# **Damming Effects on Downstream Discharge Changes of the Tigris and Euphrates Rivers: A Systematic Literature Review**

**1. Introduction**

The Tigris and Euphrates river basins represent a historically and ecologically significant region in the Middle East. Originating in the highlands of eastern Turkey, these two rivers traverse through Syria and Iraq before converging and emptying into the Persian Gulf, forming a vital artery of water in an otherwise arid and semi-arid landscape (Al-Ansari & Knutsson, 2011; Evans, 2021; Kibaroglu & Scheumann, 2013; Zargar & Abbasi Alamooti, 2023). For millennia, the basins have supported thriving civilizations through agriculture, provided essential water supplies for human consumption, and sustained diverse ecosystems adapted to the unique hydrological conditions of the region (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Zargar & Abbasi Alamooti, 2023). In recent decades, however, this vital water resource has come under increasing pressure due to extensive damming projects in the upper reaches, most notably by the Turkish government.

The Turkish government initiated the Southeastern Anatolia Project (Güneydoğu Anadolu Projesi, GAP), a large-scale, multifaceted regional development project that includes the construction of 22 dams and 19 hydroelectric power plants across both the Euphrates and Tigris river basins (Al-Ansari & Knutsson, 2011; Aygun et al., 2013; Hussein et al., 2020; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992; Savethetigris, 2015; UN-ESCWA & BGR, 2013; Zargar & Abbasi Alamooti, 2023). Key dams within this ambitious project include the Atatürk Dam on the Euphrates and the Ilisu Dam on the Tigris, both of which possess significant water storage capacities and hydroelectric power generation potential (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992). While Turkey has emphasized the benefits of these projects for energy production, irrigation, and flood control within its borders, the large scale of these interventions has raised substantial concerns among downstream riparian nations, namely Syria and Iraq, regarding the availability and quality of water resources (Beaumont, 1995; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). It is also important to acknowledge that Syria and Iran have also undertaken dam construction projects within the basin, which may contribute to the overall changes in downstream discharge (Beaumont, 1995; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

This report aims to provide a deep and systematic analysis of the peer-reviewed literature concerning the effects of damming projects, primarily those undertaken by Turkey, on the downstream discharge changes of the Tigris and Euphrates rivers in Syria and Iraq. The objective is to synthesize the key findings from a wide range of scholarly sources, to elucidate the methodologies employed in these studies, and to critically evaluate the limitations inherent in the existing body of research. By examining these aspects, this review seeks to offer a comprehensive understanding of how damming has altered the flow regimes of these crucial transboundary rivers. The structure of this report will first delve into the fundamental hydrological principles governing the impact of dams on river discharge. Subsequently, it will focus on the specific effects of Turkish damming projects on the Tigris and Euphrates rivers. Following this, the methodologies used in the reviewed literature will be detailed, and the limitations of these studies will be evaluated. The report will then synthesize the key findings regarding discharge changes before concluding with a summary of the analysis and suggestions for future research directions.

The Tigris and Euphrates rivers serve as critical water sources in a region characterized by political instability and increasing water scarcity, making the impact of damming a highly sensitive issue with significant geopolitical ramifications (Cascades, 2021; ERF, 2021; ERF, 2021; Hasan et al., 2019; Kibaroglu, 2014; Kibaroglu & Scheumann, 2013; Menga, 2016; Zargar & Abbasi Alamooti, 2023). The control and management of these rivers are inextricably linked to regional power dynamics and the potential for conflict over diminishing resources. Furthermore, the sheer magnitude of the GAP project, with its extensive network of dams, has been a long-standing point of contention and a source of apprehension for downstream nations for decades, suggesting a protracted history of potential environmental and social consequences (Beaumont, 1995; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013).

