. A BRIEF HISTORY OF THE *CARTE TOPOGRAPHIQUE DE L'ÉGYPTE*

The Napoleonic map of Egypt is the oldest source of knowledge for the landscape of the country, compiled using modern cartographic methodology. The complete series consists of 47 sheets of topographical maps at a scale of *1 Millimètre pour 100 Mètres*, i.e., 1:100.000, covering Egypt and part of Syria. Its value for the study of the ancient Egyptian landscape is well known, and many works have already used this map as a bridge between modern and past landscapes.[12]

It was published in 1818 in the framework of the ambitious *Description de l'Égypte.*[13] Pierre Jacotin was appointed as director of the survey of Syria, Palestine, and Egypt between 1799 and 1800, part of the French military campaign led by Napoleon Bonaparte. It was the French general Jean-Baptiste Kléber who organised a commission of engineers and scholars with the task of outlining and recording the actual conditions of the country. Pierre Jacotin was given the task of leading the commission in charge of the geography and hydrology. He began his work in November 1799 by compiling the instructions for the surveyors of his team.[14] Pierre Jacotin was accompanied by the astronomer Nicolas-Antoine Nouet, who in turn was assisted by the newly graduated engineer and topographer Jean-Baptiste Coraboeuf.

---

[10] A special thanks goes to Luigi Campagna and Alice Grieco who helped us with the development of the data set.

[11] Bogdani 2022c.

[12] Egyptological research combining the analysis of textual sources, the study of archaeological evidence and the use of Geographical Information Systems (GIS) has increased exponentially in recent years. Examples include the following: Graham 2010; Flaux *et al.* 2017; Graves 2017; Willems-Dahms 2017; D'Erasmo 2019.

[13] The *Description de l'Égypte* (full title: *Description de l'Égypte, ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française*) is a series of publications describing ancient and modern Egypt from a variety of scientific perspectives: Godlewska 1995, 7. An overview of the methodology and difficulties encountered during the field data collection and subsequent elaboration of Napoleonic cartography can be found in Jacotin 1822.

[14] Godlewska 1988, 13.

Nouet's work was of fundamental importance for the final edition of the cartographic series, since he identified and astronomically measured 'key' places (ground control points), whose coordinates were used for the topographical survey.[15]

It is not known when and under what circumstances it was decided to compile the topographic map; most probably the decision was made by Bonaparte himself. It is likely that the purpose of the *Carte topographique de l'Égypte* changed over the years, following the evolution of the war. At a first moment, it was aimed at providing a concrete help for the advancement of the military campaign, and successively it had to become a fundamental tool for the management of the Egyptian land by the French government. In fact, Napoleon ordered several areas to be surveyed with the aim of building new roads and facilitate the displacement of troops and supplies.[16] As reported by Anne Godlewska, one of the focal points of the survey was the mapping of the Egyptian hydrographic network. This is documented by a long correspondence between Napoleon and his generals. In these letters the concern and absolute necessity for detailed knowledge of the Egyptian landscape is evident, following the words of general Louis-Marie-Joseph Maximilian Caffarelli du Falga to Napoleon Bonaparte:

> «We still do not know the Delta, Citizen General. The waters have disappeared. Different mobile columns travel up and down it in all directions. It is time now that we know the different canals that traverse it and the position as well as the name of the different villages […]».[17]

These efforts resulted in a series of maps at different scales drawn up for the French government.[18] The mapping took place during a period of war and Napoleon's *savants* continued their work despite the increasing difficulties.[19] The impossibility of travelling to certain regions, for example, or the difficulty of transporting/repairing the topographic equipment caused many problems to the final process of publishing the cartography. Nevertheless, their perseverance made the difference: by April 1800, the engineers Pierre Simonel and Rodolphe Schouani completed the survey of the two branches of the Nile north of Cairo and that of the Menouf canal.[20]

The topographical survey was to be followed by the production of a cadastre. In 1801, general Jacques-François de Menou, despite the desperate situation of the French army, assigned the task of this surveying once again to Pierre Jacotin. As Anne Godlewska reports, the intention behind the cadastral survey was mainly to abolish the Coptic monopoly on the country's taxes and help Egyptian peasants. This venture came to nothing and was abandoned shortly after.[21]

---

15 A summary of Nouet's work in Egypt can be found in his publication within the volumes of the *Description de l'Égypte*: Nouet 1809.

16 Godlewska 1988, 6.

17 Godlewska 1988, 6; Keller 1910, n. 3674.

18 Godlewska 1988, 7-8; Keller 1910, nn. 3519, 3439 and 4225.

19 The mathematician Jean-Baptiste Joseph Fourier's words are emblematic: «[...]We were many times obliged to replace our weapons with geometrical instruments, and in a sense, to fight over or to conquer the terrain that we were to measure» (Fourier 1821; Godlewska 1995, 8).

20 Godlewska 1988, 9 and 16.

21 Godlewska 1988, 16, note 12.

The topographical map was published in 1818 in Paris, several years after the completion of the survey in Egypt. It was accompanied by a meticulous description of the operations and difficulties encountered during and after the expedition by Jacotin himself.[22] The editing of the series was not easy, since Jacotin and his collaborators had to compare and combine data from field surveys and astronomical measurements of uneven quality. The engineer used other sources as well, including historical ones, to fill the gaps.[23] Some information about toponymy was collected at a later date. Apparently, Jacotin did not put bold trust on the geographical knowledge of the locals and relied on their accounts only in the total absence of information.[24]

Domizia D'Erasmo

3. The vectorisation of the hydrographic network of 18th century Egypt: benefits and strengths

Rivers and canals have been the main travel routes of Egypt since ancient times, and literary sources from all historical periods are rich in information about the use of the hydrographic network for mobility. As documents relating to the Napoleonic campaign show, water was still the favoured means for travelling in modern times. Water-related infrastructure, such as dams and canal embankments were also important features of the communication network, as shown by the legend of another important historical map, the *Carte hydrographique de la Basse Égypte et d'une partie de l'Isthme de Suez* by the engineer Louis Maurice Adolphe Linant de Bellefonds, published in 1854 and commissioned by *wālī* of the Eyalet of Egypt Muhammad ʿAli Pasha,[25] who restored or built various canals, rivers, bridges, and dams.[26] Most of the works were carried out under the supervision of Linant de Bellefonds.[27] The map is annotated with information on the country's hydrological assets during and in the absence of floods, as well as the engineering work completed. For example, the notes «*sur les chemins*» report that dams and canal embankments were «*les meilleures voies de communication*» during the period of flooding. After the Nile flooding and during periods of drought, the terrestrial communication paths were restored.

