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A Study on Social Conflict Management in a Water Resources Development - A Case of the Conflict between India and Bangladesh over Regulation of the Ganges River -

水資源計画における社会的コンフリクトのマネジメントに関する研究
インド・バングラデシュのガンジス河利用に関するコンフリクトを対象として

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The Gages River is important water resources for Bangladesh and India from the old ages, and they have been conflicting over the Ganges water resources. The distribution of water resource from the Ganges is generally advantageous to India which is placed on the upstream of the river. The conflict between Bangladesh and India has been stagnant since they have negotiated only by themselves. In such a case, participation of third party is considered.

In this study, Conflict Analysis is used for modeling. Conflict Analysis is built based on the game theory and it provides algorism to analyze equilibriums among players who have different payoff matrix. Upon this framework of Conflict Analysis, roles of third party are classified and defined into 3 types, 'Donor', 'Coordinator', and 'Arbiter', which are called 'Complement' on the whole. This model is applied to the conflict between Bangladesh and India. First, the actual situation is described by using conflict analysis. Second, the condition which is necessary to improve circumstance of current conflict is analyzed, and the role of third party which realizes this condition is considered. Third, one role of complement, 'Coordinator', is focused on here in particular, and it is analyzed what condition is necessary so that 'Coordinator' improves circumstance of conflict.

Key Words : Conflict analysis, game theory, conflict management, water resources development

世界で発生する水資源をとりまくコンフリクトのひとつとして、バングラデシュとインドのガンジス河の水利用に関するコンフリクトがある。ガンジス河の水利用はバングラデシュの上流に位置しているインドに有利な内容になっている。こうした背景の下、2国間のみでの交渉が続けられ、コンフリクトの状況は停滞している。このように当事者間でコンフリクトの状況が硬直した場合、コンフリクトの解決へ向けて、第三者機関の介入が重要となると考えられる。

本研究では、利害の異なるプレーヤー間の均衡状態について分析するゲーム理論を基礎として構築されたコンフリクト解析を用い、この枠組みで第三者機関の役割について分類と定義を行う。まず、第三者機関を利得関数を持たない主体 'Complement' として定義する。さらに、その役割を 'Donor'、'Coordinator'、'Arbiter' の3タイプに分類する。

以上の 'Complement' のコンセプトを元に、バングラデシュとインドのコンフリクトについて分析を行う。まず、現状をコンフリクト解析を用いて記述し、次に、現状の記述から現在のコンフリクトの状況を改善するために必要な条件を分析する。そして、この条件を実現するような第三者機関の役割について考察する。さらに、第三者機関の役割として定義した中から、特に 'Coordinator' に着目し、'Coordinator' がコンフリクトの状況を改善するために必要な条件を明確にする。

キーワード : コンフリクト解析, ゲーム理論, コンフリクト・マネジメント, 水資源開発

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I. INTRODUCTION

The Ganges is important water resources for Bangladesh and India from the old ages, and they have conflicted over the Ganges water resources. This conflict situation changed drastically in 1975 because India constructed the Farakka Barrage over the Ganges in the Indian area near the border. India and Bangladesh had no consensus about this construction at all. India made it unilaterally. They made treaty about water resources use of the Ganges after construction, in 1975, 1977, and 1996. They are sometimes operative and inoperative depending on political background of the two countries.

Three treaties are different in some points. However, those are generally advantageous to India which is placed on the upstream of the river. Bangladesh is more vulnerable to flood and drought than India because of the Farakka Barrage. Bangladesh government cannot make a plan about its national water resources utilization without considering the effect of the Farakka Barrage. From this aspect, flood and drought in Bangladesh might be said as a man made disaster.

II. HISTORY OF THE GANGES CONFLICT BETWEEN BANGLADESH AND INDIA

India lies upstream of Bangladesh along the Ganges. The map of the relation of two countries is shown in Fig. 1 which is made with a figure from national geographic website, <http://www.national-geographic.com/>. Both of them have been suffering

Fig. 1 The Farakka Barrage.

