Motta, S., and J. K. L. Koehler. 2025. Who has the time? The temporality of tensions in the transboundary Red River basin. Ecology and Society 30(4):33. https://doi.org/10.5751/ES-16586-300433

Research, part of a Special Feature on The Next Wave in Water Governance

Who has the time? The temporality of tensions in the transboundary Red River basin

Stew Motta[1] and *Johanna K. L. Koehler*[1]

ABSTRACT. We address the often absent "when" issues of governing shared rivers by focusing on timing and the challenges it creates for transboundary water management. Using the Red River basin and Chinese-Vietnamese relations as an example, this study illustrates how hydropolitical tensions are linked to the temporal scale. The politics of scale have been used widely in the Mekong region to critique particular framings of transboundary water governance and hydraulic infrastructure. These critiques are often geospatial, with less attention given to the temporal scale or the timing of water governance problems. The temporal scale is discussed in the Mekong region with regard to changes in seasonality, particularly around the arrival of monsoon rains. However, the "when" of water governance is not merely in response to natural phenomena; it is heavily mediated by social processes and infrastructure. The timing of infrastructure operations in transboundary water governance is in many cases at the core of hydropolitical tensions and risk. In the highly regulated Red River basin, the timing of hydropower operations and inherent temporal misfits create hydropolitical tensions across multiple timescales from seasons to seconds. Cooperation attempts reflect these temporal scale problems and are focused on reducing uncertainties around the timing of water governance processes. Drawing on insights from interviews in Northern Viet Nam, we analyzed the tensions caused by timing across infrastructure lifecycles and the "when" of water governance in the Red River basin between Yunnan, China and Northern Viet Nam.

Key Words: *China; hydropolitics; infrastructure; politics of scale; time; Viet Nam*

INTRODUCTION

This article focuses on the transboundary Red River basin (RRB) shared by Yunnan, China (48%), Lao PDR (0.65%), and Viet Nam (51.35%; Nguyen et al. 2018). The RRB is a heavily regulated river with hundreds of hydraulic infrastructure projects. With regard to hydropolitical tensions, unilateral infrastructure construction on shared rivers has one of the most direct links to increasing hydropolitical tensions and conflict (De Stefano et al. 2017). We seek to unpack this direct relationship between infrastructure and hydropolitical tensions in the transboundary RRB by attending to the politics of temporal scales. The timing of infrastructure operations can escalate hydropolitical tensions through shorter timescales such as sudden dam releases, and problems like the lowering of the riverbed, which take place over longer periods of time. We analyzed these challenges in the transboundary RRB across six time scales; historical legacy; seasonal shifts; day and night; hours; minutes and seconds; and futures.

Water governance generally, and particularly in the Mekong region is not just spatial, it is spatial-temporal. The Mekong region has a monsoonal climate, and the rivers have extreme variation between wet and dry seasons with expected increases in both high-flow and low-flow scenarios under climate change (Hoang et al. 2016). Additionally, the region is an epicenter of hydropower dam construction, and the rivers are increasingly regulated. This is true in the RRB and relevant to other transboundary water governance arrangements in which new dam regulations disrupt the timing of water availability and can lock in or constrain future cooperation possibilities (Käkönen and Nygren 2023). With seasonally variable rivers and high levels of dam regulation, the temporal scale and the "when" question of water governance is extremely important.

The politics of scale is an important concept to analyze water governance processes. The production of scale is an ongoing process of reordering that is inherently political (Swyngedouw 1997). Scale is not a tool or a given but something that is actively produced (Lamb 2014). Typically, the politics of scale are ignored in decision making, or if engaged with, the analysis focuses on trade-offs between sectors, such as water for food versus water for energy production (Pahl-Wostl et al. 2021). When the politics of scale are engaged with more deeply, the majority of the time it is done so through a geospatial lens (Cash et al. 2006, Norman et al. 2015).

Hydraulic infrastructure in river systems is often thought about in spatial terms: edifices and pipes forming networks of a built environment. These large-scale hydraulic infrastructures can transcend spatial boundaries such as political borders and the natural watershed through energy exports, water transfers, and carbon credits (Hirsch 1996, Middleton and Allouche 2016, Motta et al. 2025). Analysis of infrastructure typically focuses on the "spatial dimensions of built environments at the expense of the temporal dimension that gives it so much political power" (Hetherington 2014:195).

Primary justifications and rationales for hydropower dam construction are that the infrastructure alters the temporal scale. Water is stored behind reservoirs for use at a later time, altering the timing of water availability and function (Harris 2015). The storage and release of water behind large dams also impact the rate, duration, and frequency of the transboundary water (Cash et al. 2006). Many of the controversial aspects of hydropower in the Mekong region are caused by the disruption of the temporal scale (Johnson 2024), i.e., the rupturing of rhythms in the landscape of predictable agriculture cycles, fish migrations, and flood pulses (Krause 2022).

With expansive dam construction, the river and those within it become disentangled from the calendar as the riparian clock clashes with linear oriented hydropower development (Johnson 2024). Conflicts in time have become seen as a crucial element to

[1]Public Administration and Policy Group, Wageningen University and Research, Wageningen, The Netherlands

understand experiences of inequality (Bear 2016). The regulated new river has rhythms of ebbs and flows that are based on rhythms of electricity use far from the river itself (Johnson 2019). The new river has aspects of both sudden risks from dam releases and of slow violence as the landscape gradually declines in productivity (Nixon 2011). Slow violence has been found to occur at both large-scale and small-scale dam sites in the Mekong region as the landscape is altered for energy production (Blake and Barney 2018, Dao 2025). This altered phenomenon has led scholars in the Mekong to conceive of rivers as a powersheds rather than watersheds (Fig. 1; Magee 2006, Middleton and Allouche 2016).

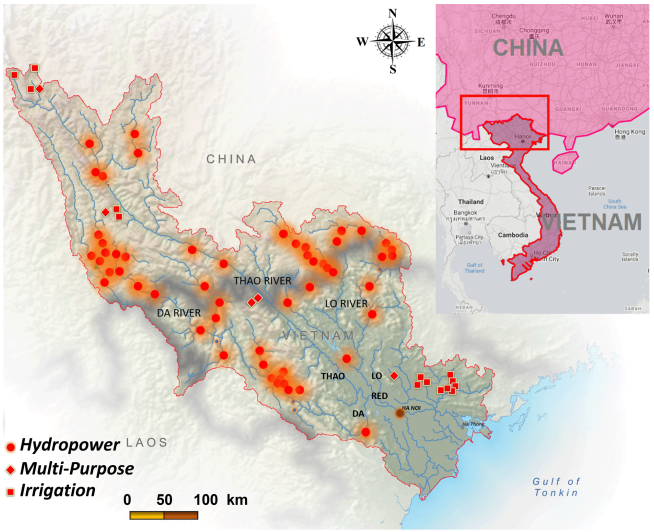
In addition to domestic infrastructure challenges, Yunnan Province has built large-scale dams in the upstream and near the border with Viet Nam. The proximity of the infrastructure means that dam operations in Yunnan directly impact Northern Viet Nam. If we are to better understand the direct links between hydropower and escalating hydropolitical tensions, the analysis needs to avoid treating the situation as a stagnant and completed process, whether or not there is the spatial existence of a commissioned dam upstream. If we examine the lifecycle of the infrastructure across multiple timescales, we can see how these projects impede cooperation and enhance hydropolitical tensions through the disruption of predictable timing.

Infrastructure impacts time as much as it does space and is never completed but instead is an ongoing process (Anand et al. 2018). This approach to understanding the hydropolitical situation as ongoing "shifts the focus back to how infrastructure is remade and reshaped in a continual fashion, signifying its 'temporal fragility,' and the ways in which it is generative of particular configurations of people, power, and nature over space and time" (Ramakrishnan et al. 2021:677). We add to the understanding of infrastructure and conflict dynamics in transboundary rivers by viewing hydropower dams as very much active processes that have varying timing dynamics across the project's lifecycle and timescales that enhance uncertainty, risk, and hydropolitical tensions.

