



Faculty of Political Science

“Project-level Analysis of Transboundary Agreements on the Irtysh and Mekong Rivers: Analyzing Hydro-Hegemony Theory Through Apt-Scale Research”

CEERES Master’s Thesis

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August 2024

Stony Brook, NY, USA

Field of Studies:

In Partial Fulfilment of the Requirements for the Degree of:

Master of International Relations (Central and East European, Russian and Eurasian Studies):
Kimep University, Kazakhstan

International Master's (IntM) in Central and East European, Russian and Eurasian Studies:
University of Glasgow, UK

Master of Arts in Social Sciences (MA) in Central and East European, Russian and Eurasian
Studies: University of Tartu, Estonia

Word count of the thesis: 22,109

Authorship Declaration: I have prepared this thesis independently. All the views of other
authors, as well as data from literary sources and elsewhere, have been cited.

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Abstract:

This research conducts an analysis of the factors which inform China's governance of the Irtys River between China and Kazakhstan and the Southeast Asian states bordering the Mekong River. Scholars have referred to China's governance as an instance of 'hydro-hegemony,' wherein China governs its transboundary water resources by initiating limited cooperation with its neighbors to extract maximum benefits for itself. This research seeks to contribute to existing Hydro-hegemony theoretical literature by presenting an 'apt-scale' study of China's dam development. This 'apt-scale' analysis seeks to rationalize China's water agreements with the implementation of dam projects at the local level and is concerned with how local stakeholders of Chinese policy implement dam projects. This research is conceived as a longitudinal study which contextualizes dam development and water use cases outlined in the bilateral agreements signed between China and Kazakhstan and cases between China and Laos under the multilateral Lancang-Mekong Compact (LMC). To gauge the impact of development projects, this research utilizes GIS satellite data to measure how China's domestic and international development of dam projects impact the quantity and quality of transboundary water resources and contributes to water disputes. To contextualize China's implementation of dam projects and their logic of hydro-hegemony, this research presents international law standards of transboundary river governance, China's domestic laws and the agreements between China and its neighbors to lay out internationally and locally accepted parameters for cooperation. The objective of this study is to establish an 'apt-lens' of enquiry to gauge the impact of transboundary dam construction on China's hydro-hegemony and to understand how China's governance of these resources informs its utilization and development of transboundary water. disputes. The 'apt-scale' lens of research contributes to a gap in existing hydro-hegemony research which does not include a serious engagement with the impacts that water governance stakeholders have on the maintenance of TBW. This study found that there is a significant disconnect between China's TBW stakeholders in their implementation of policy – leading to disjointed governance and the intensification of China's hydro-hegemony. This research presents that International Water Law could aid China in resolving its hydro-hegemonic dominance.

- **Keywords:** transboundary river governance; Hydro-Hegemony; bilateral and multilateral relations; GIS; longitudinal case study

Acknowledgements

First and foremost, I would like to thank my parents for their unending support. None of this would have been possible without them.

I would also like to thank my advisors Nygmet Ibadildin and Adrian Florea for their feedback and Professors Sergey Sayapin and Aigul Adibayeva for their help and advice on bringing this research into action.

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I. Introduction

A. Background on China’s Transboundary Water Policy in the Twenty First Century

By virtue of its geography, China has been characterized as a ‘hydro-hegemon’ to its downriver neighbors in Central, Southeast and South Asia, controlling the water resources that flow downstream to fourteen neighboring countries across forty transboundary river basins (Wouters “The Yin and Yang of International Water Law”). Due to its position

commanding the headwaters of many important rivers in the region and given the country's massive population, rapid industrialization and need for water, disputes have arisen between China and its downriver neighbors over the quality and availability of water resources along their shared rivers due to China's hegemonic geography. To study water relationships like those exhibited by China and its neighbors, the school of Hydro-hegemony was developed to characterize how states manage their shared water resources, seeking to understand the nuances that exist between cooperation and conflict over water resources (Zeitoun and Warner 436). Hydro-hegemony theory was formalized in 2006 by Mark Zeitoun and Jeroen Warner to study how states manage the 'dynamics and intensities' of conflict to elucidate how states exert control over water resources. The theoretical lens of Hydro-hegemony contributes to an existing literature on water relations that the authors believed lacked a critical analysis of the factors that drive conflict and prevent cooperation (Zeitoun and Warner 436, 437). The researchers developed Hydro-hegemony theory to answer the fundamental questions of "who gets how much water, how and why?" (Zeitoun and Warner, 435). Crucial to the exercise of Hydro-hegemony, an upriver or upper riparian state utilizes its dominant geographic position, typically by constructing physical infrastructure and dams to control the flow of water and by enforcing international and state-state treaties that act in the benefit of the more powerful state and by implicit or explicit coercion and even violence (Zeitoun and Warner, 435).

China recognizes its dominant position over many of Asia's critical rivers as well as its potential for coercion. As such, the country has sought to balance its 'hydro-hegemon' status in the region by creating partnerships with many of its neighbors with the goal - ostensibly - to equitably develop and promote cooperation over shared water resources. In doing so, China claims to affirm principles of international water law (IWL) within its governance of shared water resources with its neighbors. IWL has developed over time to allow states to resolve disputes over water resources, by encouraging them to implement dispute resolution practices and attempt to ensure that water is both equitably and rationally shared between neighbors. These standards have been codified as the 'best practices' for state-state water relations (Talozi, et al. 912). To manage these water relationships, China often states that it is following the accepted practices of IWL. Through analysis of China's transboundary water treaties conducted with its neighbors, one would believe that China has ostensibly aligned its governing standards with existing international law agreements to govern transboundary waterways and resolve disputes. China's strategy further dovetails with

the country's more recent global push to promote benevolent relations with its global partners and create positive development outcomes for all countries seeking to cooperate within China's frameworks, a policy referred to by China's President Xi Jinping as 'win-win cooperation' (Chen). Patricia Wouters, a leading scholar on China's water policy through the 2010s to 2020s has referred to China's cooperation with its neighbors as a "soft path" to cooperation, aligning China's governance of transboundary water with its greater interests to promote regional prosperity and foster positive outcomes within the framework of China-led development initiatives (Wouters and Chen 229). Despite trying to appear as a 'good neighbor' to its lower riparian partners, the very disputes that China's governance frameworks seek to address still rage on, in some cases, even decades following the formalization of transboundary water relations between China and many of its neighbors – reaffirming China's status as a hydro-hegemon.

A major facet of these disputes is the governance and management of dam and water diversionary projects along transboundary rivers. Within its borders, China is the world's largest producer of hydropower, totaling over 70,000 dams (Wouters, et al 1). Likewise, the development of water-diversionary canals has taken off within some of the country's more arid regions to fuel the development of industry and the growth of agriculture and cash crops like cotton. By their nature, dam and water diversionary projects can change the chemistry, flow and temperature of the water, with more severe impacts on ecosystems if these projects are constructed improperly or mismanaged ("Hydropower explained"). Likewise, China's release of water across its dams has raised disputes over the share of water China is coming to use and the quality it leaves the extant water in. For Kazakhstan, this has spurred the drying of crucial lakes within the country's borders, while the flow of water fueling agriculture has either been severely limited or excessively released with China's Mekong River neighbors (Wouters et al 5). With a glut of dam projects within its own borders, China's state-owned enterprises (SOEs), the main executors of dam construction projects have turned to foreign states - under the auspices of China's globe spanning Belt and Road Initiative (BRI) - to construct further projects. The agreements and the working groups that manage these foreign-built projects and the usage of water resources are likewise not made public knowledge, making it difficult to ascertain the impact of negotiations over water relations (Hall and Swain). China's transboundary rivers, sit at the confluence of these two regulatory environments - China's domestic and foreign governance of transboundary water. China's domestic border regions are relatively underdeveloped and "have significant

transboundary hydropower potential that has yet to be exploited” (Wouters, et al. 2). The rich investing opportunities afforded by BRI for Chinese firms has likewise created the opportunity for China to construct projects in developing frontier markets that have a growing need for electricity and water to fuel growing cities and agriculture. This has spurred fast-paced and competitive development for the tenders of China’s foreign and domestic dam projects alike.

To understand how China’s construction of individual dam projects feeds its regional hydro-hegemony, this study asks the following questions: Why is it that despite China’s efforts to build treaty consensus and obligations in accordance with IWL, do disputes over transboundary water continue to flare up? How do the actors involved in China’s implementation of water governance impact the country’s hydro-hegemony? How does China apply IWL principles in its governance of TBW? This research contends that while China has made many strides to implement actionable transboundary water policy, the country’s claims of adhering to ‘international best practices’ in water management have been hampered by its inaction in implementing the United Nations transboundary IWL treaties. These agreements govern the processes of transboundary cooperation along principles of “reciprocity” and “equality” between riparian partners (“International Water Law” 1). China’s inaction in treaty implementation has hindered the country’s ability to create a cohesive and mutually beneficial transboundary water relationship with its neighbors, address its regional hydro-hegemony and create cohesive partnerships between the state actors who enforce governance standards.

B. The Fuel for Hydro-hegemony: Lack of enforcement mechanisms and the principal-agent problem in enforcement

By not signing onto the international treaties which govern transboundary water, China has largely written its own rules of transboundary water governance and management (Hall and Swain). This creates a two-fold problem in resolving its transboundary water disputes. Firstly, China’s lack of adherence to international water law negates the country’s responsibility to include dispute resolution mechanisms and enforceable water management obligations under its existing treaties to address its hydro-hegemony (Wouters, et. al. 3). This enforcement is a staple of the 1969 Vienna Convention and should be adhered to under international legal obligation and is often even codified as part of a country’s domestic law (Butchard) This research contends that China’s hydro-hegemony is driven by a lack of a

unified governance standards which are typically enforced under international law. This lack of overarching regulation has led to differing standards of enforcement and differing regulations between localities, government agencies and SOEs - even at times on different stretches of the same river. This mosaic of governance responsibility contributes to a principal-agent problem or enforcement gap. The principal-agent problem refers to the Zhou Xueguang's research on the relationship between China's central government in Beijing and local policy enforcers. He describes "the causal relationships" (Zhou 2), that often lead to nonuniform policy decisions between the high echelons of government and localities. This has engendered an often-competing cast of special interests, agencies and project managers, each trying to prioritize their own interests in a nonuniform regulatory system (Zhou 11). Along a transboundary river, stretching within China's domestic borders and tied into international development interests under BRI, these enforcement gaps have created major regulatory challenges for China and its neighbors, complicating an ostensibly shared goal to equitably manage shared water resources.

C. Study Focus

To explore this regulatory web of competing water management interests between China and its riparian neighbors, this research presents a comparative analysis of governance initiatives and projects taken on two transboundary rivers. This research analyzes China's governance of the Irtysh River state of Kazakhstan and the Mekong River state of Laos. These two rivers and states have been chosen as points of comparison for their relative similarities as much as their differences. On one hand, the international governance of these rivers presents the opportunity to compare bilateral and multilateral governance efforts. The Irtysh is managed by a series of bilateral treaties between China, Russia and Kazakhstan (Muratshina). The Irtysh governance framework is legally interpreted as a "binding agreement" and granted enforceable authority via the signatures of the state representatives who signed onto the agreement - it is a demonstration of China's most effective transboundary water governance initiative to date – especially compared with its Southeast Asian neighbors (Ho). In contrast, the Mekong is governed through the multilateral Lancang-Mekong Compact (LMC), a convention which includes "built-in mechanisms" to ensure compliance (Myers). The states of Kazakhstan and Laos have been chosen because they are direct cross-border neighbors from China along both of their respective rivers. They share some of the same direct impacts of China's domestic dam development and as project sites

for China's foreign dam development. Despite these disputes, each side has varying levels of successful cooperation with China. For Kazakhstan, this governance has engendered a more long-term and cooperative relationship with China and has led to a multi-decade long negotiation process dating back to 2001 and ongoing today to manage the region's transboundary water relationship with a focus on delineating water-sharing agreements to determine the quantity and quality of water reaching downriver states (Wouters et al. 5). For the Mekong, the 2016 LMC represents a much more recent effort along a river that has been noted by scholars to be a more institutionally-weak region for China's transboundary water governance ("China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation" 145). The LMC is governed largely through Memoranda of Understanding between China and its neighbors and focuses on jointly developing the economic potential of the basin through shared tourism, infrastructure and economic development initiatives as opposed to water-sharing efforts ("China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation" 145). In both cases, the governance of these rivers is enacted using thematic working groups, which seek to address specific disputes that may arise in the governance of these rivers - however, the findings and goals of these working groups are unpublished and remain unavailable to the public. Fundamentally, there is a lack of transparency in China's water-sharing agreements.

To conduct this study of these dam cases along the Irtysh and Mekong Rivers, this research analyzes the impact of China's governance frameworks on the construction of dam projects along the Irtysh and Mekong rivers in the context of IWL and the agreements signed by China and its partners to govern their shared transboundary rivers. To measure these data on Chinese dams' impact on downstream states, this research utilizes metadata on waterflow, specifically measuring the mean of water flowing through a dam and the measuring water quality by analyzing turbidity data. These data were taken from Landsat satellite mapping on Google Earth Engine and coded with R. The specifics of these data are discussed in the Methodology section.

D. Literature Review and Hydro-Hegemony Theoretical Framework

The literature review explores the formation of Hydro-hegemony theory, beginning by briefly discussing this school in comparison to the existing theories of Realism and Liberal-institutionalism that had previously dominated the study of TBW wholistically. The former emphasizes a "Neo-Malthusian narrative" (Hayat et al. 1724) that disputes over water

are likely to end in conflict or ‘water wars’ because states will be unable to accommodate their differences in water usage. The latter, on the other hand, makes the claim that states will be able to resolve disputes by aligning their self-interests to diffuse conflicts over TBW (Hayat et al. 1724). Hydro-hegemony developed with components of both theories. In particular, the theory adopted Realist ideas that water can be weaponized by the state, while also incorporating Liberal-institutionalist theories that states can utilize institutions to mitigate the severity and scope of conflict (“Towards an Inclusive Development Framework for Governing Freshwater Resources” 97). Critiques of Realist and Liberal-institutional theories that led to the development of Hydro-hegemony theory as its own standalone lens to study water relations will be further discussed.

Following this, a review of the component parts of Hydro-hegemony theory is conducted through analysis of the theory’s constituent concepts of geographic positionality, power asymmetry and conflict intensity. These concepts will be defined to establish the theoretical analysis of TBW policy utilized in this research. The typologies of Hydro-hegemony, positive and negative hydro-hegemony are explored to contextualize how the state can weaponize its hydro-hegemony. Some of the avenues looked herein are the application of institutions, treaties and economic power, as described by Zeitoun and Warner (2006). Critiques of Hydro-hegemony theory and the call for apt-scale research in the study of Hydro-hegemony will likewise be discussed. Critiques are proposed by Hayat and Luis Paulo Batista da Silva, who state that Hydro-hegemony is limited in its in-application of apt-scales research on how higher levels of governance inform the local actors who implement water policy (Da Silva and Hussein 43; Hayat et al. 1732). These researchers see the development of ‘apt scales’ as an important theoretical contribution to the theory of Hydro-hegemony which is currently underdeveloped. Following is an analysis of scholarly works written on China’s Hydro-hegemony in the focal regions of this work – Kazakhstan and the Mekong River states. Thus, establishing the applicability of Hydro-hegemony theory to the rivers studied in this piece. This research further applies the ‘principal-agent’ dilemma as another contravening factor to China’s hydro-hegemony. The application of this theory provides an explanation to address the existing gap between the enforcement of China’s stated goals in its governance and the impact of competing interests between Chinese officials, water managing authorities and state-owned enterprises (SOEs) which implement dam construction both domestically and abroad. This theoretical analysis of China’s governance demonstrates how

China's stated intentions at times conflict with their actions in the implementation of transboundary water management initiatives.

E. Overview of Empirical Case Studies

The discussion of the empirical case studies establishes the apt-scale for this study of China's hydro-hegemony discussed in this research begins with crucial background on China's implementation and relationship to IWL. The background explores the international agreements which define IWL and discusses the documents which inform China's domestic and international governance of TBW. This establishes the baseline for international expectations for how TBW should be managed. China's National Water Law and provincial water governance policies in the cross-border provinces of Xinjiang and Yunnan are discussed in the context of their impacts on the availability and quality of water resources as they relate to the regulation and implementation of water diversionary projects and dams. In particular its Western Regions Great Development Project or "Go West" development plan on the governance of water resources in Xinjiang Province and Yunnan provinces and relevant regulations on the construction of dam projects in both provinces during the late 1990's to 2020's to trace the development of China's. The country's governance of foreign dams is gauged through a review of the governing documents of the BRI, which was announced in 2013, further highlighting the 'green governance' reforms taken in 2017 to address negative international reception that the BRI has garnered in its implementation of projects in developing economies.

Following the background information, the specific water sharing dilemmas facing the Irtysh and Mekong Rivers are explored in the context of China's development along its shared rivers. A 'profile' of the rivers is established. This moves to an exploration of the dams studied in this research. Two cases of water diversionary projects on the Irtysh: the Kara-Karamay Canal/Project 625 Dam and the Turgusen-1 Dam. On the Mekong, the Nam Ou-2 Dam and the Nuozhadu Dam are studied. Explored herein are the specific SOEs which manage China's dam projects and some information on how they have implemented some of the guidelines China has set out for foreign and domestic hydropower development.

F. Research Methodology

This research explores an apt-scale of development to Hydro-hegemony literature by conducting a longitudinal analysis of dam projects to assess changes over time and understand the impact of water management policy on the implementers of Chinese dams. The application of a longitudinal study is crucial to provide an overall understanding of the changes and dynamics of development across the river basins studied herein. Were the study not constructed in this way, it would not be possible to gain a clear understanding of the developments that shape water use in these basins. These data were measured across two epochs along both rivers. The first epoch is March 16, 1984, to December 31, 1999 and the second is January 1, 2000 to December 31, 2021. The first epoch allows for the establishment of a baseline of how the rivers' quality and quantity were before the construction of major water infrastructure occurred. The second epoch range of dates has been chosen because it represents a period where most of China's transboundary governance management regime and reforms have been established and formalized between riparian partners. These two epochs are likewise important because water interactions need to be measured over a period of multiple decades (Peng et al.) to be fully contextualized – otherwise the data would be considered incomplete.

This section analyzes the quality and quantity of available water resources taken at each dam site. It analyzes stretches of the rivers from where the dam was constructed to where the dam's water resources either flow into a tributary river or crosses the border into its neighboring country. This limited area of study seeks to minimize the impacts on water quality from confounding variables outside of the scope of this study, such as seasonal changes to water flow or the overuse of a basin from agriculture. To analyze the quantity and quality of water resources, this research utilizes Google Earth Engine GIS modeling - for both international and domestic dam projects. The research's utilizes GIS monitoring to measure data on the water quality and quality before and after dam projects were implemented along the rivers. To measure quantity, the flow of water according to the presence of 'surface water intensity was measured according to the Joint Research Centre's (JRC) Global Surface Water Dataset. JRC is maintained by the European Commission and measures instances where water is observed to flow at a particular area across two homologous points to calculate the mean of water flow occurrences. In the context of water quantity, a homologous point measures the occurrence of water flow events by comparing

surface water intensity on the same date across each recorded epoch. (François Pekel et al. 8). For data on water quality, the indicator of turbidity is measured using the NDWI scale, to measure the mean of suspended particles annually. The utilization of satellite data from Landsat-5 and Landsat-7 on Google Earth Engine has been chosen due to a lack of reliable data existing from Chinese sources and the lack of data available on working groups which implement transboundary water policy. In measuring both the quality and quantity, the mean of occurrences is measured because it provides a look at the total averages of water interactions across the measured river basins. Both the necessity for an analysis of nearly forty years of hydrological data and the ‘data reliability problem’ will be further discussed in the Methodology section.

This research addresses a two-fold gap in the existing research on China’s hydro-hegemony. Firstly, the focus on individual dam projects and the relationships between their implementers at the national and subnational levels brings a lens of “apt-scale development” to the theoretical discussion of hydro-hegemony in China’s water relations (Hayat et al. 1732). According to Hayat, much of the Hydro-hegemony literature focuses solely on power relations between state actors. Apt-scale development calls for a reexamination of all stakeholders, their policies and activities in constructing hegemonic behaviors at the basin level and refocuses this study of hydro-hegemony away from looking solely at power relations (Hayat et al. 1732).

This research looks at the top-level policies in Beijing and in Chinese cross border provinces and studies their application at the project-level – that is – how policy impacts the actors directly involved in the construction of dam projects to realize this study of ‘apt-scales’. Secondly, the use of GIS spatial mapping brings into the analysis the actual physical impact of dam projects on the ecosystem. Much of the existing literature on Chinese hydro-hegemony focuses on the legal text analysis of transboundary water agreements. This research argues, that in fact, granted that China’s agreements claim to support ‘international norms’ of transboundary water management, it is more prescient to look at how China implements transboundary water projects, instead of analyzing their legal rhetoric as much of the existing transboundary water scholarship does. Likewise, the use of satellite data undercuts dubious data that is provided by government sources, which are often censored within China. As such, this research treats the legal agreements signed between China and its

neighbors as crucial background, but the actual analysis is conducted on project-level management of transboundary rivers.

