The Perils of Modernization:

The Uncertain Benefits of the Turkish GAP Project and Downstream Iraqi Farmland

by

Anna F. Baskin

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This thesis was presented

by

Anna F. Baskin

It was defended on

December 8, 2023

and approved by

Angela Christine Lyons, Ph.D., Associate Professor, University of Illinois Urbana-Champaign, Department of Agriculture & Consumer Economics

Horia M. Dijmarescu, Ph.D., Teaching Assistant Professor, University of Pittsburgh, Department of Political Science

Joshua Cannon, Ph.D., Executive Director, Center for Governance and Markets, University of Pittsburgh Graduate School of Public and International Affairs

Thesis Advisor: Susan Lucas, Ph.D., Lecturer**,** University of Pittsburgh, Program of Urban Studies

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Anna Baskin, BPhil

University of Pittsburgh, 2023

Türkiye's Southeastern Anatolia Project (GAP) aims to inspire economic growth in an underdeveloped region of Türkiye through the construction of 22 dams along the Tigris and Euphrates rivers. Despite the purportedly humanitarian goals of the project, protests arose from both local Turkish populations and communities in downstream neighbors Iraq and Syria. To address Iraq's protests concerning their access to water, Turkish officials promised to maintain a "fair and equitable" flow of water into Iraq. However, struggling Iraqi farmers now blame Türkiye's new dams for exacerbating the effects of drought and climate change. In an attempt to address the gap in research concerning the actual impact of Turkish dams on downstream Iraq, this project quantifies changes in vegetation and population surrounding the GAP dams in Türkiye and the downstream Mosul Dam in Iraq. Using Normalized Difference Vegetation Index (NDVI) data to estimate changing vegetation over time and UN-adjusted population rasters to estimate population change, this research assesses whether Türkiye's agricultural development seems to come at the expense of Iraqi farmland and farmers. It finds that the Iraqi Mosul Dam sees greater fluctuations during periods of drought in comparison to upstream Turkish dams along the Tigris River, and yet also has also seen population growth above the national average. In light of the Mosul Dam's vulnerability to changes in precipitation, this population increase has the potential to severely strain its remaining resources. Meanwhile, land around the Turkish dams has not seen population growth on par with the national average, indicating that these dams may not be benefitting their local populations as the government claims.

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1.0 Literature Review

1.1 Dam Building Projects.

Water is necessary in almost every aspect of life: drinking and cooking, sanitation, industry, agriculture, and more. However, only 2.5 percent of Earth's total water is freshwater. Of that freshwater, less than three-tenths of 1 percent is in liquid form on the surface of the earth. And of the accessible surface freshwater, rivers and streams (the most widely accessed source of water for societies throughout history) hold only 0.006% of the total freshwater (Solomon, 2011, p. 12-13). Furthermore, the distribution of water across the earth’s surface is uneven, with some areas having more water while others have relatively little. The fates of societies throughout history can depend on their ability to access and manage water.

Today, one controversial aspect of water management is dam-building projects. By controlling a river, dams can provide flood control, irrigation, and hydropower. Large-scale dam construction projects (coined “mega dams”) became popular during the Cold War, as the United States and Soviet Union rushed to demonstrate their engineering supremacy and grow their global influence. Most dam projects at the time were funded through loans from either the competing global superpowers or the World Bank (Nixon, 2010). Meanwhile, from the perspective of governments in the global South, dam projects were considered tools of decolonization by which newly independent countries could demonstrate their prosperity, autonomy, and modernity (though the projects often placed the nations severely in debt) (Nixon, 2010).

Dam-building fervor died down after the 2000 World Commission on Dams report, which concluded that while dams made "an important and significant contribution to human development", the benefits did not outweigh the outsized social and environmental costs of dam construction – borne disproportionately "by people displaced, by communities downstream, by taxpayers and by the natural environment". Nonetheless, given the urgent need for solutions to slow global climate change, the desire for natural energy sources like hydropower has resulted in a revitalization of funding for dam development projects (Chen & Landry, 2018).

Therefore, dams are politically controversial due to the competing interests of the state (which sees dams as both demonstrations of modernity and opportunities to generate wealth through clean energy) and the local populations (including displaced peoples and downstream communities). The Southeastern Anatolia Project (GAP) dams in Türkiye (formerly the Republic of Türkiye) are no different. The following literature review discusses the political dimensions of the Turkish/Iraqi dam projects and their local impacts, with the hope of explaining why an analysis of the current and historical vegetation and population conditions around the Tigris River dams is both necessary and timely.

1.2 Region of Interest

The Tigris and Euphrates rivers in the Middle East are part of the "Fertile Crescent" – often called "the cradle of civilization" – where the first settled agricultural communities originated in the early 9th century BCE (Britannica, 2023). Today, the rivers flow north to south across the countries of Türkiye, Syria, and Iraq. The Euphrates River (the longest river in the Middle East) is primarily fed by precipitation in Türkiye (which contributes 89% of the river's water) before flowing into Syria (which contributes 11%) then Iraq (which contributes next to nothing). The Tigris River flows directly from Türkiye – which contributes 51% of waterflow through precipitation – into Iraq – which contributes 39% (with the remainder coming from rainfall in Iran) (Kaya, 2009). A map of the river basin region is shown in Figure 1:

Figure 1: Map of Euphrates-Tigris River Basin (Walker, 2020)

This research focuses on the northern Tigris River (shown in Figure 1 on the right), because it flows from Türkiye directly into Iraq, allowing an isolated study of how Turkish dam building has impacted downstream Iraq. Significantly, the Tigris River flows through the Kurdish regions of Iraq and Türkiye, including Iraq's semi-autonomous Kurdistan Region. The relationship between the Tigris River dams and the Kurdish population will be expanded upon throughout the literature review.

1.3 Türkiye: Southeastern Anatolia Project (GAP)

Türkiye's Southeastern Anatolia Project (*Güneydoğu Anadolu Projesi*, or GAP) is a $32 billion integrated regional development project, funding both industrial development projects and community-building endeavors. According to the Turkish government, the goal of the project is to reduce regional disparities through economic/social development. The project consists of 22 dams and 19 hydroelectric plants along the Tigris and Euphrates rivers providing electricity and irrigation for the region. The Figure 2 shows the distribution of GAP dams along the Tigris and Euphrates Rivers:

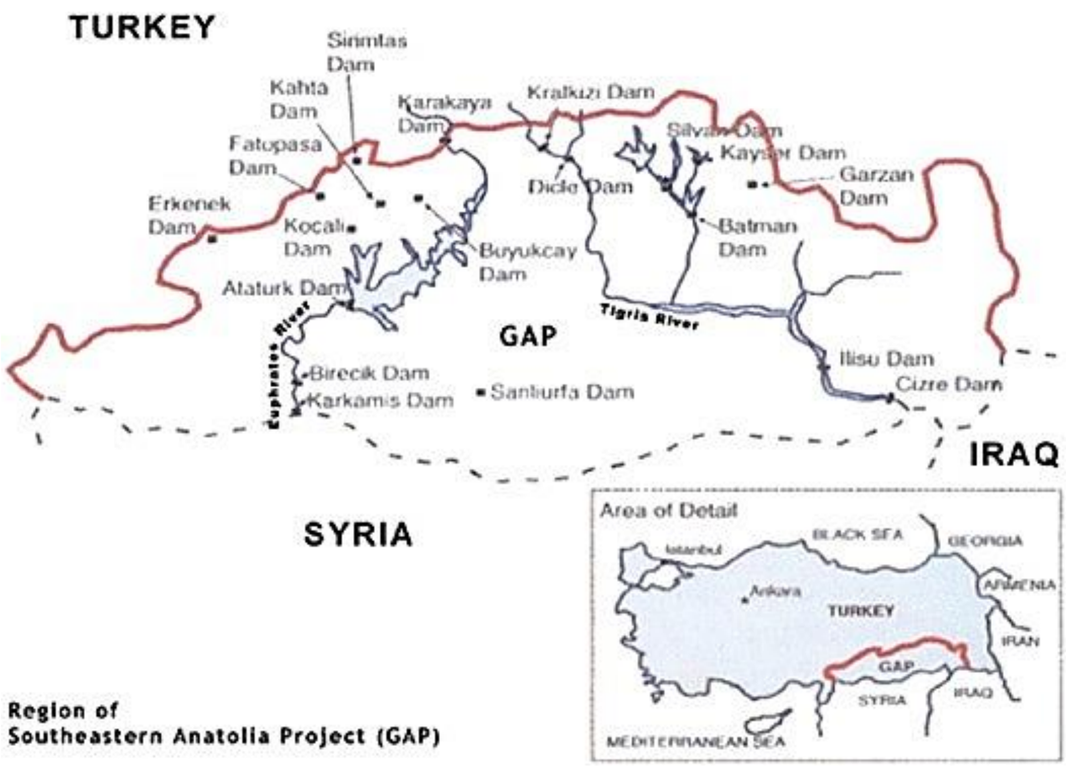

Figure 2: Map of the GAP Region Dams (Warner et al., 2014)

Along the Tigris River, which flows directly into Iraq, the GAP master plan involves the construction of 8 dams (Dicle, Kralkizi, Batman, Silvan, Kayser, Garzan, Ilisu, and Cizre) for irrigation and hydroelectricity, as shown in Table 1. Because this study is interested in the dams along the northern Tigris River, the dams from Table 1 make up the GAP dams referenced throughout the paper – minus the three dams (the Silvan, Kayser, and Cizre) which are not yet in operation.

