Conflict Management on Utilization of the Gages Water Resources Between Bangladesh and India

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Synopsis

The graph model for conflict resolution is used to formally analyze an ongoing conflict between India and Bangladesh over the regulation of the Ganges River in order to illustrate the crucial role a Third Party can play in resolving the dispute. Because a Third Party can assist in resolving a dispute in a variety of ways, a general systems approach to conflict management with a Third Party is devised. The strategic analysis of the India/Bangladesh conflict using the graph model clearly shows that one can determine, in advance, exactly how a Third Party can influence potential resolutions to the dispute.

Keywords: Conflict, Third Party, Negotiations, Systems Approach, GMCR II.

1.   Introduction

The Ganges River is the most important source for water resources for both Bangladesh and India, and this has resulted in many conflicts arising between these two countries. The distribution of water resource from the Ganges is generally advantageous to India which is situated upstream. However, it is difficult for Bangladesh to offer a new effective option for dissolution of the conflict because Bangladesh is at a disadvantage economically and topographically to India. As for India, it is hard to imagine that India will change its preference unilaterally. Therefore, the conflict between Bangladesh and India has been stagnant since they have only negotiated by themselves. In such a case, participation of a third party is thought as being able to improve the situation.

In this study, the Graph Model for Conflict Resolution (called GMCR II) is used for modeling and analyzing this conflict. It is based on game theory, and provides algorithms to calculate equilibria among decision makers (called DMs) who have different preferences. Based upon the framework of GMCR II, the roles of a third party are classified and defined into three types: Donor, Coordinator, and Arbitrator, who are jointly called a Third Party.

The graph model methodology is applied to the conflict between Bangladesh and India. First, the actual situation is modeled using GMCR II. Second, the condition which is necessary to improve the current conflict is analyzed. Third, focusing on the role of Coordinator, it is analyzed how effective a Third Party can play a role with respect to the conflict management.

2.   History of the Ganges Conflict between Bangladesh and India

India lies upstream of Bangladesh along the Ganges. A map shows the relation of two countries in Fig. 1 which is made with a figure from national geographic website, http://www.nationalgeographic. com/. Both of them have been suffering lack of water resources. Because of such a background, Bangladesh and India have conflicted with utilization of the Ganges River water resources. The details about the conflict over the Ganges River between two countries are explained referring to Kondo (1997) in the following.
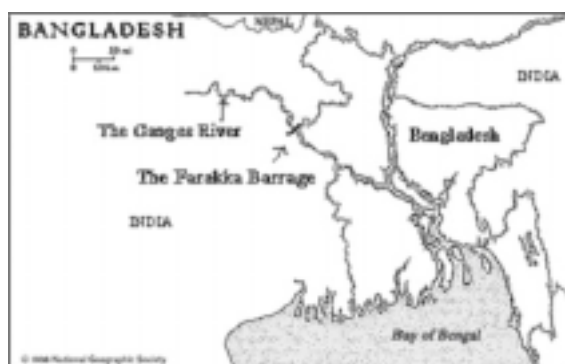
Fig. 1   The Farakka Barrage

India built the Farakka Barrage unilaterally across the Ganges River near the border in 1975.   Temporary treaty was concluded at first between them.   This treaty said that India drew 310-350 m^3/s of water at the Farakka Barrage and discharged 1,245-1,400 m^3/s of water to the downstream from April 21 to May 30, when the Ganges River has the least amount of water in a year.   A few months later, the treaty was expired, and India began to draw water without any consensus until two counties came to conclude second agreement in 1977.   The content of 1977 Treaty is shown in Table 1.

Table 1   1977 Treaty (m^3/s)

Month	Day	Flow 1948-73	Withdrawal by India	Release to Bangladesh
Jan	1-10	2,790	1,133	1,657
	11-20	2,542	1,090	1,452
	21-31	2,336	991	1,345
Feb	1-10	2,244	934	1,310
	11-20	2,096	892	1,204
	21-28	1,982	870	1,112
Mar	1-10	1,848	758	1,090
	11-20	1,798	722	1,076
	21-31	1,728	708	1,020
Apr	1-10	1,671	680	991
	11-20	1,572	588	984
	21-30	1,558	581	977
May	1-10	1,600	609	991
	11-20	1,678	680	998
	21-31	1,855	758	1,097

This treaty was concerned with the Ganges River water resources allocation during dry season.   At first, Bangladesh and India claimed different definition for dry season.   Bangladesh insisted that it was from November to May, and on the other hand India insisted that it was from March to May.   As a result of their compromise, the definition for dry season in this treaty concluded from January to May.   India got a right to draw more water than in 1975's temporary treaty.   Bangladesh was obliged to large compromise.   This treaty said that India had to control draw of water so that the rate of flow released to Bangladesh should not be less than 80%.   This treaty was carried out until 1984.

After 1984, there was no rule for the Ganges River water resources utilization between two countries until the treaty was concluded again in 1996.   A general allocation rules were stipulated in Table 2.   This treaty is still carrying out now.

