Monuments affected by the construction of dams

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ABSTRACT

Securing adequate water reserves has always been a priority for every state. This objective has been achieved, and continues to be achieved, through the construction of surface water storage projects, most notably dams. In addition, dams play a crucial role in protecting agricultural and urban areas from river flooding. However, the construction of a dam and the creation of a reservoir inevitably have environmental impacts. The most significant of this stem from the formation of the artificial lake, which results in the inundation of extensive upstream areas. In many cases, monuments located within a dam's inundation basin have been affected, with preservation measures either implemented—or, in some instances, not undertaken at all. This article seeks to present selected monuments that were impacted by the construction of dams and to examine the measures adopted for their protection or documentation.

Keywords: Monuments, dams, reservoirs, flooding

INTRODUCTION

The utilization of water for domestic and agricultural purposes is a practice that has been integral to human societies across the globe for centuries. After food, water is the most fundamental element sustaining human life and enabling the establishment and development of settlements.

Dams have been constructed since antiquity to store water, protect arable land and cities from floods, and support agricultural development. However, the construction of a dam and the creation of a reservoir inevitably entail environmental consequences. The most significant of these arise from the formation of an artificial lake, which leads to the inundation of extensive areas. Numerous monuments around the world have been located within the flood basins of dams, underscoring the delicate balance between infrastructure development and the preservation of cultural heritage. In some cases, monuments have been successfully documented, dismantled, and relocated to safer ground. In others, they remain at risk or have been permanently submerged by rising waters. Unfortunately, of the globally affected sites (conservatively estimated at over 5,000), only a very small proportion has been preserved, amounting to fewer than 50 major monuments. The best-documented rescue effort is that associated with the Aswan High Dam, where, out of over 100 identified significant monuments, 22 major monuments were saved or relocated as part of the UNESCO Nubian Campaign (Fekri Hassan, 2007). Ongoing efforts by UNESCO and other international and national organizations seek to safeguard these irreplaceable cultural treasures through coordinated conservation initiatives, emergency interventions, and long-term heritage management strategies.

This paper aims to present selected case studies of monuments around the world that have been affected by the construction of dams and the creation of associated reservoirs.

CASE STUDIES OF PRESERVED MONUMENTS

Aswan Dam

The Aswan High Dam on the Nile River (Fig. 1) is an embankment (earth-fill) dam measuring 3,830 m in length, with a base width of 980 m, a crest width of 40 m, and a height of 111 m. Its total volume is approximately 43,000,000 m³. The dam was constructed to regulate the flow of the river and to generate hydroelectric power, thereby supporting Egypt's water management and energy needs. Its construction

led to the creation of Lake Nasser. The reservoir extends approximately 550 km in length, reaches a maximum width of 35 km, covers a surface area of about 5,250 km², and has a total storage capacity of 132 km³ of water.

The formation of the artificial lake forced approximately 50,000 people to leave their homes and resettle in an area about 50 km north of Aswan. At the same time, 22 ancient monuments and architectural complexes threatened by the rising waters of Lake Nasser were dismantled and relocated to higher ground along its shores as part of the international campaign led by UNESCO to save the monuments of Nubia. Among the most prominent were the temples of Abu Simbel temples. Also relocated were the temples of Philae, Kalabsha, and Amada. In recognition of the assistance provided by several countries during the rescue operations, additional monuments were donated abroad: the Temple of Debod in Madrid, the Temple of Taffeh in Leiden, and the Temple of Dendur in New York. Despite these unprecedented preservation efforts, many other archaeological sites were ultimately submerged beneath the waters of Lake Nasser, including the fortress of Buhen.

