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Water Environment Policy and Climate Change: A Comparative Study of India and South Korea

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Abstract: Climate change is considered to be a potential cause of global warming, which leads to a continuous rise in the global atmospheric temperature. This rising temperature also alters precipitation conditions and patterns, thereby causing frequent occurrences of extreme calamity, particularly droughts and floods. Much evidence has been documented by the Intergovernmental Panel on Climate Change, illustrating fluctuations in precipitation patterns caused by global climate change. Recent studies have also highlighted the adverse impact of climate change on river flow, groundwater recovery, and flora and fauna. The theoretical political approach and scientific progress have generated ample opportunities to employ previously allusive methods against impacts caused by varying climatic parameters. In this study, the current state of India's water environment policy is compared with that of South Korea. The "3Is"—ideas, institutions, and interests—which are considered pillars in the international field of political science, are used as variables. The concept of "ideas" highlights the degree of awareness regarding climate change while formulating water environment policy. Here, the awareness of India's management regarding emerging water issues related to climate change are discussed and compared with that of South Korea. The concept of "institutions" illustrates the key differences in water environment policy under the umbrella of climate change between both countries within the associated national administrations. India's administrations, such as the Ministry of Environment, Forests, and Climate Change; the Ministry of Water Resources, River Development, and Ganga Rejuvenation; the Ministry of Rural Development; and the Ministry of Housing and Urban Affairs, are used as a case study in this work. Finally, the concept of "interest" elaborates the prioritization of key issues in the respective water environment policies. Common interests and voids in the policies of both countries are also briefly discussed. A comparison of India's water environment policies with that of South Korea is made to expose the gaps in India's policies with respect to climate change, thereby seeking to identify a solution and the optimal direction for the future of the water environment policy of India.

Keywords: climate change; sustainability; environment; water policy; India; South Korea; precipitation

1. Introduction

The Sustainable Development Goals (SDGs) were consensually adopted in September 2015 by the United Nation member states during the 2030 Agenda for Sustainable Development. These SDGs are

considered to be a blueprint to achieve a sustainable future for our planet after the expiration of the Millennium Development Goals in 2015. There is a total of 17 SDGs, which must be accomplished by the international community within 15 years, i.e., between 2016 and 2030. The SDGs are treated as "integrated and unified", thereby endorsing distinctive priorities and potentials for countries regarding the fulfillment of these goals. These distinctive characteristics of the SDGs are considered to be axiomatic and corroborate assessments of 'policy congruity', establishing a foundation for consideration of where incongruity would be most valuable [1]. Among all the SDGs, four goals deal specifically with water-related issues: Goal 6 ensures the availability of clean water and improved sanitation; Goal 13 deals with climate change; Goal 14 preserves and sustains the use of water resources; and Goal 15 protects and restores biodiversity on land [2,3]. This signifies the importance of water management and highlights the urgent need for the rectification of all possible water-related issues to achieve a sustainable future.

Climate change refers to a statistical shift of climatic variables at a regional or global level over considerable periods. Over millennia, climatic variables, including global mean temperature were relatively stable, but in the last few decades, catastrophic changes have been observed [4]. According to the European Environmental Agency, an approximately 2.7% reduction per decade with respect to ice in the Arctic Sea, an expansion of the global sea level by 1.8 mm per year since 1961, and a rise in the global mean temperature by 0.74 °C have been witnessed in the 20th century [5]. Moreover, the Intergovernmental Panel on Climate Change (IPCC) has also predicted severe floods and droughts in the 21st century due to a calamitous rise in the global mean temperature from 1.5 to 5.8 °C [6]. The IPCC has also provided evidence illustrating a significant shift in global precipitation patterns within the period from 1900 to 2005. Many regions of Central Asia and Europe, the eastern and southern parts of South America, and areas of North America have witnessed a considerable rise in precipitation levels, whereas South Asia, Southern Africa, and the Mediterranean face reduced precipitation [7,8]. Recent studies have also pointed out that climate change-derived changes in precipitation patterns are having adverse impacts on the water environment, such as river flow and the recovery rate of groundwater [9,10], and inimical alterations in the ecosystem [11].