If the temporal dimension is discussed in the water governance literature, it is often with regard to historical legacy. Some aspects of temporality are captured well in the concept of waterscapes, which are co-produced by human and non-human elements over time, typically looking at changes over years or generations (Venot et al. 2007, Budds and Hinojosa 2012). The institutions and governance arrangements in the Mekong region currently are influenced heavily by governance arrangements under previous empires, colonialism, Cold-War competition, the globalization of neoliberal paradigms, and the rise of China (Fforde 2010, Biggs 2012, Sneddon 2015, Middleton 2022, Motta and Matthews 2017).

These infrastructure processes outlast the timescale of a human generation. The projects can be designed to last over a century with typically decades of surveying, designing, financing, and construction leading up to commissioning, which is an early phase in the lifecycle of a project. Take Hoa Binh dam (1920 MW) as an example. Hoa Binh is referred to as Viet Nam's "century project" and was the first large-scale hydropower project Viet Nam undertook on the Da River tributary in the RRB with Soviet support (Ngoc 2019). The idea for the dam was formulated by the

Fig. 1. Map of major dams in the Red River basin from Nguyen et al. 2021.



1960s with construction and resettlement starting around 1979, and then took over 30 years to implement (Dao 2010). At the time of writing, Hoa Binh is under construction for new additions and a 480 MW extension project expected to be completed in 2025, emphasizing the ongoing nature of dams (EVN 2024). At the dam site, there is a time capsule from the former USSR to the Vietnamese people encased in concrete to be opened on 1 January 2100 (Anh 2020).

The reshaping of hydropower changes from 1960 to 2100, as does how society relates to a project with many shifting promises of large dams. Dams have been touted as a panacea for all problems as the "multi-use" infrastructure of modernity. Dams are seen as the bastion of modernity despite the Francis turbine being invented in 1849, which remains essentially the same technology and is the most widely used turbine in the modern world (IHA 2025). There are ongoing changes to the dam project itself, societal relations, and also the cumulative changes to the landscape brought on by other infrastructures. Since the construction of Hoa Binh, Viet Nam has approved more than 1000 hydropower projects (Dao and Phuong 2014). In Viet Nam, with this expansion of dams, the social perceptions of hydropower have shifted dramatically over the decades (Dao 2017).

Infrastructure can be understood as paradoxical, with both generative and degenerative properties (Howe et al. 2016). Hydropower projects are proposed with aggressive optimism, even though their social and ecological consequences are well-established. Hydropower has been promoted to stop the spread of communism and is a development pillar of all three communist states in the RRB (Sneddon 2015). Dams have been claimed as one of the most effective ways to cure poverty (IHA 2016) and to cause it (WCD 2000), particularly for the most vulnerable communities (Blake and Barney 2018, Golden et al. 2019). Hydropower is said to mitigate risks, to enhance them, or create new ones (Howe et al. 2016). Hydropower proponents argue for the project's ability to reduce floods, however in practice the dams

are managed for energy production and maintain a high head in the reservoir. This has led to "emergency releases" when hydropower dams actually enhance floods (Käkönen and Nygren 2023). The industry is responsible for ecological destruction and the fragmentation of the world's rivers (Grill et al. 2019) while being couched as green energy, which underpins global climate change policy (Motta et al. 2025).

Long after a dam is commissioned, communities continue to engage with the infrastructure and in land transformation, which intensifies nature-society changes (Mahanty et al. 2023). In the RRB, this change does not happen as a one off resettlement but has been shown to have multiple iterations of livelihood and land-use changes over decades (Rousseau 2021). The changes in the landscape also alter a dam's maintenance and operations because changes in land cover and economic activities have a direct link to issues like reservoir sedimentation. Therefore, society and dams are coupled in both abstract and operational ways over timescales and lifecycles.

> *Attention to temporality gives us the full weight of infrastructures in flux, and how they are mutually configured by social relations over space and time* (Ramakrishnan et al. 2021:676).

If the project is viewed as in flux (Ramakrishnan et al. 2021) across timescales and lifecycles, then it is not the mere material existence of a dam upstream escalating hydropolitical tensions. In this light, hydraulic infrastructure can impact conflict and cooperation dynamics even in their abstract or planning phase (Motta et al. 2023), financing (Motta and Koehler 2025), impact assessments (Green and Baird 2020), subcontracting, construction (Mon and Kean 2019), filling (Zaniolo et al. 2021), management (Baird et al. 2020), flushing, maintenance (Barnes 2017), communications, ownership (Ahlers 2020), decay (Mohamed et al. 2024), retrofitting, removal (Hommes 2022), collapse (Souvannaseng 2024), and futures (Käkönen and Nygren 2023). Paying attention to the temporal scale across the lifecycle of a project will allow for a clearer examination of how and when infrastructure enhances hydropolitical tensions.

Dams are imbued with ongoing contestations, symbolism, power, and are also part of the everyday. A scalar strategy of the hydropower industry is to manipulate the temporal scale by emphasizing long-term benefits and downplay the rupturing of shorter timescales due to their day-to-day operations (Pahl-Wostl et al. 2021). The changes to the rivers from dam construction are particularly visible at shorter timescales such as daily or hourly water level fluctuations, which are often dismissed in modeling studies in favor of longer-term data that attempt to link changes in river hydrology to climate change (Cochrane et al. 2014).

In contrast, we highlight how infrastructure is raising risks and tensions in shorter and medium-term timescales. To organize these temporal scale problems and hydropolitical tensions in the transboundary RRB, we used a scale-related diagnostic put forth by Pahl-Wostl et al. (2021) in *Scale-related governance challenges in the water-energy-food nexus: towards a diagnostic approach*. The diagnostic assumes that governance in a transboundary river system is inherently complex, and actors engage with the system in multi-level and multi-scalar strategies (Pahl-Wostl et al. 2021). The framework has been applied to other transboundary river systems, including the Mekong River and offers a starting point to understand scale challenges in the RRB. This is the first application of the diagnostic on the temporal scale specifically. This approach to analyzing the temporal scale has utility in understanding other transboundary water governance contexts, particularly in rivers with high levels of infrastructure regulation in which shorter timescales are significant.

Our study illustrates the linkages between hydropolitical tensions and the temporal scale by examining Sino-Viet relations in the Red River basin (RRB). We responded to the special issue call for a focus on problems in water governance and contribute to a deeper understanding of the relationship between hydraulic infrastructure and conflict in transboundary rivers by examining the timing of tensions. Our work is complementary to the *Geoforum* article that focuses on downstream governance responses in the RRB *Fractured hegemony and Vietnamese pragmatism in the Red River basin* with some of the pragmatic governance responses included as strategies in the scale analysis (Motta and Koehler 2025). We illustrate the temporal problems enhanced by infrastructure operations that many of these pragmatic governance efforts by Vietnamese actors are attempting to address. We focus on the problems of timing and the active nature of infrastructure uncertainties. These temporal misfits cause tensions across various timescales and create challenges for transboundary water cooperation.

METHODS

Data collection

Interviews were conducted in Hanoi, Viet Nam and Lao Cai Province, where the RRB mainstream forms the border with Yunnan, China. Due to Covid-19, research and travel restrictions unfortunately prohibited interviews in Yunnan. This caused the study to be reframed focusing on downstream Vietnamese perceptions of challenges in the RRB, and their actions to address them. Forty-five semi-structured interviews with Vietnamese actors were conducted through a snowball sampling approach between 2022–2024 with the Ministry of Agriculture and Rural Development (MARD), the Ministry of Natural Resources and the Environment (MONRE), the Ministry of Industry and Trade (MOIT), Viet Nam Electricity (EVN), the Viet Nam Committee on Large Dams (VNCOLD), the World Bank (WB), the Asian Development Bank (ADB), embassies, hydropower and energy corporations, consultants, academics, and non-governmental organizations (NGOs).

Ethical guidelines were followed and ethical approval was granted from the author's institution. Respondents were given consent forms, options of anonymity, and the choice of whether the interviews were recorded. A Vietnamese research assistant was present for the interviews that were carried out in Vietnamese and English, which typically lasted one to two hours. If any of the interview topics were considered sensitive, they could be discussed without any audio recording. The majority of interviews were recorded, and notes were taken when recording was not permitted before being transcribed and sent to a third party for translation. In the coding process, we ensured the anonymity of the interviewees could be guaranteed. The interview quotations have been used in the analysis to directly highlight stakeholder perspectives around water governance challenges and timing in

Table 1. Timescales integrated with scale diagnostics adapted from Pahl-Wostl et al. 2021.