Table 1: GAP Dams from the 1986 Master Plan (with updates year of operation) (Unver, 1997)

Dam Projects	Capacity (MegaWatts)	Production (Gigawatt hours)	Irrigation area (hectares)	Operation Year
Dicle-Kralkizi	204	444	130,150	1999
Batman	198	483	37,350	2003
Silvan-Kayser	240	964	257,000	Pending
Garzan	90	315	60,000	2012
Ilisu	1,200	3,833	N/A	2018
Cizre	240	1,208	121,000	Pending
Total:	2,172	7,247	605,500	N/A

The Turkish government's motivations behind the GAP are complex. The GAP region ranks above the national average in terms of infant mortality and unemployment, and below the national average in urbanization rates and average gross value added per capita (GAP-BKİ, 2016). It is also a region of widespread land inequality, with 65% of farmers owning only 10% of the land in the late 1990s (Ahmet, 1998). Turkish officials tout the development project as a humanitarian and economic effort to reduce regional disparities through improving agricultural/industrial productivity and regional economic standards. One GAP coordinator called the project an attempt to catch up with the Western world by "providing opportunities for all people to enjoy the same rights and same economic and social benefits" (Bilgen, 2018c, p. 539).

However, the GAP region is primarily Kurdish, with Kurds representing 64% of the population in the region and 26.7% of the state's total Kurdish population as of 2011 (KONDA, 2011). Thus, the development project has always been deeply tied to Türkiye's so-called

“Kurdish problem”, referring to the state’s armed conflict with various Kurdish insurgency groups. Historically, the Treaty of Severes in 1920 granted the Kurds the option of autonomy following the Ottoman Empire’s collapse, but the treaty was quickly ignored by Turkish nationalists. Despite the Kurdish population’s desire for self-governance, the modern Turkish state instead attempted to incorporate the ethnicity as part of the new secularist “Turkish” ethnic identity, leading to 3 large-scale Kurdish rebellions from 1925 to 1938, and brutal suppression of the Kurdish identity by the Turkish state. Türkiye banned Kurdish language and dress, and even prohibited the words “Kurds” and “Kurdish” – instead calling Kurds “Mountain Turks” (Hannum, 1996, p. 189). As Philip Robins explains, “The fact that the three major armed rebellions against the state were led by Kurds and based in the Kurdish region of the state firmly established the Kurds in Turkish minds as the originators of the primary challenge to their independent existence” (Robins, 1993, p. 660).

Given the scope of the project and its intentional placement within a dissenting minority region, it is important to investigate the motivations of the GAP beyond the Turkish government’s humanitarian and economic development narratives. To that end, high modernism is a helpful conceptual lens through which to analyze the GAP’s development and implementation. High modernism is characterized by a refusal to accept the natural state of the world, and a dedication to progress towards a rationally designed natural and social order. The concept originated from James Scott’s 1999 book *Seeing Like a State*, where he outlines components that, when combined, can often doom state-initiated social engineering projects to failure. These components include the administrative ordering of nature and society, dedication to “progress” as an ideology, an authoritarian state equipped to enact ambitious projects, and a weak civil society unable to combat social engineering (Scott, 1999, p. 5).

Türkiye's GAP aims to irrigate over 1.8 million hectares of arid land across the region of Southeastern Anatolia, and so certainly represents a refusal to accept the natural state of the world (a key indicator, according to Scott (1999), that the state is choosing to value "progress" above all else). Planning began in the 1970s as an economic development project, but in the late 1980s the project grew to encompass additional investments in industry, transportation, education and more. The official website states:

> "The objectives of the GAP include improving the level of income and life quality of local population by utilizing region's resources; eliminating development disparities existing between the region and other parts of the country and contributing to national economic development and social stability by enhancing productivity and employment opportunities in the region" (Republic of Türkiye, 2015).

James Scott's high modernist framework provides a useful lens to see beyond Türkiye's humanitarian narrative and better understand the GAP's deeper intentions, specifically regarding the Kurdish minority of Southeastern Anatolia. Key elements of high modernism include dedication to the ideology of progress, control over nature (human and environmental), and a weakened society unable to combat the manipulation of an authoritarian government (Scott, 1999, 5). Combined, high modernism amounts to the forced modification of nature and society to adhere to the government's vision of modernity. The 2004 president of GAP Regional Development Administration claimed that GAP was a sustainable development project – then defined sustainable development as "the optimal utilization of human and natural resources, in which the preferences and potentials of people are translated into life without compromising the opportunities of future generations" (Özgül, 2004, p. 1). The "optimal utilization" of humans and nature is the fundamental motivator of high modernist projects, because it is an extension of the idea that through science, all things (including nature and humanity) can be refined for the benefit of the state.

Indeed, the GAP's ambitious goal of constructing 22 dams and 19 hydraulic power plants along the Tigris and Euphrates Rivers certainly reflects a high modernist reconstruction of nature. Thus far, the dams have drowned ancient cities like the 10,000-year-old city of Hasankeyf (another sign that the state is valuing development above all else, including history), irrigated once-arid land, and created deep reservoirs (potentially drastically reducing waterflow to downstream countries). Overall, the project has completely reimagined the hydro-landscape and natural environment of the region. This includes the vegetation of the environment; the master plan calls for GAP region farmers to reduce their production of barley and wheat (which have been farmed in the Fertile Crescent region for over 10,000 years) and increase their production of exportable cash crops like soybeans and cotton (which require significantly more water) (Unver, 1997).

However, the dams are also implicit attempts at social, as well as natural, engineering. The timing of the GAPS's conception in the 1970s was not coincidental. The late 1970s marked the rise of the Kurdistan Worker's Party (PKK), a revolutionary Kurdish political movement (now labeled a terrorist group by the Turkish government). The PKK began as a political party advocating for Kurdish rights but grew increasingly revolutionary. It first announced an uprising in 1984, calling for an independent, unified Kurdistan through revolution and violence.

As conflict with the Kurds intensified, the focus of the GAP extended from purely engineering into sociopolitical reform. Bilgen points to the project's administrative reallocation from the Directorate of State Hydraulic Works to the State Planning Organization in the mid-1980s as the shift from technical to social-political development. His research indicates that while technical experts and bureaucrats regarded the project as non-political, Turkish political elites have always considered the GAP a remedy for the Kurdish conflict wherein economic and social reform would address underdevelopment – the state's hypothesized 'root cause' of Kurdish separatist sentiment. Bilgen quotes a parliamentary member from 1988: "the remedy of preventing anarchy and terror in [GAP] region [was] to complete crucial investments" because "when [their] social, economic, and cultural development [was] ensured, both anarchy and terror [would] be eliminated" (Bilgen, 2018a).

The Turkish state therefore intends for modern irrigation agriculture to facilitate the conversion of unhappy Kurds into happy Turkish citizens. Jongerden lays out the Turkish state's rationale: regional poverty causes dissatisfaction and disaffection, fostering PKK sympathy; modern irrigation techniques would create economic development, a new regional lifestyle, diminish the importance of tribal relations, and increase dependency on state institutions; thereby "tribal Kurds would become modern Turks" (Jongerden, 2010, p. 141).

According to government officials working with GAP, the project has succeeded in improving the local population's incomes and daily lives. According to the Ministry of Industry and Technology website for the GAP, GAP regional exports reached $9.2 billion in 2019, from $689 million in 2002. The rate of employment increased from 30.1% in 2008 to 35.7% in 2019. The GAP region now accounts for 50% of hydraulic energy production in Türkiye, generating $28.4 billion in electricity. As of 2019, a total of 571 hectares of land in the river basin had been irrigated (though the overall goal remains 1.8 million hectares – the initial development of hydropower plants took precedent over establishing irrigation networks) (Republic of Türkiye, 2019). Overall, GAP officials claim that GAP has made the region wealthier (and consequently, raised the quality of life for the people of the region). According to one expert working in the

GAP, for example, the people of the town of Harran in Şanlıurfa "had no bread to eat" in 1995. But in 2014, she claimed:

> "[y]ou can find everything now. Everything! There are lake houses … Today a flat cost one million TL[1]. There used to be horse carts in the streets. Today there are asphalt roads and double highways everywhere. Until last year, streets smelled like urine. Now they are all shiny" (Bilgen, 2018c, p. 544).