**2. Hydrological Principles of Damming Effects on River Discharge**

Dams fundamentally alter the natural flow regime of rivers by acting as physical barriers that impound water, thereby creating reservoirs (Graf, 2006; Petts, 1984; Shiklomanov, 1996). This impoundment inherently disrupts the natural patterns of river flow, leading to what is known as flow regulation (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995). Flow regulation involves the storage of water during periods of high discharge, such as wet seasons or flood events (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995), and the subsequent release of this stored water during periods of low discharge, such as dry seasons or droughts (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995; Wen et al., 2011). The primary aim of this regulation is to meet various human demands, including water supply for domestic and industrial uses, irrigation for agriculture, the generation of hydroelectric power, and the mitigation of flood risks in certain areas (Graf, 2006; Kibaroglu & Scheumann, 2013; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995).

One of the most significant hydrological impacts of dams is the alteration of peak and base flows. Dams typically reduce the peak flood discharge downstream by effectively storing a portion of the floodwaters within the reservoir (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995; Wen et al., 2011). Conversely, during dry seasons, dams can increase the discharge downstream by releasing the water that was stored during wetter periods, which can lead to a more homogenized flow regime throughout the year (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995; Wen et al., 2011). However, the extent to which these changes occur is highly dependent on several factors, including the size of the dam and its reservoir capacity, the specific rules governing the dam's operation (which can prioritize different objectives like hydropower generation or irrigation supply), and the overall water management strategy implemented within the river basin (Graf, 2006).

Furthermore, dams can significantly alter the natural hydrograph of a river. By reducing high flows and augmenting low flows, dams tend to flatten the natural variability of river discharge over time (Graf, 2006; Shiklomanov, 1996). In addition to these seasonal or event-based changes, dams can also introduce unnatural short-term fluctuations in discharge. These rapid changes are often driven by operational needs, particularly in the case of hydroelectric dams where water releases may be adjusted to meet peak demands for electricity (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995). Finally, the timing of naturally occurring high and low flow periods can be substantially altered by damming, which can have significant implications for the ecological cues that many aquatic and riparian species rely upon for various life cycle events, such as migration, spawning, and germination (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995). The fundamental alteration of the natural flow regime by dams represents a shift from a dynamic system characterized by seasonal variability and extremes to a more controlled flow pattern dictated by human needs (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995). While dams are often constructed with the intention of mitigating the destructive impacts of floods, this flood control can inadvertently disrupt ecologically vital natural flooding events that are essential for sustaining downstream ecosystems, such as floodplains and wetlands (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995). Many riverine ecosystems have evolved and adapted to the natural cycle of flooding and drying, and the imposition of a regulated flow regime can have detrimental consequences for their biodiversity and overall health.

**3. Impact of Turkish Damming Projects on the Tigris and Euphrates Rivers**

The Turkish government has implemented a series of substantial damming projects on both the Tigris and Euphrates rivers, primarily under the umbrella of the Southeastern Anatolia Project (GAP). This ambitious initiative encompasses plans for 22 dams and 19 hydroelectric power plants, aiming to foster economic growth in the region (Al-Ansari & Knutsson, 2011; Aygun et al., 2013; Hussein et al., 2020; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992; Savethetigris, 2015; UN-ESCWA & BGR, 2013; Zargar & Abbasi Alamooti, 2023). On the Euphrates River, key dams include the Atatürk Dam, which boasts a significant storage capacity, along with the Keban, Karakaya, Birecik, and Karkamış Dams (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). Similarly, the Tigris River has been subject to extensive damming, with major structures including the Ilisu Dam (the largest on the Tigris in Turkey), the Mosul Dam (located in Iraq but significantly affected by upstream Turkish activities), as well as the Kralkizi, Batman, Dicle, and Devegecidi Dams (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). These projects, along with other smaller dams and water diversion schemes, have collectively exerted a considerable influence on the flow regimes of both rivers.

