# CONFLICT RESOLUTION IN TRANSBOUNDARY WATERS: INCORPORATING WATER QUALITY IN NEGOTIATIONS

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The urgent demand of integrated water resources management has drawn attention to the issue of trans-national water bodies that comprise exploitable resources for two or more countries. It is estimated that 50% of the global surface is lying on transboundary catchments and this percentage is continually increasing due to the creation of new nations, while around 40% of the earth's population residents in transboundary water catchments. According to historical facts, no record exists of hostility due to shared water resources, but it is anticipated that in the future water will replace oil as the primary cause of war. Problems of transboundary nature in connection with the imminent threat of water shortage render the management of transboundary catchments a crucial issue that demands co-operative mechanisms for the preservation of the political stability, the environmental protection and the equitable use of the shared water resources.

The aim of the present paper is to contribute towards the development of a Negotiation Support System (NSS) for the management of transboundary water resources in compliance with the institutional and international legal framework contributing to conflict resolution in transboundary catchments. NSS comprise a special category of Decision Support Systems (DSS) which are vital for the success of resolving water conflicts (Nandalal and Simonovic, 2003). The main purpose is to expand the existing methodology on the use of mathematical methods towards conflict resolution, already developed by the authors, in order to incorporate water quality issues and specifically transboundary river pollution. In this way, a NSS will be developed that will combine quantitative with qualitative characteristics of transboundary water resources.

It is a common phenomenon in transboundary water agreements that water quality issues are absent while the majority of the agreements regard water quantity issues as the main priority (Bennett, 2000). The reasons behind this neglect of the water quality parameter is the shortage of appropriate tools for the estimation of the losses, the impediments in defining the pollution sources and the fact that it is more direct to estimate water quantity deficiencies rather than water quality parameters. The omission of quality specifications has been proven detrimental in many cases while on the other hand water quality improvement brings numerous benefits to both sides of the borders.

Water quality degradation has direct negative consequences in all water uses. The quantification of this qualitative degradation and the calculation of economic figures will allow an in-depth incorporation of water quality issues in transboundary water management negotiations. The quality parameters will be introduced in the existing methodology where Game Theory was applied in the water allocation scheme between Greece and Bulgaria. It is anticipated that the present paper will contribute to integrated transboundary water management where quantity and quality issues will be confronted in parallel.

As a reference area, Nestos/Mesta basin was chosen shared between Greece and Bulgaria. This transboundary basin presents great interest as it is shared between two countries with many differences in economic and development level. The river under study forms a very crucial asset for both countries as it supports main economic activities and contains environmental protected areas in both sides of the border. Eleftheriadou and Mylopoulos (2008) have applied game theoretical concepts in the case of Greek-Bulgarian negotiations on Nestos/Mesta River. The quantification of consequences caused by

water flow decrease for different scenarios provided the background for estimations of compromising solutions that could be acceptable by both countries as they will receive the maximum possible payoff given certain circumstances.

Game Theory was used many times in the past during the settlement of competitive situations generated by the degradation of shared water resources (Eleftheriadou and Mylopoulos, 2005). The success of the theory's implementation in such cases is due to the fact that it incorporates all those factors that can characterize these conflicting situations as each side seeks the maximization of its payoff and the players' behavior is initiated by its targets and values (Beach et al, 2000). Game Theory aims at the study of four basic elements and their interactions. These are (Rasmussen, 1994):

- Players: normally consisting of the decision-makers
- Interaction: the choices of one player affect the ones of the counter-player
- Strategy: each player holds a strategy based on the interpretation of the players' interactions
- Rationality: the players' choices are characterized by rationality

All the above elements are often found in negotiations concerning the management of shared water resources. The interested countries are acting as "players" with specific options and take decisions according to the payoffs that correspond to each option combination. In most cases the players have opposite interests as the benefit of one player entails loss for the counter-player.

It is evident that the choices of one country affect the other in the case of upstream-downstream relations. Each country-player adopts a certain strategy that forms its choices and provokes the reactions of the opponent party, while all the actions are characterized by a rational behavior aiming at the maximization of the payoffs. Moreover, game theory can incorporate the possibility of a cooperative settlement of their disputes by implementing the cooperative game theory providing the possibility of comparing and estimating the consequences of the players' behavior towards its opponent.

The proposed methodology is comprised of the following steps:

**i.** Water quality simulation model: MONERIS (Modelling Nutrient Emissions in River Systems) simulation model was selected for the reference area and is applied in the whole catchment area

**ii.** Based on the outcomes of the simulation model –i.e. concentrations of nutrients in the river-, the losses of the productive sectors due to water pollution are estimated for each country

**iii.** Game Theory is applied in order to simulate possible negotiations between Greece and Bulgaria regarding water quality issues. The two players of the game have various options of actions and reactions, while each option corresponds to a specific payoff. The payoffs entered in the Game Theory matrix are the results of the second step of the methodology and correspond to the gain or loss of each player according to the combination of their options for a specific state. The possibility of inter-connected games is investigated in order to convert non-cooperative games to co-operative ones.

**iv.** After a number of scenarios are analysed, compromising solutions are produced that will be acceptable from both countries while ensuring environmental conservation.

**v.** The results of the above steps are then connected to the previous implementation that was focused on water allocation. The merging of the two components contributes towards the development of an integrated NSS.

The results of the simulation model can be used in order to provide input for the formulation of the players' options. As a demonstration example, the model predicted that future construction of wastewater treatments plants in all the settlements of the Bulgarian basin will cause a high decrease (of approximately 80%) of the nutrients' concentration in the river. This fact can play a crucial role to the formulation of the games and the creation of additional options to each player, while it sets the basis for the incorporation of interconnected games.

The outcomes of this paper can be used in the building of agreement that incorporate water quality issues and it will provide a proposed framework for the contents of such agreements. Moreover, pollution transfer is simulated for the whole catchment and different scenarios can be analysed (such as construction of water treatment plants), while it was attempted to quantify the losses deriving from bad water quality. The achievement of cooperative solutions is not always feasible due to the absence of motives and mutual trust between the opponents (Dinar et al, 1992), thus interconnected games are

applied in order to develop common motives and ensure the viability of any agreement signed by the two countries.

The proposed methodology is expected to contribute to the development of sustainable transboundary water agreements where the principle of equity is implemented. The implementation of game theoretical methods is particularly useful to the analysis of various scenarios as it quantifies the consequences of each player's options providing information that are indicative of the outcome of the negotiations. Moreover, the equilibrium states of the games, which were formed during the negotiation simulation, can form the basis for the commencement of the real negotiations between the two parties. It is of great importance that the options discussed on the negotiation table are realistic, non-detrimental to the environment and their impacts have already been assessed and are known to the concerned parties.

At the global level there is a marked absence of comprehensive transboundary agreements where water quality is treated equivalent to the quantitative distribution. Given the continued deterioration of water quality, integration of quality issues should be a priority during the negotiations. The proposed methodology will help in addressing common quantitative and qualitative aspects of transboundary rivers, while the implementation of Game Theory will support those involved in finding compromising solutions that would satisfy the requirements of sustainable development.

It is a common perception that antagonistic approaches to transboundary water resources cannot be eliminated as antagonism is a social phenomenon observed in most of the social, economic and political issues. Cooperation cannot be enforced through legal tools but can be promoted by creating cooperation motives and cooperative solutions that are acceptable to the opponent parties and in the same time sustainable for the environment.

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