

## AN ABSTRACT OF THE DISSERTATION OF

Shira B. Yoffe for the degree of Doctor of Philosophy in Geography presented on October 12, 2001.

Title: Basins At Risk: Conflict and Cooperation Over International Freshwater Resources

Abstract approved: \_\_\_\_\_

Aaron T. Wolf

In the policy literature and the popular press, the issues of water and conflict are being raised together with increasing frequency. Geographic, international relations, and environmental security theories speculate on the linkages between geographic features, natural resources, spatial relationships, and war or acute conflict. Little quantitative or global-scale research exists, however, to test these theories regarding the relationship of water to international conflict. Moreover current literature often lacks consideration of water cooperation or spatial variability. The Basins at Risk (BAR) project addressed this gap by empirically identifying historical indicators of international freshwater conflict and cooperation and creating a framework to identify and evaluate international river basins at potential risk for future conflict. To accomplish this task, we created a database of historical incidents of water-related cooperation and conflict across all international river basins from 1948 to 1999, delineated an historical Geographic Information System (GIS) of international river basins and associated countries, derived biophysical, socioeconomic, and geopolitical variables at multiple spatial and temporal scales, and tested these variables against our event data.

We found that international relations over shared freshwater resources were overwhelmingly cooperative. Although conflicts over water occurred, violent conflict was rare and far outweighed by the number of international water agreements. International cooperation over water resources covered a wide range of concerns, including quantity, quality, hydropower, and infrastructure development. Conflict, especially acute conflict, centered on issues of quantity and infrastructure (e.g., dams,

reservoirs). The majority of commonly cited indicators (e.g., climate, water stress, government type, relative power relationships) showed no statistically significant association with international water conflict or cooperation. Rather, the tendency towards conflict was associated with rapid or extreme changes in physical or institutional systems (e.g., the building of large dams or the internationalization of a basin). The propensity for such conflict was mitigated by the presence of institutional mechanisms, such as freshwater treaties. From the results of our analyses, we identify three categories of basins at risk and present a framework for further evaluation of the potential for international water conflict in these basins.

Basins at Risk:  
Conflict and Cooperation Over International Freshwater Resources

by  
Shira B. Yoffe

A DISSERTATION  
submitted to  
Oregon State University

in partial fulfillment of  
the requirements for the  
degree of

Doctor of Philosophy

Presented October 12, 2001

Commencement June 2002

Doctor of Philosophy dissertation of Shira B. Yoffe presented on October 12, 2001.

APPROVED:

---

Major Professor, representing Geography

---

Chair of Department of Geosciences

---

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

---

Shira B. Yoffe, Author

## ACKNOWLEDGEMENT

Spanning three years, the Basins At Risk project involved the efforts of a number of faculty and student researchers at Oregon State University, many of whom spent long hours immersed in BAR project tasks. I would like to acknowledge the insights, assistance and support of Dr. Jon Kimerling, Dr. Phil Jackson, Dr. Dawn Wright, Case Bowman, Kuuipo Burleigh, Becci Dale, Meredith Giordano, Greg Fiske, Jeanne Hoadley, Kelli Larson, Kyoko Matsumoto, Marc Rothgery, Brian Ward, and Daniel Wise. In addition, others gave of their time and/or data to facilitate this research project. I would like to extend thanks to George Taylor, Oregon State Climatologist, and his assistants Nathaniel De Young and Melanie Mitchell; Mark Levy, Center for International Earth Science Information Network; Jake Brunner and Kirsten Thompson, World Resources Institute; Petra Doell, University of Kassel, Germany; Glenda Pearson, University of Washington Library; David B. Kynoch, President, Pacific Northwest GIS Consulting, Inc.; Dr. Michael D. Ward, Department of Political Science, University of Washington (Seattle); Balazs Fekete, Complex Systems Research Center, University of New Hampshire; Dr. Jerome E. Dobson, Oak Ridge National Laboratory; Joe Toth and Carrie Ottow, Oregon State University Valley Library; Jeff Danielson and Kent Lethcoe, EROS Data Center; and, The Global Event Data System, University of Maryland. I would also like to acknowledge the National Science Foundation Graduate Research Traineeship (GRT) Fellowship in Landscape Studies, for financial support of my doctoral studies.