Time scale	Fit	Strategies	Interplay	Uncertainty
Historical legacies	Hydrology and infrastructure design based on antiquated data and models of a past river without upstream hydropower	Attempts to monitor and measure Yunnan's hydropower operations via satellite. Informal cooperation within the hydropower sector	Transboundary cooperation locked in to flood season coordination, despite increases in drought. Institutional silos domestically	No formal cooperation or data sharing around hydropower operations or the enhanced dry season
Seasonal shifts	Hydrograph is shifting further into the calendar year, enhancing and extending drought in the dry season	Further investments in hydraulic infrastructure to compensate for failing irrigation systems	Tough fights between sectors on operating dams for agricultural production amidst large energy losses	Saltwater intrusion and extended droughts render infrastructure systems to decline or fail
Day and night	Water retained during the day and released during peak energy demand, often in the evening	Efforts to gain closer to real time data and increase water efficiency in irrigation systems	Interprovincial coordination necessary	Water availability during the day and night is heavily influenced by dam operations
Hours	Set hours of the day for data sharing not related to dam releases	Improved communication and early warning systems	Urgent responses necessary, rapid communication and resettlement of people from the RRB's riverbanks	Speed of water is rapid and challenges disaster response times particularly at night
Minutes and seconds	Non-real time data are too slow for urgent risk response	AI to speed up numeric calculations of floods	Horizontal coordination committees and 24-hour hotline from the border to the provinces and capital	Perfect storm: rain across the RRB when reservoirs are full, disaster potential for hydropower enhanced floods or dam collapse
Future	Wicked infrastructure and uncertainty around planned infrastructure	Viet Nam attempts to reduce reliance on transboundary water and enhance early warning systems	One-off Yunnan dam releases, cooperation diplomatic in nature, lacking meaningful hydrodiplomacy	Concerns of interbasin transfers, aging infrastructure, and a continually lowering riverbed

the RRB. The quotations used are the most illustrative and are consistent with responses we received across a wide range of stakeholders.

Data analysis

Interviews were coded in the software Atlas.ti for challenges around timing. Interviewees were asked questions to establish a historical timeline and to envision the RRB and the Sino-Viet hydropolitical relationship in 2040. In addition to the past and future, shorter timescale challenges and issues around seasonality were common responses. These temporal challenges were then grouped into six timescales and integrated into the scalar diagnostic from Pahl-Wostl et al. (2021) that identifies four scale related governance challenges (scalar fit, scalar strategy, institutional interplay, and scalar uncertainty). A table of the overlaps between the timescales and scalar diagnostics is provided below in the results section as a visual reference alongside a deeper analysis of each of the timescales (Table 1). These timescales are analyzed in turn, and the ramifications of these findings are posited in the discussion section.

THE PROBLEMS OF INFRASTRUCTURE AND TIMING IN TRANSBOUNDARY WATER GOVERNANCE

To examine the temporal scale problems and hydropolitical tensions in the transboundary RRB, we advanced Pahl-Wostl et al.'s (2021) diagnostic framework on the four core scale-related challenges. Findings from interviews in Viet Nam highlighted the actors' perspectives across all four core scale-related challenges. To unpack the various issues with timing, we incorporated six timescales to the scale diagnostic: historical legacy; seasonal shifts; day and night; hours; minutes and seconds; and futures. This approach disaggregates the types of infrastructure-enhanced problems at different timescales.

Historical legacies and fixed processes in the Red River basin

In Viet Nam, there have been investigations into the environmental governance of early civilizations (Goscha 2016), dynastic rule (Phung 2017), colonialism (Ross 2023), and how these colonial processes became embedded in water engineering and nation building efforts under American occupation (Biggs 2008) and post-colonial nation building activities later aligned with and supported by the Soviet Union (Pike 2020), the post-cold war era (Fforde 2010), and the shift from socialism to bureaucratic capitalism (Benedikter 2014). Water institutions and policies in the RRB have evolved over decades with support from development banks and donors, often disconnected from the existing governance regimes (Molle and Hoanh 2009). These periods are connected processes that did not succeed or fail based on ideologies, but because they could not escape the landscape, context, and politics that had been shaped by previous governance regimes (Biggs 2008).

Viet Nam's management of the RRB has been heavily influenced by the Soviet Union. The Soviet legacy is characterized in water institutions by interplay that is siloed in a hierarchical culture with limited horizontal coordination (Sehring 2009). The Soviet historical legacy is not limited to institutional design but also to hydropower construction and expertise. The first large-scale dams in the RRB, including the 1920 MW Hoa Binh Dam were carried out with Soviet engineering, design, machines, technical equipment, materials, and support from technical experts (Bogachenko et al. 1991).

Hoa Binh construction began in 1979 and took over a decade to complete, with the single project accounting for half of all energy production in northern Viet Nam in 1990 (Bogachenko et al. 1991). Hoa Binh was the largest dam in Southeast Asia at the time and provided crucial flood prevention for the capital Hanoi,

though this had engineering trade-offs between hydropower operations and existing dike systems downstream (Hirsch et al. 1992). This is an example of a wicked infrastructure problem in which the addition of hydraulic infrastructure compromises existing structures, a process that continues in the RRB at present (Motta and Koehler 2025).

With regard to hydropower, this time period was when many of the dams in the RRB's Da River were planned and designed with Soviet support and with approval from the Vietnamese government (Interview 11). The calculations conducted to manage the cascade of dams in the Da River for flood control were set, and these thresholds are very difficult to change (Interview 8). These designs for dams and for flood control used by Viet Nam were done prior to dozens of large-scale dams being constructed upstream in Yunnan Province (MERFI 2024). This created a historical legacy scalar misfit in which flood calculations and dam designs were based on a past free flowing river.

The retreat and eventual fall of the Soviet Union left Viet Nam alone to fight the Sino-Viet War after China launched a land border invasion in the RRB in 1979, known as the border war in Viet Nam (Zhang 2015, Ngô 2021). After high levels of conflict in the RRB, China and Viet Nam began to normalize relations in the 1990s after the fall of the USSR (Zhang 2015, Ngô 2021). The shared 1400 km land border, partially formed by the RRB's mainstream was demarcated after the conflict in 1999 (Xiaosong and Womack 2000). Chinese-Vietnamese relations are characterized by top-down diplomacy and high-level leadership visits, which have been occurring annually since the 2000s (Nguyen 2015). Although these are examples of state-to-state diplomacy, this can be misleading because it is arguably the party-to-party interplay, which goes back to the founding of both countries, that is the most crucial (Goscha 2016).

However, this formal cooperation between party states obscures other forms of polycentric diplomacy happening at multiple scales and in less formal ways. Yunnan Province took the diplomatic lead in the Greater Mekong Subregion (GMS) program starting in 1992 and frequently represented the central government while collaborating on infrastructure projects and connectivity with Vietnamese counterparts (Ho 2014). During the 2000s–2010s, there was a rapid roll-out of hydropower on both sides of the border in the RRB, accelerated by Clean Development Mechanism subsidies (Urban et al. 2018, MERFI 2024, Motta et al. 2025). The informal interplay between Viet Nam and Yunnan's hydropower industry is robust, and the cooperation predates Hanoi and Beijing reestablishing formal diplomatic relations.

Hydropower corporations and actors on both sides of the RRB were not only familiar with each other, but also studied together, collaborated on research and development projects, were members of the same organizations such as the International Commission on Large Scale Dams (ICOLD), and contractually worked together on hydraulic engineering projects from design phases to equipment sourcing (Interviews 5, 8, 18, 19; Ho 2014, Motta and Matthews 2017). Yunnan's premier hydropower design institute successfully won bids for large-scale hydropower projects within Northern Viet Nam as early as 2002 (Summers 2013). By 2014, it was estimated that up to 90% of Viet Nam's dam equipment comes from Chinese hydropower companies (Lamb and Dao 2017).

