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Research Article

Transboundary Water Resources Conflict Analysis Using Graph Model for Conflict Resolution: A Case Study—Harirud River

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One of the most important environmental issues today is the water crisis and the ensuing security challenges. Of these, transboundary waters pose the most significant security challenges. Resolving these conflicts and agreements over transboundary waters has always faced a variety of challenges, making it difficult to reach a mutually agreed solution. One of the transboundary water conflicts that have been exacerbating in recent years is the conflict between Afghanistan, Iran, and Turkmenistan over the use of the Harirud river water resources. The present paper aims to analyze, using the Graph Model for Conflict Resolution (GMCR), a game theory model, the conflict between the three countries regarding the utilization of the water resources of the border river, Harirud. To this purpose, first, the current state of the conflict was investigated. Then, each of the three countries' possible options and preferences was defined according to the past and present state of the conflict as well as the possible states. By defining the permissible movements and priorities of each decision maker, the equilibrium of the conflict was obtained. Next, four scenarios were defined, the equilibria were extracted in each scenario, and the results were interpreted. The implementation of the GMCR model algorithm regarding the Harirud water conflict between the three countries indicated that the current state is the most likely outcome of the conflict as none of the parties involved, given their preferences, and is motivated or able to change their strategy to help the conflict to a more favorable state.

1. Introduction

One of the most critical environmental issues [1] today is the water crisis and the ensuing security challenges [2]. Increasing demand for freshwater as the population grows made water scarcity a national security agenda in many countries [3]. Adopting a neo-Malthusian perspective, which draws a direct link between population growth, natural resources scarcity, and violent conflicts, some scholars such as [4, 5] have predicted violent environmental conflicts or water wars in conflict-prone regions such as the Middle East and Africa [6, 7]. Approximately 47% of the world's area (except for the South Pole) is in transboundary and shared drainage basins. There are 44 countries with at least 80% of their area in transboundary and shared drainage basins. Of these 44, 20 are in Africa, 7 in Asia, 13 in Europe, and 4 in Latin America [8, 9]. Waters flowing in 263 international and transboundary rivers constitute 60% of the global freshwater [10]. There are at least 158 international rivers with potential for regional and international problems and conflicts [11]. Meanwhile, there is no single international water agreement on transboundary rivers because each river is uniquely and intricately related to national and international interests. Water conflicts increase along with water scarcity, and water control will be part of a survival strategy for any country [12].

Some international conflicts over border rivers include those between Nicaragua and Costa Rica over the San Juan River, between the US and Canada over the Skagit River, between the US and Mexico over the Colorado, Tijuana, and Rio Grande rivers, between Guinea and Mali over the Niger River, and between China, Cambodia, and Vietnam over the Mekong River, and the conflict over the Tigris and Euphrates rivers between Syria, Turkey, and Iraq [12, 13]. Much of the conflicts are rooted in a different interpretation of water resources' share and distribution on the border rivers by neighboring countries. Therefore, it can be argued that one of the most important challenges in the twenty-first century is the distribution of international water resources [14]. Hence, some regard water as the oil for the twenty-first century [15]. This claim about water may not be entirely valid, but it is an obvious fact that having access to water will play an essential role in the development of the world economy and government policies in the coming decades [16]. Since conflicts over transboundary waters have a variety of political, economic, social, and environmental aspects and are related to national sovereignty, they involve many complications and are difficult to resolve and will continue to cause many more conflicts in the future. Unfortunately, there are conflicts and disputes, and it has even led to war. One reason is that the neighboring countries are currently supporting the Taliban and trying to win the group in Kabul. Unfortunately, there are many documents and videos of Taliban education and treatment in neighboring countries. So, the water issue in Afghanistan has practically caused conflict.

This issue is not an unexpected one for those countries in arid and semiarid areas, especially in the Middle-East countries. In these countries, surface waters such as shared rivers are expected to cause the most conflicts in the future, so the governments in these countries pay particular attention to the water issue [17].

The Harirud river, originating from Afghanistan, forms the natural border of the three countries Afghanistan, Iran, and Turkmenistan, but also constitutes a shared water source for them. Despite the particular position of the river for the three countries, there is no trilateral treaty or agreement that forms the basis for the Management or designation of a specific water right for each party [2]. Meanwhile, all three countries' preferences and conditions are in a way that makes it complicated to achieve an optimal state in a cooperative situation. Therefore, it is expected that this will increase the conflicts between the three countries over how to utilize and allocate water resources of this shared border river. It seems necessary to analyze the above situation using a comprehensive, stable approach to conduct the necessary analyses to examine the probable agreements based on the present conditions so that all stakeholders are at the highest level of satisfaction. One of these methods is game theory, whose concepts and tools can be used to analyze the conflict in question [18, 19]. GMCR is one of the most commonly used models in game theory used to model and analyze strategic conflicts [20]. Disputes over common transboundary waters are among the most common types of international disputes. Because these disputes have multiple political, economic, social, and environmental aspects and are related to the issue of national sovereignty, they have many complexities and are mostly difficult to resolve. These include the Jordan River conflict between Israel, Jordan, Lebanon and Syria [21], the Nile conflict between Egypt, Sudan and Ethiopia [22], the Tigris and Euphrates rivers between Syria, Turkey and Iraq [13], cited the Ganges River conflict between Bangladesh and India [23].

The ultimate goal of GMCR is to help decision-makers involved in a conflict to find a solution that is acceptable to all parties. Therefore, the present paper uses GMCR and different scenarios in an attempt to analyze the conflict over the utilization of the Harirud river water resources in non-cooperative conditions.

