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Socio-hydrology, politicization of water science and implication of the Eyes on Earth Study on the contemporary research dialogue in the Lancang-Mekong Basin

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Abstract.

Since April 2020, the Eyes on Earth Study has received significant media attention for considering the Chinese mainstream reservoirs as one of the main drivers for changing the natural water flow and compounding the severe droughts in the Lancang-Mekong Basin. Unlike other hydrological studies, the Eyes on Earth Study polarized the international research community and received unusual media attention. While the Eyes on Earth Study raised public awareness about upstream water operations and motivated civil society to co-develop the water knowledge, there can be found numerous shortcomings and other irregularities in the current research dialogue over the research conclusions. By drawing on the politicization of scientific theories and combining the socio-hydrology with critical political ecology, the presented paper (1) conceptualizes the human-water interaction in the context of the politicization of the EoE Study, (2) reviews current development pathways in contemporary research dialogue in the Lancang-Mekong Basin, and (3) examines contemporary challenges for water science. To re-define the politicization of water science, the constructivist discourse analysis has been applied to investigate the argumentation patterns over the Eyes on Earth Study in the last 18 months (April 2020-September 2021). In addition, we applied the adapted Baker's model to double-check the content of the EoE Study and degree of alignment with high-quality research inputs. Our data show that (i) benefits from ensuring the standard research procedures outweigh the benefits from using the alternative research procedures, (ii) gradual stratification of contemporary research channels and simplification of research findings contribute to political distrust towards the water science, and (iii) growing intervention of non-traditional actors in the research dialogue produce the gap in applied discourse practices and medialize the desirable water narratives. The topic is highly actual and beneficial for water experts and other interdisciplinary scientists who want to better understand the power of hydrological studies and clarify the incentives undermining the trust in science.

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Introduction

To date, many scientists call for better transparency of the hydrological data, improved accuracy of the predictive models and bigger diversity of the research viewpoints (Morgan et al., 2018, Brown, 2015; Spruijt et al., 2014). However, science is not value-free (Pardini et al., 2021) and the growing demand for collaboration with non-scientists can be troublesome (Hamilton et al., 2019). Perhaps, the most interesting case of politicization of science can be traced to speculations over Chinese mainstream dams in the Lancang-Mekong Basin. Although many institutions and scientists analyse the actual impact of hydropower dams on downstream countries (e.g. Binh et al., 2020; MRC, 2017; Hirsch, 2016; Biba, 2012; ICEM, 2010), numerous information gaps and sensitiveness of water issues (e.g. Mayeda and Boyd, 2020, Hamm et al. 2013) keep a plethora of water experts highly conservative to draw firm conclusions. This has changed in April 2020 when a team of two experts from the Eyes on Earth sparked a hot discussion about the actual impact of Chinese mainstream reservoirs (Basist and Williams, 2020a, SC, 2020b). To demonstrate the connection between upstream dams and alteration of the natural water flow, authors monitored the changes in the capacity of the Chinese water reservoirs in the last 28 years (1992-2019) and illustrated the negative consequences of the "missing water" at Chiang Saen gauge during the dry season (Basist and Williams, 2020a). Since then, the Eyes on Earth Study (EoE Study) has become a subject of countless interpretations (Grünwald, Feng and Wang, 2021). While many policy-makers praised the EoE Study as final proof of the negative impacts of Chinese mainstream dams (see Pompeo, 2020; Stilwell, 2020a; Stilwell, 2020b), many researchers warned against the simplification and misinterpretation of the complex water factors (see MRC, 2020a; Kallio and Fallon 2020; Ketelsen, Sawdon and Räsären, 2020). On the other hand, the EoE Study has significantly increased public awareness and motivated US researchers to establish the Mekong Dam Monitor (MDM) operationalizing the EoE Study findings. The MDM has been launched in December 2020 under the auspices of the Mekong-U.S. Partnership (MUP), Stimson Center and other partners as an additional hydrological information platform advancing the existing regional water cooperation (SC, 2020a; Basist et al., 2020; Eyler et al., 2020a). Compared to other initiatives analysing the actual impact of Chinese mainstream dams on amplifying the water fluctuations (see Biba, 2016; Lu et al., 2014; Kummu and Varis, 2007), the EoE Study widely resonated in China-US official channels (e.g. Stilwell, 2020a; PRC-EUS, 2020; PRC-ECA, 2020), science-public forums (e.g. CSDS, 2021; EWC, 2021; FCCT, 2020) and foreign media (e.g. Eyler et al., 2020b, Tian, Liu and Lu, 2020; Niseyi, 2020; Van, 2020).

So far, many multi-stakeholders are determined to facilitate accountable research dialogue and speed up the research investigations but very little has been made in advancing joint research collaboration with Chinese researchers and finding feasible solutions for downstream countries. To address these challenges, the presented paper (1) conceptualizes the human-water interaction in the context of the politicization of the EoE Study, (2) reviews current development pathways in contemporary research dialogue in the Lancang-Mekong Basin, and (3) examines contemporary challenges for water science. The key novelty of this work is the re-conceptualization of the socio-hydrological approaches (e.g. Konar et al. 2018; Melsen, Vos and Boelens, 2018; Srinivasan et al. 2016) by using the constructivist discourse analysis and using the adapted Baker's model to explore the research input quality of water science and degree of alignment with high-quality research inputs.

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1. Theory and methodology

1.1. Socio-hydrology, politicization of science and research discourse

Socio-hydrology presents a "new science" linking hydrology with socio-economic issues (Sivapalan, Savenije and Blöschl, 2012). In general, socio-hydrological studies mainly focus on understanding the dynamics of the co-evolution of the coupled human-water systems (Nüsser, 2017; Di Baldassarre et al., 2015; Elshafei et al., 2014; Di Baldassarre et al., 2013a; Di Baldassarre et al., 2013b) and exploring the causal relations, including the illogical behaviour and controversies among multi-stakeholders (e.g. Madani and Shafiee-Jood, 2020; Evers et al. 2017; Lane, 2014). Because most of the socio-hydrological studies use quantitative methods to grasp complex human-water connections and evaluate comprehensive water development trajectories via predictive mathematical models (Ghoreishi, Razavi and Elshorbagy, 2021; Gonzales and Ajami, 2017; Seidl and Barthel, 2017), some scholars began to study the conflict of ideas and values over transboundary water resources (Lu et al., 2021; Wei et al., 2020; Ert, Cohen-Amin and Dinar, 2019; Weber and Khademian, 2008). To date, there can be identified many water paradigms which have been produced upon the socially constructed assumptions (see Zeitoun et al., 2017; Earle, Jägerskog and Öjendal, 2010; Zeitoun and Mirumachi, 2008) and due to the inability to distillate the complex water knowledge for non-scientists (see Spruijt et al. 2014; Karr, 2006; McCreary, Gamman and Brooks, 2002). Although most of the solutions for dealing with the current water crisis were developed by natural scientists (Octavianti and Charles, 2019; Massuel et al., 2018; Lane, 2014), the research discourse requires more than technical answers to overcome these challenges (see Hamilton et al., 2019; Levy et al., 2016; Troy et al., 2015; Savenije, Hoekstra and van der Zaag 2014).

Issue	Drivers	Standard research procedures	Alternative research procedures
Actors	Selective reporting and self-censorship Asymmetry in code of conduct Self-interests and financial reasons Pressure to publish and bureaucracy Personal disputes and attitudes	International funding companies and banks Water institutes and other water facilities Water commissions and committees Universities and assistant companies Editorial companies and reviewers	Construction companies NGOs funded by the state Independent think-tanks Civil-society organizations Individual volunteers and activists
Uncertainty	Lack of primary data Complexity of socio-hydrological issue Insufficient mentoring Contradictory water narratives	Eliminating uncertainty Understanding causality and dynamics Consultation with interdisciplinary experts Publishing in research journals	Solving information gaps later Speculating about correlation Consultation with superiors Publishing in public and social media
Data	Time-consuming data processing Inconsistencies in data calculation Oversimplification of knowledge Lack of institutionalized data sharing	Precise data collection Robust evidence Reliable hydrological models Transparent datasets	Selective data mining Vivid evidence Illustrative hydrological models Self-explanatory datasets
Conclusions	Interpretation beyond data Difficulties in understanding Uncertainties in wisdom Acting in the "good faith"	Scientifically sound content Technical jargon Accurate conclusions Constructive feedback	Sensational sound content Emotional jargon Firm conclusions Ambiguous feedback
Verification	Errors and disinformation Overreliance on reviewers Credibility of sources Asymmetry of research studies	Fact-checking tools and mechanisms Multi-level peer-review process References on high-quality sources Reproducibility of the research	Following guarantor's knowledge No or limited peer-review process References on existing sources Double-checking the content
Mindset	Scientists and policy-makers arrogance Limited rules in public media space Limited plurality of views Controversies in argumentation	Research-related meetings and forums Research papers and other studies Centralized viewpoints Structured dialogue	Multi-stakeholder meetings Public media and other speech acts Decentralized viewpoints Unstructured dialogue

Table 1. General drivers of the politicization of science – comparison of the standard and alternative research procedures

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As the literature review of the drivers shown in Table 1, there are numerous aspects limiting the accountable research dialogue. From administrative obstacles (Young et al. 2014; Werner, 2015) and research biases (Kelly, Sadeghieh and Adeli, 2014; Ancker and Flanagin, 2007) to inconsistencies in research integrity (Morgan et al., 2018; Spruijt et al., 2014; Lupia, 2013; Sneddon and Fox, 2006) and changing research environment (Neff, 2020; Sarewitz, 2016). Standardly, it is the peer-review process that ensures the high-quality feedback on submitted research studies, verifies the robustness of research data and delimits the uncertainty from the research conclusions (Bohannon, 2013; Colquhoun, 2011). However, this is a very slow and subjective process that may eventually produce new research uncertainties (Brown, 2015; Dietz, 2013). Unlike the standard research journals possessing different research credibility, many publishers may not fact-check the research content and even accept controversial research papers with serious empirical shortcomings in exchange for mandatory publication fees (Vaikl, 2019; Martinson, 2017). Among other challenges belong the limited plurality of views on complex socio-hydrological issues (e.g. Yu et al. 2020; Roobavannan et al. 2018; Massuel et al. 2018), pressure on conceptualizing the causal relations in human-water interaction (e.g. Madani and Shafiee-Jood, 2020; Evers et al. 2017; Lane, 2014), underdeveloped fact-checking tools (e.g. Vaccari and Cadwick, 2020; Lim 2018), censoring undesirable opinions (e.g. Kerckhove, Rennie and Cormier, 2015; Jansen and Martin 2015) and misinterpretation of science (e.g. Brown, 2015; Lupia, 2013; Pielke, 2004).

