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How to Incorporate System Archetypes into Water Conflicts Analysis: Application in Euphrates, Nile, Zambezi, and Lake Kivu Transboundary Basins

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Abstract: This paper introduces and fleshes out a systemic method designed to develop a holistic understanding of states' behavior in transboundary water conflict and cooperation. Such an approach leverages causality analysis to capture the deep structural characteristics that shape the hydropolitics dynamics and may lead to the evolution of destructive behaviors with severe consequences. The paper does so by using the concepts of the system archetype. The system archetype analysis offers insight into the underlying structures from which the dynamics of hydropolitics emerge over time—cycles of conflict and cooperation. The approach provides riparian states with a diagnostic tool to recognize patterns of destructive behaviors in the management of shared water resources and warning signs that are usually too long overlooked. Using four case studies from different continents, this paper shows how a systems archetype approach is useful for developing a big-picture understanding of the hydropolitical problem, its dynamics, and potential resolution pathways. The systemic lessons learned from these case studies can be used in other contexts, helping policymakers anticipate the destructive and constructive dynamics leading to conflict and cooperation.

Keywords: system archetype; hydropolitics; Nile; Euphrates; Zambezi; Lake Kivu

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1. Introduction

Climate change is likely to increase the frequency and intensity of droughts and floods in the coming decades. Societies are also at risk of unsustainable use of freshwater resources, especially in areas vulnerable to such events. In this context, a growing amount of research over the last decades has focused on understanding and anticipating tensions and conflicts over transboundary basins in order to guide policy interventions [1–4]. This has provided a rich theoretical and practical basis for characterizing conflict and cooperation, particularly from a hydropolitical standpoint [5]. The value of research in this domain becomes more evident when considering that 40% of the world's population are living in areas where the mismatch between political borders and resource boundaries traps fellow riparian states into the spiral of competition and conflict over the use of water resources [6].

In the study of transboundary basins, much of the research efforts have been directed at predicting water conflicts in order to allow for the possibility of "preventive diplomacy" [2,4,7–16]. This would potentially provide ground for building trust and capacities across the various stakeholders and minimize the risk of violence [17–19]. For that, they investigate the correlational relationship between the emergence of the conflict event (as a dependent variable), and the basin's social and environmental attributes/drivers (independent variables) such as precipitation, river discharge, water treaties, and GDP. One of the early research attempts in this domain was a dataset created by Wolf [20]—International Water Event Database (IWED)—in which the global historical events are mapped against some hydropolitical drivers in international basins. Later, the database evolved into another

important dataset called the Transboundary Freshwater Dispute Database (TFDD), as a part of the Basins At Risk (BAR) project [8–10,21]. For example, the main insight from this project about the driving factors was that we may expect to see conflict in a place with large dams, high population density, low-income communities, an unfriendly environment between riparian states, and no existing water treaties.

Since then, other researchers have expanded the TFDD in terms of quantity or quality of data [12,13,16]; or in some cases, they have started to create new databases (with the same purpose) such as the International River Basin Conflict (ICRC) [22] and the Transboundary Water Assessment Program (TWAP) [23]. All these attempts at creating or improving datasets have paved the way for a new thread of research to emerge where the researcher employs statistics to discover the correlation between hydropolitics and hydropolitical drivers—methods such as advanced statistics [1,2] and machine learning [3,4]. Often, the ultimate goal is to better predict future hydropolitical events.

On the other hand, there has been another research approach which attempts to focus on structure/behavior dynamics, arguing that the observed correlation does not imply causation [24–26]. It starts with characterizing the transboundary basin as a nonlinear, unpredictable system in which causal relationships are central to the way the water problem is perceived and understood. The main question in this approach is not how input and output are correlated but how individual factors come together to form the big whole. It concerns finding the root causes of the problem by identifying behavioral and contextual mechanisms that drive the dynamics.

The theory that underpins this scholarship centres on systems thinking—a field that encourages researchers to move from correlation thinking toward systemic, interaction-focused analysis. Through the systems approach, the water resource systems are characterized as socioecological systems that behave in a complex manner. For operationalizing systems thinking, System Dynamics is often used to explore and represent these complexities [27–29]. System Dynamics offers both qualitative—Causal Loop Diagrams (CLDs) and Archetypes—and quantitative methodologies to analyze system behaviors through time [30,31]. Using the case of the Helmand basin shared between Iran and Afghanistan, Bazrkar et al. [25] illustrate how the approach can be used for examining the interactions between natural and social systems. Drawing on the same case study, Shahbazbegian et al. (2016) [26] introduced "hydropolitical self-organization" theory to study the system structure governing the water conflict in the basin. In a theoretical framework, they demonstrated how such a system structure evolved throughout Helmand's history and how it can be modified to generate desired behavior in the future. Focusing on the diversity of transboundary basins' morphology, Shahbazbegian and Noori (2022) introduced the "hydropolitical system archetype" concept, which accounts for determining potential hydropolitical situations in transboundary basins [32]. They mapped and discovered five potential system archetypes in hypothetical transboundary basins as well as their physical environments, feedback structures, and a diagnostic checklist to notice them in transboundary basins. It is imperative to launch the idea through relatable case studies, according to their results. These examples are among the few studies highlighting the capacity of System Dynamics in characterizing hydropolitics. In fact, the wider use of causal analysis to study water conflict, particularly System Archetype, has remained less explored, and this is one of our motivations for this paper.

However, the authors believe that hydropolitics research still lacks experience in using system archetype analysis to explain how hydropolitical mechanisms trigger conflict and cooperation, and how such mechanisms play out in the context of transboundary relations. Following up [32] on the lack of case studies, this paper aims to identify such mechanisms on the ground and explore how they contribute to engendering hydropolitical dynamics in touchable case studies.

The paper argues that system archetypes can be used as an analytical approach to examine water conflict situations and uncover the hydropolitical mechanisms that shape the dynamics in the basin and guide policy interventions. Since archetypes can be developed

easily and quickly, they are also useful tools to facilitate discussion between involved actors about (a) why things happened in the past, (b) how to think critically about the present, and (c) how to bring positive change before the problem looms larger. To contextualize the argument, we use four different case studies suffering from different issues to show how dynamic hypotheses, drawn from system archetypes, can capture the structure of transboundary relations and the hydropolitical mechanisms they generate. To this end, the Nile and Euphrates transboundary rivers bearing different asymmetrical power relative to each other, in terms of whether the asymmetry favors up-stream state or downstream state, are adopted in the paper to clearly indicate the differences in system archetypes dominating the basins. In the following, the case of Kariba dam on the Zambezi transboundary river is examined to scrutinize the system archetype which has changed riparian states' expectations of their cooperation strategies in generating energy from the transboundary river. Finally, the case of Lake Kivu, suffering from none of the mentioned issues, is brought to our attention to indicate how the Tragedy of the commons could matter in transboundary lakes. For each case study, we provide supportive theoretical arguments along with historical data.

This paper is organized as follows. Section 2 covers the basics of system dynamics and system archetypes and describes the rules of archetype mapping and functionality. In Section 3, ideas were introduced in four transboundary basins to map potential system archetypes, describe associated behaviors over time, and discuss potential interventions. Section 4 contains a discussion, including limitations and directions for further research. Finally, the paper ends up with a conclusion in Section 5.

2. Materials and Methods

2.1. System Dynamics and System Archetypes

The use of systems theory in water conflict research has been important in moving researchers beyond linear thinking to adopting a non-linear and dynamic whole-system perspective [26,32,33]. By taking a systems approach, the hydropolitics in transboundary basins can be characterized as non-linear, unpredictable, and self-organized systems that behave in a complex manner. In such a setting, the art of System Dynamics, as an approach for operationalizing systems thinking, is to discover and represent these complexities through structures and feedback loops.

System Dynamics, as developed by Forrester [27,34], and further described by Senge [29] and others (e.g., Wolstenholme [35]), is an approach that draws on both qualitative—CLDs and archetypes—and quantitative methodologies to analyze system behaviors through time. CLDs are a graphic tool used for better understanding the interrelations amongst a system's components (see Figure 1). Archetypes, the other qualitative tool, are a set of common pre-defined patterns of system behavior that can help analysts to understand specific system structure dynamics represented in the CLDs. They have been proven to be useful in representing mechanisms that create counter-intuitive behavior in the system (unintended delayed reactions) [28].

To many scientists, that is an appealing quality for an approach to have, and it is the main reason most of those interested in system thinking find systems archetypes as a useful tool for their system analysis. The applications are as diverse as global land system [36], spatial planning [37], construction safety [38], tourism planning [39], sustainable agriculture [40], capacity planning [41], healthcare [42], organic farming [43], rangeland management [44], fuel marketing [45], and water resources management [26,30,32,46–52].

In practice, each system archetype is composed of a specific combination of "reinforcing" and "balancing" loops—or circles of causality. Reinforcing loops generate exponential growth and collapse, in which the growth or failure continues at an ever-increasing rate. In contrast, balancing loops are always bound to a target, a constraint or a goal which is often implicitly set by the forces of the system. A combination of balancing and reinforcing loops is responsible for the overall behavior of the system.

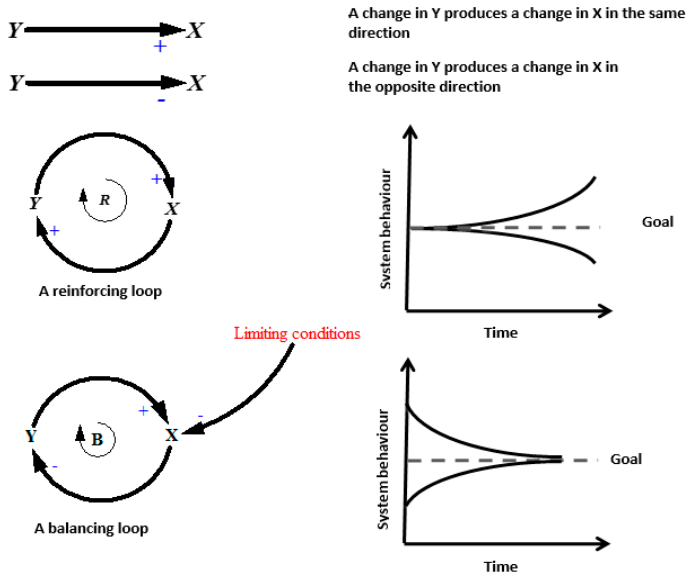

Figure 1. The features of simple "balancing" and "reinforcing" loops adapted from [28].

According to Figure 1, reinforcing loops generate exponential growth and collapse, in which the growth or failure continues at an ever-increasing rate. In contrast, balancing loops are always bound to a target, a constraint or a goal implicitly set by the system's forces. Hereof, some well-known system archetypes were introduced by Senge, 1997 [29], consisting of a standard combination of CLDs generating the same behavior.

2.2. Hydropolitical System Archetypes

Systems archetype helps the analyst not only to recognize the common patterns and mechanisms of problems in different systems, but also how to stop them from recurring [53,54]. Referred to the term as a hydropolitical system archetype, Shahbazbegian and Noori [32] indicated that this tool could provide new words and grammar, enabling the analysts to tell the story of water conflict and cooperation in a new way. Nevertheless, they failed to apply the term in case studies to shed light more on the unknown sides of the idea in practice. Using the examples of the Euphrates, Blue Nile and Zambezi River basins, and Kivu Lake, this section shows how by understanding the mechanisms that drive behavioral dysfunction in the basin, the analysts would be in a better place to explore the sources of the conflict and make an informed judgment about future interventions. These mechanisms are derived from generic systems archetypes that are identified through the literature survey on these cases.