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 water resources between two countries are shown in the following.

India built the Farakka Barrage unilaterally across the Ganges River near the border of Bangladesh and India in 1975. Temporal treaty was concluded at first between them. This treaty said that India drew 310-350m³/s of water at the Farakka Barrage and discharged 1,245-1,400m³/s of water to the downstream from April 21 to 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 countries came to conclude second agreement in 1977.

The content of 1977 Treaty is shown in Table 1. This treaty was concerned with the Ganges River water resources allocation during dry season from January to May. India got a right to draw more wa-

Table 1 1977 Treaty.

Month	Day	Flow 1948-73 (m ³ /s)	Withdrawal by India (m ³ /s)	Release to Bangladesh (m ³ /s)
Jan	1-10	2,790	1,133	1,657
	11-20	2,542	1,090	1,451
	21-31	2,336	991	1,345
Feb	1-10	2,244	935	1,310
	11-20	2,096	892	1,204
	21-28	1,982	871	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

ter than India used to have in 1975's temporal 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, and the treaty was concluded again in 1996. A general allocation rule was stipulated as shown in **Table 2**. This treaty is still carried out at the time of 2004.

In 1996 Treaty, Bangladesh made even more compromise than in 1977-1984's treaty because the amount of water that Bangladesh can get is sometime less than 800m³/s in 1996 Treaty.

1996's treaty has brought settlement to the dispute of two countries for the time being, but the conflict does not seem to be completely resolved. The treaty is advantageous to India which is upstream country, and there would be much com-

plaint in Bangladesh. Construction of positive association between Bangladesh and India is one of important ways to reduce the vulnerability regarding water resources management in Bangladesh. This kind of disastrous factor might be said as man-made disaster risk.

The severe guard system is spread around the Farakka Barrage. The unilateral execution of construction and the unilateral conclusion of treaty by India seem to have been a matter of life and death for India, and it tells how important India recognizes the Farakka Barrage is. After 1996 treaty was concluded, India/Bangladesh conflict was generally considered to be settled. However, India has more right than Bangladesh because 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 upstream country of Bangladesh along the Ganges River. Under such economical, political, and geographical background, Bangladesh has been following 1996 treaty. There is still difference between India and Bangladesh with respect to the situation of water resources utilization. This difference has not been world widely reported, but it exists.

Table 2 1996 Treaty.

Month	Day	Flow 1949-88 (m ³ /s)	Withdrawal by India (m ³ /s)	Release to Bangladesh (m ³ /s)
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	961	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

III. CONFLICT ANALYSIS (Fong, L. *et al.*, 1993; Frai-ser, N.M. *et al.*, 1984; Okada, N. *et al.*, 1988)

Conflict analysis is the method which is systematized based on game theory to classify outcomes by their stability, comparing with preference vector of each player. Conflict Analysis is characterized as below where it is compared with a standard game that is formulated by a pay-off matrix like a familiar two-by-two prisoner's dilemma game. First, Conflict Analysis generally assumes any number of players, each of whom has any number of options or alternatives to be taken. Here, a set of outcomes is defined as possible combinations of all options of all players but logically or practically impossible outcomes should be deleted.

Once a set of outcomes is determined, it is investigated how each player places each outcome in

the order according to their preference. Here, it is allowed to give same order to any subset of outcomes and thus it is even possible to give no difference in the order to all outcomes. Reliance on preference order instead of numerical benefit/cost has both advantage and disadvantage. A research subject, a player, can express its preference order with less difficulty and more confidence than numerical preference although it is impossible to express subtle difference in preference among outcomes.