II. Literature Review

A. The Realist School of Transboundary Water

The establishment of scholarly discourse around transboundary water relations arose in the late 1960's and 1970's and paralleled a time of uncertainty in the global community. In these years, a "new age of scarcity seemed to dawn," wherein – as many Realists believed – resources would not be used in an equitable manner by states (Gerlach). In the mid 1970's, compounding global droughts, famines and a population boom following the Second World War caused many policy makers and theorists to believe that interstate conflict over water resources was inevitable (Soubeyran and Tomini 282). As these new threats to water security developed, social scientists followed suit in attempting to provide an understanding of how states would work to serve their own interests in this new international environment. The early theories on TBW governance largely reflected a Malthusian approach to the governance of water resources. Elinor Ostrom, who conducted her graduate field work in the early 1960's summarized the sentiments of this approach in her 1990 work "Governing the Commons." She described Garrit Hardin's 1968 coining of the term the 'tragedy of the commons' as a seminal moment in Malthusian TBW theorization. Hardin's "pasture 'open to all'" (Ostrom 2) represented an existential threat to many who were witnessing governments mismanage their shared water resources on a global scale. This question of how to govern "many individuals use [of] a scarce resource in common" (Ostrom 2) became an animating question for this school of water relations. Indeed, most Realists believed would only end in 'water wars' between states to assert dominance over the limited, but all-important resource. The Malthusian narrative was developed further with John K. Cooley's 1984 piece "The War Over Water," which posited that water was not only a common good, as stated by Hardin, but also a 'strategic resource' that could be weaponized by states – especially in regions where water was in short supply. In his own research on the conflicts between the Arab states and Israelis, he explained that water was weaponized through the construction of diversionary projects that denied access to and polluted existing TBW resources (Cooley 5). Cooley cited research that he conducted between Israel and its Middle Eastern neighbors, wherein water was used as a tool for Israel to leverage further geopolitical concessions from its neighbors

(Cooley 4). Thomas F. Homer-Dixon took these ideas further in 1991 with his concept of environment-scarcity, citing in particular that the depletion of water resources would increase the likelihood for conflict to emerge as policymakers would not be able to contend with societal disruptions caused by the lack of water (Homer-Dixon 79). Homer-Dixon particularly studied the impact that water scarcity would have in developing nations – which he believed would be unable to contend with societal shocks that water shortages would have on crop yields, unemployment and the creation of goods – among other areas (Homer-Dixon 78). These sentiments – that states were incentivized to not only utilize, but also weaponize transboundary water resources - would go on to define one of the key pillars of Hydro-hegemony theory, as will be discussed further in the literature review. To summarize the overall sentiments of Realists, they tend to believe that cooperation is not likely, nor logical for states to embark on and that conflict is likely to break out over water resources.

B. The Liberal Institutional Approach to TBW

The rise of Malthusian ideas on the inevitability of conflict over water resources was met with counterarguments and critiques from Liberal theorists. Even as the theory underpinning the Realist argument for transboundary water conflict ossified in the 1960's, institutional cooperation over transboundary water was starting to become solidified in IWL. The concerns of overuse and mismanagement of water resources impelled practitioners of international law to meet to determine rules for how states should manage their shared water resources. Their meeting in Helsinki would later be codified into the Helsinki Rules (1966), which adopted guidelines and unified internationally recognized definitions relating to the “waters of an international drainage basin” (Article I, Helsinki Rules) which should be governed under IWL. Under Article II of the Helsinki Rules, an international drainage basin includes the geographic area extending “over two or more states” and includes all surface and groundwater. The Helsinki Rules further established blanket targets for how states should cooperate over shared water resources. Under IWL, the water users are bound to treat water as a public good and necessitated a principle of fair or reasonable-use. This doctrine further established that water users had a ‘duty’ under IWL to cooperate and should cause ‘no significant harm’ to the water resources enjoyed by the lower riparian (Meshel and Yahya “International Water Law and Fresh Water Dispute Resolution” 513). Taken together, the principles under IWL sought to redirect states towards cooperating along shared goals – for

all sides to utilize water resources - to ensure that they are equitably shared between all riparian parties (“International Water Law” 1).

As in the case of the Realist literature on TBW, Liberal attempts to institutionalize TBW would encourage theorists to develop their own dogmas on TBW relations – in this case, developing a theory on how state-state cooperation could be possible as countries attempt to prioritize their domestic water needs. Liberal theorists operate on the principle that “states are embedded in domestic and international civil society” (Moravcsik i). That is to say that are influenced not only by their domestic needs, but also by international frameworks like IWL. Moravcsik posits this classical Liberal attitude towards institutions, that “state behavior can be predicted based on the preferences of all the states involved.” (Moravcsik 12). Fundamentally, these interactions are driven by the ability of a state to resolve conflicts within its borders and outside of them and in doing so create a coalition of stakeholders that will work together for “mutual gains” (Moravcsik 16, 17). The act to bring these groups together to cooperate towards their mutual gains eschews the likelihood for conflict to break out.

Given the interwoven web of interests that states establish to maintain their coalitions, Liberals likewise do not believe that conflict over resources like water are likely to break out to the level of ‘water wars.’ Ostrom herself was one such challenger of the Realist perspectives discussed in the prior section. She believed that the Malthusian argument utilizes ‘extreme assumptions’ about how state actors will operate under opportunistic circumstances (Ostrom 183). She believed that the institutionalization of norms and the participation of states in “contingent strategies” would encourage participation in resource sharing behaviors (Ostrom 36). To her, this collective action based on shared goals could induce actors towards reducing tensions in their water relationships and establish cooperative norms that lead to long-standing, beneficial water management relationships (Ostrom 37). By working within these system-imposed constraints of differing interest groups, states would be likely to cooperate out of their shared interests to avoid conflict and instead cooperate on common principles. Pointing to documented evidence of conflict over water, Aaron T. Wolf presents the argument that when conflicts do occur between states, they are relatively more contained at a local level – they do not spiral into national conflicts between states (Wolf 256). Taking a dataset of water disputes across the Twentieth Century, he found that only seven ‘minor’ water conflicts occurred, while, in the same period “149 water-related treaties were signed

(Wolf 253, 262). The author defines a ‘conflict’ as an instance where the territory of a country was threatened, where the time period to resolve disputes was limited and the probability for military action was high (255). He states that even in these instances, conflict occurs at the “subnational level” and is waged between local governments, tribal groups or individual provinces (Wolf 256). Wolf posited in the same vein as Ostrom that “shared interests along a waterway seemed to consistently outweigh water’s conflict inducing characteristics” (Wolf 251).

C. Hydro-Hegemony Theory

Hydro-hegemony emerged as its own theory for water relations to provide a level of specificity on how conflict and cooperation can be achieved in between the prescriptions of the Realist and Liberal-institutionalist schools. At its Hayat cites the emergence of Hydro-hegemony theory as a move to resolve an inadequate focus on areas of “asymmetric power relations” between states, differing conflict intensities and the importance of geography in the analysis of riparian conflicts (Hayat et al. 1725). On the theory itself, Hydro-hegemony has been conceptualized by various scholars going back to the late 1980’s and was fully formalized over the course of a 2005 London Water Research Group conference at King’s College London. Hydro-hegemony as a school is largely concerned with Realist perspectives of power relationships and the utility of institutions to extract benefits for the upper riparian state over its lower riparian neighbor (Hayat et al. 1729). The theory underlying hydro-hegemony is concerned with three thematic areas: geographic positionality of riparian states, power asymmetry between states, and conflict intensity. These three areas seek to address some of the gaps in understanding riparian power relations that emerged in the Realist and Liberal schools through the presentation of these three components.

C.1. Geographic Positionality

The geographic positionality of a state as an upriver riparian grants the state outside control in determining practical areas like the quality and amount of water resources flowing downstream. The theoretical literature states that this grants a country further control over the policy and decision-making in the formation of transboundary water legal agreements. In 1985, Frey and Naff postulated the idea of ‘riparian positionality’ in reference to water

conflicts between Israel and Palestine on the Jordan River. The scholars established that Israel's ability to dictate infrastructure development of the upper reaches of the river put Palestinian authorities into a situation where they must accept a *'fait accompli.'* Initially, issues of concern were relegated to blockages and diversions of water resources due to the construction of dams and canals. However, as Israel developed the river further, areas such as the flow, contamination and scarcity granted Israel a greater position in negotiating the use and access of water resources to its downstream neighbor, allowing Israel to control the discussion and course of transboundary river negotiations and connect the issue of water management to other economic and geopolitical concerns that were more important in the moment to their Palestinian counterparts (Frey and Naff 78). Hayat furthered this literature to contextualize 'win-sets' by each riparian and their respective coalitions of domestic actors policy goals that "would be acceptable at the domestic level" (Hayat et al. 1730). These win-sets are all of the possible outcomes of a transboundary water agreement. For the upriver states, these criteria are much narrower than they are for downriver states, which are contented by their geographic position to accept whatever policy concessions the upriver state would be willing to grant (Hayat et al.1730).

C.2. Power Asymmetry

The power dynamics between riparian states play an important role in understanding the characteristics of water disputes. On one level of analysis, theorists like Mark Zeitoun place importance on the upper riparian state's ability to coerce its lower riparian neighbor. This theory is ascribed to Joseph Nye's maxim that "power is about achieving the desired outcome by persuading others" (Hayat et al. 1727). Zeitoun runs with this theory in two pieces published in 2006 and 2010, respectively. The 2006 piece contextualizes hydro-hegemony framework as basin-level dominance of water resources through "water resource control strategies," which center on resource capture, coercion and the use of treaties to establish a governance framework that isolates lower riparian states from being able to cooperate with other neighbors or international bodies that would seek restraint from an upper riparian state (Zeitoun and Warner 436). Zeitoun and Warner explain that these levels of coercion could either be augmented or mitigated via 'hegemonic' or 'counter-hegemonic behaviors' (Zeitoun and Warner 438). To further its dominance at the basin level, the upper riparian state can establish either a 'positive hydro-hegemony,' through the application of norm shaping or a 'negative hydro-hegemony' by setting up barriers to cooperation and

intensifying inflammatory, conflict imposing rhetoric. The 2010 theory focuses more explicitly on the use of soft power strategies in water negotiations. This piece establishes that hegemonic states may actually delay the resolution of water conflicts through the implementation of treaties and working groups that seek to maintain the status quo of water basin disputes (Zeitoun, et al. 160). To this end, water agreements are defined through either their “distributive” or “integrative ends.” For the distributive type of agreement, water policy is delegated by the more powerful upper riparian state and is accepted either by expediency or necessity from the lower riparian state. Integrative ends, meanwhile, are brought about via multiple states agreeing through consensus - often deliberated over many years - to rationally and equitably share water resources (Zeitoun, et al. 163).

In characterizing power dynamics between riparian states, other literature by John Waterbury contextualizes research capture and control strategies by upriver states. In these instances, states with greater population, implicit military strength or access to resources are able to construct water diversionary or obstructive infrastructure that can utilize water resources within their own territory. These actions take two distinct forms, active unilateralism and containment. Active unilateralism, coined by John Waterbury in 1997, prior to the 2005 King’s College meeting, occurs in instances where states do not have formal riparian treaties (the case for most riparian states globally) and as such, states utilize water resources unconstrained by legal frameworks and without consulting their neighbors. Waterbury notes that some states have sought to move away from water unilateralism and formalize their water usage to reach “integrated river basin development” and realize “optimal use” of water resources between neighbors (Waterbury 280). As such, upper riparian states have sometimes sought to take full advantage of their dominant position to create governance frameworks to reinforce their usage of water resources known as containment (Waterbury, 1997). The literature on this type of water relations is based on Amitai Etzioni’s 1961 theory of containment to gauge the drivers of power dynamics between states. These measures include: coercive power, where a “direct threat of force” is approached, utilitarian power, where “bribes and mutual trade” is encouraged between states to conclude disputes in favor of the more powerful state, and normative power, to bolster the standing of “the hegemon” (Hayat, et. al 1729).

C.3. Conflict Intensity

The measure of ‘conflict intensity’ provides a framework to characterize the prior two factors of geographic positionality and power asymmetry. Theorists place the intensity of water disputes on a scale ranging from “cooperation to conflict,” with varying degrees in between. Zeitoun and Naho Muramachi established a continuum to measure individual interactions between states to characterize state-state water relations, the Transboundary Water Interactions Scale (TWINS) outlines four areas, ranging from low conflict to high conflict interactions. A summary of this table is included below:

C.3.1. Table 1: Hydro-Hegemony Conflict Intensity Characterization

Action Characterization	Interaction Type	Interaction examples
Low Conflict - High Cooperation	Positive interaction (“cooperation on equal terms”)	<ul style="list-style-type: none"> ● Establishment and exercising of common principles ● Creation of transboundary water regimes ● Treaty negotiation based on IWL
Low Conflict - Medium Cooperation	Neutral Interaction (“Cooperation on select issues, token cooperation”)	<ul style="list-style-type: none"> ● Joint pollution management bodies ● Sharing of ‘benefits’ ● Establishment of joint water infrastructure (i.e. dams)
Low Conflict - Low Cooperation	Neutral Interaction (“minimal to no interaction, ad hoc cooperation”)	<ul style="list-style-type: none"> ● Insignificant exchange of information ● Some technical commissions
Medium to High Conflict -	Negative Interaction	<ul style="list-style-type: none"> ● Contained conflict

Low Cooperation	("Securitized conflict, violence")	<ul style="list-style-type: none"> ● Resource capture ● Treaty negotiation not based on IWL
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(Source: Zeitoun, Mark and Naho Mirumachi, "Transboundary Water Interaction I." 2008, 310.)

This framework emphasizes a contextualization of water relations not through the sum of state-state relationships, but through the characterization and labeling of individual acts as either furthering cooperation or extenuating conflict. This continuum provides a level of specificity to the analysis of agreements that proves useful in this study's characterization of individual dam projects and agreements between China and its riparian neighbors.

D. Hydro-Hegemony Limitations

Despite attempting to promote an alternative lens to study water relations, Hydro-hegemony theory has been criticized for not providing an "apt-scale" understanding of the relationships between different stakeholders (Hayat et al. 1732). Luis Batista Da Silva and Hussein Hussam, write about the need for apt-scale analysis on the Rio De la Plata River basin shared between Brazil and Argentina. They envision apt-scale development in their own research to understand how Brazil pushes its own hydro-hegemony over the Rio De la Plata River "rather than a simple case of conflict or cooperation over water resources" (Da Silva and Hussam 42) that is described in the Realist and Liberal theories. In their piece, they describes three factors that define the apt-scale analysis: the role of treaties in setting norms for cooperation (47), how cooperation is conducted over 'environmental concerns.' These include how states manage projects together, such as to build shared infrastructure and how different stakeholders operate (49). The last point is the impact of these factors on shaping hydro politics – essentially, how these factors come together to dictate how states construct their water relations in hydro-hegemonic basins (45). To elucidate how an apt-scale of development could be constructed to understand China's TBW relations, this research seeks to understand how China's different organizational levels implement policy – explained through the principle-agent problem.

D.1 Devising an Apt-scale of Hydro-Hegemony for China: the Principal-Agent Problem

To establish hydro-hegemony in the context of China's riparian relations, Zhou Xueguang's approach to 'the institutional logic of governance in China' is utilized to explore the inherent 'principal-agent' problem that exists within China's governance over its vast territory and resources. Zhou conceptualizes institutional governance as the "recurrent, predictable, and often causal relationships based on stable institutional arrangements" (Zhou 2). In China's context, this constitutes an "inherent tension" between the Central government in Beijing and its governments at the local level, which seek to carry out Party-dictated policy. This theory establishes that China has been hampered in its ability to enact the rule of law and the establishment of a professional, issue-informed bureaucracy because such an institution necessarily undermines the preeminent position that the central government in Beijing has enjoyed in directly charting the course of the country's policies. Crucial to this research, this tension has impacted the standardization of international law precepts in China's governance frameworks as it further takes power away from the capital and prevents a top-down implementation of legal standards.

This reality of China's water governance has created a situation where the more localized agencies are not vested with authority to compel regional actors to follow the policy set out by the government. This became a reality in the governance of China's transboundary rivers. Following a 2016 amendment to China's National Water Law, these agencies were headed by Party-appointed cadres called River Leaders, which, according to Shiu-Shen Chien and Dong-Li Hong often have little experience in river management and are appointed by party rank, not experience (59). These officials are granted government-appointed goals to improve the quality of the river (Chien and Hong 58). Likewise, these River Leaders are often compelled to present quick and actionable solutions to improve river management within their own communities, which often means that firstly, concerns for downstream states are not considered, while secondly areas like domestic, upriver pollution control are often emphasized at the expense of other issues that may affect a transboundary river (Shiu-Shen Chien and Dong-Li Hong 62). Suffice to say that this inherent governance tension means that often ad hoc meetings between high-level officials are the main vehicle of river management between China and its neighbors, while the targets and responsibilities for meeting China's end of the deal at the domestic level are often ping-ponged between local officials.

III. Empirical Study

The case studies explored in this study treat the Irtysh and Mekong basins, respectively, as the focal point of this study. To provide background on how IWL informs China's governance of these rivers and informs the apt-scale development of China's governance, a brief overview of the agreements UN's IWL TBW agreements will first be discussed. Following this is a discussion of China's domestic and foreign governance of TBW and the cast of stakeholders which operate within China's TBW governance environment. The presentation of this background presents the higher level of the apt-scale looked at in this research – and establishes China's relationship to IWL norms.

The case studies begin by introducing a 'profile' of these rivers, their importance to China and its lower riparian neighbors and specifics on the agreements that China has established to manage their governance. This acts to characterize the nature of some of the ongoing disputes between China and its neighbors. These problem areas which inhibit transboundary cooperation between China and its neighbors will be explored as they relate to the dam constructing SOEs and the ministries responsible for enforcing legal standards. A description of these projects includes brief background on the projects' power generation capabilities and a discussion of the SOEs which manage the projects. Including some background on their track record in implementing international standards in dam construction and maintenance for other projects they have built globally. Much of the information provided on these SOEs and their projects is provided through the International Rivers NGO, a group which covers the governance and conservation of 'frontier rivers,' which typically do not get much coverage in more traditional media ("International Rivers"). This leads to a discussion of the dam projects which are analyzed using Google Earth Engine. This introduction of dams and water diversionary reviews the history of these projects' implementation, the viewpoints of China's riparian partners – including leaders in both regions - on their construction and an overview of the provincial Chinese entity or SOE responsible for the projects' construction. These dam projects reviewed herein are presented as a longitudinal study that will cover the beginning of each river's formalized governance relationship with China - 2001 for Kazakhstan and 2016 for Laos - respectively and overview some of the programmatic efforts to implement these projects under their relevant legal governance regimes. Projects implemented throughout this range of years have been chosen

because most of China's legal reforms to its domestic water law and the codification of the governance of the BRI have all occurred prior to and during this period.

A. IWL Background

In 1992, the trends discussed in the Literature Review that led to the formalization of TBWs Realist and Liberal schools - the years of uncertainty following global water scarcity and efforts to improve cooperation under the Helsinki Accords (1966) - impelled the United Nations to meet to codify international water sharing norms under the United Nations Convention on the Protection and Use of Transboundary Watercourses and International Lakes. Under the Agreement, parties are required to cooperate to reduce their impact on transboundary water and ensure the sustainable development and management of shared water resources. The agreement is further designed to foster the implementation of existing bilateral and multilateral water agreements between states. ("About the Water Convention"). The text of the agreement itself is largely concerned with preventing chemical effluent and pollution from reaching downstream neighbors and established mechanisms for consultations and arbitration for riparian parties to resolve disputes. Of note in the Agreement, Article 2.1 calls on states to ensure 'reduction of harm' in pursuing water development. Article 2.6 further calls on states to create bilateral and multilateral water regimes with their neighbors which are based on "equality and reciprocity" ("Convention on the Protection and Use of Transboundary Rivers" 3).

The 1997 Convention of Non-navigational Uses of International Watercourses built upon the prior Agreement by establishing that all states party to the Agreement have "rights and duties" in the management of their watercourses (1). In Article 5.2, this Agreement enshrined two crucial points that firstly, states have the right to utilize and develop international watercourses, and secondly that they have the duty to cooperate with their riparian neighbors in their development and protection ("Convention on the Law of the Non-navigational Uses of International Watercourses" 4). On the first point, the Agreement refers to the principle of fair or reasonable use by invoking that riparian users have a right to utilize a watercourse's resources based on factors such as population needs, social and economic needs. Article 6 of the Agreement also cites "existing and potential use" of the watercourse as well (5). Article 9 of the Agreement further calls on Parties to exchange hydrological data to ensure 'good-neighborliness' in the management of transboundary water resources (6).

B. The Chinese Context of Transboundary Water Governance

There is an inherent tension between outright distrust and selective implementation of International Law in China. When the People's Republic of China was established in 1949, China was largely isolated and un-influenced by International Law. Among China's leaders, there is ongoing suspicion of International Law to this day as a package of Western-dictated prescriptions, reminiscent of China's Century of Humiliation in the Nineteenth Century, where the country was dominated by Europe (Williams 2). As China began to open up economically in the 1970's and formally join the United Nations, the country's leaders began to implement International Law conventions into their domestic legal system particularly to increase the confidence of foreign companies looking to invest in China, though this process largely focused on the liberalization of economic reforms (Williams 3). In enmeshing International Law norms into its own domestic institutions, China has followed a path where its governance of legal norms is applied under "specific provisions of national legislation," meaning that the country can execute its obligations under International Law through as narrow or broad frameworks as its leaders would like (Williams). Indeed, China's leaders since the 1970's have taken varying approaches to the utility and necessity of International Law within their system. In the 1990's, China's leader Jiang Zemin called on his officials to "be adept at using international law as a 'weapon' to defend the interests of our state and maintain national pride" (Williams 3). In the present-day, China's current president Xi Jinping has released statements calling for countries to respect the 'universality' of International Law, while stating the opposite at times - that no "one-size fits all" (Williams 3) approach was applicable for all countries. This tension in China's application and adherence to international legal norms becomes apparent in China's governance of transboundary water with its neighbors.

When China does implement the norms of international law in its domestic and international governance projects, China's governance of transboundary water resources is rhetorically intertwined with its guiding foreign policy principle of 'mutual respect for sovereignty and territorial integrity' (Wouters et al. 3). China's rhetorical use of international law in transboundary water management is further constrained by the realities of its water needs. Domestically, China possesses a crucial need for water resources and stands as one of the world's most water-poor states, possessing twenty percent of the world's population and only seven percent of the world's water. By 2030, the country will likely reach a deficit of

200 billion meters in its annual consumption of water (Hofstedt 73). The literature argues that this reality of China's water usage sheds light on why China has adopted a "limited (or restricted) territorial sovereignty" (Wouters and Chen 230). approach to its governance of transboundary water resources. This policy can be traced back to China's initial dissenting statement when the United Nations ratified its 1997 Watercourses Convention, with China's representative to the United Nations Gao Feng stating:

"Territorial sovereignty is a basic principle of international law. A watercourse State enjoys indisputable territorial sovereignty over those parts of international watercourses that flow through its territory" (Wouters and Chen 234).

China's leadership opposed the 1992 and 1997 UN Agreements over the fact that the United Nations sought to grant more rights to downstream states at the expense of upstream ones and necessitated that countries signed onto the Agreement are expected to resolve disputes over water (Zhang and Li 706). Indeed, China's Constitution states that all water resources within the country are considered property of the state and considered to be under total domestic governance of China's government - this applies as well to the country's development and usage of transboundary waterways ("Watershed" 7). Within this approach, China's National Water Law reflects these tensions between ensuring state control over water resources, while seeking to manage the realities of establishing uniform governance frameworks in one of the world's largest countries.