3. Results

3.1. Success to the Successful' in the Euphrates River Basin

The Euphrates River originates in Turkey and flows through Syria and then Iraq to join the Tigris in the Shatt al-Arab, which empties into the Persian Gulf. The river has become a recurring example of the potential international water war among riparian states in the literature, particularly at times of flooding and drought [55–60]. This pessimistic view, particularly in terms of international relations, has recently risen following the further development of the GAP project (the Southeastern Anatolia Project in Turkish: Güneydoğu Anadolu Projesi, GAP), a large-scale water capturing project that aims to develop dams to control and harness the tributaries of the Euphrates by Turkey [61]. Similar to any country committed to providing essential resources for its future development, Turkey justifies such water harvesting by highlighting its soaring essential needs for hydropower, irrigation, and drinking water [60]. The development of this water supply, however, has severely impacted development programs in Syria and Iraq [62]. This has created asymmetrical power relations among riparian states, in favor of the upstream state, i.e., Turkey [60–63]. It

allows Turkey to continue investment and implement its ambitious political and economic reform agenda. The "Success to the Successful" archetype, referred to as "Bully and Bullied" hydropolitical system archetype in [32], captures these dynamics.

We often observe the archetype when two activities compete for resources. Generally, it consists of two reinforcing loops interacting against each other. This archetype highlights how success can be determined by initial chance and how the structure can systematically bring bigger success for one and simultaneously bigger failure to the other, and the result is then rapidly skewed on the more successful side. The asymmetrical development between riparian states in the context of a transboundary basin implies that two reinforcing loops work against each other. Observational data and studying the relevant literature will help us to see the reinforcing loop in the basin and identify the archetype.

To this end, one can assume a reinforcing loop for each riparian state. The loop is used consistently in the literature to describe the interaction between water and development relying on water [26,32,64–68]. The loop suggests that the development depends on water as well as water withdrawal in the same direction, which ultimately feeds development processes. Depending on resource availability, the reinforcing loop tends to orient development towards either exponential increase or collapse over time. In the case of Euphrates, what connects the reinforcing loops together is the dependency of riparian states on the river's flow [69]; what set them against each other is the geographical endowment and the asymmetrical geographic power [70]—which means any withdrawal in the upstream will automatically reduce the amount of water reaching the downstream states, i.e., Iraq and Syria. The development of each riparian state depends on their available water resources (Figure 2a). On the other hand, the more dependent they are, the more legitimate they feel about water withdrawal. This constrains the riparian states to their own advantage by focusing on harvesting more water at the expense of other involved parties (Figure 2a) [71–73].

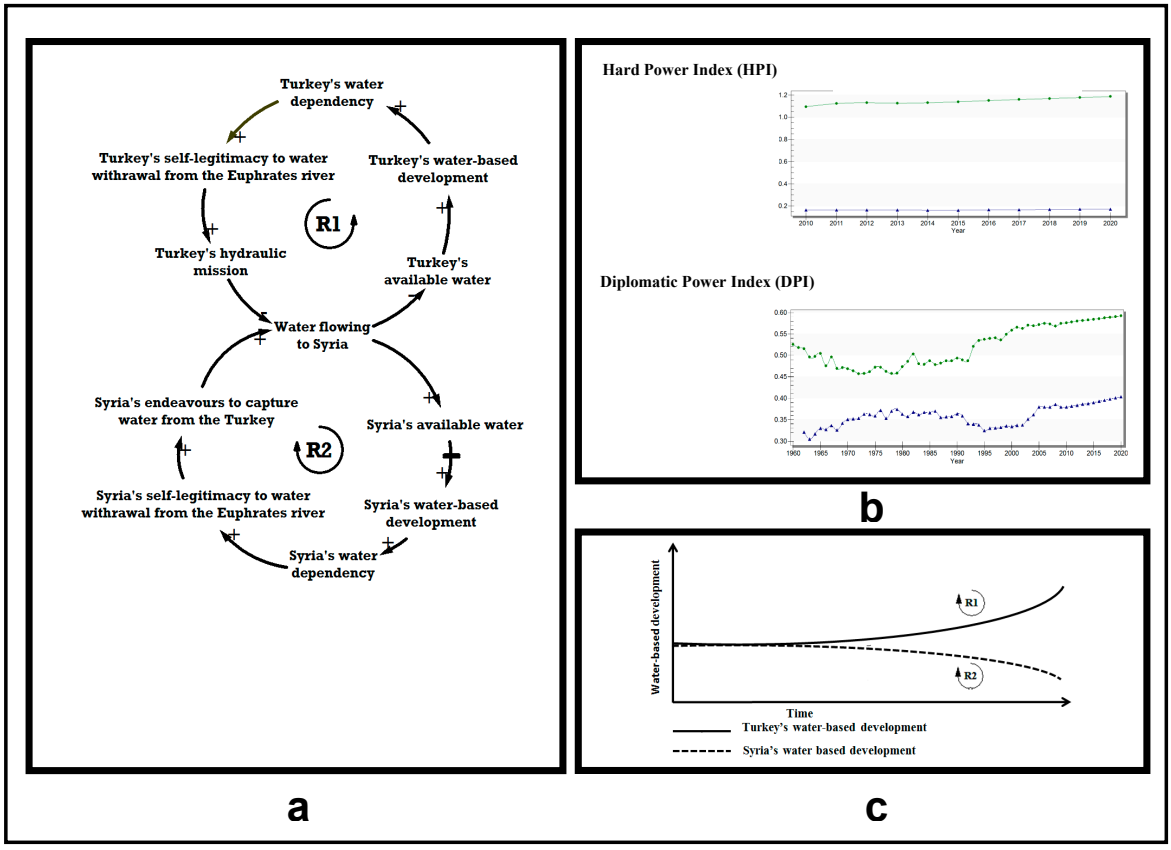

Figure 2. (**a**) The success to successful archetype in the Euphrates transboundary river basin; (**b**) Asymmetrical power, Diplomatic Power Index (DPI), and Hard Power (POWER) [74] in the

basin, Turkey (in green) and Syria (in blue), generated by IFs (International Futures) database (last update 2020) [75]; (**c**) the schematic of the expected behavior in the basin with responsible loops adapted from [32].

Given the geographical power of being an upstream state, the only step required for Turkey to make more water available to meet its desired development is to expand its hydraulic infrastructure within its borders—the strategy which is usually referred to as "hydraulic missions" [62,76]. However, the situation is much more complex for downstream states; they need to negotiate over water flow before dealing with their hydraulic missions [77]. As a result, they require some element of power to compensate for Turkey's geographical power, not to mention for negotiation over water. Nevertheless, the substantial elements of power either soft (e.g., diplomatic) or hard power (e.g., technological or even military power) skew towards Turkey (Figure 2b). This is the key reason that R1 predominantly overpowers R2. Research in this basin revealed that downstream states, in most cases, found themselves in a weak position against Turkey's strategy to fully harness water for its development purposes. These states have no choice but to climb down over their development programs which are highly reliant on water resources [63,78]. Figure 2c illustrates the general behavior stemming from these dynamics in the basin.

By identifying this archetype in the Euphrates, we could take two types of strategies. The first type seeks to strengthen the weaker loop while slowing the uncontrolled growth of the stronger loop by connecting the two reinforcing loops in such a way that the continued activity of the stronger side is subordinated to the development of the weaker side [29,79]. Taking into practice, this strategy implies providing an external force such as international law [80–83] or an internal one such as building up river basin organization [84–86] to constrain Turkey's hydraulic mission to support the development in downstream states.

The second type of strategy would aim to separate the two reinforcing loops since they do not rely on shared resource allocation [29,87]. For that, downstream states have to plan for reducing their dependence on the Euphrates river, given the fact Turkey has not yet shown any flexibility to limit its investments in water development. The rate of reduction, however, should catch up with Turkey's hydraulic mission. The strategy is particularly useful as it enables downstream states to transform their development into one that less relies on water in the long term [88,89].

Apparently, the Success to successful archetype does not capture the whole hydropolitics dynamics in the Euphrates as there are many other factors involved that are not discussed here. However, the archetype presents one of the engines responsible for exacerbating the hydropolitical situation among riparian states over time and helps to assess potential interventions in a more holistic way.

3.2. The "Escalation" in the Blue Nile River Basin

The Blue Nile rises in the Ethiopian Highlands in Lake Tana and is responsible for nearly 80% of the total flow of the Nile below Khartoum, where it joins the White Nile. The river flows through Ethiopia and Sudan, emitting an estimated 88 BCM of natural discharge in Ethiopia and a neglected amount in Sudan [90]. It helped cover 50% of the water flow of the High Aswan Dam (HAD) (55 BCM) built in Lower Egypt in 1970 and is a major source of Nile flooding in Egypt [91,92]. Rivers are also an important resource for Sudan, with dams producing 80% of the country's hydroelectric power and helping irrigate high-value cotton, wheat, and animal feed crops [93,94]. Therefore, Ethiopia's water-based development will affect downstream water flows, especially in Egypt.

The history of water relations between the three riparian states shows cooperation and conflict since the 1950s [95]. In November 2012, Ethiopia unilaterally began the construction of the Grand Ethiopian Renaissance Dam (GERD) without notifying upstream states, i.e., Sudan and Egypt. The dam was a riverside 6000 MW hydropower plant with the ability to control 79 BCM, of which 59 BCM was in use [96]. Sudan and Egypt, however, expressed concern about possible reductions in water availability (ibid.). Except for the 1959 treaty

contested by Ethiopia, there are no trilateral treaties between the three river states of Ethiopia, Sudan, and Egypt. In this regard, Ethiopia focuses on its geographical power, while Egypt emphasizes past dependencies and uses its regional and international power to destabilize Ethiopia's damming project [97,98]. Tensions have risen between Egypt and Ethiopia over GERD after Ethiopia announced that it would fill its reservoir. Historical evidence of long rounds of ebb and flow between two riparian states over controlling and syphoning of the river [94,99] shows the Escalation archetype dominating state's behavior over the last decade.

Generally, the Escalation archetype represents a situation in which two sides attempt to maximize their gain to surpass each other. It is composed of two balancing loops interacting to emerge a reinforcing loop as a vicious circle responsible for increasing non-value-added competition between the sides. In the context of hydropolitics, the competition could be about "upstream-ers use water to get more power, downstream-ers use power to get more water" [70] (p. 46) (Figure 3a). For this, Zeitoun and Warner (2006) [70] introduced the concept of hydro-hegemony, by explaining how sovereign states with water-related power control water politics. If the downstream state is the more powerful side, it can also have control over water resorting to its power. On the other hand, skewing power towards downstream has been a motive for upstream states to change the power balance by reinforcing their domination on the water flow [100]. This tends to emerge in the form of developing hydraulic missions in upstream states that strengthens their geographical power, not to mention their position as a hydro-hegemon in the basin [101]. According to Homer-Dixon (1994) [102], "Conflict is most probable when a downstream state is strong and highly dependent on river water in comparison to upstream. The downstream states often fear that the upstream states will use water as a means of coercion. This situation is particularly dangerous if the downstream state believes it has the military power to rectify the situation" [102] (p. 19).

In contrast to the Euphrates basin, the downstream state in the Nile basin has enjoyed having the upper hand in power for the years, or as it is called in the hydropolitics literature, the "hydro-hegemon" [70,101]. That has been enough to provoke Ethiopia in developing its hydraulic mission to take away the hydro-hegemon position from Egypt [99] (Figure 3b). Therefore, Ethiopia has resorted to developing GERD to promote and use its geographical power [103]. This has led to the creation of a balancing loop, B1 (Figure 3a). The loop seeks to orient to or hold on Ethiopia's position at the hydro-hegemon point. Figure 3b shows that Ethiopia has been a pioneer in the hydraulic mission relative to its neighbors, mapping the historical expenditure of riparian states on the construction of new irrigation structures.