India is the seventh largest country in the world, encompassing a population of around 1.2 billion in 29 states and seven union territories. Due to its large area, India demonstrates variable precipitation patterns depending on the geographical region. India's monsoon season precipitation is mainly concentrated in July, but since 2000, a significant shift towards August rainfall has been observed. For example, in the states of Jharkhand and Karnataka, the average August rainfall has increased by approximately 50.1% and 20.5%, respectively from 2000 to 2014, while in the same period, the states of Punjab and Uttar Pradesh have witnessed a reduction in average August rainfall by 27.3% and 13.3%, respectively, as shown in Figure 1a,b [12]. Moreover, the states of Punjab and Uttar Pradesh are facing a continuous reduction in average rainfall in both July and August by a considerable margin, as shown in Figure 1c,d [12]. The monthly rainfall (mm) of the major states of India for July and August from 2000 to 2014 are illustrated in Figure S1. Evidence shows that the consequences of climate change will continue in the future [9,13]. Therefore, frequent modifications and possible changes in water environment policies with regular monitoring for any change in the water environment due to climatic variables are necessary for the accomplishment of the water-related SDGs.

India is a fortunate country, having 20 river basins; however, most of them are water stressed owing to the high water demand for agriculture, domestic, and industrial purposes. The uneven distribution of water demand across the country, the growing population, and climate change further intensify the already stressed resources and thereby complicate water environment management. With all these water environment-related issues, India's water management appears to be fragile and requires some urgent modifications and revisions to its water policies [14]. To establish and improve the comprehensive management of the water regulation system and water policies, rectification of urban and rural water environment issues holds utmost importance. As a developing country, India is in a state of transition; thus, its potential market economy, organized economic process, and statutory

system are comparatively fragile. Therefore, it is paramount that the Indian government focuses significant attention and funding on water environmental policy. It is well accepted that bolstering the interface between public participation, policy, and science and technology is critical for effective and reliable water resource management. However, in India, there seems to be a big communication gap between policymakers and scientists. To the best of our knowledge, no researcher has pointed out this critical blind spot. In last few decades, South Korea has been able to rectify most of its water environment-related issues owing to its skillfully planned strategies and policies and nearly perfect implementations of such approaches [14]. Hence, a comparative study between India's and South Korea's environment policies is useful to identify previously unidentified solutions for the development of India's policies. The results of this study can also indirectly serve other underdeveloped and developing countries around the world by fostering more awareness and identifying executable strategies. Therefore, the present study aims to highlight the gaps in India's water policies and the potential causes for the differences in the water environment policies between India and South Korea through qualitative analysis of scientific facts particularly using the 3Is—which represent ideas, institutions, and interests—as variables. The findings of this study can also set an example for other countries regarding the significance of water environment policies related to climate change.