The hydrographic network of the *Carte topographique de l'Égypte* seems to be much closer to that of mediaeval Egypt than to those of earlier periods. For example, it is possible to identify on the map many of the waterways reported by John P. Cooper in his reconstruction of the Egyptian Delta landscape at the eve of the Islamic conquest of Egypt (641-643 AD).[28] When models of earlier periods are considered, e.g., the Pharaonic or the

[22] Jacotin 1822.
[23] Godlewska 1988, 98-111.
[24] Godlewska 1988, 59.
[25] Muhammad 'Ali was the commander of an Albanian detachment of Ottoman forces, sent to Egypt to stem the advance of Napoleon Bonaparte's troops during the French occupation. After Napoleon left the country, the commander rapidly consolidated his political position, obtaining the rank of Pasha and being appointed *wālī* of Egypt. Muhammad 'Ali Pasha's first term of office in Egypt lasted 43 years (1805-1848); a further term was interrupted by his death in 1949. The governor is still considered an innovator, and founder of modern Egypt. See al-Sayyid Marsot 1984.
[26] The information appears in the note «*travail de Mr. Linant de Bellefonds*» on the map: Linant de Bellefonds 1854.
[27] Linant de Bellefonds 1873.
[28] Cooper 2014, 303, fig. A2.9.

Hellenistic-Roman, similarities seem to dim.[29] Throughout Egypt's history, there have been many interventions on the hydrographic network, aimed at enhancing land cultivation, the goods transportation, and generally connection throughout the country. During the Pharaonic period, for example, the reorganisation of the Fayyum's irrigation system started (probably) under Sesostris II (1845/1844-1837 BC) and completed under the reign of Amenemhat III (1818/1817-1773/1772 BC).[30] As a consequence, the entire region was revitalised, if compared to the Old Kingdom when it was mostly marshland.[31] The construction of sacred canals to supply water to the temples and provide connections during festival processions are also known.[32] Another example is the so-called Alexandria Canal, today known as Mahmoudiyah, which connected the ancient metropolis to the Canopic branch and therefore to the Delta.[33] Part of its course, as far as ancient Schedia (modern Tell el-Giza) is clearly visible in Napoleonic map.[34]

Finally, human activity has determined only a small part of the hydrographic landscape during the last thousands of years.[35] The formation or destruction of islands or their annexation to the mainland are only few of the natural phenomena that actively interacts with cultural landscapes, most important to the archaeological research dealing both with the material remains and the textual sources in the attempt to reconstruct the Egyptian landscape through the centuries.

Domizia D'Erasmo

---

29 Baines - Málek 1980; Talbert 2000, 74-75; Ghiringhelli 2017, 33, fig. 5.

30 Callander 2003, 152-153 for Sesostri II and 157 for Amenemhat III.

31 Grajetzki 2006, 119. This was perfectly clear to Napoleon's *savants*: «Les premiers Égyptiens ne reconnaissaient pour beau et vraiment digne d'admiration que ce qui est durable et consacré par le sentiment de l'utilité publique. Leurs grands travaux eurent d'abord pour objet de rendre le territoire plus salubre, plus fécond et plus étendu. Ils parviennent à dessécher des marais et des lacs, à conquérir des provinces entières sur les déserts de la Libye, à compenser l'inégalité des inondations par une heureuse prévoyance et par les merveilles de l'art. Ils fondèrent leurs villes sur d'immenses chaussées détournant à leur cours du fleuve, ou le divisant en de nombreux canaux, ils virent s'élever du sein des eaux, et créèrent, pour ainsi dire, eux-mêmes, ces belles plaines du Delta, qui devaient bientôt devenir si opulentes» (Fourier 1821, CLIII).

32 Meister *et al*. 2021; Graham *et al*. 2012.

33 Flaux *et al*. 2017, 670. The Mahmoudiya canal, so called after Sultan Mahmud II (1808-1839), partly follows the ancient path of the Alexandria Canal: «Ce canal d'Alexandrie avait sa prise d'eau à Rahmaniéh, et venait à Alexandrie depuois Zawet-el-Gazal, en suivant à peu près la même direction que le Canal Mahmoudiéh d'aujourd'hui» (Linant de Bellefonds 1873, 349). It is know that it was rebuilt at the behest of Muhammad 'Ali Pasha: «Le canal Mahmoudiéh emprunte directement ses eaux au Nil, à l'Atfé, un peu plus bas que la ville de Fouâ; elles coulent vers l'Ouest jusqu'à Alexandrie en arrosant tous les terrains qui sont sur ses bords; ce canal a un parcours d'environ 72 kilomètres» (Linant de Bellefonds 1873, 21).

34 During the Hellenistic and Roman periods, the Alexandria Canal probably was not the main communication route between the city and the Canopic Branch. An analysis of the ancient literary sources has led to the assumption that this canal was subject to continuous silting and that other secondary canals connecting the river to the Mareotis lake were therefore also used for transport: Flaux *et al.* 2017, 670-671. Traces of these canals may have been preserved in Napoleonic cartography. The following studies on the waterways that connected Alexandria to the Egyptian Delta are also worth mentioning: Khalil 2004; Khalil 2010.

35 Hillier - Bunbury - Graham 2007, 1011.

4. Methodology for the vectorisation of the hydrographic network

The vectorisation of the hydrographic network of the Napoleonic cartography was carried out on QGIS, an open-source Geographic Information System platform. The georeferencing of the historical maps following a methodology that implied the correction of the error of the Napoleonic metre by manually scaling and georeferencing each plate according to two known control points.[36] Single plates were collected into a composite mosaic[37] by manually compensating discordances. This resulted in most cases in a better metric representation, in some other cases generated additional margins of error: while the Napoleonic Cartography remains a cornerstone for topographical studies of Egypt, its geometric soundness must be constantly verified.

The analysis of the rich legend accompanying the Napoleonic cartography was a very informative step. The map does not represent only canals, streams, rivers, and lakes, but also a multiplicity of topographical elements such as underground, ancient and hypothetical canals, riverbeds, ponds, springs, marshy areas, flooded area and areas inundated during the Nile floods. Finally, the map also shows watercourse crossings such as bridges and fords and detailed information about dams and aqueducts.[38] The hydronyms were transcribed using the French romanisation, as they were shown on the published map (fig. 3).