After preference order of each player is determined, equilibrium solutions, a major output of Conflict Analysis, are obtained as follows. An equilibrium solution represents an outcome where any player cannot change its option due to the possibility that less favorable outcome might be attained by succeeding change of options by other players. In this sense, an equilibrium solution represents an outcome that is a deadlock situation from which any player cannot move to a better outcome by changing its own option alone. Generally, it is possible to find one or more equilibrium solutions. As you see in the definition of equilibrium solution above, it is one of the characteristics of Conflict Analysis to take into consideration a look-ahead of each player about possible succeeding change of options by other players.

Then, mathematical characteristic of Conflict Analysis is explained as follows.

Let S_i represents the strategy set of player i . A typical element of S_i is denoted by s_i . Let the set of n players be denoted by N . If K is subset of N , S_K is a joint strategy choice by the players in set K , and S_{N-K} is the corresponding set of joint strategies. Then, S_{N-K} is the joint strategy of the players other than those contained in set K , and S_{N-K} is the corresponding set of joint strategies. A certain combination of s_i for i is called an outcome which is represented by q . Q denotes the set of all the outcomes.

To define meta-game criteria for the determination of stability thorough, the following sets of outcomes are defined.

$M_i^+(q)$ is the set of outcomes preferred by player i to q .

$M_i^-(q)$ is the set of outcomes not preferred by player i to q (set includes q);

note that $M(q) = \{M_i^+(q) \cup M_i^-(q)\} \quad q \in Q$. For $(\overline{s_i}, \overline{s_{N-i}})$ where the bar denotes the fact that the indicated strategy is fixed,

$$m_i(q) = \{(s_i, \overline{s_{N-i}}) | s_i \in S_i\} \quad (1)$$

is the set of outcomes accessible unilaterally from q by player i (includes q). Define

$$m_i^+(q) = m_i(q) \cap M_i^+(q) \quad (\text{this is a UI}) \quad (2)$$

$$m_i^-(q) = m_i(q) \cap M_i^-(q) \quad (3)$$

Note that $m_i(q) = m_i^+(q) \cup m_i^-(q)$

An outcome q is not preferred by i to an outcome p if and only if

$$M_i^-(q) \cap M_i^-(p) \neq \emptyset \quad (4)$$

This means that

$$q \in M_i^-(p) \quad (5)$$

Furthermore, *unilateral improvements* (UI) is defined as

$$s_i \in \{(s_i, \overline{s_{N-i}}) | (s_i, \overline{s_{N-i}}) \in M_i^+(q)\} \quad (6)$$

The outcomes produced by unilateral improvements are also called unilateral improvements, and are abbreviated UI. Given $q = (\overline{s_i}, \overline{s_{N-i}})$, a UI $p \in P$ from q would be given by

$$p \in \{(s_i, \overline{s_{N-i}}) | (s_i, \overline{s_{N-i}}) \in M_i^+(q)\} \quad (7)$$

Thus, a UI from q is member of the set $m_i^+(q)$

A game is an object described by the strategy sets and preference functions of all the players.

The outcome, which is stable for every player, is called equilibrium. Classification and definitions of stability are shown as follows.

1) Rational stability

If there is no outcome called *unilateral improvements* for player i , in other words, if player i cannot find an outcome preferable to q by a unilateral change of strategy, this type of a situation is called rational stability.

More formally, an outcome $q = (\overline{s_i}, \overline{s_{N-i}})$ is rational for player i if, for a fixed strategy choice $\overline{s_{N-i}}$ of the players and for all possible strategy choice for i (s_i) player i cannot find outcome preferred to q . Thus

$$R_i = \{q | s_i \in \{(s_i, \overline{s_{N-i}}) | (s_i, \overline{s_{N-i}}) \in M_i^-(q)\}\} \quad (8)$$

2) Sequential stability

Considering sequential change of outcomes, meta-game analysis indicate

s that an outcome can be made stable for a particular player if another player has a change in strategy from the particular player's UI that results in less preferred outcome for the particular player. If any outcomes that result from consistent improvement on the part of the other players are not preferable for a particular player to the outcome under consideration, the outcome is sequentially stable for that player. This is described mathematically by

$$(p, m_i(q); m_{N \setminus i}^+(p), M_i(q) = q / R_i. \quad (9)$$

3) Simultaneous stability

Sequential stability is defined based upon the deterrent effect of another player improving from the improvement made by a player. However, the mutual deterrent effect of improvements from the original outcome must also be assessed. If the outcome that results from the changes made by both players improving simultaneously is less preferred for a player, then it is a credible sanction against the possible improvement and the original outcome may be considered stable. This is defined as simultaneous stability.