It is worth noting that, due to the reasons as mentioned earlier and its geopolitical and hydro political importance, the Harirud basin has been the subject of numerous papers [2, 14, 22–28], each of which examine and analyze the state of the basin from their perspective. A literature review shows that there is no analysis of the conflict between the three countries over the distribution of Harirud water resources in non-cooperative conditions (the present conditions) using GMCR. Therefore, this paper attempts to analyze the state of the conflict using GMCR.

2. Methodology

The present paper aims to investigate the conflict between the three countries Afghanistan [29], Iran, and Turkmenistan, over the utilization of the shared border river Harirud using GMCR, one of the game's non-cooperative models theory. The first step to implementing the GMCR model algorithm (Figure 1) in the GMCR + decision support system environment was to study the subject's scientific literature. For this purpose, papers, books, related reports, and news and speeches by officials from all three countries were studied. Since the Harirud drainage basin is located between the three countries, the decision-makers will also be these same three countries. Thus, the next stage was identifying the possible options that the three countries could follow to achieve their goals. After that, the total number of the possible states was identified, and decision-makers' transfers between the permissible states were also determined. Each country's preferences for the options they could make were determined by studying the past and present utilization state and considering the future state of the nations. Then, the stable conditions were identified and analyzed for all three countries. Next, the equilibria of the Harirud river conflict were obtained using the four solutions concepts Nash stability (R), symmetric meta-rationality (SMR), general meta-rationality (GMR), and sequential stability (SEQ) in the GMCR. Finally, the probable scenarios were defined, the sensitivity analysis was carried out to identify the equilibria in different scenarios, and the results were interpreted. We must remember that, in the graph model, hypotheses are based on historical records and documents in the Ministries of Foreign Affairs and the Ministries of Energy and Water and also based on study of the reaction of officials of countries and authors' predictions of possible events are prepared.

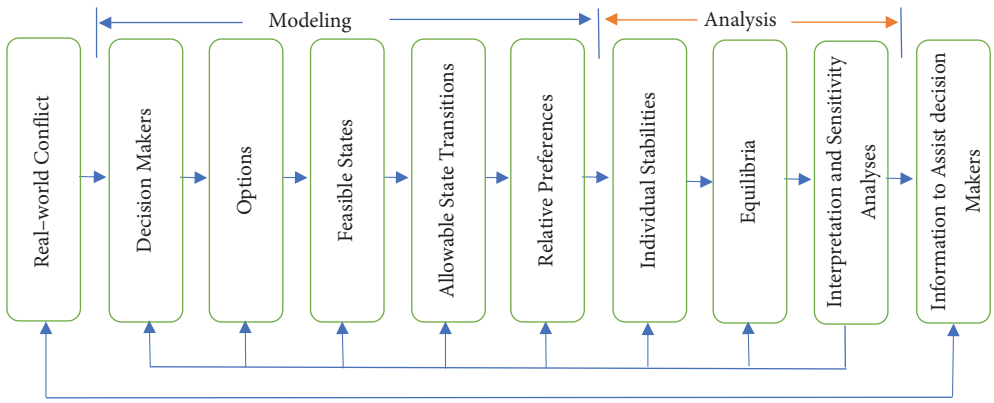

Figure 1: Conflict resolution process in GMCR adapted from [30].

3. Background

3.1. Geography. Harirud is a river shared by the three countries Afghanistan, Iran, and Turkmenistan (Figure 2). It is 1,124 km long. This river's drainage basin is about 112,000 km^2 [14, 22]. Harirud river originates from Afghanistan's central mountains, including the Hindu Kush and the La'l wa Sarjangal heights. After running about 650 km, the Harirud river reaches the Afghanistan-Iran border in the outskirts of Taybad, forming the Afghanistan-Iran border down to the Zulfiqar Strait, which is 107 km long [26]. As the Kashafrud River joins the Harirud river, it comes to be called Tejen and forms the continuation of the Iran-Turkmenistan border by this name. Tejen, which forms 117 km of the Iran-Turkmenistan border [2], extends beyond the border into the Karakum plain and disappears around the city of Tejen [32, 33]. This river is the fullest shared between Iran and Turkmenistan [32]. The Harirud drainage basin is one of the basins with the lowest precipitation in Iran and Afghanistan [26]. See [24] for more details.

Originating from Afghanistan mountain ranges, the Harirud river flows out of Afghanistan's territorial boundaries; in other words, the upstream areas of the Harirud drainage basin are all within Afghanistan's territory. Low precipitation in the plains and the hillside of Afghanistan mountain ranges has made these areas' agricultural activities dependent on runoffs flowing out of the country, including the Harirud river, and makes it necessary to control them by building hydraulic structures [34]. On the other hand, increasing demand and the necessity of higher utilization of the potential capacities in the three areas of agricultural irrigation, hydroelectricity, and drought and flood control have led to more significant efforts to control Afghanistan's surface water. Before the fall of the Taliban, the country had built no dams in the Harirud basin. However, the next Afghan government commissioned the completion and construction of the two dams Salma and Pashdan. The structure of Salma began in 1976, but due to the Soviet invasion in 1979, the construction process was completely stopped. Following the establishment of an elected central government in Afghanistan in 2004, the construction of the Salma Dam was put on the agenda again. With India's investment from 2013, the dam finally came into operation in 2016 [35]. Although Afghanistan has a superior position in controlling the flow of the shared transboundary waters of the Harirud river and has the largest share from the surface water of the basin, it still has the lowest amount of water conservation.