The peer-reviewed literature provides substantial evidence of downstream discharge changes in Syria and Iraq following the construction and operation of Turkish dams (Al-Ansari & Knutsson, 2011; Beaumont, 1995; ERF, 2021; ERF, 2021; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013; Zargar & Abbasi Alamooti, 2023). Iraq, being the furthest downstream riparian state, has consistently claimed significant reductions in its historical water supply from both the Tigris and Euphrates rivers since the 1970s, coinciding with the intensification of Turkish dam construction. Furthermore, Iraqi officials have expressed concerns that ongoing and planned projects, such as the Ilisu Dam, will exacerbate these water shortages (Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). Studies have documented a notable decrease in the mean daily discharge of the Euphrates River after the construction of major dams in both Turkey and Syria (Issa et al., 2014; Kibaroglu & Scheumann, 2013).

The magnitude of the reported flow reductions is substantial, although estimates can vary across different studies and time periods. For the Euphrates River, reductions of 40% or even greater in discharge have been reported following the completion of major Turkish dams like the Atatürk Dam (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). Similarly, the flow of the Tigris River is anticipated to decrease significantly, potentially by as much as 50% of its historical average, once all planned Turkish dams within the GAP project become fully operational (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). Beyond the overall reduction in water quantity, the seasonal flow patterns of both rivers have also been demonstrably altered. These alterations typically involve a reduction in the magnitude of peak flows that historically occurred during the spring and summer months due to snowmelt and rainfall in the upper catchments. Concurrently, there may be an increase in flows during other times of the year as stored water is released from the reservoirs for purposes such as hydropower generation or irrigation (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013; Wen et al., 2011).

The extensive damming has also led to instances of significant deviations from historical flow norms, including concerns about potential flow cessation in the Euphrates River within Iraq. Some projections suggest that the Euphrates could face the risk of drying up within Iraqi territory by the year 2040, a dire consequence attributed to a combination of upstream damming and the increasing impacts of climate change on regional water availability (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). The reduced water flow, particularly the decrease in seasonal flooding, has had a devastating impact on the vital Iraqi marshes located in the lower reaches of the river basins, leading to their significant destruction and the disruption of the unique ecosystems and livelihoods they once supported (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). Furthermore, there have been accusations leveled against Turkey of utilizing the control over the flow of the Tigris and Euphrates rivers as a political instrument, with instances of reduced or even cut-off flows occurring during periods of heightened political tension or critical water needs in downstream countries (Beaumont, 1995; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013; Zargar & Abbasi Alamooti, 2023).

**Table 1: Major Dams on the Tigris and Euphrates Rivers in Turkey and their Reported Impacts**

| **Dam Name** | **River** | **Reported Impact on Downstream Discharge** | **Source Snippet(s)** |
| --- | --- | --- | --- |
| Atatürk Dam | Euphrates | Significant reduction in flow (estimated at 40% or more) | 1 |
| Keban Dam | Euphrates | Part of GAP, contributes to overall flow reduction | 3 |
| Karakaya Dam | Euphrates | Contributes to flow reduction, led to increased salinity downstream | 2 |
| Birecik Dam | Euphrates | Part of GAP, contributes to overall flow reduction | 3 |
| Karkamış Dam | Euphrates | Part of GAP, contributes to overall flow reduction | 3 |
| Ilisu Dam | Tigris | Expected to significantly reduce flow to Iraq (estimated at 56% reduction of Tigris waters reaching Iraq) | 2 |
| Kralkizi Dam | Tigris | Part of GAP, contributes to overall flow reduction | 16 |
| Batman Dam | Tigris | Part of GAP, contributes to overall flow reduction | 16 |
| Dicle Dam | Tigris | Part of GAP, contributes to overall flow reduction | 16 |
| Devegecidi Dam | Tigris | Part of GAP, contributes to overall flow reduction | 16 |

**4. Methodologies Used in the Research**

The methodologies employed in the studies examining the effects of damming on the downstream discharge of the Tigris and Euphrates rivers are diverse, reflecting the complexity of the hydrological systems and the multifaceted nature of the impacts. A common approach involves the analysis of long-term historical streamflow data collected at various gauging stations along the rivers, both upstream and downstream of major dam construction sites (Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). These studies often compare flow records from periods before and after the construction and operation of significant dams to identify trends and quantify changes in discharge volume, seasonal patterns, and flow variability (Graf, 2006; Petts, 1984; Shiklomanov, 1996). Statistical methods, including trend analysis and the calculation of hydrological alteration indices (like the Indicators of Hydrologic Alteration - IHA), are frequently used to assess the significance and magnitude of these changes (Graf, 2006; Richter et al., 1996).

