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RETHINKING THE MOSUL DAM: A REASSESSMENT OF ITS IMPACT BEYOND THE TRADITIONAL NARRATIVES

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Abstract
The Mosul Dam, one of Iraq's most significant infrastructural projects, has been the subject of extensive debate and scrutiny, often overshadowed by negative narratives concerning its safety and environmental impact. These narratives overlook the dam's significant function in creating food and energy and fostering local, regional, and global water cooperation. This article seeks to provide a comprehensive revaluation of the dam's contributions to water management and diplomatic relations. By systematically addressing the prevalent criticisms, this study highlights the recent renovation works that extended the dam's lifespan. These works, which will be examined with a quantitative methodology in the study, involved the Iraqi Government, the Kurdish Regional Government, the United States and Italy. These four entities contributed with joint efforts to make the dam safer, forging trust and collaboration on multiple levels. The Mosul Dam serves as a model for international water cooperation, illustrating the potential for large-scale infrastructure projects to contribute to peace and stability. The reassessment provided in this study advocates for a more nuanced understanding of the Mosul Dam, recognizing its pivotal contributions to water security and international cooperation, which are essential for the region's sustainable development and beyond.

Keywords: Water strategy, constructive ecologism, water cooperation, dam management, Middle East.

Introduction

Hydraulic infrastructures have been essential to the well-being of human societies since the earliest civilizations arose. The latter, nurtured by the silt of the Tigris and Euphrates rivers, were born in Mesopotamia, the cradle of ancient civilization. From Mosul all the way down to the Shatt al-Arab, where the twin rivers meet before emptying into the Persian Gulf, the distribution of human settlements followed the bends of the two watercourses, which were organized in an extensive system of

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irrigation and drainage canals to enable crop cultivation in areas with small rainfall and were bordered by floodwalls to reduce damages from the seasonal inundations that used to sweep the basin (Husain 2021).

Nowadays, dams are a prominent tool in flow regulation, flood prevention, hydropower generation, and many other critical sectors related to the development of human communities settled near a waterway (Obertreis et al. 2016). However, mega-dams, i.e., major hydraulic constructions capable of altering the course of the river on which they are located and changing the topographical features of entire regions, can often pose a threat rather than being an asset to communities and territories. In addition to their large environmental impact, mega dams have very high construction and maintenance costs. Financing extensive water infrastructures involves multiple players, including investment funds, international organizations, and development banks. Indeed, single states seldom can afford the expenses required to complete an infrastructure project that aims to build a mega dam. Moreover, once completed, these infrastructures need expensive and ongoing maintenance to ensure better energy performance and prevent dangerous accidents.

Being one of the largest dams in the Middle East, the Mosul Dam (MD) fully falls into the category of mega dams, with all the technical, environmental and financial complexities associated with this type of hydro facilities. Moreover, the peculiar geological characteristics of the land on which it was erected make the dam susceptible to collapse if not constantly maintained and supervised by teams of experienced engineers. In this regard, several authors (Adamo et al. 2017; Warren 2006; Milillo et al. 2016; Annunziato et al. 2016) stressed on the dam's precarious condition and warned of the potentially devastating effects that its destruction would have on not only the city of Mosul but also all north-central Iraq. Expressly, Adamo Nasrat, a former senior official at the Iraqi Ministry of Irrigation and a prominent civil engineer who participated in the construction of the MD, has repeatedly and openly declared that the dam's collapse would have devastating consequences. Given the dam's precarious geological and technical conditions, Adamo and Al-Ansari believe that its collapse is "rather plausible" (Adamo and Al-Ansari 2016, 237).

Considering numerous studies carried out over time and following the considerations of one of its most prominent builders, Nasrat Adamo, the MD has been regarded as a dangerous infrastructure for the region for many years. The situation became so severe that in 2016, an international consortium in which four entities participated - the Government of Iraq (GoI), the Kurdistan Regional Government (KRG), the United States and Italy - carried out rehabilitation work on the dam, yielding significant improvements and a brighter future for the dam. However, despite the redevelopment work, even nowadays, the general perception of MD is decidedly negative both in Iraq and in the Middle Eastern context.

This article aims to answer the following questions:

- What improvements have been made by the international engineering team to make the hydraulic infrastructure safe?
- How is it possible that the MD is still perceived negatively despite the work of one of the most specialized engineering teams in the world?

- What are the hydro-strategic consequences from a local, regional, and global collaboration perspective as a result of the work completed by the international consortium?

Methodology and Structure

The overarching aim of this article was to conceptually and empirically refute the MD's negative perception in the Middle Eastern context and on a global scale. A mixed methodological approach was used, consisting of qualitative and quantitative methods. Specifically, this article entailed a structured qualitative literature review of relevant academic literature, reports and policy documents and a quantitative analysis of the most crucial criticalities concerning the MD. The critical method for conceptual discussion on the perception of the MD in Iraq was a literature review, complemented by the relevant findings from quantitative approaches. The literature was analytically reviewed to identify definitions and descriptions of the technical problems that prompted the distrust toward the dam. The identified descriptions were then compared and analyzed with the renovation works carried out by the team of international engineers, showcasing the power of local, regional and global collaboration. This led to the categorization of the three different positive outcomes in terms of water cooperation which involved multiple actors.

The article consists of an initial section describing the structural problems that the MD has encountered since the beginning of its construction. The location and the geological features have laid the foundations for the spread of a negative perception of this infrastructure. In fact, the initial skepticism about the dam, which Saddam Hussein strenuously desired to regulate water flows in northern Iraq and generate hydropower, became increasingly widespread over the years until it turned into open distrust towards the infrastructure's real benefits. The destructive potential in the event of a collapse slowly but gradually took over the benefits the MD had brought to the northern Iraqi region. Moreover, after the dam came under the control of ISIS terrorists in August 2014, the fear that it might collapse due to lack of constant maintenance increased tremendously, contributing to spreading uncertainty and fear regarding the fate of the dam.

Subsequently, the article included a section devoted to a quantitative analysis of the technical improvements that were made to expand the lifespan of the dam. In 2016, a team of Italian engineers from Trevi S.p.A. (Trevi Group), assisted by the U.S. Army Corps of Engineers (USACE) through an international bid launched by the Government of Iraq, carried out a total upgrading of the dam by structurally solving many of the problems that had characterized the MD from the beginning. After this section, an analysis of the benefits related to hydro-strategic cooperation followed. In addition to bringing significant systemic and technical benefits to the infrastructure, the dam upgrading project carried out by Trevi had significant local, trans-regional and international impacts.

Locally, the main result has been the relevant operational cooperation between Kurds and Iraqis, two peoples who have often been enemies. Kurdish peshmerga - the military groups defending the Kurdish Regional Government - have, together with an

Italian contingent, defended the dam, where Iraqi engineers work, from possible attacks by ISIS militants. This collaboration represented a critical meeting point between Kurds and Iraqis that could inaugurate a new phase in which the two entities - the GOI and the KRG - can collaborate on other projects in the future.