In 2005, Iran and Turkmenistan officially started and put into operation the Doosti Dam on the Harirud river [36]. The Harirud river supplies 93% of the inflow to the dam. According to the 2008 bilateral treaty, Iran and Turkmenistan agreed to divide the Harirud river water equally between the two countries [37]. From 1926 on, Iran has claimed 30% of the current flow as its historical water right [24]. Before putting the Salma Dam into operation, the water rights were imagined to be 40% for Afghanistan, 30% for Iran, and 30% for Turkmenistan. Operation of the Salma Dam has the most significant impact on changing the parties' water rights. Putting the Salma Dam into full operation means an increase in Afghanistan's water rights from the Harirud river to about 74% and a reduction of Iran and Turkmenistan's water rights to 13% [24].

The consequences of the Salma Dam have fueled the conflict between the three countries, especially between Iran and Afghanistan. Iran's utilization of its groundwater resources in recent years has been far greater than their capacity. Therefore, the majority of these resources are depleted. As a result, Iran has become much more dependent on the Harirud river surface flow to meet the growing demand for drinking water in Mashhad city and agricultural water in Mashhad and Sarakhs plain [38]. The country's decreased water rights from the Harirud river have created a significant gap between supply and demand for water resources. This situation will pose serious economic, social, and political challenges for Iran. Operation of the Salma Dam does not affect Turkmenistan as much as it does Iran, but with Turkmenistan's decreased water rights, this country will not have enough water to irrigate all its cultivated lands in the Sarakhs area [24].

Afghanistan's conflicts with its neighbors over its transboundary waters have raised concerns among international institutions such as the United Nations and the

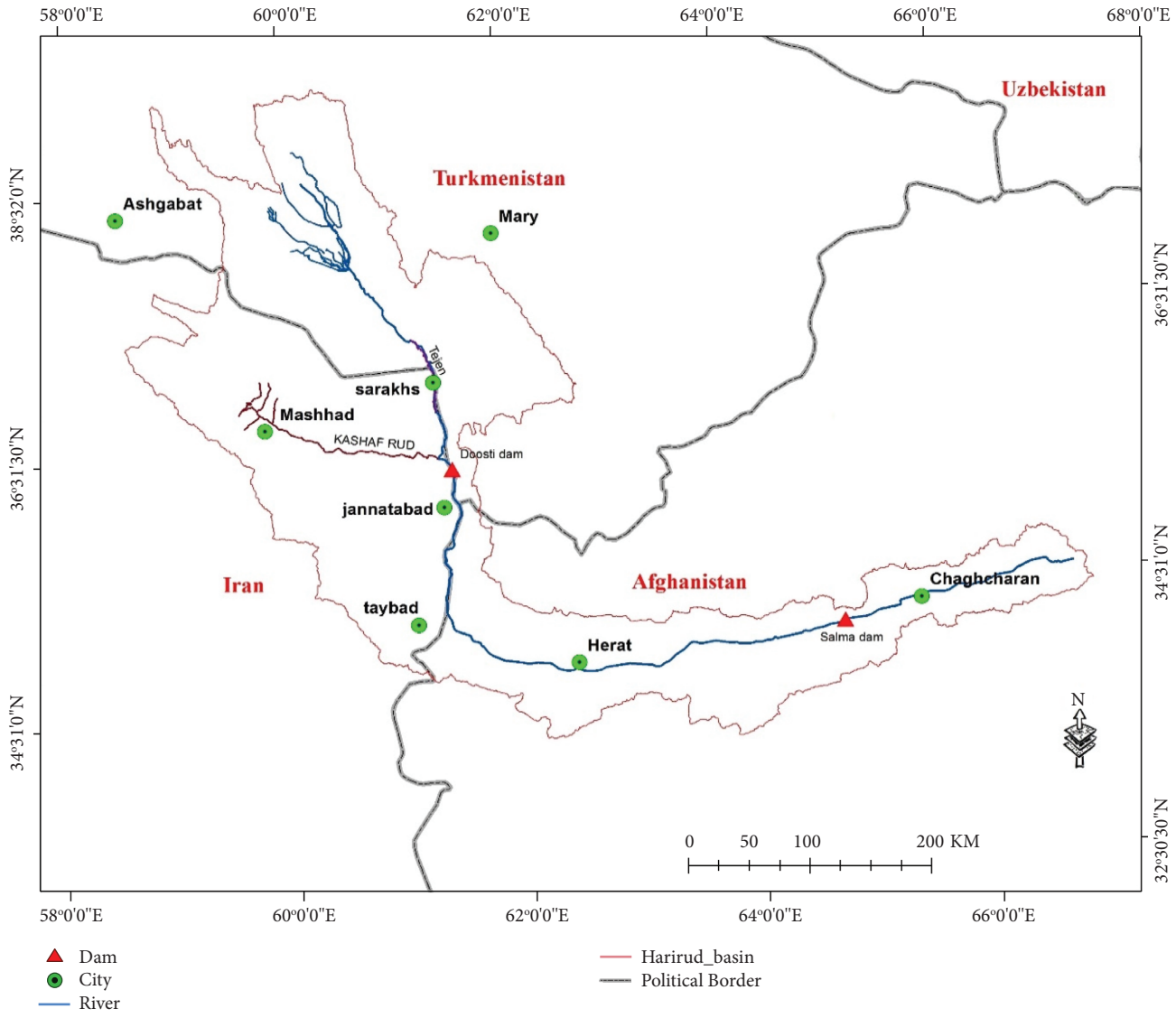

Figure 2: Harirud river basin [31].