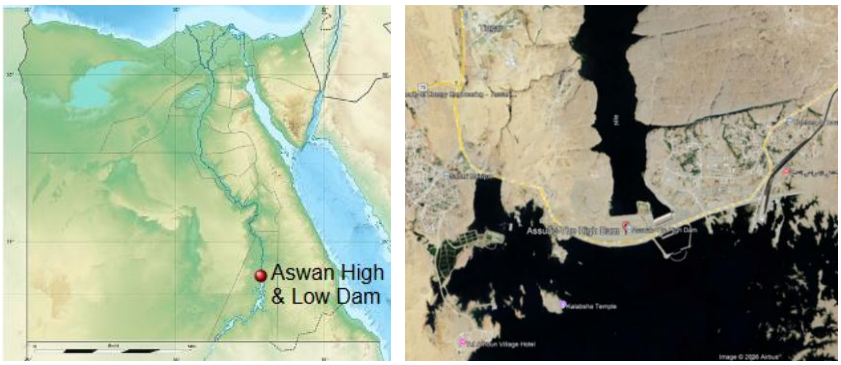

Figure 1. *Location (Wikipedia) and aerial photograph of the Aswan High Dam (Google Earth)*

The most impressive and technically demanding relocation was that of the two temples of Abu Simbel temples, which had been carved into the sandstone cliffs of the western bank of the Nile River during the reign of Ramesses II in the 13th century BC. As part of the rescue operation, the temples were relocated 65 m higher than their original position (Fig. 2) to protect them from the rising waters of Lake Nasser.

In 1959, an international campaign was launched under the auspices of UNESCO to raise funds for the rescue of the Nubian monuments. The relocation work began in 1964 and was carried out by an international team of archaeologists, engineers, and specialized heavy-equipment operators. Between 1964 and 1968, the temples were carefully cut into large blocks—some weighing up to 30 tons, with an average weight of approximately 20 tons—then dismantled, transported, and meticulously reassembled (Fig. 3) at their new site, 65 m higher and about 200 m away from the river. At the time, the cost of the rescue operation for the temples of Abu Simbel amounted to approximately $40 million, making it one of the most ambitious and expensive heritage preservation projects ever undertaken.

Figure 2. *Scale model of the original and final location of the temples of Abu Simbel (Wikipedia)*

Philae Island was an island located near the expansive First Cataract of the Nile River in Upper Egypt. Prior to its inundation by Lake Nasser, the Philae temple complex, originally built on the island, was

carefully dismantled and relocated to nearby Agilkia Island to preserve its historical and cultural significance. Between 1974 and 1976 a cofferdam was built around the temples to facilitate their relocation and rebuilding (Fig. 4).

Philae was an ancient Egyptian city located within the first nome of Upper Egypt, known as the Nome of the Country of the Arc (or Country of Nubia). The city was home to the Temple of Isis, one of the best-preserved temples in ancient Egypt. Remarkably, this temple complex was among the last strongholds of the ancient Egyptian religion, continuing to function even after the spread of Christianity in Egypt, and it was officially closed only in 550 AD.

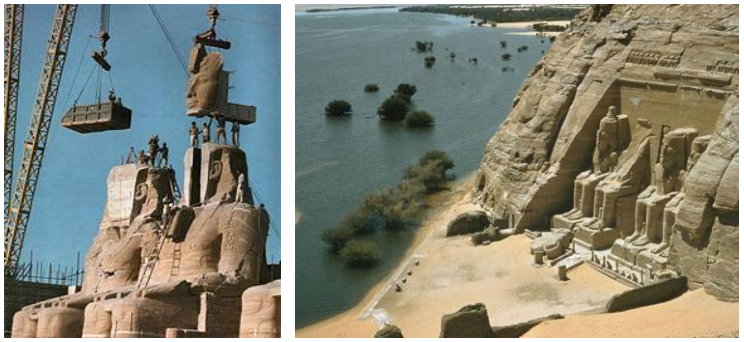

Figure 3. *Cutting and transportation of sections of the temples of Abu Simbel and their appearance after the reassembly of the sections (Wikipedia)*