In contrast to the Success to the successful archetype, the Escalation archetype refers to the situation in which the upstream states can no longer act unilaterally by relying solely on their geographical power [32]. In the case of the Nile basin, Ethiopia's strategy has not gone unanswered by Egypt, and evidence suggests that Egypt has been returning by leveraging its power over destabilizing Ethiopia's damming projects on and off [104]. The B2 loop (Figure 3a) accounts for this response and served to actualize Egypt's development goals, consequently consolidating Egypt's hegemonic position in the basin.

The expected behavior from the archetype represents an escalation between Egypt and Ethiopia, where each state tries to take advantage of the asymmetrical situation in its favor to dispossess the hydro-hegemon position in the basin. (Figure 3c).

The response to the Escalation archetype often includes a change in the system's structure to disrupt the ongoing pattern. Accordingly, the strategies could take at least two forms. One aims to move the riparian states from non-cooperative to cooperative interactions in order to stop escalating actions for finding a common ground. Some attempts have been undertaken in line with this strategy either under the banners of "benefit sharing" [100,105,106] or "water sharing" [107,108]. The underlying idea has been to change the distribution of expenses and advantages related to collaboration among the riparian states [109,110]. However, some researchers suggest that this strategy can no

longer be assumed to be effective given the existing asymmetrical power dynamics in the basin [111–113].

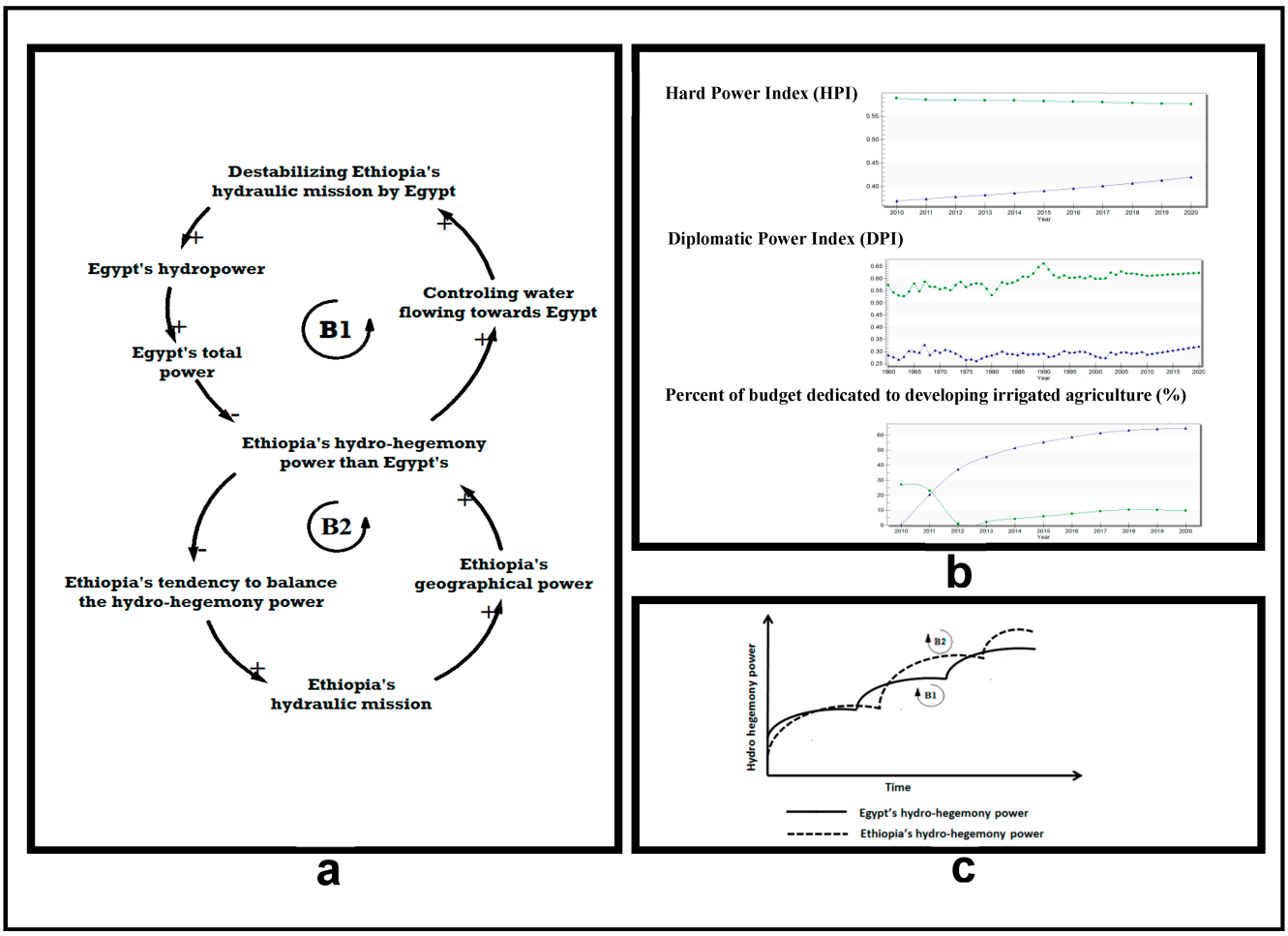

Figure 3. (**a**) The Escalation archetype in the Blue Nile River basin; (**b**) Asymmetrical power, Diplomatic Power Index (DPI), and Hard Power (POWER) [74] in the basin, Egypt (in green) and Ethiopia (in blue), generated by IFs (International Futures) database (last update 2020) [75]; (**c**) the schematic of the expected behavior in the basin with responsible loops adapted from [32].

The second group of solutions proposed for this archetype goes with identifying a larger goal encompassing both parties' goals and avoiding future escalation traps by creating a system of collaborative competition [114]. This type of intervention suggests redefining the goal of the balancing loops in as much as each side would not be relative to the other one. This is feasible by placing the concerns of each side on the prosperity of the other one (ibid). Following the causal loop structure, mediations in such a manner expand the areas of solution raising and focusing on big questions, such as how to redesign the system structure so that Ethiopia's interest for power in the basin would be satisfied as a result of the flourishing of Egypt's hydropower. This could change the undesired outcome of the balancing loop and discourage them from competing for hegemonic dominance over the river.

3.3. Shifting the Burden' in the Zambezi River Basin

The Zambezi transboundary river rises in Zambia and flows through eastern Angola, along the northeastern border of Namibia and the northern border of Botswana, then along the border between Zambia and Zimbabwe to Mozambique, where it crosses the country to flow into the Indian Ocean. Though the Kariba dam was controversially constructed at the end of the colonial period to fuel economic growth in settler colonies, it ended

up becoming central to newly-independent African states, i.e., Zambia and Zimbabwe. Currently, both countries rely heavily on the dam for electricity. Zimbabwe has long been Africa's agricultural powerhouse, and Zambia is a major global supplier of copper and cobalt, which require energy-intensive production but are crucial for energy transitions across the globe. According to this, a bilateral organization, the Zambezi River Authority, focusing on the management of Kariba Dam, was established between Zimbabwe and Zambia, [115]. However, the project has turned out to be the leading cause of altering the magnitude, timing, duration, and frequency of flooding events, resulting in adverse ecological and socioeconomic changes in the Zambezi Delta as the end downstream state in the basin [116–121]. On the other hand, the Zambezi Delta is vital to Mozambique's national economy and is a wetland of international importance [115]. That pushed Mozambique to become a potential opponent against the operation of the Kariba Dam and that shifted the transboundary hydropolitical situation towards instability [122]. Looking into the various elements that are active in sliding the basin towards instability, conflict and crisis can be captured by the Shifting the burden archetype, which is also redefined as "Water and Fire" by Shahbazbegian and Noori [32] in the hydropolitics context.

The Shifting the burden archetype generally appears when a system focuses on the problem symptom rather than its fundamental solution. Two balancing and one reinforcing loop shape the archetype's structure. One balancing loop leads the system to heal the symptoms immediately, and the other one addresses the long-term solution to the problem. Correspondingly, relying on the former loop leads to an emerging reinforcing loop that causes the system to overlook the latter loop as the long-term solution [123].

Figure 4a illustrates the case study issue using the Shifting the burden archetype. The balancing loops B1 and B2 represent the short- and long-term arrangements which can satisfy the energy demand in upstream states. The B1 loop encourages upstream states to cooperate on water capturing to meet their energy demand, keeping operating and developing the Kariba Dam on their border.

The upstream states adopted the short-term solution by continuing to operate the Kariba dam project, excluding the downstream state (B1 loop). Besides technical problems [124], the dam's operation causes severe environmental damage in the downstream state [125]. This has made Mozambique a tough opponent for this project [126]. On the other hand, the B2 loop has encouraged upstream states to forge an inclusive consensus among all riparian states that increases the chances of reaching long-term sustainable cooperation. Going with the short-term solution (R1 loop) hinders the long-term solution and decreases the chance of reaching a constructive interaction with Mozambique [121]. Moreover, as the data shown in Figure 4b illustrates, Mozambique has the biggest potential in (hydro-)energy production among all riparian states. This also unveils that there would be a potential for upstream states to address their energy demand by importing energy from Mozambique without investing in the Kariba Dam project.

Based on the above description, Figure 4c shows the schematic behavior of the archetype over time. R1 loop reduces the chance of reaching a sustainable agreement in the basin while raising the risk of energy shortage for the upstream nations. Although these states, particularly Zimbabwe, have recently changed their strategy toward the fundamental solution by shifting from bilateral to trilateral cooperation [127], the archetype suggests that they are far from forming effective cooperation.

More generally, shifting the Burdon archetype is useful in a situation where the side effect of short-term solutions hinders progress towards the fundamental solution. To forestall this, it is better to provide tools that highlight the fundamental solutions alongside the short-term ones. In the context of hydropolitics, this archetype reflects one of the common situations in which riparian states come to launch water cooperation projects on their common border. These cooperative projects tend to be realizes by constructing a cooperative dam on transboundary rivers both to meet water demand and as a means for reinforcing water diplomacy. They are often called "friendship dams" such as the

Doosti dam between Iran and Turkmenistan [128], the Salma dam between Afghanistan and India [129], and the friendship dam between Turkey and Syria [130].