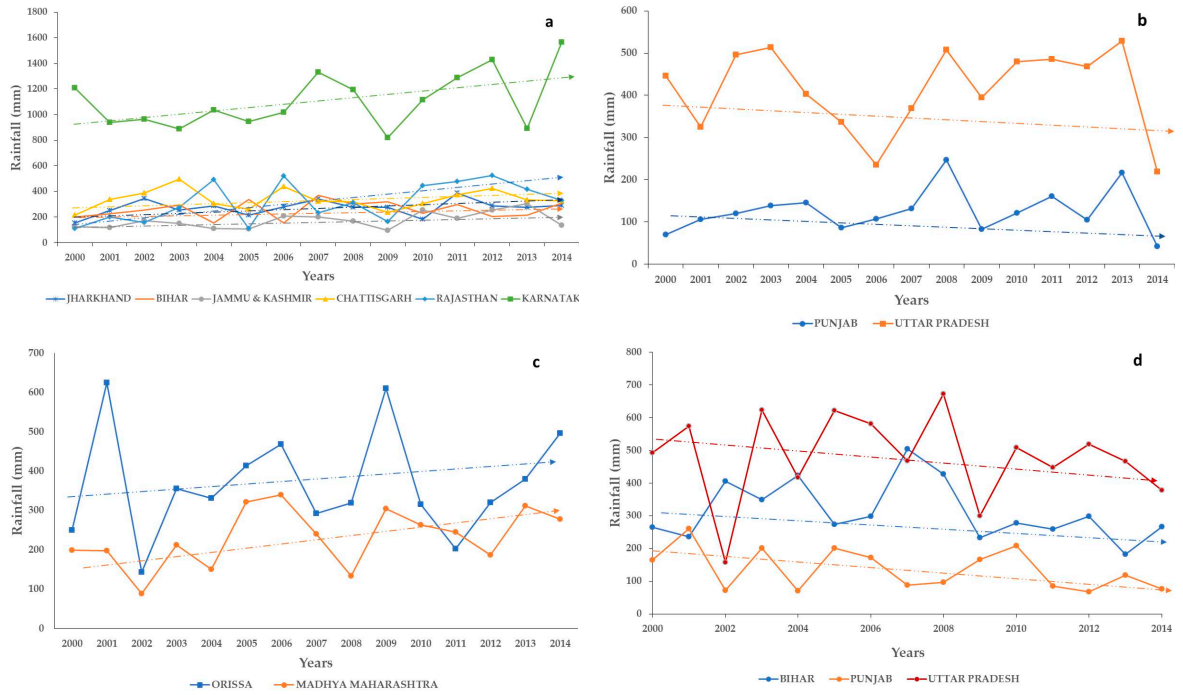

Figure 1. Rainfall patterns (mm) illustrating shifts in the amount of rainfall occurring between 2000 and 2014 in (**a**,**b**) August, (**c**,**d**) July [12].

2. Methodology

Theoretical political approaches and advancing scientific technology have generated ample opportunities for the employment of distinctive methods against climatic concerns. One of the most significant contributions of distinctive political strategies is to provide a broader understanding of analytical aspects and to highlight the validity of findings wherever required.

In the present study, the recent state of India's water environment policy was compared with that of South Korea [15]. Literature searches were conducted using PubMed, PLOS, Nature.com, ScienceDirect, MDPI, and published government reports, such as those by the IPCC and United Nations and individual ministry reports. The primary focus was to highlight the gaps in the water environment policies of India with scientific facts from peer-reviewed papers and government reports from 2000 to the present. Keywords, such as climate change, precipitation, water, policy, environment, India, and South Korea,

were used separately and in combination to obtain relevant information. Recent government reports (since year 2000) were searched to analyze recent progress and the present situation. The obtained data were categorized according to the three variables—the 3Is, idea, institutions, and interest. The first variable, idea, highlights the degree of awareness regarding climate change, while formulating water environment policy. The awareness of India's management regarding emerging water issues relating to climate change were analyzed and compared with that of South Korea. The institutions variable illustrates the major differences in water environment policies under the umbrella of climate change between India and South Korea within the associated national administrations. India's administrations, such as the Ministry of Environment, Forests, and Climate Change; the Ministry of Water Resources, River Development, and Ganga Rejuvenation; the Ministry of Rural Development; and the Ministry of Housing and Urban Affairs, were considered in a case study. The third and last variable, interests, elaborates the prioritization of key issues associated with water environment policy. Common gaps in the policy of both countries were also analyzed.

3. Results and Discussion

3.1. India's Water Environment Status under the Umbrella of Climate Change

3.1.1. Ideas

By 1980s, it was well understood that water is a crucial national resource, and a shortfall in national water policy can be a severe impediment for the formulation of rational water policies. This led to the emergence of India's first National Water Policy in 1987, which was further reformed in 2002 [16]. Since then, the core motive of policymakers has been to improve institutional frameworks through improved institutional performance, encouragement of rehabilitation schemes for the displaced, ensuring effective monitoring systems, the embodiment of private parties in water management, and ensuring the sustainable use of joint rivers by states. However, state water policies are often supplementing to the national policy. The introduction of water rights was another major step towards the effective management of water issues [17]. Those rights are considered to be a necessary premise for the encouragement of the 'management' of water resources, organizing water user associations, and induction of trading. Moreover, the idea of 'incentives' for the sustainable use of water was also encouraged. This can increase the involvement of private sectors in water control and utilization, thereby improving the planning, management, and development of the administering authority of water resources projects [17].