However, despite the alleged improvement to quality of life in the GAP region, studies have shown that the GAP's impacts have manifested unevenly (a common failure of high modernist projects). Bilgen (2021) found that only those "already possessing large amounts of land, capital, resources, and power" have seen the benefits of improvements. For example, irrigation associations were established in 1994 to distribute water, operate and maintain canals, and collect irrigation fees. These associations were intended to empower local farmers through participatory irrigation management, but association administrators were often the most influential local elites (regardless of their qualifications). As one sociology professor interviewed by Bilgen noted, "small landowners cannot afford to pay the amount determined by irrigation associations anyway. Hence, associations have actually worsened the inequality" (Bilgen, 2018c, p. 545). Consequently, one is left to wonder whether it is indeed the breadless poor of Harran who now live in those one million Turkish Lira flats, as the GAP employee would imply.

Additionally, the filling of the GAP dam reservoirs entailed massive dislocation. The Atatürk Dam alone submerged or semi-submerged three towns, four townships, and 135 villages – requiring the dislocation of 55,000 people (Bilgen, 2018b), 72% of whom described their

[1] TL = Turkish Lira (as of Nov. 2023 1,000,000 TL = $34,541.23)

economic conditions as worse compared to before, with the Kurds facing additional burden of discrimination in cities (Bilgen et al., 2021). This is a common problem for dam building projects; anthropologist Thayer Scudder estimated that the number of people displaced by mega dams ranged from between 30 to 60 million, with almost all displacements resulting in declining quality of life (Nixon, 2010).

Additionally, GAP's successful pacification of the Turkish Kurds relies on the negation of the Kurdish identity; the government hopes to subsume the minority into the general Turkish identity. As James Scott describes, the ideal citizens of high modernist states "have, for the purposes of the planning exercise, no gender, no tastes, no history, no values, no opinions or original ideas, no traditions, and no distinctive personalities to contribute to the enterprise" (Scott, 1999, 346). Given this blank-slate citizen, the state is then able to overwrite their desired characteristics for their version of an ideal citizen. The Kurds, with their rich cultural and political history, will never become "ideal" Turkish citizens, because it involves a complete restructuring of their identity. Indeed, the repeated insurgencies beginning in 2004 indicate that the GAP thus far has failed to overwrite the Kurdish identity and pacify the separatist Kurds.

Finally, the GAP project has faced significant protests from downstream states Syria and Iraq, who worry that the many dams along the Tigris and Euphrates rivers will reduce water flow downstream. The Turkish government, however, generally considers the water that flows through its land its own. In 2022, Turkish President Recep Tayyip Erdogan said, "We realise the water scarcity in Iraq, but the precipitation in Türkiye is at its lowest level in 62 years. We are going through a drought that is further deepening due to climate change," adding that Türkiye would increase waterflow for a month "as much as possible to alleviate Iraq's problem" (Mahmoud, 2023). Therefore, while the Turkish government appears sympathetic to the plight of the Iraqis, the government does not consider it the Turkish state's responsibility nor its priority to equitably share the water. The following sections will focus more heavily on the interstate political dynamics of the project – beginning by explaining the importance of Iraq's Mosul Dam and moving into Iraqi concerns over the damming of the Tigris River.

1.4 Iraq: Mosul Dam

Flow from the Euphrates and Tigris rivers form the vast majority of Iraq's water resource, but only 8% of the rivers' flow stems from internal sources. 4% comes from Syria, 6.9% comes from Iran, and 71% comes from Türkiye. Additionally, groundwater resources form only 2% of Iraq's available water resources (Al-Ansari, 2015). This creates a dangerous scenario where the majority of Iraq's available water comes from Türkiye, leaving Iraq at the mercy of its upstream neighbors.

Due to increasing demand for water and the threat of lower river flows because of upstream dam construction, Iraq began building dams for irrigation and power generation in the later twentieth century. From 1950 – 1978 the Iraqi government ordered a series of site studies for an irrigation dam in Northern Iraq along the Tigris River which could irrigate 750,000 hectares. The consulting firms eventually settled on a location 60km northwest of Mosul city for what became the Mosul Dam (Al-Ansari, 2015). The construction of the dam began in 1981 under Saddam Hussein (hence the dam was briefly called the Saddam Dam). It was completed in 1984, and the 11 billion m^3 reservoir began filling in the spring of 1985. 70 miles from the Turkish border, the dam captures waterflow from the Tigris River for use irrigating the surrounding Nineveh region of Iraq and generating hydroelectric power for the 1.7 million residents of Mosul.

The Tigris River north of the Mosul Dam flows through Iraq's Kurdistan Region (KRI) shown in Figure 1. Thus, control of the Tigris River has significant impact not just on the Turkish Kurds, but also the Iraqi Kurds. Unlike Türkiye, which is attempting to subsume the Kurdish minority into their Turkish nationality, the Iraqi constitution recognizes the KRI as an autonomous region of Iraq. Regardless, both countries continue to struggle with Kurdish nationalists (creating a common security interest between the two countries).

Regarding Iraqi national security, the Mosul Dam has historically been a significant cause of concern due to the dam's bad foundation and its location directly upstream of the city of Mosul. If the Mosul Dam fails, 6 million people will be affected and 7202 km^2 area will be flooded (Al-Ansari et al., 2020). Therefore, the dam requires continuous maintenance and could also be a target for bad actors. While the dam went untouched through the 2003 invasion of Iraq led by the United States, in 2014, the Mosul Dam was captured by Islamic State forces. While the dam was occupied, the international community feared first that the Islamic State would cut waterflow and shut down the hydropower plant, depriving the people in downstream Mosul of both water and electricity. The second concern was that the Islamic State would deliberately destroy the dam and flood downstream Mosul. However, in the end the Islamic State only held the dam for two weeks before a coalition of US, Iraqi, and Kurdish forces regained control (Oueidat, 2016).

Because of its utility for both irrigation and energy production, the Mosul Dam stays in operation despite concerns for its bad foundation and dangerous location upstream of a major city. In fact, the dam is more important than ever as climate change affects the Middle East. In 2019, the United Nation's Global Environment Outlook 6 ranked Iraq as the 5th most vulnerable county to decreasing water/food availability and extreme temperatures due to climate change

(United Nations, 2022). Drought and high temperatures have made farming more difficult in the region, and the Iraqi government expects water shortages to increase. A 2021 report by the Iraqi Ministry of Water Resources predicted that water imports to Iraq would decrease by 70% by 2035, and that the Tigris and Euphrates rivers could run dry by 2040. The report blames both drought and the creation of upstream dams in Syria and Türkiye. (Aldroubi, 2021).

The drying up of the Tigris and Euphrates rivers (Iraq's primary water sources) would have devastating effects nationwide, including decreased agricultural production, displacement, poverty, and disease. And yet, Iraq has little recourse to prevent upstream Türkiye and Syria from overuse of the shared water resources. The following section will examine the interstate politics of dam building projects on transboundary water features like the Tigris and Euphrates rivers and discuss the implications for Türkiye and Iraq.

1.5 Transboundary Water Politics

In areas of extreme drought like the Middle East, rivers and streams are valuable resources. These resources are typically international, since the large rivers crucial to agriculture in the region often wind their way through multiple countries. In order to ensure equitable and sustainable access to shared water sources, states need to cooperate in the management and utilization of these resources. However, instead of engendering cooperation, transboundary water features can also serve as points of contention – reaching even violent hostility – between states. Water is a limited resource, especially in times of drought, and each country wants enough to satisfy their own needs.

Competition between states over river access is uniquely unbalanced compared to other natural resources; while many stakeholders have access to the water, they cannot evenly share in its bounty. By virtue of geography, the upstream state has more direct control over the resource.

When they use more water, the downstream countries get less. Thus, in the absence of an existing cooperative agreement, repercussions – political reprisal, economic sanctions, or, in some cases, armed opposition – become the only recourse for downstream countries to dissuade upstream countries from overindulging. Yet if the upstream country has greater political/economic power, there is very little those downstream can do to maintain their share of the water. Indeed, in Zeitoun and Warner's (2006, p. 436) analysis of hydro-hegemony, this enduring tension between upstream and downstream countries forms the framework of political analysis. The simplest rule: "Upstreamers use water to get more power, downstreamers use power to get more water". In this case, Zeitoun and Warner regard power as the ability to influence the decisions of the other state. By holding a valuable resource which can be used in negotiations, upstream countries gain power. When downstream countries need water, they must exert power (through economic, political, or military means, for example) in order to get more water.