World Bank [39]. A comparison of power indices (Table 1) suggests that Afghanistan, as a recent and new developer of water resources in the Harirud river area, has less power than its two neighbors, especially Iran. The country seeks to balance its power with its neighbors in the conflict by taking advantage of its geographical location and the increasing international financial, political, and military support, including from the US [24]. As a limiting factor, Iran's sanctions and restrictions in the international scene have prevented it from mobilizing the international community to press Afghanistan into negotiating and concluding a water treaty. Meanwhile, Afghanistan has been able to attract and sustain the Indian financial investment in the Salma project and receive NATO military assistance in providing the security of the project [40]. Given all the reasons above, Afghanistan has sought to put unilateral control of water resources on its agenda and accelerate the construction and utilization of water resource development projects [24]. Hydropolitical issues are part of the general policy of countries and are affected by the symmetry or asymmetry of bilateral and international relations. Therefore, recognizing the level of power and influence of the parties is an important part of the study of common border water disputes.

Table 1 shows the powers and capacities of each country (Afghanistan, Iran, Turkmenistan) in various fields including economic, military, political, development, and environment.

Meanwhile, Iran and Turkmenistan seek to preserve their water rights from the Harirud river by limiting the development of Afghanistan's water resources on the one hand and, on the other, seeking to negotiate and conclude a water treaty with this country to secure their water rights. Iran's economic, political, and security interests in stabilizing western Afghanistan have prevented it from openly using its capabilities and superiority to beat Afghanistan. Instead, Iran has tried to use the double tactic of investing in Afghanistan and military and diplomatic pressure in its attempt to persuade Afghanistan to negotiate and conclude a water treaty [24]. Turkmenistan has also sought to draw the

Table 1: Power indicators of the countries involved in the Harirud conflict.

Indicators country		Iran	Afghanistan	Turkmenistan
Economic	GDP per capita (current US$, millions) (World Bank 2017)	5415.2	585.9	7355.8
	Foreign direct investment, net inflows (current US$, millions, 2016) (World Bank)	3372	53.39	4522
	Net official development assistance (US$, 2016) (World Bank)	116	4064	32
	Balance of trade (US$, millions, average 2008 until 2016) (trading economics)	7500	−5907	881.9
	Agriculture sector as percentage of GDP (2015) (World Bank)	10.4	20.5	9.3
Military	Composite index of national capabilities (average 2002 until 2013) (Omni Atlas)	0.0130428	0.0020128	0.0006438
Governance and politics	Worldwide governance index (World Bank)	−0.83	−1.59	−1.45
	Democracy level index (2017) (economist)	2.45	2.55	1.72
	Failed and fragile states index (2018) (Fund For Peace)	84.3 (ranked 52/178)	106.6 (ranked 9/178)	72.6 (ranked 86/178)
Development and environment	Human development index (2015) (UNDP)	0.774 (ranked 68/188)	0.479 ranked (179/188)	0.691 Ranked (111/188)
	Water loss in all economic sectors (billion cubic meters) (FAO)	89.7 (2001)	20.28 (2000)	24.91 (2000)
	Percentage of economic water loss toward total renewable water (FAO)	65.4 (2001)	31 (2000)	100.6 (2002)
	Water stress percentage (FAO)	86.72 (2001)	43.67 (2000)	145.5 (2000)

country toward a water agreement by contributing to Afghanistan's energy needs. Nevertheless, the incentives and concessions exchanged between the three countries have not motivated them to strategies that can lead to win-win results and share the resulting benefits.

4. Results

In Section 3, the conflict's state and the decision-makers associated with the topic were reviewed. This section outlines the options that each of the conflict parties can pursue according to their goals and position (Table 2). Then, the possible options and the probable state are presented. Next, the conflict's equilibrium is proposed by introducing the decision-makers' preferences in the scenario of continuing the status quo state. Finally, the results of the model sensitivity analysis are presented with four scenarios.

4.1. Iran's Option

4.1.1. Giving up the Water Rights. Iran decides to give up its water rights from the Harirud river and provide the water it needs by other means. Importing water from Tajikistan, transporting water from the Caspian Sea [41], and purchasing water from Turkmenistan through the Karakum Canal [25] could be possible alternatives.

4.1.2. Applying Military, Economic, and Political Pressure. This option involves various measures, all or some of which can be used to gain water rights from the Harirud river. These measures include the use of diplomatic restriction and pressure, cessation or reduction of trade with Afghanistan, reduction or termination of investment in Afghan development projects, sabotage of Afghanistan's water resources projects, and military operations against Afghanistan's hydraulic facilities [24].

4.1.3. Providing Incentives. This option consists of various measures before and after the opening of Afghanistan's dams in the Harirud basin to encourage the country to cooperate and conclude a water treaty. An example would be the current economic investments of Iran in western Afghanistan. With the Salma Dam and the completion of unfinished dams, if Afghanistan uses the Harirud river water as leverage, Iran's incentives and concessions could include purchasing water or exchanging water with economic and commercial benefits [25]. For example, in the past, Iran had offered to provide Afghanistan with access to the Chabahar and Bandar Abbas ports to export their commodities to encourage this country to conclude a water treaty over the Helmand river waters [42]. Given that Afghanistan has no access to international waters, this concession could be necessary to this country and could also be used in the Harirud river conflict.