Another important factor presents moving the apolitical water issues into the public domain (Oosterloo, 2016; Buzan, Weaver and Wilde 1998). Once the politicization of science occurs either from the marginalization of the water challenges or inadequate political response (Atkins, 2019), it is highly difficult to depoliticize water science (Sarewitz, 2015). Normally, both scientists and policy-makers motivate multi-stakeholder to put more faith in “purely technical solutions” (Cuttita 2018; Jessop 2014) and re-consider their research mindset as well as other water stereotypes (Albrecht, 2021; Grünwald 2018) to ensure the accountable research dialogue. However, a plethora of conspiracy theories and other speculations seems to be highly resilient (Cook, Ecker and Lewandowsky, 2015). Regardless of the nature of these research biases (see Kreps and Kriner, 2020; Lyengar and Massey, 2019; Petersen, Vincent and Westerling, 2019, Lorenz et al. 2013; van Laar, 2007) and applications of multifarious negotiation tools (Aspeitia, 2020; Fritz and Miller, 2018), the biggest challenge still represents the anti-scientific approaches exacerbating the science communication by developing the research arguments beyond data (Morgan et al. 2018; Hmielowski et al. 2014, Rowlands et al., 2011) and without the robust evidence (Martin and MacDonald, 2020; Bergner, 2010; Mutz, 1992). Such trend can be especially traced in the social and public media, and isolated stakeholder’s research platforms with a limited plurality of the viewpoints (Post and Ramirez, 2018; Pielke 2004). Hence, while softening the complex research jargon, developing the research arguments in non-traditional research platforms and removing language barriers among stakeholders positively raise the public awareness and help to co-develop the water knowledge facing the real-world problems (Peters, 2013; Louhiala-Salminen and Kankaanranta, 2012; Baron, 2010; Karr, 2006), these platforms are considered to have a higher chance for the overstatements (Mutz, 1992; Altheide and Snow, 1979) and supporting the content confirming the prior beliefs of the multi-stakeholders (Druckman, Fein and Leeper, 2012; Weingart, 2002).

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1.2. Evaluation of the politicized water science

By examining the strong asymmetry between various versions of the truth and clarifying the tendencies for rejecting other interpretations (Khan and MacEachen, 2021; Derrida 1997), we focus on multifarious viewpoints developing the EoE Study conclusions in official, public and social media (Morgan et al., 2018; Mutz, 1992). As the follow up for traditional socio-hydrology movements enlarging new water challenges (e.g. Madani and Shafiee-Jood, 2020; Di Baldassarre et al., 2019), our perspective is closely related to the critical political ecology (Forsyth, 2012, 2004) and interpretive policy analysis (Yanow 2000) through which we study main approaches towards the EoE Study and formulate the epistemological dangers of using the "research shortcuts" in the Lancang-Mekong Basin research dialogue (see Sivapalan and Blöschl, 2015; Hajer 1995). Unlike the content analysis or the sentiment analysis focusing on the linguistic analysis of the public speech acts and other qualitative text analysis (see Wei et al., 2021; Ching, 2020), the constructivist discourse analysis focuses on the actions, perceptions and attitudes of the multi-stakeholders (Waitt, 2005). As some previous studies have shown (e.g. Fox and Sneddon, 2019; Gerlak and Schmeier, 2014), the discourse analysis proofed to be useful for uncovering the development pathways in transboundary water governance. Traditionally, it is the policy-makers who decide which water issues will be part of the national agenda (Buzan, Weaver and Wilde, 1998) and what scientific responses will be included in the official speech acts (Colloff, Grafton and Williams, 2021; Wester, Rap and Vargas, 2009; Weible, 2008). The scientific findings are predominantly used to support the existing political regime (Molle and Mollinga, 2009; Mollinga, 2008; Haas, 1992) and justify certain water practices (Lane, 2014, Latour, 2000, Sivapalan and Blöschl, 2015). In addition, the policy-makers are important in encompassing complex problems into the official state agenda, coordinating the innovative solutions among sectors, and mediating the conflict of interests among multi-stakeholders (Pardini et al., 2021; Cech, 2010; Pielke, 2007). On the other hand, it is usually the civil society that put pressure on policy-makers to re-consider their plans (Haefner, 2016; Matthews and Geheb, 2015; Mirumachi, 2015). A similar trend also occurred in terms of politicization of the EoE Study where civil society was often encouraged to participate in hydrological monitoring and promoting public awareness (SC, 2021a; EJN., 2021). However, due to the knowledge gap and different viewpoints over the research process, many inputs from civil society may become highly unconstructive. From spreading rage comments and sharing misinformation on social media (e.g. PRC-ET, 2019, 2016) to sending insulting letters of concern (e.g. Corredor, 2017) and organizing various protests. Other politicization techniques may include using the non-scientific jargon, selective deleting of undesirable comments, making conclusions upon research abstracts, showing moral superiority or pretending the research objectivity by veiling the organization as a research platform (see MDM-F, 2021a, 2021b, 2020; MDM-T 2021a, 2020; S4M 2021a, 2021b). In contrast, the interdisciplinary researchers tend to address the scientific recommendations and get over their personal interests (Kasymov, 2011; Wade, 2004) to find innovative solutions for sustainable resources management (e.g. Jiménez et al. 2020; Houdret, Kramer and Carius, 2010). Therefore, whenever multi-stakeholders are developing their viewpoints, the accountable research dialogue should be built on mutual respect and standard research procedures (Colloff, Grafton and Williams, 2021; Pardini et al., 2021; Weber, Memon and Painter, 2011).

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To better understand the conflict of ideas among multi-stakeholders (Earle, Jägerskog and Öjendal, 2010; Swann and Bosson, 2008) and examine the quality of research inputs (Michalska-Smith and Allesina, 2017, Sarewitz, 2016), we adapted Baker's model (Baker, 2016) and outlined twelve key challenges in "standard research procedures" (see Table 2).

Indicator	Note
Selective reporting	Accuracy of results
Pressure to publish	Nature of pressure and purpose of the study
Quantitative analysis	Presence of verified statistical data
Replicability	Successful applications and common traits
Sufficient mentoring	Degree of consultation and inter-institutional collaboration
Clear methodology	Objectives and limits correspond with the content of the study
Experimental design	Degree of innovation and experimentation
Transparent datasets	Available raw data for further review
Fraud	Data manipulation to support desirable research conclusions
Peer review process	Neutrality and sufficient number of reviewers
Literature review	Complexity of references and publication dates
Argumentation	Research channels and jargon used for developing the arguments

Table 2. Adapted Baker's model for indicating the quality of the water research inputs

Contradictory to Baker's view where the main factor demonstrating the credibility presents the actual content of the research study (Baker, 2016), we believe that the root of the problem lies in the outcome-oriented research process and different research mindsets of multi-stakeholders as other studies suggest (Bouleau, 2019; Petr et al., 2019; Bolsen and Druckman, 2015; Lorenz et al., 2013). Traditionally, when the research results are published, there are limited ways how to correct the controversial assessments (Haciyakupoglu et al., 2018; Lim, 2018). From getting further feedback through multifarious research channels (e.g. multi-stakeholder conferences, respond papers, public media) to personal communication with authors. Other alternatives present using various fact-checking tools and other third parties guaranteeing the quality of the research inputs (Moreno-Gil, Ramon and Rodríguez-Martínez, 2021; Pavleska et al., 2018). However, without adopting the code of conduct that will codify more responsibilities alongside the growing privileges for the non-state actors, the actual impact of non-scientists facilitating the contemporary research dialogue remains questionable. Hence, whenever authors use the "research shortcuts" to expand the audience and innovate the research process, interpretation beyond the data and other forms of legitimizing the prior beliefs without aligning with standard research procedures may negatively obscure the water science.

1.3. Data

To better understand the multi-stakeholder interaction, feedback and causal relations, we conducted an extensive literature review regarding the EoE Study and MDM between April 2020 and September 2021. As Table 3 and Figure 1 shown, the main attention was paid to the references on the EoE Study and MDM in primary and secondary sources. In addition, we also studied the broader political context, contemporary hydropolitical dynamics and MDM activities on the official social media websites (i.e. Twitter and Facebook). After that, we double-checked the data with the Lancang-Mekong Cooperation and Conflict Database (LMCCD) to enrich the list of recorded sources. At present, the LMCCD records over 3200 water-related events between six Mekong states (China, Myanmar, Thailand, Laos, Cambodia and Vietnam). The LMCCD is designed as a comprehensive water database visualizing the development pathways in various sectors and tracking the evolution of

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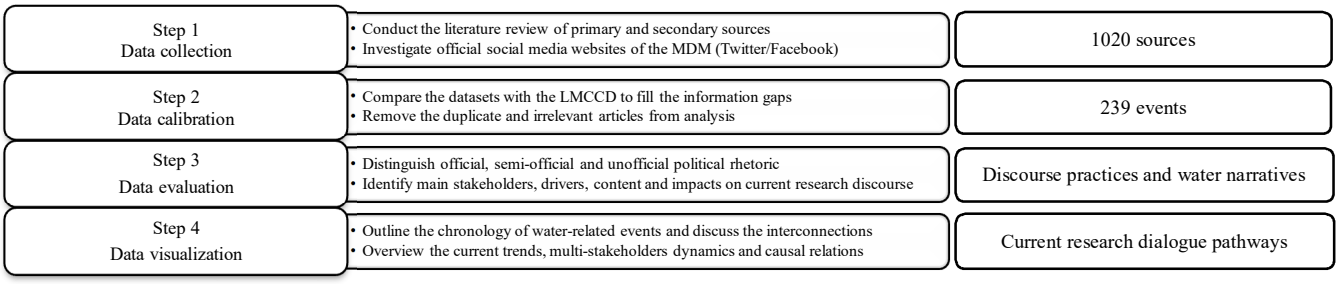
cooperation and conflict over the selected water issue. As some studies have previously shown (Grünwald, Feng and Wang, 2021; Grünwald, 2021; Grünwald, Wang and Feng, 2020; Grünwald, Feng and Wang, 2020), the LMCCD is not only beneficial for calculating the intensity of the cooperation and conflict events but also for filling the information gaps about multi-
175 stakeholders inputs. Although the LMCCD lacks a full list of available sources (e.g. absence of micro-water events, duplicated articles, confidential materials and subjective unverifiable content), the LMCCD provides a substantial number of relevant sources suitable for conducting the constructivist discourse analysis and interpretative policy analysis.