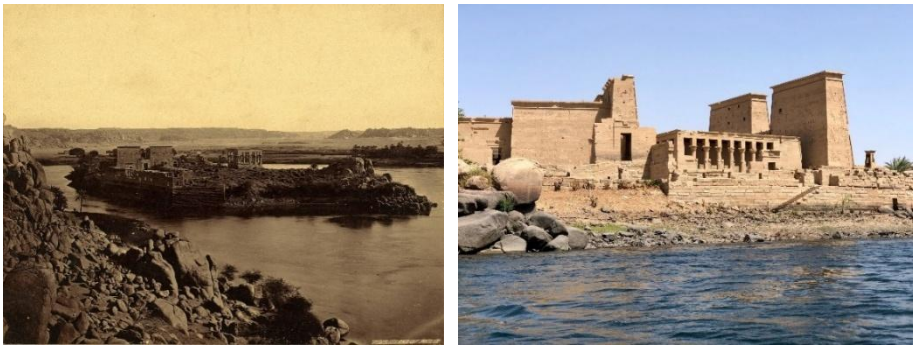

Figure 4. *1856 photo of the Island of Philae (now submerged) and the reconstructed Philae temple complex to its current home, on Agilkia Island (Wikipedia).*

Ilarionas Dam

Figure 5. *Location and downstream view of the Ilarionas Dam (REC Productions (kozan.gr))*

The Ilarionas Dam on the Aliakmonas River, near Aiani, was constructed using river gravel support shells with an impermeable clay core (Fig. 5). The dam has a maximum height of 130 m above the foundation, a crest length of 540 m, and a total volume of 8,800,000 m³. The project serves multiple

purposes: it generates approximately 330 GWh of electricity annually, supplies water to the city of Thessaloniki, regulates downstream hydroelectric projects, stabilizes the water level of the Polyfytos Dam reservoir, enhances the ecological environment of the Aliakmonas River Delta, and provides irrigation for the northern zone surrounding Lake Polyfytos.

The reservoir formed behind the Ilarionas Dam covers a surface area of 21.9 km², extends 25 km in length, and ranges from 0.3 to 1 km in width, with a useful storage capacity of 412 million m³. Its creation led to the inundation threat of several Christian monuments, including the Holy Monastery of the Dormition of the Theotokos of Tornikion and the Skete of the Monastery of Osios Nikanor.

The Monastery of the Dormition of the Theotokos of Tornikion was situated a short distance from the village of Panagia (Tourniki) in Deskati the Aliakmonas River. Its foundation dates back to the 12th century and is historically linked to the prominent Tornikios family. The Katholikon building is a two-storeyed structure, with both the ground and upper floors consisting of single-aisle, barrel-vaulted churches. Each church is richly decorated with wall paintings, which, according to contemporary inscriptions, date to 1481 and 1730. Along the southern side of the monastery, there were stone-built cells with wooden roofs and tiled coverings, constructed during the period of Ottoman rule (Fig. 6, Zafiris, 2018).

Figure 6. *The Holy Monastery of the Dormition of the Theotokos of Tornikion, Deskati, Grevena.*

To prevent its inundation, the Katholikon building of the monastery was relocated 127 m away and 27 m higher than its original site. The structure was carefully reinforced to prevent damage during transport and moved along steel rails (Fig. 7a, Zafiris, 2018). The relocation project was financed by the owner of the dam, while the other buildings and ancillary structures of the monastery were demolished.

Figure 7. *a. Moving the Katholikon on steel rails and b. The Skete of the Monastery of Osios Nikanor*

The Skete of the Monastery of Osios Nikanor is situated on the western side of Mount Kallistratos where the Aliakmonas River flows, at an elevation of approximately 100 m above the riverbank (Fig. 7b, ACA Elatos). The skete contained 16th-century Byzantine wall paintings, which were preserved during the construction of the Ilarionas Dam. To protect the skete from flooding, the reservoir's water level was intentionally lowered by 3–8 m.