According to Frey's (1993) power-analytic framework, the most stable situation is when the upstream riparian (state neighboring a river) is more powerful, because the downstream riparian will be disinclined to cause conflict. The most conflict-prone situation is when the downstream riparian is more powerful, because then the downstream state sees conflict as a feasible opportunity to enforce control of the incoming water. Though the likelihood of conflict is low given a more powerful upstream state, the likelihood of cooperation is also low; the upstream state simply has no incentive to cooperate. Therefore, situations where upstream countries have both water and power often create a power imbalance which results in unfair allocation of water resources.

There are three theories which have been applied to negotiations regarding the riparian state's rights to shared river resources. The first is the Theory of Absolute Territorial Sovereignty, by which a country has absolute property rights to all water that passes through it. This theory prioritizes the interests of upstream states by granting them unconditional ability to use or withhold river water without regard for downstream neighbors. Under the second theory, the Theory of Absolute Integrity of the River, upstream riparians may do as they like as long as they maintain the same amount of water and the same water quality as historically flowed downstream. By requiring that water continue to flow naturally, this theory is biased towards the most downstream countries, who are now able to use as much water as they please. Finally, the Theory of Common Interests views rivers not as property of any given state, but as a shared resource that must be equitably and reasonably utilized. In practice, this theory often manifests itself as the "No Harm" rule, wherein states have absolute sovereign authority over the water within their borders as long as they refrain from harming the interests of other states (Tayie, 2017).

Understanding these theories can be very helpful in formalizing cooperative frameworks by which countries can regulate the use of international rivers, but building these legalized frameworks requires all stakeholders to willingly join the negotiations. Unfortunately, as Frey describes, when the upstream riparian is the more powerful state, there is no incentive to cooperate and no accepted global system to force cooperation. Therefore, the powerful upstream state usually operates using the Theory of Absolute Territorial Sovereignty because it best suits its interests.

The struggle between Türkiye and Iraq surrounding the GAP can be understood through the Frey's framework. Iraq, as the less powerful (in terms of economics, military, and global influence) downstream neighbor, has long protested Türkiye's rampant dam construction to little avail. The Tigris and Euphrates rivers are extremely important to Iraq; Raquella Moea Thaman (2021) noted in her paper that Iraq relies on the Tigris and Euphrates rivers for 95% of their agricultural/industrial needs and 85% of their domestic needs (referring to drinking, food preparation, and sanitation). In Iraq, additional damming of the Tigris River could have significant effects on industry and agriculture. Loss of livelihoods in Iraq would only exacerbate an already tenuous political situation in the country.

In response to appeals for an equitable distribution of water to downstream countries after the construction of the Ilisu Dam began in 2010, Turkish officials publicly promised a "fair and equitable" water flow (Kurdistan 24, 2021). But such promises are not always realized, and Iraq has little political power to enforce their vaguely worded bilateral agreement. In her paper, Thaman (2021) notes that "the existing legal regime governing the use of the waters of the Tigris River provides scant protection against the potential harm caused by the dam." There is no global body able to or willing to enforce equitable water sharing between states, though the Iraqi government did explore legal options to prevent the construction of the Ilisu Dam in the early 2010s through appeals to customary international law, arguing that the Ilisu Dam failed to prevent transboundary harms because of its restriction of waterflow to downstream Iraq (Chibani, 2023).

But with no existing legal framework to protect their share of river water, Iraq (as well as Syria, also downstream of Türkiye's multiplying dams on the Tigris and Euphrates rivers) was left with few options to prevent the construction of the dam. Indeed, Warner (2012, p. 246) interpreted the frequent meeting of technical teams from all three countries (even during times of political tension and looming military intervention) as a signal of resignation to the Ilisu Dam project by Iraq and Syria, calling the meetings “a pragmatic acceptance of the faits accomplis on the part of the downstream neighbours.” While these meetings indicate a level of cooperation between states, it is not cooperation as typically defined. Instead of working together to meet a mutually beneficial shared goal, Warner tellingly defines cooperation in the basin as “a stability of expectations”. This signals the level of helplessness inherent in the problem of transboundary water management – the downstream country, with no legal recourse, is often resigned to simply accepting the water that flows to them.

1.6 The State of Research

Construction of the GAP dams generated significant concern in the academic community, with a series of papers emerging analyzing the impact on the Kurdish minorities (Bilgen, 2018a), interstate power dynamics at play (Hommes et al., 2016) and the legal framework through which protest from downstream actors emerge (Thaman, 2021). Hydrologists and environmentalists were also concerned; hydrology researchers found that in a worst-case scenario where the Turkish dams are “conducted with no consideration of downstream hydrological and environment impacts,” they expect up to 78% reduction of water inflow to the downstream Mosul Dam (Al-Madhhachi et al., 2020). In a country that relies on this river for their industrial/domestic water needs, a 78% reduction in incoming water would be a grave affliction.

The impact of the GAP dams on the Kurdish minority has been well observed since the completed construction of most of the Turkish dams. While the dams have generated hydropower and new irrigated land, the local population has seen both massive displacement (Bilgen, 2018b) and increased wealth inequality (Bilgen, 2018c) since the construction of the dams. These are problems common to state-driven large scale development projects like mega dams.

However, research on the GAP's actual (not predicted) impact downstream has been scarce. Researchers predicted that for every cubic km of water lost along the Tigris River, a 625 km^2 area will no longer able to be farmed due to lost irrigation (Thaman, 2021). According to Iraqi rhetoric, that prediction is beginning to actualize. Indeed, journalists have produced the vast majority of insight on the dams' effects on downstream countries through interviews with affected farmers and government workers. A reporter from *France 24* (2021) stated that in 2020, 927,000 tons of wheat were harvested from the Nineveh region of Iraq, site of the Mosul Dam. In 2021, only 89,000 tons were harvested. Farmers blamed drought and climate change, exacerbated by the construction of Türkiye's new dams. Another article cites an Iraqi farmer: "This year the rains failed, too, and a new Turkish dam threatens to reduce flows from the Tigris River into the Mosul Dam Lake. Nineveh is becoming a dust bowl." The farmers worry that their land will soon no longer be able to support agriculture and they will be forced to leave (El Dahan & Jalabi, 2018).

After so much academic work predicting the effects of the GAP project on downstream Iraq, an evaluation of the current status of cropland around the GAP and Mosul dams is missing. This evaluation could corroborate academic predictions and Iraqi rhetoric, or it could divulge unexpected developments. Either way, an understanding of the current status of the land in Türkiye versus Iraq given the GAP's construction in Türkiye is necessary for both Türkiye and Iraq to make policy decisions in the future. This study will fill this gap in research by analyzing both the changes in vegetation (representing changing farmland) dams, and population (looking for displacement due to drought) around the northern Tigris River dams.

2.0 Methodology

2.1 Data

2.1.1 Vegetation

Farmers in Iraq claim that the Turkish dams have made farming in Iraq more difficult, while the Turkish government claims that the dams have irrigated 571 hectares as of 2019 (Republic of Türkiye, 2019). Therefore, this research will analyze the changes in vegetation and population around the northern Tigris River dams. To monitor vegetation, this research uses Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery. MODIS's Normalized Difference Vegetation Index (NDVI) data uses infrared light reflection unique to vegetation to generate a measure of "greenness"/plant-life for a given area. Values closer to 1 indicate an abundance of green, leafy vegetation, while values closer to 0 indicate next to no vegetation. Due to its long-running history and availability through the United States government, NDVI is a popular tool among spatial analysts. A 2019 study used NDVI data to monitor how land cover has changed in Iraq from 2000 to 2017, finding that the growth of croplands in Iraq is correlated with accumulative annual precipitation using NDVI data (Othman et al., 2019). This demonstrates that NDVI has successfully been used as a proxy for cropland in Iraq.

Like the 2019 study, this research uses average NDVI vegetation levels as an indicator for the health of farmlands (more precise methods of identifying farmland exist, but no open-source tools trained on the unique climate of the Middle East could be found). Northern Iraq is made up of primarily shrublands and both irrigated and rainfed croplands (Othman et al., 2019). Croplands are more "green" than shrublands and so have much higher NDVI values. This means that croplands have a much greater impact on the average NDVI of a region than the surrounding shrublands; therefore, average NDVI values can be a good indicator of the health of irrigated farmlands around the dams.

