



# Risk assessment for transboundary rivers using fuzzy synthetic evaluation technique



Subash P. Rai <sup>a,\*</sup>, Nayan Sharma <sup>a,2</sup>, A.K. Lohani <sup>b,3</sup>

<sup>a</sup> Department of Water Resources Development and Management, IIT Roorkee, India

<sup>b</sup> National Institute of Hydrology, Roorkee, India

## ARTICLE INFO

### Article history:

Received 6 June 2014

Received in revised form 25 July 2014

Accepted 31 August 2014

Available online 9 September 2014

This manuscript was handled by Geoff Syme, Editor-in-Chief

### Keywords:

Development

Hegemony

Water sharing framework

Fuzzy synthetic evaluation

Risk assessment

Fuzzy risk

## SUMMARY

Large scale urbanization has resulted in greater withdrawals of shared waters and this withdrawal has been largely dependent on the hegemony of the riparian's. The last few decades has seen the upward surge of many countries in terms of development as well as hegemony. Existing structures of established water sharing framework typically evaluate only parameters related to historic water use such as historic water demand and supply, contribution to flow, and hydrology. Water conflicts and cooperation is affected by various issues related with development and hegemony. Characterization and quantification of development and hegemony parameters is a very complex process. This paper establishes a novel approach to predict river basins at risk; the approach addresses the issue of water conflict and cooperation within a methodologically more rigorous predictive framework. Fuzzy synthetic evaluation technique is used in this paper to undertake the risk assessment of international transboundary rivers. In this paper the fuzzy domain of risk consists of two fuzzy sets – hegemony and development, indices of which are developed with the help of fuzzy synthetic evaluation techniques. Then the compositional rule-base is framed to ascertain the fuzzy risk. This fuzzy risk can be further used to prioritize all the international river basins which can help in the identification of potentially high risk basins. Risk identification of international river basins is not only scientifically valuable, but also practically highly useful. Identifying those basins that are likely to be particularly prone to conflict or cooperation is of high interest to policy makers.

© 2014 Elsevier B.V. All rights reserved.

## 1. Introduction

There has been a substantial and consistent increase in the events of conflict as well as cooperation in the international arena. Large scale urbanization has resulted in greater withdrawals of shared waters and this withdrawal has been largely dependent on the hegemony of the riparian's. A principal hypothesis is that greater the power of the nation greater is the say in withdrawals of shared waters. The last few decades has seen the upward surge of many countries in terms of development as well as hegemony. This has led to a situation where water conflicts are inevitable as the demand for water increases in the developing nations which till date have very little access to the shared international water resources. In the recent studies, transboundary water cooperation has been dealt largely moving the focus from water conflicts. The

prime reason to this can be attributed to water being used as a medium of cooperation rather than a source of dispute. This has led to more than 350 international water treaties being signed all over the world with only 33 instances of water dispute in the last century. The research community has been largely focusing on water cooperation but they have been largely ignoring the effects of development and hegemony (power), the two major factors affecting water cooperation.

Existing structures of established water sharing framework typically evaluate only parameters related to historic water use such as historic water demand and supply, contribution to flow, and hydrology. The objective of the frameworks has been to identify the most appropriate water sharing formula. Equitable use of international rivers by various riparian's is gaining acceptance in international law. The theory of equitable use encourages the sharing of international transboundary waters by the riparian's on an equitable basis. This theory has been incorporated in the Helsinki Rules as the basis of the principles governing international water sharing, thus supplementing the sharing of transboundary waters. No national or international law allied to water rights have ever

\* Corresponding author.

<sup>1</sup> Research Scholar.

<sup>2</sup> Professor.

<sup>3</sup> Scientist F.

been developed which can answer the ecological and political challenges presented by water conflicts that have emerged because of the ignorance of people's survival and nature's sustenance needs. Water conflicts thus grow exponentially despite the establishment of conflict resolution mechanisms and legal frameworks.

Over the past few decades, a substantive scientific literature has emerged that offers important insights into the factors that might influence international river basin cooperation and conflict. This literature has developed influential theoretical frameworks that shed light on the underlying mechanisms of conflict or cooperation. Conventional risk assessment is primarily based on the transboundary freshwater dispute database which comprised of event data on international river conflict and cooperation along a continuum, i.e. the basins at risk (BAR) scale. Wolf et al. (2003) regressed this scale on a wide range of factors that might affect conflict risk or the chances of cooperation (Wolf et al., 2003). Based on the binary regression models, international water catchments that appeared particularly risk-prone have been identified and categorized into three categories: (a) basins in which water conflict was already manifest; (b) basins in which conflict is possible in the future and for which there is evidence of existing tensions; and (c) basins in which conflict is possible in the future, but there is no present evidence of existing tensions. But despite important insights, there are substantial limitations associated with the available literature. Hence, this paper establishes a novel approach to predict river basins at risk; the approach addresses the issue of water conflict and cooperation within a methodologically more rigorous predictive framework. Nonetheless, the ability to predict and forecast which international river basins are more likely to experience conflict or cooperation is of great interest to academics and policy makers alike. We consider risk identification of international river basins not only as scientifically valuable, but also as practically highly useful. Identifying those basins that are likely to be particularly prone to conflict or cooperation is of high interest to policy makers, non-governmental organizations, or international organizations.