Three Gorges Dam

The Three Gorges Dam, officially known as Yangtze River Three Gorges Water Conservancy Project is a hydroelectric gravity dam that spans the Yangtze River near Sandouping in Yiling District, Yichang, Hubei province, central China, downstream of the Three Gorges (Fig. 8, Wikipedia, *gettyimages).*

Figure 8. *Location and view of the Three Gorges Dam and reservoir (gettyimages, credit: CFOTO)*

The Three Gorges Dam has a height of 181 m, a length of 2,335 m, a base width of 115 m, and a total volume of 27,200,000 m³. The resulting Three Gorges Reservoir has a total storage capacity of 39.3 km³, a surface area of 1,084 km², and a maximum length of 600 km. The primary purposes of the project are hydroelectric power generation, flood control, and water storage.

The Three Gorges Dam Reservoir inundated more than 400 square miles of land. Over a million people were relocated, along with their homes, schools, and hospitals. This region of China is home to a unique cultural heritage. While some aspects of that culture have been preserved—through relocation or reconstruction—others have been irretrievably lost.

Figure 9. *a. The Stone Treasure Fortress includes a Taoist temple and b. the Zhang Fei Temple (Kuhn)*

The Shibaozhai Fortress, also known as the Stone Treasure Fortress (Fig. 9a), dominates the shoreline of the Three Gorges Reservoir in the county town of Zhongxian. To protect it from flooding, a protective wall was constructed around the fortress, effectively turning it into an isolated island accessible by boat or via a connecting bridge. Downstream from the fortress lies a temple dedicated to a third-century general from the Three Kingdoms period. The entire temple was carefully relocated to preserve it in its original form. Similarly, the ancient village of Dachang—once renowned for its picturesque cobbled streets and historic wooden temples—was reconstructed uphill as a kind of heritage-themed village, retaining elements of its original charm while ensuring protection from the rising waters.

In contrast, the Zhang Fei Temple (Fig. 9b), located on the hillside across the Yangtze River from Yunyang County, was submerged by the Three Gorges Dam in 2006. The temple was originally

constructed to honour General Zhang Fei, a 3rd-century military leader of the Three Kingdoms period. The complex included a large hall housing a colossal statue of Zhang Fei, the Jieyi Tower, and pavilions dedicated to the poet Du Fu, who lived in the temple for two years. Many of its monuments were however saved beforehand, including the statue of Zhang Fei and the ornate front gates.

CASE STUDIES OF NOT PRESERVED MONUMENTS

Mornos Dam

The Mornos Dam is located on the Mornos River in the Prefecture of Fokida The dam was constructed to improve the water supply for Athens by utilizing the reservoir created behind it. It is an earth-fill dam with an impermeable clay core, featuring a crest length of 815 m, a base width of 250 m, a height of 125 m, and a total volume of 17,000,000 m³. The reservoir has a surface area of approximately 19 km² at overflow level, with the water level maintained at an elevation of 446 meters (Fig. 10).

Figure 10. *Location and view of the crest of Mornos Dam (Michanikos, 2023)*

For the creation of the lake, it was necessary to evacuate the village of Kallio, which was relocated to a new site above the shores of the lake. When the lake's water level drops during periods of drought, the houses of the old settlement reappear. The ancient city of Kallion (Fig. 11a) as well as the stone arched bridge at the site "Hania tou Velouchovou" (Venetian or Frankish, most likely built by Epirote master craftsmen (Fig. 11b, Aspro and Mavro) and the settlement of Hania Stenou were also inundated.