4.2. Afghanistan's Options

4.2.1. Unilateral Utilization. In this option, Afghanistan will continue constructing the Pashdan Dam and will build and operate new dams in the basin. Besides, as the cultivated area and the water demand increase in the Harirud basin, it will increase its water rights. These dams will cause a sharp decline in Iran and Turkmenistan's water rights but will not completely stop the water flows. Because Afghanistan would need to release a certain amount of water to generate electricity by the Salma Dam [25], so the only water received by Iran and Turkmenistan will be that minimal flow which is released from the Salma dam and will fill the reservoir of the Doosti Dam on the Iran-Turkmenistan border.

4.2.2. Cooperation and Conclusion of a Water Right Treaty. Afghanistan decides to conclude a water treaty with Iran and Turkmenistan to share the water right off the Harirud river.

Table 2: DMs and options in the Harirud river conflict.

Decision maker	Option	Current situation
Iran	(1) Giving up the water rights from the Harirud river	N
	(2) Applying military, economic, and political pressure to obtain the intended water rights from the Harirud river	Y
	(3) Providing incentives for Afghanistan to encourage this country to cooperate and conclude a water treaty	Y
Afghanistan	(1) Unilateral utilization and the continuous increase of its water rights from the Harirud river	Y
	(2) Water cooperation and concluding a treaty dividing the Harirud river water rights	N
Turkmenistan	(1) Giving up the water rights from the Harirud river	N
	(2) Applying military, economic, and political pressure to obtain the intended water rights from the Harirud river	N
	(3) Providing incentives for Afghanistan to encourage this country to cooperate and conclude a water treaty	Y

4.3. Turkmenistan's Options

4.3.1. Giving up Water Rights. Giving up the Harirud river waters, which it receives through the Doosti Dam, Turkmenistan uses other resources to meet its water needs in the Karakum Plain.

4.3.2. Applying Economic Pressure. At present, much of Afghanistan's electricity and gas needs are met through Turkmenistan and Iran's transmission lines. Besides, Turkmenistan and Iran's road transportation plays a vital role in providing Afghanistan's fuel [25]. Compared to Iran, Turkmenistan has less power and a smaller variety of leverage to pressure Afghanistan. However, proposing this option can increase tariffs on electricity and gas exports, cut off electricity or gas, and close the fuel transportation road to Afghanistan.

4.3.3. Providing Incentives. Incentives such as providing Afghanistan's electricity and fuel at lower costs can be such an incentive.

4.4. Feasible States. Given the number of possible options available to each country, a total of 256 states can be imagined. Among the imaginable states, indeed, some situations cannot be possible given the conditions of each country's conflict and goals. In the Harirud river conflict, as mentioned before, there are 256 states, due to the existence of international law, conventions, cultural relations between the three countries, the presence of NATO and the United States in Afghanistan and many other issues, some situations are not possible and will be reduced to 25 after the elimination of impossible ones. Table 3 shows the remaining feasible states. State 15 is the status quo in the Harirud river conflict between the three countries. The letter Y represents acceptance, and N denotes nonacceptance.

4.5. Defining the Decision Makers' Preferences in the Status Quo Scenario. This scenario is based on the historical conditions and the background of the three countries' interactions regarding the Harirud river. The decision-makers' preferences in this scenario are formulated based on what was discussed in the conflict's history. The history of the conflict suggests that unilateral control is Afghanistan's top priority because in transboundary water conflicts where there is an imbalance between the parties' powers, if the weaker country has a water advantage, it continually tries to use water as leverage to gain more concessions from the rivals. Also, if the weaker party feels weak and suspicious of its stronger neighbors, it prefers to avoid negotiation and agreement as much as possible [43]. By putting the Salma Dam into operation, Afghanistan has gained water supremacy because it has effectively increased its water conservation capacity in addition to being located upstream of the Harirud river basin. Thus, in the status quo scenario, Afghanistan's highest preference is unilateral control. Iran chooses both pressure and incentive options. With US support, NATO presence, and international funding, Afghanistan tries to make it costly for Iran to take any serious action and challenge Iran over the water issue to gain more leverage. Given the history of the conflict, and due to Iran's security and economic interests in Afghanistan, Iran is less inclined toward the option of applying pressure and limits the extent of using pressure instruments. Iran, for instance, does not take military action against Afghanistan's hydraulic facilities. Turkmenistan is also less inclined toward applying pressure and limits the extent of using pressure instruments. For instance, it refrains from measures such as cutting off gas and electricity to Afghanistan. Table 4 shows the preferences of the three countries involved in the Harirud river conflict. Table 5 also shows the possible states of the conflict for the three countries according to their preferences. Based on the analysis of the current situation of the Harirud conflict, we have identified 25 possible situations, and this table shows the priorities of these 25 situations for each country. Table 5 shows the priority of status selection for all three countries from best to worst. For example, for Iran, the situation 17 is the best possible situation and 14 the worst situation, while for Afghanistan the situation 14 is best and for Turkmenistan 16 is the best possible situation.

4.6. Equilibrium Analysis of the Harirud River Conflict in the Status Quo Scenario. The results of conflict modeling and analysis using the GMCR model suggest that the conflict's

Table 3: Harirud river conflict feasible states.

Option		Feasible states																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Iran	1	Y	N	N	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N
	2	N	Y	N	Y	N	Y	N	Y	Y	N	Y	N	Y	N	Y	Y	N	Y	N	Y	N	Y	Y	N	Y
	3	N	N	Y	Y	N	N	Y	Y	N	Y	Y	N	N	Y	Y	N	Y	Y	N	N	Y	Y	N	Y	Y
Afghanistan	1	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	N	N	N
	2	N	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y	Y	Y	N	N	N	N	Y	Y	Y
Turkmenistan	1	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	2	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
	3	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 4: Decision makers' preference of feasible states in the current scenario (important to least).