Domizia D'Erasmo

4.1. *The major rivers, lakes, and marshy areas*

The major watercourses, such as the Nile, its principal branches, and the lakes were encoded using polygons. Some other elements emerged as particularly important for the hydrological asset of pre-modern Egypt during the vectorisation process and were encoded with the same geometry type, such as areas that were periodically flooded by water and marshlands (fig. 3). The hydrology polygon theme was completed with attributes encoding the different typologies. For each feature, the following information was filed:

- unique numeric identifier (URI)
- name, in French, as reported in the original map, when available
- type of the geographical feature, using the following map of values: lake, river, branch, canal, marshland, periodic flood, pond.

The vectorisation process was not linear: larger elements, such as the Nile or the extensive lakes of the Delta regions, were vectorised in multiple steps, and the single elements were later merged in QGIS. All the features were acquired at the approximate scale of 1:5.000, to guarantee a highly accuracy of the output.

In order to maintain a univocal relationship between geographical elements and vector features, islands in the course of the Nile were rendered by "piercing" the main polygon.

Finally, manual and automatic cross-checks and different topology validation routines were run on the vector output, to make sure that single geometries were correctly encoded and that hydronyms had been correctly transcribed.

Cecilia de Leone

---

[36] D'Erasmo 2019.
[37] Bogdani 2022a.
[38] France Dépôt Général de la guerre 1803, pl. 3-4.

4.2. *Rivers, canals, dams, and aqueducts*

The rivers, canals, dams, and aqueducts represented in the Napoleonic cartography were vectorised using (poly)line geometry. The vectorisation methodology was rather simple for all rivers, streams and canals of the area south of Cairo, consisting in parallel lines directly connected to the main course of the Nile, and forming a comb-shape (fig. 4). This pattern becomes much more complex in the region of the Delta. A clear example of this complexity is represented by the area between the branches of Damietta and Rosetta (fig. 4), where a conspicuous number of water streams mark their course towards the northern Delta, branching-off and connecting between them. This tangled network of waterways is much more difficult to extricate and required a longer time of analysis.

The very first step of analysis regarded the most effective way to provide a hierarchy of all the different river branches represented in Napoleonic cartography. The so-called "tree model" is a rather simple to encode and most effective way to define an hierarchical division in orders, and provides an exhaustive description of the relationships between main courses (1st order), their tributaries (2nd order), sub-tributaries (3rd order), etc. The main watercourse, such as the Nile and the Bahr Yussef channel, were assigned the first order, their tributaries and sub tributaries were identified by an increasing numbering (fig. 5). The artificial canals, explicitly identified as such by the map legend, were divided in two categories, 'principal' and 'ordinary'. Ordinary canals, usually of smaller dimensions, branch off the course of the main ones, which are usually represented in the map with a thicker stroke and are almost always associated with a hydronym.

Hypothetical watercourses, rendered in the map as dashed lines, were also digitised, as well as ancient channels (fig. 6). Additional information about the chronology and certainty of the trace was encoded as textual attributes.

Additional water-related infrastructure, such as dams and aqueducts were vectorised. These elements have sometimes been associated in the map to a name (e.g., *digue ruinée nommée Gam*) and/or a definition (dam, aqueduct) (fig. 7).

The list of text attributes related to each feature includes:

- unique numeric identifier (URI)
- name in French, as reported in the Napoleonic map, when available
- type of the geographical feature, using the following map of values: aqueduct, canal, dam, river
- the assigned order of each element.

Some watercourses have been labelled in the Napoleonic map as marking the border between regions but this indication has not been filed during these first steps. In Egypt, since ancient times, watercourses have always marked boundaries between lands, and it would be very useful in the future to add this additional information to the geodatabase. It can be useful, among other possible finalities, for the study of the country's geopolitics in a diachronic sense.

Arianna Giordano

4.3. *The watercourse crossings*

A layer of points has been used to encode the watercourse crossings. These are mostly bridges and fords, and a detailed distinction is made in the map legend:[39] *pont de pierre* «stone bridge», *pont de bois* «wooden bridge», *pont de bateaux* «pontoon bridge», *pont volant* «flying bridge», *bac à traille* «ferry tied to a wire which shuttles from one bank to the other», *bac* «ferry», *passage d'eau* «water passage», *lieu où les rivières deviennent navigables* «place where rivers become navigable», *lieu où les rivières deviennent flottables* «place where rivers can receive/float large quantities of wood», *guè à cheval* «ford that can be travelled on horseback» and *guè à pied* «ford that can be travelled on foot». These different crossing points are marked with a symbology which is not always clear and does not significantly help in the correct identification of the feature. For this reason, it has been decided, for the time being, to simply indicate their presence with a point geometry, without further defining their construction characteristics. The only exception are a few stone bridges whose legend was clearly visible on the maps (fig. 8).

A particular case is the intersection between watercourses and roads. The graphical result is an overlap between these two topographical elements: sometimes the watercourse is placed in the foreground, and other times the order is reversed. Since the map apparently provides no further information, it was decided to document them, and to mark them as conventionally bridges, i.e., by adding a point feature, without providing further detail, even if the map does not explicitly refer to this kind of infrastructure.

Cecilia de Leone

5. THE GEOREFERENCED GAZETTEER(S)

As already mentioned, the second set of information that has been extracted from the Napoleonic map concerns the populated places. These were manually digitised, using a polygon theme and accurately reproducing the symbology used by the map. When a single place was formed by two or more separated neighbourhoods, the multi-polygon feature was used to keep a unique record for each place. The vectorisation process was carried out at an average scale of 1:5.000 (the Napoleonic map was published in a scale of 1:100.000). Not all toponyms available in the Napoleonic map were acquired into the geodatabase: regional toponyms, oronyms, and other toponyms not directly referable to an actual populated place were programmatically excluded. Also, toponyms related to clearly delimited places but that do not bear any information about inhabitation have not been recorded for the time being. These are nevertheless important places since in most cases they are referred to archaeological sites, artificial hillocks created by their occupation during a long time, like, for example, *Koûm Farrâïn* (fig. 9) that represents the site of Buto, continuously inhabited from the Pre-Dinastic period to mediaeval times.[40] Their detailed recording is part of a future development of the project.

[39] France Dépôt Général de la guerre 1803, pl. 3; Godlewska 1988, 129.
[40] Baines - Málek 1980, 170.

5.1. *Gazetteer v.1: the Napoleonic place names*

This first recording produced almost 3.500 geometries, linked to text attributes recording the placename as it is reported in the original map, following the French-based romanisation. This is by far the richest data set available of georeferenced placenames relative to pre-modern Egypt but presents two major issues. The detail of information provided by the Napoleonic informs us not only on major centres that can be easily detected on a modern map, but also on smaller villages and neighbourhoods whose identification is much more problematic today, due to the major transformations that have involved Egyptian natural and cultural landscapes already pointed out in the previous paragraphs. Consequently, most of the identified places remained anonymous.