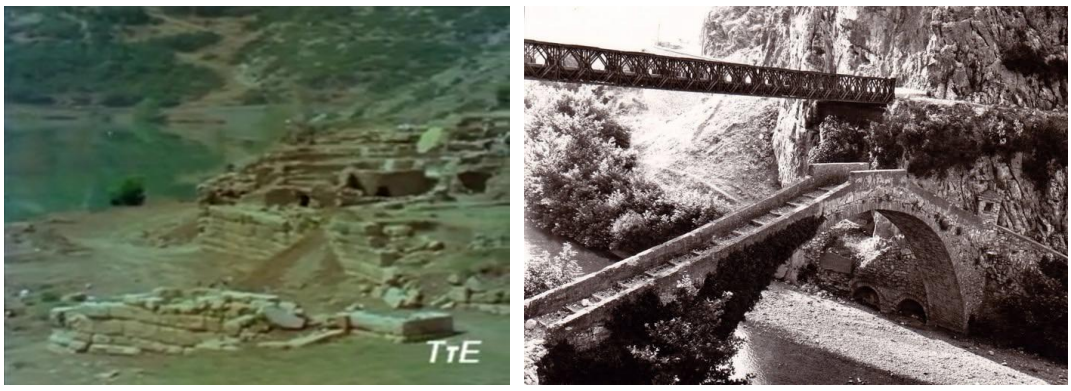

Figure 11. *a. The ruins of ancient Kallio shortly before their inundation (Themelis) and b. The Stone Bridge of Steno in Lidoriki, Phocis, which was blown up before the flooding of the area*

Although traces of habitation in the area date back to the Geometric period, Kallion—known as Kallipolis during the Hellenistic period—was systematically inhabited from the 4th century BCE. The city suffered total destruction during the Gallic invasion of 279 BCE but was subsequently rebuilt. Following the Battle of Pydna in 167 BCE, evidence suggests that Kallion was again destroyed by fire.

Two years before its complete inundation, intensive archaeological excavations were conducted at Kallion, uncovering statues, votive offerings, household items, and mosaics, all of which were carefully transferred to museums. By May 1980, the site of Kallion lay submerged under 40 meters of water.

Kremasta Dam

The Kremasta Dam is an earth-fill embankment dam on the Achelous River in Aetolia-Acarnania, Greece. It has a height of 165 m, a crown length of 456 m, a base width of 670 m, and a total volume of 8.1×10^6 m³. The dam is situated just downstream of the confluence of the Agrafiotis River, Tavropos River, and Trikeriotis River, which together form the Achelous River. Constructed between 1961 and 1965, the dam is a key component of Greece's hydroelectric infrastructure. It impounds Lake Kremasta, the largest artificial reservoir in the country, with a total capacity of 4,750 million cubic meters and a useful storage capacity of 3,800 million cubic meters. The reservoir supports not only power generation but also flood control, irrigation, and water supply (Fig. 12).

Figure 12. *Location and view of the Kremasta Dam and reservoir (GCOLD)*

The creation of the reservoir submerged the Tatarna Bridge, a single-arched bridge spanning the Achelous River (Fig. 13a, Grammatikogianni). The bridge had an impressive span, with one end resting in Valtos and the other in Evrytania. Its construction technique was particularly remarkable. The exact date of its construction is unknown, but it was most likely built in the mid-17th century by master builders from the region.

Figure 13. *a. Tatarna Bridge and b. Panagia of Episkopi church before its inundation by the Kremasta Dam reservoir (Sanidopoulos)*

Further to the inundation of the Tatarna Bridge, the submergence also erased significant cultural heritage, including dozens of churches and monasteries. Among them is an 8th century Byzantine church called "Panagia of Episkopi" (Fig. 13b).

Birecik Dam

The Birecik Dam is located on the Euphrates River, 60 km downstream of the Atatürk Dam and 8 km upstream of Birecik. It is a gravity dam with a height of 62.5 m, a length of 2,530 m, and a structural volume of 9,400,000 m³. The reservoir formed by the dam has a surface area of 56 km², a length of 25 km, and a width ranging from 0.3 km to 1 km, with a useful storage capacity of 1,220 million m³. The dam was designed primarily for irrigation and hydroelectric power generation (Fig. 14).

The reservoir behind the dam has submerged the ancient city of Zeugma, leading to the resettlement of approximately 6,000 people (Borja et al., 2015). Since 2000, about 80% of the archaeological site has been underwater. However, a significant number of mosaics have been carefully relocated to museums.