Hydrological modeling is another widely used methodology to simulate river flow under different scenarios, including with and without the presence of dams, or under various dam operation rules and climate change projections (Graf, 2006; Petts, 1984; Shiklomanov, 1996). These models can range from simple water balance models to complex, spatially distributed models that account for various hydrological processes and anthropogenic influences (Graf, 2006; Petts, 1984; Shiklomanov, 1996). Some studies utilize climate models and scenarios to project future changes in river discharge, considering the combined effects of damming and climate variability (Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

Remote sensing techniques, particularly the use of satellite imagery and indices like the Normalized Difference Water Index (NDWI), have become increasingly valuable for monitoring changes in surface water extent, which can serve as a proxy for water storage and, indirectly, for river discharge (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). These methods allow for the assessment of water level dynamics and changes in reservoir surface areas over time, providing insights into the impact of dam operations and drought conditions on water availability (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

In addition to quantitative analyses, some research incorporates qualitative methods, such as literature reviews, policy analysis, and expert interviews, to understand the broader security, environmental, and socio-political implications of damming projects, particularly in transboundary river basins like the Tigris and Euphrates (Beaumont, 1995; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; Zargar & Abbasi Alamooti, 2023). These studies often examine international water law, agreements between riparian states, and the perspectives of different stakeholders to provide a more holistic understanding of the challenges associated with water management in the region.

**5. Limitations of the Existing Research**

The existing body of research on the effects of damming on the downstream discharge of the Tigris and Euphrates rivers, while extensive, is subject to several limitations that should be considered when interpreting the findings. One significant challenge is the availability and reliability of long-term, high-quality hydrological data, particularly for periods predating large-scale dam construction (Graf, 2006). In transboundary river basins, data sharing between riparian countries can be limited due to political sensitivities and a lack of comprehensive, basin-wide monitoring systems, which can hinder the development of robust and consistent analyses (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

Another limitation arises from the complexity of disentangling the specific impacts of damming from other factors that influence river discharge, such as climate change, land-use alterations, and water abstractions for irrigation and other purposes (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). Climate change, with its potential to alter precipitation patterns and increase evaporation rates in already arid regions, adds a layer of complexity to the assessment of dam-induced changes (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). Similarly, the increasing demand for water for agriculture and domestic use can exacerbate the effects of reduced river flow caused by dams (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

The use of hydrological models, while valuable, also carries inherent limitations. The accuracy of model outputs depends on the quality of input data, the representation of complex hydrological processes, and the assumptions made in model development (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). Different models may yield varying results, and the ability of models to accurately predict future scenarios is subject to uncertainties in climate projections and human behavior (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

Studies relying on remote sensing data may be limited by the spatial and temporal resolution of satellite imagery, as well as by factors such as cloud cover or the presence of dust, which can affect the accuracy of water surface area measurements (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). Furthermore, using surface water extent as a proxy for discharge may not always capture the full picture, as changes in water depth are not directly measured (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013).

Finally, research on the socio-economic and ecological impacts of damming often faces challenges in establishing direct causal links and quantifying the full extent of these effects over long time scales and across large geographical areas (Al-Ansari & Knutsson, 2011; Beaumont, 1995; Issa et al., 2014; Kibaroglu & Scheumann, 2013; UN-ESCWA & BGR, 2013). The cumulative effects of multiple dams within a river basin can also be difficult to assess comprehensively (Graf, 2006). The lack of standardized methodologies and consistent data collection across different studies can further complicate the synthesis and comparison of findings.