LMCCD requirements	**Keyword Search**
Must include the following keywords:	Eyes on Earth Study, Mekong Dam Monitor
Include at least one of the key water-related features:	Water governance, water diplomacy, water cooperation, water conflict, transboundary water management, hydropower development, water data sharing
Include at least one of the key stakeholders:	Eyes on Earth, Stimson Center, Pact, Lower-Mekong Initiative, Chino Cienega Foundation, Lancang-Mekong Water Cooperation and Information Platform, Mekong-U.S. Partnership, Lancang-Mekong Cooperation, USA, China
Include at least one downstream country:	Myanmar, Thailand, Cambodia, Laos, Vietnam
May include indirect references:	"manipulation of data", "manipulation of the water flow", "the US Study claims", "new study found", "wetness index", "water data transparency", "natural water flow", "the Study"
Data calibration	**Parameters**
Exclude duplicate and irrelevant sources if:	more than 50% of the content is copied, author, name and publication date of the article is changed, the content could not be verified by cross-references, the content is not intended for publication

Table 3. Searching criteria for literature review



180 **Figure 1.** Outline of the data collection process

2. Results

2.1. Approaches towards the Eyes on Earth Study

By drawing on 1020 literature sources in the last 18 months, we outlined the approaches towards the EoE Study findings (Table 4). These approaches have been divided into two main groups and several sub-groups to grasp the nuances between the official
185 (i.e. policy-makers and supreme state representatives), semi-official (i.e. scientists and interdisciplinary water experts) and unofficial rhetoric (i.e. civil society and other non-state actors). For better clarification of key arguments and reflecting different water-knowledge gaps among different actors, the text compares the key stakeholders, drivers, expected outcomes and expected impacts of the EoE Study on the transboundary water governance. References on non-Mekong issues (e.g. the China-US trade war, coronavirus pandemic (COVID-19), territorial disputes over the Himalayan region) and other speculations with
190 unclear evidence have been significantly reduced to ensure information unity.

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Approach	Stakeholders	Drivers	Expected outcomes	Expected impact
Proponents	US officials Thailand officials* Vietnam officials*	+ Address negatives impacts of Chinese dams + Ensure better transparency of hydrological data + Advance regional water cooperation via MUP + Stop China's aggressive bullying actions	+ Support long-term concerns over river flow + Provide reasonable facts to draw firm conclusions + Verify manipulation of water flow by US scientists + Highlight prolonged severe droughts in recent years	+ Operationalize data via the MDM + Promote hydrological data monitoring + Motivate MRC to become part of the FLM + Enhance cooperation with foreign donors
	MUP/FLM/MDM Stimson Center Eyes on Earth Other researchers	+ Fill the information gaps about upstream dams + Understand "missing water" at Chiang Saen + Examine the link between droughts and dams + Test replicability of the wetness index	+ Upstream dams compound severe droughts + Other environmental cumulative effects are marginal + Upstream dams significantly affect water flow + Re-iterate that further investigations are needed	+ Put pressure on LMCWIP timely notification + Provide better water information by MDM + Facilitate public-research dialogue via MUP + Justify the arguments in public media
	NGOs*[1] Foreign media[2] Civil society Other	+ Secure downstream countries from China + Escalation of US-China rivalry + Comparison with territorial disputes in Asia + End up the speculations about Chinese dams	+ Show irrefutable research findings by US scientists + Provide a plausible explanation of water changes + Make undeniable proof of China's ulterior motives + Use as a tool for enforcing communication with China	+ Demonize China's upstream operations + Add research findings in a non-water context + Simplify the environmental complexities + Marginalize critics of the EoE Study
Opponents	PRC officials	+ No reason to pay attention to biased study + Worry about sabotaging regional cooperation + Unacknowledged China's cooperation pathways + Need to address rumors by scientific means	+ Concern about groundless report countering the facts + MRC already made their science-based assessment + Emphasize that China suffered from droughts too + Ensure that China guarantees reasonable discharge	+ Recommend to quote EoE Study with caution + Support research-policy meetings + Facilitate intergovernmental cooperation + Enhance joint research investigations
	PRC scientists* LMC/LMWCIP* MRC* Other researchers	+ Lack of accountable research dialogue + Slow advancements in water research + Growing politicization of water science + Impatience with lack of systemic solutions	+ Hydro-meteorological conditions affect river flow + Chinese mainstream dams may not amplify droughts + Concern about the misinterpretation of EoE Study + Provide suggestions for improving the EoE Study	+ Advance LMC water cooperation + Revise the LMWCIP agenda + Explore environmental cumulative effects + Call for more international research debates
	PRC media[3] Civil society Other	+ Justify the establishment of MUP + MRC does not support EoE Study conclusions + LMC-MUP contestation in Southeast Asia + Exaggerate the real impact of Chinese dams	+ Question the accuracy of the EoE Study findings + Raise doubts about objectivity due to the US funding + Warn against irregularities and technical shortcomings + Emphasize China's achievements in water cooperation	+ Encourage PRC scientists to do more research + Stress the reliance on international scientists + Motivate LMC to minimize data inconsistency + Stimulate LMWCIP to better communicate

* Indicates general inclination rather than the official stance of multi-stakeholders
[1] Mainly environmental NGOs, including Scientists for the Mekong, Save the Mekong, International Rivers, etc.
[2] Mainly international public media (e.g. Reuters, The Diplomat) and regional public media (e.g. Bangkok Post, Vietnam+).
[3] Mainly Chinese state media (e.g. Xinhua) and public media (e.g. South China Morning Post, Global Times, CGTN).

Table 4. Summary of mainstream approaches towards Eyes on Earth Study.

The results show that there is a stark contrast between proponents and opponents of the EoE Study. For proponents, the EoE Study conclusions present "new evidence" supporting the long-term concerns about the actual impact of Chinese mainstream dams. These conclusions have mainly circulated in official channels (e.g. LKY, 2020; Pompeo, 2020; Stilwell, 2020a, 2020b) and public media (Grünwald, Feng and Wang, 2021). However, since the proponents of the EoE Study predominantly focus on the negative effects of Chinese mainstream dams on the natural water flow and other non-water related security concerns, the debates about the solutions for downstream countries remains vague. To date, the popularity of the EoE Study conclusions is mainly driven by US research discourse, long-term preconceptions, particularly towards the Chinese actions and upstream multipurpose water projects (Grünwald, 2021, 2020, 2018). Other reasons for growing awareness of the EoE Study present high medialization (Van, 2020; Niseyi, 2020; Eyler, 2020; Eyler et al. 2020b), simplified research jargon (e.g. Eyler and Weatherby, 2020; EWC, 2021) and frequent interventions of the EoE Study proponents in science-public meetings (e.g. Keshap, 2021; SC, 2021a).

For opponents, the EoE Study conclusions widely resonated in Chinese official (e.g. MOFA PRC, 2020a, 2020b; PRC-EUS, 2020; SCPRC, 2020; PRC-ECA, 2020) and public media (Grünwald, 2021). So far, the opponents mainly speculated about the ulterior motives of the EoE Study authors, the geopolitical context of US-China rivalry and other sources of prejudice against Chinese actions (see Grünwald, Feng and Wang, 2021). Most of the attempts refuting the EoE Study were driven by highlighting China's positive advancements in regional water cooperation (e.g. LMWCIP, 2021a; MOFA PRC, 2020c) and raising the concerns about the objectivity of research that overlook the scientific responses (MRC, 2020b; Kallio and Fallon, 2020; Ketelsen, Sawdon and Räsärenen, 2020). Special attention from opponents of the EoE Study has been paid to

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advancements in hydrological data sharing through the Lancang-Mekong Cooperation Water Information Platform (LMCWIP) established in November 2020 (MOFA PRC, 2020a) and China's research study re-examining the actual impacts of Chinese mainstream dams on the river (Tian et al., 2020). Although the unofficial response from Tsinghua University presents an important step for facilitating the research dialogue without confronting the EoE Study findings (Kallio, Räsären and Ketelsen 2020; Kallio, 2020), the research study was published outside of the traditional research channels and have not provided robust evidence for showing the positive effects of Chinese mainstream dams on the river (see Han, Mea and An, 2021; MRC, 2019c; Wang et al., 2017). A similar problem can be also found in terms of the LMWCIP which due to the communication shortcomings of the LMCWIP (LMWCIP, 2021b) and the prolonged water fluctuation after the Jinghong hydropower dam maintenance since January 2021 (MRC, 2021a) received strong criticism from EoE Study proponents (Eyler et al., 2021; Eyler, 2021a; Price, 2021).

Other reasons why the proponents of the EoE Study present a strong group of narrators lies in open support from environmental activists and other individuals in downstream countries. Since December 2020, the MDM becomes very active in improving its datasets (Basist and Williams, 2021; SC, 2021b) and sharing water-related announcements, including those from the MRC and LMWCIP (LMWCIP, 2020a, 2020b). In practice, it is the civil society in downstream countries that often provide the MDM first-hand information and verify the tangible impacts of natural water flow changes (e.g. MDM-F 2021b, 2021d, MDM-T 2021b). While this type of fact-checking has been already institutionalized by the MUP (USE-THA, 2021, EJN 2021), the overdependence on non-water scientists and paying volunteers for "desirable content" raise concerns about the future pathways of the research dialogue. In contrast, since China's government started tackling the ongoing COVID-19 and facilitating the economic recovery of its neighbours through the Lancang-Mekong Cooperation (LMC) (MOFA PRC 2021a, 2021b), the most significant attempt to address the politicization of Chinese mainstream dams have been found in conducting the "Joint Study on the Changing Pattern of Hydrological Conditions in the Lancang-Mekong River Basin and Adaptation Strategies" and advancing the research collaboration with regional partners, particularly with the MRC (SCPRC, 2021; MOFA PRC, 2021b; MRC, 2020c).