Recently, the government has initiated a mammoth project called the 'National River-Linking Project', which aims to link rivers throughout the country. The rationale behind this project is the fact that some states in India are suffering from water shortages while others have excess [18]. Through this project, excess water in the form of floods caused by heavy rains can be transferred to water-deficient basins, which can indirectly serve as stores and means of capturing those excess rain waters. The desirable distribution of water, the promotion of economic activities in water-deficient areas, and drought and flood protection are some of the arguments in favor of the River-Linking Project [19]. However, arguments against this project include the huge expenditure, soil contamination through salination and seepage, and the absence of surplus water for most of the year [20,21]. Furthermore, apart from the criticisms against big dams, activists within India claim that there are various ecological, economic, and social shortcomings inherent to the project [21]. Hence, clear and properly defined criterion should be met to justify such schemes.

3.1.2. Institutions

Currently, a total of 40 ministries are functioning under the government of India. Among them, four ministries manage all distinctive parts of the water environment: the Ministry of Environment, Forest, and Climate Change (MoEFCC); the Ministry of Water Resources, River Development, and Ganga

Rejuvenation; the Ministry of Rural Development; and the Ministry of Housing and Urban Affairs. More specifically, the water quality, quantity, and other environment-related anthropogenic aftermath (e.g., coastal areas and river cleaning, and municipal sewage) and natural calamities (e.g., flood, drought, tsunami, heavy precipitation, and earthquake) are managed by the government of India. The MoEFCC is the nodal administrative organization responsible for the designing, promotion, coordination, and monitoring of the implementation and execution of environment-related policies and programs in India. Its total budget in 2018–2019 was US $370 million, of which US $110 million was allocated to the water environment, including protection and sustainable development projects, while US $5.7 million was distributed for managing the climate change action plan [22]. The Ministry of Water Resources, River Development, and Ganga Rejuvenation is the central administrative agency responsible for the sustainable development of water resources through the regulation of the country's water resources-related policy guidelines and programs. The total budget of this ministry in 2018–2019 was US $1.28 billion, which was used mainly in the irrigation sector, flood control management, and river conservation projects [23]. The distribution of the total budgets allocated to the Ministry of Environment, Forest, and Climate Change; the Ministry of Water Resources, River Development, and Ganga Rejuvenation; the Ministry of Rural Development; and the Ministry of Housing and Urban Affairs in 2018–2019 are depicted in Table S1. The Ministry of Rural Development and the Ministry of Housing and Urban Affairs hold a small portion of the budget regarding the water environment in the form of water supply management under a scheme called 'Pradhan Mantri Awas Yojna' (PMAY) in rural and urban regions, respectively. This scheme under the Ministry of Rural Development provides US $3.03 billion, which accounts for 18.60% of the total budget of this ministry in 2018–2019, while the Ministry of Housing and Urban Affairs is allocated US $44.67 million, a mere 0.75% of the total budget on water environment issues [24,25]. The budget for the Ministry of Water Resources, River Development, and Ganga Rejuvenation was almost thrice that of the Ministry of Environment, Forest, and Climate Change for 2018–2019, thereby managing all major water environment projects, such as irrigation, dam projects, and river conservation projects. Focusing particularly on the budget of water-related projects, the Ministry of Environment, Forest, and Climate Change is attempting to maximize their management, manpower, and budget through water resources-related projects, which currently account for 29.73% of the total budget, thereby contending with the jurisdiction budget [22]. The Ministry of Water Resources, River Development, and Ganga Rejuvenation allocates almost all of its budget to water resources-related projects, thus securing hegemony in water environment business, although other environmental issues are mostly managed by the Ministry of Environment, Forest, and Climate Change.

Such conflicts are generally common in large, territorial, democratic countries, which leads to duplicate, similar, or overlapping project and policy objectives, thereby causing wastage of the budget [15]. This further encourages the emergence of competition for the quantitative results that these ministries are expected to display. Moreover, enforcement of different policies by ministries for similar issues exposes the inconsistency in the policy objectives and applications. For example, 'Pradhan Mantri Awas Yojna' (PMAY) and 'National Livelihood Mission–Ajeevika' are the schemes underlying both the Ministry of Rural Development and the Ministry of Housing and Urban Affairs. Separate funds are allocated to these schemes under both ministries (refer to Table S1). Therefore, there is an urgent need for the integration of policies wherever required. These should be designed with extreme clarity along with accurate future predictions and should also include possible solutions for all similar water environment issues. Proper division and simplification of water management projects among ministries are highly desirable. Although individual projects by ministries may prosper, a high likelihood of failure always beleaguers the overall management.