4) Unstable

The player has at least one UI from which the other players can take no credible action that results in a less preferred outcome for that player. This is defined as unstable.

A player 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 player can improve his utility payoff by changing their strategy, this outcome constitutes equilibrium.

IV. CONFLICT MANAGEMENT WITH COMPLEMENT

In this section, a concept for conflict management with 'complement' is proposed. The concept of 'complement' is drawn in Fig. 2.

In the concept for conflict management with 'complement', third party is assumed to improve the conflict situation, and it is called as 'complement' in this study. Then, the relationship between equilibriums and roles of 'complement' is analyzed.

Fig. 2 shows the difference among roles of 'complement'. The comparison of each results brought by different roles will provide the important information to support conflict management with a third party.

'Complement' means something that makes perfect or make whole or entire (Random House New York. 1997). We define that 'complement' is another party who does not participate in the actual game, and that it participates the game with the motivation for conflict management. We classify 'complement' into 3 types by its role which can be seen in Fig. 2; one is 'donor', another is 'coordinator', and the other is 'arbiter'. 'Donor' generally means a person who presents as a gift, grant, or contribution (Random House New York. 1997). 'Coordinator' generally means a person or thing that combine in harmonious relation or action (Random House New York. 1997). 'Arbiter' generally means a person who has the sole or absolute power of judging or determining (Random House New York. 1997).

The flow of Fig. 2 shows that if a party has its own preference vector, it can be thought as one player. If it does not have its preference vector, it is defined as the complement, and the role of the complement can be classified into 'arbiter', or 'donor' or 'coordinator'. The difference among them is whether it has options or not. If it has options, then it is classified into 'donor', or 'coordinator'. If it does not have any option, it is classified into 'arbiter'.

The difference between 'donor' and 'coordinator' is whether it can change other players' preference vector at that time or not. If it can change players' preference at that time by offering some options to other players, the role of the complement is defined as 'coordinator'. If it cannot, the role of the complement is defined as 'donor'. The donor offers options which do not give the direct influence to the conflict situation at the moment, such as funding, transferring technologies, building an education system, and in the long term they might help other players to bear a new option by themselves, or to change its lifestyle and preference essentially.

If the complement does not have its own prefer-

Fig. 2 The Classification of the Roles of Complement.

ence vector and options, the role of the complement is defined as 'arbiter'. The arbiter has the power to exclude some outcomes, and restricts players to move to other outcomes.

Players have their own options and preference vector in Conflict Analysis, and equilibriums are provided under each preference which is insisted

on by all players. In this respect, the concept of the complement is different from original Conflict Analysis.

Mathematical characteristic of the complement is shown as follows.

Let subscript ' c ' represent the complement, and let the dashed sets ' q ', ' Q ', ' S ' represent the set

Table 3 Rules of Allocation on 1996 Treaty(m³/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

which has changed after the complement participates in the game. $P_i(Q)$ is preference vector of player i ($i = c$) and to make the meaning of complement's participation clear, the preference vector $P_{i,s'-s_c}(Q')$ is defined. It means the preference vector without the complement's strategies. If the time shift is considered, $P_{i,s'-s_c}^t(Q')$ is used.