C. China National Water Law

In designating regulatory control over its water resources, China vests governance authority over all of its rivers, including its transboundary rivers, under two ministries, the Ministry of Water Resources and the Ministry of Environmental Protection. Since 2009, the responsibility of managing transboundary rivers has been delegated to the Division of International Rivers, managed by the Ministry of Water Resources (Zhang and Li 709). In 2016, an amendment was granted to China's National Water Law, taking into account "integrated basin planning," which sought to ensure that all future development of water infrastructure along China's watercourses would need explicit approval from "basin management institutions" ("Watershed" 28). These agencies set out top-down policies to manage water resources with respect to the country's National Water Law and in accordance with international treaties, ostensibly allowing China to rhetorically claim adherence to IWL

standards – “the substantive rule of ‘equitable and reasonable use’, the duty to cooperate” (Zhang and Li 706). However, the fundamental lack of a specific governance mandate of transboundary rivers through the country’s National Water Law lessens the responsibility of the country’s transboundary river managers to consider the downstream effects of domestic development – this extends to the SOEs managing foreign projects.

D. China’s Dam Construction Abroad through BRI: Policies and SOEs

Since 2013, the Belt and Road Initiative has served as China’s executor of foreign development projects from railroads, extractive projects and even dams. From the time the Initiative was first announced, it had been criticized by international observers for taking advantage of governments in the Global South for debt-trapping, not using best practices in the construction of the projects and exporting outdated technology which contributes to pollution, among other concerns (Nakano). Seeking to address this backlash, China unveiled a package of ‘green’ reforms in 2017, to present the Initiative as a tool for countries to reach environmental and sustainability targets. The first of the green policies is “The Belt and Road Ecological and Environmental Cooperation Plan,” which calls for “in-depth eco-environmental cooperation and intense eco-environmental protection” in Section IV to create a green, ecologically conscious Silk Road (“The Belt and Road Ecological and Environmental Cooperation Plan”). The second green governance plan instituted by China is the “Guidance on Promoting Green Belt and Road,” includes a policy framework called the Five Goals: the promotion of resource efficiency, environmental friendliness, embedding “the concept of green [development]” into policy, facilitating connectivity, and people-to-people bonds. This policy document further states that the Initiative can assist countries in realizing the United Nations SDG Goals, which will be fully integrated into the BRI by 2025 (“Guidance on Promoting Green Belt and Road”). Despite these assurances, these policy inclusions academics and policymakers are not taking China at its word. This concern has extended to the governance of transboundary water projects around the world. Jesper Svensson, a professor of sustainable development at Oxford University stated that the initiative “does not involve any transboundary water cooperation frameworks” (“The ‘One Belt, One Road’ project and the implications of Central Asia’s water crisis”).

SOEs in the Chinese context are governed through a bifurcated structure of ‘political’ and ‘corporate’ governance (Jin et al. 2). On paper, this creates a structure where these bodies are beholden to both “social” concerns of China’s citizenry, overseen by the Party and

economic concerns, or the corporate dividends of SOE projects. Since China pursued its Reform and Opening Up policy of the 1970's, there has been an inherent conflict between the Party managers and corporate interests, which has been the subject of SOE reform for decades (Jin et al. 23). Despite intentions to reform this system, there is still an inherent difficulty in rectifying governance under these two systems, due to "insufficient oversight" of the SOE managerial class (Jin et. al 3). To rectify these issues, reforms were taken in 2013 under President Xi to bring SOEs more firmly in-line with Party standards and appoint managers who are inclined towards 'Party-building,' namely the construction of CCP values in the management of China's fifty-three 'backbone SOEs.' This, according to some scholars, has had the adverse effect of creating an insulated managerial class who are able to mobilize their Party credentials to avoid demotion and maintain their positions of power. Likewise, this class remains insulated and isolated from lower-level managers and focuses on "short-sighted" governance practices and emphasizes the construction of 'prestige' projects at the expense of sound management practices (Xin et al.). Even with these reforms, the structure of the state-SOE relationship creates a fundamental challenge in "strictly enforcing both water quality and quantity restrictions (as the state that is responsible for the regulation of activities is also the shareholder of the entity it is overseeing. This can create challenges in strictly enforcing both water quality and quantity restrictions.

China's dams built abroad are funded through China's Export-Import Bank (China EXIM) and typically include partnerships and additional funding with local financing entities. Under these frameworks, China has built 330 dams across 74 countries, largely in Southeast Asia and Africa ("The New Great Walls"). Under guidelines adopted in 2007, China EXIM states that all of its funded projects should be constructed and managed "with reference to regulations and procedures for environmental and social assessments of other international financial organizations" and in alignment with host country standards ("Guidelines for Environmental and Social Impact Assessments for China Import-Export Bank"). Likewise, the SOEs which manage and implement China's foreign dam projects have their own environmental governance and corporate social responsibility standards. The SOEs of interest to this study and their governance standards will be discussed alongside the dam project case studies below.

E. Profile of the Irtysh River

For Kazakhstan, the Irtysh River is dominated by China's geographic positionality, controlling the headwaters and construction of infrastructure that reaches Kazakhstan downriver. To the east of Kazakhstan, the Pamir and Tianshan mountains in Xinjiang provide significant water resources for the country and for communities further downriver in Russia. For this river's surface water to reach the province of Eastern Kazakhstan, it first must snake its way down the mountains and across Kazakhstan and China's shared 1,700-kilometer border, as part of a broader ecosystem of twenty four rivers in the Irtysh Valley basin ("China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation" 142). The Irtysh basin and its tributaries are shown in Image 1, below.

Image 1: Irtysh Basin Map

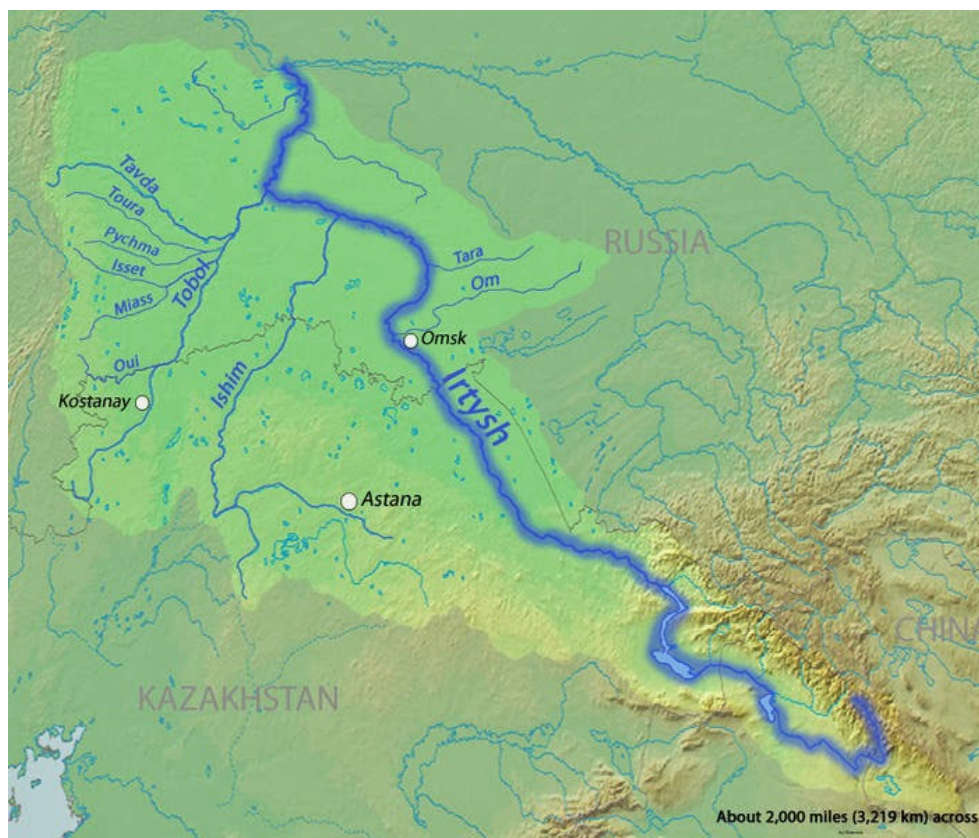


Image 1 shows a map of Kazakhstan, Russia and China with the Irtysh River Basin demarcated in light green. The Irtysh crosses from China, through Eastern Kazakhstan and the border with Russia. (Source: Geology Page, 2014)

. China's governance of the river basin begins at home. In Xinjiang, across the border from Kazakhstan, China's 'Go West' policy, which began in 2000, serves as the basis of the framework for the development of the Irtysh basin and other rivers in western China. This policy emphasizes the promotion of economic and resource development in China's underdeveloped and underpopulated western regions with an emphasis on "sustainable and ecological development" ("西部大开发"17). In section 3.3, the document sets out "comprehensive ecological "and restoration projects along the Irtysh and Ili Rivers ("西部大开发"18). The document adds further in section 5 that the government should monitor, maintain and disassemble dams that negatively affect the western region's ecology and impact the livelihoods of the people who live there ("西部大开发"45,46).

Under the 'Go West' policy, China has instituted a specific Irtysh River governance plan in 2010 under Xinjiang's provincial water management authority for the construction and development of dam projects in the region. Within the Irtysh plan, there is an emphasis on constructing projects that divert water resources from 'cross-border' regions to facilitate oil extraction and cotton production in the border region and further divert water towards the water-poor provincial capital, Urumqi ("额河建管局工程建设"). The plan establishes a timeline for projects such as the Project 635 dam, which diverts water further east into central Xinjiang. There is an emphasis in this policy to 'safeguard' national water rights and the planning at this provincial level does not take into account the utilization needs of downriver Kazakhstan on the Irtysh River ("额河建管局工程建设").

F. China and Kazakhstan Transboundary Water Agreements: 2001 to 2011

China and Kazakhstan signed their first landmark water sharing agreement in 2001, "The Agreement between the Government of the Republic of Kazakhstan and the Government of the People's Republic of China on Cooperation in the Use and Protection of Transboundary Rivers." In the preamble, the text states that the agreement is "governed by generally accepted principles and norms of international law" while also applying "non-interference" and respect for each other's internal affairs ("Cooperation in the Use and Protection of Transboundary Rivers" 1). The Agreement applies to all rivers crossing the borders of the two countries, calls for both sides to prevent serious harm, and not limit each other on the "rational use of water resources" (1). Specifically, Article 4 invokes a norm of IWL and calls for both sides to "prevent or mitigate serious harm caused to a State Party as a

result of flooding disasters and man-made accidents” (“Cooperation in the Use and Protection of Transboundary Rivers” 1). The agreement further establishes a Kazakhstan-China Joint Commission on the Use and Protection of Transboundary Rivers to regulate the agreement, established in Article 8 (“Cooperation in the Use and Protection of Transboundary Rivers” 3). Article 6 states that neither side may share hydrological data, nor the contents of the Joint Commission meetings with any third parties (3). Article 9 establishes that the Joint Commission shall meet yearly to discuss bilateral efforts to manage transboundary water resources and either Party may call ‘extraordinary meetings’ whenever the need arises (3). Article 12 establishes that both sides shall resolve any disagreements that may arise “through consultations” (4). Article 14 establishes that the Agreement would be in force for eight years following both parties’ ratification, wherein it would be extended for an additional four years if neither party sought to terminate their end of the Agreement (4).

In 2006, the prior Agreement was updated with an addendum to mutually exchange hydrological data on the major transboundary rivers shared between both countries. This Agreement compels both states to inform each other on “the presence of materials in the rivers that may lead to the diminishing of water quality due to chemicals.” It further establishes two bodies responsible for water quality management: Kazakhstan’s “Kazhydromet” from the Ministry of Security and China’s Bureau of Hydrology of the Ministry of Water. It allows both sides to establish consultations and negotiations in the case that disputes arise.

The 2001 Agreement was renewed in 2011, prior to its final expiration. The renewed 2011 Agreement was largely similar in its content to its predecessors, though it contains some significant changes from the prior Agreement. The 2011 Agreement changed the relevant governing joint commission to the Kazakh-Chinese Commission in the field of Environmental Cooperation under the purview of the Ministry of Environmental Protection of the Republic of Kazakhstan and the Ministry of Environmental Protection of the People's Republic of China, respectively (“Transboundary rivers water quality protection” Articles 4, 5) - centralizing transboundary water management under the central government. Article 5 further establishes that the Commission shall meet annually - notably the 2011 Agreement removes the prior Agreement’s Article 9 clause allowing either side to call ad hoc meetings in the case that ‘emergency situations’ would arise, though Article 10 affirms that both sides could resolve disputes through “consultations and negotiations” as disputes present

themselves. Article 7 reaffirms that both sides may not share hydrological data discussed in Joint Commission meetings with ‘third parties’ (“Transboundary rivers water quality protection”).

E.1. Characterizing Sino-Kazakh TBW Disputes

Despite being a relatively successful case of transboundary water cooperation, China and Kazakhstan have maintained long-standing disputes - largely over the quantity of water resources going downstream – despite the presence of the agreements mentioned above. Kazakhstan’s disputes with China on the Irtysh River revolve around China’s excessive usage of water resources, accounting for half of the total water resources before they even reach Kazakhstan’s borders (“Kazakhstan strives to strike water-management deal with China”).

These disputes have been extenuated by a lack of “dispute-settlement” mechanisms and actionable monitoring agreements of water quality and quantity on the Irtysh River (“China’s transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation”) that are commonly accepted principles of IWL. Concerns range at the local level from Kazakhstani fishermen citing reductions of fishery stocks in the river to naturalists stating that the ‘Ile Alatau’ national park will become a desert in the coming years if China’s overuse of water is not addressed (Kukeyeva et al.). Despite these ‘grassroots’ protests, Kazakhstan’s government has had mixed results in raising its citizens’ concerns with China’s government. In the early years of this relationship, some disputes were raised, yet as the relationship became codified in the early 2000’s, opposition quieted, which will be demonstrated in the cases discussed below. A theory proposed by Selina Ho, connected with China’s hydro-hegemony, contends that this situation has come to be due to ‘issue-linkages,’ wherein China’s relative economic position and importance for trade negates Kazakhstan’s ability to contest China’s hydro-hegemony through official channels (“China’s transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation” 144). China is Kazakhstan’s largest trading partner and a crucial partner for the country’s Belt and Road Initiative infrastructure projects, which link China to Europe. Thus, Kazakh officials publicly praise water negotiations with China “out of a position of pragmatism” (“Kazakhstan strives to strike water-management deal with China”).

This is not to say that Kazakhstan does not also receive benefits from China’s investments. The country has become more energy independent in the years since it has

participated in China's investment frameworks. The construction of new dams allowed Kazakhstan to become a net exporter of electricity, where it had previously mainly imported electricity from neighboring Kyrgyzstan. In fact in 2019, Kazakhstan sold 4.8 million kilowatts of electricity per day to its southern neighbor, a country it would normally be buying electricity from ("Kazakhstan starts returning electricity to Kyrgyzstan"). As such, BRI projects, including dam projects, continue to be funded in Kazakhstan and received well by the government.

E.2. Karamay-Irtysh Canal and Project 635

(Image 2): Karamay-Irtysh Canal and Project 635 GIS image



Image 2 shows the Project 635 dam and the Hinghe reservoir which developed following the dam's construction (source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 47°08'11"N 88°53'10"E)

China's first domestic transboundary dam project, marking the beginning of the countries' transboundary governance relationship is the Kara-Irtysh Canal, a water diversionary project which would supply water to Xinjiang's growing cotton production and oil extraction industry. The dam was constructed from 2000 to 2008 (Peyrouse). On the Kazakh side of the border, the Irtysh flows to Lake Zaysan, a major feeder for the Irtysh and the world's last surviving lake from the Cretaceous Period (Dorfman 1376). This The canal

was built to connect the Irtysh to the Burqin River, which flows inland towards central Xinjiang, south of the Irtysh River (Sievers. This effort to bolster the Burqin's water resources is part of a domestic water conservation program to improve the availability of water resources in Chinese rivers that are increasingly becoming water-stressed due to overuse and desiccation (“额河建管局工程建设”). The dam and canal were constructed by Xinjiang province's local government through the Xinjiang Irtysh River Basin Development Project Construction Management Bureau under the auspices of the ‘Go West’ policy. The Bureau is responsible for maintaining and constructing ecological projects within Xinjiang's borders, however in press releases taken from the government site, significant emphasis is placed on the agency's party-building activities, as opposed to the projects they oversee (“新疆额尔齐斯河流域开发”). As the canal and dam were being constructed, Kazakh researchers and government officials were concerned that the projects could displace between “10–40% of the Irtysh River to Ulungur Lake” (one of China's largest freshwater lakes) and a source of transboundary water for Kazakhstan. (“China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation”). As it came into operation, the canal would facilitate the creation of “140,000 new hectares of agricultural fields” and divert water to the Karamai oil fields near Urumqi, Xinjiang (Peyrouse). Estimates at the time predicted that the canal may divert up to 1 billion cubic meters of water as it reached full capacity in 2020 (“China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation”). The canal was constructed along with the Project 635 dam. The dam supports the existence of a reservoir, the 635 Hinge Reservoir which supports diversionary water projects to the Burqin.

Prior to its institutionalized transboundary water relationship with China, Kazakhstani officials raised concerns over the construction of the project. When construction was announced in 1998, Murat Auezov, the main political opposition figure in the country and the former ambassador to China referred to the Chinese constructors of the project as “stonewalling prevaricators and the Kazakhstan government as incompetent collaborators” (“China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation”). Over the course of this dispute the Chinese government claimed that the canal would not create any drawbacks for the ecosystem along the Irtysh River and that the water dispute would be resolved to the “full satisfaction of both sides” (“China's transboundary river policies towards Kazakhstan: issue-linkages and incentives for cooperation”). However, eventually China agreed to negotiate with Kazakhstan in what would become their formalized

TBW relationship, beginning with the 2001 Agreement. As the years have gone by, there is no evidence that the Kazakhstani government have publicly raised any of their earlier objections with China over the water resources reaching downstream from Xinjiang, suggesting that China has been successful in its issue-linkages campaign

E.3. China-Kazakhstan BRI Cooperation: The Turgesen-1 Dam

(Image 3): Turgusen-1 Dam GIS image



The Turgusen-1 dam as seen from remote sensing data taken from Google Earth Engine (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 53°09'48"N 63°36'59"E)

The Turgusun-1 Dam, located on the Turgusen River, a tributary of the Irtysh began construction in 2018 and came into operation in 2021. According to a report from Xinhua News, the project was expected to provide “79.8 million kilowatt hours of electricity per year,” and enable Kazakhstan to further develop its carbon neutral capabilities (Huaxia). Furthermore, the construction of the dam would address a power deficit of Altai district in East Kazakhstan province. The project was jointly constructed by China International Water & Electric Corporation (CWE) and received some funding support from the Development Bank of Kazakhstan - a sum of \$23 million (Shalabayev, Yau). CWE has a history of operating within Kazakhstan. Prior to the construction of the Tursusun-1 Dam, CWE constructed the Moinak dam on the Ili River in 2013 (Yau).

Despite maintaining a positive relationship with Kazakhstan’s government authorities, civil society groups have protested the company’s activities within the country. Though the project would ostensibly provide benefits to East Kazakhstan, activists writing for Transrivers, an international NGO, stated that the project presented huge environmental risks for Eastern Kazakhstan province. In the early stages of construction, the project endured eight floods in three months, frequently halting the building of the project. Transrivers states that the project was beset by environmental disasters due to “poor planning and lack of climate adaptation” on behalf of the Chinese implementers and a lack of awareness and compensation of the traditional flood patterns of the river (“The Turgusun-1 Project Demonstrates Why Hydropower Is a Bad Option for Kazakhstan”). The NGO states that the controversies in the implementation of the project demonstrate a lack of commitment to facilitate connectivity between the implementers and BRI regulators, failing to achieve a key guideline of the Initiative’s ‘green policy.’ Outside of Kazakhstan’s borders, CWE had further been ‘debarred’ by the World Bank for violating transparency policies that CWE agreed to uphold in its construction of a hydro-electric project in Africa and road construction in Southeast Asia. As a result, the SOE was prevented from working with any other ‘multilateral development banks’ (“World Bank Sanctions China International Water and Electric Corp”).

F. Profile of the Mekong River and Dispute Characterization

(Image 4): Map of the Mekong basin



This map in Image 4 denotes the upper and lower reaches of the Mekong River, as separated by the Chinese border and showcases some of the dam projects that China has built along the Mekong River in its own borders and in its Laotian and Cambodian neighbors (Source: Radio Free Asia “Interview with Brian Eyler.”)

The Mekong River extrapolates many of the disputes between China and Kazakhstan on the Irtysh on a much greater scale. The Mekong River extends 5,000 kilometers from China’s border through Southeast Asia and serves as the main source of food, employment - and water for the region's sixty million denizens (Simmala and Lee). On China’s side of the river, the country has built eleven mega dam projects to facilitate regional development for bordering Yunnan province (Eyler). The two largest domestic dams among these eleven are the Nuozhadu and Xiaowan dams, which hold more water than the next fifty-three largest dams combined (Son). Water flow on the Mekong River is dictated by seasonal fluctuations

during times of drought and the rainy season and the downstream states along the river rely significantly on China for their water resources – largely for agriculture (Simmala and Lee).

Typically, during the rainy season, water from within China’s borders provides roughly 15% of the region’s needed water. During times of drought, this number can rise from between 50% to 70% of the Mekong’s water resources (Funaiole and Hart). In past instances, China has a record of closing the floodgates to its dams to hoard water for its own purposes and during the rainy season, when there is a surplus of water upstream, opening the floodgates. This has contributed to irregular seasons for harvests for the denizens of the Mekong basin and has even led to the devastation of villages downriver due to unpredictable periods of flooding outside of the monsoon season. A report from Stimson states that this phenomenon occurs because China “optimizes” the disbursements of water it allows to reach downstream states to get better prices to sell hydro-electric power to its downstream neighbors (Eyler and Sun).