On a trans-regional level, it is prominent to emphasize the deep collaboration between Italy and Iraq, two allied countries that are part of the Mediterranean and Middle Eastern region, respectively. Italy, in addition to providing technical, technological and engineering support, has sent a contingent of military personnel to defend the MD, a strategic Iraqi infrastructure. This multi-pronged collaboration - military and technical - has improved relations between the two nations, helping to spread stability in the region.

Finally, on a global level, it is worth noting the collaboration between the United States and Italy, two critical players in the Atlantic Alliance that have cooperated jointly on both technical and logistic levels to secure the dam. The work carried out by Trevi was perfected by the technical support provided by the USACE. Undoubtedly, this project stimulated the sharing of data, the joint handling of sensitive technical issues, and boosted the general operation of the Italian and U.S. engineers.

Constructive ecologism and the perception of reality

Mega dams significantly alter local economies, social structures and, often, entire regions. While some observers and communities may perceive these projects as opportunities for development, with promises of improved irrigation, electricity, and employment, others experience disruption and displacement. The forced relocation and resettlement associated with dam construction often lead to a loss of ancestral land, cultural heritage, and social networks. These experiences shape a territory's perception of mega dams, with displaced communities likely to view them with skepticism and resentment (Dryzek 2013). Environmental changes caused by mega-dams also contribute to how they are perceived. Alterations in water flow, changes in fish populations, and loss of biodiversity impact communities differently based on their reliance on the natural environment. For instance, communities with a deep spiritual and cultural connection to the river may view these environmental changes as a violation of their way of life, leading to strong opposition to the dam. Furthermore, perceptions of risk and uncertainty, which are socially constructed, vary widely. The potential for dam failure, environmental degradation, and long-term sustainability are viewed through the lens of past experiences and trust in authorities (Dryzek 2013; Peet et al. 2010).

In this article, Constructive Ecologism (CE) was used as the theoretical framework to evaluate how different environmental perspectives shape the perception of reality. The constructivist ecologist perception of mega dams offered a rich profound understanding of how these massive infrastructure projects are experienced and interpreted by local and international experts. Constructivism, as a theory of knowledge, posits that individuals and communities construct their understanding of the world through their experiences, interactions, and cultural contexts (Naess, 1989). This perspective is particularly valuable in examining the diverse and often conflicting

views surrounding mega dams. At the heart of the CE is the recognition that the perception of reality plays pivotal roles in shaping how mega dams are perceived. In this regard, the negative narrative of an event, a fact or, in the case of MD, a water infrastructure, significantly impacts how it is perceived locally and in a broader context. From the beginning, the dam has been surrounded by an inherently negative representation due to several well-documented features. Over time, the image of the MD has taken on a granitic negative connotation that represents only part of the reality. In fact, the perception of the dam, even after the upgrading works carried out in 2016, has remained the same. This is because, despite the activities completed by an international team of experts involving highly qualified engineers, the dam continues to be portrayed as a threat rather than an opportunity for the region.

Through the lens of CE, this article aims to provide innovative insight to academic scholarship regarding the actual impact of the MD on various fronts. The perception of the dam, which has been the subject of numerous quantitative studies for many years, has been fed negatively, contributing to the portrayal of a very complex and dangerous reality. However, following the upgrades, there were fewer quantitative studies aimed at understanding what had been accomplished and what improvements had been made. Consequently, the dam remained "captive" to a pessimistic narrative that not only prevented its structural progress from being verified but also prevented light from being shed on the remarkable achievements of hydro-strategic collaboration on the local, regional and global fronts. Using a CE theoretical approach, this article sought to make an original contribution by attempting to overturn the negative perception constructed around the MD.

CE, as a theoretical variant of Constructivism, has allowed for an alternative representation of the reality surrounding the perception of the MD. The works of Dryzek (2013), Sessions (1995), Merchant (2005), and Peet, Robbins, and Watts (2010), among others, have been instrumental in the comprehensive theoretical and conceptual analysis of the distorted perception of the MD in the Middle Eastern context. By recognizing the multiplicity of environmental realities and the importance of multiple perspectives, CE can provide valuable and alternative insights for developing more holistic and sustainable approaches to the environmental challenges associated with the MD.

Historical overview and the structural problems of the Mosul Dam

To fully understand the negative perception that has been floating around the MD, it is essential to provide a historical overview of some structural problems concerning its technical features and the projections of potential damage in the event of a systemic collapse. As previously mentioned, besides being the biggest dam in Iraq, the MD is one of the most relevant water facilities in the Middle East. The dam, constructed between 1981 and 1986, is located on the Tigris's shores in the northern part of the country (42°49'19''E, 36°37'48''N). With an impoundment of 11.1 billion m^3, it adds to Iraq's water resources another 8.16 billion m^3 of live storage, forming an artificial lake that holds 11.1 km^3. This quantity is a vital resource in an arid country like Iraq, supporting the irrigation of 1 million hectares of fertile land. The dam also plays a

significant role in electricity generation, housing a 750 Megawatts (MW) power station. This capacity is further enhanced by an additional 60 MW installed in its reregulating dam (8 kilometres south of the main dam) and another 200 MW installed in the pump storage scheme on its right part (Adamo et al. 2017).

It is relevant to consider that the MD is situated in a region characterized by varied topography, including mountainous terrain to the north and relatively flat plains to the south. The dam itself is located approximately 50 kilometres north of the city of Mosul. The Tigris River, which the dam impounds, originates in the mountains of southeastern Turkey and flows through Syria and Iraq, creating a diverse and complex river basin. The average annual rainfall in the Mosul Dam's catchment area varies significantly due to its extensive geographical coverage. In the northern mountainous regions, the rainfall can exceed 800 mm per year, while in the southern plains, it decreases to around 200-300 mm per year. This variation impacts the flow and storage capacity of the dam (Adamo et al. 2017).

Figure 1. The Mosul Dam geographic location

Data courtesy of the BBC. Accessed August 29, 2024. https://www.bbc.com/news/world-middle-east-28772478

The hydrological regime of the basin is characterized by significant seasonal variations. Snowmelt from the mountains contributes to high flow rates in the spring, while the summer months see reduced flow due to lower precipitation and higher evaporation rates. Consequently, the average flow of the Tigris River at the Mosul Dam site is influenced by seasonal changes, with higher flows occurring during the winter and spring months due to snowmelt and rainfall in the upstream regions. The

average annual flow rate of the Tigris River at this location is approximately 370 m^3/s), though this can fluctuate significantly based on climatic conditions and upstream water management practices (Husain 2021; USACE 2017).