The focal point of this methodological analysis is risk. As defined by Rowe, risk is the potential of an event and activity to produce undesirable negative consequences (Rowe, 1977), whereas according to Lowrence, risk is the severity and probability of negative adverse effects (Lawrence, 1976). Hence, physical consequences of unwanted events and estimation of their frequency which has the capability to produce harm, is called risk analysis (Ricci et al., 1981). We can conclude that risk is the combination of event's probabilities of occurrence and its consequences. In this study risk assessment is used as the cornerstone to enhance the understanding towards international river basins. This will aid the limited and case specific knowledge base on transboundary river management to evaluate developmental risks merged with hegemonic factors. Hegemonic parameters are used to infer the potential risks arising due to developments in the international river basins. The present approach couples the fuzzy synthetic evaluation technique with the risk assessment methodology which has the capability to propagate and dilute uncertainty in results. Hence this risk (due to hegemony and development parameters of the riparian's) quantification approach and subsequent identification of international river basins at risk would increase the reliability of the results.

## 2. Basins at risk (BAR) index

The history of transboundary rivers has a rich collection of both cooperative as well as conflicting international transboundary water events. International conflict and water appear with increased frequency both in policy literature as well as popular press (Elhance, 1999; Gleick, 1993; Homer-Dixon, 1994; Hughes

**Table 1**  
BAR scale.

Bar scale	Event description
-7	Formal declaration of war
-6	Extensive war acts causing deaths, dislocation or high strategic cost
-5	Small scale military acts
-4	Political-military hostile actions
-3	Diplomatic-economic hostile actions
-2	Strong verbal expressions displaying hostility in interaction
-1	Mild verbal expressions displaying discord in interaction
0	Neutral or non-significant acts for the inter-nation situation
1	Minor official exchanges, talks or policy expressions – mild verbal support
2	Official verbal support of goals, values or regime
3	Cultural or scientific agreement or support (non-strategic)
4	Non-military economic, technological or industrial agreement
5	Military, economic or strategic support
6	International freshwater treaty; major strategic alliance
7	Voluntary unification into one nation

Butts, 1997; Remans, 1995; Westing, 1986). The literatures frequently discuss numerous indicators used to study and analyze water conflict, which includes proximity, type of government, water availability and rapid inhabitant growth. The major drawback of the existing literature was that it consisted of specific case studies from the most volatile basins which excluded various factors influencing water and international conflict. Despite numerous case studies examining and comparing water related conflicts, no global scale on water and international conflicts could be developed. This prompted Wolf et al. (2003) to create a global basins at risk (BAR) Scale. Wolf developed a 15-point "basins at risk (BAR) scale" which ranged from +7 to -7, including 0.+7 represented the most cooperative event while -7 represented the most conflictive event and 0 represented neutral or non-significant events (Wolf et al., 2003). The BAR Scale developed by Wolf, incorporates water specific terminologies and considerations with the International Cooperation and Conflict Scale developed by Edward Azar (Azar, 1980). The higher BAR Scale refers to higher level of cooperation hence low conflict potential. Table 1 describes the 15 categories of BAR scale.

The BAR Scale provided great insights about water and international conflict and cooperation and also developed various indicators. But it has some drawbacks. None of the indicators could predict the behavior of transboundary rivers in the context of large scale developments (in terms of enhanced water use) and the hegemony of the riparian's. The parameters of development and hegemony will define the future course of water and international conflicts as they are the major emerging issues in transboundary water management.

## 3. Development and hegemony effects

The status of transboundary river basins in the developing countries can very well describe the effects of hegemony and development on the future course of water and international conflicts. The authors have taken up Nile river basin to explain the present scenario in developing countries. The effects of development can be understood by the prevailing situation in Nile basin. In most parts of Africa, one of the most significant issues for human survival is access to water as more than one third populations are still devoid of proper access to water. Egypt has very long been the prime negotiator of the Nile Rivers and has had undisputed access to the Nile waters. Due to the independence from Colonial powers the Nile riparian disputes became international and as a result more contentious, particularly among Egypt, Sudan and Ethiopia (Beach, 2000). The result of which is many riparian are expressing direct stake in the Nile waters (Rahman, 2011). The riparian's of

Download English Version:

<https://daneshyari.com/en/article/6411951>

Download Persian Version:

<https://daneshyari.com/article/6411951>

[Daneshyari.com](https://daneshyari.com)