Similarly to the Irtysh River, China’s domestic development of the Mekong River is governed at the provincial level. In Yunnan province, which borders the Mekong River, the 2011 development framework “Opinions of the State Council on supporting Yunnan province in accelerating the construction of an important bridgehead for opening up to the southwest” emphasis is placed on the ecological construction and management of dams in the province. Article 6(25) emphasizes cross-border monitoring and that risk reduction measures should be taken to reduce the impact of upriver projects and that cooperation in monitoring should be strengthened with ASEAN (“国务院关于支持云南省”). In Yunnan’s case, the development of its rivers would be further governed under the LMC, introduced in 2016.

G. China-Mekong States Transboundary Water Agreements: 2016 to 2020

China’s cooperation with the states of the Mekong River became formalized through 2016’s LMC, a cooperative body formed by China so that the country could more actively participate in the governance of the Mekong River. This agreement is seen by scholars as a means for China to promote its brand of foreign policy, ‘win-win cooperation’ by creating a forum for foreign ministers to cooperate directly on the management of the Mekong basin (Junlin et al). Writing for *The Diplomat*, Shang-su Wu, a research fellow of the Regional Security Architecture Programme at the S. Rajaratnam School of International Studies at Nanyang Technological University in Singapore refers to the LMC as a “*fait accompli*” on

the part of Beijing. In implementing the initiative, China sacrifices some of its unilateral power to allow lower riparian states to have some of their interests heard (“Diaspora + Fait Accompli”). China does this at some risk to its own interests. The country could take the blame for ecological and natural disasters and disruptions in the flow of the river, which may potentially harm its relations with its neighbors for limiting the flow of water resources and inaction in the implementation of its MOUs (Wu). At the same time, LMC sacrifices a little to develop “amicable relations” based on economic linkages between China and its lower riparian neighbors so that China can support further trade and economic development for the region to directly benefit Chinese markets (Gao). Wu also adds that LMC acts as a “miniature version of” the BRI (“The Trouble with the Lancang Mekong Cooperation Forum”), facilitating Chinese soft power in the region. The agreement cites a vision based on “sub-regional economic and social development” and efforts to support community building with the states that make up ASEAN (“The Trouble with the Lancang Mekong Cooperation Forum”).

Prior to this agreement, China had been absent from institutionalized governance projects on the river. LMC was preceded by the Mekong River Commission, an organization with a “limited mandate” (“Water Governance in the Mekong”) including only the lower riparian states of the river, while excluding Myanmar and China. Thus, China implemented the LMC ostensibly to improve cohesion between all the riparian states along the Mekong. In contrast to the ad hoc meetings that define Kazakhstan’s transboundary water relationship with China, the Mekong-Lancang Compact is executed through annual, scheduled meetings between foreign ministers of all states a-party to the agreement. The Compact further acts as a foreign relations catch-all for China and its riparian neighbors, not only promoting riparian cooperation, but also including such cooperative areas as the development of political, security and people-to-people ties in addition to the development of ecological cooperation (Nguyen).

The 2016 Agreement which codified the LMC was preceded by a Ministerial meeting between the heads of state of China and its riparian partners on the Mekong. The meeting cited that China and its neighbors would build on existing “closely-linked” (“First Lancang-Mekong Cooperation Foreign Ministers' Meeting”) geographic and social ties to enhance their economic, political and ecological cooperation along the Mekong basin. Particular attention was paid in this meeting on establishing that the LMC would strive to implement

cooperation with “respect for the United Nations Charter and international laws” (“First Lancang-Mekong Cooperation Foreign Ministers’ Meeting”). This establishing forum preceded a March 2016 meeting where the Sanya Declaration was signed, officially bringing the LMC into force and codified the rules by which parties to the Agreement would use in their cooperation. The Agreement echoed the consensus that China was seeking to establish that the LMC would be based on cooperation and high-level ministerial meetings as being the drivers of cooperation for LMC activities. Sanya further connected project development to China’s BRI, by seeking to “encourage synergy” with Chinese-funded projects in the region and develop a Master Plan in conjunction with country partners on the further development of the region (“Sanya Declaration”). The Agreement further cites goals towards the UN 2030 Agenda for Sustainable Development, ostensibly aligning the Agreement with international law standards. Sanya further established a ‘Lancang-Mekong’ water cooperation center within China to coordinate efforts at sustainable water management along the countries’ shared Mekong basin (“Sanya Declaration”) and to further the LMC’s goal of providing a forum for its neighbors to provide feedback on multilateral uses of the Mekong River.

The Sanya Declaration directly laid out some of the early targets for the LMC’s high-level Ministerial meetings. In the area of infrastructure construction, Sanya further laid out forty-five “Early Harvest projects,” which includes railways and other physical infrastructure projects. It is important to note that a specific list of projects under this category has not been made available by China. The pilot projects would serve as a baseline for future, more expansive projects to be piloted in 2022, of which one hundred thirty-two have been planned, the majority of which are railway projects (“Third LMC Foreign Ministers’ Meeting”). To date, China has not publicly announced which projects fall specifically under LMC governance and which are administered through other governance frameworks (Nguyen). In 2018, China’s then-Foreign Minister Li Keqiang announced that the Early Harvest Projects were underway, with some having been completed (“Second LMC Foreign Ministers’ Meeting”).

2020 saw a significant update to LMC cooperation in the area of transboundary basin management with the signing of the Vientiane Declaration with China’s establishment of the Mekong-Lancang Water Resource Cooperation Center. Vientiane marked the first substantial effort by China to codify a basin monitoring strategy, to measure water quality and quantity

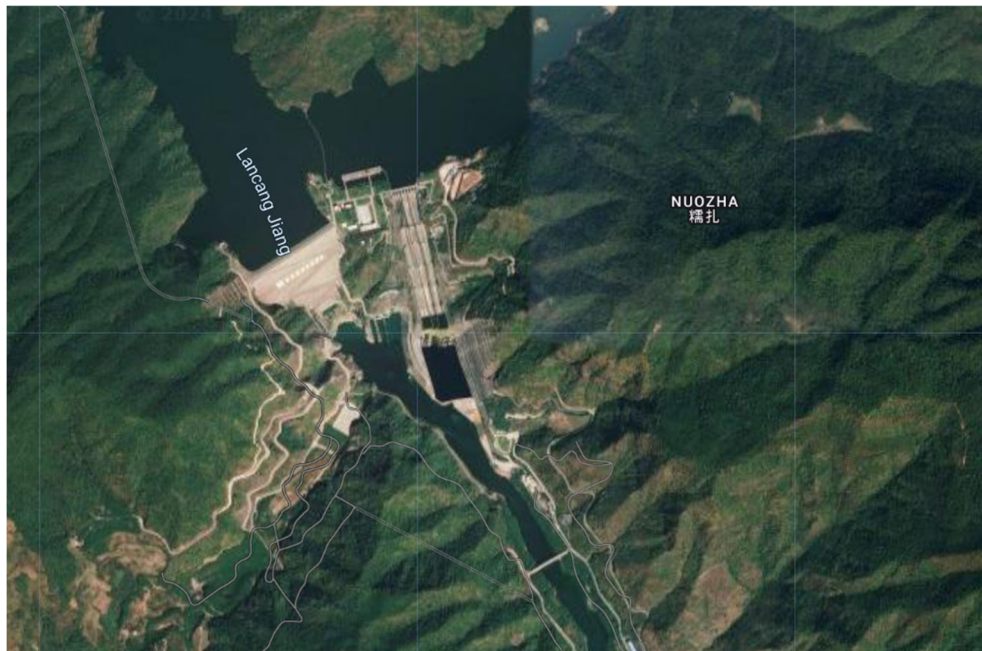
along the Mekong with the goal being to unify water monitoring practices and standards between China and its downriver neighbors on the Mekong (“Vientiane Declaration”).

For the Mekong states, China’s water withdrawals from its side of the Mekong River have significantly impacted communities downstream from China along the river. Similarly to Kazakhstan, China began constructing dam projects within Southeast Asia in the mid-1990’s, prior to the establishment of any cooperative agreements. From these early days, up to the present, the disputes held by the Southeast Asian states remain the same. The Mekong states cite “water shortages, flow alterations, sediment trapping [and] habitat destruction” (“Dam projects and disputes in the Mekong River Basin”). In 2019, China’s usage of water resources upstream resulted in a “record-breaking” drought during the Mekong’s rainy season, wherein water levels dropped to their lowest in a century (Eyler et al.; Funaiole and Hart). In response to China’s handling of the drought, the countries of the Mekong River Commission released “tepid statements” asking China to provide more transparency in its management of TBW (Funaiole and Hart).

For Laos in particular, China’s cross border management of TBW has provided some benefits for the country’s economy - despite the negative effects of water withdrawals. The benefits and drawbacks of China’s investments can be seen through the developments employed under BRI. Laos has been referred to as the “battery of Southeast Asia” due to significant Chinese investment in dam projects across the country - by 2020 China had built ninety dams - an \$11 billion investment (“Laos and its dams”). Even though the development brought some benefits, as along the Irtys, development of the Mekong caused impacts to the ecosystem, affecting crops and schools of fish living in the river. Additionally, given the significant funding received from China, Laotian debt rose to \$13.6 billion, while critics stated that China’s loan practices lacked transparency and were predatory against Laos (“Laos and its dams”). To understand the impacts on water resources at the project level, this research analyzes the impacts of the domestic Nuozhadu dam and Nam Ou 2 dam built across the border from China in Laos.

G.1. Nuozhadu Dam

(Image 5): Nuozhadu dam Google Earth Engine Image



An overview of the Nuozhadu dam in China (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 22°38'16"N 100°26'02"E).

As mentioned, the Nuozhadu dam stands as one of the largest of China's Mekong region dams. The dam, which was constructed in 2006 and opened in 2012 holds a volume of 23.7 million gallons of water and generates 24,000 gigawatts of power for Yunnan province and its adjacent southern neighbors. In 2011, the dam operators began to fill the reservoir behind the dam, beginning to divert water from that would flow downstream along the Mekong River (Fan et al). In the 2020 drought, this dam and its partner the Xiaowan dam resulted in the significant limitations of downstream water flow discussed previously. As such, this dam has become the symbol of China's development of the Mekong River through its dam project construction.

The project was developed by Yunnan Huaneng Lancang River Hydropower and is owned by the company's parent company China Huaneng Group ("Power plant profile"). China Huaneng is the country's largest power generating company and has contributed to the construction of dam projects around the country and in significant part abroad ("China

Huaneng Group Company Profile”). The SOE has taken some efforts to engage with downriver stakeholders regarding its construction of transboundary dam projects - though with mixed engagement. In 2015, the SOE participated in a 2015 Forum in Phnom Penh, Cambodia to consult with Southeast Asian NGOs in what was seen as a “unprecedented step for greater transparency” from one of China’s largest foreign-operating SOEs (Jensen-Cormier). Even given its engagement with NGOs, the SOE was granted the lowest rating for its compliance with World Bank standards in environmental and risk management and community engagement for its projects domestically and its other dam projects across Southeast Asia. (Jensen-Cormier). In response to this ranking, the company had sought to leverage its previous NGO engagement to boost its environmental score with International Rivers, a global river monitoring NGO. This “quick fix” (Jensen-Cormier) to boost the public perception of its projects backfired, however. When the NGO refused to change its score the SOE ceased conducting interviews and engagement with all NGOs. In 2018, the group was expelled from the Global Compact, a United Nations forum for company CEOs and other leaders to set sustainability standards in their project development initiatives (Jensen-Cormier) for its lack of engagement with the global water management community.

G.2. Nam Ou-2 Dam

(Image) 6: Google Earth Engine Image of the Nam Ou-2 Dam on the Nam Ou River



An overview of the Nam Ou-2 dam in Laos (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 20°08'37"N 102°18'58"E).

The Nam Ou-2 Dam is one among a series of projects constructed along the upper reaches of the Mekong River in Laos. The Nam Ou cascade is significant because it represents the first case where China had been granted permission to develop an entire tributary - the Nam Ou tributary of the Mekong River - with a total of seven dam projects (Jensen-Cormier). Nam Ou-2 is the first among these projects to have been constructed and produces 120 megawatts of power. When the dam first went into operation, in 2016, water levels behind the dam rose during the dry season and ebbed during the wet season, according to a report by the NGO International Rivers (“Watered Down” 89). Though the project began construction in 2011, before the BRI was enacted, it has been coopted by Chinese planners as a “key BRI project” (“Nam Ou River Cascade Hydropower Project”).

The Nam Ou array is further owned as a “concession” of the Chinese SOE that constructed the project and will be held by the SOE project implementer Sinohydro, a subsidiary of PowerChina Resources - a major Chinese dam building SOE. The company would hold ownership of the dam for twenty-nine years starting in 2016 (“Watered Down” 86). In exchange, PowerChina is expected to manage the dam according to local laws and to also conduct environmental assessments of the dams’ impacts. In reviewing Nam Ou-2 the NGO International Rivers states that proper environmental reviews have not been released publicly - indicating a lack of transparency - this is despite local civil society organizations in Laos calling for China to release their findings (“Watered Down” 86). Likewise, the local people of the Ou River tributary expressed discontent with the project. In field research, conducted by International Rivers, farmers living along the river did not receive compensation for relocating from the dam’s construction site and locals had low confidence that PowerChina would adequately compensate or respond to the needs of the local community in their execution of dam project construction (“Nam Ou River Cascade Hydropower Project”).

IV. Methodology

A. Measuring Water Quantity

To quantify the impact of China’s governance regime of transboundary water management across the Irtys and Mekong Rivers, this research utilizes GIS data from Google Earth Engine to gauge the impact of China’s foreign and domestic dam construction on the “transformations in the river hydrological regime” of both rivers in this study (Peng et al). This approach gauges the use of the rivers in alignment with riparian doctrine principles of ‘equitable and fair use’ in both the quality and quantity of water resources. These data are used to conduct a quantitative analysis of the mean amount of water that flows from China’s dam constructions downriver and the quality of the rivers’ water based on the water’s turbidity or presence of particulate matter floating within the resource.

The first indicator in this study is the ‘change of discharge’ taken from before and after dam construction. In a 2022 study conducted by Peng Fangjun et al. on the Yangtze River in China, the researchers found this indicator to be the most significant factor in determining how a river affects the flow of water resources downriver as the “main cause of

changes” to downriver environments, particularly impacting the utilization of the river’s water resources (Peng et al).

In other research on hydrology, the change of discharge is typically measured through country-provided hydrological data that is made publicly available. In Peng’s research, for instance, these data were collected through the ‘Hydrology Yearbook of the People’s Republic of China.’ There is a dispute within academic circles and experts as to the validity of these data published by the government. Data is first collected by local working groups, censored by provincial government authorities and then published in the national ‘Yearbook’ by the Central government. Data published herein is received critically due to local governments “falsifying” data to get preferential usage and benefits for local officials for their efforts at properly managing water resources (“An Overview of China’s Water Statistics”). Given the skepticism around government provided data, this research calculates the change of discharge utilizing GIS data.

In this research, the point where the change in discharge is measured occurs at the location of where a dam or water diversionary project is constructed. This research measures the change in discharge at the point where a river flows beyond where the dam was built. These data demonstrate the increase or decrease of water passing within a certain region of interest. For this study of dam projects, this represents how often the gate to a dam would be opened or closed to let in or restrict more water flowing downstream. To measure the change in discharge, this research looks at the value of ‘long-term overall surface water occurrence’ at the point the dam was constructed and down the watercourse until a tributary river branches off into other bodies of water (Pekel et al. 8). This change is measured through comparing the mean surface water occurrence between ‘homologous pairs of data’ that show the intensity of surface water changes. The intensity measurement shows episodes where surface water has fluctuated - either a positive or negative fluctuation. The data for this research was acquired on Google Earth Engine through the publicly available Joint Research Centre’s (JRC) Global Surface Water Dataset, created by the European Commission. JRC specifically classifies homologous pairs of data as “the same months that carry valid (measurable) observations in both epochs (Pekel et al. 8). The two epochs, or ranges of dates measured by these data sets are the [16th of March 1984 to 31st of December 1999] and the [1st of January 2000 to 31 December 2021]. The range of this dataset was decided on due to scaling issues when measuring water changes over time. If one were to present smaller

periods of data in the few years around when a dam project was constructed and after it was completed, this would present a less accurate picture of the change in water flow overtime. According to Peng et. al, “generally, nearly 10 years of data [or more] are needed” (Peng et al). Thus, the longer data series used herein will make the analysis results more accurate. JRC further classifies water according to differing categories, namely as ‘seasonal water’ or ‘permanent water,’ which provides a level of specificity in ruling out seasonal fluctuations of water quantity according to the prevalence of droughts or the rainy season (Pekel et al. 8). This indicator provides an accurate understanding and comparison between epochs of how China’s dam projects have impacted the availability of water resources to its downriver neighbors than what could be taken from official hydrological reports.

B. Measuring Water Quality

The measurement of turbidity in this study is utilized to understand the presence of suspended solids in the rivers analyzed in this research. Significant increases in turbidity can lead to highly negative impacts on the environment. Dams can concentrate the flow of water at a narrow point, leading to significant inflows of sediment that harm ecosystems (Schellenberg, et. al). The increase in turbidity is connected to an influx of particles that may carry pollutants, chemicals and heavy metals, harming animals, people and ecosystems (Schellenberg, et. al).

To measure changes in turbidity across bodies of water, research from S.K. McFeeters conceptualizes the measurement of the Normalized Difference Water Index (NDWI) as a “tool in the study of water quality issues” (McFeeters 1431). NDWI specifically measures the presence of reflected near-infrared radiation (NIR) bands compared against green or red-light multispectral bands. Both the green and red bands are light that is visible to the human eye (Wollager and Hunkle). NIR is used to compare against visible light because it is absorbed by water and is reflected by suspended solids, such as vegetation or pollutants found within a body of water (McFeeters 1425). The use of green and red light built upon earlier conceptualizations of turbidity measurements and was adopted by McFeeters because it maximizes the reflectiveness of water and minimizes the low reflectiveness of NIR against suspended solids (McFeeters 1429). Red light, alternatively, enhances features with “higher near-infrared reflectance and lower red light reflectance,” i.e. solid suspended particles while suppressing and/or eliminating “low red light reflectance and very low NIR reflectance” i.e. water (McFeeters 1427). McFeeters calculates NDWI through the simple equations below,

herein ‘Green’ represents visible green light, while ‘Red’ represents visible red light. The turbidity data is expressed on a scale of -1 to +1. The negative values indicate areas where there is less water and more dry land, while positive values indicate significant occurrences of water, as in a lake or large body of water (McFeeters 1428).

$$\text{Equation 1: } \frac{\text{Green}-\text{NIR}}{\text{Green}+\text{NIR}}$$

$$\text{Equation 2: } \frac{\text{NIR}-\text{Red}}{\text{NIR}+\text{Red}}$$

(McFeeters, 1996: 1429)

It is important to note that NDWI represents an effective method to analyze turbidity in cases where one is unable to take accurate measurements of water quality in the field. It was utilized in this way in 2020 by Garg et al. to measure the turbidity of the Ganges and Yamuna rivers in India during the COVID-19 pandemic when in-person enumeration was impossible. The researcher utilized Sentinel-2 data from Google Earth Engine to measure changes in pollution before and after the pandemic lockdown in the country (Garg et al). Even so, NDWI is unable to discriminate between the type of solid that is suspended within a body of water, be that pollutant particulate matter or organic plant matter – though it is useful in obtaining an overall estimation of the turbidity of a particular body of water (McFeeters 1431). McFeeters further proposes that green light measurements provide a clearer picture of suspended solids because they enhance “only the water features” (McFeeters 1428) in a particular body of water. Red light measurements are taken in this study because they are utilized by the first generations of satellites where the 1984 to 2000 data is taken from in this study.

With the utility and limitations of NDWI established, this research on China’s transboundary water relations seeks to utilize NDWI to estimate the overall water quality in the river cases in this study from 1984 to 2021, measuring their turbidity. It is important to note that particulate matter does not need to be measured across decades in the same way that homologous pairs. This research presents water quality data from 1984 to create parity between the homologous pairs to measure water quality and present a complete picture of pre dam and post dam construction. NDWI is calculated from three datasets, from NASA

satellites in partnership with the United States Geological Survey (USGS). These satellites are Landsat-5 and Landsat-7. Landsat 5 was launched in March of 1984 (“Landsat-5”), while Landsat-7 was launched in 1999 (“Landsat-7”). The launch of each Landsat represented a new generation in the sensing technology available to researchers. As stated above, Landsat-5 relies on red light multispectral measurements, while the subsequent generations solely utilize green light measurements. The use of Landsat-5 provides somewhat less accurate data compared to later Landsat generations; however, it is necessary to use the data from this satellite to complete the range of water occurrences looked at in this study. There is no other satellite that offers green light sensing prior to the year 2000. Each subsequent generation of Landsat operates more specific tools to measure multispectral bands to the nearest millimeter (μm) (“Landsat Satellite Missions”). With the change in the tools to measure bands, the equations to measure multispectral light within each Landsat also differs. The equations used to obtain NDWI in Google Earth Engine are calculated as follows:

$$\text{Landsat-5: } \frac{(B3-B5)}{(B5+B3)}$$

$$\text{Landsat-7: } \frac{(B2-B4)}{(B2+B4)}$$

(From Sentinel Hub, “Normalized Difference Water Index,” 2020)

Table 2: Multispectral Bands used by each generation of Landsat

Landsat	First Band	Second Band
Landsat-5 (1984-1999)	Band 3 (B3) Visible Red (0.63 - 0.69 μm)	Band 5 (B5) Near-Infrared (1.55 - 1.75 μm)

Landsat-7 (1999-2021)	Band 2 (B2) Green (0.52 - 0.60 μm)	Band 4 (B4) Near- Infrared (0.77 - 0.90 μm)
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(From USGS “Landsat Missions”)

All the data used in the methodology section is freely available through Google Earth Engine’s dataset library. The data is publicly available and there was no need to get approval for its use in this research. A potential limitation of using these data is that while the data are used to measure the impacts of dam project impacts on ecosystems, these data cannot clearly explore the impacts of larger ecosystem impacts on water quality and availability, such as glacial melting further upriver and has no way to differentiate between water withdrawal activities, such as from farming in a more localized area. The research attempts to minimize these compounding factors from the data by measuring very limited sections of the rivers downstream from Chinese built dams.