Until now, the proponents of the EoE Study often perceive these activities as highly insufficient and too slow considering the vast potential of the LMC (Grünwald, 2020). Nevertheless, sharing the operational hydrological data is still controversial among riparian states (see Matthews and Geheb, 2015; Mirumachi, 2015; Molle et al., 2009). For some, it presents the ideological tool promoting the comprehensive basin development (Backer, 2007; Sneddon and Fox, 2006) and limiting the speculations about the planned water projects (Thu and Wehn, 2016; Cronin and Hamlin, 2010). Others interpret sharing the hydrological data as an essential international right and as a minimum commitment in tackling the political animosities among multi-stakeholders (Hutjens et al. 2016; Gerlak and Schmeier, 2014). Hence, promoting various data exchanges and using remote sensing data for dealing with a lack of information is fully rational and highly beneficial for further transboundary water cooperation. Yet, such a symbolic practice should be also associated with facilitating the accountable research dialogue over these datasets and building the verification mechanisms to distinguish the asymmetrical quality of the research inputs.

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2.2. Alignment of the Eyes on Earth Study with standard research procedures

In this section, we have drawn on the contemporary theories of politicization of science (Moges et al., 2021; Atkins, 2019; Thu and Wehn, 2016) and used the adapted Baker's model (Baker, 2016) to examine the alignment of the Eyes on Earth Study with the standard research procedures (see Table 5).

Issue	Y/N	Results	References
Selective reporting	Yes*	• Using a simple bucket model to determine the alteration of the water flow by Chinese mainstream dams • Excluding the left-bank tributaries and other environmental cumulative effects from the analysis[1] • Limited corrections and no significant changes after controversies over the research conclusions[2]	Kallio and Fallon, 2020; MRC, 2020a, 2020b, 2017, 2010; Eyler et al., 2020a; SC, 2021b
Pressure to publish	Yes*	• Funded by the U.S. Department of State through the Lower Mekong Initiative (LMI) • Necessity to address the occurrence of severe droughts in July 2019 and estimate the amount of "missing water" • Within 3 days, it has been followed by Stimson Center Commentary to raise awareness about the EoE Study[3]	Basist and William,s 2020a, 2020b; Eyler and Weatherby, 2020; Basist et al., 2020; Eyler et al., 2020a
Quantitative analysis	Yes	• Using the MRC data and land surface wetness index to monitor the river discharge in the 28 years • The changes in the inter-annual natural water flow have been calibrated to Chiang Saen gauge[4] • Authors plan to observe Sekong, Nam Ou and other river tributaries to monitor the impact of hydropower dam	Basist and Williams, 2021, 2020a Eyler, 2021b; Eyler et al., 2020
Replicability	Yes	• Wetness index used at Zambezi and Mekong River and it is 89% accurate to simulate the natural water flow • Wetness index is expected to be applied on other international rivers with limited access to hydrological data • More research needs to be done to compare the effectiveness of the wetness index with other hydrological methods	Basist et al., 2020, 2018, 2001; Eyler et al., 2020a; Blankespoor et al., 2018
Sufficient mentoring	Yes	• In collaboration with the LMI, United Nations Environmental Program (UNEP), Pact and Stimson Center • No draft or final review of the EoE Study have been consulted since the MRC provided the datasets • Uncertain which Chinese multi-stakeholders have been contacted to provide feedback to the EoE Study	Eyler and Weatherby, 2020; MRC, 2020a; Van, 2020; Niseyi, 2020; Eyler, 2020; Eyler et al. 2020a
Clear methodology	No*	• Unclear application of the MRC datasets and undefined solutions for removing the biases in datasets • Unexplained influence of groundwater and accumulated rainfall from previous years • Plans to co-develop water knowledge and promote citizen science with civil society	EJN, 2021; Eyler et al., 2021, 2020a; SC, 2021a; Kallio and Fallon, 2020; Ketelsen, Sawdon and Räsären, 2020
Experimental design	Yes	• Using undertested Special Sensor Microwave Imager/Sounder (SSMI/S) regression model • Wetness index primarily used for smart agriculture rather than hydrological assessment • More innovative way to fill the information gaps and highly understandable for civil society	Basist and Williams, 2020a; Eyler and Weatherby, 2020; MRC, 2020a
Transparent datasets	Yes*	• The visualized data samples are publicly available and reasonably visualized • The data and methods are operationalized at the MDM Facebook, MDM Twitter and Stimson Center websites • Majority of the MDM indicators (4/13) do not draw on MRC existing hydrological dataset nor LMWCIP data	SC, 2021b; Basist et al., 2020; Basist and Williams, 2021; Eyler et al., 2020a; MRC, 2020a
Fraud	No*	• The interpretation of the EoE Study beyond data was made by Stimson Center, not by EoE Study authors • No high-quality research study proofing the new evidence has been published in high-impact journals, yet • Since the EoE Study was reviewed multiple times, it is highly unlikely that the data was anyhow manipulated[5]	CSDS, 2021, 2020a, 2020b; Ketelsen, Sawdon and Räsären, 2020; MRC, 2020a; Eyler et al 2021
Peer review process	No*	• No clues indicating that the EoE Study underwent the standard peer-review process • Highly unlikely that the EoE Study has not been reviewed among its partners • Since August 2021, the MRC becomes a member of the FLM to advance the collaboration with the MDM	USE-CAM, 2021; Basist and Williams, 2020a; MRC, 2021b
Literature review	Yes*	• Limited references on the contemporary research studies and using references on outdated research papers • No references on long-term conclusions from the MRC long-term studies • No references on existing Chinese research regarding the Lancang-Mekong River water flow	MRC, 2020a; Kallio and Fallon, 2020; Ketelsen, Sawdon and Räsären, 2020
Argumentation	Yes*	• The EoE Study has been published outside of standard research channels • Published without subsequent high-quality research studies in indexed research journals • Arguments have been developed in public media, public-research meetings and other isolated platforms	Grünwald, Feng and Wang, 2021; Ketelsen, Sawdon and Räsären, 2020; Van, 2020; Niseyi, 2020; Eyler, 2020

* Indicates general inclination rather than a firm conclusion
[1] EoE Study authors rejected the assumption that the water changes can be significantly influenced by tributaries in Myanmar and Laos.
[2] Despite some reflection of the criticism (Basist and Williams, 2021; Basist and Williams, 2020b), the EoE Study conclusions remain unchanged.
[2] EoE Study authors have closely collaborated with the Stimson Center despite they have not been mentioned in the final version of the manuscript.
[3] Until August 2021 when the Xieng Kok station on water discharge and sedimentation monitoring has been established, the Chiang Saen gauge was considered one of the northmost hydrometeorological stations within the Mekong Basin.
[4] No evidence and any electronic correspondence has been found to verify the author's effort to consult the research results with Chinese stakeholders.
[5] Until now, there is no evidence that EoE Study authors invited Chinese researchers to research dialogue over the EoE Study.

Table 5. Research assessment of the politicization of the Eyes on Earth Study

Our data show that the EoE Study has been published outside of the standard research channels and has not been followed up by any associated research article published in high-impact factor journals that will appropriately develop the research findings. Also, despite the EoE Study findings have been operationalized in the MDM (Basist et al., 2020; Eyler et al., 2020a) and widely discussed at various public-research platforms (EJN, 2021; Keshap, 2021; SC, 2021a, 2020; Basist et al., 2020; Eyler et al., 2020b), the contemporary Chinese research studies on the Lancang-Mekong River (e.g. Hou et al., 2021; Li et al., 2021; Tian et al., 2020; Sun et al., 2019; Lu et al., 2018) remain marginalized. Regarding the technical design of the EoE Study,

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authors have chosen the wetness index over other remote sensing methods (e.g. Standardized Precipitation Evapotranspiration Index, Standardized Precipitation Index) that may be more suitable for monitoring the complex hydrological changes in international rivers (Basist et al., 2018; Blankespoor et al., 2018; Basist et al., 2001) without further explanation. Other technical issues include the lack of hydrological assessment of upstream (e.g. Manzhang, Manan, Liusha and Nanban Rivers) and downstream tributaries (e.g. Ruak/Nam Mae Sai River, Nam Yawng River or Nam Ou Rivers), number of references on outdated research studies and insufficient review of the MRC long-term observations on the environmental cumulative impact on the natural water flow (see Grünwald, Feng and Wang, 2021; Zhang et al., 2020; Kallio and Fallon, 2020; MRC, 2020a, 2020b, 2017, 2010).

Finally, by exploring the form of argumentation, the main discussion over the EoE Study findings have occurred in "isolated research platforms" without China's involvement (e.g. CSDS, 2021; SC, 2021a; EWC, 2021; FCCT, 2020) and have been developed in the public (e.g. Van, 2020; Niseyi, 2020; Eyler, 2020; Eyler et al., 2020b) and official media (e.g. Stilwell, 2020a, PRC-EUS, 2020; PRC-ECA, 2020) with a limited reflection of the contemporary research commentaries (MRC, 2020a, Ketelsen, Sawdon and Räsären, 2020; Kallio and Fallon, 2020; CSDS, 2020a, 2020b). However, since the EoE Study received a very shallow and indirect official response from downstream governments (Grünwald, Feng and Wang, 2021; SC, 2020a; MDM-T, 2020), it seems there is less political confidence over the EoE Study conclusions that the mainstream media illustrate. Also, since none of the riparian researchers has been officially involved in the MDM advisory board (Basist et al., 2020), the MDM remains an exclusive research platform fully depending on the US water knowledge. Last but not least issue present the decentralization of the research process. So far, the main input for the MDM announcement was derived from foreigners living in downstream countries (e.g. MDM-F, 2021d) and occasionally from the environmental NGOs concerning the local water issues (e.g. MDM-F, 2020b). Unlike the successful citizen science initiatives such as Thai Baan research (e.g. Heis and Vaddhanaphuti, 2020; Kircherr, 2019), such research decentralization seems more focused on providing audio-visual materials for US-funded journalists (USE-THA, 2021; EJN, 2021) rather than systematic hydrological monitoring and incentives for further collaboration with the regional water institutions in downstream countries.