Decision maker	Desirability	Favorable situation	Explain
Iran	1	(- - - - Y - - -)	Afghanistan agrees to conclude a treaty dividing the water rights
	2	(- NY–Y - - -)	If Afghanistan agrees to the treaty, Iran will only provide Afghanistan with incentives
	3	(- YY–N - - -)	If Afghanistan does not agree to the treaty, Iran will apply political and covert pressure on Afghanistan as well as providing incentives. Pressure does not include serious economic and military action.
	4	(Y - - - - - - -)	Iran gives up its water rights from the Harirud river and finds another way to meet its water needs
	5	(- - - - Y–NY)	If Afghanistan agrees to the treaty, Turkmenistan will only provide Afghanistan with incentives
	6	(- - - - N–YY)	If Afghanistan does not agree to the treaty, Turkmenistan will apply economic pressure to Afghanistan as well as providing incentives.
	7	(- - - - - Y - -)	Turkmenistan gives up its water rights from the harirud river and finds another way to meet its water needs
Afghanistan	1	(- - - Y - - - -)	Afghanistan unilaterally utilizes and increases its water rights from the harirud river
	2	(- N - - - - - -)	Iran does not apply economic and military pressure on Afghanistan
	3	(- - Y - - - - -)	Iran keeps providing Afghanistan with incentives
	4	(Y - - - - - - -)	Iran withdraws its claim to the Harirud river water rights
	5	(- - - - - - N -)	Turkmenistan not to apply economic pressure on Afghanistan (stopping electricity and energy exports)
	6	(- - - - - - - Y)	Turkmenistan keeps providing Afghanistan with incentives (exporting electricity and energy)
	7	(- - - - - Y - -)	Turkmenistan withdraws its claim to the Harirud river water rights
Turkmenistan	1	(- - - - Y - - -)	Afghanistan agrees to conclude a treaty dividing the water rights
	2	(- - - - - - NY)	Turkmenistan only provides incentives to Afghanistan and refrains from applying pressure
	3	(- Y - - - - - -)	Iran applies economic and military pressure on Afghanistan to make this country agree to a water treaty
	4	(- - - - - Y- -)	Turkmenistan gives up its water rights from the Harirud river and finds another way to meet its water needs

Table 5: Decision makers preference of feasible states.

Decision maker	Preference of feasible states (important to least)																								
Iran	17	10	24	16	18	9	11	23	25	22	4	8	15	19	1	5	12	20	21	2	3	6	7	13	14
Afghanistan	14	3	21	7	12	1	19	5	15	4	22	8	13	2	20	6	17	24	10	18	25	11	6	23	9
Turkmenistan	16	18	17	9	11	23	25	10	24	13	15	12	14	2	4	6	8	20	22	1	3	5	7	19	21

Equally preferred states indicated by grouping with common sell.

equilibrium is state 15 (Table 6). As the table shows, state 15 is stable for all three parties to the conflict according to all solution concepts. In this state, Afghanistan will choose unilateral control and increase its water rights from the Harirud river water resources. Iran will try to change Afghanistan's behavior and lead it to the treaty's conclusion by providing incentives to Afghanistan, including investing in Afghanistan's development projects. Iran will also

covertly try to limit and slow Afghanistan's ability to increase its water rights from the basin's resources by sabotaging Afghanistan's water resources development projects. Turkmenistan will keep providing incentives such as electricity and gas to Afghanistan to encourage the country to conclude a water treaty or continue its water rights. Thus, it can be said that the results correspond to the objective reality of the conflict and the circumstances that have been hitherto brought about in the conflict in the outside world.

Table 6 shows which situation is suitable for which country in which method (R, GMR, SEQ, and SMR). For example, situation 18 is suitable for Iran in three methods (SEQ, GMR, and SMR) but not in method (*R*). The same situation (18) is not suitable for Afghanistan in any way, and in all four methods is reported to be suitable for Turkmenistan. Position 15 in all four methods has been suitable for all three countries, so the status of 15 becomes the equilibrium point of all three countries.

Stability concepts mathematically define the possible stable resolutions of a conflict. GMCR commonly employs four stability concepts, including Nash stability (Nash), general metarationality (GMR), symmetric metarationality (SMR), and sequential stability (SEQ). The corresponding definitions are given as follows:

> Nash: a state is Nash stable if a decision maker cannot leave it for a preferred one unilaterally
>
> GMR: a state is GMR stable if all of a decision maker's unilateral improvements can be sanctioned by other decision makers' subsequent unilateral moves
>
> SMR :a state is SMR stable if all of a decision maker's unilateral improvements can still be sanctioned by other decision makers, after a potential response from the main decision maker
>
> SEQ: a state is SEQ stable if all of a decision maker's unilateral improvements can be sanctioned by other decision makers

The "Preference Information" refers to how much information is needed to identify the corresponding stability. For Nash, decision makers only need their own preference information, while all preference information is needed for each decision maker in other three stabilities. The "Foresight" represents the max-count of foreseen moves of a decision maker. Nash checks one move in advance; both GMR and SEQ check two moves in advance; and SMR checks three moves in advance. The "Disimprovement" indicates a decision maker's tendency to move to a relatively less preferred state for the purpose of reaching a relatively more preferred state. No disimprovement is allowed in Nash and SEQ, while sanctions from other decision makers can be disimprovements in GMR and SMR. It should be noted that Nash is the most stable equilibrium because if a state is Nash, all other stabilities [44].