Monthly MODIS NDVI (MOD13A3) data for Iraq and Türkiye was obtained through NASA Earthdata for December 2002 – August 2023 at a 1-kilometer resolution. MOD13A3 data is generated through a weighted temporal average of the best satellite images collected over the month (selecting images with low cloud cover, low view angle, and the highest NDVI scores). Thus, no data preprocessing is needed except to apply the required scaling factor of 0.0001 to the NDVI values (Didan, 2015). After scaling the NDVI values, the average NDVI will be found around each dam and around the river (creation of the zones is discussed in Section II of the methodology) in order to evaluate changes in vegetation over time.

2.1.2 Precipitation

Precipitation is a measurement of how much water (in the form of rain, sleet, or snow) falls to the earth. Changes in vegetation must be considered alongside precipitation, in order to account for periods of drought. This is important because vegetation varies significantly in accordance with the amount of rain. Changes in vegetation cannot be meaningfully observed without simultaneously recognizing periods of high/low rainfall; it is possible that some dams may be more/less affected by periods of drought than others. Total monthly precipitation data was obtained from North American Land Data Assimilation System (NLDAS_FORA0125_M) (NLDAS project, 2022). Using NASA Earthdata's Giovanni tool, the sum of monthly precipitation for the Tigris-Euphrates River Basin was obtained using the bounding box [-125, 25, -67, 53] for the years 2000-2023. From this, the researcher is able to identify periods of drought when yearly rainfall for the river basin is below average.

2.1.3 Population

Displacement caused by agricultural drought is a major concern. To investigate whether Iraqi farmers are being displaced by increasingly difficult farming conditions, this research used the geospatial WorldPop population count dataset, which estimates annual subnational census-based population distributions. Using unconstrained, United Nations-adjusted, 100-meter resolution data for Türkiye and Iraq from 2000-2020, change in population was observed in Türkiye and Iraq (WorldPop, 2020).

2.2 Zones

The dams under consideration are the Mosul Dam, as well as the currently constructed GAP dams along the Tigris River: the Dicle, Kralkizi, Batman, Garzan, and Ilisu dams (shown in Table 1). Note that the Batman, Garzan, and Ilisu dams finished construction during the timeframe of this study (in 2003, 2012, and 2018 respectively). The Kralkizi, Garzan, and Batman dams are the most upstream dams, each on tributaries that flow into the Tigris. The Kralkizi Dam flows into the Dicle Dam, then all the tributaries join and flow into the Ilisu and Mosul dams (as can be seen in Figure 2).

A circular buffer with a radius of 48,860 meters was created around each dam. This buffer is of total size 3 million donums (a donum is an old Ottoman unit of measurement, equivalent to 0.25 hectares), which is the maximum area that could be irrigated by the Mosul dam, according to the original master plan from 1965 (Al-Ansari, 2015, p. 16). Because this zone around the Mosul Dam includes parts of the city of Mosul, when observing changes in population the zone sizes are reduced by half. This isolates the changes in population around the dams (potential deruralization due to difficulties farming) from the growing population of cities.

However, it is difficult to determine exactly what farmland is irrigated by each dam, especially when irrigation occurs downstream from the dam. Therefore, to ensure that the dam zones are not missing significant irrigated land, a zone was also created for the Tigris River for each country. The zones were created using a buffer with the same radius (48860 meters) around the Tigris River. In Türkiye, the buffer spans the Tigris River from start to the Turkish-Iraqi border. In Iraq, the buffer spans the Tigris River from the Turkish-Euphrates border to the city of Baghdad. The Iraqi Tigris River zone ends in Baghdad to isolate the system from the intersection of other rivers like the Euphrates River or Iranian tributaries. Changes in vegetation and population will be examined for each set of zones: the zones around each dam, and the system-level river zones.

2.3 Processing

NDVI and population data were downloaded in raster format (a pixelated grid where each pixel is associated with a geographic location). Because of the manner in which data was generated for both the NDVI rasters (using a weighted temporal average for each pixel) and the WorldPop population rasters (using a machine learning estimation for the subnational census-based population distributions), no preprocessing was needed to clean the data except to transform all data into the same projected coordinate system (EPSG:4326) in order to accurately overlap the zones on top of the rasters. For all zones (dam zones and river system zones), the mean NDVI was taken across all pixels in the zone to get average NDVI for each month. For the Worldpop rasters, the sum of all pixels was taken in order to get total population in the zone for each year. All data manipulations and calculations were done using Python.

2.4 Theory & Analysis

Before moving into analysis, it can be helpful to clearly articulate the theoretical positioning of this paper. This research is concerned with accurately representing the social and natural world through observable metrics. As such, it fits neatly within Patrick Thaddeus Jackson's (2016) "neopositivist" philosophical-ontological framework. Subscribers of neopositivism believe that there exists a world separate from the researcher that can be observed, and that knowledge about that world is generated through observation. In practice, neopositivist research generates testable hypotheses and attempts to falsify them, in order to arrive at law-like explanations.

In this case, given the Iraqi rhetoric that the GAP dams have affected Iraqi farmland and farmers by reducing the amount of farmable land and displacing farmers, the falsifiable theory is that dam projects can negatively impact downstream neighbor's farmland. Given the confounding effect of factors like precipitation, soil salinity, and irrigation practices on farmland and the lack of available data from before the construction of the GAP dams, this research does not have a large enough sample size to establish causality between the construction of the GAP dams and the loss of Iraqi farmland. Instead, the research will attempt a more feasible metric of falsifiability: evaluating whether there are significant differences between changes in vegetation and population between Turkish dams and the downstream Mosul Dam. To do this, average NDVI and total population values will be compared over time for each dam, and at the river system level for each country. In the case that there are not significant differences between Türkiye and Iraqi dams, then the claim that Iraqi farms are uniquely suffering due to their status downstream of the Turkish dams would be false. If there are unique differences, then there is cause for further research to test the hypothesis, and potentially useful observations can be made.

3.0 Results

3.1 Vegetation

Monthly average NDVI data was calculated for each dam zone and for the river system levels. Results aggregated to yearly averages are available in Appendix Table 5 and Table 6 and used in the below figures.

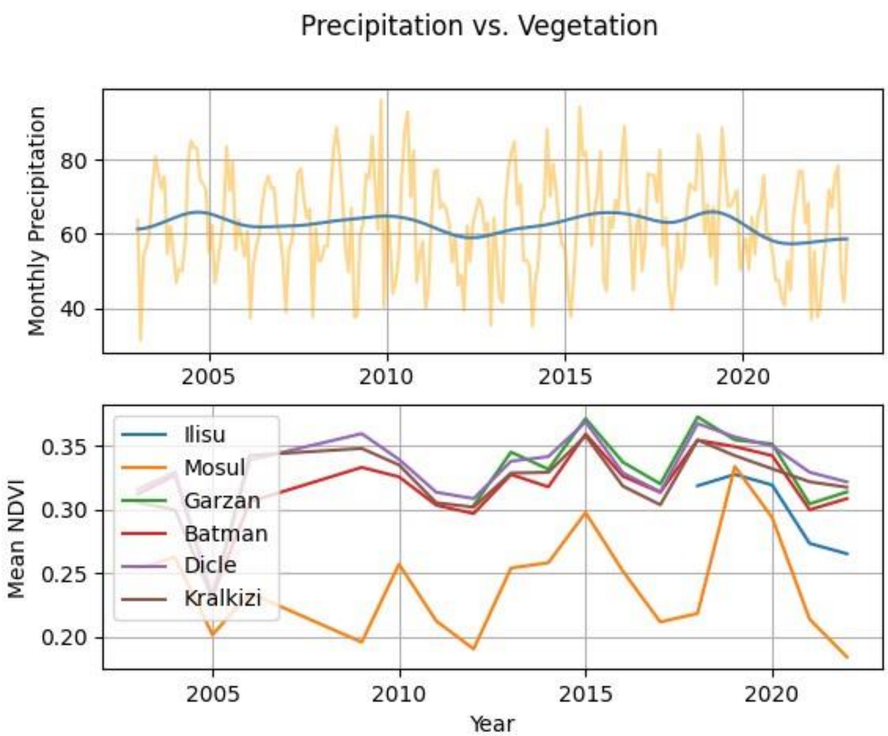

Figure 3: Monthly Precipitation and Average NDVI (Dam Level)

The top of Figure 3 shows the orange average monthly precipitation of the Tigris Euphrates River Basin in kg/m^2, with a blue trend line calculated using a 1-D Gaussian filter using sigma = 6. The bottom chart shows the average yearly NDVI values around each dam zone, an indicator of the amount of vegetation around each dam. The Mosul Dam has a lower average NDVI value (0.24124), compared to the average Turkish dam's NDVI value of 0.32717. The Mosul Dam has a wider range than the average Turkish dams (0.44489 vs. 0.37934).