1) Donor

The donor has some options, and it does not influence actual preference vectors, but after some time shifts, it will change players' preference. Following equations describe requirement for the donor.

$$S_c \neq \emptyset \quad (10)$$

$$P_{i,s'-s_c}^t(Q') = P_i^t(Q) \quad (11)$$

$$P_{i,s'-s_c}^{t+T}(Q') = P_i^{t+T}(Q) \quad (12)$$

2) Coordinator

The coordinator has some options, and they influence players' actual preference vectors. Following equations describe requirement for the coordinator.

$$S_c \neq \emptyset \quad (13)$$

$$P_{i,s'-s_c}^t(Q') = P_i^t(Q) \quad (14)$$

3) Arbiter

The arbiter does not have any options. They can reduce outcomes, and it restricts players' action. Following equations describe requirement for the arbiter.

$$S_c = \emptyset \quad (15)$$

$$|Q'| \leq |Q| \quad (16)$$

Note that $|Q'|$ means the number of elements which are included in the set Q' .

V. A CASE STUDY ON THE FARAKKA BARRAGE PROBLEM

1. GAME 1 : Description of the Actual Situation

In this paragraph, the actual situation is described by Conflict Analysis. Players and options

Table 4 Players, Options, and Outcomes on the Farakka Barrage Problem.

Options	Outcomes							
Bangladesh								
Agree	0	1	0	1	0	1	0	1
India								
Use	0	0	1	1	0	0	1	1
Reconsider	0	0	0	0	1	1	1	1
Decimal	0	1	2	3	4	5	6	7

are set, referring to the reality, as shown in **Table 4**. In the following, the option 'agree' means that Bangladesh agrees to use the Farakka Barrage, 'use' means that India uses the Farakka Barrage, and 'reconsider' means that India reconsiders the rule of using the Farakka Barrage.

The execution of an option by a given player is indicated by a 1 opposite it; a 0 indicates the option is not executed. When either a 1 or 0 is written for all of the options of a given player, this constitutes a strategy for the player. An outcome is formed by all of the strategies of all players; therefore in **Table 4** each column of 1s and 0s constitutes an outcome for the Farakka Barrage Problem. For example, in the seventh column from the left in **Table 4**, the 0 for the Bangladesh option indicates that Bangladesh does not agree to use the Farakka Barrage. Then, Bangladesh has selected the strategy (0) By using the Farakka Barrage and reconsidering the rule of using the Farakka Barrage, India has chosen the strategy (1,1) Combining Bangladesh strategy (0) and India strategy (1,1) the outcome (0,11) is composed. The notation using 1s and 0s is designed for convenient representation of each outcome. A shorter style of symbol is developed from the outcomes by considering them as binary numbers and then converting them to decimal numbers like converting (0,11) into $1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$. The decimal values of all the outcomes are listed below outcomes in **Table 4**.

The next step of the modeling process is to order the outcomes of **Table 4** to reflect the prefer-

ences of each player. Bangladesh's preference is assumed as in **Table 5** according to the historical background (Kondo, N., 1997)

Then, the decimal notation of Bangladesh's preference vector is {7, 5, 4, 0, 1, 6, 2, 3}, where the outcomes are ordered with the most preferred on the left and the least preferred on the right. As can be seen, the most preferred situation for Bangladesh is state 7 in which India operates the Farakka Barrage according to the changed rules and Bangladesh agrees to this. The least preferred state is 3 in which India operates the barrage according to the original rules and Bangladesh accepts this.

On the other hand, preference vector for India is assumed as following 2 types. These can realize the outcome '2' as equilibrium, which describes the actual situation. The difference of these preference vectors is India's priority over Bangladesh's option 'Agree'. India has higher priority over the option 'Agree' in CASE A than in CASE B.

CASE A : India has priority over using the Farakka Barrage, and Bangladesh's agreeing is second preferred. As for the option 'reconsider', India

does not want to reconsider the rule, and this option is the least priority for India. Then, India's preference is assumed as in **Table 6**. From these settings, the outcomes '2' and '7' are achieved as equilibriums.