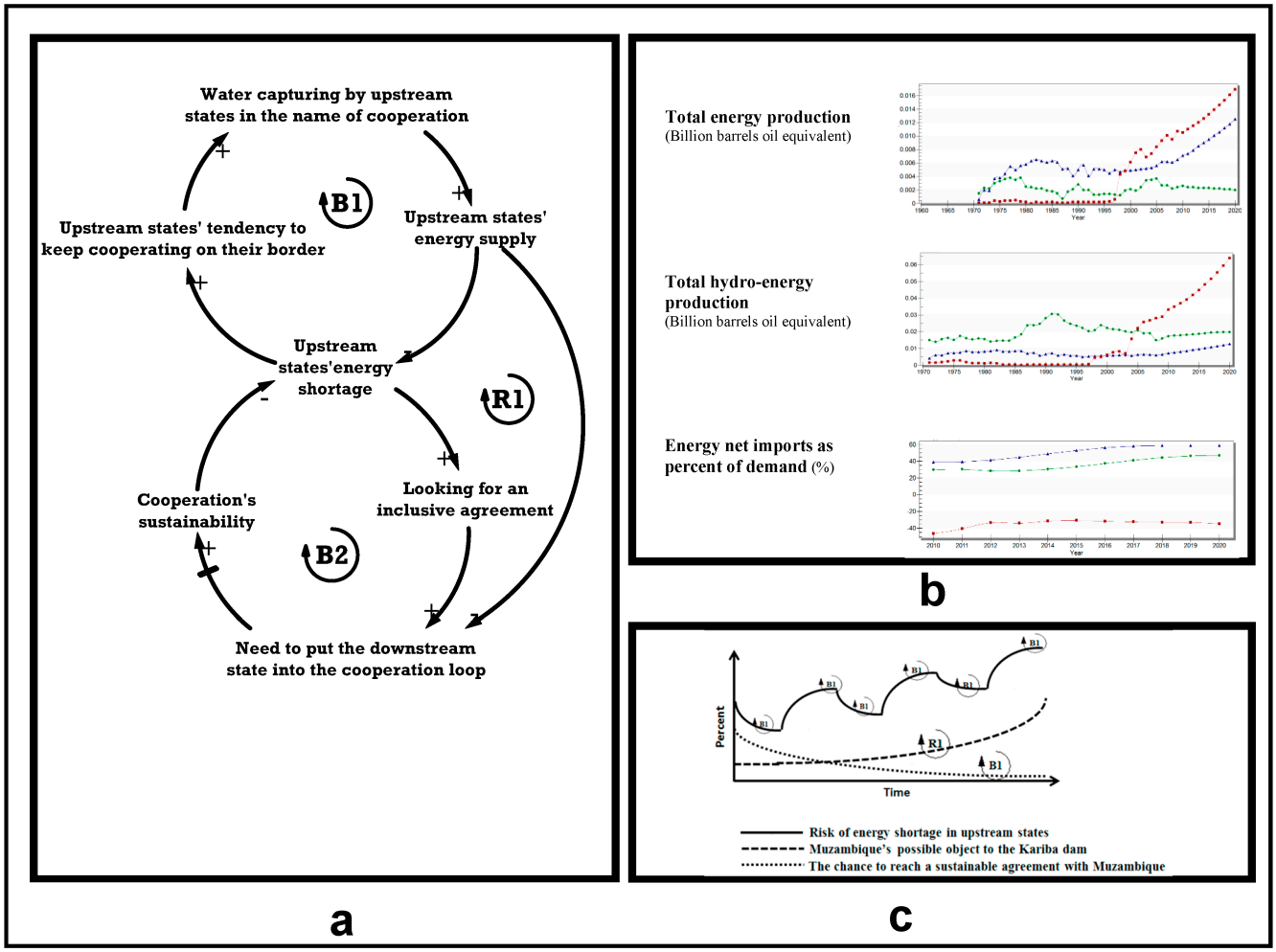

Figure 4. (**a**) The shifting the burden archetype in the Zambezi river basin; (**b**) energy production's state of qua in the basin, Mozambique (in red), Zambia (in blue), and Zimbabwe (in green), generated by IFs (International Futures) database (last update 2020) [75]; (**c**) the schematic of the expected behavior in the basin with responsible loops adapted from [32].

These projects, in the form of either upstream-and-upstream cooperation (e.g., the Salma dam) or downstream-and-downstream cooperation (e.g., Harirud river), have been inaugurated with good intentions. Sooner or later, however, they found themselves surrounded by externalities stemming from the state(s) who have not been respected in the cooperation. Simply put, the cooperative countries shift the burden of their water issues to the excluded riparian state. The archetype instructs the basins being capable of going into this collaboration model to involve all riparian states in the project ahead of any activity.

Let us dive in-depth into the Doosti dam case which was constructed in 2004 by Iran and Turkmenistan on the Harirud transboundary river. The river originates from Afghanistan and constitutes the border between Iran and Afghanistan. The dam was constructed at the time Afghanistan was under US control. However, the situation changed in 2016 when the new government in Afghanistan built the Salma dam with the support of the Indian government. The Salma dam now could control the whole water flowing downstream, most importantly, the Doosti dam [131,132]. Both projects in the basin have been launched under the title of "friendship dam", the former between Iran and Turkmenistan and the latter between Afghanistan and India. According to the Escalation archetype, if the downstreamers in the Harirud river had involved the upstream states

in the doosti dam project, the development of the Salma dam undertaking would have been unnecessary.

The Shifting the burden archetype clearly shows the significance of embedding an inclusive agreement in the cooperation projects, particularly if riparian states seek to build hydraulic infrastructure on their water border. The insights from this archetype can also be incorporated into the studies which deal with monitoring cooperation in transboundary basins [133–135] and developing conventions such as the United Nations Economic Commission for Europe (UNECE) [136].

3.4. Tragedy of the Commons in the Lake Kivu

Lake Kivu lies on the border between the Democratic Republic of Congo (D.R.Congo) and Rwanda in Africa. It is a freshwater lake fed by river discharges coming from two riparian states and then drains into Lake Tanganyika in the south through the Ruzizi (Rusizi) River. It is known to undergo limnic eruptions and Methane gas from Lake Kivu, which is used as a nitrogen fertilizer and converted into compressed fuel for trucks [137]. While attempts have focused on extracting the lake's potential methane or preventing its possible volcanic activities [138], investigations on the Lake's pollution are needed to stop severe anthropogenic catastrophes [139,140]. On this subject, evidence indicates that both riparian states are responsible for loading wastewater pollution into the Lake with a limited self-purification ability exacerbating the overall pollution in the Lake over time [141]. In the cooperation problem, this pattern of behavior is known as the Tragedy of the commons, where there is an interaction between two or more sides with open-access resources that are in exposure to exploitation and sometimes destruction. The undesired outcome of this will affect all sides in the long run [142,143].

Using the language of system archetype, the structure of the Tragedy of the commons consists of four causal loops, including two reinforcing loops (R1 and R2) and two balancing loops (B1, B2) (Figure 5a). In Lake Kivu, the archetype's activity has been triggered by the increasing population in both riparian states, generating ongoing needs for food and water (Figure 5b). This results in increased crop production and development in the riparian states (R1 and R2) (Figure 5b). Crop production on both sides amplifies non-point wastewater pollution loading into Kivu Lake, including enormous industrial and agricultural pollution [139,140,144,145].

Figure 5b indicates that both riparian states have decreased their spending on water treatment, which worsens the situation. Consequently, the two balancing loops (B1 and B2) increase the riparian states' share of loading pollution into Lake Kivu (Figure 5b). Figure 5c shows the potential behavior due to the archetype's activity and responsible loops for each behavior. Here, the archetype's main driver draws on an undefined and unrestricted share of riparian states in emptying pollution into the lake. As per the typical behavior of the archetype, the lake has phased in an enormous source of contamination, influencing all riparian states no matter what the nature of the interactions between countries happens to be. Soon, there will be increased tensions between riparian states blaming each other for driving the human-centric crisis in the basin.

Studies in transboundary river management tend to use the lens of the tragedy of the common to highlight a situation where two or more parties overexploit a transboundary aquifer [146–150] or overfish from a transboundary lake [151–153], affecting riparian states in the long term as they run out the common resources. Nevertheless, looking at Lake Kivu as a sink with limited capacity, we indicate that transboundary aquifers or lakes with a limited capacity of self-purification, into which riparian states inject their pollution either directly or indirectly, may also suffer from the Tragedy of the commons archetype.

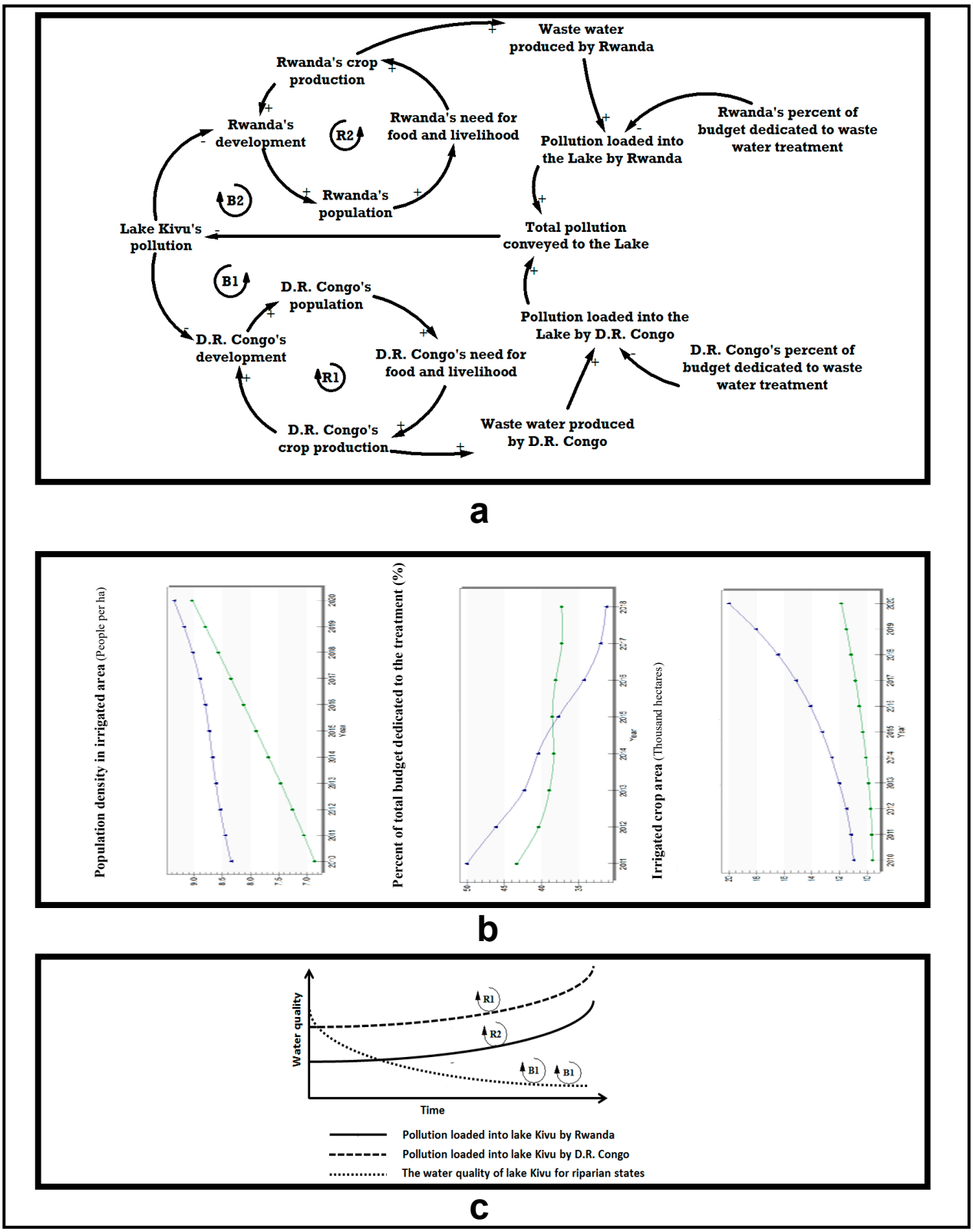

Figure 5. (**a**) The Tragedy of the commons archetype in the lake Kivu basin; (**b**) population density per crop area, irrigated area and the budget dedicated to the wastewater treatment in the basin, D.R Congo (in blue) and Rwanda (in green), generated by IFs (International Futures) database (last update 2020) [75]; (**c**) the schematic of the expected behavior in the basin with responsible loops adapted from [32].

The most effective strategy suggested to address this archetype, also treated as "Covert Measures and Overt Effects" in the context of hydropolitics [32], is to turn the destructive reinforcing loop into the desired balancing loop which controls the exploitation of the common property [154–156]. This can be accomplished by wiring in feedback links from each side's activity, exploiting common resources to the resource limit so that they use additional resources promoted by all sides' activities [29,50,51]. In the case of Lake Kivu, this would allow each riparian state to pollute the lake less than the amount that it can treat. The strategy also calls for robust monitoring and measuring of the system that can control each side's activity. Thus, if the riparian states do not individually measure their pollution level, the total contamination will impact the development programs on both sides.