If assessing cooperation or lack thereof merely through Hanoi to Beijing relations, one would miss the deep historical legacy of cooperation within the hydraulic engineering community and in the border regions of the RRB. The Yunnan-Viet relationships are solid and survive regardless of diplomatic fallout between the two nation states. This complicates the cooperation picture because rather than elite party-to-party politics, the relationships and knowledge necessary to improve real-time or near real-time transboundary water management exists in the very industry that is causing all of the temporal disruptions.

A formal cooperative agreement for data exchange during the monsoon season in the RRB between China and Viet Nam was reached in 2009. The 2009 agreement does not entail any data exchange around dam designs, locations, operations, or future infrastructure plans. Prior to the use of satellite technologies, which can provide Viet Nam with some of these hydropower details, information on dams upstream came to Viet Nam via these relationships with Yunnan counterparts in the hydropower sector, not through official state-to-state channels with Beijing (Interview 5). With advancements in technology, this information is acquired via satellite from monitoring Yunnan's dams, a strategy that is pervasive across agencies and institutions (Interview 42; Vu et al. 2023, Motta and Koehler 2025).

Seasonal shifts

Transboundary cooperation and interplay mirror historical legacies around flood prevention in the monsoon season. China and Viet Nam exchange data on the RRB only five months of the year from 15 May to 15 October (Interview 16). The river bed, water levels, and flood pulse have dropped significantly over the past 20 years, with water levels in Hanoi hitting century level lows on multiple occasions during the dry season (Interview 11). The severity of the drought level is beyond any lived experience in the RRB, and the low water point is shifting later into the dry season. The low flows in the dry season also have quality concerns because salt water intrusion is reaching deep inland in the RRB (Interviews 8, 9). Despite many actors stressing the importance of drought risks and the need for data sharing during the dry season, there is no formal cooperation, and only sporadic interplay during this time.

> *If we have to compare between the two seasons, then the data in the dry season is more critical, much more critical. What is it? But they say, OK, we only provide the data in the wet, which is better than before, but it's been far from expectation* (Interview 30).

The duration of droughts is elongating in the RRB. Additionally, the RRB's minimum value or lowest recorded level is temporally occurring later and later into the calendar year. The minimum value was previously recorded in January or into February, but now the minimum value is creeping up the calendar into March (Interview 11). As the monsoon comes off the Himalayas and moves east, Yunnan receives rain before Northern Viet Nam (Interview 17). One of the reasons the dry season is elongating and moving a month further into the year is because at this time Yunnan is filling over 50 large-scale Chinese reservoirs upstream (MERFI 2024).

These temporal changes are not just comparisons between wet and dry seasons but are instead pendulum swings outside of

recorded ranges enhanced by dam operations. In the dry season when the river levels are low, the dam operations create high levels of variation, which impacts the irrigation systems' ability to pump, and this erodes the riverbanks (Interview 19). One of the strategies to compensate for failing infrastructure systems is to install further infrastructure, creating a wicked infrastructure cycle in the overbuilt RRB.

These temporal uncertainties pose serious challenges to agricultural planting and harvesting cycles. The changes also create unpredictability for Vietnamese dam operations. Formal cooperation around these temporal challenges and exchanges around dry season data or dam operations are absent. It is not the overall quantity or quality of water that are the primary downstream concerns, but often the timing of transboundary water.

> *A short-term change in the amount of water coming from China does not significantly affect the operation. Long-term changes such as seasonal or monthly changes do. That is the information we need…the time and process of water flowing into Viet Nam changed. The total amount of water running into Viet Nam hardly changes. The water regime does. This is our concern* (Interview 19).

Day and night

Hydropower dams release water based on peak energy demand. This has led scholars to analyze these river systems not as watersheds, but instead as powersheds in which flows are based on dam releases for distant energy transfers (Magee 2006, Middleton and Allouche 2016). The hottest time of the year takes place in the dry season when water availability is low and energy demand is highest. Within a given day, the timing of peak energy demand often occurs in the evening when people come home from work.

> *The peak hour for electricity demand is from 5 pm to 10 pm. All the hydropower plants are the same. Additionally, you have to account for the time water flows from China's hydropower to Viet Nam* (Interview 16).

Water is released after the end of the workday to produce electricity, and then there is the time it takes water to flow downstream before it can be pumped up by irrigation systems. There is also a one-hour time zone difference between Yunnan and Northern Viet Nam because even though China crosses five global time zones spatially, all of China operates on Beijing time. This means during the daytime, when farmers would be tending crops, dams retain water for use in the evening (Interview 8). Later at night, well after dark when the energy demand has declined, hydropower dams only operate a single turbine to maintain a minimum flow (Interview 9). Water availability within a single day is significantly dictated by evening energy demands and infrastructure operations. With less reliable day time water levels, a strategy for Viet Nam has been to focus on increasing water efficiency in these irrigation systems (World Bank 2019).

Hours and non-real-time data

Vietnamese actors have to account for the time it takes water to flow downstream from China's reservoirs, but the 2009 agreement and the formal cooperation around data exchange do not (Interview 16). Sharing of river levels occurs at preset hours and is not shared with any relation to the timing of dam operations.

> *Currently, they provide us with hydrological data at their hydrographic stations every 6–8 hours (only during the flood season). The frequency of every 6–8 hours is not enough to update. Only when we have hourly-updated data can we promptly respond to floods. This data is provided in fixed time frames such as 12 AM, 6 AM, 12 PM, and 6 PM; not according to the time China releases the flood* (Interview 4).

Sharing changes to river flows on a preset o'clock creates temporal misfits and unnecessary stresses. Red River basin water levels are communicated internationally at prescribed times of institutional interplay that are divorced from hydropower operations. This creates a non-real-time data exchange that enhances risk through timing. If data were shared at 6 PM and energy demand in Yunnan increased sharply at 7 PM causing a number of hydropower dams to release water, this would not be captured in the exchange. Yunnan would not communicate again until midnight. Viet Nam would only be aware of the impending flash flood waters after they already went over the border and were picked up at the hydrological station in Lao Cai Province, a strategy to collect real-time data around the clock. This creates a weak non-real-time data exchange as the pinnacle example of transboundary cooperation in the RRB.

Compounding this issue is that the magnitude of the dam releases is much higher and moving at a faster pace once the released water reaches the border station than perceived and communicated by Yunnan (Interview 11). For example, Yunnan communicated a dam release and the mainstream flow increasing by 2 m, but by the time that dam release gains momentum from other tributaries downstream it can more than double that surge once it enters Viet Nam (Interview 16). This temporal misfit means a 4–5 m surge of water could silently and swiftly be moving downstream. This can be dangerous for Vietnamese response times because they have a shortened timespan to react and resettle villagers from the banks of the river. This is particularly dangerous to try and move villagers in a timely fashion at night, when people are more likely to be asleep (Interview 16).

Minutes and seconds

Minutes and seconds are heavily valued in terms of response times and limiting risk for downstream Viet Nam. With the high levels of upstream uncertainty, these condensed timescales become critical to the rate in which actions can be mobilized. With regard to Viet Nam's downstream pragmatism (Motta and Koehler 2025), this is also the timescale in which there are multiple strategic investments in hard and soft technologies to manage risk response in the RRB in a more timely fashion.

This is especially the case for Lao Cai's institutional interplay because the province is the first point of communication for issues on the RRB mainstream (Thao River). Due to a variety of geographical features, the Thao River is not well suited for hydropower, and the mainstream is undammed on the Vietnamese side of the border. This means Lao Cai is critical for communicating to provinces downstream quickly and is investing in technologies to speed up their rate of response.

> *Lao Cai province has mobilized multiple sources for capital to equip all automatic monitoring systems to improve monitoring quality, ensure continuity and*

> *timeliness in monitoring activities. It takes about 10 to 60 minutes to get results. In the past, it had to be done all by human power* (Interview 16).

Automatic monitoring is a benefit for Viet Nam nationwide and for the capital Hanoi. Temporally, non-automatic monitoring requires someone to check the report before issuing the information causing prolongation. However, although this approach helps lower risks downstream, it does not alleviate the stress on the provinces in the border regions, which are reporting and receiving the alerts simultaneously. These improvements in monitoring are positive in reducing risk for the RRB on the whole, but these benefits do not accrue evenly.