Table 2   1996 Treaty (m^3/s)

Month	Day	Flow 1949-88	Withdrawal by India	Release to Bangladesh
Jan	1-10	3,045	1,133	1,912
	11-20	2,766	1,133	1,633
	21-31	2,553	1,133	1,420
Feb	1-10	2,445	1,133	1,312
	11-20	2,347	1,133	1,214
	21-28	2,240	1,133	1,107
Mar	1-10	2,108	1,116	991
	11-20	1,952	960	991
	21-31	1,832	991	841
Apr	1-10	1,789	798	991
	11-20	1,774	991	783
	21-30	1,727	736	991
May	1-10	1,907	991	916
	11-20	2,084	1,093	991
	21-31	2,318	1,133	1,185

In 1996 treaty, Bangladesh made even more compromise than in 1977-1984's treaty because the amount of water which Bangladesh can get is sometime less than 800m^3/s in 1996 treaty.   Table 3 clearly says that India has certain amount of water to keep in itself, and the rest of water is discharged to Bangladesh if it is satisfied.

1996's treaty over 30 years has brought settlement to the dispute of two countries for the time being, but the conflict is not seemed to be completely resolved. The treaty is advantageous to India which is situated upstream so that Bangladesh had much complaint

about the treaty. Amount of the Ganges River water flow in Bangladesh conspicuously receives consequence of amount of water drawn at the Farakka Barrage. Constructing positive association between Bangladesh and India is one of important ways to reduce the vulnerability in water resources management of Bangladesh. This kind of disastrous factor might be said as man-made disaster risk.

Table 3　Rules of Allocation on 1996 Treaty (m^3/s)

Availability at Farakka	India	Bangladesh
1,982 less	50%	50%
1,982 2,124	Balance of Flow	991
2,124 more	1,133	Balance of Flow

The severe guard system is spread around the Farakka Barrage now. The unilateral execution of construction and conclusion of treaty by India tell how important India recognizes the Farakka Barrage is. Bangladesh is one of the world's eminent poor countries, and it is most down stream country of the Ganges River. On the other hand, India has a great economic power comparing with its neighborhoods, and it is situated upstream. Under such economical, political, and geographical background, how may Bangladesh turn the Ganges River water resources utilization for the better?

3. GMCR II

GMCR II is used to describe and analyze the India/Bangladesh conflict. Here, brief explanation is given in the following.

Fraser and Hipel (1984, 1988) developed earlier theory of GMCR II, Conflict Analysis, and Fang, Hipel, and Kilgour (1993, 2003) advanced it as GMCR II using graph approach. GMCR II is widely used to analyze the conflict resolution practically, such as Hipel (2001) et al. studied about the service industry. GMCR II is the method which is systematized based on game theory to classify states by their stability, comparing preferences of each DM. The methodology of GMCR II is characterized as below.

First, GMCR II generally assumes any number of DMs, each of whom has any number of options. Here, a set of states is defined as possible combinations of all options of all DMs but logically or practically impossible states should be deleted.

Once a set of states is determined, it is investigated how each DM places each state in the order according to their preferences. After preference order of each DM is determined, equilibrium, a major output of GMCR II, are obtained. Equilibrium represents a state where any DM cannot change its strategy due to the possibility that less favorable state might be attained by succeeding change of strategies by other DMs. In this sense, equilibrium represents a state that is a deadlock situation from which any DM cannot move to a better state by changing its own option alone.

Then, mathematical characteristic of GMCR II is explained as follows.

Let R_i represent reachable set of states for DM i, and $\mathbf{U}$ represent the set of all the states. R_i displays exactly which unilateral moves to state q are available to DM i from any starting state k ($q, k \in \mathbf{U}$). Specifically, for DM $i \in \mathbf{N}$, $\mathbf{R_i}$ is defined by

$$R_i(k,q) = \begin{cases} 1 \text{ if DM } i \text{ can move (in one step)} \\ 0 \text{ otherwise} \end{cases} \quad (1)$$

$$R_i(k,k) = 0 \quad (2)$$

An equivalent expression of DM i's decision possibilities is the reachable list of DM i. For $i \in \mathbf{N}$, let $\mathbf{S}_i(k)$ represents reachable list for a state k for DM i. $\mathbf{S}_i(k)$ is the set of all states to which DM i can move (in one step) from state k. Therefore,

$$\mathbf{S}_i(k) = \{q : R_i(k,q) = 1\} \cdot \quad (3)$$

With reachable matrix $\mathbf{R_i}$ a unilateral improvement is defined. A unilateral improvement from a particular state for a specific DM is a preferred state for that DM to which he or she can unilaterally move. Note that the DM must strictly prefer the resulting state to the initial state. To represent unilateral improvements, each DM's reachable stability matrix can be replaced by $\mathbf{R_i}^+$, defined by

$$R_i^+(k,q) = \begin{cases} 1 \text{ if } R_i^+(k,q) = 1 \text{ and } P_i(q) > P_i(k) \\ 0 \text{ otherwise.} \end{cases} \quad (4)$$

Where $P_i(k)$ represents the payoff of DM i for a state k.

Similarly, DM i's reachable list $\mathbf{S}_i(k)$ can be replaced by $\mathbf{R_i}^+$, defined by

$$\mathbf{S}_i^+(k) = \{q : R_i^+(k,q) = 1\} \quad (5)$$

GMCR II provides various kinds of solution

concepts, such as Nash satiability, general metarationality, and symmetric metarationality, sequential stability, limited-move stability, nonmyopic stability, and Stackelberg stability. The Specific solution concepts that are considered as more essential are explained in the following.