4. Discussion

4.1. Contribution to the Hydropolitics Research

There is growing interest and efforts by researchers, decision-makers, and other actors to understand the complexity of hydropolitics in order to predict water conflicts and to allow for the possibility of preventive diplomacy. For them, it is important to assess early on the destructive dynamics that may cause violent conflict, regional insecurity, and instability [21].

A foundational premise of using the "systems archetype" approach for understanding the dynamics of hydropolitics is that the structure of transboundary relations (physical, social, political) defines its behavior over time [32]. Therefore, reproducing and analyzing the archetypes in the transboundary basin will provide an early warning when typical behavior occur. Since similar hydropolitical mechanisms can be observed for different transboundary water resources systems, we can consider that the archetype underlying the systems which show similar dynamics are also similar. That means two transboundary basins could be similar from a hydropolitical perspective not just because they are made of the same "variables", but because a similar hydropolitical mechanism drives the dynamics within them.

Unlike research that focuses on complicated mathematical formulation with the aim of finding the correlation between single factors [2–4,16], the systems archetype analysis seeks to find the hydropolitical mechanism that shapes the complex dynamics in the basin, understanding and representing the interactions between social, political, and natural factors [26]. This dynamic perspective enables analysts to identify major hydropolitical characteristics and vulnerabilities which is related to the complexity of transboundary relations. The insights will provide answers to how, when, and why conflict and cooperation happen from a systems standpoint.

The identified archetypes in the previous section are not specific to the suggested basins, nor are they the only archetype that one can consider for them. They are presented to showcase the applicability and effectiveness of systems archetype analysis for studying hydropolitical dynamics.

They are high-level conceptual models that allow the analysts to identify adverse behaviors, synergies, and potential interventions. Tables 1 and 2 summarize systems archetype used in the case studies discussed and map them against the hydropolitical mechanisms they generate and the potential system-oriented interventions to address the problems.

4.2. Limitations

Several limitations need to be considered in using archetype analysis. First, like all methods, systems archetype can be applied effectively and successfully for specific objectives but can also be used poorly and unethically [31]. Multiple levels of "boundary judgments" are to be made by the analysts, decision-makers, and stakeholders to identify the dominant archetype in each transboundary basin. To minimize the risk of unethical use of the systems archetype, the analyst needs to use the method in a more complete manner, that is actively engaging with qualitative, quantitative, and participatory approaches [32].

This will ensure that the archetypes, CLDs, "and the judgments underpinning their development, are effectively embedded in societal and political contexts that allow their use for supporting sustainability" [31] (p. 312).

Table 1. Summary of systems archetypes, potential behaviors, and perspective actions.

System Archetype	Pattern of Behavior	Prescriptive Action
Success to the successful (Figure 2a)	The rich becoming richer and the poor becoming poorer.	Designing the relation between the two reinforcing structures so that the winner's activities simultaneously cause a reduction in the loser's dependency on the allocation of shared resource(s).
Escalation (Figure 3a)	Each side will try harder and harder to surpass the other one.	Launching a negative link from one side's activity to another side's tendency following the escalation contributes to emerging a balancing loop that tackles the unintended behavior of the archetype.
Shifting the burden (Figure 4a)	Preferring a short-term solution rather than the long-term one shifts the responsibility to a third party.	Shortening the time taken to recognize the long-term solution can prevent states from falling into the archetype's trap.
Tragedy of the commons (Figure 5a)	Individuals with access to a common sink or source act in their own interests and, in doing so, ultimately deplete common resources.	The key solution in this archetype is launching a balancing loop to prevent parties from individual exploitation activities.

Table 2. Potential behavior over time in the case studies and system interventions.

Transboundary Basins	Potential Behavior over Time	System Interventions
Euphrates	We would probably would witness incremental changes in the upstream state's development, relying on water and reducing that of the downstream state in the transboundary basin, resulting from R1 and R2 loop's activities, respectively.	Here, decreasing the downstream state's dependency on the water by changing its development path towards less dependency on the water in a transition period alongside the upstream state's development will increase the downstream state's resilience and negate the archetype's unintended behavior in weakening the downstream states. This measure could be met by Turkey, Syria itself, or the interventions of third parties.
Nile	The typical behavior expected from the prototype suggests an escalation taking place between Egypt and Ethiopia because each state tries to take advantage of this asymmetrical situation to become the hydro-hegemon in the region.	The solution is grounded on providing a negative causal link travelling from "Egypt's development" to "Ethiopia's tendency to balance the hydro-hegemony". In that regard, benefit-sharing would be a well-fitting strategy.
Zambezi	Exclusive cooperation reduces the chances of a sustainable deal with other riparian states and increases the risk of the cooperation projects failing.	Taking a shortcut by making a positive causal link between "riparian states' tendency to cooperation" and the "need for an inclusive agreement" will highlight the awareness of the long-term solution that prevents states from having unilateral cooperation. Including a mandatory provision in water treaties or international water law of so-called "friendship dam" projects can help establish a constructive link to deal with the archetype's draw back.
Lake Kivu	Regardless of the power asymmetry between the riparian states or their intentions towards each other, the lake's persistent pollution could become the Tragedy of the commons archetype. An undesirable future consequence of the archetype would be growing tensions between riparian states who blame each other for such an anthropological crisis.	Assessing and monitoring the pollution contribution of each riparian state is central to efforts to combat this archetype activity. This can start by engaging riparian states themselves or by building into international water law a commitment to monitor and exchange data on transboundary lakes between riparian states.

The second limitation of using archetypes for studying hydropolitics concerns the generalization of the results. Although the archetypes need to be extracted through interviews and extensive literature reviews, it is important to acknowledge that they provide simple abstractions of a wicked problem [157]. Thus, they should be used with caution and the insight from that needs to be treated as indicative, not definitive.

Another limitation is that archetypes are high-level conceptual models that are designed to focus on small subsets of myriad feedback loops that drive the dynamics of hydropolitics. It is up to the analysts to identify key feedback loops to explain the dynamics of hydropolitics in the region or the ones that may lead to adverse behavior and disastrous consequences. Thus, it is recommended that participatory approaches are used, through a feasible level of active stakeholder engagement to map a "rich picture" [158] view of the problem and solutions. This could include surveys, interviews, focus groups, and workshops.

The final limitation concerns using the archetypes in system dynamics models. Given the simple nature of archetypes in problematizing the complexity, there is a risk that the archetypes, and the dynamic hypotheses that they suggest, actually mischaracterize the dynamics in the basin. This could occur for various reasons such as a lack of information about the context or misrepresenting the dynamics of the interactions between social, political, technological, and natural subsystems.

4.3. Future Research

This initial work on using archetype analysis for hydropolitics raises several research questions that future research should explore. First, how does insight from systems archetypes analysis inform the understanding of hydropolitical drivers [159]? In what ways can one extract hydropolitical drivers from the system archetypes? If it is possible, how is it different from other existing frameworks that deal with understanding hydropolitics? Arguably, exploring these questions in future research could be the most exciting frontier for advancing the use of archetype analysis in hydropolitics research.

Second, future research can develop frameworks and guidelines to assess the validity of archetype analysis through system dynamics modelling. This is particularly important as validation in archetype analysis is often overlooked or carried out in an unsystematic way. Thus, new research that can provide an overarching approach to validation in archetype analysis would be valuable (similar to [160]).

Third, future research should also focus on developing other archetypes that capture the hydropolitics in transboundary water resources, and the structure that drives the complexities involved.

5. Conclusions

Understanding the complex nature of hydropolitics has been pursued for decades with the aim of transforming transboundary water conflicts [161,162]. This requires that analysts pay close attention to the complex interactions between social, political, technological, and natural factors that create the situation from which formal and informal conflict and cooperation emerge. The paper argues in support of a systemic way of framing hydropolitics, where the dynamics of interactions are understood through systems archetypes. The archetypes represent new ways of seeing water conflict and cooperation through understanding the "structural" characteristics of these complexities. This is an integrated approach to the analysis of interactions between a complex array of factors, which allows for an early diagnosis of the damaging effects of "hydropolitical mechanisms" that could drive the conflict into intractability. In other words, the insights from using system archetypes to study hydropolitics dynamics would ideally enable the decision-makers to address the root causes of the problems rather than the symptoms. What systems archetype analysis suggests is that the root causes of chronic problems in a hydropolitical context often relates to the underlying structures and mechanism that drive the behavior of actors in the basin. The lessons learned will support (a) holistic thinking; (b) diagnosing the evo-

lution of destructive mechanisms (i.e., accelerating reinforcing loops); and (c) anticipating unintended consequences and managing them.

The system archetypes approach enables the analysts and decision-makers to identify the presence of vicious circles in the system through the concepts of reinforcing and balancing loops. Recognizing the loopssupportan early understanding of the issues at stake and help promote realistic measures and strategies in a timely manner.

As shown in case studies from the Euphrates, the Blue Nile and Zambezi River basins, and Kivu Lake, using systems archetype analysis would allow us to see common hydropolitical mechanisms that transboundary basins are often facing, such as the Success to the successful, Shifting the burden, Escalation, and Tragedy of the commons archetypes. These case studies are provided to showcase several of the many ways to apply the systems archetype analytical approach in capturing the dynamics of hydropolitical situations and recognizing common patterns of dynamic behavior. This would allow for more sustainable strategies to transform water conflicts.

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References

1. Beck, L.; Bernauer, T.; Siegfried, T.; Böhmelt, T. Implications of hydro-political dependency for international water cooperation and conflict: Insights from new data. *Political Geogr.* **2014**, *42*, 23–33. [CrossRef]
2. De Stefano, L.; Petersen-Perlman, J.D.; Sproles, E.A.; Eynard, J.; Wolf, A.T. Assessment of transboundary river basins for potential hydro-political tensions. *Glob. Environ. Chang.* **2017**, *45*, 35–46. [CrossRef]
3. Farinosi, F.; Giupponi, C.; Reynaud, A.; Ceccherini, G.; Carmona-Moreno, C.; De Roo, A.; Gonzalez-Sanchez, D.; Bidoglio, G. An innovative approach to the assessment of hydro-political risk: A spatially explicit, data driven indicator of hydro-political issues. *Glob. Environ. Chang.* **2018**, *52*, 286–313. [CrossRef] [PubMed]
4. WPS. Water, Peace and Security Partnership. The Netherland. Available online: https://waterpeacesecurity.org (accessed on 15 February 2023).
5. Elhance, A.P. *Hydropolitics in the Third World: Conflict and Cooperation in International River Basins*; US Institute of Peace Press: Washington, DC, USA, 1999.
6. Oregon State University. Transboundary Freshwater Dispute Database (TFDD). 2016. Available online: https://transboundarywaters.science.oregonstate.edu/content/transboundary-freshwater-dispute-database (accessed on 15 February 2023).
7. Wolf, A.T. International water conflict resolution: Lessons from comparative analysis. *Int. J. Water Resour. Dev.* **1997**, *13*, 333–366. [CrossRef]
8. Wolf, A.T. The transboundary freshwater dispute database project. *Water Int.* **1999**, *24*, 160–163. [CrossRef]
9. Wolf, A.T.; Wolfe, S.B.; Giordano, M. *International Waters: Indicators for Identifying Basins at Risk*; UNESCO: Paris, France, 2003.
10. Yoffe, S.; Fiske, G.; Giordano, M.; Giordano, M.; Larson, K.; Stahl, K.; Wolf, A.T. Geography of international water conflict and cooperation: Data sets and applications. *Water Resour. Res.* **2004**, *40*, 1–12. [CrossRef]
11. Wolf, A.T. A long term view of water and international security 1. *J. Contemp. Water Res. Educ.* **2009**, *142*, 67–75. [CrossRef]
12. Brochmann, M. Signing river treaties—Does it improve river cooperation? *Int. Interact.* **2012**, *38*, 141–163. [CrossRef]
13. Dinar, S. The geographical dimensions of hydro-politics: International freshwater in the Middle East, North Africa, and Central Asia. *Eurasian Geogr. Econ.* **2012**, *53*, 115–142. [CrossRef]
14. Bernauer, T.; Böhmelt, T. Basins at risk: Predicting international river basin conflict and cooperation. *Glob. Environ. Politics* **2014**, *14*, 116–138. [CrossRef]