A very detailed modern gazetteer is needed if we wanted to try to match as many places as possible and refer (link) them to a well-known reference. Geonames[41] provided an excellent base of highly detailed information about toponymy; in fact, it provided much more information that was initially needed. After a preliminary analysis it was possible to clearly link about one third of the entire dataset (1.402 of 3.478 places) to the Geonames database and for the remaining part (2.076) it was impossible to suggest a proper identification (fig. 10). This state of art was marked as version 1 of the Napoleonic gazetteer.

5.2. *Gazetteer v.2: the Napoleonic place names referred to current space*

The thorough changes that the Egyptian landscape has experienced in the last two hundred years is the reason behind the mismatch of the placenames, and on the other hand, the georeferenced 18th century map provides an extraordinary tool to further investigate this process. A second reason behind the difficulty of identifying 18th century place name is related to the inherent, uneven, and unsolvable accuracy issues of the Napoleonic base map, as have been clearly shown previously.[42] Since different areas of the map present different grades of metric accuracy it is impossible to apply to the entire dataset a parametric fix. It is thus impossible to use the geographic position alone to align data from the Napoleonic map to modern gazetteers.

The gazetteer v.1 was re-process to obtain a new set (gazetteer v.2), both correctly georeferenced and representative of the historical information contained in the Napoleonic map. It was straightforward to relocate (when needed) identified places of v1 gazetteer, using correct coordinates provided by Geonames.org. Since their identification heavily relied on location proximity, little to none shifting was necessary. To address the issue of the historical places that have radically changed their position, their name or that have completely disappeared in present-day gazetteers, an additional source of information was added to the analysis, the already mentioned map published in 1914 by the Egyptian Ministry of Finance.[43] From the chronological point of view, this edition stands almost exactly half way between the Napoleonic map and present day. It has been compiled following modern cartographic methodologies and it is highly accurate from the metrical point of view. Finally, it has already been georeferenced and published online by LAD.[44] The version 2 of the

41 https://www.geonames.org/ (accessed 15 April 2022).
42 D'Erasmo 2019.
43 Bogdani 2022b.
44 https://docs.paths-erc.eu/data/#min-fin-1914

gazetteer uses the point representation of the centroid of each geometry (polygon) and each feature is assigned a distinct numeric identifier, a stable URI, to be able to trace the entire history of changes that a record might go through (fig.11).

The v.2 of the gazetteer has not been completed yet for the entire extension of the Napoleonic map and at present the Upper Egypt has been completed. The identification of the places requires long times and a good knowledge of the topography of the region, and we are optimistic that we will be able in the next months to complete the entire work and to release it as open data (see below).

5.3. *Gazetteer v.2.5: a possible statistical approach for unidentified places*

As it is hopefully clear, not all places recorded in the Napoleonic map will be precisely identified and positioned. At present, there are no other options left for georeferencing places that have not been identified other than a statistical approach. As an untested hypothesis, the mean length and direction of nearby shift vectors can be used to suggest a possible position of unidentified places, as shown in fig. 12. This statistical approach can be mapped in the textual attributes of the vector to provide a clear indication of the different methodologies used. Some testing has been made to validate the methodology, but no further time is being invested towards this version of the dataset up to present, since most of the energies are being spent to complete v.2.

5.4. *Gazetteer v.3: towards a (more) linked gazetteer*

Linking the Napoleonic gazetteer with other both historical and current date data sets is not only a matter of providing in/outbound citation means; it is mostly a matter of knowledge, since identification is the very prerequisite of positioning. For this reason, other tools aimed at providing (semi-)automatic linking possibilities are being exploited. The most interesting, is by far the World Historical Gazetteer (WHG),[45] a software platform focused on bringing together historical information about places by also providing a temporal dimension and following the Linked Data paradigm. A paramount feature of the WHG are standards and tools to enable a collaborative effort of linking historical places. Users are invited to upload their gazetteer using a specific format that provides both spatial and temporal context and a matching routine is run on the remote servers. Matching suggestions can be reviewed through a fully graphical Web interface and eventually accepted or rejected. Output results can be downloaded as a custom Linked Places format (LPF), which is an extended version (including temporal dimension) of GeoJSON and is JSON-LD compatible. Private data sets can be published and shared or kept private.

Some tests made with the v.1 of the Napoleonic gazetteer have provided promising results, and it will be much more interesting to have some more tests with the most geographically reliable versions of the database.

[45] Mostern 2016; Grossner - Mostern 2021; https://www.whgazetteer.org/ (accessed 25 August 2022).

All versions of the data set listed in the above paragraphs have already been published as open data (CC BY-SA 4.0 International) on Github and archived for long term preservation in Zenodo.[46]

Julian Bogdani

6. Conclusion

Scholars have for long time used the Napoleonic map as a fundamental study tool for both archaeological and historical research regarding Egypt, since it is the most antique map of the country drafted following modern cartographic methodology. Since then, the Egyptian landscape has undergone significant changes, for many of them this map being the only testimony. Nevertheless, the 47 plates of the map have never been republished in the digital format and georeferenced, since many issues, both theoretical and methodological make it very difficult to bring this map into GIS platforms.

These issues have been taken on systematically in the context of LAD: Laboratory for Digital Archaeology at Sapienza and have been the object of this paper. Although it is impossible to offer definitive solutions to all problems, a detailed documentation has been created to provide a complete overview on methodologies used and to clearly assess the value of the digital data created and published. The raster data set and the vector layers created have been further investigated to provide a higher metric accuracy and the many versions of the data have been published as open data for the scholars to evaluate. In terms of numbers, about 348 bridges and crossings, 2448 minor watercourses, canals, dams and aqueducts, 271 major watercourses, lakes, ponds and marshlands, and almost 3500 places were recorded.

The Napoleonic map has not exhausted its informative potential and it is firm intention of the LAD to pursue this path, by following the open science paradigm and the collaborative effort that characterised these first steps.

Julian Bogdani

References

Al-Maliyah, W. - Al-Misahah, M.
1914a *Atlas of Egypt compiled at the Offices of the Survey Department* (Lower Egypt comprising maps of the cultivated area between the Mediterranean Sea and Cairo vol. I), Cairo 1914.
1914b *Atlas of Egypt compiled at the Offices of the Survey Department* (Upper Egypt comprising maps of the cultivated area between Cairo and the Sudan boundary vol. II), Cairo 1914.
Al-Sayyid Marsot, A.L.
1984 *Egypt in the reign of Muhammad Ali* (Cambridge Middle East Library 4), Cambridge 1984.
Baines, J. - Malék, J.
1980 *Cultural Atlas of Ancient Egypt*, Oxford 1980.
Bogdani, J.
2022a Carte topographique de l'Égypte et des pays environnants by Pierre Jacotin (1818, 1828): *PATHs data Repository & Documentation* (2021), available online at: https://docs.paths-erc.eu/data/ (accessed May 2022).