Nash Stability: Let $i \in \mathbf{N}$. A state $k \in \mathbf{U}$ is Nash stable for DM i iff $\mathbf{S}_i^+(k) = \varnothing$. Under Nash stability, DM i expects that DM j will stay at any state DM i moves to, and consequently that any state that DM i moves to will be the final state. The initial state k is therefore stable iff DM i cannot move from k to any state DM i prefers. Nash stable is also called rational.

Sequential Stability: A state is sequentially stable for a given DM iff he is deterred form making a unilateral improvement because a sequence of individual unilateral improvements by the other DMs could result in a state less preferred (for the original DM) than the initial state. For $i \in \mathbf{N}$, a state $k \in \mathbf{U}$ is sequentially stable for DM i iff for every $k_1 \in \mathbf{S}_i^+(k)$ there is at least one state $k_x \in \mathbf{S}_{N-i}^+(k_1)$ with $P_i(k_x) \le P_i(k)$.

Under Nash stability, DM i expects that DM j will stay at any state i moves to, and consequently that any state that i moves to will be the final state. The initial state k is therefore stable iff i cannot move from k to any state i prefers.

The state, which is stable for every DM, is called the equilibrium. A DM will choose a strategy that he (or she) believes will maximize his utility, veering in mind that his opponent desires to do the same for himself. If there is an ordered pair of strategies such that neither DM can improve his utility payoff by changing their strategy, this state constitutes equilibrium.

4. Conflict Management with a Third Party

In this section, the procedure outlined in Fig.2 is put forward as a system management approach for handling conflict when a Third Party may improve the situation. In particular, by examining how a Third Party can bring about more preferred equilibria, one can determine the best role for a Third Party to play in a real world dispute.

A role of a Third Party has been well studied, such as by Raiffa (1982), Raiffa, Richardson and Metcalfe (2002), and researchers who contributed to a set of encyclopedia papers on the topic of conflict resolution (Hipel, 2002).

Raiffa defines the roles of a Third Party, which is called an intervenor in his book (1982), as a facilitator, mediator, arbitrator, and rules manipulator. "A facilitator is a person who arranges for the relevant parties to come to the negotiating table." The facilitator might choose not to be involved in the actual process of negotiation, but he or she might play a facilitating role to achieve the agreement. "A mediator is an impartial outsider who tries to help the negotiators in their quest to find a compromise agreement." The mediator can assist with the negotiation process, but he or she does not have the authority to suggest a solution; rather, his or her purpose is to induce the negotiators to determine whether there is compromise preferred by each party to the no-agreement alternative. "An arbitrator, after hearing the arguments and proposals of all sides and after finding out "the facts," may also try to lead the negotiators to devise their own solutions or may suggest reasonable solutions" "A rules manipulator is given the authority to alter or constrain the process of negotiation - or, put another way, to modify the rules of the game." The rules manipulator can in fact not only propose such rules, but can also forbid the use of various moves that might lead to disastrous outcomes.

Later work by Raiffa, Richardson and Metcalfe (2002), they defines the roles of a Third Party which is called an external helper in their book, as facilitation, mediation, arbitration, and rules manipulation. They say it's difficult to categorize roles as either of them. Alternatively, they introduce concepts of evaluative and nonevaluative. Evaluative means an external helper determines who gets what on the basis of his or her determination of which party is right; which party has behaved more appropriately. As for a nonevaluative external helper, it's not question of who is right or wrong.

In this study, a Third Party is defined to be another party who is not an actual stakeholder but is motivated to assist in bringing about a more desirable state or equilibrium. As pointed out in Fig.2, if a party has its own preferences with respect to the conflict, it can be considered to be an actual DM in the dispute. On the other hand, if the new party doesn't have its own
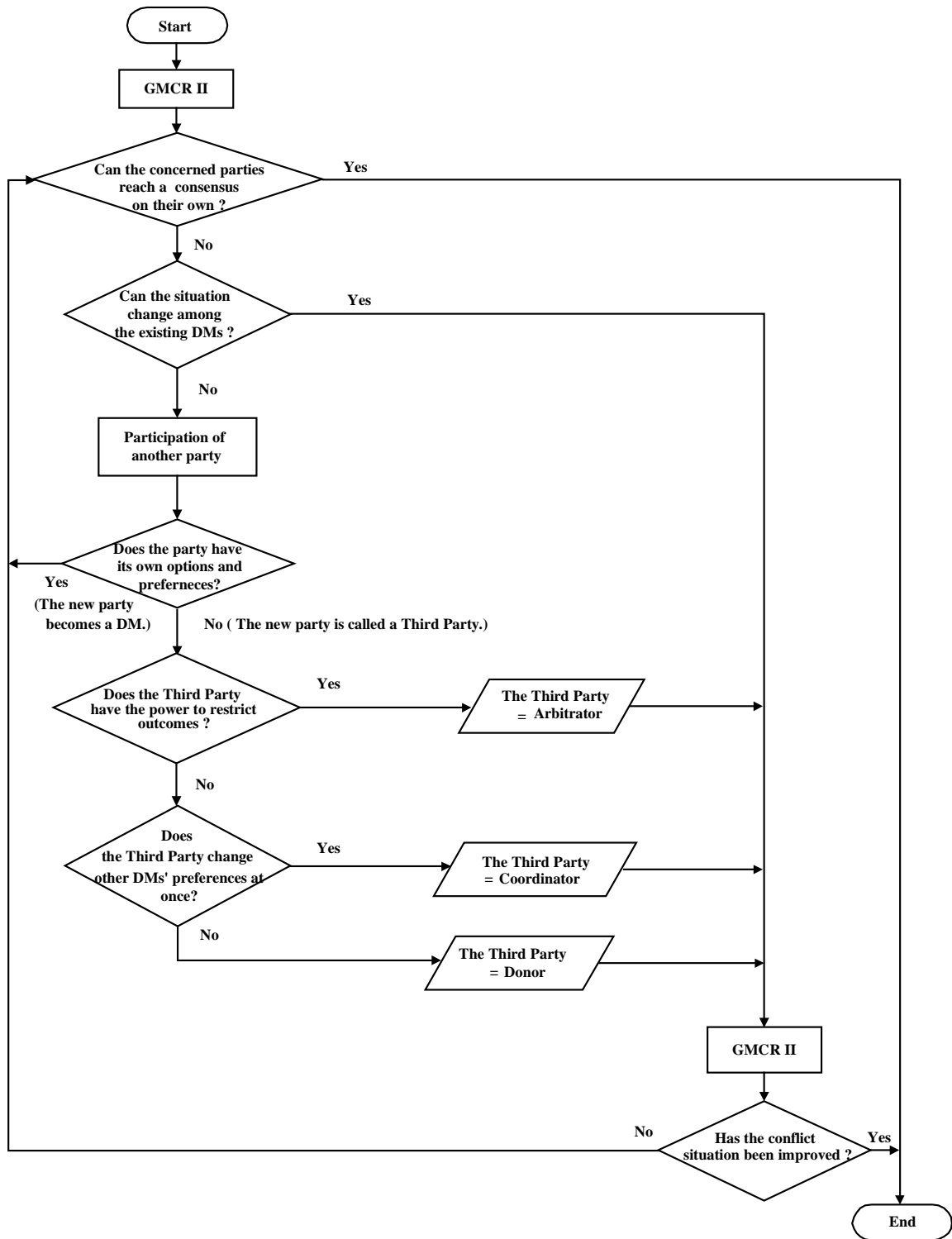
Fig. 2 : Conflict Management with a Third Party