A graph analysis of the Harirud river conflict in the status quo scenario, which shows a transition from each initial state to possible states according to the preferences of each of the three decision-makers, suggests that the only state where no unilateral move is possible for any of the players is state 15. In other words, if we assume this situation (15) to be the starting point of the analysis (the beginning of the conflict and the decision-makers' moves), then, assuming the continuity of the present ranking of preferences in this scenario, none of the parties will be able to move from this state to a better one. This is because this state is the equilibrium of this conflict. The choice of this state as the equilibrium of the conflict indicates that if the parties' present preferences continue, then the conflict will be in a deadlock, and, in other words, there will be no way to resolve the conflict. Thus, it can be predicted that Afghanistan, despite suffering from Iran's pressures and taking advantage of Iran and Turkmenistan's incentives, will continue to increase its water rights from the Harirud river and unilaterally control the water resources of this basin. Also, Iran and Turkmenistan will not be able to change Afghanistan's behavior using a policy of tolerance, limited pressure, and incentives. Therefore, any change in the conflict's outcome and conditions would require a difference in the Harirud river conflict structure, which will be dealt with in the sensitivity analysis scenarios.

4.7. Scenario Making and Sensitivity Analysis. As shown in the analysis of the Harirud river conflict in the status quo scenario, due to the structure of the conflict—imbalance of the parties' powers, water supremacy of the weaker party (Afghanistan), lack of trust in the intentions and behaviors of the other parties—there is little possibility of cooperation and agreement between the parties in the present situation, and changing the outcome and conditions of the conflict would require changing the structure of the conflict. Therefore, after modeling the status quo state and analyzing the conflict under the current non-cooperative conditions, scenarios were defined to identify the results' sensitivity to changes in the decision-makers' preferences. In this regard, four probable scenarios were defined and analyzed. These four scenarios, respectively, include Iran and Turkmenistan's offensive approach (TOA), the intervention of a third party to support (ITS) Afghanistan against the rivals, mediation of a third party for reconciliation (MTR) between the parties to the Harirud river conflict, and the arbitration of a third party to resolve (ATR) the conflict (Table 7). By performing inverse GMCR, each scenario was analyzed, and model sensitivity analysis was carried out. Finally, four strong equilibria were obtained in different scenarios (one status quo scenario and four sensitivity analysis scenarios) as the most probable solutions to the Harirud river conflict.

Based on the modeling results, the following insights were obtained from the analysis of the Harirud river conflict:

(i) The strategy of unilateral control and increased utilization of the Harirud river water resources is Afghanistan's dominant strategy in the Harirud river conflict. Afghanistan's choice of strategy, regardless of what strategy Iran and Turkmenistan are adopting against Afghanistan, will always benefit Afghanistan the most. The suspicion and mistrust between the parties to the conflict have led the present state of the Harirud river conflict into both uncooperative and competitive rules and structures.

Table 6: Equilibrium states of the Harirud river conflict.

Decision maker	Feasible states																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Iran	—	—	—	R	—	—	—	R	—	R	-	—	—	—	R	—	R	—	—	—	—	R	—	R	—
	—	—	—		GMR		—	—	—	GMR	GMR	GMR	GMR	—	—	—	GMR	GMR	GMR	GMR	—	—	—	GMR	GMR
	GMR																								GMR
	—	—	—	SMR	—	—	—	SMR	SMR	SMR	SMR	—	—	—	SMR	SMR	SMR	SMR	—	—	—	SMR	SMR	SMR	SMR
	—	—	—	SEQ	—	—	—	SEQ	SEQ	SEQ	SEQ	—	—	—	SEQ	SEQ	SEQ	SEQ	—	—	—	SEQ	SEQ	SEQ	SEQ
Afghanistan	R	R	R	R	R	R	R	R	—	—	—	R	R	R	R	—	—	—	R	R	R	R	—	—	—
	GMR	GMR	GMR		GMR		GMR	GMR	GMR	GMR	—	—	—	GMR	GMR	GMR	GMR	—	—	—	GMR	GMR	GMR	GMR	—
	—	—																							
	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	—	—	—	SMR	SMR	SMR	SMR	—	—	—	SMR	SMR	SMR	SMR	—	—	—
	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	—	—	—	SEQ	SEQ	SEQ	SEQ	—	—	—	SEQ	SEQ	SEQ	SEQ	—	—	—
Turkmenistan	—	—	—	—	—	—	—	—	—	—	—	R	R	R	R	R	R	R	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	—	—	—	—	GMR	GMR	GMR
	—	—	—	—	—	—	—	—	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	—	—	—	—	SMR	SMR	SMR
	—	—	—	—	—	—	—	—	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	—	—	—	—	SEQ	SEQ	SEQ
Equilibrium state															R GMR SMR SEQ										

Table 7: Scenarios equilibrium states of the Harirud river conflict in scenarios.

Decision maker	Option	Conflict equilibrium in different scenarios				
		Current situation	TOA	ITS	MTR	ATR
		15	9	6	17	
Iran	Giving up the water rights	N	N	N	N	
	Applying military, economic, and political pressure	Y	Y	Y	N	
	Providing incentives	Y	N	N	Y	
Afghanistan	Unilateral utilization	Y	N	Y	N	
	Cooperation and conclusion of a water right treaty	N	Y	N	Y	
Turkmenistan	Giving up the water rights	N	N	N	N	
	Applying military, economic, and political pressure	N	Y	Y	N	
	Providing incentives	Y	N	N	Y	

This is the most important cause of the deadlock in the conflict and the difficulty of resolving it.