[46] DOI: https://dx.doi.org/10.5281/zenodo.6475339. A demonstrative version is available as Vector Web Tiles at https://lab-archeologia-digitale.github.io/jacotin-1828/.

2022b Ministry of Finance, Egypt-Atlas of Egypt: Lower and Upper Egypt: *PAThs data Repository & Documentation* (2022), available online at: https://docs.paths-erc.eu/data/ (accessed May 2022).

2022c *MoveIT: proof of concept of a road graph for Late Antique Egypt*: D. D'ERASMO - C. GONZALEZ ESTEBAN - P. ROSATI - M. SERPETTI - L. TIRABASSI (eds.), *Proocedings of the 15th edition of ArcheoFOSS International conference on Open software, hardware, processes, data and formats in archaeological research, online, 23-26 November 2021*, in press.

BUZI, P. - BERNO, F. - BOGDANI, J.

2017 The "PAThs" project: an effort to represent the physical dimension of coptic literary production (third-eleventh centuries): *Comparative Oriental Manuscripts Studies Bulletin* 4.1 (2017), pp. 39-58.

CALLANDER, G.

2003 The Middle Kingdom Renaissance (c. 2055-1650 BC): I. SHOW (ed.), *The Oxford History of Ancient Egypt*, Oxford 2003, pp. 148-183.

COOPER, J.

2014 *The Mediaeval Nile: Route, Navigation, and Landscape in Islamic Egypt*, New York 2014.

D'ERASMO, D.

2019 Georeferencing Napoleonic cartography to reconstruct ancient Egypt landscapes: methods in comparison and the case of the island of *iw-rd* in the 16th nomos of Upper Egypt: *GROMA* 4 (2019), pp. 1-18. DOI: http://dx.doi.org/10.12977/groma22

FLAUX, C. - EL-ASSAL, M. - SHAALAN, C. - MARRINER, N. - MORHANGE, C. - TORAB, M. - GOIRAN, J.P. - EMPEREUR, J.Y.

2017 Geoarchaeology of Portus Mareoticus: ancient Alexandria's Lake harbour (Nile Delta, Egypt): *Journal of Archaeological Science* 13 (2017), pp. 669-681. DOI: https://doi.org/10.1016/j.jasrep.2017.05.012.

FOURIER, J.-B.J.

1821 *Preface historique*: C.L.F. PANCHOUCKE (ed.), *Description de l'Égypte ou recueil des observations et des recherches qui ont été faites en Egypte pendant l'expédition de l'armée française*, Tome I, Paris 1821, pp. I-CLV.

FRANCE DEPOT GENERAL DE LA GUERRE

1803 *Mémorial topographique et militaire rédigé au dépot général de la guerre par ordre du ministre* (Topographie IIIe trimestre de l'an XI, vol. V), Paris 1803.

GHIRINGHELLI, F.

2017 Les branches du Nil dans le Delta à l'époque Pharaonique: état de la question: *Égypte, Afrique et Orient* 88 (2017), pp. 25-34.GODLEWSKA, A.

GODLEWSKA, A.

1988 *The Napoleonic survey of Egypt: a masterpiece of cartographic compilation and early nineteenth-century fieldwork* (Cartographica 25), Toronto 1988.

1995 Map, Text and Image. The mentality of Enlightened Conquerors: a new look at the Description de l'Egypte: *Transactions of the Institute of British Geographers* 20.1 (1995), pp. 5-28.

GRAHAM, A.

2010 Islands in the Nile: A Geoarchaeological Approach to Settlement Location in the Egyptian Nile Valley and the Case of Karnak: M. BIETAK - E. CZERNY - I. FORSTNER-MÜLLER (eds.), *Cities and Urbanism in Ancient Egypt. Papers from a workshop in November 2006 at the Austrian Academy of Sciences (AAS)* (Denkschriften der Gesamtakademie LX; Untersuchungen der Zweigstelle Kairo des Österreichischen Archäologischen Instituts XXXV), Vienna 2010, pp. 125-143.

GRAHAM, A. - STRUTTM, K.D. - HUNTER, M. - JONES, S. - MASSON, A. - MILLET, M. - PENNINGTON, B.
2012 Reconstruction Landscapes and Waterscapes in Thebes, Egypt: *eTopoi* Special Volume 3 (2012), pp. 135-142.

GRAJETZKI, W.
2006 *The Middle Kingdom of Ancient Egypt: History, Archaeology and Society* (BCP Egyptology), London 2006.

GRAVES, C.
2017 *The Orix nome: an Egyptian cultural landscape of the Middle Kingdom* (unpublished PhD thesis), Birmingham 2017.

GROSSNER, K. - MOSTERN, R.
2021 Linked Places in World Historical Gazetteer: L. MONCLA - C. BRANDO - K. MCDONOUGH (eds.), GeoHumanities'21: *Proceedings of the 5th ACM SIGSPATIAL International Workshop on Geospatial Humanities*, New York 2021, pp. 40-43.

HILLIER, J.K. - BUNBURY, J.M. - GRAHAM, A.
2007 Monuments on a migrating Nile: *Journal of Archaeological Science* 34.7 (2007), pp. 1011-1015.

JACOTIN, P.
1818 *Carte Topographique de l'Égypte et de plusieurs parties des pays limitrophes; levée pendant l'Expédition de l'Armée Française par les Ingénieurs-Géographes, les Officiers du Génie Militaire et les Ingénieurs des Ponts et Chaussées; assujettie aux Observations des astronomes, Construite par M. Jacotin. Gravées au dépôt Général de la Guerre, à l'échelle de 1 Millimètre pour 100 Mètres. Publiée par ordre du Gouvernement*, Paris 1818.
1822 Mémoire sur la construction de la carte de l'Égypte: C.L.F. PANCHOUCKE (ed), *Description de l'Égypte, ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française, publié par ordre du gouvernement* (État moderne, vol. II, IIe partie), Paris 1822.