preferences with respect to possible states in the conflict, it is defined to be a Third Party, which can be categorized as Donor, Coordinator or Arbitrator. If a Third Party has the power to exclude some states, and restrict DMs to move to other states, the Third Party is called Arbitrator. The difference between Donor and Coordinator is whether it can change other DMs' preferences at the current moment or not. If it can change DMs' preferences right away by offering some options to other DMs, the role of the Third Party is defined as Coordinator. If it can't, the Third Party is defined as Donor. Donor doesn't have a direct influence on the conflict situation at the present moment, but in the long term, it might help other DMs to devise a new option by themselves, or change their preferences.

Precise definitions about roles of a Third Party are given in the following. Let subscript *TP* represent a Third Party, and the dashed sets represent the set which has changed after a Third Party participates in the conflict. The definitions of sets are same as in section three. In addition, $\mathbf{P_i(Q)}$ is defined as a state ranking of DM i $(i \neq TP)$, which shows the order of preference about possible states. Furthermore, to make the meaning of Third Party's participation clear, let $\mathbf{U'_{-TP}}$ represent states without Third Party's strategies after Third Party's participation. If the time shifting is considered, $\mathbf{P^t_i(U)}$ is used.

a) Donor

Donor has some options, and it doesn't influence actual state rankings, but after some time shifts, it does.

$$\mathbf{U' = U} \tag{6}$$

$$\forall i, \ \mathbf{P^t_i(U') = P^t_i(U)} \tag{7}$$

$$\exists i, \ \mathbf{P^{t+T}_i(U') \neq P^{t+T}_i(U)} \tag{8}$$

b) Coordinator

Coordinator has some options, and they influence DMs' actual state rankings.

$$\mathbf{U' \neq U} . \tag{9}$$

$$\exists i, \ \mathbf{P^t_i(U'_{-TP}) \neq P^t_i(U)} \tag{10}$$

c) Arbitrator

Arbitrator doesn't have any options. They can exclude states, and it restricts DMs' action.

$$\mathbf{U' = U} \tag{11}$$

$$\exists k, \ \left|\mathbf{S'_i(k)}\right| < \left|\mathbf{S_i(k)}\right| \tag{12}$$

Note that $\left| \bullet \right|$ means the number of elements which are included in the set $\bullet$.

Comparing with Raiffa's definition, a rules manipulator is almost the same as an Arbitrator. Other definitions don't have similarity with each other because Raiffa's definition presumes that a structure of a conflict is fixed and also that a Third Party doesn't have a power to change the settings. On the other hand, a Third Party in this study may change a structure of a conflict implicitly or explicitly. As for the concepts of evaluative and nonevaluative, a Third Party in this study can perform both roles by considering the final desirable outcome from either of roles' aspects.

5. A Case Study of the Farakka Barrage Conflict

5.1 Conflict 1: Description of the Present Situation

The DMs and options for the present situation in the Farakka Barrage conflict are given on the left in Table 4. Notice that Bangladesh has the single option of agreeing to the current operation of the Farakka Barrage (called Agree, for short, in Table 4). India has the two options of operating the Farakka Barrage according to the existing operating rules (Operate) and changing the present operating rules to benefit Bangladesh (Change).