Figure 14. *Location and upstream view of the Birecik Dam and remains of Zeugma ancient city (Wikipedia)*

Zeugma was a Hellenistic-era city of the Greek world and later part of the Roman province of Commagene. Its name derives from the Greek word ***zeugma***, meaning “bridge of boats,” which spanned the Euphrates River at that location.

The site was initially excavated sporadically, during which many exquisite mosaics were discovered. However, with the impending inundation threatening the antiquities, American philanthropist David W. Packard donated USD 5 million to fund an emergency excavation of the site. This effort enabled archaeologists to preserve mosaics that would otherwise have been lost to the reservoir (NTV-MSNBC, 2000). The recovered mosaics were initially stored at the Gaziantep Museum and are now displayed at the Zeugma Mosaic Museum.

Zeugma has been on the UNESCO World Heritage tentative list since 2012. The extant archaeological remains include the Hellenistic Agora, the Roman Agora, two sanctuaries, a stadium, a theatre, two bathhouses, a Roman legionary base, administrative structures of the Roman legion, most of the residential quarters, Hellenistic and Roman city walls, and the East, South, and West necropolises.

Ilisu Dam

The Ilısu Dam is a concrete-face rock-fill dam on the Tigris River, near the village of Ilısu, along the border of Mardin Province and Şırnak Province. The dam has a height of 135 m, a length of 1,820 m, a base width of 610 m, and a structural volume of 43,800,000 m³. The Ilısu Reservoir has a total capacity of 10,410 million m³, a surface area of 313 km², and a maximum length of 244 km (Fig. 15, Daily Sabah, AA Photo). The dam’s primary purposes are hydroelectric power generation, flood control, and water storage.

The Old Bridge (Hasankeyf), also known as the Old Tigris Bridge, is a ruined four-arch bridge spanning the Tigris River in the town of Hasankeyf in southeastern Turkey. It was constructed by the Artuqid Turkmens in the mid-12th century, around 1147–1167, and at the time its central arch was among the largest in the world. The bridge was later repaired by Ayyubid Kurdish and Aq Qoyunlu Turkmen rulers during the 14th and 15th centuries and appears to have eventually collapsed in the early or mid-17th century. The bridge’s ruined piers still stand—two in the river itself—and one arch remains (Fig. 16). Since 2020, the ruins, along with much of Hasankeyf, have been submerged by the filling of the Ilısu Dam reservoir. The town was relocated to Yeni Hasankeyf on a nearby hill, and most historical structures were moved there before the reservoir was filled.

Figure 15. *Location and view of the Ilisu Dam and reservoir*

Figure 16. *Remnants of the Old Hasankeyf bridge (https://www.dreamstime.com) and city (Dûrzan - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19151427)*

CONCLUSIONS

In this paper, selected examples are presented to illustrate the effects of dam construction and the creation of associated reservoirs on cultural monuments and archaeological sites. These cases highlight the complex and often delicate interplay between large-scale infrastructure development and the preservation of cultural heritage. While dams can provide significant economic and social benefits—such as hydroelectric power generation, irrigation, and flood control—they may also lead to the inundation of historically and culturally significant landscapes.

In some instances, remarkable international cooperation has enabled the successful documentation, dismantling, and relocation of endangered monuments. In others, however, limited resources, time constraints, or technical challenges have resulted in irreversible losses. Entire cultural landscapes—encompassing not only individual monuments but also settlements, sacred spaces, and intangible heritage—have been submerged beneath rising waters.

Organizations such as UNESCO, along with national authorities, research institutions, and local communities, continue to play a crucial role in mitigating these impacts. Through emergency salvage archaeology, digital documentation, protective engineering works, and awareness campaigns, they strive to safeguard what remains and to record what cannot be saved. These ongoing efforts underscore the importance of integrating cultural heritage considerations into the early planning stages of infrastructure projects, ensuring that development proceeds in a manner that respects and preserves humanity's shared and irreplaceable cultural legacy.

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