Additionally, the Mosul Dam sees a larger decrease in vegetation levels during periods when precipitation decreases in comparison to prior years, visible from 2010 – 2012, 2015 – 2018, and 2019 – 2022. Table 2 below shows the change in NDVI values around each dam during each drought period:

Table 2: Change in NDVI During Drought Periods

Dam	**2010 – 2012**	**2015 – 2018**	**2019 – 2023**
Kralkizi	0.033096	0.054062	0.024764
Dicle	0.030671	0.054883	0.035324
Garzan	N/A	0.051156	0.050141
Batman	0.028799	0.045724	0.049445
Ilisu	N/A	N/A	0.062208
Mosul	0.066508	0.085751	0.149435

Thus, the Mosul Dam varies more widely when precipitation falls. This is supported when observing the Pearson correlations between each dam's monthly average NDVI and the monthly total precipitation values for the region, as shown in Table 3:

Table 3: Correlation NDVI and Precipitation

Dam	**Correlation**
Kralkizi	0.023350
Dicle	0.027463
Garzan	0.089985
Batman	0.136948
Ilisu	0.221445
Mosul	0.318726

At the river systems level, similar trends are observed. As Figure 4 shows, the zone around the northern Tigris River in Iraq has lower average NDVI values than the zone around the northern Tigris River in Türkiye (the same way that the Iraqi Mosul Dam's NDVI values are lower than any other Turkish dams). The Iraqi river system also sees greater decreases in vegetation during periods when precipitation falls than the Turkish river zone sees. This is again supported by looking at the Pearson correlation between the monthly average NDVI and the monthly total precipitation values around the Tigris River: in Iraq, the correlation value was 0.165263, while in Türkiye the correlation was 0.074732. Therefore, both the river system zones and individual dam zones show that Iraq has a lower average NDVI score, a greater decrease in vegetation during periods of drought, and a greater correlation between vegetation and precipitation than Türkiye.

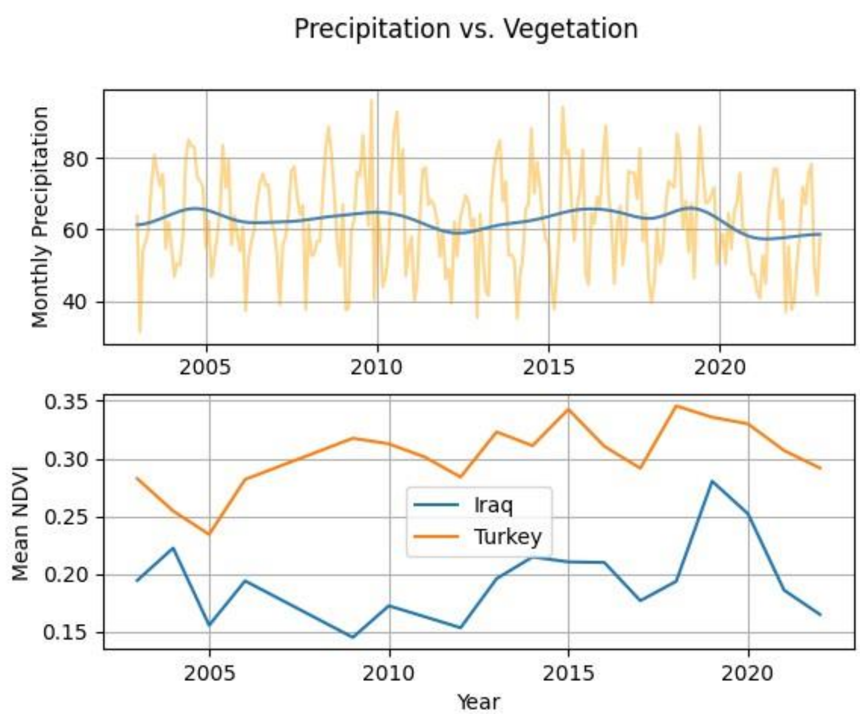

*Figure 4:*Monthly Precipitation and Average NDVI (River Level)

3.2 Population

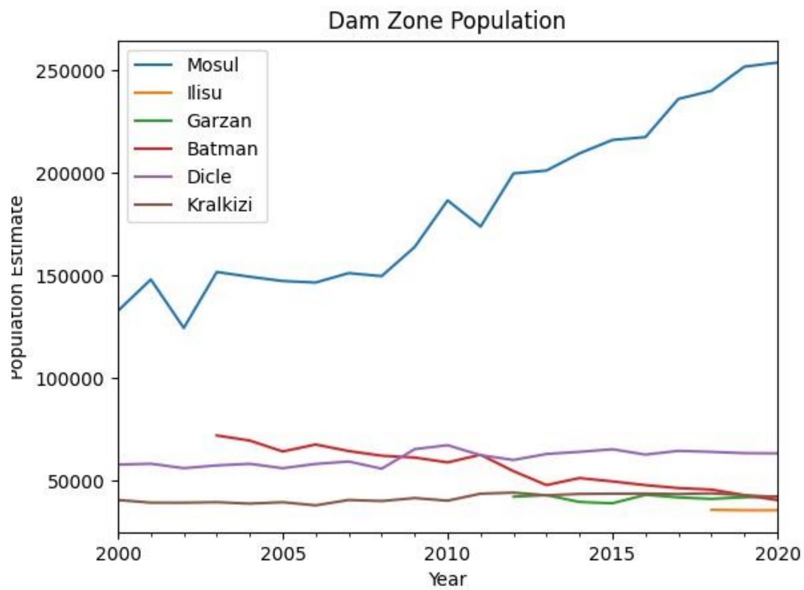

Figure 5: Population around Dams

Figure 5 shows that around the Mosul Dam (which does not include the city of Mosul), the population has almost doubled from an estimated 132,863 people in 2000 to an estimated 253,902 people in 2020 (an increase of 121,039). This increase in population around the Mosul dam does not seem to support the Iraqi farmers' claims that more difficult farming is causing the displacement of Iraqi farmers. In Türkiye, the Kralkizi Dam saw an increase of only 1,513 over the twenty-year period and the Dicle Dam saw an increase of 5,495. Since its completion in 2003, the area around the Batman Dam has seen a population decrease of 31,495. The Garzan Dam has seen a population increase of 106 since completion in 2012, and the Ilisu Dam has seen a decrease of 211 people. The relatively small increase in population levels (and occasional decrease) is surprising given the Turkish government's rhetoric surrounding the success of the GAP dams.

Looking at the river system level (shown in Figure 6), one sees a similar picture. The population along the Tigris River in Iraq has increased greatly, from 7,221,035 in 2000 to 11,855,890 in 2020 (an increase of 4,634,855). The population along the Tigris River in Türkiye has increased at a much slower rate, from 2,212,245 in 2000 to 2,749,523 in 2020 (an increase of 537,278).

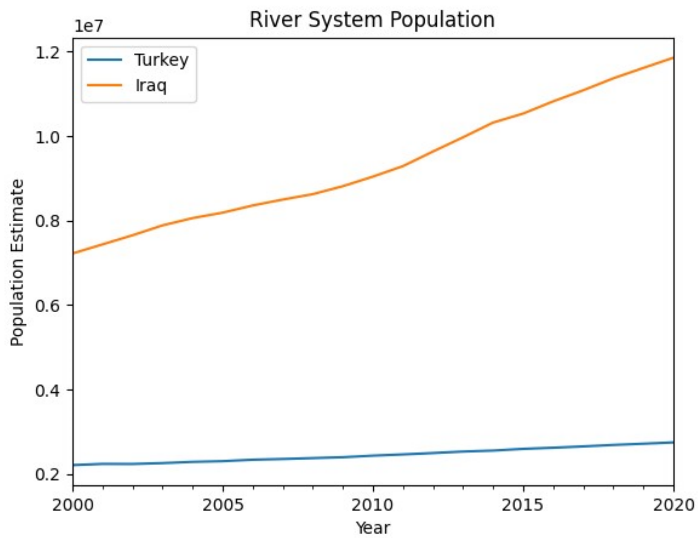

Figure 6: Population around Tigris River

Yearly population counts for the dam zones and river system are available in Appendix Table 7and Table 8.