Table 4   DMs, Options, and States
in the Farakka Barrage Conflict

DMs and Options		States
Bangladesh		
Agree	Agree to the current operation of the Farakka Barrage	N Y N Y N Y N Y
India		
Operate	Operate the Farakka Barrage according to the existing operating rules	N N Y Y N N Y Y
Change	Change the present operating rules	N N N N Y Y Y Y
Label		1 2 3 4 5 6 7 8

The possible states or scenarios that could occur in the Farakka dispute are shown as columns of Ys and Ns on the right side of Table 4. The selection of an option by a given DM is indicated by a Y opposite the option and not taking an option is marked using an N. When either a Y or N is written opposite all of the options of a given DM, this constitutes a strategy for the DM. A state is formed when each DM selects a strategy; therefore in Table 4 each column of Ys and Ns constitutes a state for the Farakka Barrage conflict. For example, in the seventh state from the left in Table 4, the N for the Bangladesh option indicates that Bangladesh doesn't agree to the current operation of the Farakka Barrage. Hence, Bangladesh has selected the strategy (N). By operating the Farakka Barrage according to the existing operating rules, which are the changed rules, India has chosen the strategy (Y,Y). Combining Bangladesh's strategy (N) and India's

strategy (Y,Y) creates state (N,Y,Y), when written horizontally in text. For convenience, state (N,Y,Y) is given the label 7 in Table 4.

The next step of the modeling process is to order the states in Table 4 to reflect the preferences of each DM. Accordingly, Table 5 shows the states in the conflict ranked form most preferred on the left to least preferred on the right according to Bangladesh's preferences. As can be seen, the most preferred situation for Bangladesh is state 8 in which India operates the Farakka Barrage according to the changed rules and Bangladesh agrees to this. The least preferred state is 4 in which India operates the dam according to the original rules and Bangladesh accepts this.

Table 5   Ordering of States for Bangladesh

DMs and Options	States							
Bangladesh								
Agree	Y	Y	N	N	Y	N	N	Y
India								
Operate	Y	N	N	N	N	Y	Y	Y
Change	Y	Y	Y	N	N	Y	N	N
Label	8	6	5	1	2	7	3	4

Two different situations are considered for India's preferences as explained below according to Cases A and B. For both cases, state 3 is found to be an equilibrium.

Case A: A decision maker often expresses his or her preferences in terms of which options he or she would like to see selected or not (Fang et al., 1993, 2003). Under Case A, India highest priority is that it operates the Farakka Barrage according to the existing operating rules. Hence, in Table 6, in which states are ranked from most preferred on the left to least preferred on the right for India, notice that the set of states having a Y opposite the option Operate (states 4, 8, 3, and 7) are positioned to the left of the other four states having an N beside the option Operate (states 2, 6, 1 and 5). Next, India would like to see Bangladesh agree to the current operation of the Farakka Barrage (option Agree). Therefore, for the set of four states on the left (states 4, 8, 3 and 7) in Table 6, one can see that states 4 and 8 are more preferred than states 3 and 7. Likewise, for the set of four states listed on the right in Table 6 (states 2, 6, 1 and 5), notice that states 2 and 6 are more preferred than states 1 and 5. Finally, India's

third priority is not to select its option Change. The way in which this affects the final ordering of states in Table 6 can be clearly seen. When needed, conditional preference statement can also be taken into account using option prioritization (Fang et al., 1993, 2003).

Table 6   Ordering of States for India

DMs and Options	States							
Bangladesh								
Agree	Y	Y	N	N	Y	Y	N	N
India								
Operate	Y	Y	Y	Y	N	N	N	N
Change	N	Y	N	Y	N	Y	N	Y
Label	4	8	3	7	2	6	1	5

This ranking of states for Bangladesh and India shown in Tables 5 and 6, respectively, constitute the key modeling information required as input to a stability analysis. The decision support system, GMCR II described in Section 3, can be utilized to calculate stability for each state and each DM according to a range of solution concepts. Additionally, GMCR II can be used with small, medium and large conflicts. Because the conflict considered here is small in size, some of the stability calculations for Nash and sequential stability are now explained for Case A.

When determining stability by hand for a small conflict, the format, given in Table 7, is quite convenient to use. Notice that for Bangladesh and India in Table 7, the ranked states are given according to the ordering shown at the bottom of Tables 5 and 6, respectively, using the state numbers to designate states. The stability of each state for each DM is indicated using the lettering r, s and u to stand for Nash stable, sequentially stable, and unstable, respectively.

Each number written under a given state in Table 7 is a unilateral improvement (UI). A UI is a state to which a particular player can unilaterally move by a change in strategy, assuming that the other player's strategy remains the same. A UI from a state is preferred by the player under consideration and appears to the left of that state in the ranking of states. For example, consider state 6 for India in Table 6. For this state, India has selected the strategy of not operating the Farakka Barrage according to the existing operating rules and changing the present operating rules. Thus,

India has the strategy (N,Y). If Bangladesh maintains the strategy (Y), India could unilaterally change from state 6 to any of 4, 8, or 2 by appropriately changing its option selections from (N,Y) to (Y,N), (Y,Y), or (N,N), respectively. Of these, state 4 is most preferred by India, and is therefore placed immediately under state 6 in the state ranking for India in Table 7. State 2 is also preferred to 6, but it is the least preferred among the UIs, 6, 8, and 2. Therefore, state 2 is written at the bottom of the column.