2.4. Eyes on Earth Study implications on accountable research dialogue

To better illustrate the positive and negative implications of the politicization of the EoE Study, we created the list of ongoing discourses practices associated with the MDM operationalizing the EoE Study findings (Table 6) and added a detailed chronology of 239 events visualizing the multifarious feedback on the EoE Study and MDM in the context of transboundary water governance (see Table S1). While the majority of events present intergovernmental meetings, official press conferences and other relevant events advancing the water cooperation, we also include other activities advancing the joint research dialogue in the Lancang-Mekong River. In addition, we also studied various notifications from the MDM websites and tracked a plethora of public-research activities of the EoE Study/MDM leading authors to better understand the current development pathways in the Lancang-Mekong research dialogue.

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	Limiting research dialogue	Facilitating research dialogue
I. Scientific role		
Interpretation	• Simplification of the cumulative environmental impacts • Use of the non-scientific jargon to attract more media attention • Speculate about water fluctuations without robust evidence • Mainly focus on Chinese mainstream dams (70-90% of MDM content)	• Adapting content to non-scientists to overcome the knowledge gap • Raising public awareness about environmental issues • Frequent notifications and announcements on the MDM websites • Put more pressure on investigating tributary dams in the 3S Basin
Authority	• MDM authors fully control the content of the MDM database • Knowledge is co-produced by US agencies and non-state actors • MDM does not acknowledge existing MRC/Chinese research studies • MUP overlaps with the MRC and LMWCIP agenda (no mandate)	• MDM encourages journalists to use MDM and write their stories • MDM serves as a basis for promoting public-research dialogue • MDM models deal with a lack of operational hydrological data • MUP accelerates the water cooperation with foreign donors
Research environment	• Methodological and other technical shortcomings of the wetness index • Biases in the EoE Study and MDM datasets • MDM develops arguments outside of the traditional research channels • MDM conclusions do not align with standard research procedures	• Providing detailed methodology on the Stimson Center websites • Interactive, user-friendly, publicly accessible and free database • MDM includes feedback from water practitioners and local people • MDM conclusions build upon the long-term mainstream dam concerns
II. Performance		
Scientific style	• MDM rarely responds to critique from international researchers • MDM occasionally use non-scientific jargon and biased rhetoric • MDM exercises over-confidence over its research conclusions[1] • MUP legitimize the accuracy of datasets by non-water experts	• MDM shares citizen-science activities and other MDM achievements • MDM updates on Stimson Center are timely and reasonably notified • MDM collects more information before outlining feasible solutions • MUP actively interacts with the MRC and other foreign donors
Dynamics	• MDM received shallow and indirect support from downstream governments • MDM models use stereotypes to support their conclusions[2] • MDM shares datasets without achieving research consensus • MDM authors speeding up research through non-traditional platforms	• MDM facilitates unofficial policy-research dialogue with policy-makers • MDM mobilized US assets existing and resources to multiply the benefits • MDM maps are accurate enough to track sudden water changes • MDM enlarges the target audience outside of the Lancang-Mekong Basin
Dialogue	• Predominant politicization of Chinese dams and other actions • MUP agenda does not consider further collaboration with China • No consultation over the MDM conclusions before posting on social media • No consideration of the positive effects of dams on the water flow	• Putting more pressure on strengthening water cooperation with China • MUP contests China's role in complex basin development • Encourages LMWCIP to re-consider communication and notification mode • MUP motivates civil society to engage in transboundary water governance
III. Identification		
Determination	• Lack of transparent hydrological data about upstream water operations • Marginalization of the non-mainstream dam cumulative effects[3] • Research uncertainties and conflict of interests[4] • Interpretation of the hydrological findings beyond data	• Improve transparency of hydrological data through remote sensing • Explore the water peaking caused by the hydropower dam operations • Advance collaboration with regional partners, particularly with the MRC • Re-considering transboundary water management practices
Facilitators	• Communication shortcomings of the LMWCIP • Insufficient networking with Chinese multi-stakeholders • Data inconsistencies between MDM, MRC and LMWCIP • Rise of anti-scientific movements disturbing the plurality of viewpoints	• MDM provides additional information to existing mechanisms • Improving the wetness index to provide higher accuracy predictions • Closer collaboration with regional partners, particularly the MRC • Co-produce and develop indigenous water practices and local knowledge
Identities	• MUP tends to enforce normative standards by "blame game" scheme[5] • MDM narrows the plurality of views on cumulative environmental impacts • Further water cooperation is pushed by MUP than Mekong governments • Marginalize joint responsibility for transboundary water management[7]	• MUP as the "moderator with muscles" to ensure stricter water regime • MDM as a tool to overcome existing information gaps in water science • Continue in the US legacy in Southeast Asia (draw on the MRC and LMI)[6] • Unite downstream countries to set hydrological monitoring as a top priority
IV. Perception		
Outcomes	• Mismatched the EoE Study and Stimson Center commentary[8] • Caused distrust towards new research studies correcting the MDM conclusions • Transferred resentment from dam operators to Mekong governments[9] • MDM overshadowed the MRC and LMWCIP hydrological monitoring	• Motivated China to set more ambitious goals in water cooperation • Provided hope for increasing sustainability of the Lancang-Mekong River • Showed the empathy of the international community with current water issues • Encouraged MRC and LMWCIP to innovate their current agenda
Processes	• MDM authors more stepped in geopolitical debates than feasible solutions[10] • No high-quality research article follows up since the establishment of the MDM • Ostracization of the scientists sharing different views on the MDM • Dependence on western and other foreign experts over the water situation	• Exposed the need for the reliable fact-checking mechanisms • Re-emphasized the problem of different quality of hydrological studies • Highlighted the problem of interpretation of water science by non-scientists • Showed the lack of understanding of the pace of accountable research work

[1] Despite the defensive rhetoric (e.g. Eyler and Sun 2020, Van 2020, Niseyi 2020, Eyler 2020, Eyler et al 2020b), the recent Eyes on Earth report (Basist and Williams, 2021) and the MDM scientists willingness to deal with biases in datasets (SC, 2021a) may indicate the positive change in the research mindset.

[2] For example, not every dry season are droughts, not every average dry event is extreme, calculating the wetness index without addressing different soil retention capacities, using "cloud-piercing" satellites tracking the basin water levels without considering the different density of forested areas, etc.

[3] For example, unaddressed impact of sand-mining, modernization of agriculture practices, water conservation, irrigation and other water-related projects.

[4] The Eyes on Earth is widely considered as an independent NGO regardless of its connections to the US government funding (LMI 2019a, 2019b).

[5] Since December 2020, the MDM has predominantly focused on China's biggest dams (notably Nuozhadu, Xiaowan and Huandeng) and several controversial dams in Sekong-Srepok-Sesan Basin (particularly Lower Sesan II, Xayaburi, Xepian-Xenamnoy and Yali Falls). However, the impact of upstream tributary water projects in the Golden Triangle (Myanmar, Thailand, Laos) and Lower-Lancang River (China) remains unanswered.

[6] The US government was a historical patron of the basin development since 1953 not only to promote peace among Southeast Asian nations but also to ensure its influence in Thailand military outputs and deter the spread of communism during the Cold War in Southeast Asia (Glassman, 2003).

[7] Since most of the MDM calls for better transparency of the operational hydrological data have been related to the Chinese and Laotian mainstream dams, more information gaps about other ongoing downstream hydropower dams need to be addressed (Zhong et al 2016, Mirumachi 2015).

[8] Most of the references mismatch the EoE Study for the Stimson Center commentary which already develops the EoE Study conclusions (see Table S1).

[9] While most of the pressure to change the water utilization practices is paid to the Lancang-Mekong policy-makers, the dam operators, sub-contractors, financial institutions and other assistant companies backing these projects remain widely overlooked.

[10] Apart from MDM water science activities, some of the MDM authors are very active in outlining Lancang-Mekong multi-stakeholders ulterior motives, identifying contemporary political-security threats in Southeast Asia and speculating about the political-ecological implications of dams both individually (e.g. Eyler et al 2021, Eyler et al 2020b, Eyler 2020) or on behalf of the MDM (e.g. MDM-T 2021b, 2020, MDM-F 2020).

Table 6. Summary discourse practices exercised by the Mekong Dam Monitor and Mekong-U.S. Partnership

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Contradictory to existing knowledge, the strengthening of the hydrological data sharing via the LMWCIP and MDM has not been initiated by the politicization of the EoE Study but by China's willingness to advance existing water cooperation with Mekong countries since December 2019 (MOFA PRC, 2020; MRC, 2019a). A similar trend can be also found in terms of the opponents of the EoE Study where critics consider the USA-China geopolitical rivalry and close connection of the Eyes on Earth on US governmental funds as the main trigger for the politicization of science (Grünwald, Feng and Wang, 2021). By investigating the discourse practices limiting and facilitating the research dialogue, we noticed several trends.

Firstly, the Stimson Center's commentary (Eyler and Weatherby, 2020) is more often quoted than the original EoE Study (Basist and Williams, 2020a). Unlike the EoE Study concerning "compounding the alternation of natural river flow" by five Chinese dams built since 2017 (Basist and Williams, 2020a: 18) and stressing that "more research will be required to better understand [the' unnatural flows" (Basist and Williams, 2020a: 17), the Stimson Center's Commentary present the EoE Study findings as a proof "beyond reproach" (Eyler and Weatherby, 2020). This form of justification of research findings combined with using the non-scientific jargon and accusations based on rumours then contributed stronger prejudice against Chinese activities and acceptance of the EoE Study findings in US official discourse without further research consideration (Grünwald, Feng, Wang, 2021: 12, 7).

Secondly, water science along with other scientific fields experience severe crisis (Pardini et al., 2021; Sarewitz, 2015). Partially because of the systemic failures, human errors and other unintentional consequences during the research observation (de Zwart, 2015). But most importantly, there is a lack of trust in the standard research procedures where anyone can stir up doubts about the long-term findings without producing higher scientific inputs. While such behaviour is usually expected from the non-scientific community whose knowledge gap and expectations about the pace of the research process are far beyond the expectations (Pielke, 2004), using the numerous "research shortcuts" by scientists (i.e. publishing the research without peer-review and through non-scientific channels) to speed up the standard research procedures and justify contradictory solutions for facilitating the research dialogue (i.e. calling for better communication with Chinese stakeholders without incorporating this goal into the MDM agenda) slowly becomes a "new normal" of politicization of water science.