15. Hussein, H.; Menga, F.; Greco, F. Monitoring transboundary water cooperation in SDG 6.5. 2: How a critical hydropolitics approach can spot inequitable outcomes. *Sustainability* **2018**, *10*, 3640. [CrossRef]
16. McCracken, M.; Wolf, A.T. Updating the Register of International River Basins of the world. *Int. J. Water Resour. Dev.* **2019**, *35*, 732–782. [CrossRef]
17. Cuppari, R.; Schmeier, S.; Demuth, S. Preventing Conflicts, Fostering Cooperation—The Many Roles of Water Diplomacy. 2017. Available online: https://www.waterandchange.org/wp-content/uploads/2018/02/PUB_Water-Diplomacy_Bericht.pdf (accessed on 15 February 2023).
18. Marshall, D.; Salamé, L.; Wolf, A.T. A call for capacity development for improved water diplomacy. In *Water Diplomacy in Action: Contingent Approaches to Managing Complex Water Problems*; Anthem Press: London, UK, 2017; Volume 1, p. 141.
19. Krzymowski, A. Water Diplomacy and Its Strategic Significance for Sustainable Development Goals and Global Security Architecture. *Sustainability* **2021**, *13*, 13898. [CrossRef]
20. Wolf, A.T. Conflict and cooperation along international waterways. *Water Policy* **1998**, *1*, 251–265. [CrossRef]
21. Wolf, A. *Hydropolitical Vulnerability and Resilience along International Waters*; UNEP: Nairobi, Kenya, 2009.
22. Kalbhenn, A.; Bernauer, T. International Water Cooperation and Conflict: A New Event Dataset. Available online: https://ssrn.com/abstract=2176609 (accessed on 15 February 2023).
23. Fanning, L.; Mahon, R.; Baldwin, K.; Douglas, S. *Transboundary Waters Assessment Programme (TWAP) Assessment of Governance Arrangements for the Ocean Volume 1. Transboundary Large Marine Ecosystems*; UNESCO: Paris, France, 2015.
24. Aldrich, J. Correlations genuine and spurious in Pearson and Yule. *Stat. Sci.* **1995**, *10*, 364–376. [CrossRef]
25. Bazrkar, M.H.; Tavakoli-Nabavi, E.; Zamani, N.; Eslamian, S. System dynamic approach to hydro-politics in Hirmand transboundary river basin from sustainability perspective. *Int. J. Hydrol. Sci. Technol.* **2013**, *3*, 378–398. [CrossRef]
26. Shahbazbegian, M.R.; Turton, A.; Mousavi Shafaee, S.M. Hydropolitical Self-Organization theory; system dynamics to analyse hydropolitics of Helmand transboundary river. *Water Policy* **2016**, *18*, 1088–1119. [CrossRef]
27. Forrester, J. Industrial Dynamics. *J. Oper. Res. Soc.* **1961**, *48*, 1037–1041. [CrossRef]
28. Sterman, J. *Instructor's Manual to Accompany Business Dyanmics: Systems Thinking and Modeling for a Complex World*; McGraw-Hill: New York, NY, USA, 2000.
29. Senge, P.M. The Fifth Discipline. *Meas. Bus. Excell.* **1997**, *1*, 46–51. [CrossRef]
30. Mirchi, A.; Madani, K.; Watkins, D.; Ahmad, S. Synthesis of system dynamics tools for holistic conceptualization of water resources problems. *Water Resour. Manag.* **2012**, *26*, 2421–2442. [CrossRef]
31. Nabavi, E.; Daniell, K.A.; Najafi, H. Boundary matters: The potential of system dynamics to support sustainability? *J. Clean. Prod.* **2017**, *140*, 312–323. [CrossRef]
32. Shahbazbegian, M.; Noori, R. Hydropolitical System Archetypes: Feedback Structures, Physical Environments, Unintended Behaviors, and a Diagnostic Checklist. *Hydrology* **2022**, *9*, 207. [CrossRef]
33. Nabavi, E. More-Than-Water, More-Than-Human: A Transdisciplinary Sociology of Water Conflict in Central Iran. Ph.D. Thesis, The Australian National University, Canberra, ACT, Australia, 2017.
34. Forrester, J.W. System dynamics, systems thinking, and soft OR. *Syst. Dyn. Rev.* **1994**, *10*, 245–256. [CrossRef]
35. Wolstenholme, E. Using generic system archetypes to support thinking and modelling. *J. Syst. Dyn. Soc.* **2004**, *20*, 341–356. [CrossRef]
36. Václavík, T.; Lautenbach, S.; Kuemmerle, T.; Seppelt, R. Mapping global land system archetypes. *Glob. Environ. Chang.* **2013**, *23*, 1637–1647. [CrossRef]
37. BenDor, T.K.; Kaza, N. A theory of spatial system archetypes. *Syst. Dyn. Rev.* **2012**, *28*, 109–130. [CrossRef]
38. Guo, B.H.; Yiu, T.W.; González, V.A. Identifying behaviour patterns of construction safety using system archetypes. *Accid. Anal. Prev.* **2015**, *80*, 125–141. [CrossRef]
39. Bach, M.P.; Zoroja, J.; Merkac-Skok, M. Social responsibility in tourism: System archetypes approach. *Kybernetes* **2014**, *43*, 587–600. [CrossRef]
40. Banson, K.E.; Nguyen, N.C.; Bosch, O.J. Using system archetypes to identify drivers and barriers for sustainable agriculture in Africa: A case study in Ghana. *Syst. Res. Behav. Sci.* **2016**, *33*, 79–99. [CrossRef]
41. Špicar, R. System dynamics archetypes in capacity planning. *Procedia Eng.* **2014**, *69*, 1350–1355. [CrossRef]
42. Gillies, A.; Maliapen, M. Using healthcare system archetypes to help hospitals become learning organisations. *J. Model. Manag.* **2008**, *3*, 82–99. [CrossRef]
43. Brzezina, N.; Biely, K.; Helfgott, A.; Kopainsky, B.; Vervoort, J.; Mathijs, E. Development of organic farming in Europe at the crossroads: Looking for the way forward through system archetypes lenses. *Sustainability* **2017**, *9*, 821. [CrossRef]
44. Hartel, T.; Fagerholm, N.; Torralba, M.; Balázsi, Á.; Plieninger, T. Social-ecological system archetypes for European rangelands. *Rangel. Ecol. Manag.* **2018**, *71*, 536–544. [CrossRef]
45. Kwon, T.-H. Building a Market Share Model of Alternative Fuel Vehicles: From Generic System Archetypes to System Dynamics Modeling. *Korean Syst. Dyn. Rev.* **2008**, *9*, 27–43.
46. Shahbazbegian, M.; Bagheri, A. Rethinking assessment of drought impacts: A systemic approach towards sustainability. *Sustain. Sci.* **2010**, *5*, 223–236. [CrossRef]

47. Mirchi, A.; Watkins, D.; Madani, K. Water resources system archetypes: Towards a holistic understanding of persistent water resources problems. In Proceedings of the AGU Fall Meeting Abstracts, San Francisco, CA, USA, 5–9 December 2011; pp. H11F–1142.
48. Grigg, N.S. Problem archetypes as common ground for water resources management education. *Water Resour. Manag.* **2015**, *29*, 3535–3550. [CrossRef]
49. Zare, F.; Bagheri, A.; Elsawah, S. Using system archetypes for problem framing and a qualitative analysis: A case study in Iranian water resource management. In Proceedings of the 22nd International Congress on Modeling and Simulation (MODSIM), Hobart, Tasmania, 3–8 December 2017; Volume 3–8, pp. 1433–1439.
50. Bahaddin, B.; Mirchi, A.; Watkins, D., Jr.; Ahmad, S.; Rich, E.; Madani, K. System archetypes in water resource management. In *World Environmental and Water Resources Congress 2018: Watershed Management, Irrigation and Drainage, and Water Resources Planning and Management*; American Society of Civil Engineers: Reston, VA, USA, 2018; pp. 130–140.
51. Bahri, M. Analysis of the water, energy, food and land nexus using the system archetypes: A case study in the Jatiluhur reservoir, West Java, Indonesia. *Sci. Total Environ.* **2020**, *716*, 137025. [CrossRef]
52. Winz, I.; Brierley, G.; Trowsdale, S. The use of system dynamics simulation in water resources management. *Water Resour. Manag.* **2009**, *23*, 1301–1323. [CrossRef]
53. Braun, W. The System Archetypes. 2002. Available online: http://www.albany.edu/faculty/gpr/PAD724/724WebArticles/sys_archetypes.pdf (accessed on 10 June 2020).
54. Kut, G. Burning waters: The hydropolitics of the Euphrates and Tigris. *New Perspect. Turk.* **1993**, *9*, 1–17. [CrossRef]
55. Belül, M.L. *Hydropolitics of the Euphrates-Tigris Basin*; Middle East Technical University: Ankara, Türkiye, 1996.
56. Scheumann, W. The euphrates issue in turkish-syrian relations. In *Security and Environment in the Mediterranean: Conceptualising Security and Environmental Conflicts*; Springer: Berlin/Heidelberg, Germany, 2003; pp. 745–760.
57. Warner, J. Contested hydrohegemony: Hydraulic control and security in Turkey. *Water Altern.* **2008**, *1*, 271–288.
58. Akbulut, B.; Adaman, F.; Arsel, M. Troubled waters of hegemony: Consent and contestation in Turkey's hydropower landscapes 1. In *Water, Technology and the Nation-State*; Routledge: England, UK, 2018; pp. 96–114.
59. Firat, M.K. An Approach to the Reasons and Factors Behind Hydro-Hegemony; The Turkish Stance Vis-à-vis Syria in the Euphrates Basin between 1970–2000. 2021. Available online: http://lup.lub.lu.se/student-papers/record/9037482 (accessed on 15 February 2023).
60. Unver, I.O. South-eastern Anatolia integrated development project (GAP), Turkey: An overview of issues of sustainability. *Int. J. Water Resour. Dev.* **1997**, *13*, 187–208. [CrossRef]
61. Haghighi, A.T.; Sadegh, M.; Bhattacharjee, J.; Sönmez, M.E.; Noury, M.; Yilmaz, N.; Noori, R.; Kløve, B. The impact of river regulation in the Tigris and Euphrates on the Arvandroud Estuary. *Prog. Phys. Geogr. Earth Environ.* **2020**, *44*, 948–970. [CrossRef]
62. Conker, A. Understanding Turkish water nationalism and its role in the historical hydraulic development of Turkey. *Natl. Pap.* **2018**, *46*, 877–891. [CrossRef]
63. Conker, A.; Hussein, H. Hydraulic mission at home, hydraulic mission abroad? Examining Turkey's regional 'pax-aquarum'and its limits. *Sustainability* **2019**, *11*, 228. [CrossRef]
64. Bagheri, A.; Hjorth, P. Planning for sustainable development: A paradigm shift towards a process-based approach. *Sustain. Dev.* **2007**, *15*, 83–96. [CrossRef]
65. Rehan, R.; Knight, M.A.; Haas, C.T.; Unger, A.J. Application of system dynamics for developing financially self-sustaining management policies for water and wastewater systems. *Water Res.* **2011**, *45*, 4737–4750. [CrossRef] [PubMed]
66. Kotir, J.H.; Brown, G.; Marshall, N.; Johnstone, R. Systemic feedback modelling for sustainable water resources management and agricultural development: An application of participatory modelling approach in the Volta River Basin. *Environ. Model. Softw.* **2017**, *88*, 106–118. [CrossRef]
67. Barhagh, S.E.; Zarghami, M.; Ghale, Y.A.G.; Shahbazbegian, M.R. System dynamics to assess the effectiveness of restoration scenarios for the Urmia Lake: A prey-predator approach for the human-environment uncertain interactions. *J. Hydrol.* **2021**, *593*, 125891. [CrossRef]
68. Shahbazbegian, M. Morphology of transition pathway matters: System dynamics to assess alternative livelihood policy towards groundwater sustainability. *Groundw. Sustain. Dev.* **2023**, *21*, 100928. [CrossRef]
69. Kibaroglu, A. State-of-the-art review of transboundary water governance in the Euphrates–Tigris river basin. *Int. J. Water Resour. Dev.* **2019**, *35*, 4–29. [CrossRef]
70. Zeitoun, M.; Warner, J. Hydro-hegemony–a framework for analysis of trans-boundary water conflicts. *Water Policy* **2006**, *8*, 435–460. [CrossRef]
71. Kuruk, P. Customary Water Laws and Practices: Nigeria. This Paper Was Commissioned by the International Union for the Conservation of Nature (IUCN) under a Joint FAO/IUCN Research Project Investigating the Interface of Customary and Statutory Water Rights. 2004. Available online: https://www.fao.org/fileadmin/templates/legal/docs/CaseStudy_Nigeria.pdf (accessed on 15 February 2023).
72. Bates, R. The road to the well: An evaluation of the customary right to water. *Rev. Eur. Community Int. Environ. Law* **2010**, *19*, 282–293. [CrossRef]
73. Ndeunyema, N. Unmuddying the waters: Evaluating the legal basis of the human right to water under treaty law, customary international law, and the general principles of law. *Mich. J. Int. Law* **2020**, *41*, 455. [CrossRef]