Table 7　Stability Analysis Tableau

Bangladesh								
	E					E		
Stability	r	r	s	r	s	s	r	u
State ranking	8	6	5	1	2	7	3	4
Uis			6		1	8		3
India								
Stability	r	s	r	u	u	u	u	u
State ranking	4	8	3	7	2	6	1	5
Uis		4		3	4	4	3	3
					8	8	7	7
						2		1

Any state that does not have a UI written below it is Nash stable for the DM under consideration. Hence, an r is written above states 8, 6, 1 and 3 for Bangladesh and states 4 and 3 for India in Table 7 to indicate Nash stability. For a state to be sequentially stable (s), all UIs below the state for a given DM must be sanctioned by the other DM. Consider, for example, the stability of state 2 from the viewpoint of Bangladesh. From the upper portion of Table 7, one can see that Bangladesh has a UI form state 2 to 1. Hence, in state 2 in which Bangladesh agrees to the current operation and India is doing nothing, Bangladesh can improve its situation by deciding not to agree (state 1). However, as shown in the lower portion of Table 7, India has a UI from state 1 to state 3 or 7. By moving to state 3, India follows the current operating rules. Because state 3 is less preferred to state 1 by Bangladesh (see the upper portion of Table 7), the UI by Bangladesh is effectively blocked. Since all the possible UIs from state 2 are sanctioned (in this case there is only one UI), an s is written above state 2 in the state ordering for Bangladesh to indicate sequential stability.

For a state to be unstable for a DM, at least one UI is not sanctioned. Consider, for instance, state 7 from the point of view of India. From the lower portion of Table 7, one can see that India has a UI to state 3. Because Bangladesh has no UI form state 3 (state 3 is Nash stable for Bangladesh), the UI by India cannot be blocked and therefore a u is written above state 7 for India to indicate that the state is unstable for India.

For a state to form an equilibrium or possible compromise resolution it must be stable for all of the DMs. Notice in Table 7 that state 8 is rational (r) for Bangladesh and sequentially sanctioned (s) for India. Hence, state 8 is an equilibrium. The only other state that is an equilibrium is state 3, which is rational for both DMs. In Table 7, an E is written above states 8 and 3 in Bangladesh's ordering of states to indicate that they are equilibria.

As indicated by the Y-N notation in Tables 5 and 6, state 8 represents the desirable situation in which India operates the Farakka Barrage according to changed operating rules and Bangladesh agrees to this. In contrast, state 3 stands for the scenario in which India does not change the rules and operates according to the existing rules without Bangladesh's consent. However, as can be seen, both DMs prefer state 8 over the status quo situation, state 3. Unfortunately, if either of the DMs independently changes its strategy selection to try to improve the situation, the resulting state is less preferred for that DM. This process is shown in Table 8. As illustrated in the third column from the right in Table 8, if Bangladesh changes its option selection from not agreeing to agreeing, the result is state 4 which is less preferred than state 3 by Bangladesh (see Table 5). Therefore, this change of option choice is a unilateral disimprovement for Bangladesh. As shown in the middle part of Table 8, if India unilaterally decides to change the present operating rules, this creates a unilateral disimprovement for India from state 3 to7.

In summary, neither DM on its own has the motivation to move from state 3 to 8, because such a movement constitutes a unilateral disimprovement. To reach state 8, which is more preferred over state 3 by both DMs, Bangladesh and India must cooperate with one another and jointly move to state 8, as is illustrated in the right column in Table 8. In fact, a Third Party is needed to encourage communication and understanding between the two DMs to bring about a win/win resolution.

Table 8   Transitions from state 3

DMs and Options	Bangladesh		India		Together	
Bangladesh						
Agree	N	→ Y	N	N	N	→ Y
India						
Operate	Y	Y	Y	Y	Y	Y
Change	N	N	N	→ Y	N	→ Y
Label	3	→ 4	3	→ 7	3	→ 8
	unilateral		*unilateral*		*joint*	
	disimprovement		*disimprovement*		*improvement*	

Case B: India's highest priority is that it operates the Farakka Barrage according to the existing operating rules.   Next, India would not like to select the option Change.   Finally, India's third priority is to see Bangladesh agree to the existing operating rules.   The way in which this affects the final ordering of states in Table 9 can be clearly seen.

Table 9   Ordering of States for India

DMs and Options	States							
Bangladesh								
Agree	Y	N	Y	N	Y	N	Y	N
India								
Operate	Y	Y	Y	Y	N	N	N	N
Change	N	N	Y	Y	N	N	Y	Y
Label	4	3	8	7	2	1	6	5

The only state which is stable according to rational or sequential stability for both DMs is state 3, which is rational for each of them.   Hence, state 3 is an equilibrium.

Interpretation: For Conflict 1, in which there is no Third Party, state 8 is the most preferable state for Bangladesh, and this state can be realized when the state ranking for India is that given under Case A.   As for Case B, if India prefers state 8 to 3, and 6 to 1, the state ranking for India can be changed to be the same one as in Case A, where state 8 is achieved as an equilibrium.   This change in preference can be brought about if India's third priority under Case B becomes its second priority, which is identical to Case A.   In other words, India prefers that Bangladesh agrees to the current operation of the Farakka Barrage

more than India not changing the present operating rules.   This change in priorities by India would cause state 8 to become more preferred than state 3, and state 6 more preferred than 1.

