AN ABSTRACT OF THE DISSERTATION OF

Marloes H. N. Bakker for the degree of Doctor of Philosophy in Geography presented on December 06, 2006
Title: Transboundary River Floods: Vulnerability of Continents, International River Basins and Countries

Abstract approved: Aaron T. Wolf

Floods are the most frequent and damaging of all types of natural disasters and annually affect the lives of millions all over the globe. However, researchers seem to have overlooked the fact that floods do not recognize national boundaries. Therefore, the phenomena of shared, or transboundary floods occurring in international river basins (IRBs) is rarely touched upon. Consequently, vulnerability to shared floods is poorly understood and not much is known about the present quantity and quality of institutional capacity to deal with such events. Hence the primary purpose of the present work is to fill this gap in knowledge. We explore transboundary river flood events and related institutional capacity in more detail, starting at a global scale, zooming in on international river basins (IRBs) and ending with a country-scale perspective.

The first section assesses how many of all floods were riverine and how much of these were shared between two or more countries. The results show that transboundary floods are more severe in their magnitude, affect larger areas, result in higher death tolls, and cause more financial damage than non-shared river floods do. The second section reveals an alarmingly low institutional capacity related to transboundary river floods: more than 15% of the IRBs do not have any type of institutional capacity in the form of a river basin institution, nor any focused on floods. The third section examines flood events, international water treaties signed and institutions created in the Netherlands and Mozambique. The comparison indicates that lower levels of development or the absence of development capital do not necessarily have to result in future (shared) flood-related disasters.

Collectively, these results significantly increase our current knowledge on vulnerability to –transboundary– river floods and indicate that there might be more need for official international institutions dealing with these events. However, selecting the one country, continent or IRB that is the most vulnerable to –transboundary– river floods is impossible

since the answer greatly depends upon the specific definition of vulnerability. This indicates that vulnerability to floods is a complex phenomenon that cannot be explained by using the results of only this study.

Transboundary River Floods: Vulnerability of Continents, International River Basins and Countries

by
Marloes H. N. Bakker

A DISSERTATION

submitted to

Oregon State University

in partial fulfillment of
the requirements of the
degree of

Doctor of Philosophy

Presented December 06, 2006
Commencement June 2007

Doctor of Philosophy dissertation of Marloes H. N. Bakker presented on December 06, 2006.

APPROVED:

Major Professor, representing Geography

Chair of the 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.

Marloes H. N. Bakker, Author

ACKNOWLEDGEMENTS

For their generosity of time, guidance and spirit, I would like to genuinely thank my dissertation committee members: Drs. Aaron Wolf, Brent Steel, Gregg Walker, Ron Doel, Steve Hostetler, and graduate representative Kevin Boston.

For much needed and appreciated grants awarded, I thank the Ryoichi Sasakawa Young Leaders Fellowship Fund and the supporters of the K. Muckleston Scholarship Fund. In addition, I would like to thank the Department of Geosciences at Oregon State University for the funding that supported this research.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF APPENDIX FIGURES

Transboundary River Floods: Vulnerability of Continents, International River Basins and Countries

Chapter One: Introduction

Floods are among the world's most frequent and damaging types of disasters and annually affect the lives of millions all over the globe. The application of science and medicine has undoubtedly improved humankind's ability to predict, alleviate and survive flood disasters, but over time population growth, climate related factors aggravated by urbanization, and social, economic and political processes have massively increased and will continue to increase human exposure and vulnerability to floods. Nonetheless, vulnerability of societies to floods is still poorly understood.

Studies until now have focused on a single (historical) flood events (Wind, 1999; Christie and Hanlon, 2001), a single river (Hesselink, 2002; Mudelsee *et al.*, 2003), a single country (Tol, 2003) or combinations of these topics. Only recently researchers have begun to analyze flood data on a global scale (Hossain and Katiyar, 2006), and but a few have touched upon the regularly occurring phenomena of shared, or transboundary floods occurring in international river basins (IRBs) (Marsalek *et al.*, 2006). At present though, there are 279 IRBs (TFDD, 2006; unpublished data) and almost 30% of these have experienced shared river floods in the period 1985-2005. Thus the overarching goal of the present work is to fill this gap of knowledge by investigating transboundary flood events.

The first section of the dissertation comprises a global analysis that reveals how many river floods have taken place and how many of these were shared between two or more countries. Specific attention is paid the financial damages, the number of casualties and how this relates to the national Gross National Income (GNI), the Human Development Index (HDI) and the national population density. The results indicate massive impacts of both national and transboundary flood events on a global scale, but clearly show that transboundary floods are more severe in their magnitude[1], resulting in higher death tolls except in the high developed countries, higher displacement tolls in high developed countries, and cause more financial damage than non-shared river floods do.

[1] The magnitude of a flood is calculated as follows: flood magnitude = ln (duration) x severity class x $^{v(\text{affected region})}/_{100}$

The second section of the dissertation is dedicated to the identification of the quality and quantity of institutional capacity within the IRBs that is focused on transboundary floods. To this end, we examine the current state of existing transboundary river institutions, international water events and international fresh water treaties related to shared flood events. The results indicate that there might be more need for official international institutions dealing with transboundary flood-events.

Floods strike the developed and less developed countries alike, and people may face the same potential risks, but they may not be equally vulnerable because they may face different consequences to the same hazard. This presumably results in different responses, measures taken and institutions created. The last section of this dissertation therefore examines a developed downstream country prone to flooding (the Netherlands) and a lesser developed yet relative equally exposed country (Mozambique) and uses a historical perspective to look for differences or similarities in responses, measures taken, international water treaties signed and institutions created. It shows flood management strategies adopted in developed countries like the Netherlands have helped them evolve into the powerful societies that they are today. It would therefore be very tempting to adopt similar flood policies in developing countries like Mozambique. However, it is now recognized in the Netherlands (and many other developed countries) that completely controlling the floodwaters is not the optimal strategy. In addition, anticipated anthropogenic and climatic pressures will most likely demand a less rigid system of flood management. Therefore, Mozambique should choose to investigate the options of implementing the more flexible flood management strategy of learning to live with floods. In order to implement such strategies, very little needs to be undone in Mozambique, so the country can even end up leading the way and setting an example for the developed countries when it comes to post-modern flood management.

The results of this research provide us with a more detailed picture of the world of – transboundary – river flood events and have allowed us to discover new insights in the relations between flood losses (human and financial) and vulnerability factors, including developmental characteristics. Together, the results significantly increase our current knowledge on transboundary flood events and flood-related international institutions, and could also help policy-makers identify and evaluate potential vulnerability to transboundary river floods, which in turn can aid international water management and international cooperation over shared river floods.