Although the dam was completed in the mid-1980s, the desire to build an extensive infrastructure capable of controlling downstream flows and generating hydroelectric power had already emerged in the early 1950s (Al-Abayachi 2016). In this regard, the Iraq Development Board took the first step to build the dam in 1952, when a joint venture of two European firms was selected to prepare a preliminary study by performing some investigations, selecting a dam site and drawing up a final design. In addition to flow control and energy production, the Iraqi government aimed to secure a vital water reserve to increase the portion of arable land. This led to contracting three more consulting firms to prepare the required designs. Finally, Bagdad rested with the Swiss Consultant Consortium in 1978 to do the designs the final draft of the project (Al-Abayachi 2016; Adamo et al. 2017).

It ought to be highlighted that all the consultants recognized the presence of soluble gypsum, anhydrite and limestone - i.e. water-soluble minerals - in the dam's foundations. Dams built on this kind of rock are subject to a phenomenon called karstification, in which the foundation becomes shot through with voids and vacuums. As a result, the experts warned that water could easily seep under the dam and compromise its stability, posing the risk of a systemic failure. The remedy suggested by the consulting firms that the Iraqi government contracted to carry out preliminary studies consisted of constantly maintaining the dam using the grouting technique. This technique, involving the injection of a cement mixture into compromised spots**,** is designed to prevent potential new leaks (Annunziato et al. 2016). In this way, the artificially injected cement prevents the constant erosion of the foundations from causing the dam to structurally fail.

Since the earliest stages, cement injection under the dam encountered several difficulties. Many areas in the layers could not be sealed despite repeated grouting using different types and mixtures of mortar. Although maintenance grouting over the past thirty years had succeeded in closing the holes temporarily, they kept cyclically opening to be plugged again and again (Kelley et al. 2007). As reported by Adamo: "these maintenance operations conducted over the years have only lengthened the life of the dam. (…) Experts consider them as not going to save it in the long run" (2017, 268). This critical situation has fuelled fears and concerns about the adequate structural stability of the dam. Given its size, a possible infrastructure collapse could have catastrophic consequences, potentially affecting hundreds of thousands of Iraqi citizens dwelling downstream. Consequently, several projections have been performed to calculate the dam break propagation from the MD into the downstream valley in the six days following the break event (Adamo et al. 2017; Kelley et al. 2007; Annunziato et al. 2016).

Table 1. Projections of hydraulic calculations depending on the break size (Adamo et al. 2017; Annunziato et al. 2016)

Item	Height (metres a.s.l.)	Distance (km)	Slope	Average speed (km/h)	Time of wave arrival (h)	Time of max height (h)	Max height (m)
Dam break	252	0	-		0	0	78
Mosul	217	69	-0.05	40.	1.7	6.2	26.4
Bayji	109	180	-0.06	11.	16.8	23.5	14.3
Tikrit	89	47	-0.04	11.	21.0	26.5	14.4
Samarra	66	54	-0.04	18.	25.8	30.8	16.1
Bagdad	38	108	-0.03	2.6	67.0	117.0	7.9

According to Annunziato's predictions (2016), the total population affected by flood waters would be just over 6 million people or a significant 16% of the total population of Iraq and the flooded area would entail almost 2% of the country's total area. Approximately a running total of more than half a million people would be exposed to floodwaters more than 5 meters in height, thus putting their lives at risk. As shown in Table 2, many people involved in this severe environmental crisis would have less than two hours' notice. Furthermore, a very significant surface area could be flooded, destroying critical infrastructure, homes, crops and all means of livelihood.

Table 2. Projections of the population affected in the event of the collapse of the Mosul Dam (Adamo et al. 2017; Annunziato et al. 2016)

Inundation	Population	Area (square km)
0.1-0.5 m	948 000	637
0.5-2.0 m	3 144 000	2022
2-5 m	1 626 000	2482
5-10 m	260 000	1 150
Over 10 m	270 000	916
Total	6 248 000	7 202

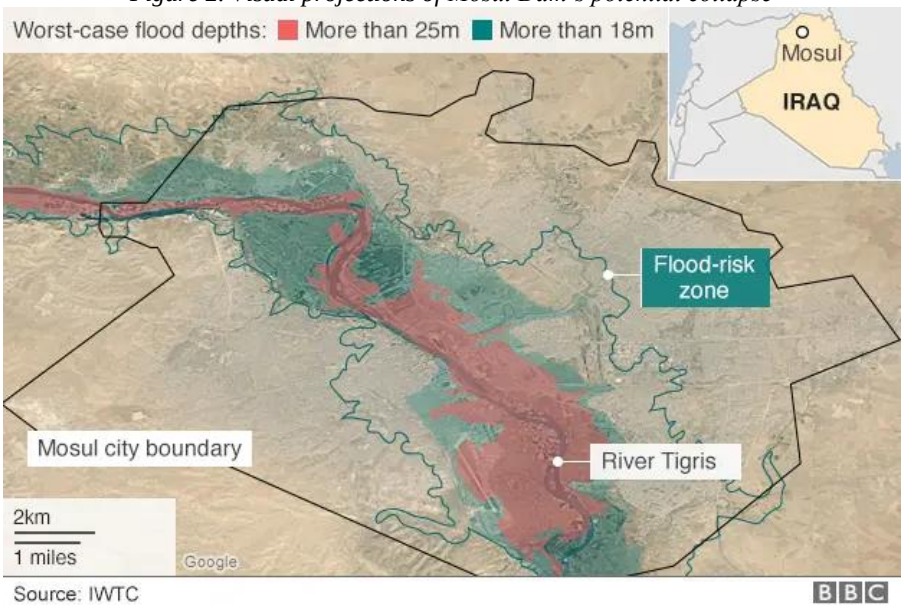
As reported in Table 3, a possible dam collapse would have repercussions throughout the whole country and not just in the northern territories. The lower part of Table 3 provides an estimate of the time for the arrival of the first volume of water, the projection of maximum height (which, in general, has a considerable delay of at least a several hours concerning the first wave) and the maximum water height in meters. Based on these projections, it is essential to note that Mosul, the largest and most important city in northern Iraq, would suffer the most devastating consequences within hours of the collapse of the structure. As pointed out by several scholars (Sissakian et al. 2014; Husain, 2021; Adamo et al. 2017; Annunziato et al. 2016), the city is built on either side of Tigris, with densely inhabited areas close to the river. As a result, a huge number of people would be exposed to prodigious peaks of floodwater. Specifically, approximately 183 000 people, more than 10% of the city's population of 1.7 million, would be affected by more than 10m wave height, which could entail catastrophic destruction. In addition, as Annunziato (2016) argued, the warning time would be very short; even if a dam breach is signaled immediately, within 3 hours, the water height in Mosul would have already reached close to 20m.

In the event of a dam's collapse, significant damage and loss of life should also be expected in other cities along the river, with very high-water levels exceeding 10 meters. Concerning Baghdad, projections have calculated heights of up to 8 meters; the average value in the Baghdad metropolitan area, however, is rather lower, around 2 meters. More than 1 million people would be exposed to depths of between 2 and 5 meters. What is worrying in this case, as can be seen in the height-time section in the lower part of Table 3, is that floodwaters take much longer to drain from the Baghdad area due to the flat morphology of the land. In the event of a dam collapse, the wave caused by the release of water would also reach the southern city of Basra, about 800 km away from Mosul, with a much lower destructive potential (Sissakian et al. 2014).