4.0 Discussion

The findings from population and vegetation showed very similar trends between the dam zones and the river system zones. These trends include Iraq having lower average NDVI values and a higher correlation between NDVI and precipitation, as well as Iraq quickly growing in population over the timeframe while Türkiye has seen only moderate population growth. The shared trends between the dam zones and the river system zones provide reassurance that the circular zone buffers do faithfully represent the trends concerning farmlands irrigated by the Tigris River. Therefore, this discussion will analyze the changing vegetation/population around the individual dams, which enables finer-granularity analysis, in order to compare GAP dams to the Mosul Dam and determine whether there are significant differences in terms of the changes in population and vegetation around the dams.

4.1 Vegetation

If the dams are not carefully managed in order to maintain equitable water access, dam-building projects can decrease waterflow into downstream countries. As Türkiye gains more control over the river basin, Iraqi farmers blame the Turkish dams for their crops dying. Because there is no available NDVI data from the region before the creation of GAP dams, and because there is no openly available river flow data, establishing a causal relationship between Türkiye's dam building project and downstream Iraq's vegetation levels is not possible. This research will instead make observations about the system of dams from 2000 to 2023 without drawing causal conclusions. These observations about the status of vegetation around the dams can expose differences between the conditions around Turkish and Iraqi dams which could be helpful for policymakers.

The first and most obvious difference between the GAP dams and the Mosul Dam is that the Mosul Dam's average vegetation level is significantly lower than that of the Turkish dams (as seen in Figure 3). However, the Mosul Dam is older than the more recently constructed Turkish Dams; it was completed in 1986 while the GAP dams' construction dates range from 1999-2018. Older dams can face challenges like older irrigation piping (resulting in greater water losses along the irrigation network) and increased soil salinity caused by improper irrigation methods (Al-Hedny & Muhaimeed, 2020). These factors would affect the amount of farmland that could be successfully irrigated. Therefore, while we can observe that the Mosul Dam on average has less vegetation, this difference cannot be confidently attributed to the upstream/downstream dynamics of the Turkish and Iraqi dams.

What can be more meaningfully observed is the changes in vegetation during periods of drought (which should not be dependent on features like soil salinity and pipeline loss). Figure 3 shows the monthly precipitation and average annual NDVI values around each dam. NDVI data is unitless, but values closer to 1 indicate an abundance of green, leafy vegetation, while values closer to 0 indicate little to no vegetation. In Figure 3, during years when the average precipitation in the river basin falls, the level of vegetation around the Mosul Dam decreases more sharply that the upstream Turkish Dams. For example, the vegetation around the Mosul Dam decreased by 0.085751 during the 2015-2018 drought; 2018 is when the Iraqi farmer claimed, "Nineveh is becoming a dust bowl" (El Dahan & Jalabi, 2018). In the same years, the Turkish dams only decreased by an average 0.05145. Similarly, from 2019-2022 (when wheat production took such a dramatic fall, according to the *France 24* article (2021)), vegetation around the Mosul Dam decreased by 0.149435, while Turkish Dams on average decreased by 0.044376.

Whether or not this difference can be directly attributed to Türkiye's upstream creation of dams is unclear given the limited available data from before GAP. However, the Ilisu Dam is the last Turkish dam before the Tigris River crosses into Iraq and is only about 83 miles upstream of the Mosul Dam. During the period of low rainfall from 2019-2022, the Mosul Dam saw a decrease in vegetation of 0.149435. The Ilisu Dam upstream saw a decrease of 0.06221 (less than half the Mosul Dam). During the same period, the Dicle Dam – which is 100 miles upstream from the Ilisu Dam, similar to the distance between the Ilisu Dam and the Mosul Dam – saw a decrease of only 0.035324. Thus, there was a significantly larger difference between the fall in vegetation around the dams as the Tigris River crossed the Turkish-Iraqi border (a difference of 0.087225 between the Mosul and Ilisu dams) than there was between dams a comparable distance apart within Türkiye (a difference of 0.026886 between the Ilisu and Dicle dams). While this is not conclusive evidence, it is therefore reasonable to hypothesize that this gap could be attributed to the Ilisu Dam reducing water flow to the Mosul Dam (which is less likely to occur internally because Türkiye would want all of their dams to have adequate water to irrigate and generate hydropower). Finally, Table 1 shows that the vegetation around the Mosul Dam is more correlated to precipitation than any of the Turkish Dams. This means that the extent of vegetation around the Mosul Dam varies more strongly in accordance with the monthly rainfall.

Overall, these differences indicate that the Iraqi Mosul Dam is more vulnerable to periods of drought, losing more vegetated land when there is less precipitation. This is logical because Türkiye, being the upstream county, can withhold additional water during periods of drought. Iraq, meanwhile, is left with however much water Türkiye chooses to pass on. However, it could be hypothesized that these differences between Turkish and Iraqi dams are solely due to the Mosul Dam being farthest downstream – not that Türkiye is using more water. Table 4 shows the correlations between vegetation and precipitation around each dam as the river flows downstream (excluding the Garzan and Batman Dams, which join the Tigris River from tributaries):

Table 4: Precipitation/Vegetation Correlation Moving Downstream

Distance between dams: 14 mi. 100 mi. 83 mi.

Dam	Kralkizi	Dicle	Ilisu	Mosul
Correlation	0.023350	0.027463	0.221445	0.318726

The distances between the Dicle and Ilisu dams and the Ilisu and Mosul dams are roughly equivalent, and the change in correlation is also quite similar. This indicates that changes in vulnerability to drought may be a result of the Mosul Dam being the most downstream dam, not the result of deliberate water policy decisions by Türkiye. Even without dams, less water would reach downstream during times of drought, causing greater fluctuations to downstream vegetation during periods of low precipitation. Nonetheless, by enabling the storage of massive amounts of water, dams drastically increase the scale of the problem. Therefore, it is unlikely the differences in vulnerability to drought as the river flows south are entirely natural. More research is needed to causally determine how Turkish water policy decisions affect Iraqi vegetation; comparison would need to be made between the status of vegetation before and after the construction of the dams.

However, regardless of whether the Mosul Dam's vulnerability to drought is a result of its position as the most downstream dam or a result of Turkish water policy, this research shows that Iraqi farmers are more vulnerable to changes in precipitation, while Türkiye is better able to mitigate the impacts of drought. This is concerning even if the cause of Iraq's vulnerability cannot be directly linked to the new Turkish dams. Iraq's vulnerability to drought increases the power imbalance between Türkiye and Iraq by giving Türkiye more negotiating power through control of the Tigris River waterflow. For example, in March 2023 Türkiye and Iraq representatives met to discuss water and security issues. While not explicitly a quid pro quo scenario, Turkish President Recep Tayyip Erdoğan agreed to increase water flow to Tigris for a month in order to alleviate Iraq's drought problem while stating in the same meeting: "We expect our Iraqi brothers to recognise PKK a terrorist group and purge Iraqi territory of these bloody terrorist organisations" (Mahmoud, 2023). Thus, the Tigris River dams become an additional tool against the Kurdish minority not just as a development project but also as a form of leverage against neighboring countries.

4.2 Population

As Figure 5 shows, the population around the Mosul Dam is increasing over time. Meanwhile, the population around Turkish dams has held steady or (like around the Batman Dam) decreased. Unlike Iraq's vulnerability to drought, which is unsurprising based on the complaints of Iraqi farmers, the changes in population around each dam are unexpected.

The increase in the population around the Iraqi Mosul dam is surprising given the media stories of farmers – no longer able to make a living off the land – forced to migrate to urban centers. From 2000 to 2020, Iraq's population increased from 24,628,858 to 42,556,984, a percent increase of 72% (Worldometer, 2023). The percent increase in the area around the Mosul Dam is even higher at 91%. Because the zone around the Mosul Dam does not include the city of Mosul, urbanization cannot explain this population increase. So why are so many people moving to a rural area that is becoming more susceptible to drought? Further research reveals that southern Iraq is actually experiencing a greater degree of drought than the Mosul Dam area (possibly due to the compounded effects of dams along the Tigris and the Euphrates). A 2019 report by the International Organization for Migration (IOM) estimated that over 21,000 people in the southern provinces were displaced due to scarcity of water for agricultural, livestock, and drinking purposes (Salih, 2023). It appears that those displaced from the south may be moving north (which is experiencing a less dramatic loss of farmable land). The increase in Iraqi farmers around the Mosul Dam is a concern because it will increase the pressure on an already vulnerable resource.

Meanwhile, while Türkiye claims that the GAP project has been successful so far in creating wealth and increasing the standard of living for locals, the population around the dams has not significantly increased, and in fact has decreased in some zones. From 2000 to 2020, the general Turkish population increased from 64,113,547 to 84,135,428 (a percent increase of 31.23%) (Worldometer, 2023). Therefore, the population of the GAP region is falling far behind the national average. Notably, these measurements begin after the completion and filling of the dam reservoirs, so any population decreases caused by state-mandated displacement to fill the reservoir are not included. That the area around the GAP dams is not seeing population growth on par with the national average (an indeed, seeing some migration away from the area) suggests a disconnect between the Turkish government's narrative and the local population's lived experiences. This disconnect is consistent with James Scott's model of high modernism, wherein state implemented development projects often come at the expense of the people they purport to help.