CHAPTER TWO: VULNERABILITY TO –TRANSBOUNDRY– RIVER FLOODS OF CONTINENTS, INTERNATIONAL RIVER BASINS, AND COUNTRIES [2]

Author: Marloes H. N. Bakker

Abstract

This paper distinguished two types of river floods: those shared by more than one country, the so called transboundary events, and floods taking place in a single country. In the period 1985-2005 a total of 1760 worldwide river flood events killed over 112 thousand people, affected 354 million individuals, and caused 687 billion US dollars of damage. Almost one tenth, 175 of the 1760, of all river floods were shared by two or more countries, but globally accounted for 32% of all casualties, almost 60% of all affected individuals and 14% of all financial damage. These figures point to the massive impacts of both national and transboundary flood events on a global scale. However, not much is known about vulnerability of societies to –transboundary– floods, so we tried to uncover which and why societies are most vulnerable to these steadily increasing events. Our objective measures of vulnerability are both physical aspects, namely the magnitude of the river floods, and socio-economic, non-physical variables, i.e. the financial damages, number of casualties and number of displaced individuals they cause.

On a worldwide scale and for the considered period, the lesser developed countries experience more casualties than the more developed countries do. The average flood-related affected amount of individuals per million population increases when the average annual number of river flood-related displacements increases, but this relationship does not seem to be linked to the level of development of a country. Our research furthermore shows that intermediate developed countries experience higher financial losses relative to their GNI than the more developed or the less developed countries do.

When the two types of floods are compared using our vulnerability framework on a global and per country scale, shared floods are more severe than all river floods combined. High developed countries experience higher death tolls relative to their population during all river floods, while the low developed countries experience higher death tolls relative to their

[2] The major findings of this article have been presented as a poster at the World Water Forum (20-26 August 2006, Stockholm, Sweden).

population during shared flood events. Transboundary floods are more severe in their magnitude, resulting in higher death tolls except in the high developed countries, and higher displacement tolls in high developed countries, and cause more financial damage than non-shared river floods do. Transboundary events are becoming more frequent on every continent, especially Asia. In addition, Asian IRBs have had the most casualties and the highest quantity of affected individuals. The Ganges, Danube and Rhine river basins experienced the largest amount of transboundary floods, but the highest average death tolls were found in the Pedernales, Coatan Achute and Sembakung river basins, while the Ganges, Irrawaddy and Indus river basins experienced the highest total amount of casualties and affected people, even though the severity of shared floods was found to be the highest in the Irrawaddy, the Okavango and Chamelecon river basins. The highest amount of financial damages was found in the Danube, Elbe, and Ganges river basins.

The variety of answers indicate that when one wants to know which country, continent or river basin is the most vulnerable to –transboundary– floods, the answer heavily depends upon the specific definition of vulnerability. This indicates that vulnerability to floods is a complex phenomenon that cannot be explained by using the results of this study only.

Introduction

Floods are among the world's most frequent and damaging types of disasters and annually affect the lives of millions all over the globe. The application of science and medicine has undoubtedly improved humankind's ability to predict, alleviate and survive flood disasters, but over time population growth, climate related factors aggravated by urbanization, and social, economic and political processes have massively increased and will continue to increase human exposure and vulnerability to floods. Nonetheless, vulnerability of societies to floods is still poorly understood.

Using global data, this paper examines the nexus of flood events and society's vulnerability to it in two sections: river floods in general and shared, or transboundary, river floods. Previous studies have focused on all flood type data for specific countries or continents (Hoyois and Guha-Sapir, 2003) or looked at general statistics of various natural disasters on a worldwide scale (Mutter, 2005; Guha-Sapir *et al.*, 2004; Haque, 2003). This paper will investigate one type of flood, the river flood, and will pay attention to the financial damage caused by these events in addition to the number of casualties and how this relates to the national Gross National Income (GNI), the Human Development Index from the United Nations (HDI) and the national population density.

The second focus of this paper is the phenomenon of transboundary river floods. Studies until now have focused on a single (historical) flood events (Wind, 1999; Christie and Hanlon, 2001), a single river (Hesselink, 2002; Mudelsee *et al.*, 2003), a single country (Tol, 2003) or combinations of these topics. Only recently researchers have begun to analyze flood data on a global scale (Hossain and Katiyar, 2006), but few have touched upon the phenomena of shared, or transboundary floods occurring in international river basins (IRBs) (Marsalek *et al.*, 2006). But rivers ignore political boundaries and have created 279[3] (TFDD, 2006; unpublished

[3] New basins have been 'discovered' or were created since the last update of the TFDD, but not yet published; a manual count of the IRBs resulted in an increase of basins from the reported 263 on the TFDD website to 279 basins when writing this paper. The 'new' basins in Asia are: the Johore, Tebrau, and Scudai (shared between Malaysia and Singapore), the Loes (between Indonesia and Timor L'Este), and the Shu and Talas (shared between Kazakhstan and Kyrgyzstan). In Latin or Central America, six more basins were found: the Temash and Moho (shared between Guatemala and Belize), the Corredores/Colorado, the El Naranjo and Conventillos (shared between Costa Rica and Panama), the Chamelecon (shared between Guatemala and Honduras). In Africa, four more basins were added: the Thukela (between

data) IRBs, all of which, without exception, create some degree of tension among the societies that they bind[4]. One source of tension is the (naturally occurring) extreme hydrological conditions like floods. Using global data, the present study will fill this gap of knowledge by looking at transboundary flood events and look at the relations between the number of flood-related casualties, the HDI and the national river basin population density. In doing so, this paper will provide insight in the magnitude of loss of life and financial damage in relation to the level op development by country, continent and IRB.

To these ends, figures from two different databases, the Office of United States Foreign Disaster Assistance/Centre for Research on the Epidemiology of Disasters International Disaster Database, or OFDA/CRED Database, and the Dartmouth Flood Observatory Database, or DFO Database, will be joined to look at floods that have occurred worldwide between the period 1985-2005. Combined with the geographic dataset of the world's international river basins (Wolf *et al.*, 1999) a useful basis for truly global studies of (transboundary) flood events will be created. We will investigate vulnerability using the biophysical variable of flood magnitude and the socio-economic variables of (1) the level of development, (2) Global National Income (GNI) and how this related to the total financial damage, (3) population density per country and per international river basin and how these relate tot the casualties and affected individuals. Our working hypotheses are that all 3 categories are linked to the vulnerability of a society; lower developed countries will experience more floods and have more flood-related casualties because as a society and individuals, they have lesser means to protect themselves. People and societies with resources and economic alternatives tend to be better protected from harm and are able to recover more quickly than people with fewer options and resources. The financial damage on the other hand will be higher in more developed countries because more costly properties are build in the floodplains of developed countries. When applied specifically to IRBs, we anticipate being able to identify those IRBs that have proven to be the most vulnerable to transboundary flood events.

Lesotho and South Africa), the Sanaga (between the Central African Republic, Cameroon and Nigeria), the Pungwe (shared between Mozambique and Zimbabwe), and the Pangani (shared betweenTanzania and Kenya). There is indication of the existence of more basins between Timor L'Este and Indonesia, but there is not yet enough spatial information to confirm this.

[4] The word 'rival' has the same root as 'river', derived from the riparian concept of dwellers on opposite riverbanks.

While we have attempted to obtain all data available about global flood events in order to get a firmer grasp on vulnerability to floods, it must be kept in mind that measuring the global flood problem is fraught with problems because of (a) gaps and numerous deficiencies in data, (b) the highly variably quality of available data and (c) the problems of comparing flood impacts along the socio-economic development spectrum (Parker, 2000). As media penetration and information communication have improved, events that might not have been reported in previous years are now routinely reported. Still, in many parts of the world there is no reliable data on the extent of exposure of people and property to flood hazards and reports of the effects of flood disasters are always likely to be less complete in regions with limited resources, such as Africa.