Table 3. Estimates of the damage caused by the collapse of the dam on the main northern Iraqi cities and Baghdad (Adamo et al. 2017; Annunziato et al. 2016)

Inundation	Mosul	Bayji	Tikrit	Samarra	Bagdad
0.1-0.5 m	21 000	0	0	0	746 000
0.5-2.0 m	55 000	300	100	3 000	2 949 000
2-5 m	41 000	400	2 500	100	1 134 000
5-10 m	60 000	17 000	14 000	5 500	26 000
Over 10 m	183 000	2 000	4 000	3 500	0
First wave arrival	1h 40 min	16h	21h	25h	67h
Max wave arrival	6h	23h	27h	31h	4-5 days
Max wave height	26 m	14 m	14.5 m	16 m	8 m

Figure 2. Visual projections of Mosul Dam's potential collapse



Data courtesy of the BBC. Accessed August 29, 2024.
https://www.bbc.com/news/world-middle-east-35351888.

In response to the catastrophic projections regarding the potential collapse of the MD, a solution may consist in the resumption of construction of the downstream unfinished Badush Dam. The latter has a history intertwined with the broader context of Iraq's water management efforts and the safety concerns surrounding the MD, which is located approximately 15 kilometres upstream. This relatively short distance emphasizes the strategic role of the Badush Dam as a secondary barrier to control and mitigate the effects of a potential failure of the MD (Sissakian et al. 2018). After its completion in 1984, the structural vulnerabilities of the MD propelled the Iraqi establishment to conceive alternative solutions to provide a secondary line of defence in case of failure. As a result, construction of another water facility - the Badush Dam - began in 1988. It was designed primarily as a flood control dam, intended, as mentioned, to mitigate the impact of a potentially catastrophic failure of the MD. However, the Badush Dam was also planned to generate hydroelectric power and provide water for irrigation (Sissakian et al. 2018; Adamo et al. 2017).

Despite its relevance, the construction of the Badush Dam was interrupted in 1991 due to the Gulf War. The subsequent years of sanctions and political instability in Iraq further delayed the completion of the dam, which was resumed in 2003, only to be interrupted again due to a lack of funds (Al-Muslih and Al-Ansary 2013). Currently, the Badush Dam remains incomplete. Financial constraints, security issues, and political instability have hampered efforts to complete the dam. However, it continues to be considered a critical project for Iraq's water management and disaster mitigation strategy (Sissakian et al. 2018; Al-Muslih and Al-Ansary 2013).

Figure 3. The Badush Dam in relation to the MD and Mosul city (Saeedrashed and Benim 2018: 1-6)

Figure 4. The Badush Dam abandoned construction site

Data courtesy of Wikimapia. Accessed August 29, 2024.
https://wikimapia.org/29926635/Badush-Dam-construction-site.

The Mosul Dam under ISIS' control

The complex situation of the MD from a structural standpoint has been a severe problem since the very beginning of its construction. In fact, as previously analysed, the MD is one of the most strategic infrastructures in the Middle East and was built on unstable foundations that require constant and immediate maintenance by highly specialised experts. In the event of a lack of maintenance, the likelihood of the dam's structural failure is very high. Continuous and constant maintenance is not just important, it is indispensable for any mega dam, as these complex infrastructures always require special attention. However, in the case of the MD, given its precarious foundations due to the peculiar geological characteristics of the soil on which it was built, structural maintenance through grouting is indispensable.

The precarious foundations of the MD attracted significant international attention when the infrastructure came under the control of ISIS. In early August 2014, the Islamist militants launched an offensive to capture the dam, and on August 7th, after overpowering the defending Kurdish Peshmerga forces, they seized control of the water facility (Al-Ansari et al. 2015). The capture of the MD had several prominent implications. First, the control of the dam provided ISIS with a powerful bargaining chip. The potential to use the dam as a tool of warfare by either destroying it or manipulating water flow posed a severe threat to Iraqi national security and regional stability. In addition, the possibility of a dam breach created an immediate humanitarian crisis, prompting mass evacuations and heightened anxiety among downstream populations. As examined, the potential flooding could have resulted in

widespread loss of life and extensive infrastructural damage (Al-Abayachi 2016; Adamo et al. 2017; Annunziato et al. 2016).

The control exercised by ISIS militants over the MD did not last long. In mid-August 2014, a coalition of Kurdish Peshmerga forces and Iraqi troops, backed by U.S. airstrikes, launched a counter-offensive to retake the MD. After intense fighting, the coalition forces managed to reclaim the dam by August 18th (Adamo et al. 2017). Therefore, the dam remained under the control of Islamist forces for only 11 days. During this short period of time, the infrastructure received no maintenance and grouting was discontinued. Following the recapture, immediate efforts were made to stabilize and secure the dam. With international assistance, the Iraqi government resumed grouting and maintenance operations to address the structural vulnerabilities exacerbated by the period of neglect (Al-Ansari et al. 2015). As a result, the USACE and the Italian engineering firm Trevi SPA were contracted to provide technical support and ensure the dam's safety.

Trevi's intervention

The contract between Iraq and Trevi was signed in early March 2016 (Trevi Foundation 2018; USACE 2017). The GoI assigned the roles of engineer and Contract Administrator to the USACE, which has been monitoring the MD since May 2015. To accomplish its tasks of monitoring and supervising the activity before Trevi was awarded the contract by the GoI approximately 70 engineers were deployed from the USA (USACE 2017). The contract awarded to Trevi, amounting to Euro 273M, envisioned six months for mobilization site installation and twelve months of drilling and grouting works. Along with the maintenance grouting, Trevi was awarded with the training of the owner's personnel and rehabilitation of the bottom outlet tunnels (i.e. guard gates and intake bulkheads) through electromechanical works and diving operations (Trevi Foundation 2018; Milillo et al. 2016; Sissakian et al. 2018).

Trevi's activities concerned the resumption of the grouting technique with an innovative approach and the use of remote-control technology capable of assessing the structural risks of the dam in real time. Regarding the first activity, the grouting works carried out by Trevi foresaw the execution of a double grout curtain line along the dam axis, from both the grouting gallery and the crest (between the spillway and fuse plug), and a single grout curtain line along the eastern side of the spillway (from grout lines on the crest to the river). Multipurpose drilling rigs for specific drilling techniques and space constraints were deployed (Trevi Foundation 2018). Two diesel crawler-mounted SOILMEC SM-16 units and six electric crawler-mounted SOILMEC SM-5 units were selected and mobilized for the drilling works in the crest and grouting gallery, respectively. The grout holes executed from the crest/surface required drilling through the dam's embankment and clay core. For this specific scope, the SOILMEC SM-16 was equipped with a powerful double rotary, allowing the dry encasement of the embankment while advancing the borehole with auger strings down to the bedrock (Trevi Foundation 2018).