Thirdly, there is an issue of better transparency of the hydrological data from upstream countries and preventing data biases (Price, 2021; CNMC, 2021; MRC, 2021a, 2020c). To date, there are 68 hydrological stations within the basin (MRC, 2021a, 2021c, 2021d). The most important information about upstream operations come from Jinghong and Manan hydro-meteorological monitoring station in the Lower Lancang River and Xieng Kok, the northernmost station between Laos and Myanmar. Although the MDM authors showed a strong willingness to incorporate non-Chinese reservoirs such as Nam Ou, Nam Khan and Sekong rivers to test their models (Eyler, 2021b; Eyler et al., 2020), the persisting biases in the MDM datasets (MDM-F, 2021c; Eyler et al., 2021) and MRC concerns over the misinterpretation of the EoE Study conclusions (MRC, 2020a) continue to co-develop multiple speculations. A similar problem can be also found in terms of the LMWCIP where data inconsistencies over the water discharge need to be significantly improved (LMWCIP, 2021b; MRC, 2021a, 2021d, 2021e).

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Fourthly, there is an issue of water fluctuation and timely notification of any abnormal water changes. While both proponents and opponents are seeking better accuracy of the hydrological data models, the low flow itself is not a problem. The actual problem lies in unacknowledged temporal water fluctuations of Chinese mainstream dams (MRC, 2021b, 2019b, 2019c) and fragmentation of the accountable research dialogue (Grünwald, 2021; CSDS, 2021, 2020a, 2020b, 2020c). Such a trait can be specially identified in terms of scheduled upstream water operations (LMWCIP 2021a; LMWCIP 2021c; MRC 2021a, 2021d) and sudden water fluctuations caused by hydro-meteorological changes (MRC 2021f, 2021g, MDM-T 2020c). In the past, some MDM observers considered water fluctuation as unprecedented proof of "manipulating the water flow" and as a failure of the LMWCIP to timely notify the downstream countries (Eyler, 2021a). Soon after, it turned out that the Jinghong dam maintenance was scheduled a year earlier (LMWCIP, 2019). Nevertheless, there is always space for an improvement, particularly in terms of when China's Ministry of Water resources should send the notification to downstream governments in advance and how much water should be restored after any temporal water fluctuation caused by the upstream operations (MRC, 2021f, 2021g).

3. Discussion and conclusions

3.1. Socio-hydrological framework

The presented framework has been designed to visualize the socio-hydrological pathways and factors affecting the dynamics of the accountable research dialogue in the Lancang-Mekong Basin. As shown in Figure 2, the framework is built upon the socio-hydrological works conceptualizing the human-water interaction (Madani and Shafiee-Jood, 2020; Evers et al. 2017; Lane, 2014). By considering the contemporary conflict of ideas over the EoE Study conclusions, we studied the correlation patterns between (a) discourse practices, (b) water narratives and (c) multi-stakeholders inputs in the last 18 months (April 2020-September 2021). To outline the causal relations in the accountable research dialogue (d), we analysed the contrast between the standard and alternative research procedures (e, f), and considered various external factors (i) demonstrating the nuances in the actual human water interaction. Contradictory to popular narratives illustrating any water dispute as an obstacle in transboundary water management (e.g. driven by growing water consumption, ineffective water practices, insufficient legal system) and transboundary water governance (e.g. driven by lack of multi-level coordination, incoherent research communication), we believe that any progress requires a certain time to adapt a new way of thinking in practice. Therefore, whenever multi-stakeholders agree or disagree on specific water issues, multi-stakeholders code of conduct, values, mandate, mindset, motives, access to research dialogue, research integrity, identity, capacity, power status and experience along with other factors should be put in further consideration.

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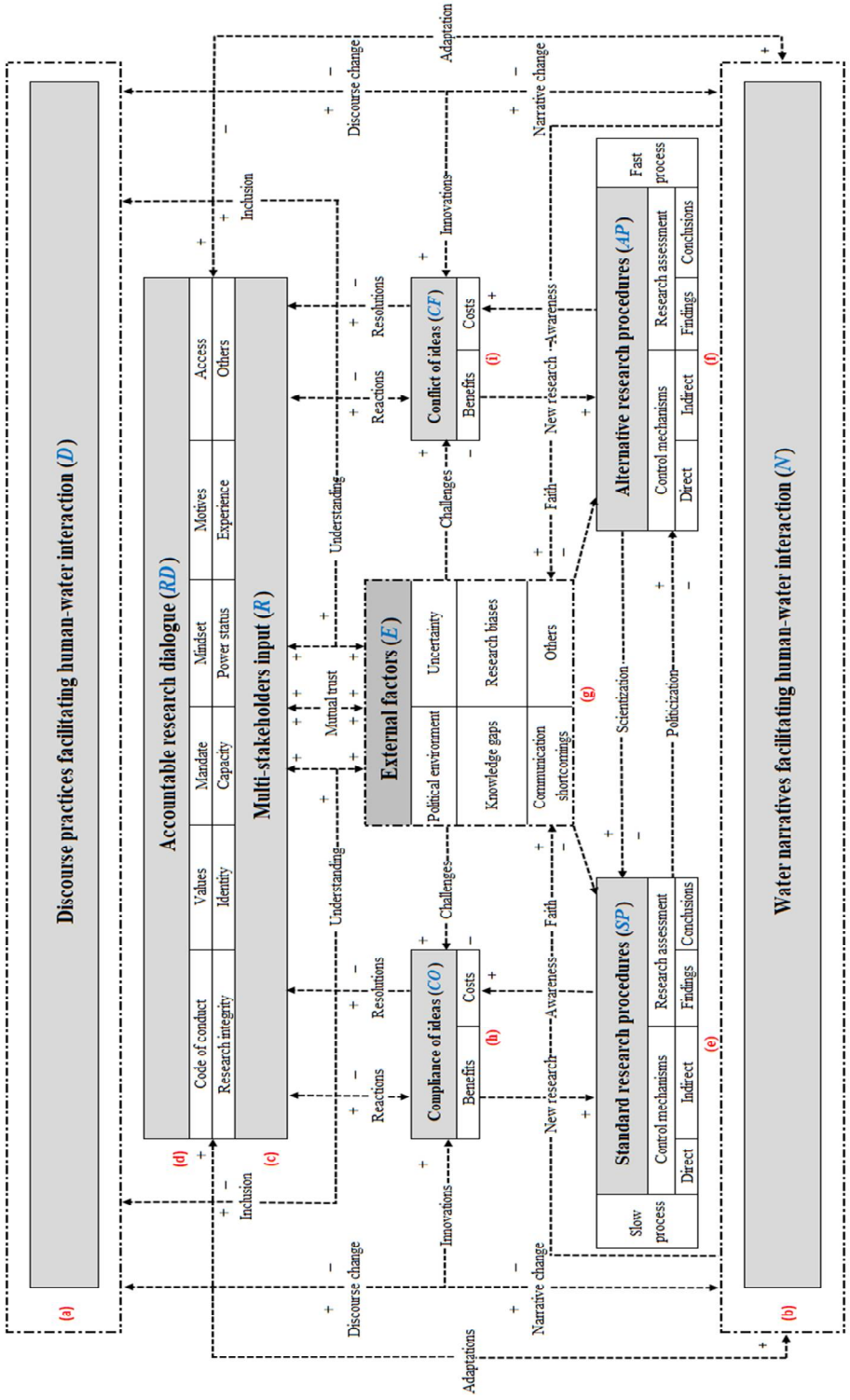

Figure 2. Accountable research dialogue diagram showing the complexity and interlinkages in human-water interaction

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3.1.1. Socio-hydrological mechanism

The presented equation describes the mechanism facilitating the accountable research dialogue during the politicization of water science. Unlike the equations considering the entanglement of different sectors (Di Baldassarre et al., 2013a) or system components in cooperation and conflict (Wei et al., 2021), we consider the accountable research dialogue as an interchanging competitive process in which multi-stakeholders constructively propose the feasible solutions, build mutual trust and jointly fill the information gaps in an appropriate manner. The dashed arrows indicate the actual changes and evolution of the accountable research dialogue in time and space. The plus (+) and minus (–) symbols represent the expected outcomes and causal relations between variables. For simplification, we outlined the binary choices from these coupled processes and showed the theoretical inclination of several variables affecting the human-water interaction. Thus, the formula clarifying the pathways for establishing the accountable research dialogue is set as follows:

$$RD_{xy} = \frac{\frac{R_x(CO - CF)}{\mathrm{D} + \mathrm{N}} + \frac{R_y(SP - AP)}{\mathrm{D} + \mathrm{N}}}{E} \quad (1)$$

where,

RD_{xy} = Accountable research dialogue among multi-stakeholders

R_x = Multi-stakeholder interaction (Policy-makers)

R_y = Multi-stakeholders interaction (Researchers)

CO = Compliance of ideas

CF = Conflict of ideas

D = Discourse practices

N = Water narratives

E = External factors

As shown in Table 7, there can be identified dozens of inputs produced by multi-stakeholders. By dividing these inputs into three groups (standard, alternative and other), we noticed a significant disproportion between research and policy responses. While the *RD* was mainly dominated by $R_{x1\text{-}3}$ organizing multifarious meetings with downstream officials and by $R_{y4\text{-}5}$ initiating the public-science encounters about the *D*, the *CO* seems to be highly affected by the *E* and existing shortcomings in the *AP*. So far, most of the written research responses towards the EoE Study and MDM were published in *AP* whereas only very few inputs underwent the *SP* (e.g. Keovilignavong, Nguyen and Hirsch, 2021; Grünwald, Feng and Wang, 2021). Another interesting trend can be found in terms of timing and feedback to the multi-stakeholders inputs. While most of the references on the EoE Study from the $R_{x1\text{-}3}$ oscillated in April 2020 (i.e. publishment of the EoE Study), September-November 2020 (i.e. launching the MUP, LMWCIP, MDM) and February-March 2021 (i.e. water flow changes and communication shortcomings from the LMWCIP), the responses from the $R_{y1\text{-}5}$ were more systemic and complex. However, the number of the standard scientific responses to the EoE Study (i.e. respond papers, research articles, reports) is significantly lower than the total number of the alternative research inputs (e.g. public-science meetings, interviews and other conferences).