This paper has five major parts. Part two will briefly describe the science of floods and touch upon the effects floods can have. Part three will describe the methodology used. Part four presents the results of the investigations. Part five presents the discussion and conclusions.

The Science behind Floods

Types of Floods

Flood events have been defined in many ways:

> 'a relatively high flow which overtaxes the natural channel provided for the runoff' (Chow, 1956); and 'a body of water which rises to overflow land which is normally not submerged' (Ward, 1978)

are just two of many. A flood event in general is any type of situation where water temporarily covers land outside its normal confines. In general, flooding is associated with harm and damage and considered an undesirable occurrence. Although every flood is a unique phenomenon, several types of floods can be distinguished. The most common type is where a river overflows its banks due to a large input of rainfall or snowmelt. These are types of flood that can be predicted and explained in terms of catchment physical characteristics and climatic inputs (Arnell, 2002). When one looks at the size of the affected area and the duration of precipitation (or, in other words, the spatial[5] and temporal scale of the flood events), there are two categories of floods (Waggoner, 1990; Bronstert, 2003). The first category includes extensive, long-lasting floods (plain floods). These describe the flooding of larger areas that is almost invariably caused by rainfalls lasting several days or weeks in connection with high antecedent soil saturation. Flooding caused by extensive and long-lasting rainfalls, partly connected with the melting of snow and ice, occurs mostly in plain areas when the dikes along the big rivers can no longer contain the flood discharges. This can lead to flooding of wide areas, as, for example, during the flooding of the European Rhine/Meuse rivers in December 1993 and in January and February 1995. The second category is local, sudden floods, or flash floods, which describe flooding in small catchments that is mainly caused by short and highly intensive precipitation (e.g., thunderstorm). Flash floods occur primarily in hilly or mountainous areas due to prevailing convective rainfall mechanisms, thin soils, and high runoff velocities. The warning time for these events is short. In general, the duration of the flood events is also short, but this flood type is also frequently connected with severe damages. Flash floods are in fact the number one weather-related killer in the United States of America, killing about 200 people every year, with most deaths caused by drowning (Ohl and Tapsell, 2000).

[5] Note that catchment size is always an important parameter when discussing floods since unit area flow in floods of the same risk decreases with an increase of catchment area, influencing forecast, warning, response, defense and coping with floods.

Although heavy rain is the prime initiator of flooding worldwide, it does not follow that all floods are necessarily caused by an excess of rainfall or snowmelt. For instance, rivers can overflow because ice-dammed lakes are released. Some massive landscape-forming floods were caused in North America and the Himalaya in this way during deglaciation (Arnell, 2002), and much smaller floods occur still from the periodic release of water stored behind or within glaciers. Landslides too can create temporary dams which produce floods when breached. Lastly, floods can be the result of an unusually high rise in groundwater levels, such that the water table reaches the surface (Arnell, 2002). Similarly, a rise in lake levels can lead to inundation of the surrounding land. Both these types of floods are generated by prolonged heavy rainfall or snowfall. Finally, floods can also be generated by humans (Vevjevich in Rossi *et al.*, 1994), for instance when structures built by society break (e.g., break of a levee, break of a dam or dike), or by errors in operation (such as mismanagement of flood control gates or equipment).

Vulnerability, Risk, Adaptability and Resilience to Floods

Floods occur all around the world, but the effects on communities differ per location and event. Some events take place in inhabited areas and have no impact on societies, others are so small that they are not noticeable on an economic or personal scale, and yet others wipe away entire villages. No matter how big the impacts, the damages resulting from flood are commonly categorized into tangible and intangible losses. Tangible damages can be measured in monetary terms, such as the damage to a building, although such a measurement relies heavily on damage estimation procedures. Intangible losses are those which either defy monetary measurement (the loss of an archaeological site by erosion caused by flooding, the loss of valuable art treasures, the potential loss of eco-tourism regions or other productive areas), and/or those for which monetary estimates are considered to be undesirable or unacceptable (such as placing a monetary value on someone's life). Thus, at one time all flood impacts were 'intangibles'; as the state of the art has developed, some have been converted into 'tangibles'. At any time, therefore, 'intangibles' are the bits left out of the analysis and because they are not quantified, they may be the most or less important impacts of flooding. It has been found rather consistently (Allee *et al*., 1980; Green and Penning-Rowsell, 1986, 1989; Penning-Rowsell *et al.*, 1992) that the 'intangible' impacts of flooding on households - the stress, disruption and loss of items of sentimental value - are more important to the affected households than the damage to their home and its replaceable contents. Another distinction can be made between direct and indirect flood losses. Direct flood losses are those caused by the physical contact of floodwater with damageable property, as for example in floodwater damaging the carpets and furniture of a home through immersion, whereas indirect losses are those caused by the consequences of physical contact of floodwater with property – so when floods drown livestock this is a direct loss, but when the income from the livestock product sales is lost, this is an indirect loss. Finally, a third way of categorizing losses is through multiple-order effects so that primary, secondary and tertiary losses are identified.

There is no unique all-encompassing definition for 'risk' and any attempt to develop one would inevitably satisfy only a proportion of risk managers. In essence, risk is the possibility of loss, damage, or any other undesirable event and has two components: the chance (or probability) of an event occurring and the impact (or consequence) associated with that event.

The effects of floods are extraordinarily complex and include both beneficial[6] (i.e. positive) and adverse (i.e. negative) impacts on society and the environment. Generally, however, flood management is concerned with protecting society and hence risk is typically concerned with the likelihood of an undesirable consequence and our ability to manage or prevent it.

One of the problems of flood impact assessments is that they often focus solely or mainly upon the adverse impacts and a truly balanced flood impact assessment methodology has yet to emerge. There is no doubt that floods destroy economic resources of value to society, but it is also true that floods can generate beneficial gains which can offset financial losses (Parker, 2000).

Vulnerability, adaptability and resilience are crucial concepts when talking about the impacts of floods. Vulnerability is the condition of an individual, a group, a society, property and the environment, in terms of their ability and capacity to anticipate, cope with, resist, respond and recover from the impact of a natural hazard such as a flood. For example, elderly people may be less able to evacuate in the event of a flood than young people and so have greater vulnerability to harm. The vulnerability of any physical, structural or socio-economic systems[7] to a natural hazard is its probability of being damaged, destroyed or lost. A building incorporating specific flood resistant construction techniques should have less vulnerability to flood damage than one without these features. Vulnerability is not a static but a dynamic process that depends upon the social, economic and political contexts that change over time, so the probability of loss also varies. Hence, strengthening social resilience capacity could hypothetically reduce vulnerability. This can happen to a community that is exposed to regular disturbances, like communities build in a floodplain; they may have developed organizational and infrastructural responses to absorb disturbances more easily than other societies. Adaptive

[6] Potential beneficial effects of floods may be that they replenish the soils with alluvial silt which adds to soil fertility and subsequently, soil productivity. They may replenish soil moisture, which can result in increased crop yields. They can be beneficial to the aquatic ecosystem and to human livelihoods associated with them (e.g. fishing). On a medium to long term, industrial efficiency may be increased because plants and factories based on out-dated designs will be replaced or redesigned and updated. Lastly, the family and community spirit and bonding may be increased.