In the present circumstances, it may be difficult for Bangladesh and India on their own to reach state 8.   Nonetheless, the participation of a Third Party may cause this to happen.   Accordingly, in the next section a Third Party is brought into the study to ascertain if a breakthrough can be achieved.

5.2 Conflict 2: Analysis with a Third Party

It is explained in Section 4 and depicted in Fig. 2 that a Third Party can play one of three possible roles: Arbitrator, Coordinator or Donor.   In this section, a Third Party is brought into the study of the Farakka Barrage conflict in order to encourage India to change its preferences to bring about a more desirable result.   Hence, the Third Party is acting as a Coordinator.   Below, both Cases A and B are strategically examined for the situation when a Coordinator is present.

A Donor can be used to bring about significant changes in preferences and other model parameters over a long period of time.   Sakamoto and Hagihara (2001) present a decision model for conflict which allows for preferences in a conflict to change over time.

To control a conflict, an Arbitrator can exclude certain states.   For example, assume that Bangladesh and India have the ranking of states shown in Tables 5 and 9, respectively.   This, of course, is Case B in which only state 3 is an equilibrium.   This undesirable situation could be improved if an Arbitrator excludes state 3 as a possible solution.   When state 3 is omitted from the conflict model, a stability analysis finds states 1 and 4 to be equilibria.   If the Arbitrator does not allow states 1 and 3, or 3 and 4, then state 5 is achieved as an equilibrium.   Additionally, if the Arbitrator simultaneously excludes states 1, 3, and 4, then states 5 and 6 are found to be equilibria.   From Bangladesh's point of view state 6 is more preferred than state 3.

The modeling and analyses given below are similar to Cases A and B in Section 5.1, except that a Coordinator is now present.   In the ensuring analyses, it is assumed that all states are equally preferred by the Coordinator who must act in an unbiased manner to assist in bringing about an acceptable solution to the Farakka Barrage dispute.

Case A: When a Coordinator or Third Party is

participating in the Farakka Barrage conflict, the DMs, options and states are as shown in Table 10. The Third party has the option of taking some type of action (called Act in Table 10) that will encourage Bangladesh and India to reach a mutually attractive agreement. As can be seen in Table 10, the states are numbered from 1 to 16 in order to be able to refer to them conveniently. The equivalent state numbers from Conflict 1 in Section 5.1 are given at the bottom of Table 10 under the assumption that the Third Party is ignored. However, unless stated otherwise, the state numbers for the conflict with a Third Party are used in the remainder of this section. The status quo situation is captured by state 3 in Conflict 2.

Table 10　DMs, Options, and States with a Third Party

DMs and Options	States															
Bangladesh																
Agree	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
India																
Operate	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Change	N	N	N	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
Third Party																
Act	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Label	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
State numbers in Conflict 1	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

To set Bangladesh's preferences, it is assumed that Bangladesh prefers that the Third Party takes an action more than when it doesn't. Other than that, the essential preferences of Bangladesh are the same as in Conflict 1. The ranking of states for Bangladesh is shown in Table 11. Once again, the state numbers from Conflict 1 are listed at the bottom of Table 11.

Table 11　Ordering of States for Bangladesh with a Third Party

DMs and Options	States															
Bangladesh																
Agree	Y	Y	Y	Y	N	N	N	N	Y	Y	N	N	N	N	Y	Y
India																
Operate	Y	Y	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y
Change	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	N	N	N	N
Third Party																
Act	Y	N	Y	N	Y	N	N	Y	N	Y	Y	N	N	Y	N	Y
Label	16	8	14	6	13	5	1	9	2	10	15	7	3	11	4	12
State numbers in Conflict 1	8	8	6	6	5	5	1	1	2	2	7	7	3	3	4	4

As for India, it is assumed that India prefers that the Third Party takes an action more than when it doesn't. Except for this preference assumption, the preferences for India are essentially identical to those given under Case A in Section 5.1. Therefore, India's highest priority is operating the Farakka Barrage according to the existing operating rules. Secondly,

India would like to see Bangladesh agree to the current operating rules. Thirdly, India would like the Third Party to act. Finally, India's fourth priority is not to change. Based upon these assumptions, the state ranking for India is as shown in Table 12.

Table 12　Ordering of States for India with a Third Party

DMs and Options	States															
Bangladesh																
Agree	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	N	N	N
India																
Operate	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Change	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Third Party																
Act	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N
Label	12	16	4	8	11	15	3	7	10	14	2	6	9	13	1	5
State numbers in Conflict 1	4	8	4	8	3	7	3	7	2	6	2	6	1	5	1	5

Assuming the preferences displayed in Tables 11 and 12 for Bangladesh and India, respectively, an analysis is carried out to determine the stable states for each DM as well as the equilibria. The four equilibria in Conflict 2, Case A, are found to be states 3, 8, 11 and 16. States 3 and 11 are rational for both DMs, states 8 and 16 are rational for Bangladesh and sequentially sanctioned for India.