3.1.3. Interests

India is known to be composed of agricultural land, and hence, irrigation and river projects are sanctioned and implemented on a priority basis. In 2015, the government of India created an umbrella

program called "Namami Gange". The allocated budget of this program was US $2.86 billion for 2015–2020 with the aim of cleaning India's biggest river 'Ganga' and its tributaries. In mid-2017, the Ministry of Water Resources, River Development, and Ganga Rejuvenation reported that from all 163 projects sanctioned under Namami Gange, which deals with the rejuvenation of the >1500-miles-long Ganga river, 41 projects have been completed. A sewage capacity of 223.13 MLD and 1339 km of sewer network was reported as an accomplishment of those completed projects [26]. However, a project such as the 'National River-Linking Project' often encounters more complications and is critical to successfully implement, as research shows many possible catastrophic post-effects. Studies provide evidence for a significant reduction in inflow and sediment deposits in the northern rivers [27,28]. For example, the Ganga can witness a 24% flow reduction, while its tributaries such as Gandak and Ghaghara can face a reduction in flow by 68% and 55%, respectively. A minor loss of 6% can be observed in the Brahmaputra, another major river in northern India, while its tributaries, such as Manas, Sankosh, and Raidhak, can face a massive flow reduction of 72%, 73%, and 53%, respectively [27]. This not only reveals a critical knowledge gap, but also highlights significant lacking in comprehensive pre-planning and surveys by the Ministry of Water Resources, River Development, and Ganga Rejuvenation.

3.2. South Korea's Water Environment Status under the Umbrella of Climate Change

The influence of climate change in South Korea is similar to the rest of the world. Apart from the rising temperature, South Korea's monsoon season is also concentrated in the month of July. It has been reported that since 1980, South Korea's precipitation pattern, particularly in August, has increased by over 25%, resulting in frequent localized downpours [15]. With the recognition of the adverse effects of climate change and to mitigate climate change-related water environmental problems, the government of South Korea has modified their following five ministries: the Ministry of Environment (MOE); the Ministry of Land, Infrastructure, and Transport (MOLIT); the Ministry of the Interior and Safety (MOIS); the Ministry of Trade, Industry, and Energy (MOTIE); and the Ministry of Agriculture, Food, and Rural Affairs (MAFRA). They together manage all the water quality, quantity, and natural environment-related calamities, such as flood, storm, drought, heavy rain, and earthquakes. Being a central administrative agency, the Ministry of Environment, with an allocated budget of US $23 billion (in 2015), managed all projects related to water quality improvement in response to climate change [29]. With regard to the water environment, the ministry of Land mostly manages water resources projects, such as the management of rivers and groundwater with an allocated budget (in 2015) of US $2 billion [30]. Of the overall budget of the South Korean government, 1.2% was allocated for all water environment projects in 2015.

Unlike India's management policies, South Korea's management strategy is more precise, accurate, and well implemented. Being a small country compared to India, the allocated budget to the respective ministries is much higher, and there is almost no overlapping of similar projects among ministries. The distribution of respective allocated budgets and the implementation strategies are superior to those of India. South Korea is ahead with respect to their policies, designs, and progress regarding climate change and is almost on the verge of meeting the SDGs. For example, in 2013, the Ministry of Environment asked the Korea Environment Institute to organize a sustainable layout for waterfront regions, which was accomplished by early 2014. As per the plan, the 1-km area surrounding the banks of the rivers, which accounts for a total length of >1300 miles for just five major rivers of South Korea, was considered to be the highest priority transition area and thus required conservation and restoration management. As another example, the Ministry of Environment is putting strenuous effort into enhancing tap water drinking rates. It is trying to achieve this by changing people's vague anxiety towards tap water through various promotional activities and regular water quality tests. Since 2013, the "Tap Water Loving Villages" project has been implemented and is playing a key role in improving the reputation of tap water. A remarkable rise and much progress have been reported in only one year as the number of Tap Water Loving Villages have increased to 50 [29].

In 2017, the Ministry of Environment reported on South Korea's water management progress, which mainly highlights improvements in the quality and sustainable utilization of groundwater and surface water [31]. The government is also focusing on setting stringent guidelines to conserve groundwater ecosystems. The inclusion of groundwater, via the extension of groundwater ecosystem conservation guidelines, in the water environment policy, which is centered on surface water, illustrates that South Korea's management is progressing towards an integrated water environment policy. The integration of water environment policies can be a driving step in achieving water-related Sustainable Development Goals.