(ii) Due to its national interests, Iran is currently reluctant to use all its leverage, including economic sanctions and putting pressure on Afghanistan. Instead, it prefers to encourage Afghanistan to cooperate by applying limited pressure, such as diplomatic pressure, as well as providing incentives such as investing in the reconstruction of Afghanistan and exporting cheap energy. As a possible alternative, the study examined Iran's scenario adopting an aggressive approach, including an economic sanction of Afghanistan or an attack on its hydraulic facilities, to force the country to negotiate and conclude a treaty dividing the Harirud river water rights. The conflict analysis results show that if Iran adopts a strategy of applying intense pressure on Afghanistan, and Turkmenistan stops exporting energy to Afghanistan in coordination with Iran, Afghanistan would be very likely to cooperate and negotiate. Of course, this will be brought about if Afghanistan is unable to introduce an external factor into the conflict to stop Iran and Turkmenistan from exerting pressure.

(iii) Given what was discussed above, the question to be investigated was whether the military and economic support of an influential foreign party could help Afghanistan resist the economic and military pressure on Iran and continue its unilateral control strategy. This influential foreign party could be the US and NATO, which have military bases and strategic interests in Afghanistan. According to the analysis results, the supportive Role of such a powerful foreign party is so strong and vital that it can act as a regulating element in the conflict and thwart Iran's use of threat or military attack on Afghanistan's hydraulic facilities by creating a power balance. However, the results showed that the escalation of Afghanistan's water conflict with Iran and Turkmenistan over the Harirud river to the point of military conflict or economic sanctions would be an improbable behavior and approach. That is to say; such a situation would have great costs and negative consequences for all parties. Therefore, Afghanistan would accept such a high risk only if it were willing to risk its interests and security to punish Iran.

(iv) This study examined the Role of using internationally agreed frameworks such as international conventions or engaging the relevant international institutions trusted by all parties to resolve the Harirud river conflict and transcending its deadlocked. The analysis results indicated that employing the common legal rules for the utilization of border waters, particularly the 1997 UN Convention, and the intervention of a relevant international institution as a third party, could change the structure of the conflict and transcend the deadlock. Whether in the form of mediation and regulation or arbitration, this intervention will ensure that Afghanistan would no longer derive the most benefit by adopting a unilateral control strategy. For example, the mediation of the World Bank and its pressure on Afghanistan to negotiate and resolve its water conflicts with its neighbors will likely lead to Afghanistan abandoning its unilateral control strategy and seeking cooperation with Iran and Turkmenistan to reach a fair treaty dividing the water rights because foreign aid allocated to the country under the World Bank has the largest share of the reconstruction budget, including Afghanistan's water resources development projects. Therefore, Afghanistan would feel obliged to accept this institution's recommendations, even if they are not legally binding, to continue to benefit from these aids.

(v) Meanwhile, the World Bank mediation would require that Iran and Turkmenistan, in good faith, cease to apply any covert or open, limited or intense pressure on Afghanistan, and, instead, provide incentives to draw Afghanistan to cooperation. Thus, such mediation will facilitate the formation of a compromise profitable to all the parties. The analysis results also show that the Iran-Turkmenistan's lawsuit against Afghanistan in the International Court of Justice and the ICJ's arbitration decision on requiring Afghanistan to negotiate could also help both Afghanistan's abandoning unilateral control strategy and the conclusion of a treaty dividing the Harirud river water rights.

5. Conclusion

Transboundary waters have always been challenging throughout the world, especially in recent years when freshwater resource shortage and population growth have made this commodity a major leverages for governments. This goes so far that most experts admit that there will be great wars over water resources in the upcoming years. The water war is a concept that will gradually find the conditions to materialize in the twenty-first century. Basically, the existence of shared water resources in the border regions, as an economic resource, is an important factor in the countries' border conflicts. The type of interactions between governments in the utilization of the shared water resources encompasses a wide range with complete adaptation and cooperation at one extreme and incompatibility and war at the other. An excellent example of the positive Role of water resources in regional collaboration and convergence in Iran and Turkmenistan decides to build the Doosti Dam on the Harirud border river and formulate a shared utilization legal system [33].

Nevertheless, there is no comprehensive agreement on the division of the Harirud river water rights, but there are also numerous conflicts that make it difficult to reach a trilateral deal. Therefore, analyzing the present conflict state by scientific tools and models can provide a set of probable measures and states. This, in turn, can influence the insights and policymakers of the parties to the conflict. Thus, this study used GMCR to identify and present equilibria in the status quo state and probable scenarios. The results of implementing the GMCR model algorithm (Table 6) showed that state 15 (status quo) was recognized by the model as the equilibrium. That is to say, based on the set of non-cooperative solution concepts used to analyze the conflict, there is no unilateral progression from this state for any of the parties to the conflict. Therefore, this state is the most probable outcome of the conflict because none of the parties, given their preferences, is motivated or able to change their strategies to turn the conflict into a more favorable state for themselves. Also, in the scenario of Iran and Turkmenistan's offensive approach, state nine was recognized as the equilibrium. The equilibrium for the scenario of the intervention of a third party to support Afghanistan against the pressures on the part of the rivals was state 6, whereas it was state 17 in the case of the mediation of a third party for reconciliation between the parties to the Harirud river conflict, as well as the arbitration of a third party to resolve the conflict. Given the current situation in Afghanistan, the analysis in this article may need to be revised in the future.

Data Availability

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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