[7] In the broadest terms, a system may be described as the social and physical domain within which risks arise and are managed. An understanding of the way a system behaves and, in particular, the mechanisms by which it may fail, is an essential aspect of understanding risk. This is true for an organizational system like flood warning, as well as for a more physical system, such as a series of flood defenses protecting a flood plain.

capacity is an aspect of resilience that reflects learning, flexibility to experiment and adopt novel solutions, and it also reflects development of generalized responses to broad classes of challenges. In short, adaptive capacity is the capacity to respond to and shape change (Folke *et al*. 2002). In theory, people occupying a system have the capacity to influence the level of resilience (Walker *et al*., 2004) which amounts to the capacity of humans to manage resilience. Resilience can be defined in many ways (see Adger, 2000), but overall it is the capacity of the system to absorb or recover from the damaging effect of extreme loads, for instance the disturbances resulting from floods. Social resilience has been defined as the ability of human communities to withstand external shocks to their social infrastructure, such as environmental variability or social, economic, and political upheaval. The greater the resilience of societies, the greater is their ability to absorb shocks and perturbations and adapt to change. Conversely, the less resilient a system, the greater is the vulnerability of societies to cope and adapt to change.

If a society would want complete and total safety, the only way to achieve that would be to move out of the flood plain. If they choose not to, or do not have this choice, they can become resilient or sustainable to flood events. Resilient or sustainable communities are ones that know about and are involved in managing their flood problems. They have good information about those areas which are flood prone. They strive to avoid exposure to floods, or they at least constrain the extent to which they are exposed. They seek to strike a balance in which flood risk is weighed against other social and economic goals and benefits. They recognize that some exposure to floods is probably inevitable and that other important community goals may be achieved by occupying and using floodplains. They seek to adapt to floods and increase their resilience to them, including through developing effective flood warning and response systems. They do not necessarily rely on traditional engineering remedies. The desired level of safety is a matter of societal choice (see chapter three, page 67 and further).

Methodology

Measures of Vulnerability

In this paper, vulnerability[8] is we will look at vulnerability from a biophysical point of view, i.e. using the flood magnitude, but also from a non-physical socio-economic position, i.e. the total amount of damages, casualties, people affected and level of development. All variables are obtained using the methodology described below.

The OFDA/CRED International Disaster Database

The Centre for Research on the Epidemiology of Disasters (CRED) in Brussels in cooperation with the United States Office for Foreign Disaster Assistance (OFDA), maintains the OFDA/CRED International Disaster Database (EM-DAT). EM-DAT is publicly accessible at http://www.em-dat.net/. The main objective of the database, as given on the CRED website, is to serve the purposes of humanitarian action at national and international levels. It contains essential core data on the occurrence and effects on international disasters, including floods. It is an initiative aimed to rationalize decision-making for disaster preparedness. Each disaster is recorded by type, date, country of disaster and numbers of people dying, injured and affected/injured/homeless. Data is collected for events in which there are ten or more deaths, or when international assistance is requested. The data is obtained from insurance companies (Munich Re, Suisse Re and Lloyds of England), Federation of Red Cross, UN-OCHA, WHO, Reuters and governments. Although the data shows an increase in hydro-meteorological disasters between 1960 and 2000, flood data in developed countries is poor (WHO, 2002).

Events in EM-DAT are categorized in a way that issues can arise. For instance, in some cases multiple separate events are aggregated to one record in EM-DAT, such as the separate floods that occurred in multiple parts of China throughout August of 1998, but are found as one combined event in the database (as was also experienced by Jonkman, 2005). Other

[8] Vulnerability is the condition of a person or a group or a society, in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard such as a flood. The vulnerability of any physical, structural or socio-economic systems to a natural hazard is its probability of being damaged, destroyed or lost. Vulnerability is not static but a dynamic process that depends upon the social, economic and political contexts that change over time, so the probability of loss also varies. So for instance, strengthening social resilience capacity would theoretically reduce vulnerability. This can happen to a community that is exposed to regular disturbances, like communities build in a floodplain; they may have developed organizational and infrastructural responses to absorb disturbances more easily than other societies.

classification problems may occur in assigning a disaster type because the distinction between different types may not always be clear; a tsunami may result in flooding, and landslides might be triggered by floods.

Dartmouth Flood Observatory Database

The second database used in this study in combination with the EM-DAT database, is compiled and maintained by the Dartmouth Flood Observatory (DFO) in New Hampshire. The DFO database is a global listing of extreme flood events compiled from diverse sources for the period 1985-present. Unlike the EM-DAT database that lists events per country, the DFO database lists individual floods. Consequently, the combination of the two databases enabled us to detect transboundary floods. The DFO database is publicly accessible at http://www.dartmouth.edu/~floods/. The Observatory detects, maps, and measures major flood events world-wide using satellite remote sensing. Each flood is recorded by country, location, date, victims, displaced people, damage and more details about the type of flood. The future ideal is, as the archive of reliable data grows, that it will be possible to predict where and when major flooding will occur, and to analyze trends over time.

The data used processed in the DFO database is derived from a wide variety of news sources, governmental, instrumental, and remote sensing sources. Current events are added almost instantly. Deaths and damage estimates for tropical storms are totals from all causes, but tropical storms without significant river flooding are not included. DFO data are poor or missing in the early-mid 1990s.

Selection of Floods

Because the DFO Database starts in 1985, we limited the period we look at accordingly, thus to the period 1985-2005. In this study, only fresh water flooding of rivers will be analyzed. A river flood is defined as the inundation of land along a riverbank due to a river or stream overflowing natural or constructed confines. Both databases have gaps in their description of the floods; main causes were not mentioned and/or it was not clear whether the flood was exclusively a river flood. When in doubt about the actual nature of the flood and when additional sources (articles, newspapers, World Wide Web) could not provide clarity about the event, the event was excluded. Other examples of flood events that were excluded are tsunamis and tidal waves. These events may result in river flooding in coastal areas, but they are generally regarded different natural hazards than floods and are therefore excluded.

Typhoons and hurricanes that led to river flooding are categorized as separate hazards and also excluded from this study. The notion that every flood is unique and has its own unique characteristics is not lost on the authors. However, it is assumed that patterns may be observed when a large number of floods is taken into consideration.

Classification of Shared River Floods

The EM-DAT database lists disasters like floods per country and the DFO database lists flood events with the exact location. Thus by combining the two sets, it can be distilled whether the event is shared by one or more countries or, in other words, whether the flood was transboundary or not.

However, the DFO only reports one number per event for the number of casualties and financial damage, making it unclear how much damage each individual country has experienced. Therefore, every shared flood reported by the DFO was compared to data from EM-DAT. If the floods were similar in date and location, the DFO-numbers for deaths, displaced and damage were cut and replaced by the country-specific EM-DAT data. This resulted in a database that had numbers for every country that experienced a shared flood.