Among the four possible equilibria, the most desirable resolution for both Bangladesh and India is state 16. The process required to reach state 16 is depicted in Table 13. As shown in the bottom right in Table 13, if Bangladesh, India, and the Third Party move together from state 3, they can bring about state 16, which is an improvement for all concerned. However, Bangladesh may not trust India to implement its strategy, Change, to bring about state 16 and likewise India may not have confidence in Bangladesh to behave in a trustworthy fashion. As shown in the top part of Table 13 on the left on center, if either Bangladesh or India moves alone, the resulting state is a unilateral disimprovement. Therefore, the assistance of the Third Party is required to help build confidence. From the top right part of Table 13, if Bangladesh and the Third Party move together from state 3, a unilateral disimprovement (state 12) occurs for Bangladesh. However, as can be seen in the bottom left portion of Table 13, when India and the Third Party move together from state 3, the result is state 15, which is more preferred by India. It should be emphasized that state 15 is an improvement for India even though Bangladesh is not changing its position when going

from state 3 to 15. Based upon this finding, the Third Party can make Bangladesh believe that India and the Third Party can move together with Bangladesh. Therefore, state 16 is reached through this mutual trust. Even when the Third Party does not act and Bangladesh and India cooperate on their own, as shown in the middle lower column in Table 13, Bangladesh and India have a joint improvement from state 3 to 8, which is more preferred by both DMs. However, India prefers state 4 more than state 8, which is achieved by a unilateral improvement of India. Hence, the movement from state 3 to 16 is more likely to occur since the Third Party is more actively involved and state 16 is more preferred to state 8 by both Bangladesh and India.

Table 13   Transition from state 3

DMs and Options	Bangladesh			India			Bangladesh & Third Party		
Bangladesh									
Agree	N	→	Y	N		N	N	→	Y
India									
Operate	Y		Y	Y		Y	Y		Y
Change	N		N	N	→	Y	N		N
Third Party									
Act	N		N	N		N	N	→	Y
Label	3	→	4	3	→	7	N	→	Y
		unilateral disimprovement			*unilateral disimprovement*			*joint disimprovement*	

DMs and Options	India & Third Party			Bangladesh & India			All together		
Bangladesh									
Agree	N		N	N	→	Y	N	→	Y
India									
Operate	Y		Y	Y		Y	Y		Y
Change	N	→	Y	N	→	Y	N	→	Y
Third Party									
Act	N	→	Y	N		N	N	→	Y
Label	3	→	15	3	→	8	3	→	16
		joint improvement			*unilateral improvement*			*joint improvement*	

Case B: The ranking of states for Bangladesh is assumed to be the ordering given for Case A in Table 11. India prefers that the Third Party acts over situations in which it does not act. India's highest priority is that it operates the Farakka Barrage according to the existing operating rules. Secondly, India would like the Third Party to take an action. Thirdly, India would not like to select the option Change. Finally, India would like to see Bangladesh agree to the current operating rules. Based upon these assumptions, the state ranking for India is set as in Table 14.

Table 14   Ordering of States for India
with a Third Party

DMs and Options	States															
Bangladesh																
Agree	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
India																
Operate	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N
Change	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
Third Party																
Act	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	N	N	N
Label	12	11	16	15	4	3	8	7	10	9	14	13	2	1	6	5
State numbers in Conflict 1	4	3	8	7	4	3	8	7	2	1	6	5	2	1	6	5

Using the ranking of states given in Tables 11 and 13, for Bangladesh and India, respectively, GMCR II calculates states 3 and 11 to be the only equilibria. States 3 and 11 are rational for both DMs. In Conflict 1, these states are similar to state 3 which represents the present situation. Nothing has changed by participation of the Third Party. Hence, a further assumption is required to improve the conflict situation.

One approach is to add an Arbitrator who has the power to dictate changes. The Arbitrator could, for example, remove state 11 from the conflict in Table 10 and maintain the state rankings of Bangladesh and India shown in Tables 11 and 14, respectively. This is done in order to assign relevance to an action taken by the Third Party, since it will not have an action if it cannot persuade India to change. Under this changed model, GMCR II calculates states 3, 12, and 15 to be equilibria. States 3 and 12 are rational for both DMs, and state 15 is sequential sanctioned for Bangladesh and rational for India.

State 15 implies improvement of the conflict situation because both DMs prefer it more than state 3. However, state 15 indicates that India operates the Farakka Barrage although Bangladesh doesn't agree so that this state cannot be considered as an essential resolution for the India/Bangladesh conflict. On the other hand, state 15 also shows that India changes the present operating rules to benefit Bangladesh. This attitude change by India can be interpreted as an improvement of the conflict situation.

The essential resolution for the conflict is represented by state 16. To obtain state 16 as an

equilibrium, state 12 should be eliminated, although this is procedure that only an Arbitrator can implement.

As the India/Bangladesh conflict, in the case that DMs have been conflicted over years among themselves and the situation has been stiff, it would be difficult to resolve a conflict situation with a single measure because DMs' preferences are essentially different. To improve a situation, some steps by different roles of the Third Party would be required. Our framework about the Third Party could be also useful to analyze clearly the process of conflict management.

6. Conclusions

Intervention by a Third Party is often said to be an important matter for the conflict. However, it's not clearly defined the roles in which a Third Party plays, and there is not an only way to intervene among DMs as shown in this study. Sometimes, a party who concerned to a conflict as a Third Party turns out to be a DM who has its own preference.

It is needed for the future conflict management that the process and background of conflict is considered, and fair and equitable procedures should be taken. Upon this recognition, this study focused on the roles of a Third Party, which is one of ways to resolve a conflict situation, and the concept of a Third Party for conflict management is proposed within the framework of GMCR II. Then, it is shown that mediation effect of a Third Party can bring possibility of dissolving a conflict.

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GMCR II

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