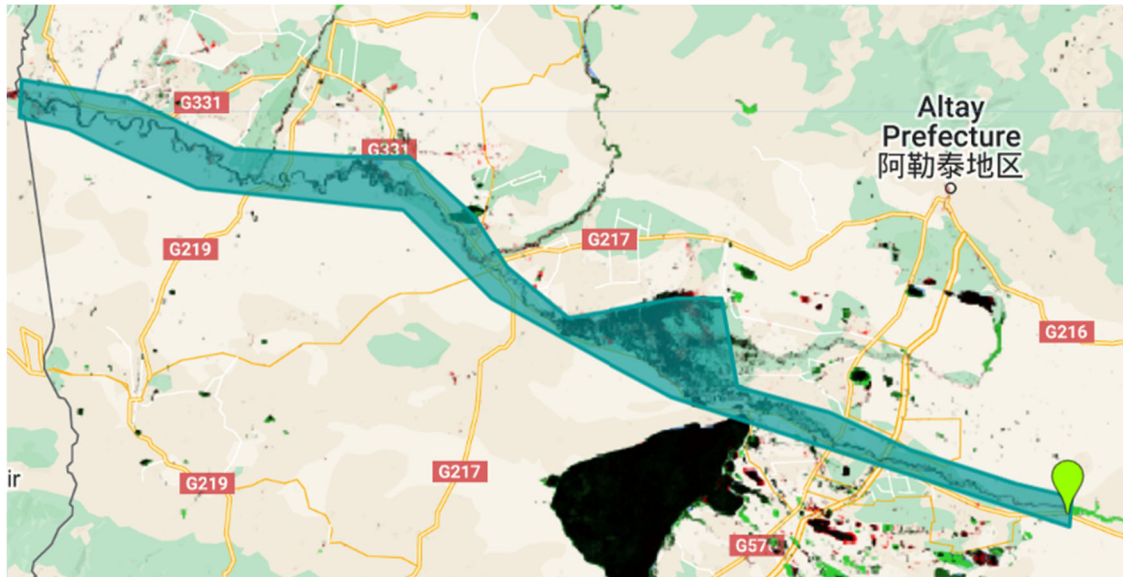
V. Analysis

This analysis provides an overview of the quantitative data taken from Google Earth Engine for each of the dam projects that were discussed in the ‘overview of empirical cases’ section. The first part of this analysis discusses the findings taken from this data to underscore how China’s dams have contributed to Chinese hydro-hegemony on these rivers through their impact on water quantity and quality. The second section of this analysis discusses the quantitative findings in the context of China’s hydro-hegemony and ‘principal-agent problem’ theories that were previously introduced in the ‘theoretical frameworks’ section. All the photos and data in this section were taken by the author of this research from datasets found on Google Earth Engine. The datasets used and code are included in Appendix 1. Appendix 1 demonstrates how the data were extracted from the datasets available on Google Earth Engine and allows the study to be replicated for future research.

A. Sino-Kazakh Transboundary Water Dams on the Irtysh River

A.1. Karamay-Irtysh Canal and Project 635

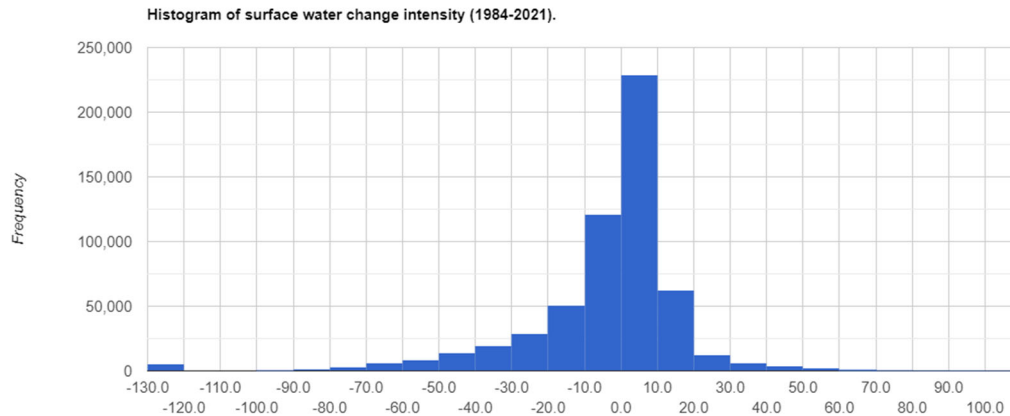
(Image 7): The span of the Irtysh River Measured in this Study



The stretch of the Irtysh river where data is reviewed. This range begins from the site of the Project 635 dam – where the lime green reticule is located - and stretches to the Sino-Kazakhstan border. Lake Zaysan is the large darkened body of water to the left of the picture, while Ulungur Lake sits below the dam on the Chinese side of the border. (Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 47°08'11"N 88°53'10"E)

Measuring water quantity through the frequency of water intensity events:

Chart 1: Histogram of Surface Water Change Intensity for the Irtysch River after the Project 635 dam

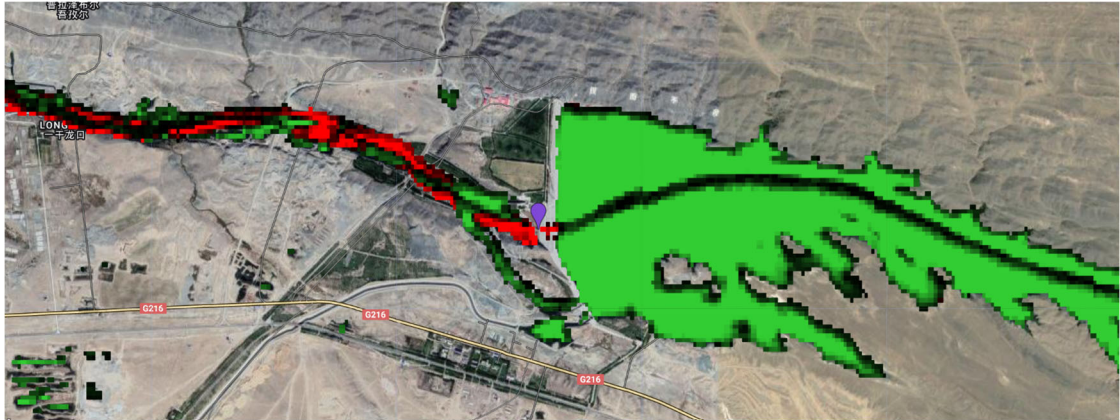


(Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine)

First, a note on interpreting histogram graphs which discuss water intensity. The X-axis in this type of chart represents the intensity of surface water changes, with negative values indicating a decrease in intensity and positive values denoting an increase. The zero (0.0) value represents no change and indicates a more stable, unchanging flow of water between locations. The Y-axis represents the frequency of occurrences of surface water changes. The height of each bar demonstrates how often a change of intensity occurs.

The Kara-Karamay canal and its adjoining 635 Dam project represent a water relationship that has been gradually decreasing in its mean flow of water availability at the stretch of river recorded in this research. The mean change in the intensity of water extraction has decreased over this period of time, at a mean change of -4.87 in its flow. This suggests that China has increased its withdrawals between the two recorded epochs, demonstrated by a lowering of mean water flow between the two periods. Satellite data further demonstrates that while the volume of water has remained consistent in both pre and post dam epochs, the actual volume of water reaching downstream has been very limited compared to its upstream feeder.

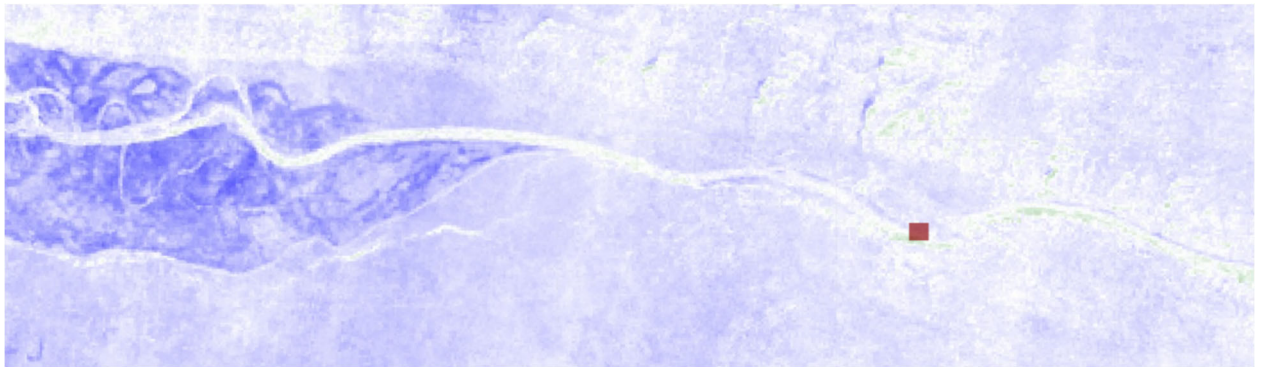
Image 8: The water quantity at the point where the Project 635 Dam is built



The Project 635 dam can be seen holding back a significant amount of water resources which would otherwise reach further downstream towards Kazakhstan. (Source: JRC Imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 47°08'11"N 88°53'10"E)

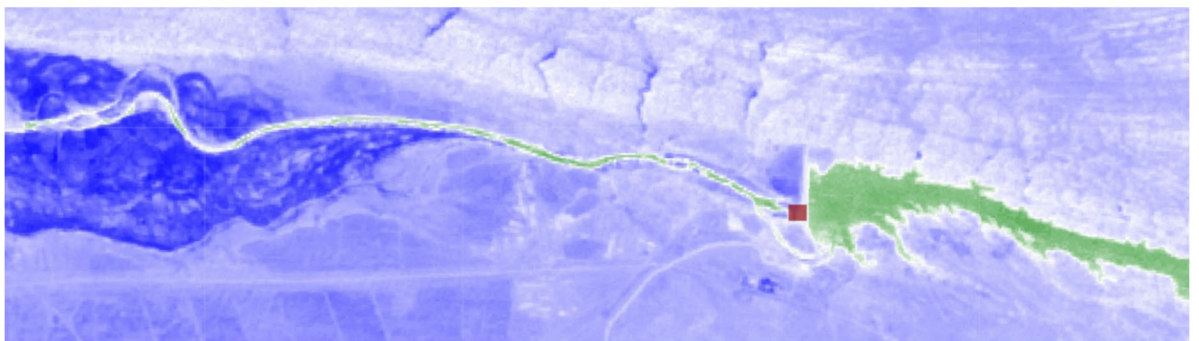
Measuring water quality through turbidity data:

Image 9: Turbidity of the Irtysch River at the point where the Project 635 Dam would be constructed, 1984 to 1999 NDWI data



The state of the Irtysch River in China from 1984 to 1999 before the project was constructed. The red square represents the site where the dam would later be constructed (Data retrieved from USGS Landsat-5, processed via Google Earth Engine. Coordinates 47°08'11"N 88°53'10"E).

Image 10: Turbidity of the Irtysch River at the point where the Project 635 Dam would be constructed, 1984 to 1999 NDWI data



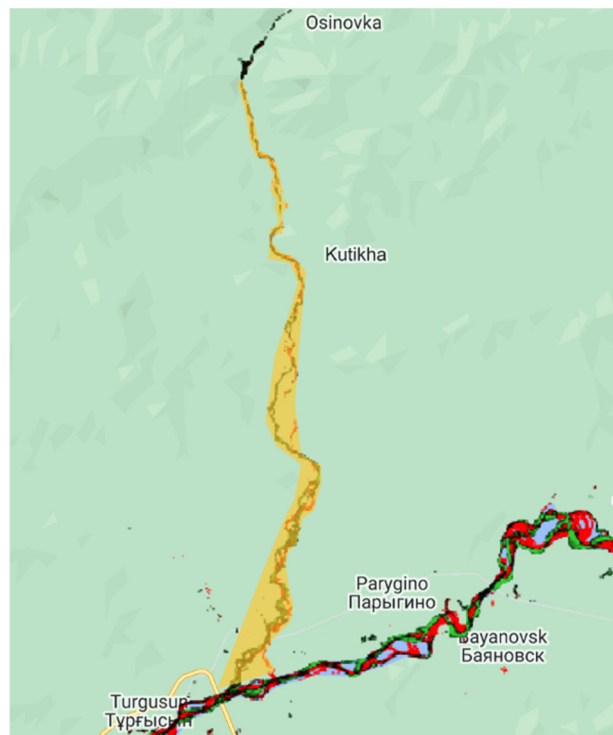
The Irtysch River following the construction of the Project 635 dam from 2000 to 2021. The presence of green particles represents an increase percentage of suspended solids (Data retrieved from USGS Landsat-7, processed via Google Earth Engine. Coordinates 47°08'11"N 88°53'10"E).

The construction of the Project 635 dam saw a major increase in suspended particles at the point where the dam was constructed up to the Sino-Kazakh border. Within both recorded epochs, the turbidity in the Irtysch River nearly doubled, with the presence of

particles in the water changing from -0.114 in the first epoch to -0.216 in the second recorded from where the dam was constructed to where the river feeds into Kazakhstan. As stated previously, a decrease in scale means that less NIR and visible light is being reflected off of a body of water (McFeeters 1429). This indicates an increase in floating particles in water which has a negative impact on water quality.

A.2. Turgusen-1 Dam

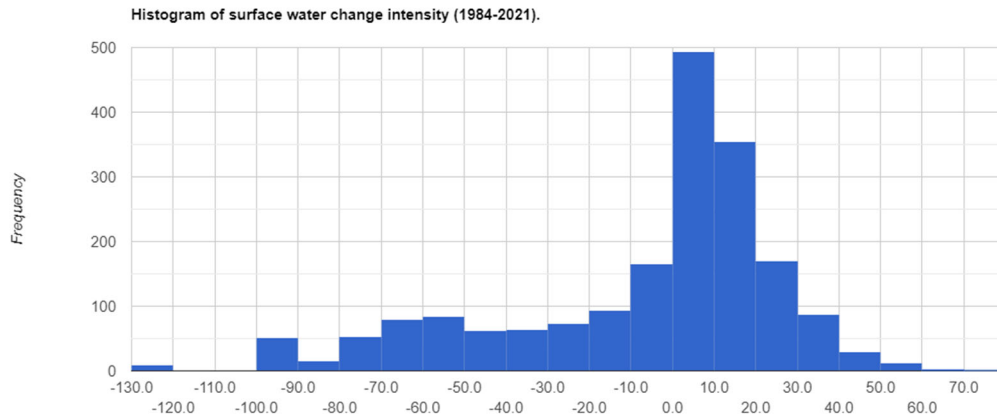
Image 11: The Range of the Turgusen River measured in this study



The range of the Turgusen River - the tributary of the Irtysh river that flows into the greater Irtysh explored in this study - focuses on the range of the river extending from the Turgusen-1 Dam to where the Turgusen River flows into the Irtysh River and is highlighted in yellow (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 53°09'48"N 63°36'59"E).

Frequency of water intensity events:

Chart 2: Histogram of Surface Water Change Intensity for the Irtysch River after the Project 635 dam



(Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine)

The Turgusen-1 dam represents a slightly more significant overall decrease in water occurrences than the previous Karamay-Irtysch example. While there are a plurality of more occurrences within the -10.0 to 10.0 range, trending towards a stable 0.0, there are other occurrences where water flow is more difficult to ascertain, generally trending towards negative occurrences. This is demonstrated in the mean change in the intensity of water extraction. This value has decreased over this period of time, at a difference of -7.38 when comparing both epochs of pre and post dam construction.

Image 12: Water quantity at the Turgusen-1 dam

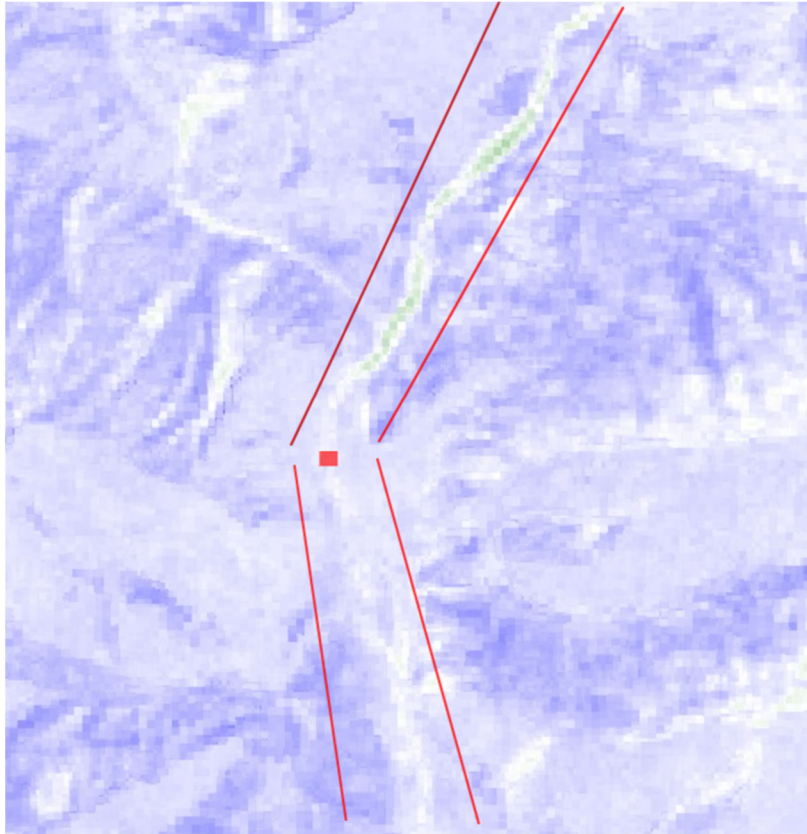


Water accumulation in front of and behind the Turgusen-1 dam. (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 53°09'48"N 63°36'59"E).

It should be noted in particular for the review of this dam that the satellite data available for the river in the dam's vicinity was less available. This is represented herein by the black pixels. The black pixels demonstrate a lack of available data of homologous pairs - fewer occurrences were interpreted via satellite data. Thus, the analysis of the Turgusen-1 water flow presents less of a complete picture of water intensity phenomena than some other analysis conducted on different rivers. This is, unfortunately, a problem in studying smaller river tributaries where there is less access to recorded data.

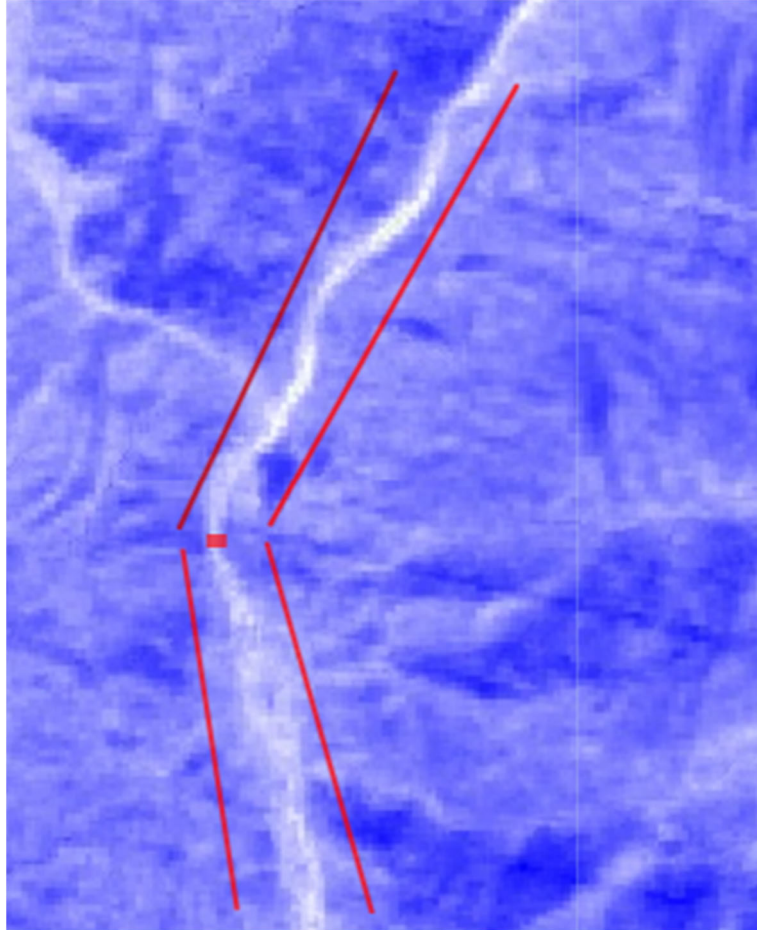
Water turbidity data:

Image 13: Epoch one of water quality at the Turgusen-1 dam



The 1984 to 2000 stretch of the Turgusen River by the Turgusen-1 dam is shown here. Similarly to the flow accumulation factor, it is difficult for the satellite to interpret water in the vicinity of the dam itself, however more water data is evident further downriver. (Data retrieved from USGS Landsat-5, processed via Google Earth Engine. Coordinates 53°09'48"N 63°36'59"E).

Image 14: Epoch 2 of water quality Turgusen-1 Dam



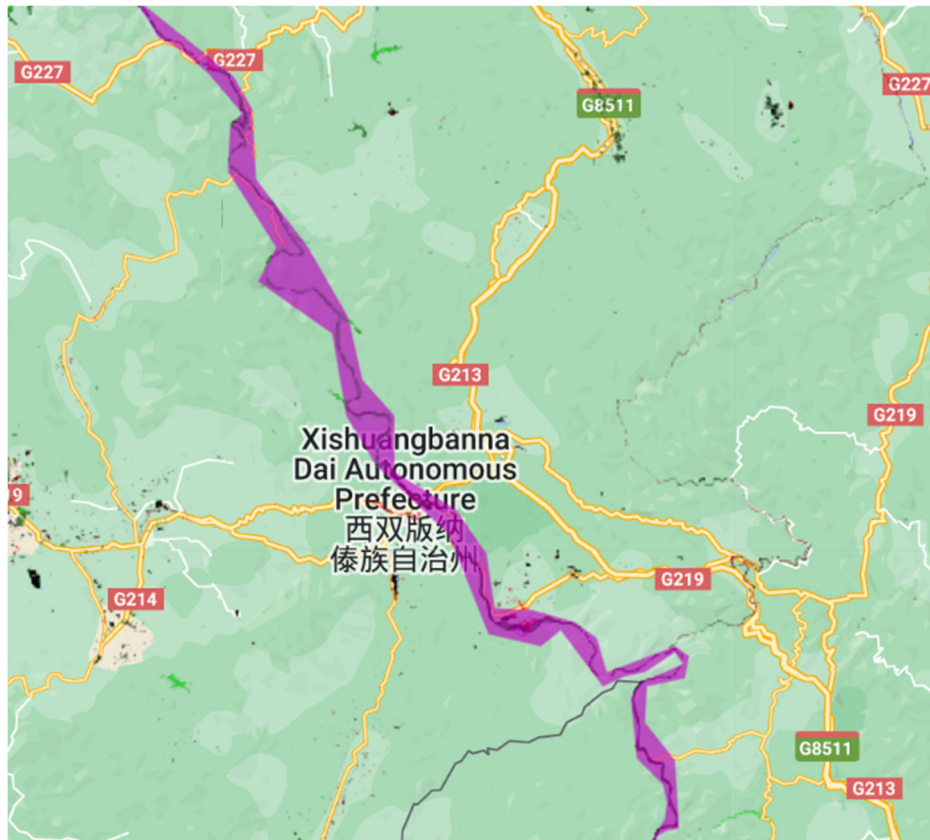
The span of measured water quality near the Turgusen-1 Dam. Image 14 provides a somewhat more clear view of suspended solids in the water than Image 13. This can be attributed to the change in Landsat generation (Data retrieved from USGS Landsat-7, processed via Google Earth Engine. Coordinates 53°09'48"N 63°36'59"E).