Figure 5. Trevi's engineers working at MD's project

Data courtesy of the Trevi Foundation. Accessed August 29, 2024.
https://www.trevispa.com/it/

Concerning the second activity, Trevi developed a T-Grout system, where "T" stands for "Trevi", which is a computer-automated web application allowing the remote management of grouting activities. It is a standalone software that also allows offline management and provides daily charts, information about stages and boreholes completed, volumes, solid takes and pressures. According to the company (Trevi Foundation 2018), T-Grout can remotely manage and operate the grouting pumps from a Control Room. The T-Grout system stores raw data into a relational database every second of grouting operations.

Through Trevi's work and the techniques used in trying to make the infrastructure more stable, the dam is now fully operational and safe. During the months of activity, the Trevi workforce reached a peak of more than 700 units, with Italian management and supervision, third-country national staff and local personnel. According to the company (Trevi Foundation 2018), through June 2018, with 24/6 operations, Trevi completed 295 000 linear meters of grouted boreholes, injecting an equivalent to 25 353 tons of solids into the ground. The work carried out by the engineers involved in the renovation of the dam was characterized by significant logistical difficulties. Trevi commenced the works with the war conflict against ISIS at 13Km from the dam (Gerges 2016; Trevi Foundation 2018). The presence of the Coalition Forces, together with the Italian Army, guaranteed the required security of the Project Area. In 2018, as a reward for the technical reliability of the activity, carried out under pressure and not optimal conditions, the government of Iraq awarded Trevi with an additional 11 months of maintenance grouting works.

Discussion

The dam rehabilitation and safety activities carried out by Trevi, supported by the technical and technological expertise of USACE, have effectively brought improvements to the MD. In this regard, the water infrastructure has undergone significant structural improvements in the grouting technique and the predictive

analysis of potential holes using T-Grout software. As proof of this, the Iraqi government not only extended the contract with Trevi for the supervision of the dam for 11 months but also asked the Italian company to provide support in training the local engineers involved in maintaining the dam. Therefore, from a technical and structural standpoint, the joint activities of Trevi and USACE were successful.

However, despite the clearly positive impact of the international engineering team in renovating the Mosul Dam, the perception of this infrastructure in the Iraqi and Middle Eastern context is still overwhelmingly negative. As mentioned, notwistanding the extensive and costly maintenance work that has been carried out recently, the granitic negative perception of this dam over time still prevails. As reported by numerous scholars who have documented with quantitative analyses following Trevi's intervention (Sissakian et al. 2018; Sissakian et al. 2020; Hmaza and Msaewe 2023; Agha and Khattab 2023), it seems that the MD is destined to collapse in any case, entailing dire consequences for the populations living downstream.

To understand the reasons behind the MD's negative perception, it is essential to look at it through the lens of Constructivist Ecologism. The latter, which derives from the broader theoretical framework of Constructivism, provides a robust theoretical tool for understanding how the perception of reality shapes and is shaped by our efforts to decipher it, especially regarding environmental issues linked with quantitative methods. In the MD case, deciphering the perception around the dam is a complex matter. As extensively documented, the water infrastructure was built on an unsuitable site due to karstic soil characteristics that did not meet the standards required to support the dam's foundations. This fact, which is incontrovertible and not subject to any kind of interpretation, has laid the foundations for the spread of a very negative, alarmist and pessimistic narrative around the dam. In this regard, following the numerous articles that have been produced over time on the structural deficits of the dam, it would be appropriate to ask ourselves how it is possible that the dam, after almost 40 years of structural deficiencies, is still standing. In fact, in addition to the already highlighted serious structural problems, the MD has had a very eventful past.

During the First Gulf War, the MD was bombed multiple times as part of the strategic air campaign led by coalition forces. The primary objective of these bombings was to disable Iraq's ability to control water resources, which were seen as critical to both military and civilian infrastructure (Chin 2019; McMahan and McKim 1993). Specifically, the U.S. and its allies targeted the dam due to its importance in providing water and electricity to a large part of Iraq. The dam's destruction would have had significant downstream effects, potentially causing the already examined widespread flooding and disrupting the Iraqi military's logistical operations. As Fappiano and Baraniuk (2020) pointed out, the attacks on the dam were part of a broader strategy to weaken Saddam Hussein's control over vital infrastructure, thereby hastening the end of the conflict. However, despite the multiple bombings, the dam resisted (Chin 2019; McMahan and McKim 1993).

Furthermore, in addition to the bombings, maintaining the MD after the First Gulf War was fraught with difficulties, primarily due to the international sanctions imposed on Iraq. These sanctions, which were intended to limit Iraq's ability to rebuild its military capabilities, had severe repercussions on the country's infrastructure, including

essential maintenance operations for critical structures like the MD. As Chin (2019) and Adamo (2017) documented, the sanctions regime severely restricted Iraq's ability to import the necessary spare parts and equipment for the dam's upkeep. Critical machinery and technology needed for routine maintenance and emergency repairs became increasingly difficult to obtain, leading to a gradual degradation of the dam's operational efficiency. Essentially, the sanctions crippled Iraq's economy, drastically reducing the funds available for infrastructure maintenance. The Iraqi government prioritized immediate humanitarian needs over infrastructure, leading to underfunded and neglected maintenance programs for the MD which, as examined, necessitates constant attention (Pearce 2014). It is paramount to highlight that the sanctions also affected the ability of Iraqi engineers and local technical workers to receive training or collaborate with international experts. The lack of updated technical knowledge and reduced opportunities for capacity building further hindered effective maintenance efforts concerning the MD (Adamo et al. 2017).

Thus, in addition to the structural problems, since the 1990s the dam has faced phases of considerable difficulty due to both wartime actions and the lack of funds necessary to guarantee its maintenance. Even after the second Gulf War, the situation did not change. The lack of funds prevented renovations that could secure the water infrastructure. These circumstances of constant uncertainty, imminent danger and catastrophe crystallised the negative perception of the dam. Why has the narrative about the MD not changed over the years?

From the constructivist ecologist perspective, the MD is not merely a concrete and steel structure, but a dynamic entity deeply intertwined with the region's social, cultural, and ecological fabric. As Peet et al. (2010) and Sessions (1995) pointed out, constructive ecologism suggests that perception and reality are mutually constitutive. Perception is shaped by the immediate affordances of the environment, which are themselves influenced by the perceiver's prior knowledge and experiences. This dynamic interaction means that reality is deciphered through a continuous feedback loop: perception informs action, and action, in turn, refines perception. In this regard, the negative perception of the dam, which has been spread on a quantitative basis for many years, has fuelled a view of reality that does not correspond to the truth. Indeed, even from a quantitative standpoint, the negative portrayal of the MD does not correspond to reality. In fact, especially following the renovation works carried out between 2016 and 2018, the infrastructure is not just safer, but has also been equipped with advanced technological instruments capable of predicting potential structural failures before they can jeopardise the foundations of the whole infrastructure, providing a sense of reassurance which is seldom taken into consideration.