Note that whenever the date and location reported in the DFO database did not match any of the EM-DAT events, the DFO numbers were assigned to only one country. Whenever the EM-DAT data only had values for the number of casualties, but no figures for financial damage or displacements for shared floods, the DFO figures for the casualty-count were replaced by the EM-DAT counts, because the EM-DAT database is more accurate on a country-by-country base.

Cautionary Remarks about Databases

Both the EM-DAT and DFO databases are important collections of data from other sources, but some issues must be kept in mind when analyzing and interpreting the data. First, the data are inadequate for understanding absolute levels of risk posed by floods, but they are adequate for analyzes of areas or basins that that have had a history of floods. Furthermore, the data should not be considered standardized, accurate or complete (see for instance footnote #11). The quality and the reliability of underlying sources determine the quality of the data incorporated in the databases. Especially the estimates of numbers of people of killed may include considerable uncertainty and the figures should therefore not be regarded as the exact

truth. Differences in development of the structures for reporting disaster damage might also play a role when it comes to the reliability of data, as well as the availability and accuracy of demographic data, and misrepresentation of events for political reasons (Jonkman, 2005). In addition, smaller disasters in developing countries may be under-reported or not reported at all.

Given the uncertainties in the estimations of numbers of people killed and affected, the presented results should not be used as predictors for the loss of life to be expected for every flood event per country, or floods in specific river basins. However, these global statistics do provide insight in typical patterns in the consequences of (transboundary) river floods per IRB, continent and country.

Some general problems arose as a result from the combination of the two datasets. Floods mentioned in the one are not always mentioned in the other and vice versa. As said, both datasets are incomplete (indicated as 'no data available') and have 'guesstimates' entries (noted as 'hundreds of deaths' or 'millions of dollars damage'). And mentioned earlier, the quality of the data is defined by what is made available through the sources used. Floods can reportedly have no financial damage, but this might just as well be the result of deliberate missing or poor communication. Therefore, the numbers in the datasets do not necessarily reflect actual data, and even sometimes misrepresent factuality. Overall, data for the mid and low HDI countries are less accurate (more guesstimates), while the values for the high HDI countries seem more complete and precise. However, aggregating all the entries in both databases helps compensate for missing data and reported inaccuracies. In the absence of consistent, accurate loss estimates for individual events, the aggregate indexes reflect broad patterns across flood events. This is particularly important in case of economic losses, which are unevenly recorded in EM-DAT and assessed using non-standardized methodologies.

The data shows, especially in the late 1990s, a significant increase in the number of flood events included in the datasets per year. Whether this growth is due to an increase in the number of occurring floods, or due to a more accurate and extensive data collection cannot be directly derived from the data. However, the improvement in data collection is believed to play an important role in this increase, since WHO (2002) states with respect to EM-DAT: "Since 1975 there was a substantial improvement in reporting and data collection, and since the 1990s more than 90% coverage was achieved." It must also be noted that the quality of

reports on flooding in the United States is considerably higher in both databases used. This might be attributed to the fact that both databases have an American element in them (based in an American institution or financed with American funds).

In summary, the combination of the two datasets does not cover all flood events that occurred throughout the world, and it did not result in a complete and accurate calculation of the flood-related victims and flood-related financial damages per country, continent or IRB, but is believed to form a representative sample of worldwide flood events and their impacts.

Global Analysis of Floods and related Socio-Economic Variables

Analyzed Flood Data

Information from the two datasets were combined as described in the previous sections, using the following types of information in the database: location (in EM-DAT noted as country, in the DFO noted as city or region), number of people killed, number of people displaced or affected, and financial damage (at the time of occurrence) in United States dollars (USD). The result was a database that consisted of 2850 floods. However, as previously outlined, this general category still includes floods that are not freshwater river floods, so distilled from these were the river floods, resulting in a total of 1760 floods, causing over 112,000 people their lives, affecting around 354,370,000 people and causing USD $6{,}87 \times 10^{11}$ in financial damage. As can be seen in figure 2.1, the total amount of river floods differs per year, but a steady increase is noticeable. The distribution per year per continent and reveals that 43% of all river floods take place on the Asian continent, while only four per cent have taken place on Oceania.

There is no question about the fact whether socio-economic factors are related to the impact of disastrous events. Haque (2003) for instance looked at the disaster losses in South and South-East Asia and showed that disaster losses cannot by separated from societal and developmental factors[9]. But what about losses specifically caused by floods - are these also a function of human vulnerability to floods? To this end, we evaluate whether anything can be said about the relationships between location, the level of development, population density of a country and population density while looking first at national and later on at shared flood events. We will use the combined dataset, and add, if available, the most current ranking at the time of research by the World Bank of the Gross National Income (GNI) (World Bank, 2004), the country population in 2003 (UNDP, 2005), the total population per national river basin (calculated with data from the TFDD, 2005) and the United Nations Human Development

[9] Many of the socio-economic and demographic variables significantly influence disaster-related deaths and injuries in this part of the world. Haque's nine socio-economic and demographic variables correlated to natural disaster induced losses were: population size, population density, labor force, population ages, life expectancy, adult illiteracy rate, GNP, GNPG, urban population and energy consumption. His results show that demographic variables have become prominent predictors of disaster-loss in South, Southeast and East Asian and the Pacific states, inferring that intervention into population growth and distribution could be used as disaster mitigation instruments (Haque, 2003).