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Stakeholders	Responses		
	Standard	Alternative	Other
EoE Study authors (R_{y1})	• N/A	• EoE Study (April 2020) • EoE Study researcher's commentary (April 2020) • EoE Improvement report (June 2021)	• SC-EoE Study researcher commentary (July 2020)
US researchers (R_{y2})	• MDM has been launched (December 2020) • 1st and 2nd MDM alert (January 2021) • 3rd MDM alert (February 2021) • 4th – 6th MDM alert (March 2021) • 7th – 9th MDM alert (April 2021) • 10th – 16th MDM alert (May 2021) • MDM launched a major update (June 2021) • 17th – 19th MDM alert (July 2021) • 20th MDM alert (September 2021)	• Stimson Center commentary (April 2020) • Indo-Pacific Conference (October 2020) • MDM announced biases in datasets (April 2021) • MDM informal online meeting (April 2021) • MDM informal online meeting (May 2021) • MDM informal online meeting (June 2021) • MDM virtual workshop (August 2021)	• SC researcher commentary (April 2020) • SC researcher commentary (May 2020) • SC and EoE Study authors commentary (May 2020) • SC researcher commentary (June 2020) • SC-EoE Study authors commentary (July 2020) • SC researcher commentary (January 2021) • SC researcher commentary (January 2021) • SC and Can Tho University commentary (May 2021) • SC researcher webinar (June 2021)
Chinese researchers (R_{y3})	• 3rd International Water Security Forum (April 2021)	• Tsinghua University Study (July 2020) • Lu Xing commentary (July 2020) • Zhong Yong commentary (October 2020) • Xingjun Yu commentary (December 2020)	• Tsinghua University commentary (August 2020)
Interdisciplinary researchers (R_{y4})	• CSDS Dialogue Forum 4 Mekong (July 2020) • CSDS-CDRI report (August 2021)	• AMPERES commentary (April 2020) • Aalto university commentary (April 2020) • CSDS seminar on the EoE Study (August 2020) • CICP Conference on Sustainable Mekong (October 2020) • CICP webinar on US-China (March 2021) • EWC Dialogue (April 2021) • Chulalongkorn University and SEVANA researcher commentary (May 2021)	• FCCT public discussion on EoE Study (April 2020) • Webinar on China-Southeast Asia (September 2020) • Webinar on Damming the Mekong (September 2020) • Webinar on China-India Politics (November 2020) • Webinar on Chinese projects (November 2020) • CICP webinar on ASEAN (January 2021) • CICP webinar on US-China (May 2021) • CSIS webinar on US-Laos Partnership (September 2021)
Intergovernmental institutions and foreign donors (R_{y5})	• MRC report on EoE Study (April 2020) • MRC report on Chinese dams (August 2020) • 1st ASEAN-MRC Water Security Dialogue (August 2021)	• UNECE webinar on Data sharing (February 2021) • Mekong Delta conference (March 2021)	• MRC unofficial commentary (April 2020) • SUMERNET grant for Mekong journalist (April 2020)
US officials (R_{x1})	• Indo-Pacific Conference (October 2020) • EWC-MUP conference report (February 2021) • MUP Track 1.5. Policy Dialogue (March 2021) • 1st MUP Track 1.5. Policy Dialogue (September 2021)	• Michael Pompeo commentary (April 2020) • Michael DeSombre commentary (April 2020) • David R. Stilwell commentary (July 2020) • Michael Pompeo commentary (September 2020) • David R. Stilwell commentary (October 2020) • Ned Price commentary (February 2021) • W. Patrick Murphy commentary (February 2021) • Atul Keshap commentary (March 2021) • W. Patrick Murphy commentary (June 2021) • W. Patrick Murphy commentary (August 2021)	• David R. Stilwell commentary (September 2020) • David R. Stilwell commentary (December 2020) • David R. Stilwell commentary (December 2020) • Mekong People's Council Forum (December 2020) • EJN-EWC-SC grant for Mekong journalist (February 2021) • Kamala Harris commentary (April 2021)
Chinese officials (R_{x2})	• LMWCIP has been launched (November 2020) • LMWCIP announced the maintenance (January 2021) • LMWCIP-MRC water data meeting (March 2021) • LMWCIP announced the maintenance (July 2021) • LMWCIP postponed the maintenance (July 2021)	• Shuang Geng commentary (April 2020) • Keqiang Li commentary (August 2020) • Lijian Zhao commentary (September 2020) • Zhaohui Luo commentary (November 2020) • Zhaohui Luo commentary (November 2020) • Chunying Hua commentary (December 2020) • Wenbing Wang commentary (December 2020) • Chungying Hua commentary (March 2021) • Wang Yi commentary (June 2021) • Wenbin Wang commentary (June 2021) • Keqiang Li commentary (September 2021)	• N/A
Downstream officials and relevant donors (R_{x3})	• 1st MUP Meeting (September 2020) • 3rd LMC Leader's Meeting (August 2020) • 24th MRC Dialogue Meeting (October 2020) • 1st FLM Policy Dialogue (January 2021) • 6th LMC Foreign Minister's Meeting (June 2021) • 2nd MUP Ministerial Meeting (August 2021) • FLM Ministerial Meeting (August 2021) • 4th MRC Expert Group Meeting (September 2021) • 25th MRC Dialogue Meeting (September 2021)	• LMC JWG meeting on LMWCIP (May 2020) • LMC Water Symposium (September 2020) • 2nd LMC JWG meeting on water (September 2020) • LMC water resources meeting (October 2020) • LMC Workshop on Hydropower (October 2020) • Prak Sokhonn commentary (March 2021) • LMC delegates commentary (April 2021) • Sreng Sataro commentary (May 2021) • 1st MUP Senior Official Meeting (June 2021) • MUP-SIP training (July 2021)	• Thailand unofficial commentary (April 2020) • Vietnam unofficial commentary (December 2020)

Note: Australia-Mekong Partnership for Environmental Resources & Energy (AMPERES), Cambodian Institute for Cooperation and Peace (CICP), Cambodia Development Resources Institute (CDRI), Center for Social and Development Studies at Chulalongkorn University (CSDS), Environmental Journalist Network (EJN), Eyes on Earth Study (EoE Study), East-West Center (EWC), Friends of the Lower Mekong (FLM), Foreign Correspondents' Club of Thailand (FCCT), Joint Working Group (JWG), Lancang-Mekong Cooperation (LMC), Lancang-Mekong Water Cooperation Information Platform (LMWCIP), Mekong Dam Monitor (MDM), Mekong River Commission (MRC), Mekong-U.S. Partnership (MUP), Sustainable Infrastructure Partnership (SIP), Stimson Center (SC) and United Nations Economic Commission for Europe (UNECE). For more detailed information about the events, please see the Table S1.

Table 7. List of research and policy inputs from multi-stakeholders intended for facilitating the research dialogue

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By comparing the normative form of the *RD* illustrated in Figure 2 with the list of existing research and policy inputs from stakeholders in Table 7, we identified the following correlations:

(1) Multi-level collaboration among $R_{y4\text{-}5}$ positively facilitates the *RD* and effectively helps with the structural depoliticization of the water science in the *AD*, particularly by the anti-scientific movements;

(2) Increasing data transparency and supporting the *AD* activities by $R_{y1\text{-}2}$ did not motivate the R_{x3} and $R_{y3\text{-}5}$ to advance the water cooperation. The exception presents the establishment of the LMWCIP (November 2020) and MDM (December 2020).

(3) Growing communication access restrictions and marginalization of the $R_{y3\text{-}5}$ research viewpoints contribute to the *CF* among R_{xy} and expand the scope of the *E*;

(4) Despite the *CO* among the proponents of the EoE Study, legitimizing the interpretation of the water science beyond data and growing use of the anti-scientific tools in that *AD* continuously decreasing the quality of the research inputs in the *RD*;

(5) The *CF* over the EoE Study conclusions was primarily driven by $R_{x1\text{-}2}$ whose capacity, power status and other motives negatively influence the R_{x3} bargaining position and finding feasible solutions reflecting their values and national interests;

However, by studying the current discourse practices over the EoE Study and MDM, we found several issues which will require further investigations to provide robust evidence. Firstly, *SP* seems very unattractive for the $R_{x1\text{-}3}$ due to the high research costs, immense time requirements and uncertainty with the research conclusions that may not align with their prior beliefs and not provide a plausible explanation of the complex socio-hydrological phenomena (Jasanoff, 1987). Also, by calling the $R_{y1\text{-}5}$ for raising the awareness and conceiving new research regardless of their lack of mandate (i.e. MDM) and research integrity (i.e. overreliance on the *AD*), the expected *RD* changes and all ongoing research on depoliticizing the water science remain unknown.

Secondly, numerous research fallacies and other argumentation techniques are distorting both the *RD* and *AD* research communication which was not extensively analysed. While putting the EoE Study conclusions in the non-water and non-basin context along with other speculations may be considered harmless, such water narratives (i.e. comparison of the Lancang-Mekong water disputes with Himalayan and South China Sea disputes) may negatively contribute to perception fallacy and eventually to harmful connotations used during the negotiations. From using the false traces (i.e. pointing out the unclear impact of the Losuo tributary dams in Lancang basin rather than hydro-meteorological effects), underling the irrefutable character of the operationalized EoE Study findings (i.e. proofing the compounding effects of Chinese mainstream dams without operational hydrological data) to showing the compassion for current water challenges (i.e. illustrating R_{x3} as defenceless victims and providing faith in changing the water insecurities risks by calling for non-reciprocal hydrological data sharing) or implying the false dilemma (e.g. over-focus on upstream mainstream dams with limited acknowledgement of the downstream water projects). Thus, rather than finding the “iron rule” in human-water interaction, we open the debate on how to better understand the changing dynamics of the *RD* over water science, how to conceptualize the politicization of water science and how to develop better fact-checking tools to improve the quality of the research inputs negatively affecting the transboundary water governance.