> *It took the flood only a few hours to reach our country, which was swift. It only takes about 4 hours from the reservoir close to the border to Viet Nam. It takes about 48 hours from Muong Te to Hanoi, then we can react. But it is difficult for the provinces near the border to prepare* (Interview 11).

When Lao Cai does receive urgent alerts from Yunnan in advance, the formal cooperation goes through official channels and there can be delays (Interview 14). This is because the notification from Yunnan is first made in writing and then has to be sent over and work through Lao Cai's Department of Foreign Affairs (DOFA; Interview 11). Once it is in the DOFA system, it can be quickly communicated to other Vietnamese departments and is sent out in only a few minutes (Interview 15).

Hanoi is on the receiving end of the data and alerts from the border provinces and is attempting to reduce their response from minutes to seconds. After receiving a notification, the capital needs to process the information and attempt to model out the risks posed. One of the goals of this modeling is to reduce agricultural damage. With dam releases and floods, the time spent in processing the information from the borders is critical and is being reduced with investments in AI and machine learning to reduce response times from minutes to seconds.

> *Numerical versus machine learning's main difference is the timing of inundation. Numerical takes half an hour, whereas the machine brings it to 2 seconds* (Interview 38).

Red River basin futures

The future interplay in the RRB and the outlook for improvements in transboundary cooperation is not viewed with optimism by Vietnamese actors due to the historical legacy. The Mekong River Commission (MRC) was often cited as an example of pessimism for improvements in cooperation in the future because China has declined to become a full member after decades of involvement (Interview 15). Formal RRB water cooperation is based on limited data exchanges for less than half the year. Although this data is better than nothing, the cooperation is superficial and characterized by the Vietnamese saying of "willing speech, unwilling heart" (Nguyen 2015).

Future infrastructure plans for the RRB are not discussed between China and Viet Nam, adding uncertainty. Future infrastructure plans and the possibility of interbasin transfers in the RRB are a looming concern for Viet Nam (Interviews 22, 39, 48). China has constructed interbasin transfer megaprojects on rivers domestically, and there are fears of even more infrastructure coming online upstream. Beyond just sharing limited data a few times a day at preset times, meaningful cooperation would be long-term and include discussions of future infrastructure planning.

Institutional interplay, both on a state-to-state level and also in new platforms such as the Lancang Mekong Cooperation (LMC), are perceived to be diplomatic in nature and lacking water expertise. The formal cooperation is handled through foreign affairs ministries, in which hydrodiplomacy becomes deprioritized in arenas that also include security issues and trade (LMC 2024). The decision-making arena is outside of the basin in Beijing and has many non-water issues and state interests at play.

DISCUSSION

This study illustrates the role of the temporal scale in infrastructure enhanced hydropolitical tensions in the transboundary RRB. The many timing challenges often linked to infrastructure operations identified by Vietnamese actors in the RRB create temporal misfits and high degrees of uncertainty. In many cases, it is these uncertainties caused by scalar misfits that are the building blocks of hydropolitical tensions even without a catastrophic event or open conflict. Yunnan and Viet Nam have avoided a sudden catastrophic event such as a transboundary dam failure and collapse with loss of life (Baird 2021). However, even though catastrophe has thus far been avoided, these infrastructure uncertainties still create sudden risks and associated anxiety and concerns in the day-to-day governance of the RRB.

There are slow and incremental aspects of increasing risk in the RRB. These happen alongside non-incremental and urgent governance problems for Vietnamese actors in which short timescales are crucial. There are challenges in the RRB that have aspects of slow violence, for example the gradual lowering of the riverbed due to sediment retention behind dams and sand mining that happens without much spectacle (Nixon 2011). In addition to elongated processes around infrastructure construction and the slow violence that can be associated with hydropower in the Mekong region (Blake and Barney 2018, Dao 2025), this study shows how infrastructure enhances transboundary tensions at much more condensed timescales.

In the RRB, downstream Viet Nam is not anti-dam and has built a greater number of dams of much larger magnitude compared to Yunnan Province. Viet Nam is also both an upstream and downstream state in how it conducts itself in transboundary relations. Viet Nam does not appear to be against working with China to develop hydropower in the RRB and has collaborated to do so (Lamb and Dao 2017). Our findings suggest it is not the presence of Chinese dams upstream that is causing hydropolitical tensions, but the uncertainty brought about by the hydropower projects' disruption of the temporal scale.

The importance of these often-ignored timescales and differences in day and night-time water releases or how many hours it takes for a dam release to reach a riverside community underscore the immediacy of the governance problem. Similar to spatial strategies, the hydropower industry likes to scale up benefits and scale down the costs (Lebel et al. 2020). Hydropower proponents focus on increases in water availability in the dry season while downplaying the shorter scalar impacts of day-to-day dam operations (Pahl-Wostl et al. 2021).

The importance of condensed timescales in transboundary water governance is clearly reflected in Viet Nam's downstream pragmatic strategies. These strategies entail costly investments in technology and human resources to improve their knowledge and response times within shorter timescales. Continuous hydrologic monitoring stations, 24-hour hotlines, AI accelerated models for flood damages, rapid communication, and resettlement of RRB residents exemplify the timely nature of these tensions and risks (Motta and Koehler 2025).

In addition to hydrological risks, Viet Nam is vulnerable to trade sanctions and although there are suspicions of Chinese coercion happening behind closed doors, on the whole the relationship is moving in a positive direction toward greater integration and increasing trade (Oh 2023). With regard to trade, the Ministry of Agriculture and Rural Development (MARD) needs to maintain vital open market access for agriculture exports to China. The same ministry at times needs to request water releases in the dry season and is interested in obtaining improved water related information and cooperation from China. Put another way, what is the point of requesting water releases from Yunnan's dams from your Chinese counterparts to grow agricultural products, if the finished products cannot go back over the border to be sold?

The Ministry of Agriculture and Rural Development has a working relationship with their Chinese counterparts, one that could even at times be considered cooperative. However, the issue of water quantity or quality in the RRB may be usurped as a top priority issue for the agriculture focused ministry. China is the most important market for Viet Nam's agricultural exports, and similar to the formal hydrodiplomacy, water can become deprioritized by trade even within the agricultural ministry. In this light, it is broader political economy considerations rather than the RRB's hydrology that is guiding transboundary water governance decisions (Woodhouse and Muller 2017). These transboundary water requests are also very time sensitive; MARD has to request water releases from dams upstream when levels are low and also needs to request Yunnan not to discharge when the rice is still planted. These shorter timescale communication and coordination needs in the RRB are not realistically in line with the Ministry of Foreign Affairs' (MOFA) longer-term strategies and are best handled at a lower administrative scale within the basin.

Improvements in transboundary cooperation in the RRB would need to include joint infrastructure management sensitive to the temporal scale (Hecht et al. 2019). This would mean coordination of hydropower dams that are currently constructed, particularly near the border. This would entail an agreed-upon power generation schedule. Rather than elite party politics between capitals or MOFA, this coordination capacity and relationships required reside within the hydraulic engineering community in Yunnan and Northern Viet Nam. The Ministry of Foreign Affairs could assist in providing legal permissions to share relevant RRB information because there are still concerns at lower administrative levels over breaking national laws and not being allowed to discuss water openly because it is considered a state secret. The agreement would need to be imbued with trust and some level of accountability because even agreed upon dam rules are frequently overridden in times of risk and fall victim to ad hoc political decisions (Molle et al. 2024).

Water administrators are gatekeepers of data, and they decide what counts and what to leave out (Molle et al. 2024). They also decide when to communicate. In the case of the RRB, the dry season is left out and the timing of hydropower operations. This is not a coincidence; in the dry season the river flows are low and variability in the river is more dramatically influenced by dam releases. Scheduling and coordination should not be limited to set times of year but should be continuous and fill a much-needed cooperation void in the dry season. The seasonality of cooperation and data sharing continues to be based on historic flood risks, and although this is important, there is a pressing need for cooperation around drought management.