KHALIL, E.
2004 Submerged sites and geomorphological changes in the coastal zone of Alexandria: *ENALIA, Journal of the Hellenic Institute of Marine Archaeology* 8 (2004), pp. 51-60.
2010 The sea, the river and the lake: all the waterways lead to Alexandria: H. DI GIUSEPPE - M. DALLA RIVA (eds.), *Proceedings of XVII International Congress of Classical Archaeology. Meetings between cultures in ancient Mediterranean, Rome (FAO) 22-26 September 2008*, (Bollettino di Archeologia online, volume speciale), Roma 2010, pp. 33-48.

KELLER, A.
1910 *Correspondance, bulletins et ordres du jour de Napoléon* (Expédition d'Égypte V), Paris 1910.

LINANT DE BELLEFONDS, L.M.A.
1854 *Carte hydrographique de la Basse Égypte et d'une partie de l'Isthme de Suez où sont indiqués les travaux exécutés ou à exécuter d'après les ordres de Son Altesse Méhémet-Ali vice-roi d'Egypte. Avec le projet de communication directe des deux mers au travers de l'Isthme*, Paris 1854.
1873 *Mémoires sur les principaux travaux d'utilité publique, exécutés en Égypte depuis la plus haute antiquité jusqu'à nos jours*, Paris 1873.

MEISTER, J. - GARBE, P. - TRAPPE, J. - ULLMANN, T. - ES-SENUSSI, A. - BAUMHAUER, R. - LANGE-ATHINODOROU, E. - ABD EL-RAOUF, A.
2021 The Sacred Waterscape of the Temple of Bastet at Ancient Bubastis, Nile Delta (Egypt): *Geosciences* 11.385 (2021), pp. 1-19.

MOSTERN, R.
2016 World-Historical Gazetteer Research Report: *Journal of World-Historical Information* 3/4.1 (2016), pp. 41-42.
NOUET, M.
1809 *Observations astronomiques faite en Égypte pendant les années VI, VII et VIII [1798, 1799, 1800]*: *Description de l'Égypte ou Recueil des observations et des recherches qui ont été faites en Égypte pendant l'expédition de l'armée française* (État moderne, tome I vol. 5), Paris 1809.
TALBERT, R.J.A.
2000 *Barrington Atlas of the Greek and Roman World*, Oxford 2000.
WILLEMS, H. - J.-M. DAHMS (eds.)
2017 *The Nile: Natural and Cultural Landscape in Egypt*, Verlag, Bielefeld 2017.

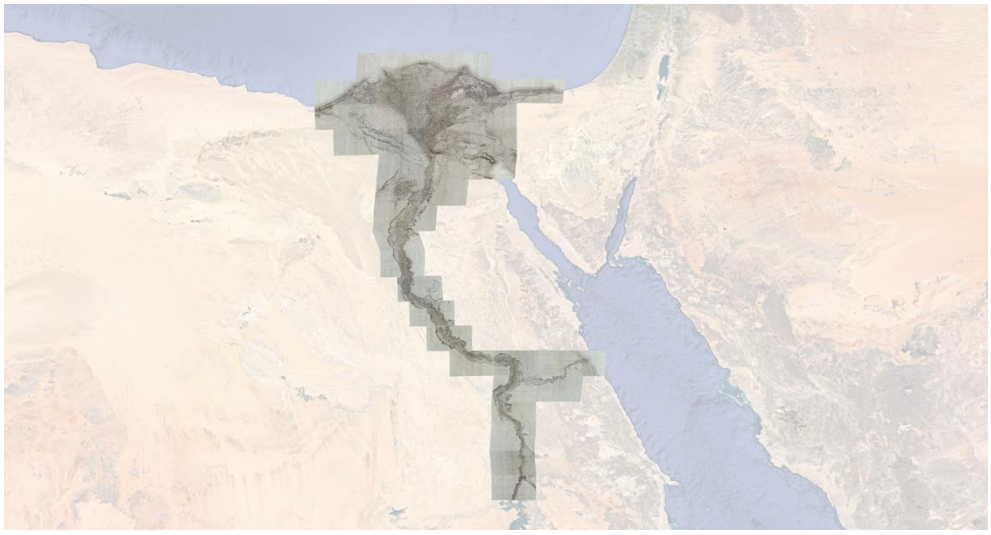

Fig. 1 - General view of the spatial coverage of the "Napoleonic Map" overlayed to Google Maps Satellite imagery (image by J. Bogdani).

Fig. 2 - Comparative view of the area around Damanhur in the "Napoleonic Map" on top and in the 1914's Atlas of Egypt Compiled at the Offices of the Survey Department (image by J. Bogdani).

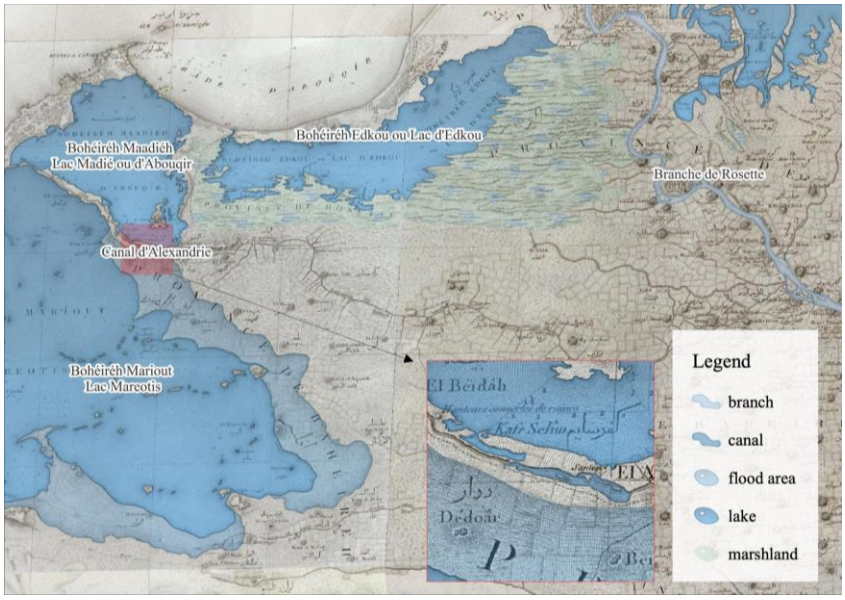

Fig. 3 - Result of vectorisation of the main watercourses of the western Delta. In the bottom right-hand box a zoom of a part of the Alexandria canal (image by D. D'Erasmo).