**6. Synthesis of Key Findings on Discharge Changes**

The systematic review of the literature reveals a consistent pattern of reduced downstream discharge in the Tigris and Euphrates rivers following the construction of dams, particularly those associated with Turkey's GAP project. Multiple studies, employing various methodologies including historical flow data analysis, hydrological modeling, and remote sensing, indicate a significant decrease in the average annual flow of both rivers reaching Syria and Iraq (Al-Ansari & Knutsson, 2011; Beaumont, 1995; ERF, 2021; ERF, 2021; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Kucukmehmetoglu, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013; Zargar & Abbasi Alamooti, 2023). Estimates of the reduction in flow for the Euphrates River after the completion of major Turkish dams, such as the Atatürk Dam, range from 40% to over 80% of its historical discharge (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). The Tigris River has also experienced and is projected to undergo substantial flow reductions, with some estimates suggesting a decrease of up to 50% or more after the full implementation of the GAP project, including the operation of the Ilisu Dam (Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013).

Beyond the overall decrease in the quantity of water, the timing and variability of river flows have also been significantly altered. Dams tend to reduce peak flows, which historically occurred during the wet seasons, and can increase base flows during drier periods due to the release of stored water (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995; Wen et al., 2011). This regulation can flatten the natural hydrograph, diminishing the magnitude of seasonal flow variations (Graf, 2006; Shiklomanov, 1996). However, the operation of hydroelectric dams can also introduce short-term, unnatural fluctuations in discharge in response to energy demands, leading to rapid changes in downstream water levels (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995). The timing of high and low flow periods, crucial for ecological processes, has also been affected by damming (Graf, 2006; Petts, 1984; Shiklomanov, 1996; Ward & Stanford, 1995).

The consequences of these discharge changes are far-reaching. Reduced flow has led to increased water scarcity in downstream Syria and Iraq, impacting agriculture, water supply for domestic and industrial uses, and the health of riverine ecosystems (Beaumont, 1995; ERF, 2021; ERF, 2021; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). The dramatic shrinkage of the Iraqi marshes, which are heavily reliant on the Tigris and Euphrates for their water supply, serves as a stark example of the ecological devastation resulting from altered flow regimes (Al-Ansari & Knutsson, 2011; Issa et al., 2014; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013). Furthermore, the control over water resources has become intertwined with regional politics, with accusations of upstream countries, particularly Turkey, using water flow as a means of exerting political pressure on downstream neighbors (Beaumont, 1995; Kibaroglu & Scheumann, 2013; Salman & Salman, 1992; UN-ESCWA & BGR, 2013; Zargar & Abbasi Alamooti, 2023).

**7. Conclusion**

The systematic literature review unequivocally demonstrates that the extensive damming projects on the Tigris and Euphrates rivers, particularly those undertaken by Turkey as part of the GAP initiative, have resulted in significant reductions and alterations to the downstream discharge reaching Syria and Iraq. The construction of major dams has led to a substantial decrease in the average annual flow of both rivers, altered seasonal flow patterns by reducing peak flows and potentially increasing base flows, and introduced unnatural short-term flow fluctuations. These hydrological changes have had profound and multifaceted consequences for the downstream riparian states, impacting their water security, agricultural productivity, ecological health, and even contributing to regional political tensions.

The methodologies employed in the research are varied and include the analysis of historical streamflow data, hydrological modeling, and remote sensing techniques, each with its own strengths and limitations. While these studies provide valuable insights into the impacts of damming, challenges remain in fully disentangling these effects from other influencing factors such as climate change and water abstraction, as well as in obtaining comprehensive and reliable data across the entire transboundary river basin.

Future research should focus on enhancing the accuracy of hydrological models for the region, improving data sharing and collaborative monitoring efforts between riparian countries, and conducting more integrated assessments that consider the complex interactions between damming, climate change, and increasing water demands. Further investigation into the long-term socio-economic and ecological consequences of altered flow regimes is also crucial for developing sustainable water management strategies in this vital and increasingly stressed region. Additionally, exploring and implementing environmental flow regimes that aim to balance human needs with the ecological requirements of the river systems could offer a pathway towards mitigating some of the negative impacts of damming on the Tigris and Euphrates rivers.

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