The Merowe Dam on the Nile

The Merowe Dam on the Nile - by Amelia Carolina Sparavigna

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An image from the International Space Station shows the huge reservoir of the Merowe Dam (see **Figure 1**). This image is recent, dating 5 October 2010 [1]. The dam is located near the Fourth Cataract of the river, in that part of Nubia desert where the river Nile is creating the Great Bend, a contorted path through the bedrocks of Bayuda Massif. The satellite imagery of Google Maps, which is few years old, shows the region during the building of the dam, with the Nile and river banks creating a fertile strip of land with many villages. In the Google images, it is possible to see the paleochannels of the Nile, hosting cultivated fields (we consider as "paleochannels" the old dry riverbeds). Figure 1 is showing that a huge part of this valley is inundated.

The dam was created to produce hydroelectric power, with the intention of helping the industrial and agricultural development of the country. All the gates were closed in 2008 and the dam inaugurated on March 3, 2009. Let us shortly remember the framework of the total project where Merowe Dam is only a part. Following Sudan's independence from Egypt and the United Kingdom in 1956, allocation and control of Nile River water was shared between Egypt and Sudan under the Agreement for the Full Utilization of the Nile Waters (Nile Waters Treaty), signed on 8 November 1959 [2]. In May 1999, the Nile Basin Initiative (NBI) was launched, joining all nations of the basin. The aims of NBI (see [3]) include the development of water resources in an equitable way, to ensure efficient water management, cooperation and joint actions. In May 2004, the "Nile Transboundary Environmental Action Project", the first of eight basin-wide projects under the NBI regulation, was started in Sudan. The river diversion and the building of the dam began in early 2004 [4].

Merowe Dam is the second huge dam after that of Aswan which is obstructing the waters of river Nile [5-8]. Before the Aswan Dam was built, the river flooded the Egypt every year during the late summer, because of waters flowing down its African drainage basin. These floods were enriching the soil with the consequence that the lands along the Nile were ideal area for farming. Egypt developed the Aswan dam to control the floods with the aim of protecting and supporting the farmlands. However, damming the Nile caused several environmental and cultural problems. It flooded a large part of Lower Nubia and 50,000 people were displaced [7,8]. The silt, deposited by the river in its yearly floods, is now held behind the dam. The deposition of the silt in the dam reservoir is slowly lowering the water storage capacity of Lake Nasser. Ref.5 lists several facts about erosion and others problems connected with the dam and the huge damages that concerned the archaeological sites. The rescue of some of them began in 1960 under UNESCO: a well-known example of this rescue is the relocation of the Great Temple of Abu Simbel on the shores of Lake Nasser [7]. Other monuments were granted to countries that helped with the works. Nevertheless, many archaeological sites have been flooded by Lake Nasser.

Again, the creation of the Merowe Dam constrained several settlements to be displaced in desert regions [9,10]. The water covered a region having significant but little-studied archaeological sites [4,11]. For instance, downstream the dam, there is the town of Napata, one of the archaeological sites of Nubia (on Nubia, see references [12-19]): this site is not directly threatened but the local climate change could create problems for a optimal preservation of the archaeological remains (see **Figure 2** for a map). Many international institutions performed the

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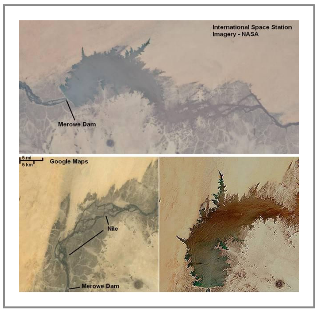

Figure 1: The reservoir of Merowe Dam on river Nile as photographed on 5 October 2010 by a crewmember on the International Space Station, NASA. The dam is located near the Fourth Cataract of the river. In the lower part of the figure, on the left, the region before the inundation as found from Google Maps and, on the right, the same area as shown by the NASA image, after enhancing with a suitable image processing for comparison.

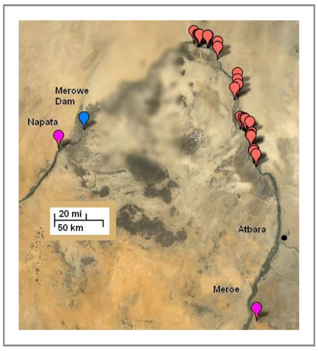

Figure 2: This image is showing the locations of the dam (blue marker) and of two famous archaeological sites (Napata and Meroe, purple markers). The map was obtained with ACME Mapper. The red markers indicate the distribution of villages in that part of the river valley where Google imagery has a resolution suitable to localize possible archaeological remains (the blurring represents the areas where maps have low resolution). Near these settlements, there are areas where the ground is covered by small mounds, round with flattop or with a depression as a hole, probably burial sites (see http://arxiv.org/ftp/arxiv/papers/1011/1