In the same regard as the water flow accumulation, the data on river flow near the dam is limited. To the north of the dam, water is clearly visible – as exhibited through the green pixels representing water flowing into and through the dam. However, the water flowing to south, where the Turgusen tributary meets the Irtysh River still demonstrates data on suspended particles in this part of the Irtysh River. The first epoch in Image 13 totals a mean NDWI of -0.0465 , while the second epoch in Image 14 totals a mean NDWI of -0.2391 . This represents a nearly five times increase in suspended solids in the Turgusen River over this time.

B. Mekong Dams

B.1. Nuozhadu Dam

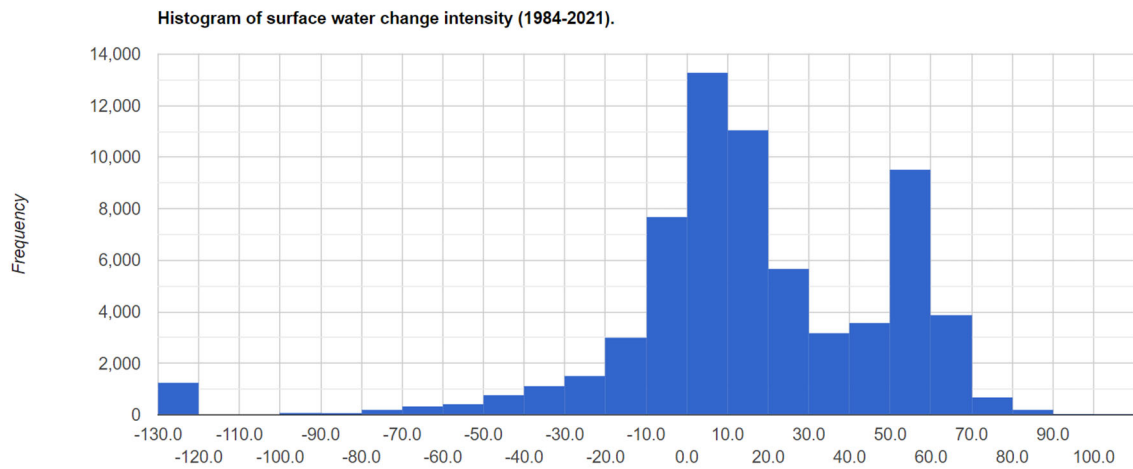
Image 15: The range of the Nuozhadu dam measured in this study



*The Nuozhadu dam extending into Laos, from the upper to lower region of the Mekong river.
(Source: JRC imagery. Data retrieved from European Commission, processed via Google
Earth Engine. Coordinates 22°38'16"N 100°26'02"E)*

Frequency of water intensity events:

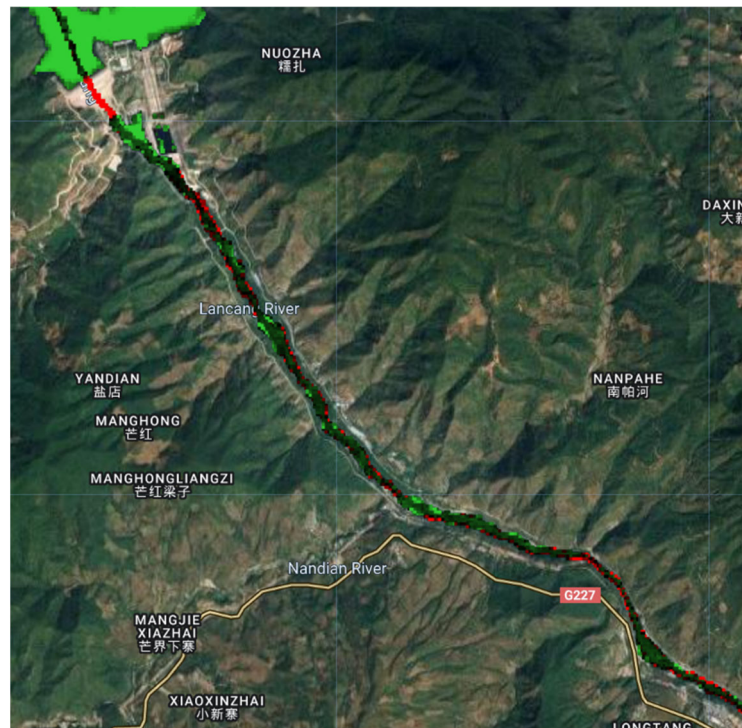
Chart 3: Histogram of Surface water change Intensity Nuozhadu Dam



(Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine)

Compared to the other dam projects reviewed herein, the Nuozhadu dam demonstrates a far more significant a change in water intensity events across the Mekong watercourse. These data show a significant net increase in water occurrence of 16.92 across the entire water course to the border with Laos. This goes against the expectations of how much water has been flowing through the dam, from when it had been constructed. The increased flow is connected to the floodgates of the dam being opened more frequently.

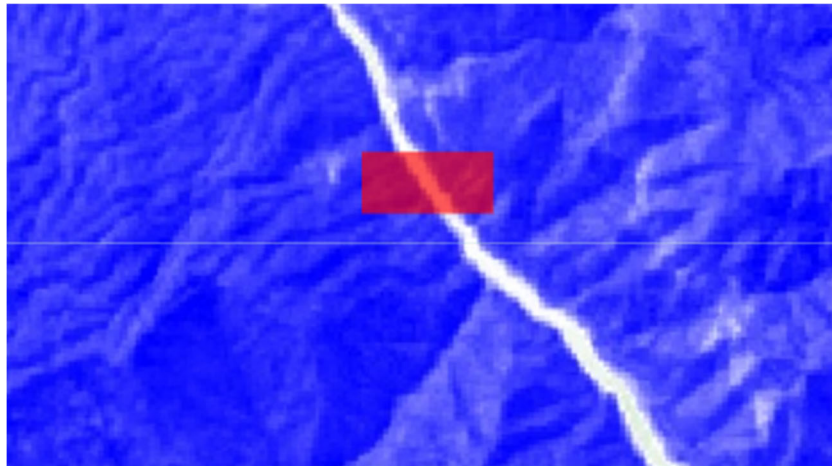
Image 16: Water Flow at the Nuozhadu Dam



Similar to the Project 635 dam, the Nuozhadu dam impacts the flow of water that is available for downstream use, with the dam acting as a chokepoint. (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine. Coordinates 22°38'16"N 100°26'02"E)

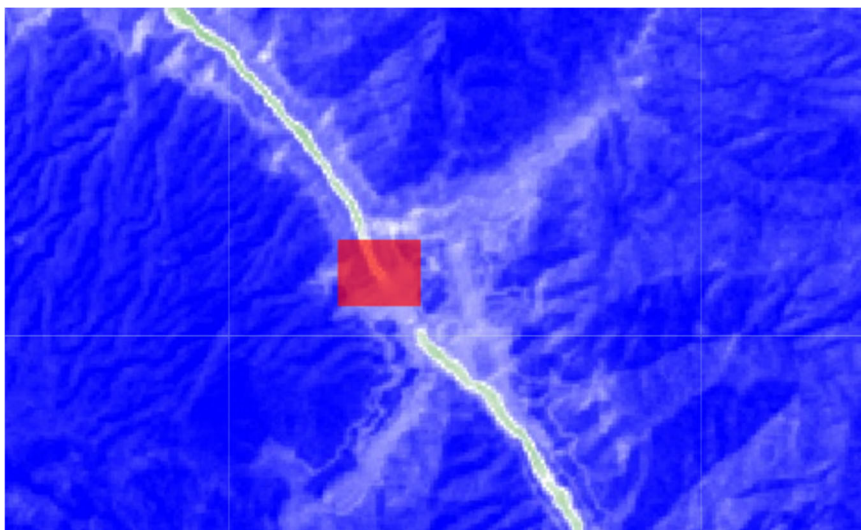
Water turbidity data:

Image 17: Image of NDWI scale at the Nuozhadu Dam Epoch 1



This image shows the location of the Nuozhadu Dam and the turbidity near the dam (Source: Data retrieved from USGS Landsat-5, processed via Google Earth Engine. Coordinates 22°38'16"N 100°26'02"E)

Image 18: Image of NDWI scale at the Nuozhadu Dam Epoch 2:



The turbidity for the Nuozhadu Dam at the second epoch. The suspended particles are seen more clearly with the utilization of Landsat-7 (Source: Data retrieved from USGS Landsat-7, processed via Google Earth Engine. Coordinates 22°38'16"N 100°26'02"E).

The Nuozhadu dam across the first epoch from 1984 to 1999 measured a mean NDWI of -0.337, while the NDWI for the second epoch from 2000 to 2021 registered at a mean NDWI of -0.416. This registers at a roughly twenty percent increase in suspended solids

across the two epochs, demonstrating the likelihood of higher pollution and turbidity in the river body.

B.2. Nam Ou-2

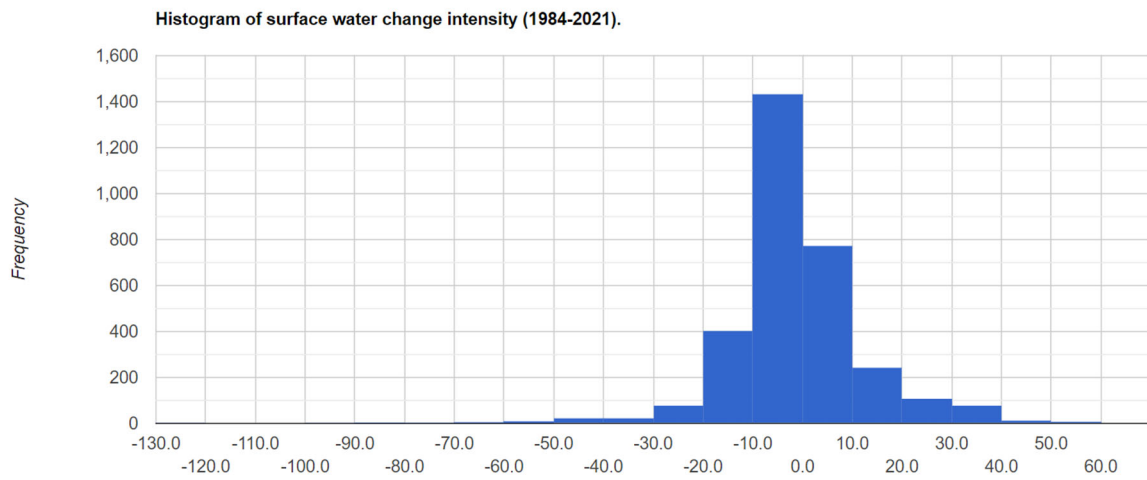
Image 18: Area of study for the Nam Ou River



The Nam Ou tributary of the Mekong River from the Nam Ou-2 dam, linking up further with the Mekong River. (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine Coordinates 20°08'37"N 102°18'58"E).

Frequency of water intensity events:

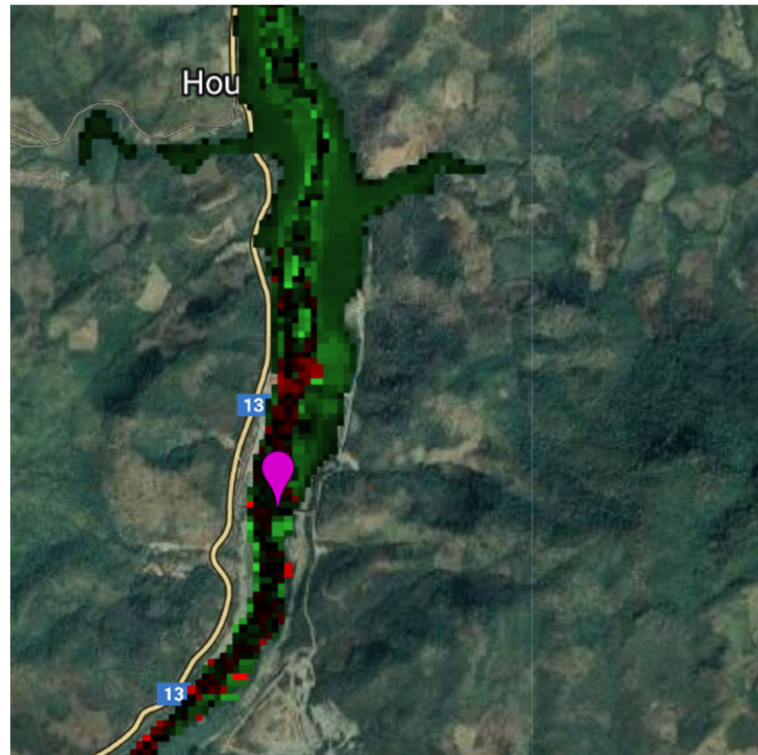
Chart 4: Histogram of Surface Water Change Intensity Nam Ou River



(Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine)

The Nam Ou-2 dam has a mean change in water intensity occurrences of -2.46. This water relationship is generally less stable and trends downward, indicating that water flow is below stable levels to fuel the Mekong River further downstream.

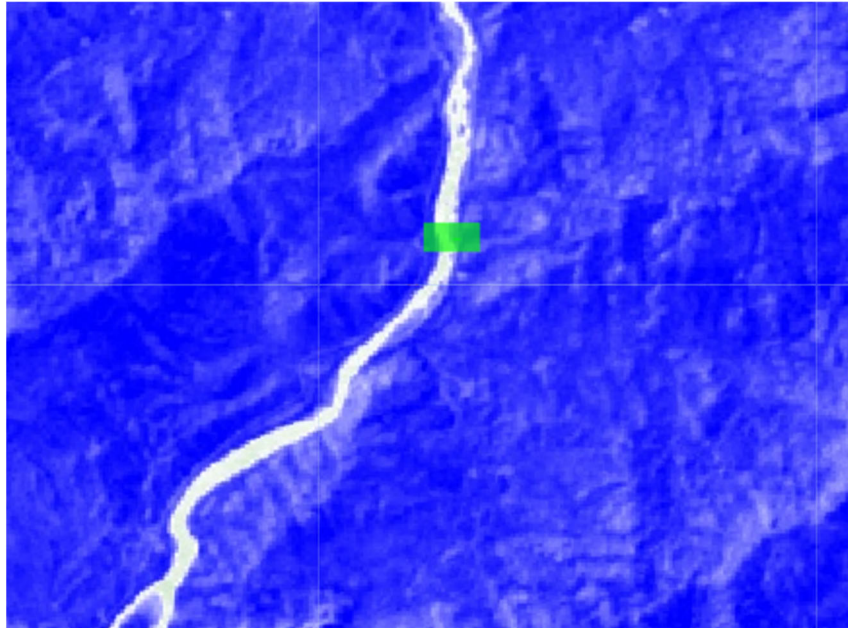
Image 19: Water flow at the Nam Ou-2 Dam



The point where water passes through the Nam Ou-2 dam. The location of the dam is denoted by the pink reticule. As in the case of most of the dams regarded in this study, the water of the Nam Ou-2 dam becomes bottlenecked prior to and after passing through the dam's floodgates. (Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine Coordinates 20°08'37"N 102°18'58"E).

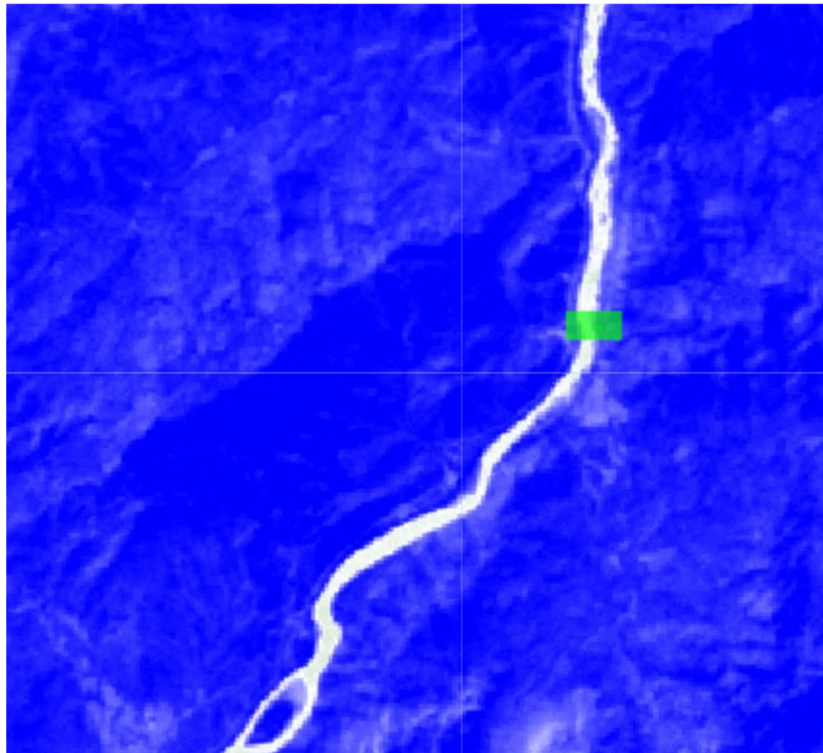
Turbidity data:

Image 20: Turbidity of the Nam Ou River during the first epoch



*This image shows the location of the Nam Ou-2 Dam and the turbidity along the river
(Source: Data retrieved from USGS Landsat-5, processed via Google Earth Engine.
Coordinates 20°08'37"N 102°18'58"E)*

Image 21: Turbidity of the Nam Ou-2 Dam during the second epoch



*This image shows the location of the Nam Ou-2 Dam and the turbidity along the river
(Source: Data retrieved from USGS Landsat-7, processed via Google Earth Engine.
Coordinates 20°08'37"N 102°18'58"E)*

In both recordings of turbidity, the suspended solids are unfortunately a bit harder to see across both epochs. Despite not appearing clearly in these data, the first epoch registered a -0.335 on the NDWI scale, while the second epoch registered at -0.382. This represents a modest increase in the amount of suspended solids and of turbidity for the two periods measured at the Nam Ou-2 Dam.

Analyzing China's project-level transboundary water governance within the lens of hydro-hegemony and China's 'principal-agent' governance gap

Taken together, China's governance of its shared river basins at the project-level holds a significant impact on the quantity of water resources available to downstream communities - these impacts are most observable in the vicinity where the dam projects are located – excluding the Turgusen-1 dam where data was more limited. The data on water flow intensity from the two epochs indicates that there has been a general decrease of water flow occurrences at the dam locations along transboundary rivers in most dam cases reported.

This is attributed to the flow of water that each dams lets out - and is disconnected from the season - whether the rainy season or drought as, according to a Stimson report, “dams generally operate the same way year after year regardless of low flow and drought conditions” (Stimson). This can be seen in the examples of dam projects reviewed in this research. The author will note that the Nuozhadu dam represents a significant outlier when compared to the other dam projects, which have noted modest to significant decreases in water quality. This difference in the Nuozhadu could be explained in a couple of ways: On one hand, the Nuozhadu represents one of China’s largest global hydro projects, and as such, requires greater inputs of water to maintain the southern reaches of the Mekong. Thus, this swing in the data could demonstrate that when China does open its flood gates, it releases a great deal of water. There are, however, other factors which may be inhibiting clarity of the data. For a project like the Nuozhadu dam, the ability to understand the mean flow of water is harder to ascertain as the dam has a larger distance to cross before reaching the Laotian border and is refilled by other tributaries, while its water resources are utilized further in agriculture. These other factors for the river could potentially be skewing the data. For ease of access to compare dam cases for the reader, the mean flow of water resources has been collected into a concise table below (Table 2), as well the mean change in NDWI for each river have been collated in Table 3:

Table 2: Mean flow of water occurrences

Project	Mean instance of water occurrence (quantity)
Kara-Irtysh Canal	-4.87
Turgusen-1 Dam	-7.38
Nuozhadu Dam	16.92
Nam Ou-2 Dam	-2.46

(Source: JRC imagery. Data retrieved from European Commission, processed via Google Earth Engine)

Table 3: Mean NDWI across both epochs to measure turbidity

Project	Mean NDWI Epoch 1	Mean NDWI Epoch 2
Kara-Irtysh Canal	-0.114	-0.217

Turgusen-1 Dam	-0.047	-0.239
Nuozhadu Dam	-0.337	-0.416
Nam Ou-2 Dam	-0.335	-0.382

(Source: Data retrieved from USGS Landsat-7 and USGS Landsat-5, processed via Google Earth Engine.)

Considered with the existing hydro-hegemony literature, China’s usage of water resources at the project level demonstrates that China is flexing its hydro-hegemony at even this most fundamental level of transboundary river governance. China’s dam constructions have very real and observable impacts on water quality and quantity. Given the country’s position as a hydro-hegemon and the policy interdependencies it has created, China is able to maintain its reckless dam construction without worry of being compelled to negotiate or change its practices towards the same time. Of practical importance, these data demonstrate how inconsistently China manages the quality and quantity of water between projects.

The quantitative data further sheds light on China’s project-level hydro hegemony and the ‘principal agent’ problem of China’s governance can likewise be seen herein. The disparity in the data demonstrates different management standards in the implementation of Chinese dams. These data describe instances overall where water quality and quantity has sharply decreased in the second epoch. To examine this project-level phenomenon this section of the analysis examines the dam projects reviewed in this study in concert with the theoretical concepts - positionality, power asymmetry and conflict intensity - which define hydro-hegemony theory and China’s principal-agent problem governance gap.