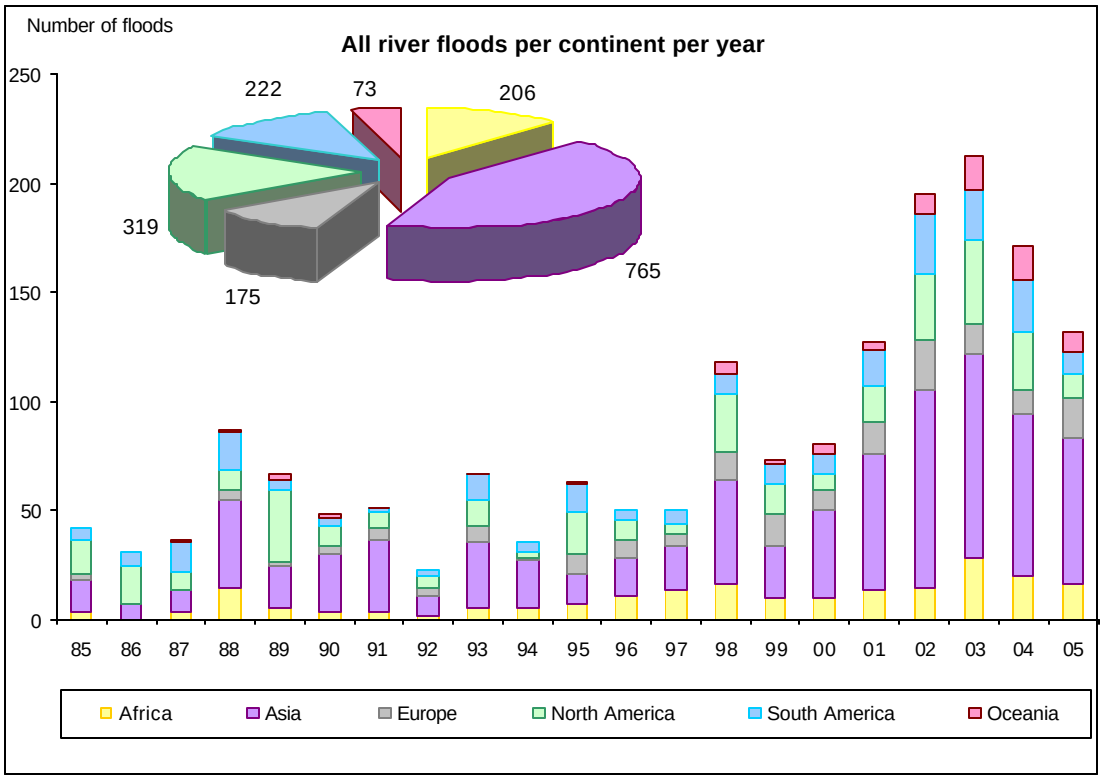


Figure 2.1: the distribution of river floods per continent and per year shows that, with only a few exceptions, every continent experiences river floods every year. The pie chart shows the total amount of river floods that have occurred all over the world during the period 1985-2005. Although the number of (transboundary) river floods per year differs, a steady increase is noticeable. The sums of all the years together reveal that most river floods have taken place on the Asian continent, followed by the North American and African continents.

Index, further referred to as HDI, as included in the United Nations Development Programme Report 2005 per country (UNDP, 2005).

Floods, HDI, GNI and Population

The GNI, previously known as Gross National Product (GNP), comprises the total value of goods and services produced within a country (i.e. its Gross Domestic Product), together with its income received from other countries (notably interest and dividends), and less similar payments made to other countries. For operational and analytical purposes, it is the World Bank's main criterion for classifying economies. Based on its GNI per capita, every economy is classified as low income, middle income or high income.The HDI is a comparative measure of poverty, literacy, education, life expectancy, childbirth, and other factors for countries worldwide. It is a standard means of measuring well-being, especially child welfare. It is used to distinguish whether or not the country is a first, second or third world country (high,

medium, low HDI score, respectively) (UNDP, 2005). An HDI below 0.5 is considered to represent low development and 30 of the 32 countries in that category are located in Africa, with the exceptions of Haiti and Yemen. The bottom ten countries are all in Africa. The highest-scoring Sub-Saharan country, South Africa, is ranked 120th (with an HDI of 0.66), which is well above most other countries in the region. An HDI 0.8 or more is considered to represent high development. This includes countries of northern and western Europe, Australia, New Zealand, Canada, United States, Japan, Israel and East Asian Tigers. Other countries that exhibit high human development amidst countries with lower HDIs include (with their position) Costa Rica (47th), Cuba (52nd), Mexico (53rd) and Panama (56th) (UNDP, 2005).This categorization leads to 57 countries with a high HDI score, 88 countries with a medium HDI score and 32 countries with a low HDI score[10].

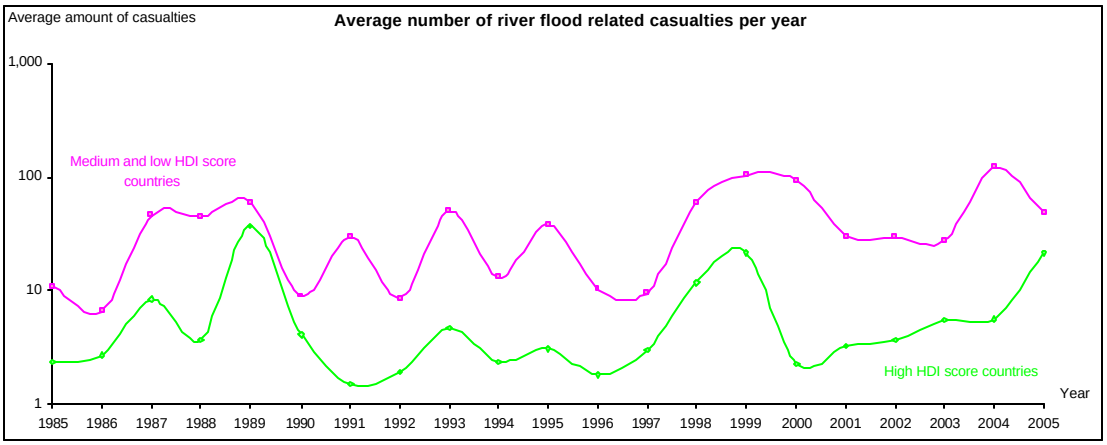


Figure 2.2: The average number of casualties divided by the amount of countries in that class per year clearly shows that the average annual amount of river flood-related casualties in high developed countries is always lower than that in the medium and low developed countries combined.

We looked for a relationship between floods, the flood-related casualties and the level of development. The working hypothesis is that human fatalities caused by river floods are higher in the less developed countries than in high developed countries. When we look at the number of flood-related casualties per year for all high, medium and low developed countries grouped together, taking into account the fact that there are only 57 countries with a high HDI

[10] The list has 194 countries, but not all UN member states choose to or are able to provide the necessary statistics. Notable absences from the list (excluding micro-states) are Afghanistan, Iraq, Liberia, North Korea, Serbia, Montenegro, and Somalia. These countries are generally considered of medium to low human development. Although they have also experienced floods, they have been omitted from the calculations and, consequently, the graphs.

score and 120 countries with low or medium scores, therefore plotting the average number of casualties divided by the amount of countries in that class on a log scale (see figure 2.2), we clearly see that the line representing the medium and low score countries is always above the line representing the high score countries.

However, this relationship might be skewed because of the amount of floods a country experiences. In other words, is the average annual number of flood-related casualties correlated to the total number of floods a country has experienced from 1985-2005? We plotted the average annual number of flood-related casualties per country against the total number of floods. An upper right placement indicates that the country experienced many floods and has high casualties on average; placed in the lower left indicates the opposite. The wide spread in the resulting figure (figure 2.A in appendix, page 178) indicates that there are a variety of factors at play here, thus the number of river flood-related casualties is not only dependent on the level of development of a country. The general trend is that the more floods a country experiences, the higher the average annual number of flood-related casualties.