There have been improvements in data sharing from China in recent years, which assists in cooperation and reducing the politicization of hydrologic data, however this still does not include data on infrastructure operations or plans (Grünwald et al. 2021). This has been assisted by a slow normalization process in Viet Nam to more openly discuss and study the politically sensitive impacts of hydropower (Dao and Phuong 2014, Dao 2017). By opening up the temporal scale of analysis across the hydraulic infrastructure lifecycle, the presence of a dam upstream can be unpacked into more detailed analyses to formulate what creates hydropolitical tensions in transboundary rivers. The infrastructure operations, communication, maintenance, and inability to accurately plan for the future are all different points of contention.

The problem with wicked infrastructure and the lowering of the riverbed is a process that keeps getting worse year after year. This, in combination with aging dams, could bring about discussions of sediment transport, dam removals, and managing the entire lifecycle of hydraulic infrastructure (Hommes 2022). Although many of the large-scale projects have decades left in their lifecycles, there are hundreds of smaller projects, often privately owned, that dot the landscape of the RRB and are of varying quality. It is the coordination of the myriads of dams across the landscape that induces fears of a perfect storm in which the timing of a rain event occurs outside of the typical monsoon cycle when dam reservoirs are already full. This disaster scenario in which filled dams become overwhelmed by badly timed precipitation could lead to dam enhanced floods, dam failures, or cascading chains of dam collapses in the future. For the current generation of water managers in the RRB, these transboundary infrastructure risks are not gradual or futuristic and are very much present.

CONCLUSION

We expanded on the often-missing problem of timing in transboundary water governance by examining the relationship between infrastructure and hydropolitics through the analysis of the temporal scale. The transboundary governance of the RRB is locked in to data from a past river and has limited flood season only cooperation. The infrastructure is creating longer-term risks, particularly with regard to sediment. However, there are many more condensed timescales and changes to the water regime in which losses occur and tensions arise. It is not the mere material presence of hydropower dams upstream that raises hydropolitical tensions, but the disruption of the temporal scale and increasing uncertainties for downstream Viet Nam. The sensitivities to timing of infrastructure operations within a single day point to

the need for a more constant and embedded cooperation between Viet Nam and Yunnan Province. The timescales involved make diplomacy with Yunnan actors a much better fit, rather than navigating the interplay of high echelons of elite politics with Beijing through foreign affairs ministries in which hydrodiplomacy gets lost amid multiple diplomatic agendas. Attention to the temporal scale of transboundary water governance is crucial in understanding what creates a hydropolitical tension. Cooperation efforts and investments to shorten timescales and reduce uncertainty reflect the importance of timing in hydrodiplomacy and the transboundary governance of the Red River basin.

Acknowledgments:

The work was supported by the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie Innovative Training Network NEWAVE (grant agreement No 861509).

Data Availability:

The data and code that support the findings of this study are available on request from the corresponding author, SM. None of the data and code are publicly available because of the sensitivity of the interviews and the privacy of research participants. Ethical approval for this research study was granted by VU Amsterdam.

LITERATURE CITED

Ahlers, R. 2020. Where walls of power meet the wall of money: hydropower in the age of financialization. Sustainable Development 28:405–412. https://doi.org/10.1002/sd.1994

Anand, N., A. Gupta, and H. Appel. 2018. The promise of infrastructure. Duke University Press, Durham, North Carolina, USA. https://doi.org/10.1215/9781478002031

Anh, D. 2020. Dấu ấn Nga trên Thủy điện Hòa Bình. Quân đội nhân dân (People's Army). https://www.qdnd.vn/cuoc-thi-viet-nuoc-nga-trong-trai-tim-toi-nam-2020/dau-an-nga-tren-thuy-dien-hoa-binh-645202

Baird, I. G. 2021. Catastrophic and slow violence: thinking about the impacts of the Xe Pian Xe Namnoy dam in southern Laos. Journal of Peasant Studies 48:1167–1186, https://doi.org/10.1080/03066150.2020.1824181

Baird, I. G., K. Manorom, A. Phenow, and S. Gaja-Svasti. 2020. Opening the gates of the Pak Mun Dam: Fish migrations, domestic water supply, irrigation projects and politics. Water Alternatives 13(1):141–159. https://www.water-alternatives.org/index.php/alldoc/articles/vol13/v13issue1/568-a13-1-7/file

Barnes, J. 2017. States of maintenance: power, politics, and Egypt's irrigation infrastructure. Environment and Planning D: Society and Space 35(1):146–164. https://doi.org/10.1177/0263775816655161

Bear, L. 2016. Time as technique. Annual Review of Anthropology 45:487–502. https://doi.org/10.1146/annurev-anthro-102313-030159

Benedikter, S. 2014. The Vietnamese hydrocracy and the Mekong Delta: water resources development from state socialism to bureaucratic capitalism (Vol. 25). LIT Verlag, Münster, Germany.

Biggs, D. A. 2008. Breaking from the colonial mold: water engineering and the failure of nation-building in the Plain of Reeds, Vietnam. Technology and Culture 49:599–623. https://doi.org/10.1353/tech.0.0089

Biggs, D. A. 2012. Quagmire: nation-building and nature in the Mekong Delta. University of Washington Press, Seattle, Washington, USA. https://doi.org/10.1515/9780295801544

Blake, D. J. H., and K. Barney. 2018. Structural injustice, slow violence? The political ecology of a "best practice" hydropower dam in Lao PDR. Journal of Contemporary Asia 48:808–834. https://doi.org/10.1080/00472336.2018.1482560

Bogachenko, P. T., A. B. Vasil'ev, and N. S. Lok. 1991. The Hoabinh hydraulic development - an object of Soviet-Vietnam cooperation. Hydrotechnical Construction 25:301–303. https://doi.org/10.1007/BF01423752

Budds, J., and L. Hinojosa. 2012. Restructuring and rescaling water governance in mining contexts: the co-production of waterscapes in Peru. Water Alternatives 5:119–137. https://www.water-alternatives.org/index.php/volume5/v5issue1/161-a5-1-8/file

Cash, D. W., W. N. Adger, F. Berkes, P. Garden, L. Lebel, P. Olsson, L. Pritchard, and O. Young. 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. Ecology and Society 11(2):8. https://doi.org/10.5751/ES-01759-110208

Cochrane, T. A., M. E. Arias, and T. Piman. 2014. Historical impact of water infrastructure on water levels of the Mekong River and the Tonle Sap system. Hydrology and Earth System Sciences 18:4529–4541. https://doi.org/10.5194/hess-18-4529-2014

Dao, N. 2010. Dam development in Vietnam: the evolution of dam-induced resettlement policy. Water Alternatives 3:324–340. https://cawater-info.net/bk/dam-safety/files/dao.pdf

Dao, N. 2017. Reflecting on the role of academics-activists in shifting hydropower narratives in Vietnam. Critical Asian Studies 49:444–447. https://doi.org/10.1080/14672715.2017.1339450

Dao, N. 2025. Small hydropower, slow violence, and gendered struggles in Northwest Vietnam. Environment and Planning C: Politics and Space 43(6):1158–1176. https://doi.org/10.1177/23996544251318589

Dao, N., and B. L. Phuong. 2014. Rethinking development narratives of hydropower in Vietnam. Pages 173–197 in N. Matthews and K. Geheb, editors. Hydropower development in the Mekong Region: political, socio-economic and environmental perspectives. Earthscan, London, UK.

De Stefano, L., J. D. Petersen-Perlman, E. A. Sproles, J. Eynard, and A. T. Wolf. 2017. Assessment of transboundary river basins for potential hydro-political tensions. Global Environmental Change 45:35–46. https://doi.org/10.1016/j.gloenvcha.2017.04.008

Fforde, A. 2010. Vietnam: water policy dynamics under a post-cold war communism. Water Alternatives 3(3):552–574. https://www.water-alternatives.org/index.php/allabs/116-a3-3-6/file

Golden, C. D., A. Shapero, B. Vaitla, M. R. Smith, S. S. Myers, E. Stebbins, and J. A. Gephart. 2019. Impacts of mainstream hydropower development on fisheries and human nutrition in the Lower Mekong. Frontiers in Sustainable Food Systems 3:93.

Goscha, C. 2016. Vietnam: a new history. Basic, New York, New York, USA.