CASE B : India has priority over using the Farakka Barrage, and not reconsidering the rule is second preferred. As for the option 'agree', India does not care if Bangladesh agrees to use the Farakka Barrage or not, and this option is the least priority for India. From these characteristics, India's preference vector is described as in **Table 7**. Then, the outcome '2' is achieved as equilibrium.

To help comprehending the process of Conflict Analysis to classify outcomes and define equilibriums, the stability analysis tableau for **CASE A** is shown in **Table 8** and **Table 9** for an example.

Numbers under some of the outcomes in **Table 8** are 'UIs' (unilateral improvement). An 'UI' is an outcome to which a particular player can unilaterally move by a change in strategy, assuming the other player's strategy remains the same. Under normal circumstances, UIs from an outcome are preferred by the player under consideration and

Table 5 Preference Vector for Bangladesh.

Options	Outcomes
Bangladesh	
Agree to use the Farakka Barrage	1 1 0 0 1 0 0 1
India	
Use the Farakka Barrage	1 0 0 0 0 1 1 1
Reconsider the rule of using the Farakka Barrage	1 1 1 0 0 1 0 0
Decimal	7 5 4 0 1 6 2 3

Table 6 Preference Vector for India.

Options	Outcomes
Bangladesh	
Agree to use the Farakka Barrage	1 1 0 0 1 1 0 0
India	
Use the Farakka Barrage	1 1 1 1 0 0 0 0
Reconsider the rule of using the Farakka Barrage	0 1 0 1 0 1 0 1
Decimal	3 7 2 6 1 5 0 4

Table 7 Preference Vector for India.

Options	Outcomes
Bangladesh	
Agree to use the Farakka Barrage	1 0 1 0 1 0 1 0
India	
Use the Farakka Barrage	1 1 1 1 0 0 0 0
Reconsider the rule of using the Farakka Barrage	0 0 1 1 0 0 1 1
Decimal	3 2 7 6 1 0 5 4

Table 8 Stability Analysis Tableau for CASE A.

Bangladesh								
player stability	<i>r</i>	<i>r</i>	<i>s</i>	<i>r</i>	<i>s</i>	<i>s</i>	<i>r</i>	<i>u</i>
preference vector	7	5	4	0	1	6	2	3
UIs		5		0	7		2	
India								
player stability	<i>r</i>	<i>s</i>	<i>r</i>	<i>u</i>	<i>u</i>	<i>u</i>	<i>u</i>	<i>u</i>
preference vector	3	7	2	6	1	5	0	4
UIs		3		2	3	3	2	2
					7	7	6	6
						1		0

Table 9 Overall Stability for CASE A.

Outcomes	0	1	2	3	4	5	6	7
	×	×	E	×	×	×	×	E

appear to the left of that outcome in the preference vector. For example, consider outcome 5 for India. From the binary interpretation, it can be seen that in this outcome India has selected the strategy of not using the Farakka Barrage and reconsidering the rule; thus, this is notated as (0,1). If Bangladesh maintains the strategy (1) India could unilaterally change the outcome '5' to any of '3', '7', or '1' by appropriately changing its option selections from (0,1) to (1,0) (1,1) or (0,0) respectively. Of these, the outcome '3' is most preferred by India, and is therefore placed immediately under the outcome '5' in the preference vector for India in Table 8. The outcome '1' is also preferred to '5', but it is the least preferred among UIs, '5', '7', and '1'. Then, the outcome '1' is written the most bottom of the column.

In Table 8, 'r' means *rational*, 's' means *sequentially sanctioned*, and 'u' means *unstable*. The definition of these stabilities is given above, in the part of explaining mathematical characteristics of Conflict Analysis.

If an outcome possesses some type of stability for all the players in a game, that is, here in Table 8, if an outcome is given 'r' or 's', it is called an equilibrium, and this outcome constitutes a possible resolution to the conflict. For example, the outcome '7' is rational for Bangladesh and sequentially stable for India. Equilibriums are shown in Table 9. An outcome that is unstable for at least one player is marked with an $\times$.