4. Common Voids

Slight changes in climate in the form of temperature rise or alteration in evaporation and precipitation can dramatically influence climate-associated hydrological behavior globally [32]. The hyporheic zone, a region where surface water and groundwater interact, is characterized by unique biogeochemical reactions. Recent studies have revealed that these hyporheic zones are very sensitive to climatic parameters, thereby working as a valuable gauge in climate and water environment research [32,33]. Traditionally, surface water and groundwater have been researched independently under hydrology; due to this, a definitive understanding of hyporheic zones is missing. However, the European Commission (EC) and other European studies have been focusing on hyporheic zones in response to climate change in recent years [15,34]. Contrastingly, South Korea and India both manage surface water and groundwater separately; hence, a coherent concept and distinctive management of hyporheic zones are lacking. There is no policy, scheme, or plan for managing these zones in both countries. Even if both countries wish to incorporate these zones into their management strategies, there will be a debate regarding in which sector, i.e., groundwater or surface water, they should be included. For example, if the concept of hyporheic zones is perceived as being more associated with groundwater, then such zones should be managed through the laws concerning groundwater by the Ministry of Water Resources, River Development, and Ganga Rejuvenation in India and by the Ministry of Land in South Korea, respectively. However, if these hyporheic zones are perceived as a hydro-ecological gauge, then such zones should be managed through the laws concerning hydro-ecological conservation and water quality by the Ministry of Environment, Forest, and Climate Change in India and by the Ministry of Environment in South Korea respectively. This ambiguity around the perception of hyporheic zones exposes the inadequacy of the management policies and laws of the managing institutions, placing the management of climate change-related water environment in a blind spot.

5. Concerns in the Formulation of Water Environment Policy

It is evident that each country possesses a unique set of social, environmental, institutional, physical, economic, and legal conditions that influences its water environment policies and strategies. Global monitoring and experience can be beneficial while searching for options, and the solutions to any country's problems must be tailored to its specific needs. The designing and implementation of any national water environment policy or strategy can be an intricate task as it involves numerous factors, such as its hydrological conditions, size, diversity of stakeholders, and political organization of the country. For example, floods may be an important issue in the countries of North America, South America, and Asia, whereas water scarcity is more catastrophic in the Middle East and Africa. While formulating any new policies or modifying existing water environment policies, consideration of the following four points can be critical for respective organizations and their governments. First and foremost is the formulation or shifting towards integrated water environment strategies. This will not only lead to sustainable solutions for present issues, but also will cover a wide variety of unpredictable circumstances related to the water environment. Second, comprehensive pre- and post-surveys are very much required in figuring out the consequences of any water environment policy. Third, increased attention and focus are required in order to avoid any overlapping of schemes, policies, or projects, which not only help economically, but also minimize various disputes among ministries. Lastly,

the implementation of any strategy or policy can be a defining step for any organization. A great policy without proper implementation is worthless.

6. Conclusions

India's water environment policy may have several drawbacks when compared with South Korea's, but it surely consists of some unique idea, which may suit its specific needs. The cluster of shortcomings found in India's water environment policy in the present study can be compiled into three points: i) The concept of integrated water environment policy, which can deal with the whole water environment as an interlinking unit, has not been introduced in Indian water policy. Therefore, the conservative attitude towards traditional bifurcated practices concerning the water environment is anticipated to persist. ii) This ambiguity led to the overlapping of policies and schemes, resulting in hindered implementation and disputes among administrators, which was further deepened by a lack of comprehensive surveys on the water environment regarding climate change. iii) The concept of sustainability is very limited in Indian water environment projects. As opposed to South Korea, India still is not focusing on hyporheic zones and other ecological maintenance, which are critical strategies in response to climate change. Eventually, the Indian government should expand its water management system by including cultural and recreational objectives, prioritizing the need for clean water while perpetuating the ecosystem.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/11/12/3284/s1, Figure S1: Rainfall patterns (mm) of major states of India. (**a**) illustrates shifts in the amount of rainfall occurred between the years 2000–2014 in the month of July; (**b**) in the month of August [12], Table S1: The total budgets allocated to various ministries and their distribution in water management sectors [22–25].

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