Green, W. N., and I. G. Baird. 2020. The contentious politics of hydropower dam impact assessments in the Mekong River basin. Political Geography 83:102272. https://doi.org/10.1016/j.polgeo.2020.102272

Grill, G., B. Lehner, M. Thieme, B. Geenen, D. Tickner, F. Antonelli, S. Babu, P. Borrelli, L. Cheng, H. Crochetiere, H. Ehalt Macedo, R. Filgueiras, M. Goichot, J. Higgins, Z. Hogan, B. Lip, M. E. McClain, J. Meng, M. Mulligan, C. Nilsson, J. D. Olden, J. J. Opperman, P. Petry, C. Reidy Liermann, L. Sáenz, S. Salinas-Rodríguez, P. Schelle, R. J. P. Schmitt, J. Snider, F. Tan, K. Tockner, P. H. Valdujo, A. van Soesbergen and C. Zarfl. 2019. Mapping the world's free-flowing rivers. Nature 569:215–221. https://doi.org/10.1038/s41586-019-1111-9

Grünwald, R., Y. Feng, and W. Wang. 2021. Politicization of science in the Lancang-Mekong Basin: the Eyes on Earth Study. International Journal of Water Resources Development 39 (2):184–210. https://doi.org/10.1080/07900627.2021.1990025

Harris, A. L. 2015. Introduction to part III. Pages 207–214 in A. L. Harris, editor. Race, radicalism, and reform. Routledge, New York, New York, USA. https://doi.org/10.4324/9781351317443-20

Hecht, J. S., G. Lacombe, M. E. Arias, T. D. Dang, and T. Piman. 2019. Hydropower dams of the Mekong River Basin: a review of their hydrological impacts. Journal of Hydrology 568:285–300. https://doi.org/10.1016/j.jhydrol.2018.10.045

Hetherington, K. 2014. Waiting for the surveyor: development promises and the temporality of infrastructure. Journal of Latin American and Caribbean Anthropology 19(2):195–211. https://doi.org/10.1111/jlca.12100

Hirsch, P. 1996. Large dams, restructuring and regional integration in Southeast Asia. Asia Pacific Viewpoint 37(1):1–20. https://doi.org/10.1111/apv.371001

Hirsch, P., T. S. Bach, N. H. V. Nguyen, T. H. Do, Q. H. Nguyen, N. N. Tran, V. T. Nguyen, and Q. T. Vu. 1992. Social and environmental implications of resource development in Vietnam: the case of Hoa Bing reservoir. RIAP Occasional paper NO. 17. Research Institute for Asia and the Pacific, Camperdown, New South Whales, Australia. https://riverresourcehub.org/resources/social-and-environmental-implications-of-resource-development-in-vietnam-the-case-of-the/

Ho, S. 2014. River politics: China's policies in the Mekong and the Brahmaputra in comparative perspective. Journal of Contemporary China 23(85):1–20. https://doi.org/10.1080/10670564.2013.809974

Hoang, L. P., H. Lauri, M. Kummu, J. Koponen, M. T. H. van Vliet, I. Supit, R. Leemans, P. Kabat, and F. Ludwig. 2016. Mekong River flow and hydrological extremes under climate change. Hydrology and Earth System Sciences 20(7):3027–3041. https://doi.org/10.5194/hess-20-3027-2016

Hommes, L. 2022. The ageing of infrastructure and ideologies: contestations around dam removal in Spain. Water Alternatives 15(3):592–613. https://www.water-alternatives.org/index.php/alldoc/articles/vol15/v15issue3/674-a15-3-3/file

Howe, C., J. Lockrem, H. Appel, E. Hackett, D. Boyer, R. Hall, M. Schneider-Mayerson, A. Pope, A. Gupta, E. Rodwell, A. Ballestero, T. Durbin, F. el-Dahdah, E. Long, and C. Mody. 2016. Paradoxical infrastructures: ruins, retrofit, and risk. Science, Technology, and Human Values 41(3):547–565. https://doi.org/10.1177/0162243915620017

International Hydropower Association (IHA). 2016. 2016 hydropower status report. IHA, London, UK.

International Hydropower Association (IHA). 2025. A brief history of hydropower: from its earliest beginnings to the modern era. IHA, London, UK. https://www.hydropower.org/iha/discover-history-of-hydropower

Johnson, A. A. 2019. The river grew tired of us: spectral flows along the Mekong River. HAU: Journal of Ethnographic Theory 9(2):390–404. https://doi.org/10.1086/706045

Johnson, A. A. 2024. Hidden flows: hydropower and the rhythms of development on the Mekong. Pacific Affairs 97(2):391–409. https://doi.org/10.5509/2024972-art2

Käkönen, M., and A. Nygren. 2023. Resurgent dams: shifting power formations, persistent harms, and obscured responsibilities. Globalizations 20:866–886. https://doi.org/10.1080/14747731.2022.2098668

Krause, F. 2022. Rhythms of wet and dry: temporalising the land-water nexus. Geoforum 131:252–259. https://doi.org/10.1016/j.geoforum.2017.12.001

Lamb, V. 2014. Making governance "good": the production of scale in the environmental impact assessment and governance of the Salween River. Conservation and Society 12(4):386–397. https://doi.org/10.4103/0972-4923.155582

Lamb, V., and N. Dao. 2017. Perceptions and practices of investment: China's hydropower investments in Vietnam and Myanmar. Canadian Journal of Development Studies/Revue canadienne d'études du développement 38(3):395–413. https://doi.org/10.1080/02255189.2017.1298519

Lancang-Mekong Cooperation (LMC). 2024. Five-year plan of action on Lancang-Mekong Cooperation (2023–2027). Lancang-Mekong Cooperation, Beijing, China. http://www.lmcchina.org/eng/2024-03/11/content_42720837.html

Lebel, L., A. Haefner, C. Pahl-Wostl, and A. Baduri. 2020. Governance of the water-energy-food nexus: insights from four infrastructure projects in the Lower Mekong Basin. Sustainability Science 15:885–900. https://doi.org/10.1007/s11625-019-00779-5

Magee, D. 2006. Powershed politics: Yunnan hydropower under great western development. China Quarterly 185:23–41. https://doi.org/10.1017/S0305741006000038

Mahanty, S., S. Milne, K. Barney, W. Dressler, P. Hirsch, and P. X. To. 2023. Rupture: towards a critical, emplaced, and experiential view of nature-society crisis. Dialogues in Human Geography 13(2):177–196. https://doi.org/10.1177/20438206221138057

Mekong Region Futures Institute (MERFI). 2024. Dataset on the dams of the greater Mekong. Mekong Region Futures Institute, Bangkok, Thailand. https://www.merfi.org/mekongregiondamsdatabase

Middleton, C. 2022. The political ecology of large hydropower dams in the Mekong Basin: a comprehensive review. Water Alternatives 15(2):251–289. https://www.water-alternatives.org/index.php/alldoc/articles/vol15/v15issue2/668-a15-2-10/file

Middleton, C., and J. Allouche. 2016. Watershed or powershed? Critical hydropolitics, China and the 'Lancang-Mekong Cooperation framework.' International Spectator 51(3):100–117. https://doi.org/10.1080/03932729.2016.1209385

Mohamed, A., Y. Mohamed, and J. Kemerink. 2024. Escalation of dam failure risk during wartime: the case of Jebel Aulia Dam, Sudan. IHE Delft, Delft, The Netherlands. https://wdpprepository.org/catalogue/#/document/769

Molle, F., and C. T. Hoanh. 2009. Implementing integrated river basin management: lessons from the Red River Basin, Vietnam. IWMI Research Report 13. International Water Management Institute (IWMI), Colombo, Sri Lanka. https://cgspace.cgiar.org/items/b660436e-eed5-40da-9d58-48837da804a8

Molle, F., B. Lankford, and R. Lave. 2024. Water and the politics of quantification: a programmatic review. Water Alternatives 17 (2):325–347. https://www.water-alternatives.org/index.php/alldoc/articles/vol17/v17issue2/758-a17-2-16/file

Mon, Y., and T. Kean. 2019. War and business: Kachin's 'frontline' hydropower dam. Frontier, 29 July.