In GAME 1, the outcome '7', the most preferable outcome for Bangladesh, can be realized when the preference vector for India is set as in CASE A. As for CASE B, if India prefers the outcome '7' more than '2', and '5' more than '0', the preference vector for India can be changed to the same one as that in CASE A where the outcome '7' is achieved as equilibrium. This change of preference can be interpreted that India comes to want more strongly Bangladesh to agree to use the Farakka Barrage than not to reconsider the rule of using the Farakka Barrage. In CASE A, India prefers Bangladesh's agreeing to not reconsidering the rule, and it is opposite in CASE B. If adverse change of preference for the outcomes '2' and '7', and '0' and '5' is

produced, the conflict might change from stiff situation to the compromise under mutual agreement.

However, if the actual situation is taken into consideration, it is hard to occur that India changes its preference under the settings of GAME 1 - CASE B. Therefore, when a conflict becomes stiff among parties, a breakthrough of the situation is considered by participation of the complement.

As for the donor, analysis is done by using Conflict Analysis successively assuming time shifts. Sakamoto and Hagihara (Sakamoto, M. *et al.*, 2001) present a decision model for a conflict which allows players' preferences to change over time. Therefore, in this study, analysis with the arbiter and the coordinator are shown in the following.

2. GAME 2 : Analysis with Arbiter

The arbiter can exclude outcomes, and control a conflict. For example, let's assume that India has the preference described as in CASE B which is the worse conflict situation than CASE A in general because only the outcome '2' can be achieved as equilibrium in CASE B, which means that there is no possibility to improve the conflict situation. If the arbiter excludes the outcome '2', then the outcomes '3' and '6' are achieved as equilibriums. If the arbiter excludes the outcomes '2' and '6', then the outcomes '1' and '3' are achieved as equilibriums. In the real world, court, or committee, or organization which are given legislative measures can be the arbiter.

3. GAME 3 : Analysis with Coordinator

Setting with the coordinator is assumed as in Table 10, where the coordinator is represented by 'Third Party' and it has an option 'take an action'.

Table 10 Players, Options, and Outcomes with the Coordinator.

Options	Outcomes														
Bangladesh															
Agree	0	1	0	1	0	1	0	1	0	1	0	1	0	1	
India															
Use	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1
Reconsider	0	0	0	0	1	1	1	0	0	0	0	1	1	1	1
Third Party															
Take an Action	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Origins	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6

In the following, the model analysis is done with eliminating the outcome '10' because the outcome '10' in **GAME 3** seems not to be changed comparing to the actual situation described in **GAME 1**, nevertheless Third Party takes the action. This means that Third Party's action has no executive power. If the actual situation has to be restricted by Third Party, only the role of Arbiter can realize it. However, the role of the arbiter is sometimes too strong to consider the result as a conflict resolution with players' mutual understanding. Intervention by the arbiter should be the last measure in the conflict management. In **GAME 3**, the actual situation can be restricted with less force by participation of the coordinator than by that of the arbiter. Eliminating the outcome '10' is based on the assumption that the coordinator will bring the effect for better or worse. On the other hand, if analysis is done with the outcome '10', the outcomes '2' and '10' are provided as equilibriums in **GAME 3**. Preferences for Bangladesh and India are set in the following.

It is assumed that Bangladesh prefers that Third Party takes an action rather than it does not if the strategy selection of the other options is fixed. Regarding the other options, the priority and essential preference are not different from those in **GAME 1**. Under such assumptions, the preference vector for Bangladesh is set as in **Table 11**.

Seeing the bottom of Table 11, which shows origins of outcomes in **GAME 1**, it can be understood that the preference vector of Bangladesh does not change essentially.

As for India, it is assumed that India prefers that

Table 11 Preference Vector for Bangladesh with the Coordinator.