archaeological surveys to gain as much information as possible from all those places that are now under the water of the reservoir. From Italy, a determinant contribution was given by Angelo and Alfredo Castiglioni [20,21]. We will see in the next future many people displaced and lost of archaeological remains again, because other three huge dams have been planned: Kajabar at the Third Cataract of the Nile, Saiteet on Atbara River and Al-Sheraik at the Fifth Cataract of the Nile, northern of Atbara city [22]. This project is then involving the archaeological Nubian regions of Kerma and Meroe. Let us remember that the archaeological evidence has confirmed that Nubia was inhabited at least 70,000 years ago, with a settled culture appearing around 8,000 B.C [13-14]. By the 5th millennium BC, the people who inhabited what is now called Nubia participated to the so-called Neolithic revolution [15,16]. Nubia hosted the Kingdoms of Kerma and Kush, having strong connections with Egypt [17-18].

The fact that a remote sensing is able to see the old channels buried under the sand is well known. For what is concerning the Nile, a huge paleochannel was discovered with a SIR-C/X-SAR imaging radar system [23] during two flights of the NASA space shuttle Endeavor in 1994. These data revealed how the geological structures control a large part of the Nile's flow. More recently, a Shuttle Radar Topographic Mission (SRTM) revealed many segments of an inactive drainage channel systems in eastern Sahara [24]. One of the examined regions is the border between Egypt and Sudan: as reported in [24], SRTM analysed the drainage system which is actually under the sandy surface of the desert. It could be surprising, but Google Imagery shows these old dry channels as well as if we were observing them with SAR/SRTM methods. We discussed in Ref. [25], that the paleochannel of Nile, the same discovered in [23], is clearly displayed by the Google Maps [26]. Let us then consider the reservoir of the Merowe Dam and compare the ancient drainage system of the Nile with the current reservoir extension. We can use the image from NASA, shown in the upper part of Figure 1, and the images from Google Maps, which are showing the region when the dam was under construction. In Figure 3, we can see the two images from the lower part of Figure 1, superposed to have a better comparison. Note that many dendritic drainage systems appear clearly inundated by the reservoir of Merowe Dam. Figure 4 shows in more detail one of these dendritic structures. The upper/left image is a Google Maps image after processing. The lower/right image is the NASA one. The other two images are giving a result with different percentage of superposition. Note that Google clearly displays a paleochannel: the water inundated this paleochannel as NASA image is evidencing.

Has the dam reservoir produced effects on the huge paleochannel of the Nile discovered by the Shuttle X-SAR mission [23,25]? The answer to our question is positive: from Fig.5, we see a branch of the reservoir moving into the old channel. A further increase of the water level could provoke the inundation of this old and dry bed of the Nile, revitalizing it.

Studies on the inundation processes produced by dam reservoirs are fundamental, first of all for the safety of people and animals, and for the best preservation of monuments and archaeological and historical places. It is author's opinion that a detailed study of the Merowe Dam reservoir can help improving models and simulations for any future project of building of dams. If the creation of new dams in unavoidable, it is necessary to have precise simulations of the consequent reservoir created by the dam, to save archaeological and historical heritages for the future.

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The archaeological sites are generally located in paleochannels of the Nile, that is, old dry beds of branches of the river.

Figure 3: The two images from the lower part of Fig.1 after superposition, to have a better comparison. Note the dendritic drainage systems inundated by the reservoir of Merowe Dam.

Figure 4: The image shows in detail one of the dendritic structures of the Merowe Dam reservoir. The upper/left image is coming from Google Maps after processing as in Ref.25. The lower/right image is the NASA one after being rotated, resized and image-processed. The other two images are giving the result with different percentages of superposition. Note that in the upper/left one the paleochannel is clearly displayed. The water inundated it as NASA evidenced.

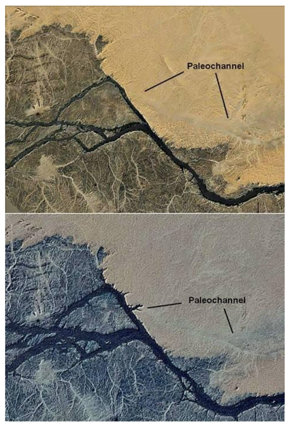

Figure 5: The reservoir is starting to affect the huge paleochannel of the Nile discovered by the Shuttle X-SAR mission [23,25]. The upper panel shows an image obtained from Google after a proper enhancement. The lower panel shows the same structure as obtained after rotation, resize and enhancement of a detail from the NASA image of Fig.1.

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