I extend special thanks to members of my committee, Dr. Gordon Matzke, Dr. Chuck Rosenfeld, and Dr. Court Smith, for their insights, encouragement, and “reality-checks,” and Dr. Julia Jones, for all the above and her discerning and patient editorial eye. Last, but certainly not least, I thank my advisor, Dr. Aaron Wolf, for his energy, enthusiasm, encouragement, advice, patience, and friendship.

## **CONTRIBUTION OF AUTHORS**

Kelli Larson assisted with the compilation of the event data, specifically the identifying, obtaining, coding, and entering of the information from electronically searchable news databases. Greg Fiske provided Geographic Information System expertise to the project, including the updating of the TFDD basin layers, manipulation of the historical GIS country and basin coverages, data layer calculations for a number of spatial indicator variables, and creation of map images associated with these tasks. Mark Giordano participated in the coding of the event data and provided statistical expertise in data manipulation and running of some of the statistical analyses.

## **DEDICATION**

This dissertation is dedicated to my parents, Graenem and Helene Yoffe, for their support, encouragement, and chocolate chip cookies.

# **BASINS AT RISK: CONFLICT AND COOPERATION OVER INTERNATIONAL FRESHWATER RESOURCES**

## **CHAPTER 1 INTRODUCTION**

In the policy literature and popular press, issues of water and international conflict are linked with increasing frequency (Westing 1986; Elliott 1991; Gleick 1993; Homer-Dixon 1994; Remans 1995; Butts 1997; Elhance 1999). In particular, the past few decades have seen an increase in geopolitical, international relations, and environmental security literature on water's role in international conflict. This literature often stresses various indicators for conflict, including proximity, government type, aridity and rapid population growth. Yet despite the number of case studies analyzing and comparing water-related conflict in various international river basins, little global-scale or quantitative evidence has been compiled. Existing work often consists of case studies from the most volatile basins and excludes examination of cooperation, spatial variability and precise definitions of conflict.

My dissertation research, the Basins at Risk project (BAR), addresses a series of overarching gaps in research on freshwater resources and international conflict by providing a quantitative, global scale exploration of the relationship between freshwater resources and conflict – in essence, asking whether the theories and claims hold true. I also incorporate a spatial perspective and consider the full spectrum of interactions, using precise definitions of conflict and cooperation.

The specific purpose of my dissertation research was threefold:

- To identify historical indicators of international freshwater conflict and cooperation;
- To use these indicators to create a framework to identify and evaluate international river basins at potential risk for future freshwater conflict;
- To enhance understanding of the driving forces that may cause water to become a focus of conflict or cooperation.

It is hoped such information can contribute to the development of international management approaches designed to mitigate the potential for international water conflict.

To accomplish these goals required three main elements: creation of an event database documenting historical water relations, including a methodology for identifying and classifying events by their intensity of cooperation and conflict; construction of a geographic information system (GIS)<sup>1</sup> of countries and international basins, both current and historical; and the collection or creation of indicator variables (biophysical, socioeconomic, and geopolitical) for testing of hypotheses about factors associated with water conflict.

The accompanying chapters describe the methods and findings of my dissertation research. Chapter 2, “Basins at Risk: Water Event Database Methodology,” describes the backbone of my dissertation research – the water-event database. This database catalogs historical incidents of international water cooperation and conflict for all countries from 1948-1999. For the purposes of the Basins at Risk Project, water events were defined as instances of conflict and cooperation that occur within an international river basin, involve the nations riparian to that basin, and concern freshwater as a scarce or consumable resource or as a quantity to be managed. These events were classified by the international river basin in which they occurred, the countries involved in the event, the date, level of intensity of conflict or cooperation, and the main issue associated with each event. All the event information collected and coded was compiled in a relational database to allow for analyses at an array of spatial and temporal scales. The database methodology is described in detail in order to facilitate evaluations of the project’s findings, to facilitate others’ use of the data in further research, and to offer a model for those interested in following a similar methodology for exploration of other issues. The chapter concludes with a detailed picture of patterns of historical conflict and cooperation over international freshwater resources.