Through the lens of constructive ecologism, we can appreciate that deciphering the reality surrounding the MD is an active, dynamic process that involves multiple observations from multiple points of view. As mentioned, the hitherto dominant approach has been epistemologically and intrinsically negative, accompanied by an equally negative narrative and representation of events and reality. Specifically, this negative narrative can be traced in the language associated with the description of the dam issues. For instance, Annunziato (2016) repeatedly uses future tense in connection with the projections of the disasters caused by the giant wave in the event of a collapse:

"Moreover, a very significant surface area will be inundated, with subsequent destruction of critical infrastructure, houses, crops and all livelihood" (Annunziato 2016, 14)". "(...) a very large number of people will be exposed to prodigious heights of floodwater" (Annunziato 2016, 16). This approach, based on the conceptual certainty that an event will occur, implies an almost mathematical certainty that the collapse of the MD is inevitable. Similarly, Nasrat Adamo also adopts this narrative approach. For instance, in one of his numerous articles, he underlines that the maintenance grouting is not a permanent solution and that the only answer for solving the MD case would be: "the resumption of construction of the unfinished downstream Badush Dam" (Adamo et al. 2017, 272). By recommending this solution, Nasrat Adamo almost takes it for granted that the dam will collapse sooner or later without considering the potential positive impact of renovation works on the management of one of the largest dams in the Middle East.

Results

The negative perception surrounding the MD is still deeply crystallised in the region. This situation has hitherto prevented to acknowledge the several positive aspects that have resulted from the maintenance and renovation activities carried out by Trevi from a hydro-strategic standpoint. In fact, in addition to the infrastructural improvements and personnel training that have significantly improved the structural conditions of the dam, from a water cooperation perspective, important agreements involving various players have been reached.

Water cooperation on a local level

On a local basis, it is crucial to highlight the collaboration between the Kurds and the Iraqis in managing the MD following the maintenance contract awarded to Trevi. This partnership became especially significant following the turmoil and security challenges posed by ISIS. The Kurdish-Iraqi collaboration manifested itself in two variants: military cooperation and civil-engineering joint activities. From a military standpoint, the recapture of the MD from ISIS in August 2014 was a significant operation that showcased the collaboration between Kurdish Peshmerga forces and the Iraqi Army. As mentioned, this joint effort, which was supported by U.S. airstrikes, was essential in preventing ISIS from using the dam as a weapon of mass destruction (Tinti 2023). In addition, after the liberation from ISIS, the continued stability and security of the dam have necessitated ongoing cooperation between Kurdish and Iraqi forces. This collaboration was extended to ensuring that the dam's infrastructure is adequately protected from potential sabotage and that maintenance operations can be carried out safely (Tinti 2023).

From a civil engineering standpoint, nowadays, the technical management of the dam involves engineers and specialists from both Kurdish and Iraqi backgrounds (Trevi Foundation 2018; USACE 2017). These teams work together to address the dam's persistent structural issues, such as the need for continuous grouting to stabilize

its gypsum foundation. Trevi's activity fostered technical cooperation between the Kurdish and Iraqi components to train local experts to replace Italian engineers.

The military and technical cooperation between Kurds and Iraqis on the MD is a highly significant achievement, especially given the recent past of hatred and persecution between these two peoples. From being inherently rivals, the two segments of Iraqi society are now actively involved in a strategic project as important as the management and security of the MD. In this regard, the management of the water facility requires a high level of political coordination between the Kurdistan Regional Government (KRG) and the central Iraqi government. This coordination is vital for securing funding, implementing maintenance projects, and managing the dam's operations in a way that benefits all communities relying on its resources (Pearce 2014; Tinti 2023). The hydro-strategic cooperation between Kurds and Iraqis around the MD represents a very significant step forward in the normalisation of relations between these two communities.

Water cooperation on a trans-regional level

From a trans-regional standpoint, water cooperation between Iraq and Italy has brought these two countries diplomatically closer. In fact, the collaboration between Rome and Baghdad following the MD renovation has expanded beyond water management into broader political and economic spheres. This partnership reflects a strategic effort by both countries to leverage their cooperation on infrastructure to enhance bilateral relations and mutual economic benefits. The diplomatic rapprochement between Rome and Baghdad and the success of the work carried out by Trevi inaugurated a new phase in the management of trade relations between the two nations. In this regard, Italian companies have shown interest in participating in Iraq's broader reconstruction efforts beyond the MD. This includes infrastructure projects such as roads, bridges, and public buildings. As reported by Tinti (2023), Italian expertise in engineering and construction is highly valued in Iraq's post-conflict rebuilding phase. Moreover, following the joint management of the MD, economic cooperation has also seen an increase in bilateral trade and investment. Nowadays, Italian firms are exploring opportunities in various sectors, including energy, agriculture, and manufacturing. Iraq, in turn, benefits from Italian technology and expertise, which are critical for its economic diversification and development goals (Tercovich 2016).

In addition to the diplomatic partnership and increased commercial exchanges, the successful collaboration on the MD renovation has paved the way for enhanced military cooperation between Italy and Iraq (Coticchia and Ruggeri 2022). This partnership has evolved to address various security challenges and strengthen Iraq's defence capabilities through joint efforts in training, strategic support, and mission command. Notably, Italy has played a pivotal role in NATO Mission Iraq (NMI), a non-combat training and advisory mission of strategic importance that aims to build the capacity of Iraqi security forces (Tercovich 2016). Following the MD project, Italy's involvement has increased, with Italian military personnel providing training in various domains, including counterterrorism, bomb disposal, and military engineering. This training is crucial for enhancing the operational capabilities of the Iraqi army and

police forces (Tinti 2023; Coticchia and Ruggeri 2022). Similarly, Italy has supplied Iraq with military equipment and technology to support its defence needs. This includes vehicles, communication systems, and other tactical gear essential for modernizing the Iraqi military. The provision of such equipment is part of broader defence cooperation agreements aimed at enhancing Iraq's self-reliance in defence (Howard and Dayal 2018).

Military cooperation between Italy and Iraq has had significant local impacts, especially in relation to the Kurdish Regional Government (KRG). Italy's strategic role in training the Kurdish Peshmerga forces, which were crucial in the fight against ISIS and in maintaining regional security in Northern Iraq, cannot be overstated. As highlighted by Tinti (2023) and Coticchia and Ruggeri (2022), Italian military trainers have provided comprehensive training programs focusing on counterterrorism, urban warfare, and advanced military tactics. These programs were meticulously designed to enhance the operational effectiveness of the Peshmerga and ensure they were well-equipped to handle various security challenges. The success of the MD project stands as a testament to the effectiveness of this collaboration. Following this achievement, high-level consultations between Italian and Kurdish officials have become a regular feature of their collaboration. These dialogues focus on assessing security needs, planning joint exercises, and discussing long-term strategies for regional stability (Coticchia and Ruggeri 2022).