C. Positionality

Within its borders through the construction of domestic dam projects, China has no inhibitions on its ability to construct dam projects that are aligned with international standards of riparian governance. Firstly, looking at China’s domestic governance frameworks - at the provincial level - there is no discussion or consideration of cross border water sharing with China’s downstream neighbors. From this first principle, within the parameters by which a project is governed, there is emphasis on China building up its own capabilities for industry and domestic conservation according to Chinese ‘National Law’ and to utilize water resources as they see fit. Though the definition of riparian positionality

traditionally applies to China's hydro-hegemony within its own borders, BRI has extended Beijing's hydro-hegemony beyond the borders of China and created a situation where the governments of both countries must accept China's investment projects. In the case of Laotian dam constructions, these projects are literally run as SOE-owned "concessions" that will be the property of ChinaPower for the greater part of the next two decades ("Watered Down" 86).

Connecting this to Hayat's literature on "win-sets," where the upper riparian generally has a 'narrower' set of criteria that would count as a win (Hayat et al. 1730). China has negated this by moving the boundaries of riparian positionality through its project-level imposition of hydro-hegemony. Touching on the win-sets for the lower riparian states, meanwhile, their win-sets are also generally met. In most instances, the frontier regions where these dam projects are built are sparsely populated and are underdeveloped - they are located in the hinterlands of their respective countries. Thus, the communities that are impacted the most by the construction of dam projects and China's extended riparian positionality are generally smaller and less densely populated. As such, there is less of a concerted pressure from large segments of society to encourage the government to reform their riparian cooperation with China.

Furthermore, as seen through the data on water occurrence intensity in this research, the impacts of an individual dam project on the occurrence of water resources is negligible. In this research, the Nuzhaduo dam, which is one of the region's largest, could not have its withdrawals observed in the data on water occurrence by the time it reached the Laotian border. Thus, for the vast amount of a downstream population living outside of a frontier region, the impacts of project-level hydro-hegemony will be harder to observe. Extrapolating this to a country like Kazakhstan, which has a far smaller population living spread out across the Irtysh, China's few dam projects on the Irtysh are unlikely to stir much public consternation and thus does not play significantly into Kazakhstan's calculation for its win-sets in its transboundary water negotiations. Indeed, for both Kazakhstan and Laos, they get the added benefit of selling greener electricity to their neighbors and the promise of economic development as a benefit to their cooperation within China's landscape of transboundary water development. This benefit of cooperation connects directly to the next concept; to keep the benefits from cooperation with China coming, both sides must sacrifice some of their autonomy to gain Chinese investments.

D. Power Asymmetry

China's use of its transboundary water resources fall within Mark Zeitoun's (2010) conception of "coercion." While not utilizing obliquely threatening posturing, China exhibits 'basin-level' dominance of the Irtysh and Mekong Rivers through its imposition of economic power. Zeitoun's conception of basin-level dominance can be seen on one level in China's legal agreements. In this area, China is a 'positive' hydro-hegemon (Zeitoun, 2006). It creates legal frameworks that build on accepted norms of global TBW law. In its bilateral and multilateral agreements with Kazakhstan and the Mekong states, respectively, China rhetorically invokes that its rules agree with 'internationally accepted' water governance laws and norms. Though it invokes these norms, China further delays the agreeable resolution of a water-sharing conflict because it allows China to create its own norms of cooperation - through opaque working groups - with reports that go unpublished to the general public. As such, China demonstrates in both cases of its governance cooperation between Laos and Kazakhstan that it is a "distributive" hegemon (Zeitoun, 2010). China uses its hydro-hegemony to get its lower riparian states to agree to the consensus without actively resolving existing disputes.

Selina Ho's literature on 'issue linkages' in transboundary water management further figures heavily into China's TBW consensus. Using its economic power and the promises of BRI investment, China has muted complaints that had arisen in the past from its transboundary neighbors over the use of water resources. This change is observable in Kazakhstan, where early complaints from officials helped to create the bilateral water governance regime which underpins both transboundary states' water relationship to date.

As investments have increased and dams have proliferated in Kazakhstan, its ability to dispute China's growing usage of water has lessened. For the Irtysh, despite having more 'formalized' cooperative frameworks than the Mekong, it is still impacted by water withdrawals and overuse by China's upriver province of Xinjiang. In 2022, Eurasianet, a publication from Columbia University, went as far to state that "China has won water dispute with Kazakhstan" by weaponizing the legal regime and project-level dominance it has grown within Kazakhstan. The article states that China has completely negated Kazakhstan's ability to raise disputes over water use, despite their formalized, institutional relationship, given the country's hydro-hegemony and compounded by its relative economic, political and importance as a trade partner to Kazakhstan (Trilling). A year later, in 2023, the site reported

that China's "increased water consumption" and "construction of dams" has further brought the Irtysh to its lowest levels in decades. Russia, Kazakhstan's lower riparian partner on the Irtysh, has further blamed Kazakhstan for this period of drought, with an "unnamed" official stating "Kazakhstan gives us very little water" ("Low water levels on Irtysh River create quandary for Kazakhstan"). In this instance of bilateral governance on the Irtysh, China denies Kazakhstan the opportunity to address its water usage with Russia. Herein, China's project-level of governance for its dam projects has an outsize impact on the entire system-level of governance for the Irtysh River. The Mekong suffers similarly from this same 'dam problem.' Despite being able to ostensibly negotiate its water relationship with China as a bloc under the LMC Compact, the states of the Mekong were not able to voice their discontent with the 2020 drought to constructively address water shortage disputes with China. In 2010, after Vietnam was impacted by the "worst drought in ninety years," discussed previously, the countries affected could largely not effect change in their water-sharing relationship with China. As such, through China's flexing of economic power and investment through BRI, it has proven that as its economic power and prominence through the BRI has grown, its economic grasp over its TBW neighbors cannot be disconnected from their shared governance over water resources. Taking this into concert with Etzioni's theory of coercive power, China uses "bribes and mutual trade" - the promises of its economic investment into both regions - to increase its hegemonic basin power (Hayat, et. al 1729).

E. Conflict Intensity

China's project-level exercise of hydro-hegemony demonstrate 'negative interactions' between China and its riparian partners. Despite there not being outbreaks of violence within China's transboundary water relationship with its neighbors, China has effectively utilized "resource capture" strategies, while its treaty negotiations through the auspices of its water working groups remain clandestine - the results being unknown by the general public or experts who seek to review China's TBW relations with its neighbors (Zeitoun and Mirumachi, 2008). Indeed, this transparency of agreements forms a crucial aspect in ensuring the 'reasonable' and 'equitable' use of water - it is the basis of trust within a state-state water relationship. Further characterizing their project-level transboundary dam interactions as 'negative' is the securitization of water by China. Through dominating water usage at the project level, China has turned water its conception of TBW policy into a 'frozen' conflict, where it is able to set the norms of the relationship, control the levers of negotiation and

‘release’ or ‘hold’ the taps on its TBW dams as needed to extract maximum benefits along its transboundary rivers. The extenuation of water conflict, thus serves China’s interests more than their resolution.

F. The ‘principal-agent’ problem and apt-scales

The theoretical concepts that explain the underpinnings of China TBW relationship with its neighbors discuss the ‘gameboard’ that China’s TBW dams operate within. This defines the norms of cooperation and the parameters of the water conflict. China’s governance of these resources at the provincial, national and SOE level define the different actors that operate within the set of rules set out in TBW concepts of TBW governance.

As stated previously, China’s TBW actors are fundamentally at odds with one another. Looking first at the local level of governance at the provincial level, local administrators often fabricate data to spin their management decisions – as stated by Peng et al. - in a positive light while many administrators do not maintain a background in water management policy. On the other hand, the local policies that are a part of China’s domestic landscape do not really have a consideration for TBW effects of China’s dam building policies. Even outside of the local river managers, China’s provincial guidelines are focused on improving the quality of water as it impacts their own standing in the ranks of government and generally are more concerned with economic development within the central government-appointed regional plans of development like the ‘Go West’ policy (Zhang and Li 706). From the highest levels, the policies mandated by Beijing do not resolve this gap. Thus, the downstream impacts of TBW are not even an afterthought for local water managers - these impacts are completely taken out of the calculus for TBW governance and management within China’s provinces. For Beijing, it is better to maintain the status quo - the imposition of lofty goals for cooperation - while handling TBW cooperation through its opaque set of meetings.

The last actor within China’s governance of TBW resources at the project-level is made up of the SOEs - the individual companies -which operate China’s foreign and domestic dam investments. These companies have demonstrated that they are not constrained by China’s policies governing the development of BRI projects. In many instances, as explored previously, SOEs have been debarred by international bodies like the World Bank for short terms and lack oversight from China’s central and provincial governments. Under

the current landscape of China TBW governance, these companies have been incentivized to maximize their profits at the expense of the quality and quantity of water resources on the stretches of river they are responsible for managing.

Putting these factors in terms of Da Silva's apt scales conception of Hydro-hegemony, the treaties set between China and its neighbors fundamentally not concerned with pushing for equitable water management. Thus, environmental cooperation is largely concerned with the development of 'prestige projects' that do not resolve underlying TBW disputes. This constructs a hydro politics that fuels Beijing's hydro-hegemony with its neighbors. This is the state of China TBW governance regime - on one hand, the system of hydro-hegemony itself disincentivizes China's different organelles of TBW management from instituting meaningful cooperation - fragmenting the ability of China's TBW coalitions to institute meaningful policy changes. As such, the Agreements between China and its transboundary neighbors exhibit a disconnect between what is stated in the and what is practiced in the implementation of BRI projects. This disconnect reverts to the ability of high-level state organelles to enforce the text and spirit of legal agreements at the project level. Likewise, there is a major sticking point in the enforcement of these Agreements given the fact that all Agreements lack 'dispute resolution' mechanisms, which do not provide space for disputes to be addressed beyond the level of ad hoc consultations between Parties. Thus, in instances where disputes arise, there is no onus of responsibility on China as the upper riparian partner to resolve the conflict according to any legal guidelines.

Even despite this gap, China has demonstrated that it has made efforts to pursue some type of governance regime over transboundary water resources shared with its neighbors. However, more work needs to be taken by Chinese authorities to repair the disconnect between policy and action and align the spirit of their transboundary water legal agreements with the reality of compliance with international law standards adopted in the 1990's to prevent the abuses seen by dam construction authorities in the construction of their projects within and outside of China. This is extenuated by the vast scale of China's ever-growing dam empire abroad as it pursues projects further afield in Asia and in Africa. China needs to implement international legal standards to meet this enforcement gap it has been experiencing in its management of dam projects - both on transboundary waterways and on rivers abroad.

VI. Conclusion

A. Implications on future research

The results of this study demonstrate that an ‘apt scale’ analysis of China’s transboundary governance policies and development practices that there is little cohesion between the policy and practice of TBW relations. This study aimed to present a snapshot of China’s TBW governance across minimal stretches of gigantic rivers. This small lens was deliberately chosen to show the outsize impacts of project-level dam projects on a vast river course. More in-depth research on the overall system impacts, not just dams, but glacial melting, impacts of rainfall and so forth would provide a more comprehensive picture on project-level impacts to the total system of transboundary water management. This research sought to use this lens to prove that China uses its TBW governance consensus to enforce its own water and development needs and that it is in its interest to continue to allow for disputes to exist and flare occasionally to reinforce its self-made TBW consensus. It applies the principles of IWL rhetorically to enforce this power dynamic with its neighbors, while building its own norms of cooperation to enrich the country’s hydro-hegemonic position.

Outside of providing benefits between China’s provinces, this comparative study presents implications for China’s neighbors in Central Asia - who face similar challenges to Kazakhstan and Laos in their use of transboundary water resources yet lack any sort of agreements whatsoever to govern shared water resources with China. For the countries of Kyrgyzstan and Uzbekistan, specifically which share transboundary rivers with China, Kazakhstan and each other, the questions imposed by China’s differing frameworks of transboundary water governance are worth considering. This is particularly true for the development of cooperative frameworks to work among each other and with China, in considering the positives and negatives in developing the forum approach as seen in the LMC or the bilateral approach with Kazakhstan. The cases explored herein in this research suggest that the forum for cooperation may not matter in actionably changing the usage of transboundary water but may be the only way to raise disputes. Kazakhstan’s transboundary bilateral relationship with China necessarily isolates it from its neighbors and from IWL organizations that seek to document and resolve water disputes. Even along the same transboundary Irtysh River, Kazakhstan is isolated from negotiating between China and Russia over the three countries’ shared usage of water. This creates unintended negative relations in the relationship with Kazakhstan and Russia, as seen in the previous complaints

lodged by Russian authorities. In the case of the LMC states, they are at least granted the option to discuss their shared disputes over water in a forum with China - however the efficacy of this forum is again lost because of a lack of transparency and dispute resolution frameworks. As such, these questions for the other countries of Central Asia are both precinct and provide unsatisfactory resolution for the other states' TBW relationship with China. This however, would be simplified for all parties with the application of international TBW law.

B. Why International Law?

There is a saying from the Yuan Dynasty of China: 天高皇帝远 (*Tiangao Huangdi Yuan*) which translates as "heaven is high and the emperor is far away." This has been the fundamental trouble in providing actionable governance frameworks back in the day of the Yuan Dynasty five hundred years ago and still applies to the China of the present day. There exists a major difficulty in rationalizing and enforcing different legal frameworks across a massive territory - this has been further complicated by the enforcement of the BRI, which has its own frameworks for governance and managers separate from the central and local governments. China has reservations in adopting international TBW standards due to the country's historical context. Following its Century of Humiliation in the Nineteenth Century, China has not wanted to implement legal frameworks that may risk its "national security and sovereignty" (Parry and Jocheim 1). This is why China has taken on its selective approach to implementing international legal reforms to serve its own interests - especially when it comes to economic areas - while rhetorically adopting IWL norms in its TBW policy and adjudicating its own legal frameworks outside of international law. Indeed, this selective approach is what brought China into its status as a more global power in the Twenty-First Century. The adoption of a series of economic reforms brought China into the global economy in the 1990's as it joined the World Trade Organization, it brought the country out of its period of isolationism following Deng Xiaoping's reforms in the 1970's. As such, China practically has very little to gain from following international law to the letter of the law. However, it has more to gain from adopting a less selective approach to IWL.

First of all, IWL provides a level of standardization for China's own domestic system to follow. As stated at the very beginning of this research in regard to the Vienna Convention, the imposition of IWL standards promotes 'dispute resolution' frameworks - an area sorely missing from China's management of TBW and the standards of international treaties

typically become standardized as domestic law for a country. For China this is critical. China's 'principal-agent' problem of governance creates significant inefficiencies with its province-province management of transboundary water resources. As seen in the case of the Burqin River, China is already beginning to siphon water from its less depleted rivers to fill up depleted rivers - particularly in its more arid regions. For China, an already water poor country, there will be a rising dispute, not only between China and its foreign TBW neighbors, but also between China's provinces which share water along transboundary rivers. As climate change worsens the availability and access to the glacial water that forms the source for China's water resources in its western provinces will also worsen without proper management. Thus, IWL provides a ready pathway for China's own provinces to adopt to manage their water needs. The time to adopt a standardized framework for transboundary water governance - within and outside the country's borders - is now.

Appendix:

Kara-Karamay Canal

Calculation of water intensity:

```
// Define Region of Interest (ROI) and load data
var roi = ee.Geometry.Polygon([[[[88.3189, 47.2889], [88.0278, 47.3522], [87.8025, 47.4229],
[87.5444, 47.4712], [87.5004, 47.6380], [87.3741, 47.6380],
[87.0720, 47.6010], [86.9017, 47.6972], [86.8083, 47.7932],
[86.6270, 47.9038], [86.4457, 47.9038], [86.1381, 47.9185],
[85.8415, 48.0142], [85.5449, 48.0472], [85.5394, 47.9774],
[85.6767, 47.9553], [86.0337, 47.8449], [86.6105, 47.8043],
[86.8577, 47.6380], [87.3576, 47.4526], [88.4727, 47.2069],
[88.4782, 47.2628]]]]]);
var gsw = ee.Image("JRC/GSW1_4/GlobalSurfaceWater");
var occurrence = gsw.select('occurrence');
var change = gsw.select('change_abs');
```

```

// Constants

var VIS_OCCURRENCE = {min: 0, max: 100, palette: ['red', 'blue']};
var VIS_CHANGE = {min: -50, max: 50, palette: ['red', 'black', 'limegreen']};

var VIS_WATER_MASK = {palette: ['white', 'black']};

// Water mask

var water_mask = occurrence.gt(90).mask(1);

// Histogram of change intensity

var histogram = ui.Chart.image.histogram({
  image: change,
  region: roi,
  scale: 30,
  minBucketWidth: 10,
}).setOptions({
  title: 'Histogram of Surface Water Change (1984-2021)',
});

print(histogram);

// Map setup

Map.setCenter(88.3189, 47.2889);

Map.addLayer(water_mask, VIS_WATER_MASK, '90% Water Mask', false);
Map.addLayer(occurrence.updateMask(occurrence.divide(100)), VIS_OCCURRENCE, 'Water Occurrence',
  false);

Map.addLayer(change, VIS_CHANGE, 'Water Change Intensity');

// Mean change intensity

var meanChange = change.reduceRegion({
  reducer: ee.Reducer.mean(),
  geometry: roi,
  scale: 30,
  bestEffort: true,
});

print('Mean Change:', meanChange.get('change_abs'));

```

```

// Statistics for water occurrence
var stats = occurrence.reduceRegion({
reducer: ee.Reducer.mean().combine({
reducer2: ee.Reducer.sum(),
sharedInputs: true,
}),
geometry: roi,
scale: 30,
bestEffort: true,
});

print('Mean Water Occurrence:', stats.get('occurrence_mean'));
print('Sum of Water Occurrence:', stats.get('occurrence_sum'));

```

Kara Calculation of NDWI:

```

// Define the region of interest (ROI)
var roi = ee.Geometry.Polygon(
[[[88.3189, 47.2889], [88.0278, 47.3522], [87.8025, 47.4229],
[87.5444, 47.4712], [87.5004, 47.6380], [87.3741, 47.6380],
[87.0720, 47.6010], [86.9017, 47.6972], [86.8083, 47.7932],
[86.6270, 47.9038], [86.4457, 47.9038], [86.1381, 47.9185],
[85.8415, 48.0142], [85.5449, 48.0472], [85.5394, 47.9774],
[85.6767, 47.9553], [86.0337, 47.8449], [86.6105, 47.8043],
[86.8577, 47.6380], [87.3576, 47.4526], [88.4727, 47.2069],
[88.4782, 47.2628]]]);

// Define time periods
var period1984_1999 = ee.DateRange('1984-03-16', '1999-12-31');
var period2000_2021 = ee.DateRange('2000-01-01', '2021-12-31');

// Landsat 5 NDWI for 1984-1999
var landsat5 = ee.ImageCollection('LANDSAT/LT05/C02/T1_TOA')

```

```

        .filterBounds(roi)
        .filterDate(period1984_1999);
    var image1984_1999 = landsat5.median();
var ndwi1984_1999 = image1984_1999.normalizedDifference(['B2', 'B4']).rename('NDWI_1984_1999');
    var meanNDWI1984_1999 = ndwi1984_1999.reduceRegion({
        reducer: ee.Reducer.mean(),
        geometry: roi,
        scale: 1000
    }).get('NDWI_1984_1999');
print('Mean NDWI 1984-1999 (Landsat 5):', meanNDWI1984_1999);

    // Landsat 7 NDWI for 2000-2021
var landsat7 = ee.ImageCollection('LANDSAT/LE07/C02/T1_TOA')
    .filterBounds(roi)
    .filterDate(period2000_2021);
var image2000_2021 = landsat7.median();
var ndwi2000_2021 = image2000_2021.normalizedDifference(['B2', 'B4']).rename('NDWI_2000_2021');
    var meanNDWI2000_2021 = ndwi2000_2021.reduceRegion({
        reducer: ee.Reducer.mean(),
        geometry: roi,
        scale: 1000
    }).get('NDWI_2000_2021');
print('Mean NDWI 2000-2021 (Landsat 7):', meanNDWI2000_2021);

    // Visualization parameters
var ndwiVisParams = {
    min: -0.5,
    max: 0.5,
    palette: ['blue', 'white', 'green']
};

    // Map layers
Map.centerObject(roi, 10);

```

```

Map.addLayer(ndwi1984_1999, ndwiVisParams, 'NDWI 1984-1999 (Landsat 5)');
Map.addLayer(ndwi2000_2021, ndwiVisParams, 'NDWI 2000-2021 (Landsat 7)');
Map.addLayer(roi, {color: 'red', fillColor: '00000000', strokeWidth: 2}, 'Region of Interest');

```

Turgusen-1 Dam

Calculation of water intensity

```

////////////////////////////////////
// Asset List
////////////////////////////////////

var gsw = ee.Image("JRC/GSW1_4/GlobalSurfaceWater");
var occurrence = gsw.select('occurrence');
var change = gsw.select("change_abs");
var roi = /* color: 0B4A8B */ee.Geometry.Polygon(
  [[[84.04835666698224,49.92690948437582],
    [84.08380673060516,49.78361556936949],
    [84.08552334437469,49.896913505629094],
    [84.05306306019243,49.948768211006154],
    [84.04782738819536,49.94883724804716],
    [84.04835666698224,49.92690948437582]]]);

////////////////////////////////////
// Constants
////////////////////////////////////

var VIS_OCCURRENCE = {
  min:0,
  max:100,
  palette: ['red', 'blue']
}

```

```

        };
    var VIS_CHANGE = {
        min:-50,
        max:50,
        palette: ['red', 'black', 'limegreen']
    };
    var VIS_WATER_MASK = {
        palette: ['white', 'black']
    };

    ///////////////////////////////////////////////////////////////////

    // Calculations

    ///////////////////////////////////////////////////////////////////

    // Create a water mask layer, and set the image mask so that non-water areas are transparent.

    var water_mask = occurrence.gt(90).mask(1);

    // Generate a histogram object and print it to the console tab.

    var histogram = ui.Chart.image.histogram({
        image: change,
        region: roi,
        scale: 30,
        minBucketWidth: 10,
    });

    histogram.setOptions({
title: 'Histogram of surface water change intensity (1984-2021).',
    });

    print(histogram);

    ///////////////////////////////////////////////////////////////////