74. Hughes, B.B. The international futures (IFs) modeling project. *Simul. Gaming* **1999**, *30*, 304–326. [CrossRef]
75. Hughes, B.B. International Futures (IFs) model. In *Integrated Global Models of Sustainable Development*; Eolss Publishers Co.: Abu Dhabi, United Arab Emirates, 2009; Volume I, p. 151.
76. Molle, F.; Mollinga, P.P.; Wester, P. Hydraulic bureaucracies and the hydraulic mission: Flows of water, flows of power. *Water Altern.* **2009**, *2*, 328–349.
77. Yaseen, Z.M.; Sulaiman, S.O.; Sharif, A. The Nature of Tigris–Euphrates Rivers Flow: Current Status and Future Prospective. In *Tigris and Euphrates Rivers: Their Environment from Headwaters to Mouth*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 229–242.
78. Hussein, H.; Conker, A.; Grandi, M. Small is beautiful but not trendy: Understanding the allure of big hydraulic works in the Euphrates-Tigris and Nile waterscapes. *Mediterr. Politics* **2022**, *27*, 297–320. [CrossRef]
79. Gerrits, L.; Marks, P.K.; Pagliarin, S.; Rauws, W. Strategic archetypes of planning processes: Model and evidence. *Environ. Plan. B Urban Anal. City Sci.* **2022**, *49*, 2516–2530. [CrossRef]
80. Kaya, I. The Euphrates-Tigris basin: An overview and opportunities for cooperation under international law. *Arid. Lands Newsl.* **1998**, *44*.
81. Altinbilek, D. Development and management of the Euphrates–Tigris basin. *Int. J. Water Resour. Dev.* **2004**, *20*, 15–33. [CrossRef]
82. Yetim, M. *Negotiating International Water Rights: Natural Resource Conflict in Turkey, Syria and Iraq*; Bloomsbury Publishing: London, UK, 2016.
83. Navari, A. Utilization of Ilisu Dam in Turkey and the Rules of International Water Law. *Public Law Researsh* **2019**, *21*, 163–190.
84. Kibaroglu, A.; Unver, I.O. An institutional framework for facilitating cooperation in the Euphrates-Tigris river basin. *Int. Negot.* **2000**, *5*, 311–330. [CrossRef]
85. Kibaroglu, A.; Gürsoy, S.I. Water–energy–food nexus in a transboundary context: The Euphrates–Tigris river basin as a case study. *Water Int.* **2015**, *40*, 824–838. [CrossRef]
86. Kibaroglu, A. *Building a Regime for the Waters of the Euphrates-Tigris River Basin*; Brill: Leiden, The Netherlands, 2021.
87. Christensen, C.; Raynor, M. *The Innovator's Solution: Creating and Sustaining Successful Growth*; Harvard Business Review Press: Brighton, MA, USA, 2013.
88. Tàbara, J.D.; Ilhan, A. Culture as trigger for sustainability transition in the water domain: The case of the Spanish water policy and the Ebro river basin. *Reg. Environ. Chang.* **2008**, *8*, 59–71. [CrossRef]
89. Islam, M.R.; Khan, N.A.; Reza, M.M.; Rahman, M.M. Vulnerabilities of river erosion–affected coastal communities in Bangladesh: A menu of alternative livelihood options. *Glob. Soc. Welf.* **2020**, *7*, 353–366. [CrossRef]
90. Basheer, M.; Nechifor, V.; Calzadilla, A.; Siddig, K.; Etichia, M.; Whittington, D.; Hulme, D.; Harou, J.J. Collaborative management of the Grand Ethiopian Renaissance Dam increases economic benefits and resilience. *Nat. Commun.* **2021**, *12*, 5622. [CrossRef]
91. Kendie, D. Egypt and the hydro-politics of the Blue Nile River. *Northeast. Afr. Stud.* **1999**, *6*, 141–169. [CrossRef]
92. Pascual-Ferrer, J.; Pérez-Foguet, A.; Codony, J.; Raventós, E.; Candela, L. Assessment of water resources management in the Ethiopian Central Rift Valley: Environmental conservation and poverty reduction. *Int. J. Water Resour. Dev.* **2014**, *30*, 572–587. [CrossRef]
93. Swain, A. The Nile River Basin Initiative. *SAIS Rev.* **2002**, *22*, 293–308. [CrossRef]
94. Basheer, M. Cooperative operation of the Grand Ethiopian Renaissance Dam reduces Nile riverine floods. *River Res. Appl.* **2021**, *37*, 805–814. [CrossRef]
95. Obengo, J.O. Hydropolitics of the Nile: The case of Ethiopia and Egypt. *Afr. Secur. Rev.* **2016**, *25*, 95–103. [CrossRef]
96. Yihdego, Y.; Khalil, A.; Salem, H.S. Nile River's basin dispute: Perspectives of the Grand Ethiopian Renaissance Dam (GERD). Glob. *J. Hum. Soc. Sci.* **2017**, *17*, 1–21.
97. Tekuya, M. The Egyptian hydro-hegemony in the Nile basin: The quest for changing the status quo. *J. Water Law* **2020**, *26*, 2.
98. Tadese, M.; Kumar, L.; Koech, R.; Kogo, B.K. Mapping of land-use/land-cover changes and its dynamics in Awash River Basin using remote sensing and GIS. *Remote Sens. Appl. Soc. Environ.* **2020**, *19*, 100352. [CrossRef]
99. Lawson, F.H. Egypt versus Ethiopia: The conflict over the Nile Metastasizes. *Int. Spect.* **2017**, *52*, 129–144. [CrossRef]
100. Atwan, M.N. Egyptian-Ethiopian Water Relations: A Benefit Sharing Perspective. 2018. Available online: https://fount.aucegypt.edu/cgi/viewcontent.cgi?article=1471&context=etds (accessed on 15 February 2023).
101. Kehl, J.R. Hydropolitical complexes and asymmetrical power: Conflict, cooperation, and governance of international river systems. *J. World-Syst. Res.* **2011**, *17*, 218–235. [CrossRef]
102. Homer-Dixon, T.F. Environmental scarcities and violent conflict: Evidence from cases. *Int. Secur.* **1994**, *19*, 5–40. [CrossRef]
103. Verhoeven, H. The mirage of supply-side development: The hydraulic mission and the politics of agriculture and water in the Nile Basin. In *Oxford Research Encyclopedia of Environmental Science*; Oxford University Press: Oxford, UK, 2019.
104. Melesse, A.M.; Abtew, W.; Setegn, S.G. *Nile River Basin: Ecohydrological Challenges, Climate Change and Hydropolitics*; Springer: Berlin/Heidelberg, Germany, 2014.
105. Hensengerth, O.; Dombrowsky, I.; Scheumann, W. *Benefit-Sharing in Dam Projects on Shared Rivers*; Discussion Paper; Springer: Berlin/Heidelberg, Germany, 2012.
106. Muluye, G.Y. Benefit-Sharing Framework in the Nile River Basin. In *Nile and Grand Ethiopian Renaissance Dam: Past, Present and Future*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 143–150.
107. Wheeler, K.G.; Hall, J.W.; Abdo, G.M.; Dadson, S.J.; Kasprzyk, J.R.; Smith, R.; Zagona, E.A. Exploring cooperative transboundary river management strategies for the Eastern Nile Basin. *Water Resour. Res.* **2018**, *54*, 9224–9254. [CrossRef] [PubMed]