The military collaboration between Italy and Iraq, following their successful cooperation on the MD, underscores a robust partnership aimed at enhancing Iraq's security and stability. Through training, strategic support, provision of equipment, and high-level dialogues, Italy continues to play a pivotal role in strengthening Iraq's defence capabilities and ensuring regional security. This comprehensive military partnership reflects the deepening ties between the two nations and their commitment to addressing mutual security challenges.

Water cooperation on a global level

Finally, the collaboration between Italy and the US Government has deepened significantly following their joint efforts to renovate and stabilise the MD. This cooperation has expanded into various strategic, military, and technical domains, reflecting a robust partnership to enhance regional security and rebuild critical infrastructure in Iraq. From a military standpoint, the two countries have conducted combined military operations to combat ISIS remnants in Iraq (Tinti, 2023). These operations involved intelligence sharing, strategic planning, and logistical support. The collaborative military efforts aimed to disrupt terrorist networks and prevent their resurgence, ensuring the security of critical infrastructures, including the MD. The Italian soldiers sent from Rome to protect the Trevi engineers working a few kilometres from the front received considerable support from the American forces, who were also engaged in securing the region (Coticchia and Ruggeri 2022).

From a technical perspective, the collaboration between Italy and the United States has been very close. Trevi Group, which, as mentioned, was renowned for its specialized ground engineering capabilities, brought advanced grouting techniques to

the project. USACE, on the other hand, provided critical oversight and technical support, leveraging its extensive experience in managing large-scale infrastructure projects. USACE engineers worked alongside Trevi experts to design and implement the grouting strategy, ensuring it met the necessary safety and effectiveness standards. One of the significant contributions from the USACE was the implementation of advanced monitoring systems to continuously assess the dam's structural health (USACE 2017). These systems included piezometers, inclinometers, and automated data logging equipment to monitor water pressure, movement, and other critical parameters in real time. Trevi Group integrated these monitoring systems with their ongoing grouting operations.

The real-time data provided by USACE's monitoring equipment allowed Trevi engineers to make informed decisions on where to focus their grouting efforts, optimizing the repair process and enhancing the dam's stability (Trevi Foundation 2018; USACE 2017). The technological collaboration between the Trevi Group and the USACE was instrumental in the successful renovation of the MD. Combining Trevi's advanced grouting techniques and USACE's monitoring and technical oversight ensured that the dam's structural integrity was restored and maintained. This partnership not only addressed immediate safety concerns but also established a framework for ongoing maintenance and capacity building, contributing to the long-term stability and safety of the MD.

The collaboration between Italy and the U.S. Government after the MD project exemplified a comprehensive partnership between two key NATO allies to ensure regional security and rebuild critical infrastructure in Iraq. Through joint military training, combined operations, technical assistance, and high-level strategic dialogues, both nations demonstrated their commitment to stabilizing Iraq and supporting its long-term development. This multifaceted cooperation showed the importance of international partnerships in addressing complex challenges in the Middle East.

Conclusion and discussion

The MD has been a cornerstone for the development and prosperity of northern Iraq. Its multifaceted benefits have not only supported economic growth and environmental sustainability but also improved the quality of life for the people in the region. The positive aspects of this significant infrastructure are manifold and cover many areas. The dam, in fact, besides playing a crucial role in providing water for irrigation in an arid country such as Iraq, ensures a reliable supply of potable water to the surrounding communities, improving overall living conditions and public health not only on a national level. In addition, the dam helps regulate the flow of the Tigris River, is a significant source of hydroelectric power and helps reduce Iraq's consumption of fossil fuels.

However, despite the multiple benefits, the dam is still associated with a strongly negative narrative that conditions the perception of reality. The karst foundations of the infrastructure are undoubtedly a complex structural problem and a critical fact. The karstification of the foundations and the fragility of the land on which the dam was built are factors that cannot be modified, and which represent - and will represent - a

constant problem for the structural stability of the dam. Nonetheless, today's engineering technologies allow the situation to be monitored much more efficiently than in the past and guarantee the resolution of problems promptly. In this regard, the work carried out by Trevi with the supervision of USACE has made the dam much safer by limiting potential catastrophic structural failures and extending its lifespan by many years.

Like the friability of its foundations, the structural improvement of the dam following the renovation work is also a fact. However, while a negative narrative of the dam has emerged due to the dangerousness of the foundations, after the structural improvement works, equally positive representations of the reality surrounding the dam have not emerged. This is because the MD still remains "captive" to a strongly negative conception that prevents the perception of reality from being distanced from reality itself. Furthermore, given that the dam has significant structural deficiencies, there are currently no alternative solutions to improving the existing infrastructure. The project to resume work on Badush Dam to build a defence barrier in the event of a collapse of the MD was halted in the late 1980s and never resumed due to lack of funds. Moreover, the demolition of the MD and the construction of an alternative infrastructure with more solid and secure foundations has never been seriously considered, given the prohibitive costs of this operation for the Iraqi government and because of the environmental and social inconvenience that dismantling the current dam would cause.

Over time, the negative perception of the MD has become so entrenched that it has prevented the work on its maintenance from being appreciated not only from a technical-structural standpoint but also in relation to hydro-strategic cooperation. The collaboration between Kurds and Iraqis for the defence and maintenance of the dam, the friendly diplomatic relations between Iraq and Italy, and the close relationship between Rome and Washington for the exchange of sensitive data are three significant achievements that deserve to be underlined. In an arid and desert region such as the Middle East, where water and water infrastructure management are often a source of conflict, the MD has been a paramount example of hydro-strategic cooperation with results on many levels. Considering such positive effects on cooperation between peoples, nations and organisations, the MD should be portrayed with an alternative narrative to the classical one, which defines it as inherently and atavistically dangerous. On the contrary, following the recent developments, the dam is an infrastructure that has had enormous positive impacts not only in regulating water flows, limiting floods and producing hydro-electric power but also in spreading a paradigm of hydro-strategic cooperation involving multiple actors with local, national and international results.

Supplementary material

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The author affirms this research did not involve human subjects.

References

Adamo, Nasrat, and Nadhir Al-Ansari. 2016. "Mosul dam the full story: Engineering problems." *Journal of Earth Sciences and Geotechnical Engineering* 6 (3): 213-244.

Adamo, Nasrat, Nadhir Al-Ansari, Sven Knutsson, et al. 2017. "Mosul Dam: A Catastrophe Yet to Unfold." *Engineering* 9 (3): 263-278. https://doi.org/10.4236/eng.2017.93014.

Al-Abayachi, Shirouk. 2016. Report on Mosul Dam, Iraqi House of Representatives. Agriculture, water, and Marshes Sub-Committee. Baghdad.

Al-Ansari, Nadhir, Nasrat Adamo, Issa E. Issa, Varoujan Sissakian, and Sven Knutsson. 2015. "Mystery of Mosul Dam the Most Dangerous Dam in the World: Karstification and Sinkholes." *Journal of Earth Sciences and Geotechnical Engineering* 5 (3): 33-45.