```

```

// Initialize Map Location
////////////////////////////////////

Map.setCenter(84.03869127459855,49.782511605028915); // Turgusen River, KZ

////////////////////////////////////

// Map Layers
////////////////////////////////////

Map.addLayer({
  eeObject: water_mask,
  visParams: VIS_WATER_MASK,
  name: '90% occurrence water mask',
  shown: false
});

Map.addLayer({
  eeObject: occurrence.updateMask(occurrence.divide(100)),
  name: "Water Occurrence (1984-2021)",
  visParams: VIS_OCCURRENCE,
  shown: false
});

Map.addLayer({
  eeObject: change,
  visParams: VIS_CHANGE,
  name: 'occurrence change intensity'
});

//mean change

// Calculate mean change intensity over the ROI
var meanChange = change.reduceRegion({

```

```

        reducer: ee.Reducer.mean(),
        geometry: roi,
scale: 30, // Adjust scale as needed
        bestEffort: true
    });

    // Print the mean change to the console
print('Mean Change:', meanChange.get('change_abs'));

// Optionally, you can add it as a layer to the map
Map.addLayer({
    eeObject: change,
    visParams: VIS_CHANGE,
    name: 'occurrence change intensity'
});

```

Turgusen-1 NDWI

```

// Define the region of interest (ROI)
var roi = ee.Geometry.Polygon(
[[[84.04835666698224,49.92690948437582],
[84.08380673060516,49.78361556936949],
[84.08552334437469,49.896913505629094],
[84.05306306019243,49.948768211006154],
[84.04782738819536,49.94883724804716],
[84.04835666698224,49.92690948437582]]]]);

// Define time periods
var period1984_1999 = ee.DateRange('1984-03-16', '1999-12-31');
var period2000_2021 = ee.DateRange('2000-01-01', '2021-12-31');

```

```

// 1. Landsat 5 NDWI calculation for the period 1984-1999

// Import Landsat 5 TOA Collection
var landsat5 = ee.ImageCollection('LANDSAT/LT05/C02/T1_TOA')
    .filterBounds(roi)
    .filterDate(period1984_1999);

// Compute median composite for the period
var image1984_1999 = landsat5.median();

// Calculate NDWI (using green and NIR bands: B2 and B4)
var ndwi1984_1999 = image1984_1999.normalizedDifference(['B2', 'B4']).rename('NDWI_1984_1999');

// Compute mean NDWI for the period with larger scale to reduce memory usage
var meanNDWI1984_1999 = ndwi1984_1999.reduceRegion({
    reducer: ee.Reducer.mean(),
    geometry: roi,
    scale: 1000 // Increased scale to 1000 meters
}).get('NDWI_1984_1999');

// Print mean NDWI value for the period
print('Mean NDWI 1984-1999 (Landsat 5):', meanNDWI1984_1999);

// 2. Landsat 7 NDWI calculation for the period 2000-2021

// Import Landsat 7 TOA Collection
var landsat7 = ee.ImageCollection('LANDSAT/LE07/C02/T1_TOA')
    .filterBounds(roi)
    .filterDate(period2000_2021);

```

```

// Compute median composite for the period
var image2000_2021 = landsat7.median();

// Calculate NDWI (using green and NIR bands: B2 and B4)
var ndwi2000_2021 = image2000_2021.normalizedDifference(['B2', 'B4']).rename('NDWI_2000_2021');

// Compute mean NDWI for the period with larger scale to reduce memory usage
var meanNDWI2000_2021 = ndwi2000_2021.reduceRegion({
  reducer: ee.Reducer.mean(),
  geometry: roi,
  scale: 1000 // Increased scale to 1000 meters
}).get('NDWI_2000_2021');

// Print mean NDWI value for the period
print('Mean NDWI 2000-2021 (Landsat 7):', meanNDWI2000_2021);

// Visualize NDWI for both periods
var ndwiVisParams = {
  min: -0.5,
  max: 0.5,
  palette: ['blue', 'white', 'green'] // Blue for low, white for neutral, green for high NDWI
};

// Add NDWI layers to the map
Map.centerObject(roi, 10);
Map.addLayer(ndwi1984_1999, ndwiVisParams, 'NDWI 1984-1999 (Landsat 5)');
Map.addLayer(ndwi2000_2021, ndwiVisParams, 'NDWI 2000-2021 (Landsat 7)');

// Add the ROI polygon as a highlighted layer

```

```
Map.addLayer(roi, {color: 'red', fillColor: '00000000', strokeWidth: 2}, 'Region of Interest');
```

Nam Ou-2 Dam

Nam Ou-2 Water flow

```
var gsw = ee.Image("JRC/GSW1_4/GlobalSurfaceWater");  
var occurrence = gsw.select('occurrence');  
var change = gsw.select("change_abs");  
var geometry = /* color: #98ff00 */ee.Geometry.Polygon(  
  [[[102.2918135852579, 20.121515198329842],  
    [102.26008433667978, 20.0867898009808],  
    [102.24789637891611, 20.088563208850324],  
    [102.24102992383798, 20.08324292502472],  
    [102.23701119666063, 20.070443867456973],  
    [102.23203301672899, 20.056335028475846],  
    [102.2176992917534, 20.062946185294454],  
    [102.2097231017986, 20.055517158818564],  
    [102.21362839812429, 20.053904630890862],  
    [102.2209240066448, 20.05648466762277],  
    [102.2322536575237, 20.051082667154795],  
    [102.23999057241234, 20.059159102926728],  
    [102.24568717585734, 20.080863340796334],  
    [102.26002090083293, 20.081991918081734],  
    [102.26527482959182, 20.086097837031115],  
    [102.28767763441813, 20.10378084916405],  
    [102.30549649271774, 20.125299315905306],  
    [102.31861448607754, 20.143514482252645],  
    [102.3139796288998, 20.14427999684804]]]);  
  
var VIS_OCCURRENCE = {
```

```

        min:0,
        max:100,
        palette: ['red', 'blue']
    };
    var VIS_CHANGE = {
        min:-50,
        max:50,
        palette: ['red', 'black', 'limegreen']
    };
    var VIS_WATER_MASK = {
        palette: ['white', 'black']
    };

// Create a water mask layer, and set the image mask so that non-water areas are transparent.
    var water_mask = occurrence.gt(90).mask(1);

// Generate a histogram object and print it to the console tab.
    var histogram = ui.Chart.image.histogram({
        image: change,
        region: roi,
        scale: 30,
        minBucketWidth: 10,
    });
    histogram.setOptions({
title: 'Histogram of surface water change intensity (1984-2021)!'
    });
    print(histogram);

Map.setCenter(102.44879265511987,20.388962852155984); // Kara Canal, CN

```

```

        Map.addLayer({
            eeObject: water_mask,
            visParams: VIS_WATER_MASK,
            name: '90% occurrence water mask',
            shown: false
        });

        Map.addLayer({
eeObject: occurrence.updateMask(occurrence.divide(100)),
            name: "Water Occurrence (1984-2021)",
            visParams: VIS_OCCURRENCE,
            shown: false
        });

        Map.addLayer({
            eeObject: change,
            visParams: VIS_CHANGE,
            name: 'occurrence change intensity'
        });

        //mean change
        // Mean change intensity over the ROI
        var meanChange = change.reduceRegion({
            reducer: ee.Reducer.mean(),
            geometry: roi,
            scale: 30,
            bestEffort: true
        });

        print('Mean Change:', meanChange.get('change_abs'));

        Map.addLayer({
            eeObject: change,

```

```
visParams: VIS_CHANGE,  
name: 'occurrence change intensity'  
});
```

Nam Ou-2 NDWI

```
// Define the region of interest (ROI)  
var roi = ee.Geometry.Polygon(  
[[[102.2918135852579, 20.121515198329842],  
[102.26008433667978, 20.0867898009808],  
[102.24789637891611, 20.088563208850324],  
[102.24102992383798, 20.08324292502472],  
[102.23701119666063, 20.070443867456973],  
[102.23203301672899, 20.056335028475846],  
[102.2176992917534, 20.062946185294454],  
[102.2097231017986, 20.055517158818564],  
[102.21362839812429, 20.053904630890862],  
[102.2209240066448, 20.05648466762277],  
[102.2322536575237, 20.051082667154795],  
[102.23999057241234, 20.059159102926728],  
[102.24568717585734, 20.080863340796334],  
[102.26002090083293, 20.081991918081734],  
[102.26527482959182, 20.086097837031115],  
[102.28767763441813, 20.10378084916405],  
[102.30549649271774, 20.125299315905306],  
[102.31861448607754, 20.143514482252645],  
[102.3139796288998, 20.14427999684804]]]);  
  
// Define time periods
```

```

var period1984_1999 = ee.DateRange('1984-03-16', '1999-12-31');
var period2000_2021 = ee.DateRange('2000-01-01', '2021-12-31');

// 1. Landsat 5 NDWI calculation for the period 1984-1999

// Import Landsat 5 TOA Collection
var landsat5 = ee.ImageCollection('LANDSAT/LT05/C02/T1_TOA')
    .filterBounds(roi)
    .filterDate(period1984_1999);

// Compute median composite for the period
var image1984_1999 = landsat5.median();

// Calculate NDWI (using green and NIR bands: B2 and B4)
var ndwi1984_1999 = image1984_1999.normalizedDifference(['B2', 'B4']).rename('NDWI_1984_1999');

// Compute mean NDWI for the period with larger scale to reduce memory usage
var meanNDWI1984_1999 = ndwi1984_1999.reduceRegion({
    reducer: ee.Reducer.mean(),
    geometry: roi,
    scale: 1000 // Increased scale to 1000 meters
}).get('NDWI_1984_1999');

// Print mean NDWI value for the period
print('Mean NDWI 1984-1999 (Landsat 5):', meanNDWI1984_1999);

// 2. Landsat 7 NDWI calculation for the period 2000-2021

// Import Landsat 7 TOA Collection
var landsat7 = ee.ImageCollection('LANDSAT/LE07/C02/T1_TOA')

```

```

        .filterBounds(roi)
        .filterDate(period2000_2021);

// Compute median composite for the period
var image2000_2021 = landsat7.median();

// Calculate NDWI (using green and NIR bands: B2 and B4)
var ndwi2000_2021 = image2000_2021.normalizedDifference(['B2', 'B4']).rename('NDWI_2000_2021');

// Compute mean NDWI for the period with larger scale to reduce memory usage
var meanNDWI2000_2021 = ndwi2000_2021.reduceRegion({
    reducer: ee.Reducer.mean(),
    geometry: roi,
    scale: 1000 // Increased scale to 1000 meters
}).get('NDWI_2000_2021');

// Print mean NDWI value for the period
print('Mean NDWI 2000-2021 (Landsat 7):', meanNDWI2000_2021);

// Visualize NDWI for both periods
var ndwiVisParams = {
    min: -0.5,
    max: 0.5,
palette: ['blue', 'white', 'green'] // Blue for low, white for neutral, green for high NDWI
};

// Add NDWI layers to the map
Map.centerObject(roi, 10);
Map.addLayer(ndwi1984_1999, ndwiVisParams, 'NDWI 1984-1999 (Landsat 5)');
Map.addLayer(ndwi2000_2021, ndwiVisParams, 'NDWI 2000-2021 (Landsat 7)');

```

```
// Add the ROI polygon as a highlighted layer
Map.addLayer(roi, {color: 'red', fillColor: '00000000', strokeWidth: 2}, 'Region of Interest');
```

NuoZhadu Dam

Nuozhadu Water Flow

```
var gsw = ee.Image("JRC/GSW1_4/GlobalSurfaceWater");
var occurrence = gsw.select('occurrence');
var change = gsw.select("change_abs");
var geometry = /* color: #bf04c2 */ee.Geometry.Polygon(
[[[100.43197174429754, 22.633956540906386],
[100.4351689374433, 22.629143829099743],
[100.45065519274813, 22.610057514476182],
[100.45924945608571, 22.59382012014153],
[100.48362537161306, 22.58161610724025],
[100.49323840872243, 22.576702498061387],
[100.52791400686696, 22.54800986354543],
[100.57317425070319, 22.496672769977472],
[100.55909801779303, 22.4785913886153],
[100.5562076410793, 22.424163583353007],
[100.62130275491889, 22.32842508141279],
[100.59535435150136, 22.28477418128622],
[100.69903782318104, 22.218998935449285],
[100.71846095475924, 22.113214079816803],
```

[100.75862971696627, 22.05054066147739],
[100.85605922991742, 21.963391905523086],
[100.91196743512059, 21.83501666332757],
[100.98477816524509, 21.82160414601621],
[101.01018404903415, 21.842000913392773],
[101.05000948848728, 21.79259748625986],
[101.06889223995212, 21.770280674619343],
[101.09773135128025, 21.7827147553375],
[101.12614042331688, 21.788513660186823],
[101.16802579929345, 21.812261983840575],
[101.17832548191063, 21.79743966642571],
[101.1213339047622, 21.773529471528303],
[101.10680850436506, 21.753414163771758],
[101.11573489596663, 21.67845926828124],
[101.15016584364209, 21.645246638431832],
[101.12956647840771, 21.564169075722763],
[100.90749609922317, 21.360317772290774],
[100.93269324035711, 21.34629081956711],
[101.04494580857698, 21.404637522499968],
[101.18776807420198, 21.54265774666612],
[101.16854199998323, 21.67416599309701],
[101.12593960337824, 21.72375942733439],
[101.12971615367121, 21.768722887483232],
[101.18155788951105, 21.781157103246137],

```
[101.18567776255793, 21.80825358071348],  
[101.1674816566009, 21.82164053630467],  
[101.07306789927668, 21.78721440755229],  
[101.06020442220104, 21.83082120985038],  
[101.02964869710338, 21.851853973565],  
[100.97172186524355, 21.8657861965769],  
[100.92125342041933, 21.8689723981064],  
[100.90845643983768, 21.937643917047094],  
[100.86855593666027, 21.993503236960578],  
[100.78380910293299, 22.043155251026256],  
[100.78277913467127, 22.112487527629362],  
[100.7402071131869, 22.159236091456624],  
[100.72101838845481, 22.238027989595174],  
[100.66569720282511, 22.32614722466603],  
[100.59443327876157, 22.414724203654064],  
[100.58825346919126, 22.501481513151866],  
[100.56458675434685, 22.542371551628772],  
[100.43983952761707, 22.634614337792684]]];
```

```
var VIS_OCCURRENCE = {
```

```
    min:0,
```

```
    max:100,
```

```
    palette: ['red', 'blue']
```

```
};
```

```
var VIS_CHANGE = {
```

```

        min:-50,

        max:50,

        palette: ['red', 'black', 'limegreen']

        };

    var VIS_WATER_MASK = {

        palette: ['white', 'black']

        };

    //////////////////////////////////////

    // Create a water mask layer, and set the image mask so that non-water areas are transparent.

    var water_mask = occurrence.gt(90).mask(1);

    // Generate a histogram object and print it to the console tab.

    var histogram = ui.Chart.image.histogram({

        image: change,

        region: roi,

        scale: 30,

        minBucketWidth: 10,

        });

    histogram.setOptions({

    title: 'Histogram of surface water change intensity (1984-2021).')

    });

    print(histogram);

    Map.setCenter(100.43197174429754,22.633956540906386); // Kara Canal, CN

```

```

        Map.addLayer({
            eeObject: water_mask,
            visParams: VIS_WATER_MASK,
            name: '90% occurrence water mask',
            shown: false
        });

        Map.addLayer({
eeObject: occurrence.updateMask(occurrence.divide(100)),
            name: "Water Occurrence (1984-2021)",
            visParams: VIS_OCCURRENCE,
            shown: false
        });

        Map.addLayer({
            eeObject: change,
            visParams: VIS_CHANGE,
            name: 'occurrence change intensity'
        });

        //mean change

        // Mean change intensity over the ROI
var meanChange = change.reduceRegion({
            reducer: ee.Reducer.mean(),
            geometry: roi,

```

```

        scale: 30,

        bestEffort: true

    });

print('Mean Change:', meanChange.get('change_abs'));

    Map.addLayer({

        eeObject: change,

        visParams: VIS_CHANGE,

        name: 'occurrence change intensity'

    });

```

Nuozhadu NDWI

```

// Define the region of interest (ROI)

var roi = ee.Geometry.Polygon(

[[[100.43197174429754, 22.633956540906386],

[100.4351689374433, 22.629143829099743],

[100.45065519274813, 22.610057514476182],

[100.45924945608571, 22.59382012014153],

[100.48362537161306, 22.58161610724025],

[100.49323840872243, 22.576702498061387],

[100.52791400686696, 22.54800986354543],

[100.57317425070319, 22.496672769977472],

[100.55909801779303, 22.4785913886153],

[100.5562076410793, 22.424163583353007],

[100.62130275491889, 22.32842508141279],

[100.59535435150136, 22.28477418128622],

```

[100.69903782318104, 22.218998935449285],
[100.71846095475924, 22.113214079816803],
[100.75862971696627, 22.05054066147739],
[100.85605922991742, 21.963391905523086],
[100.91196743512059, 21.83501666332757],
[100.98477816524509, 21.82160414601621],
[101.01018404903415, 21.842000913392773],
[101.05000948848728, 21.79259748625986],
[101.06889223995212, 21.770280674619343],
[101.09773135128025, 21.7827147553375],
[101.12614042331688, 21.788513660186823],
[101.16802579929345, 21.812261983840575],
[101.17832548191063, 21.79743966642571],
[101.1213339047622, 21.773529471528303],
[101.10680850436506, 21.753414163771758],
[101.11573489596663, 21.67845926828124],
[101.15016584364209, 21.645246638431832],
[101.12956647840771, 21.564169075722763],
[100.90749609922317, 21.360317772290774],
[100.93269324035711, 21.34629081956711],
[101.04494580857698, 21.404637522499968],
[101.18776807420198, 21.54265774666612],
[101.16854199998323, 21.67416599309701],
[101.12593960337824, 21.72375942733439],

```
[101.12971615367121, 21.768722887483232],  
[101.18155788951105, 21.781157103246137],  
[101.18567776255793, 21.80825358071348],  
[101.1674816566009, 21.82164053630467],  
[101.07306789927668, 21.78721440755229],  
[101.06020442220104, 21.83082120985038],  
[101.02964869710338, 21.851853973565],  
[100.97172186524355, 21.8657861965769],  
[100.92125342041933, 21.8689723981064],  
[100.90845643983768, 21.937643917047094],  
[100.86855593666027, 21.993503236960578],  
[100.78380910293299, 22.043155251026256],  
[100.78277913467127, 22.112487527629362],  
[100.7402071131869, 22.159236091456624],  
[100.72101838845481, 22.238027989595174],  
[100.66569720282511, 22.32614722466603],  
[100.59443327876157, 22.414724203654064],  
[100.58825346919126, 22.501481513151866],  
[100.56458675434685, 22.542371551628772],  
[100.43983952761707, 22.634614337792684]]];
```

```
// Define time periods
```

```
var period1984_1999 = ee.DateRange('1984-03-16', '1999-12-31');
```

```
var period2000_2021 = ee.DateRange('2000-01-01', '2021-12-31');
```

```

// 1. Landsat 5 NDWI calculation for the period 1984-1999

// Import Landsat 5 TOA Collection

var landsat5 = ee.ImageCollection('LANDSAT/LT05/C02/T1_TOA')

    .filterBounds(roi)

    .filterDate(period1984_1999);

// Compute median composite for the period

var image1984_1999 = landsat5.median();

// Calculate NDWI (using green and NIR bands: B2 and B4)

var ndwi1984_1999 = image1984_1999.normalizedDifference(['B2', 'B4']).rename('NDWI_1984_1999');

// Compute mean NDWI for the period with larger scale to reduce memory usage

var meanNDWI1984_1999 = ndwi1984_1999.reduceRegion({

    reducer: ee.Reducer.mean(),

    geometry: roi,

    scale: 1000 // Increased scale to 1000 meters

}).get('NDWI_1984_1999');

// Print mean NDWI value for the period

print('Mean NDWI 1984-1999 (Landsat 5):', meanNDWI1984_1999);

```

```
// 2. Landsat 7 NDWI calculation for the period 2000-2021
```

```
// Import Landsat 7 TOA Collection
```

```
var landsat7 = ee.ImageCollection('LANDSAT/LE07/C02/T1_TOA')
```

```
.filterBounds(roi)
```

```
.filterDate(period2000_2021);
```

```
// Compute median composite for the period
```

```
var image2000_2021 = landsat7.median();
```

```
// Calculate NDWI (using green and NIR bands: B2 and B4)
```

```
var ndwi2000_2021 = image2000_2021.normalizedDifference(['B2', 'B4']).rename('NDWI_2000_2021');
```

```
// Compute mean NDWI for the period with larger scale to reduce memory usage
```

```
var meanNDWI2000_2021 = ndwi2000_2021.reduceRegion({
```

```
  reducer: ee.Reducer.mean(),
```

```
  geometry: roi,
```

```
  scale: 1000 // Increased scale to 1000 meters
```

```
}).get('NDWI_2000_2021');
```

```
// Print mean NDWI value for the period
```

```
print('Mean NDWI 2000-2021 (Landsat 7):', meanNDWI2000_2021);
```

```
// Visualize NDWI for both periods
```

```

var ndwiVisParams = {

    min: -0.5,

    max: 0.5,

palette: ['blue', 'white', 'green'] // Blue for low, white for neutral, green for high NDWI

    };

// Add NDWI layers to the map

Map.centerObject(roi, 10);

Map.addLayer(ndwi1984_1999, ndwiVisParams, 'NDWI 1984-1999 (Landsat 5)');

Map.addLayer(ndwi2000_2021, ndwiVisParams, 'NDWI 2000-2021 (Landsat 7)');

// Add the ROI polygon as a highlighted layer

Map.addLayer(roi, {color: 'red', fillColor: '00000000', strokeWidth: 2}, 'Region of Interest');

// Create a FeatureCollection for charting

var ndwiFeatures = ee.FeatureCollection([

ee.Feature(null, { 'Period': '1984-1999', 'Mean NDWI': ee.Number(meanNDWI1984_1999) }),

ee.Feature(null, { 'Period': '2000-2021', 'Mean NDWI': ee.Number(meanNDWI2000_2021) })

]);

```

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