108. Wheeler, K.G.; Jeuland, M.; Hall, J.W.; Zagona, E.; Whittington, D. Understanding and managing new risks on the Nile with the Grand Ethiopian Renaissance Dam. *Nat. Commun.* **2020**, *11*, 5222. [CrossRef]
109. Sadoff, C.W.; Grey, D. Beyond the river: The benefits of cooperation on international rivers. *Water Policy* **2002**, *4*, 389–403. [CrossRef]
110. Grey, D.; Sadoff, C.; Connors, G. Effective cooperation on transboundary waters: A practical perspective. *Misc. Knowl. Notes* **2009**, *25*, 15–20.
111. Tawfik, R. The Grand Ethiopian Renaissance Dam: A benefit-sharing project in the Eastern Nile? *Water Int.* **2016**, *41*, 574–592. [CrossRef]
112. Tawfik, R.; Dombrowsky, I. GERD and hydropolitics in the Eastern Nile: From water-sharing to benefit-sharing? In *The Grand Ethiopian Renaissance Dam and the Nile Basin*; Routledge: England, UK, 2017; pp. 113–137.
113. Hussein, H.; Grandi, M. Dynamic political contexts and power asymmetries: The cases of the Blue Nile and the Yarmouk Rivers. *Int. Environ. Agreem. Politics Law Econ.* **2017**, *17*, 795–814. [CrossRef]
114. Kim, D.H.; Lannon-Kim, C. Toolbox A Pocket Guide to Using the Archetypes. *Syst. Think.* **1994**, *5*.
115. Masundire, H. The effects of Kariba Dam and its management on the people and ecology on the Zambezi River. In *Water Management and Wetlands in Sub-Saharan Africa*; IUCN: Gland, Switzerland, 1996; pp. 107–118.
116. Reeve, W.H. Progress and geographical significance of the Kariba Dam. *Geogr. J.* **1960**, *126*, 140–146. [CrossRef]
117. Mikhailov, V.; Kravtsova, V.; Isupova, M. Impact of reservoirs on the hydrological regime and morphology of the lower reaches and delta of the Zambezi River (Mozambique). *Water Resour.* **2015**, *42*, 170–185. [CrossRef]
118. Magadza, C.H. Kariba Reservoir: Experience and lessons learned. *Lakes Reserv. Res. Manag.* **2006**, *11*, 271–286. [CrossRef]
119. Khan, O.; Mwelwa-Mutekenya, E.; Crosato, A.; Zhou, Y. Effects of dam operation on downstream river morphology: The case of the middle Zambezi River. *Water Manag.* **2014**, *167*, 585–600. [CrossRef]
120. Teodoru, C.R.; Nyoni, F.C.; Nyambe, I.; Borges, A.; Bouillon, S. Wetlands influencing river biogeochemistry: The case study of the Zambezi and the Kafue Rivers. In Proceedings of the 2nd International Conference "Water Resources and Wetlands", Tulcea, Romania , 11–13 September 2014; University of Liège: Liège, Belgium, 2014.
121. Tumbare, M.; Tsokodayi, C. Hydro-electric development schemes on the Zambezi River–The Batoka case. In *Management of River Basins and Dams*; CRC Press: Boca Raton, FL, USA, 2021; pp. 113–120.
122. Mukono, S.; Mulendema, B. Activities around Lake Kariba; The impact on the lake and environment. In *Management of River Basins and Dams*; CRC Press: Boca Raton, FL, USA, 2021; pp. 33–36.
123. Zhao, X.; Liu, J.; Yang, H.; Duarte, R.; Tillotson, M.R.; Hubacek, K. Burden shifting of water quantity and quality stress from megacity S hanghai. *Water Resour. Res.* **2016**, *52*, 6916–6927. [CrossRef]
124. Darbourn, K. Impact of the failure of the Kariba dam. *Inst. Risk Manag. South Afr.* **2015**, *18*, 2021. Available online: https://cdn.ymaws.com/www.irmsa.org.za/resource/resmgr/2016_case_studies/kariba_report.pdf (accessed on 15 February 2023).
125. Mashingaidze, T.M. The Kariba Dam: Discursive Displacements and the Politics of Appropriating a Waterscape in Zimbabwe, 1950s-2017. *Limina* **2019**, *25*, 1–15.
126. Serpell, N. *Learning from the Kariba Dam*; The New York Times Magazine: New York, NY, USA, 2020.
127. Latham, B.; Nhamire. Zimbabwe, Mozambique in Power Deal that could Close Kariba Hydro Plant Deal would Result in Harare Getting Discounted Power. Bussiness Day. 2019. Zimbabwe. Available online: https://www.businesslive.co.za/bd/world/africa/2019-07-11-zimbabwe-mozambique-in-power-deal-that-could-close-kariba-hydro-plant/ (accessed on 15 February 2023).
128. Thomas, V.; Warner, J. Hydropolitics in the Harirud/Tejen river basin: Afghanistan as hydro-hegemon? *Water Int.* **2015**, *40*, 593–613. [CrossRef]
129. Kaura, V. India-Afghanistan Relations in the Modi-Ghani Era. *Indian J. Asian Aff.* **2017**, *30*, 29–46.
130. Scheumann, W.; Shamaly, O. *The Turkish-Syrian Friendship Dam on the Orontes River: Benefits for All?* Water Resources Managment in the Lower Asi-Orontes Basin: Issues and Opportunities; German Institute of Development and Sustainability: Bonn, Germany, 2016; pp. 125–139. Available online: https://www.idos-research.de/en/others-publications/article/the-turkish-syrian-friendship-dam-on-the-orontes-river-benefits-for-all/ (accessed on 15 February 2023).
131. Goad, D. Water law be dammed?: How dam construction by non-hegemonic basin states places strain on the customary law of transboundary watercourses. *Am. Univ. Int. Law Rev.* **2019**, *35*, 907.
132. Nagheeby, M.; Piri, M.; Faure, M. The legitimacy of dam development in international watercourses: A case study of the Harirud river basin. *Transnatl. Environ. Law* **2019**, *8*, 247–278. [CrossRef]
133. Wouters, P. International Law–Facilitating Transboundary Water Cooperation. Global Water Partnership, TEC Background Papers. 2013. Available online: https://www.gwp.org/globalassets/global/toolbox/publications/background-papers/17-international-law---facilitating-transboundary-water-cooperation-2013-english.pdf (accessed on 15 February 2023).
134. McCracken, M.; Meyer, C. Monitoring of transboundary water cooperation: Review of Sustainable Development Goal Indicator 6.5.2 methodology. *J. Hydrol.* **2018**, *563*, 1–12. [CrossRef]
135. De Chaisemartin, M. Measuring transboundary water cooperation within the framework of Agenda 2030: A proposal for a revision of SDG Indicator 6.5.2. *Water Int.* **2020**, *45*, 60–78. [CrossRef]
136. Libert, B. The UNECE Water Convention and the development of transboundary cooperation in the Chu-Talas, Kura, Drin and Dniester River basins. *Water Int.* **2015**, *40*, 168–182. [CrossRef]

137. Boehrer, B.; Von Tuempling, W.; Mugisha, A.; Rogemont, C.; Umutoni, A. Reliable reference for the methane concentrations in Lake Kivu at the beginning of industrial exploitation. *Hydrol. Earth Syst. Sci.* **2019**, *23*, 4707–4716. [CrossRef]
138. Yalire, M.; Rusimbuka, B.; Kasereka, M.; Bizimungu, L.; Mutoni, A.; Sakindi, G.; Karume, K. Towards a Volumetric Variation of Lake Kivu Gases by the Nyamulagira and Nyiragongo Volcanoes. *J. Geosci. Environ. Prot.* **2022**, *10*, 1–9. [CrossRef]
139. Fowkes, N.; Mason, D. Modelling the Surface Water Pollution in Lake Kivu. In Proceedings of the Mathematics in Industry Study Group 2019, Adelaide, Australia, 21–25 January 2019; University of the Witwatersrand: Johannesburg, South Africa, 2019; pp. 1–12. Available online: https://www.wits.ac.za/media/wits-university/conferences/misgsa/documents/2019/kivupollution19.pdf (accessed on 15 February 2023).
140. Amisi, M.F.; Mulungula, M.P.; Kisse, K.T.; Muhigirwa, B.C.; Natacha, P.; Lwikitcha, H.B.; Eric, M.R.; Désiré, A.B.; Déo, N.; Migeni, A.Z. Current status and strategic way forward for long-term management of Lake Kivu (East Africa). *J. Great Lakes Res.* **2022**.
141. Olapade, O.J.; Omitoyin, B. Anthropogenic pollution impact on physico-chemical characteristics of Lake Kivu, Rwanda. *Afr. J. Food Agric. Nutr. Dev.* **2012**, *12*, 6517–6536. [CrossRef]
142. Hardin, G. The tragedy of the commons: The population problem has no technical solution; it requires a fundamental extension in morality. *Science* **1968**, *162*, 1243–1248. [CrossRef]
143. Ostrom, E. Tragedy of the commons. *New Palgrave Dict. Econ.* **2008**, *2*, 1–4.
144. Olapade, O.J. Anthropogenic pollution impact on microbial contamination of Lake Kivu, Rwanda. *West Afr. J. Appl. Ecol.* **2012**, *20*, 23–31.
145. Majaliwa, J.; Bashwira, S.; Tenywa, M.; Kansiime, F.; Bagalwa, M.; Karume, K.; Adidja, M.; Adipala, E. An overview of pollution loading into Lake Kivu basin. In Proceedings of the Third RUFORUM Biennial Meeting, Entebbe, Uganda, 24–28 September 2012; pp. 24–28.
146. Chermak, J.M.; Patrick, R.H.; Brookshire, D.S. Economics of transboundary aquifer management. *Groundwater* **2005**, *43*, 731–736. [CrossRef]
147. Linton, J.; Brooks, D.B. Governance of transboundary aquifers: New challenges and new opportunities. *Water Int.* **2011**, *36*, 606–618. [CrossRef]
148. Arvanitidis, P.A.; Nasioka, F.; Dimogianni, S. Water resource management in Larisa: A "Tragedy of the Commons?". In *Sustainable Water Use and Management*; Springer: Cham, Switzerland, 2015; pp. 65–89.
149. Penny, G.; Müller-Itten, M.; de los Cobos, G.; Mullen, C.; Müller, M.F. Trust and transboundary groundwater cooperation. *Authorea Prepr.* **2022**.
150. Malasha, I. *Contested Fishing Grounds: Examining the Possibility of a Transboundary Management Regime in the Lake Kariba Fishery*; Institute for Poverty Land and Agrarian Studies (PLAAS): Cape Town, South Africa, 2005.
151. Whande, W.; Malasha, I.; Njaya, F. Challenges and Prospects for Trans-Boundary Fisheries in Lakes Chiuta and Kariba. 2006. Available online: https://www.africaportal.org/publications/challenges-and-prospects-for-trans-boundary-fisheries-in-lakes-chiuta-and-kariba/(accessed on 15 February 2023).
152. Ochieng, O.E.; Kevin, O.; Mbonge, M.J. Lake Victoria and the Common Property Debate: Is the Tragedy of the Commons a Threat to Its Future? 2013. Available online: https://repository.maseno.ac.ke/handle/123456789/2283 (accessed on 15 February 2023).
153. Gaden, M. Cross-border Great Lakes fishery management: Achieving transboundary governance capacity through a non-binding agreement. *Int. J. Water Gov.* **2016**, *4*, 53–72.
154. Branz, M.; Farrell, A.; Hu, M.; Liem, W.; Ballard, E. *Accumulations*; Social System Design Lab, Washington University: St. Louis, MO, USA, 2021.
155. Rosenfeld, S.N.; Rus, I.; Cukier, M. Modeling the 'Tragedy of the Commons' Archetype in Enterprise Computer Security. *J. Inf. Assur. Secur.* **2009**, *4*, 10–20.
156. Dacko, M. The Issue of Environmental Resources Management in the Light of the Model of Tragedy of the Commons–Systemic Approach. *Probl. Ekorozw. Probl. Sustain. Dev.* **2015**, *10*, 21–30.
157. Rittel, H.W.; Webber, M.M. Dilemmas in a general theory of planning. *Policy Sci.* **1973**, *4*, 155–169. [CrossRef]
158. Checkland, P.; Poulter, J. *Learning for Action: A Short Definitive Account of Soft Systems Methodology, and Its Use for Practitioners, Teachers and Students*; John Wiley & Sons: Hoboken, NJ, USA, 2007.
159. Turton, A.R. Hydropolitics and security complex theory: An African perspective. In Proceedings of the 4th Pan-European International Relations Conference, Canterbury, UK, 8–10 September 2001; pp. 8–10.
160. Piemontese, L.; Neudert, R.; Oberlack, C.; Pedde, S.; Roggero, M.; Buchadas, A.; Martin, D.A.; Orozco, R.; Pellowe, K.; Segnon, A.C. Validity and validation in archetype analysis: Practical assessment framework and guidelines. *Environ. Res. Lett.* **2022**, *17*, 25010. [CrossRef]
161. Zeitoun, M. The relevance of international water law to later-developing upstream states. *Water Int.* **2015**, *40*, 949–968. [CrossRef]
162. Zeitoun, M.; Mirumachi, N.; Warner, J.; Kirkegaard, M.; Cascão, A. Analysis for water conflict transformation. *Water Int.* **2020**, *45*, 365–384. [CrossRef]