Al-Muslih, Shehla S.Z., and Nadhir A. Al-Ansary. 2013. "Hydrological and Hydrochemical Situation of Badush Dam Site, Central North of Iraq for the Period between 1988-1990." *Iraqi Bulletin of Geological Mining* 9 (1): 35-51.

Annunziato, Alessandro, Ioannis Andredakis, and Pamela Probst. 2016. "Impact of Flood by a Possible Failure of the Mosul Dam." EU Commission: Joint Research Centre: Institute for the Protection and Security of the Citizen. https://doi.org/10.2788/689469.

Chin, Warren. 2019. "Technology, war and the state: past, present and future." *International Affairs* 95(4): 765-783. https://doi.org/10.1093/ia/iiz106.

Coticchia, Fabrizio, and Andrea Ruggeri. 2022. "An International Peacekeeper. The Evolution of Italian Foreign and Defence Policy." *IAI - Istituto Affari Internazionali* 22 (6): 1-21.

Dryzek, John S. 2013. The Politics of the Earth: Environmental Discourses. Oxford University Press.

Fappiano, Cayla M., and James N. Baraniuk. 2020. "Gulf War Illness Symptom Severity and Onset: A Cross-Sectional Survey." *Military Medicine* 185 (7-8): e1120-e1127. https://doi.org/10.1093/milmed/usz471.

Fosnot, Catherine T. 2013. Constructivism: Theory, Perspectives, and Practice. New York: Teachers College Press.

Gerges, Fawaz A. 2016. ISIS: A History. Princeton, NJ: Princeton University Press.

Hmaza, H. H., and Hussein Alwan Mahdi Msaewe. 2023. "Investigation of the deformations in Mosul dam by geodetic measurements of total stations and GNSSs." *AIP Conference Proceedings* 2787 (1): 1-15. https://doi.org/10.1063/5.0148327.

Howard, Lise Morjé, and Anjali Kaushlesh Dayal. 2018. "The use of force in UN peacekeeping." *International Organization* 72 (1): 71-103. https://doi.org/10.1017/S0020818317000431.

Husain, Faisal H. 2021. Rivers of the Sultan: The Tigris and Euphrates in the Ottoman Empire. New York: Oxford University Press.

Kelley, Julie R., Lillian D. Wakeley, Seth W. Broadfoot, et al. 2007. Geologic Setting of Mosul Dam and Its Engineering Implications. Final Report, U.S. Army Engineer District, Gulf Region, Baghdad.

Mahmood Agha, Omar M. A., and Mohammed A. Khattab. 2023. "The impact of Ilisu Dam on water flow toward Iraq and identifying the optimal operational strategy for Mosul Dam. Sustain." *Sustainable Water Resources Management* 9 (112). https://doi.org/10.1007/s40899-023-00889-0.

McMahan, Jeff, and Robert McKim. 1993. "The Just War and The Gulf War." *Canadian Journal of Philosophy* 23 (4): 501-541. https://doi.org/10.1080/00455091.1993.10717333.

Merchant, Carolyn. 2005. Radical Ecology: The Search for a Livable World. NY: Routledge. https://doi.org/10.4324/9780203084212.

Milillo, Pietro, Roland Bürgmann, Paul Lundgren, et. al. 2016. "Space Geodetic Monitoring of Engineered Structures: The ongoing Destabilization of the Mosul Dam, Iraq." *Scientific Reports* 6: 37408. https://doi.org/10.1038/srep37408.

Naess, Arne. 1989. Ecology, Community, and Lifestyle: Outline of an Ecosophy. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511525599.

Obertreis, Julia, Timothy Moss, Peter Mollinga, and Christine Bichsel. 2016. "Water, infrastructure and political rule." *Water Alternatives* 9 (2): 168-181. https://doi.org/10.18452/21560.

Pearce, Fred. 2014. "Mideast Water Wars: In Iraq, A Battle for Control of Water." *Yale environment 360, August 25, 2014*. Accessed August 29, 2024. https://e360.yale.edu/features/mideast_water_wars_in_iraq_a_battle_for_control_of_water.

Peet, Richard, Paul Robbins, and Michael Watts (eds.). 2010. *Global Political Ecology*. Routledge. https://doi.org/10.4324/9780203842249.

Saeedrashed, Younis S., and Ali Cemal Benim. 2018. "A computational investigation of the hydrodynamics of the Badush dam in northern Iraq." *MATEC Web of Conferences* 240. 04009: 1-6. https://doi.org/10.1051/matecconf/201824004009.

Sessions, George (ed.). 1995. *Deep Ecology for the Twenty-First Century*. Shambhala.

Sissakian, Varoujan K., Nadhir Al-Ansari, and Sven Knutsson. 2014. "Karstification Effect on the Stability of Mosul Dam and Its Assessment, North Iraq." *Engineering* 6: 84-92. https://doi.org/10.4236/eng.2014.62012.

Sissakian, Varoujan K., Nasrat Adamo, and Nadhir Al-Ansari. 2020. "Badush Dam: Planned And Designed As A Protection Dam, Nw Iraq". Journal of Duhok University 23 (2): 31-39. https://doi.org/10.26682/csjuod.2020.23.2.3.

Sissakian, Varoujan K., Nasrat Adamo, and Nadhir Al-Ansari. 2020. "The Role of Geological Investigations for Dam Siting: Mosul Dam a Case Study." *Geotechnical and Geological Engineering* 38: 2085-2096. https://doi.org/10.1007/s10706-019-01150-2.

Sissakian, Varoujan K., Nasrat Adamo, Nadhir Al-Ansari, Sven Knutsson, and Jan Laue. 2018. "Badush Dam, NW Iraq: A Geological Study." *Journal of Earth Sciences and Geotechnical Engineering* 8 (2): 1-15.

Tercovich, Giulia. 2016. "Italy and UN Peacekeeping: Constant Transformation." *International Peacekeeping* 23 (5): 681-701. http://dx.doi.org/10.1080/13533312.2016.1235094.

Tinti, Alessandro. 2023. "Scales of justice. Large dams and water rights in the Tigris–Euphrates basin." Policy and Society 42 (2): 184-196. https://doi.org/10.1093/polsoc/puad003.

Trevi Foundation. 2018. "Trevi's Challenge in Iraq: Mosul Dam." Accessed August 29, 2024. https://www.soilmec.com/downloads/5245/684/FoundationDrillin_-Oct2018.pdf.

USACE. 2017. Engineering Manual EM 1110-2-3506 Engineering and Design: Grouting Technology. Washington, DC: U.S. Army Corps of Engineers. Accessed August 29, 2024. https://www.publications.usace.army.mil/Portals/76/Publications/-EngineerManuals/EM_1110-2-3506.pdf.

Warren, John K. 2006. Evaporites: Sediments, Resources and Hydrocarbons. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-32344-9.