Mutter (2005) showed that when HDI is plotted against latitude, there is a clear separation between high and low HDI countries. Lower HDI countries are mostly located near the equator and appeared much more vulnerable for flooding than the other, higher scoring HDI countries. However, floods in that study included all types, not only river floods. So we looked for a relationship between the number of people killed by river floods and the level of development. However, looking at the total population of a country and comparing it to the flood-related death toll is not completely fair since the minority or majority of a country's population might not be living in a river basin and therefore not be as vulnerable to flooding as those living closer to the threat. Thus, we plotted the flood-related death toll against the amount of people living in the international river basins (IRBs) of that country. Data solely describing the national population living in national river basins (NRBs) is available for 22 countries (calculated with data from IUCN *et al.*, 2003) and included for those countries. In this resulting graph (figure 2.B in appendix, page 179), highly impacted countries will be found in the upper right, where many deaths occur and those deaths are in high proportion to the population living in the river basins. For instance, the Netherlands, number 12 on the HDI list, has experienced floods during the period 1985-2005 (7 in total), but has had no casualties over the last 21 years and so is plotted on the lower left. Mozambique, number 158 on the HDI list, on the other hand has seen 15 floods and casualties each and every time, about 50 on

average for 21 years, which comes down to 52 deaths per million population over the 21 years. Noticeable is a great deal of spread which indicates that a variety of influences are important when looking at complex relationships like this. However, also visible is a fair relationship between human development and mortality risk from floods: the majority of countries with a high HDI score are in the lower left rather than the upper right of the graph. It is worth mentioning that countries with a low HDI score are plotted all over the graph, from the upper right to the lower left. This again indicates that vulnerability to river floods can not only be described by these factors. The United States is number 10 on the HDI list. There is a notable difference when the casualties from Hurricane Katrina are included[11]. Nevertheless, it is noticeable that the USA, together with Mexico, is one of the few higher developed countries that has a high death toll relative to the population living in the river basins. With Katrina, there are about 155 deaths per year, which is about 16 deaths per million population. Without Katrina, the death toll drops to 105, which is still about 11 deaths per million population. The medium-HDI country that is the most in the upper right is India. India is well-known for having to experience devastating floods every year. The flood-related casualties averages out at about 1360 deaths per year and this is about 42 deaths per million river basin population. Saudi-Arabia, a quite extreme outlier in the graph, has experienced only three floods, which resulted in 51 casualties. However, less than one percent of the country is situated in the Tigris-Euphrates/Shatt al Arab river basin and only a tiny part of the total population lives in that area, resulting in a relatively high average death toll for this country.

Evident from the data is that high numbers of floods do not always result in high average death tolls relative to the population in the river basins (figure 2.C in appendix, page 180). This does not seem to have any relation to the level of development of a country, although the higher scoring HDI countries do not cross the value of 65.6 deaths per million river basin population.

[11] Hurricane Katrina was the costliest and one of the deadliest hurricanes in the history of the United States. Katrina formed in late August during the 2005 Atlantic hurricane season and devastated much of the north-central Gulf Coast of the United States. Katrina caused more than 1000 casualties (according to the databases used, at the time of analysis), which is a little bit less than half of the total amount of flood casualties. Reports later on reported over 1,800 victims.

Number of Affected Individuals

Human casualties related to flood events can be avoided by evacuation of specific areas prior to the actual flooding event. Evacuation presumably happens more often in countries that have the ability to predict flood events and have the financial and human resources to warn people beforehand and help evacuate the area, hypothetically increasing the amounts of displaced/affected people, since governments will in all probability move more and not less people away from the hazard. Situations where the flood event happens unexpectedly are likely to occur more often in countries without adequate warning systems, but that does not necessarily mean that more or less people will be displaced/affected because again, when sufficient warning systems are in place, it is likely that more people will be vacated. This section will look more closely at the figures of river flood-related displacements to see if there are any relations to the level of development.

We looked at relationships between the average annual numbers of flood-related displacements against the total number of river floods, but this did not reveal any apparent pattern, indicating that there are more factors at play, although the low HDI countries seem to have higher amounts of affected people compared to the more developed countries that experienced similar amounts of floods.

When we look at the displacement toll relative to the population and plot that against the average annual amount of affected people, we see that the average flood-related affected amount of individuals per million population increases when the average annual number of river flood-related displacements increases . However, this includes the entire population, so to neutralize any effects that people not living in the river basins might have, we also looked exclusively at the population living in the vulnerable river basins. The resulting graph (figure 2.D in appendix, page 181) shows no apparent patterns between the level of development and the displacement toll, which indicates the importance of only including the population actually vulnerable to river floods. When we plot the number of floods a country has experienced against the death toll relative to the population living in the river basins, the scatter is again too dominant to reveal any patterns.

When we look at the relationship between the average displacement toll and the average death toll (both relative to the basin population) of individual countries (see figure 2.E in appendix, page 182), the expected trend is that higher displacement tolls would result in lower death

tolls, assuming the displacement tolls are the result of evacuation. This does seem the case in general for the high developed countries, but the middle and low developed countries display the opposite trend: higher displacement tolls seem to be associated to higher death tolls; this might point to the fact that the event was unexpected and/or severe, resulting in high amounts of displaced people, but also high amounts of victims. We also see that the spread for the death toll is much bigger for the medium and low HDI countries, while the death toll of the high HDI countries does not exceed 73.6.

Financial Damages

Where economic growth takes place within flood-prone areas, it is reasonable to expect that whenever per capita incomes rise, so will property value at risk and average annual flood losses in real terms: more developed countries will have higher monetary damages related to floods. We summed up the total amount of financial damages at the time of the event caused by river floods in USD, took the average of the damage per year and divide that by the GNI of a country, expecting to find that the developed countries to have more financial damage per year and to see the increased losses as compared to impacts of flood events in the past, because of the general trends to increase investment and population in flood plains.

Data shows that annual economic losses associated with floods for the low HDI scoring countries is the lowest almost every year (figure 2.F in appendix, page 183). However, as figure 2.G in the appendix (page 184) shows, the countries that have suffered the most financial damage relative to their GNI are mostly medium HDI-score countries. There are only two low-developed countries that experience a relatively high financial damager per year. This indicates that the medium developed countries experience higher financial losses relative to their GNI than the more developed, but also the lesser developed countries do. In a way, this is logical, since these countries have lower GNI compared to developed countries, so if there is a catastrophic flood event, the relative financial impact will be higher. The low-score HDI countries theoretically have less to lose, from a material point of view, and thus when floods strike, they do not cause as much financial damage. The structures in the floodplains of the high developed countries seem to be better protected from harm caused by floods. Nonetheless, the types and severity (Jonkman, 2005) and locations of the flood event are important factors contributing to the amount of damage and nothing concrete can be said without looking at each event separately.

When we look at possible relations between the amount of flood-related victims and the total amount of damage per year, there appear to be clusters per level of development, especially for the medium and high scoring HDI countries, emphasizing that the number of casualties in general is higher for the medium countries. This might be due to poor reporting skills in the lesser developed countries, the severity of the flood event or the number of people in the vicinity of the flood event. As figure 7 already implied, on average, the total amount of damage per year for the medium developed countries is higher than that of the high developed countries and accumulated over the 21 years, the medium scoring countries have the most financial damage. This trend, however, is heavily influenced by the extreme outliers, resulting in a slight misrepresentation of the facts. Taking the medians of these observations, however, thus weighing the outliers less heavily, results in a more theory-confirming trend (figure 2.3): high developed countries experience the highest amount of financial damage per flood and the least amount of casualties, low developed countries experience the least amount of financial damage, but the highest amount of casualties per flood. The medium developed countries are just in between these two extremes. The standard errors indicated in the graphs emphasize the uncertainties in the estimation of the numbers of people killed and the financial damage.