This water event database represents a unique resource that allows evaluation of historical incidents of water conflict and cooperation and exploration of relationships

---

<sup>1</sup> A GIS is a computerized system that enables storage, management, analysis, modeling, and display of spatial and associated data.

between these incidents and a wide range of biophysical, socioeconomic, and political data. Chapter 3, “Use of GIS for Analysis of Indicators of Conflict and Cooperation Over International Freshwater Resources” describes the spatial complement to the water event database – the creation of an historical GIS that delineates all current and historical international basins and their riparian countries, from 1948-1999, and the use of this GIS to calculate variables for statistical analysis.

Because not all basins were international across the entire time period of the study and many events researched for the event database (Chapter 2) turned out to be related to intra-national, rather than international water resources, the GIS had to account for all changes in international river basins and national political boundaries from 1948 to the present, both spatially and temporally. Creating these temporal GIS layers facilitated our ability to associate events with basins that were international at the time the event occurred. More importantly, the historical GIS allowed the linkage of the incidents of international water conflict and cooperation with socioeconomic, biophysical, and political indicators specific to the year in which the event occurred.

While the GIS allowed analyses at a range of spatial scales, including country, region, and basin-country polygon,<sup>2</sup> the key unit of analysis considered was the international river basin. An international river basin comprises all the land that drains through that river and its tributaries into the ocean or an internal lake or sea and that includes territory of more than one country. Most of the broad analyses of international water conflict have examined data compiled at the country level. The historical GIS allowed questions to be framed in terms of river basins and provided some accountability of within-country variation. Geomorphologists have long considered the river basin to be a natural framework of study when considering the physical aspects of water resources (Leopold, Wolman et al. 1964). The same consideration holds true when considering the relationship of freshwater to international conflict and cooperation.

BAR’s GIS includes 263 current international basins and two historical basins. This historical GIS enabled incorporation of both temporal and spatial variability into our analyses. It allowed us to derive data, including population, climate, or water

---

<sup>2</sup> A basin-country polygon refers to a country’s territorial share of an international basin. It is the smallest spatial grain used in the BAR study.

availability, at the basin level or other scales and to explore correlations between these variables and the event data. This ability to explore why an event occurred is integral to the power of the BAR Event Database, and the lack of such an ability has been a major criticism of the utility of event datasets in the past (Lanphier 1975; Andriole and Hopple 1984; Laurance 1990).

Exploring the question of why an event occurred is a key part of Chapter 4, “Cooperation and Conflict Over International Freshwater Resources: Indicators and Findings of the Basins at Risk Project”. After describing the project’s methodology and statistics, Chapter 4 discusses the commonly cited theories and indicators linking water to conflict and our own hypothesis, which concerns infrastructural development and institutional mechanisms. Based on the results obtained, I present a framework for identifying and evaluating basins at potential risk for future international conflict over freshwater resources. I identify three categories of basins at risk. The first are basins negotiating current conflicts, well known “hot spots” where the potential for continued dispute, at least in the near term, is therefore considered likely. The second category are basins in which factors point to the potential for future conflict and in which up-coming development projects or other stresses upon the water system have raised protests among the riparians. The third category is similar to the second in that there is a confluence of factors which indicate the potential for future conflict. Unlike category 2 basins, however, there is no evidence of existing tensions in public policy or media fora. When all the categories are viewed together, what stands out is that the majority of basins at risk fall in southern Asia and central and southern Africa.

Categorizing a basin as “at risk” does not presume to identify basins in which acute conflict *will* occur, but to point to basins worth more detailed investigation. Assessing basins at risk is as much art as science and requires a mix of quantitative and qualitative research approaches.

Chapter 5 provides an overview and conclusion to this dissertation. Further details of the statistical methodologies and data sources associated with the indicators used and BAR findings may be found in the Appendices. These data and methodological information, in addition to that contained in the previous chapters, will become part of the

TFDD website (<http://www.transboundarywaters.orst.edu>), where the Basins at Risk project data and findings will be made publicly available.