

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

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### 1. Introduction

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. This conflict situation changed drastically in 1975 because India constructed the Farakka Barrage over the Ganges in the Indian area. India and Bangladesh had no consensus about this construction at all, and India made it unilaterally. They made treaty about water resources use of the Ganges after construction, in 1975, 1977, and 1996. They were 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. From this aspect, flood and drought in Bangladesh might be said as a man made disaster.

However, it is difficult for Bangladesh to offer a new effective option for dissolution of the conflict because Bangladesh is disadvantageous economically and topographically to India. As for India, it is hard to think that India changes its attitude internally. Therefore, the conflict between Bangladesh and India will exist if they negotiate only by themselves. In such a case, participation of third party is considered.

### 2. Modeling

In this study, Conflict Analysis is used for modeling the conflict situation. Conflict Analysis is built based on the game theory, and it provides algorithm to analyze equilibriums among players who have different payoff matrix. Upon the framework of Conflict Analysis, roles of third party are classified and defined. First of all, third party is defined as ‘Complement’ which does not have payoff matrix. At this aspect, third party is modeled as a different party

from a traditional player in conflict analysis and game theory. Then, the role is classified into 3 types of ‘Donor’, ‘Coordinator’, and ‘Arbiter’. Mathematical characteristics of complement are shown as follows.

Let subscript ‘c’ represent the complement, and let the dashed  $Q'$ ,  $S'$  represent the set which has changed after the complement participates in the game.  $Q$  means the set of outcomes, and  $S$  means the set of players’ strategies.  $P_i(Q)$  is preference vector of player  $i$  ( $i \neq c$ ) for all the outcomes, and to make the meaning of complement’s participation clear, the preference vector  $P_i, S', Sc(Q)$  is defined, which means the preference vector without the complement’s strategies. If the time shift is considered,  $P_i^t, S', Sc(Q')$  is used.

#### a) Donor

Donor has some options, and they don’t influence actual preference vectors, but after some time shifts, it does. Following equations describe the requirement for donor.

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

$$P_i^t, S', Sc(Q') = P_i^t(Q). \quad (11)$$

$$P_i^{t+T}, S', Sc(Q') \neq P_i^{t+T}(Q). \quad (12)$$

#### b) Coordinator

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

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

$$P_i, S', Sc(Q') \neq P_i(Q). \quad (14)$$

#### c) Arbiter

Arbiter doesn’t have any options. They can reduce outcomes, and it restricts players’ action. Following equations describe the requirement for arbiter

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

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

This model is applied to the conflict between Bangladesh and India, and. it is analyzed what condition is necessary so that ‘Complement’ improves circumstance of conflict.