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3.1.2. Comparison of the standard and alternative research procedures

In the COVID-19 era, the pressure on a fast research process and medialization of research findings provide several benefits for the *RD*. More multi-stakeholders, particularly the civil society organizations in downstream countries may step into the negotiations, share their experience and provide valuable feedback about the current water-related challenges at the local level. The *AP* is also more friendly towards the R_{y4} who may put less effort to provide relatively accurate research results for $R_{x1\text{-}3}$. Among other benefits of the *AP* are diversifying the notification process through the MDM social network websites (i.e. Facebook and Twitter) and engaging the civil society into the hydrological data monitoring as the indirect control mechanism. While such acceleration of the research process may positively decentralize the research process (Bouleau, 2019; Haefner, 2016; Banks, Hulme and Edwards, 2014), the growing pressure from civil society on ensuring practical results and immediate structural changes may not necessarily enhance the *RD* (Weng 2015; Besley and Nisbet, 2013). Perhaps, the biggest challenge presents the intervention of the $R_{y1\text{-}4}$ into the public media and political rhetoric escalation between R_{x1} and R_{x2} that contribute to the *CF*. Unlike the *SP* relying on the long peer-review process and other control mechanisms ensuring the high-quality of the research publications, the *AP* is contributing to double standards in the *N* and feeding the politicization of the *E*.

While the $R_{y1\text{-}2}$ overlook the existing research from the R_{y3}, criticize the lack of determination from the $R_{x2\text{-}3}$ and marginalize the feedback from a plethora of $R_{y4\text{-}5}$, the $R_{y1\text{-}2}$ continue to narrow the *D* (e.g. leaving the MDM without external control, absence of dialogue with R_{y3}, lack of high-impact publications) and leverage the *N* (e.g. sharing speculations without robust evidence, using non-scientific jargon, absence of high-quality research inputs). Such example can be found in terms of the MRC (R_{y5}) before April 2020 when the MRC received a request to provide water level data from 1960 to 2019 but have not been contacted to review the draft or final version of the EoE Study (MRC, 2020c: 1, 3). Although R_{y1} has the full right to not share any information about the ongoing research nor any obligation to consult the preliminary results, the R_{y5} has no authority to refute any hydrological study. In response, the R_{y5} published several reply papers (MRC, 2020a, 2020c) and presented research conclusions on the MDM websites (MRC, 2021a, 2021b, 2021c) rather than mediating the conflict of ideas alone.

The politicization of science is not necessarily bad and may serve as an "icebreaker" for putting new water challenges for further consideration in the political agenda. To date, the current *D* is mainly focused on supporting "science without politics" (Madani and Shafiee-Jood, 2020; Hamilton et al., 2019; Levy et al., 2016; Troy et al., 2015; Savenije, Hoekstra and van der Zaag 2014), addressing the contemporary water challenges by highly sophisticated research innovations (Cuttita, 2018; Jessop, 2014) or simple low-cost solutions (Bouleau, 2019; Haefner, 2016; Banks, Hulme and Edwards, 2014). However, despite the multi-stakeholders are free to speculate and refute the current *N* by all means, we believe that the current development pathways in the *AP* brings more costs than benefits for the *RD*. The only exceptions present the R_{y4}, particularly researchers from the Chulalongkorn and Aalto University discussing the benefits of the *SP* and enhancing the *CO* among R_{y4}. A similar positive trend can be also found in terms of the R_{y3} who abandoned the *AP* responses through media (Tian et al. 2020, Tian, Liu and Lu 2020, Lu 2020) and put more effort in *SP* (e.g. Hou et al., 2021; Lu et al. 2021; Wei et al., 2021; Hou et al., 2020, Li et al. 2021, Sun et al. 2019).

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3.1.3. Contrast between compliance and conflict of ideas

The actual gap between $R_{x1\text{-}3}$ and $R_{y1\text{-}5}$ present an inevitable conflict of interests in transboundary water management (Wei et al., 2020; Ert, Cohen-Amin and Dinar, 2019; Weber et al., 2011). Although the $R_{x1\text{-}3}$ formally ensure national water security and decide which water issues will become part of the national agenda (Grünwald, 2018; Oosterloo, 2016; Cook and Bakker, 2012; Buzan, Weaver and Wilde, 1998), $R_{y1\text{-}5}$ can influence the national water plans and affect the transboundary water governance. For $R_{y1\text{-}5}$, the faith in standard research procedures, plurality of technocratic views and comprehensive control mechanisms present a solid basis for examining the current water-related challenges and designing new water policies. Since April 2020, the EoE Study was used by the R_{x1} as diplomatic leverage improving the transparency of the hydrological data and blaming Chinese water projects for amplifying the severe droughts in downstream countries (e.g. Pompeo, 2020; Stilwell, 2020a; Stillwell, 2020b; Price, 2021). However, without operational hydrological data from Chinese dams and excluding the left-bank tributaries (notably Ruak/Nam Mae Sai River, Nam Yawng River or Nam), determining the real impact of the upstream dams on the natural flow can be challenging. On the other hand, thanks to sophisticated visualization of the hydrological changes through the satellite images (Eyler and Weatherby, 2020), the non-scientific community was capable to understand complex hydrological changes without further explanation. Also, despite these efforts to provide simple hydrological models, no high-quality research inputs following the *SP* nor lawsuit or mass protest actions were made in the name of the EoE Study. Surprisingly, regardless of the numerous statements from R_{x1} that highly resonated in official and public media, there were very shallow official responses to the EoE Study from R_{x3}, including from Thailand where the research was conceived (see Grünwald, Feng and Wang, 2021). This may indicate the lack of unity among multi-stakeholders but also the limited utility of the EoE Study findings in transboundary water governance. On the other hand, the EoE Study clearly demonstrated the true power of the politicized hydrological studies provided by third parties (Elbers and Arts, 2011; Hirsch, 2003) and the determination of the R_{x1} to advance the existing water cooperation in hydrological data sharing.

Therefore, $R_{x1\text{-}5}$ are not apolitical and their capacity to be an arbiter for mediating the conflicts between multi-stakeholders is limited to the willingness of the $R_{y1\text{-}3}$ who may accept or deny the scientific recommendations (Pardini et al., 2021). In other words, no matter how accurate hydrological models are and what negative implications could present the proposed agenda for transboundary water governance, the legal responsibility still lies on the $R_{y1\text{-}3}$ (Colloff, Grafton and Williams, 2021; Wester, Rap and Vargas, 2009; Weible, 2008). While both R_{y1} and R_{y2} demonstrated some determination for improving the transboundary water management and promoting further collaboration with China (Eyler and Weatherby, 2020; Van, 2020; Niseyi, 2020; Eyler, 2020), a qualitative asymmetry between hydrological studies (Michalska-Smith and Allesina, 2017), personal beliefs of scientists (see Kreps and Kriner, 2020; Lyengar and Massey, 2019; Petersen, Vincent and Westerling, 2019) and anti-scientific movements are much bigger challenge for the *RD*. Hence, whenever R_{y1} and R_{y2} are committed to actively "open a door to discussion" with multi-stakeholders (Eyler and Weatherby, 2020) and "find avenues for [closer] collaboration with China" (EWC, 2021: 22-23), finding the financially feasible, politically acceptable and administratively convenient solutions (Molle, Mollinga and Wester, 2009; Sivapalan and Blöschl, 2015) can be easily reversed by the $R_{x1\text{-}3}$.

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3.1.4. Discourse practices and water narratives in socio-hydrology

Unlike the *SP* where various research articles, water reports and other high-quality inputs undergo multiple peer-review processes, the newspaper articles and other online speech acts published through the *AP* are getting more popular due to the growing professionalization of the NGOs and integration of the public-science movements (see Banks, Hulme and Edwards, 2015; Bergner, 2010). However, neither numerous editors nor fact-checking tools are fast enough to simultaneously verify the research content (see Moreno-Gil, Ramon and Rodríguez-Martínez, 2021; Zhou and Zafarani, 2020; Kanozia, 2019; Pavleska et al., 2018; Bohannon, 2013; Colquhoun, 2011). Once the misinformation, overstatement or disinformation is published from $R_{y1\text{-}5}$, retrospective correcting of errors and retracting the inaccurate beliefs of popular narratives (Dickson, 1988) can be challenging. As showed in the adapted Baker's model applied on the EoE Study case study, the R_{y1} attempt to identify how the Chinese dams are altering the natural flow (Bassist and Williams, 2020) significantly backfired. While closer collaboration with $R_{y4\text{-}5}$ multi-stakeholders and providing additional hydrological monitoring through the MDM positively strengthen the *RD*, organizing more public-research meetings and other trainings along with the R_{x2} and R_{y2} (e.g. SC, 2021a; EWC, 2021; EJN, 2021; Keshap, 2021; SC, 2021a) only highlight the ineffectiveness of the applied research inputs in depoliticizing the water science. Another weakness of using the *AP* over *SD* present the rise of the anti-scientific movements and growing distrust among the $R_{x1\text{-}3}$. Since all of the R_{y1} inputs were made outside of the *SD* (Basist and Williams, 2021, 2020a, 2020b) and unilaterally co-developed by the R_{y1} through the MDM (Basist et al., 2020), such content is more prone to politicizing the *E* and confirming the prior beliefs without taking any responsibility for the published content.

To conclude, socio-hydrology like any other interdisciplinary scientific field struggle with a crisis of knowledge that does not necessary implicate the wisdom of how to underpin sustainable water management (Srinivasan, 2015: 787; Loucks, 2015: 4790; Sivapalan, Savenije and Blöschl, 2012: 1273). As we mentioned above, the politicization of science is a complicated process of re-considering existing water paradigms and vigorous capacity to test alternative interpretations of complex phenomena. With growing medialization and misinterpretation of science, it is highly rewarding to diversify research channels and put more pressure on reasonable scientific etiquette. Also, despite the standard research procedures may not be perfect, sharing the hydrological data and facilitating the *RD* between scientists and non-scientists is a good start how to delimit the unconstructive water narratives and promote mutual trust between multi-stakeholders. However, trust among multi-stakeholders cannot be granted. It can be only earned by mutual respect, solidarity and patience in improving the accuracy of the predictive hydrological models (Jiménez et al. 2020; Head, 2017). While the quality of hydrological science may vary, we strongly believe that socio-hydrology may more effectively address these discrepancies and positively strengthen the conceptualization of the *RD* through the *SD* that is currently more viable than the *AD*.

Disclosure statement

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Author contribution

WW, RG and FG conceived, designed, and supervised the research. All authors contributed to the writing of the manuscript.

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