Options	Outcomes														
Bangladesh															
Agree to use the Farakka Barrage	1	1	1	1	0	0	0	0	1	1	0	0	0	1	1
India															
Use the Farakka Barrage	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1
Reconsider the rule of using the Farakka Barrage	1	1	1	1	1	1	0	0	0	0	1	1	0	0	0
Third Party															
Take an Action	1	0	1	0	1	0	0	1	0	1	1	0	0	0	1
Decimal	15	7	13	5	12	4	0	8	1	9	14	6	2	3	11
Origins of outcomes in GAME 1	7	7	5	5	4	4	0	0	1	1	6	6	2	3	3

Table 12 Preference Vector for India with the Coordinator.

Options	Outcomes														
Bangladesh															
Agree to use the Farakka Barrage	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0
India															
Use the Farakka Barrage	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Reconsider the rule of using the Farakka Barrage	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
Third Party															
Action	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
Decimal	11	15	14	3	2	7	6	9	8	13	12	1	0	5	4
Origins of Outcomes in Game 1	3	7	6	3	2	7	6	1	0	5	4	1	0	5	4

Third Party takes an action rather than it does not, and that the first priority for India is using the Farakka Barrage, the second is Third Party's taking an action, the third is not reconsidering the rule, and the last is Bangladesh's agreeing. With ignoring Third Party's option, Indian's priority over the other options is same as in **GAME 1 - GAME B**. Under such assumptions, the preference vector for India is set as in **Table 12**.

Seeing the bottom of **Table 12**, it can be understood that the preference vector of India has partially changed comparing to that in **GAME 1**. This change can be interpreted that the preference of India has transformed as a result of mediation effect by Third Party's predicating.

Under above settings, equilibriums are analyzed through Conflict Analysis with the coordinator, and the outcomes '2', '11', and '14' are obtained as equilibriums. The outcome '2' means that Bangladesh does not agree to use the Farakka Barrage, India uses the Farakka Barrage and does not reconsider the rule, and Third Party does not take an action. This equilibrium is almost similar to the actual situation. The outcome '11' means that Bangladesh agrees to use the Farakka Barrage, India uses the Farakka Barrage and does not reconsider the rule, and Third Party takes an action. The outcome '14' means that Bangladesh does not agree to use the Farakka Barrage, India uses the Farakka Barrage and reconsiders the rule, and Third Party does not take an action. Then, the outcome '14' which means improvement of the conflict situation is provided as one of equilibriums.

It is difficult for Bangladesh to offer a new effec-

tive option for dissolution of the conflict because Bangladesh is disadvantageous economically and topographically. As for India, it is hard to think that India changes its preference by itself. Therefore, the conflict between Bangladesh and India will exist if they negotiate between only them with the preference described as in **GAME 1 - CASE B**. However, as shown in this section, if Third Party can offer the option which is more attractive to India than the option 'reconsider the rule' and it has enough executive ability, mediation effect of Third Party's participation as the coordinator can bring possibility of dissolution to the conflict.

VI. CONCLUSIONS

Mediation is often said to be an important matter for the conflict. However, it's not clearly defined what the mediation means, and there is not an only way to mediate between stakeholders as shown in this study. Sometimes, a party who is concerned in a conflict as the complement turns to be a player who has its own preference vector.

It is needed for the future conflict management that the process and background of conflict are considered, and fair and equitable procedures should be taken. Upon this recognition, this study focused on the role of third party, which is one of ways to resolve the conflict situation, and proposed the concept of the complement for conflict management. Then, it is shown that mediation effect of the complement can bring possibility of dissolving the India/Bangladesh conflict.

This study aims at providing a support system for the future conflict management. Hence, even if the roles of Third Party defined in section 4 do not be really satisfied by actual parties, it will be important to share the point of view to organize such a party which fulfill the role of Third Party to resolve the conflict situation in the future.

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