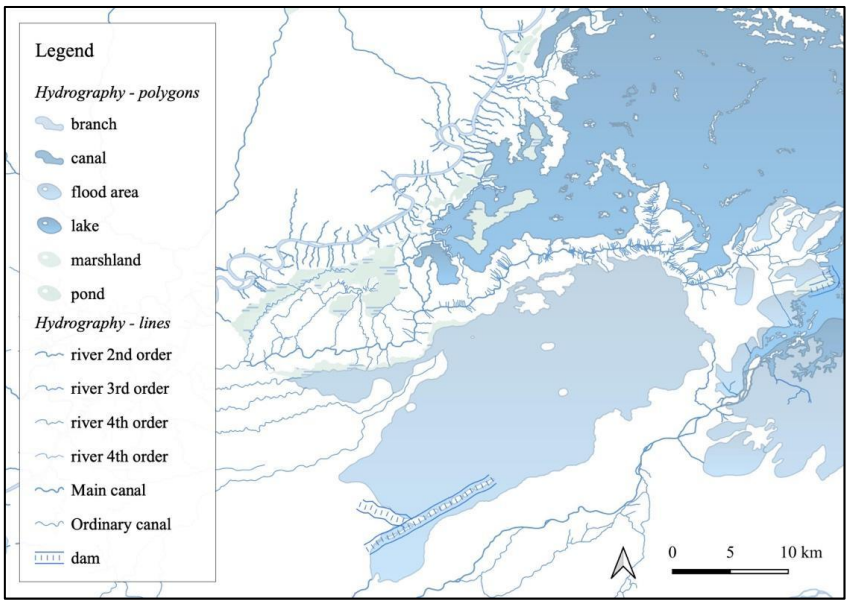

Fig. 4 - Detailed view of the density of canals and rivers between the Damietta branch and the lake Manzaleh (image by D. D'Erasmo).

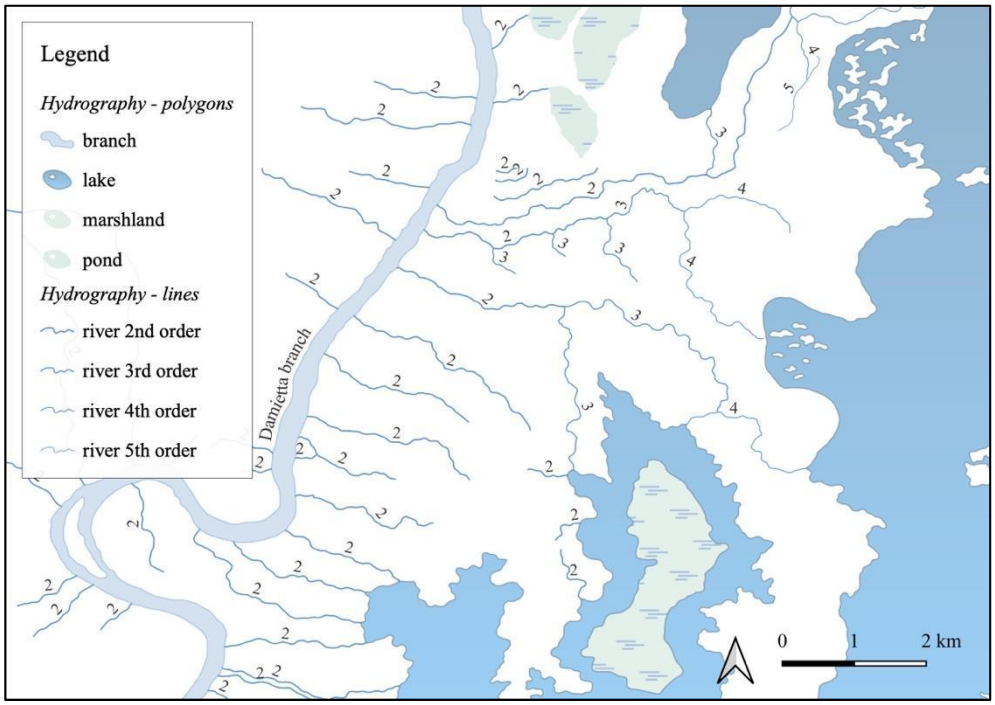

Fig. 5 - A categorization by "order" of the stream layer labels is shown in the image. The so-called "tree model" can be distinguished (image by D. D'Erasmo).

Fig. 6 - On the right, an example of an ancient canal (*canaux abandonné*). On the left, an example of a hypothesized path of a canal near lake Maryut (image by D. D'Erasmo).

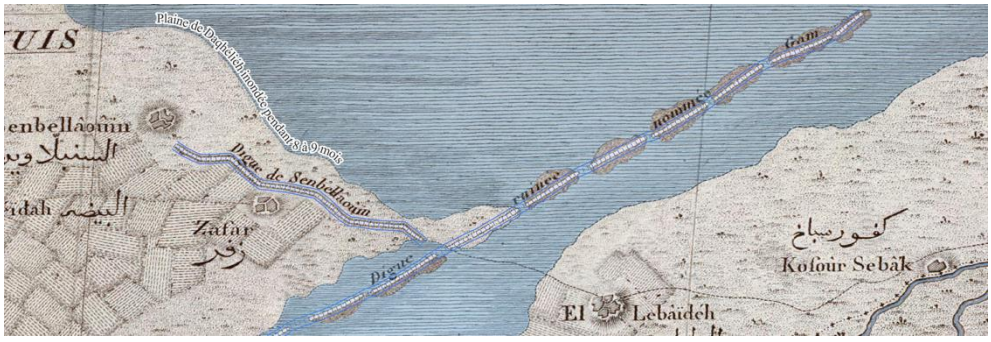

Fig. 7 - An example of two vectorised dams (image by D. D'Erasmo).

Fig. 8 - On the right, a stone bridge with the characteristic symbol, accompanied by the legend "pont en pierres". On the left, a series of bridges and fords around Lake Manzala (image by D. D'Erasmo).

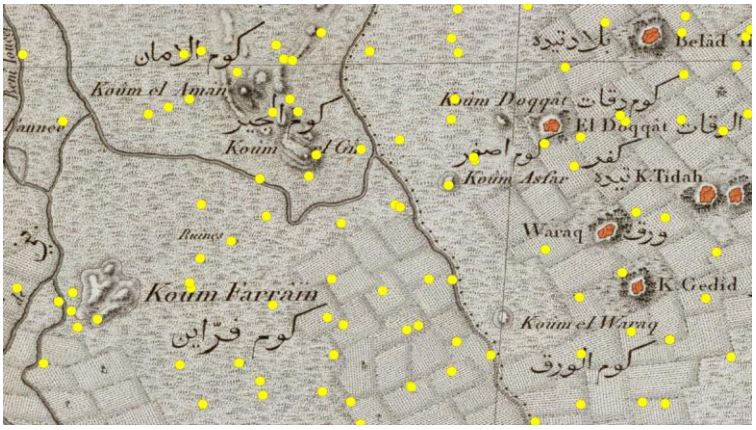

Fig. 9 - Detail with v.1 gazetteer overlayed with Geonames.org data set (image by J. Bogdani).