Motta, S., I. Böck, J. Koehler, A. T. Wolf, and P. Pattberg. 2025. The financialization of rivers: clean development mechanism (CDM) subsidized hydropower in the Mekong Region's basins at risk. Global Environmental Change 90:102962. https://doi.org/10.1016/j.gloenvcha.2024.102962

Motta, S., and J. Koehler. 2025. Fractured hegemony and Vietnamese pragmatism in the Red River basin. Geoforum 161:104269. https://doi.org/10.1016/j.geoforum.2025.104269

Motta, S., and N. Matthews. 2017. Rewards and risks of Chinese hydropower in the Greater Mekong Subregion (GMS). Pages 14–34 in G. Siciliano and F. Urban, editors. Chinese hydropower development in Africa and Asia. Routledge, London, UK. https://doi.org/10.4324/9781315440040-2

Motta, S., A. T. Wolf, and E. L. F. Schipper. 2023. Immaterial infrastructures and conflict in the Salween River basin. Water Alternatives 16(3):793–820. https://www.water-alternatives.org/index.php/alldoc/articles/vol16/v16issue3/722-a16-3-6/file

Ngô, T. T. 2021. Bones of contention: situating the dead of the 1979 Sino-Vietnamese border war. American Ethnologist 48 (2):192–205. https://doi.org/10.1111/amet.13015

Ngoc, T. 2019. Hoa Binh power plant, construction of the 20th century. VN Express, 18 November. https://e.vnexpress.net/photo/news/hoa-binh-power-plant-construction-of-the-20th-century-4012791.html

Nguyen H. H., D. L. Nguyen, T. V. N. Tran, T. H. Bui, T. T. H. Ung, D. D. Bui, D. L. Vu, F. Hossain, and L. Hyongki. 2018. Hydrological model using ground- and satellite-based data for river flow simulation towards supporting water resource management in the Red River Basin, Vietnam. Journal of Environmental Management 217:346–355. https://doi.org/10.1016/j.jenvman.2018.03.100

Nguyen, N. L., T. N. Do, and A. D. Trinh. 2021. Application of water stable isotopes for hydrological characterization of the Red River (Asia). Water 13:2051. https://doi.org/10.3390/w13152051

Nguyen, V. C. 2015. China's "Comrade Money" and its social-political dimensions in Vietnam. Pages 53–84 in Y. Santasombat, editor. Impact of China's rise on the Mekong Region. Palgrave Macmillan, New York, New York, USA. https://doi.org/10.1057/9781137476227_3

Nixon, R. 2011. Slow violence and the environmentalism of the poor. Harvard University Press, Cambridge, Massachusetts, USA. https://doi.org/10.4159/harvard.9780674061194

Norman, E. S., C. Cook, and A. Cohen. 2015. Negotiating water governance: why the politics of scale matter. First edition. Routledge, London, UK.

Oh, Y. A. 2023. Vietnam's economic dependence on China: understanding vulnerability through a typology of trade shocks. Pages 139–170 in N. Truong and T. Vu, editors. The dragon's underbelly: dynamics and dilemmas in Vietnam's economy and politics. ISEAS Publishing, Singapore. https://doi.org/10.1355/9789815011401-007

Pahl-Wostl, C., P. Gorris, N. Jager, L. Koch, L. Lebel, C. Stein, S. Venghaus, and S. Withananchchi. 2021. Scale-related governance challenges in the water-energy-food nexus: toward a diagnostic approach. Sustainability Science 16 615–629. https://doi.org/10.1007/s11625-020-00888-6

Phung, H. M. 2017. Land and water: a history of fifteenth-century Vietnam from an environmental perspective. Dissertation. University of Hawai'i at Mānoa, Honolulu, Hawai'i, USA. https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/de6d44bf-7b77-499f-8b2f-ee92744811e7/content

Pike, D. 2020. Vietnam and the Soviet Union: anatomy of an alliance. Routledge, New York, New York, USA. https://doi.org/10.4324/9780429266966

Ramakrishnan, K., K. O'Reilly, and J. Budds. 2021. The temporal fragility of infrastructure: theorizing decay, maintenance, and repair. Environment and Planning E: Nature and Space 4(3):674–695. https://doi.org/10.1177/2514848620979712

Ross, C. 2023. Constrained river, constrained choices: seasonal floods and colonial authority in the Red River Delta. International Journal of Asian Studies 2023:1–19. https://doi.org/10.1017/S1479591423000190

Rousseau, J.-F. 2021. As time goes by... longitudinal analysis of dam impacts upon livelihood strategies in the Red River Valley. Pages 171–189 in J.-F. Rousseau and S. Habich-Sobiegalla, editors. The political economy of hydropower in Southwest China and beyond. International Political Economy Series. Palgrave Macmillan, Cham, Switzerland. https://doi.org/10.1007/978-3-0-30-59361-2_9

Sehring, J. 2009. Path dependencies and institutional bricolage in post-Soviet water governance. Water Alternatives 2(1):61–81. https://www.water-alternatives.org/index.php/all-abs/36-a2-1-5/file

Sneddon, C. 2015. Concrete revolution: large dams, Cold War geopolitics, and the US Bureau of Reclamation. University of Chicago Press, Chicago, Illinois, USA. https://doi.org/10.7208/chicago/9780226284453.001.0001

Souvannaseng, P. 2024. Fast finance and the political economy of catastrophic dam collapse in Lao PDR: the case of Xe Pian-Xe Namnoy. Pacific Affairs 97(2):261–283. https://doi.org/10.5509/2024972-art7

Summers, T. 2013. Yunnan - A Chinese bridgehead to Asia: a case study of China's political and economic relations with its neighbours. Elsevier, Philadelphia, Pennsylvania, USA. https://doi.org/10.1533/9780857094452

Swyngedouw, E. 1997. Neither global nor local: 'glocalization' and the politics of scale. Pages 137–166 in K. Cox, editor. Spaces of globalization: reasserting the power of the local. Guilford, New York, New York, USA.

Urban, F., G. Siciliano, L. Wallbott, M. Lederer, and A. Dang Nguyen. 2018. Green transformations in Vietnam's energy sector. Asia and the Pacific Policy Studies 5(3):558–582. https://doi.org/10.1002/app5.251

Venot, J.-P., H. Turral, M. Samad, and F. Molle. 2007. Shifting waterscapes: explaining basin closure in the Lower Krishna Basin, South India. IWMI Research Report 121. International Water Management Institute (IWMI), Colombo, Sri Lanka. https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers15-08/010047105.pdf

Vietnam Electricity (EVN). 2024. Hoa Binh hydropower expansion project: ahead of schedule in 2024 third quarter. EVN Vietnam Electricity, 8 October. https://en.evn.com.vn/d6/news/Hoa-Binh-Hydropower-Expansion-Project-Ahead-of-schedule-in-2024-third-quarter-66-163-4380.aspx

Vu, D. T., T. D. Dang, F. Pianosi, and S. Galelli. 2023. Calibrating macroscale hydrological models in poorly gauged and heavily regulated basins. Hydrology and Earth System Sciences 27 (19):3485–3504. https://doi.org/10.5194/hess-27-3485-2023

Woodhouse, P., and M. Muller. 2017. Water governance - an historical perspective on current debates. World Development 92:225–241. https://doi.org/10.1016/j.worlddev.2016.11.014

World Bank. 2019. Vietnam: toward a safe, clean, and resilient water system. World Bank, Washington, D.C., USA. https://www.worldbank.org/en/country/vietnam/publication/vietnam-toward-a-safe-clean-and-resilient-water-system

World Commission on Dams (WCD). 2000. Dams and development: a new framework for decision-making: the report of the world Commission on Dams. Earthscan, London, UK.

Xiaosong, G., and B. Womack. 2000. Border cooperation between China and Vietnam in the 1990s. Asian Survey 40(6):1042–1058. https://doi.org/10.2307/3021201

Zaniolo, M., M. Giuliani, S. Sinclair, P. Burlando and A. Castelletti, 2021. When timing matters - misdesigned dam filling impacts hydropower sustainability. Nature Communications 12:3056. https://doi.org/10.1038/s41467-021-23323-5

Zhang, X. 2015. Deng Xiaoping's long war: the military conflict between China and Vietnam, 1979–1991. University of North Carolina Press, Chapel Hill, North Carolina, USA.