5.0 Future Work

Due to the limited available data from before the construction of the GAP dams, this work is unable to establish a direct link between the construction of the dams and the degeneration of downstream Iraqi farmland. Expanding the scope of the project would increase the sample size of upstream versus downstream dams. This would allow researchers to draw stronger conclusions on whether downstream dams are more vulnerable to drought, and potentially whether the construction of upstream dams causes drought vulnerability in downstream dams. This study focused on the northern Tigris River but could feasibly be expanded to include the entire Tigris/Euphrates River system. This would allow comparison over three different upstream/downstream river crossings: the Tigris as it flows from Türkiye into Iraq, the Euphrates as it flows from Türkiye into Syria, and the Euphrates as it flows from Syria into Iraq.

Additional data could be useful to draw more direct causal conclusions. Given that most farmland in Iraq must be irrigated, this study assumes that falls in vegetation are related to a combination of lower precipitation levels, which in turn cause less water flow through the Tigris River, in conjunction with dam activity. A more direct way of examining the impact of the Turkish dams on the Tigris River would be to obtain river flow data. Both the Turkish and Iraqi governments maintain river gauging stations. Future work could request this historical river flow data from the governments and examine changes in vegetation in conjunction with both river flow and precipitation data.

On a wider scale, vegetation and precipitation data are available across the globe, so this comparison could even be implemented at a global level. By increasing the sample size of the study to dams across the globe, researchers could make a stronger case for causation between the creation of upstream dams and increased vegetation vulnerability to drought around the downstream dams. By increasing to a global scale, researchers could also identify if this phenomenon applies more strongly as a transboundary river crosses a state border, or if vulnerability to drought increases uniformly as the river flows upstream to downstream, regardless of state boundaries.

Finally, this study demonstrates the potential value of applying a high modernist lens to evaluate the deviation between Türkiye's narrative surrounding the construction of the dams and the dams' real impact on local populations. A more in-depth case study of how GAP's impacts do/do not fit James Scott's high modernist framework could help conversation surrounding the GAP project to circumvent the dominant Turkish narrative of humanitarian development. Finally, a study as to how the pursuit of modernity influenced the creation of GAP would also help explain why some of the goals of the project have failed to materialize. Research of this nature would join a growing body of literature challenging the idealization of progress/modernization through large-scale state development projects.

6.0 Conclusion

States are drawn to development projects like dams as both symbols of the state's modernity and opportunities to generate wealth (Nixon, 2010). By implementing GAP, Türkiye aims to boost the economic productivity of a rural region through industrial development. However, the state's pursuit of modernity through large-scale development projects often overlooks the lived experiences of local populations.

The World Commission on Dams report in 2000 found that the costs of dam-building projects were disproportionately borne by displaced local populations and downstream communities (Chen & Landry, 2018). By looking at the vegetation and population changes around the northern Tigris River dams, this research found that to be true for the GAP in two ways. First, the population growth around the GAP dams was lackluster, and in some cases, there was a migration away from the dams. This indicates that despite the Turkish promises that the GAP would improve standards of living throughout the area, locals are not seeing the benefits of the development projects. Secondly, vegetation around the downstream Mosul Dam is more vulnerable to periods of lower precipitation than its upstream counterparts. While this cannot be causally linked to the creation of the GAP dams due to limited data, the finding is important to Turkish and Iraqi policy making. During periods of drought, Türkiye as the upstream country is able to withhold water in order to irrigate their land, while Iraq receives the water Türkiye chooses to pass on. This makes the water an important negotiation tool between Türkiye and Iraq. This is especially important given that the population around the Mosul Dam is increasing faster than the average Iraqi population growth, possibly due to intensifying drought in Southern Iraq. This means Iraq faces a situation where a growing population is putting stress on an already strained resource.

Iraq will need to make some difficult decisions moving forward in order to allocate their remaining water resources, provide for their growing population, and effectively negotiate for a larger water allocation from Türkiye. Meanwhile, Türkiye (in the absence of global enforcement concerning the equitable distribution of shared water resources) will retain control of the Tigris and Euphrates rivers. However, the Turkish government will need to evaluate how their development projects are affecting their local populations in order to truly live up to the humanitarian ideals of the GAP development plan.

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8.0 Appendix

Table 5: Average Yearly NDVI Dam Zones

Year	Ilisu	Mosul	Garzan	Batman	Dicle	Kralkizi
2003		0.253718		0.312025	0.315707	0.305438
2004		0.262356		0.326826	0.329275	0.299595
2005		0.20155		0.231879	0.232431	0.230004
2006		0.23438		0.305926	0.338678	0.342255
2009		0.195815		0.332906	0.359359	0.347743
2010		0.256985		0.325471	0.339108	0.334819
2011		0.212426		0.303291	0.313377	0.305129
2012		0.190477	0.302966	0.296672	0.308437	0.301724
2013		0.253979	0.344876	0.327287	0.337739	0.328447
2014		0.258071	0.331418	0.317625	0.341344	0.329019
2015		0.297393	0.371117	0.359114	0.368611	0.357616
2016		0.251483	0.336989	0.325914	0.328512	0.318185
2017		0.211641	0.319961	0.31339	0.313727	0.303554
2018	0.318468	0.218365	0.372469	0.35427	0.367259	0.35436
2019	0.327362	0.33364	0.354428	0.349161	0.356822	0.342079
2020	0.319086	0.293471	0.35133	0.342082	0.349679	0.331782
2021	0.273284	0.21393	0.304287	0.299716	0.329072	0.32162
2022	0.265154	0.184205	0.313668	0.308395	0.321498	0.317314

Table 6: Average Yearly NDVI River System

Year	Iraq	Türkiye
2003	0.19446	0.282595
2004	0.222518	0.254589
2005	0.155636	0.234296
2006	0.194063	0.281875
2009	0.145145	0.317521
2010	0.172514	0.312697
2011	0.163069	0.301298
2012	0.153482	0.283952
2013	0.195996	0.322994
2014	0.214748	0.311156
2015	0.210542	0.342585
2016	0.209973	0.310548
2017	0.17692	0.291548
2018	0.19369	0.345514
2019	0.280348	0.335733
2020	0.25208	0.329969
2021	0.186038	0.30693
2022	0.164986	0.291716

Table 7: Population in Dam Zones

Year	Mosul	Ilisu	Garzan	Batman	Dicle	Kralkizi
2000	132862.9				57944.54	40701.11
2001	148178.1				58394.26	39422.09
2002	124549.5				56225.18	39396.99
2003	151839.6			72162.14	57566.28	39636.21
2004	149520.6			69681.19	58355.38	38957.1
2005	147447.3			64356.89	56204.63	39627.96
2006	146697.1			67754.8	58291.65	38102
2007	151298.3			64561.9	59467.67	40726.38
2008	149826.5			62293.43	55972.14	40203.8
2009	164004			61404.38	65491.45	41651.85
2010	186738.7			59036.41	67410.41	40382.79
2011	173964.8			62757.23	62552.68	43797.7
2012	199877.3		42320.05	54753.85	60223.5	44303.33
2013	201294.9		43086.32	47981.67	63145.6	42993.11
2014	209668.3		39748.61	51408.41	64185.21	43655.82
2015	216197.6		39110.2	49763.47	65441.57	43785.23
2016	217591		43233.36	47947.23	62826.79	43815.96
2017	236199		41962.09	46518.98	64675.58	43589
2018	240140.9	35925.29	41264.36	45788.82	64168.4	43968.04
2019	251925.5	35704.26	42023.65	43091.67	63545.54	43012.09
2020	253901.6	35714.42	42425.6	40667.49	63439.89	42214.23

Table 8: Population in River System Zones

Year	Türkiye	Iraq
2000	2212245	7221035
2001	2240604	7437031
2002	2238727	7652688
2003	2259528	7887450
2004	2289289	8059534
2005	2305243	8188443
2006	2339826	8358328
2007	2357015	8498434
2008	2377815	8626455
2009	2398939	8814705
2010	2436297	9041495
2011	2465369	9289996
2012	2497794	9636086
2013	2533191	9972457
2014	2556565	10320861
2015	2596450	10534125
2016	2623823	10823290
2017	2654645	11085156
2018	2689883	11368204
2019	2718531	11614235
2020	2749523	11855890