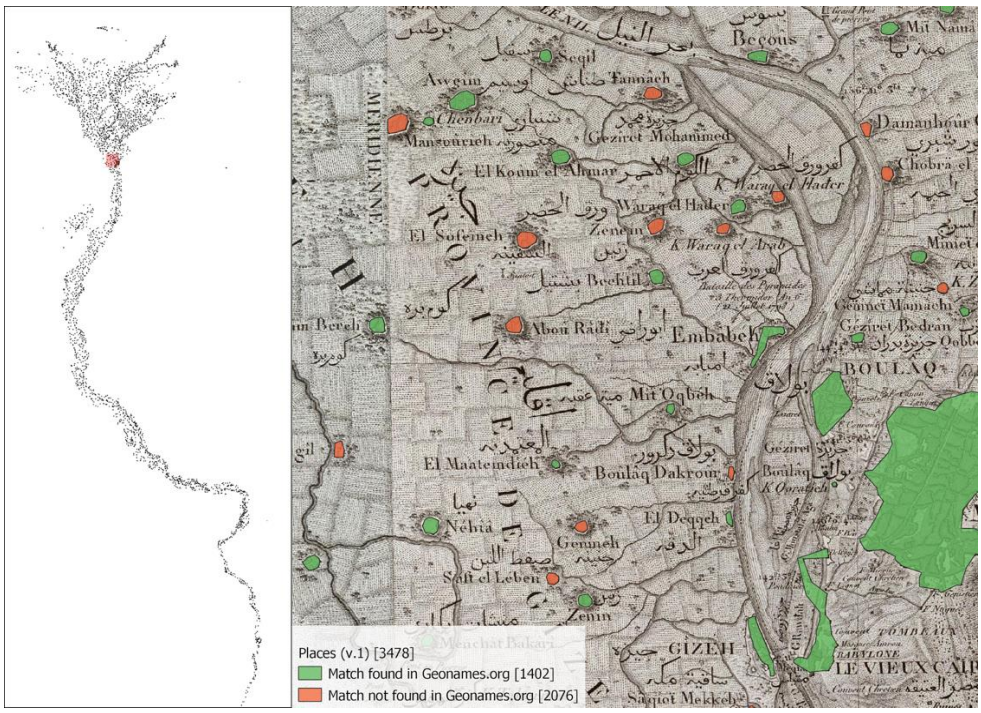

Fig. 10 - Example of distribution of places having a Geonames reference (in green) and places that have not been identified (in red), in the Napoleonic gazetteer v.1. (image by J. Bogdani).

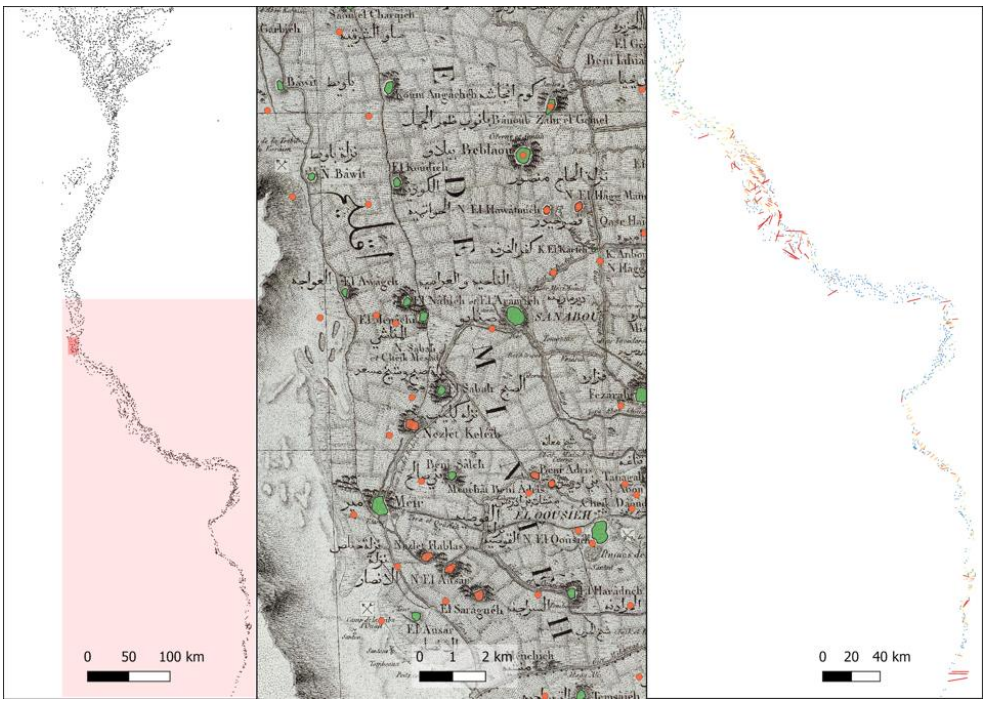

Fig. 11 - Centre: overlay of the gazetteer v.2 (points) andv.1 (polygons). On the left, the displacement vectors between the two versions are displayed, different colours indicating different displacement distances (image by J. Bogdani).

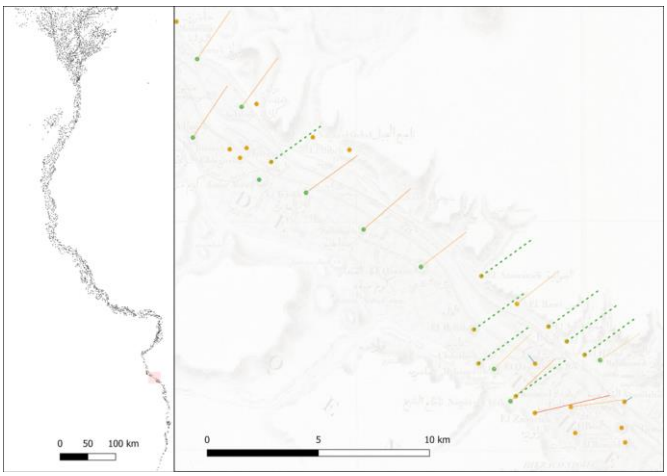

Fig. 12 - Example of the implementation of the v.2.5 of the gazetteer: in dashed lines are reported the hypothetical displacement vectors, for missing matches (image by J. Bogdani).