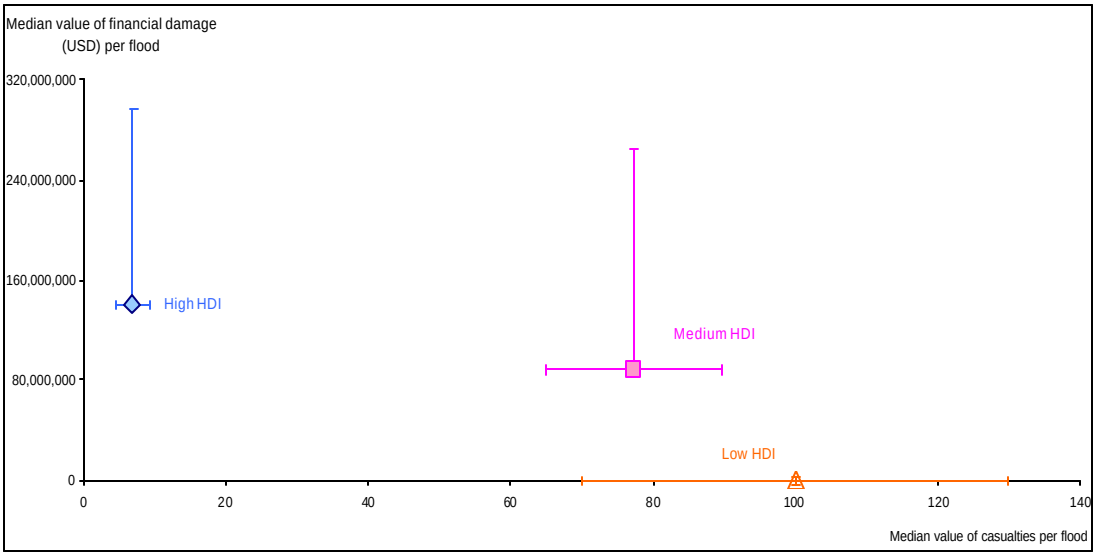


Figure 2.3: The median values of financial damages per flood accumulated for all high, medium and low scoring HDI countries, plotted against the median value of the casualties per flood. Low HDI countries experience the most casualties per flood, and the least amount of financial damage, whereas high developed countries have the least amount of victims, but the highest amount of financial damage.

Comparison between Transboundary and All River Floods Events

At present, there are 279 rivers around the world that cross the boundaries of two or more nations (TFDD, 2006, unpublished data). The catchment areas that contribute to these rivers comprise approximately 42% of the land surface of the earth[12], include 40% of the world's population, and contribute almost 80% of freshwater flow (TFDD, 2006; UNEP, 2006). Much like rivers, floods respect no political boundaries. Therefore, transboundary floods are not uncommon. From the 194 countries[13] on the UN HDI list, 42 (a bit more than 21%) of those have not experienced any river floods during the period 1985-2005. Of the remaining 152 countries, including countries that are not part of IRBs, like Australia and small island states, 40 did not experience any transboundary floods, but the remaining 112 did. In other words, 75% of countries that experience river floods share this event with other countries. In spite of this, the phenomenon of shared floods has not received much attention in the past. However, before we explore the phenomenon of shared floods further, we first need to establish whether a more detailed look at these transboundary events is justified or if they are not that different from regular floods.

The data shows that during the considered period, 175 out of the total 1760 river flood events were transboundary river floods and caused almost 37,000 people their lives, affected about 210×10^6 people and resulted in more than 97×10^9 USD financial damage. In other words, although only about one tenth of all the river floods from the last 21 years were categorized as transboundary, they represent a considerable amount – always more than 10% - of the total amount of casualties, affected people and financial damage caused by all river floods (see figure 2.4). For a complete list of the transboundary river flood events, see appendix table 2A (from page 196).

[12] Numbers used for calculation: land area of the Earth: 147,142,344 km^2, and the land area of all the 279 international river basins combined is 61,852,502 km^2.
[13] As noted earlier, some countries are not ranked on the HDI list and could therefore not be included in the graphs. However, they have experienced floods, so are included in this calculation.

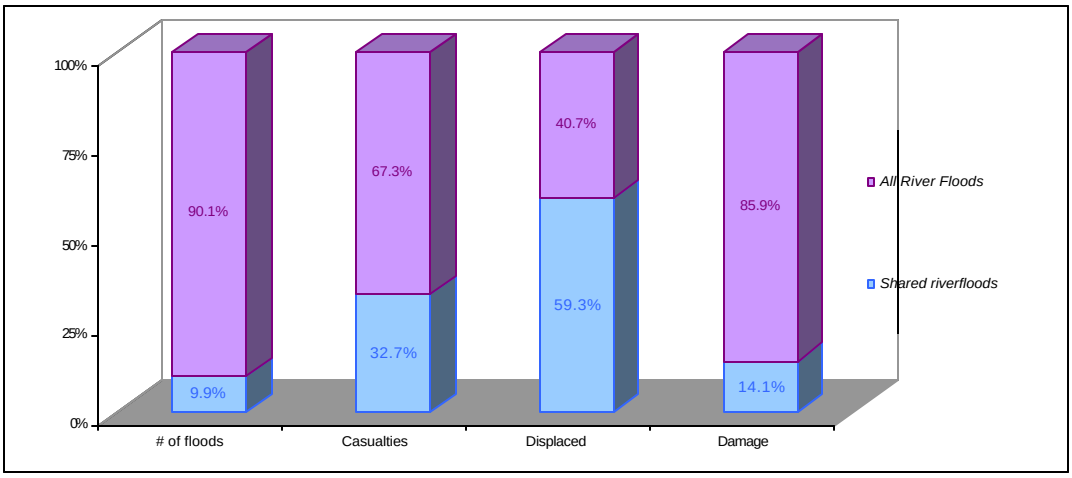


Figure 2.4: Almost ten per cent of all river floods are transboundary, but represent a considerable amount of the total amount of casualties, displaced/affected individuals and financial damages.

The findings summarized in figure 2.4 could possibly be explained by the difference in the severity of the different events. To test this hypothesis, we use the DFO-variable of the flood magnitude per flood, which is the result of the following calculation:

$$\text{Flood magnitude} = \ln(\text{duration}) \times \text{severity class} \times {}^{\text{v(affected region)}}/_{100}$$

in which the severity class is a magnitude assessment and floods are ranked on a 1-3 scale, where a class I flood stands for a large flood event with significant damage to structures or agriculture, fatalities and/or a 1-2 decades-long reported interval since the last similar event. A class II flood is a very large event with a greater than two decades but less than 100 year estimated recurrence interval, and/or a local recurrence interval of at one-two decades and it has affected a large geographic region (> 5000 km^2). A class III flood is an extreme event with an estimated recurrence interval greater than 100 years. The flood magnitude is seen as a more appropriate variable to compare floods than only the severity class, since the outcome accounts for the most important flood-characteristics: duration, severity and size of the affected region.

When we analyze the flood magnitudes for all floods and all shared floods, we find that the average flood magnitude for the shared floods is higher for 19 of the 21 years. When comparing the median values, it is clear that shared floods, with a median of 18.5 ± 1.7 are almost twice as severe as non-transboundary floods with a median of 10.0 ± 0.12 (figure 2.5).

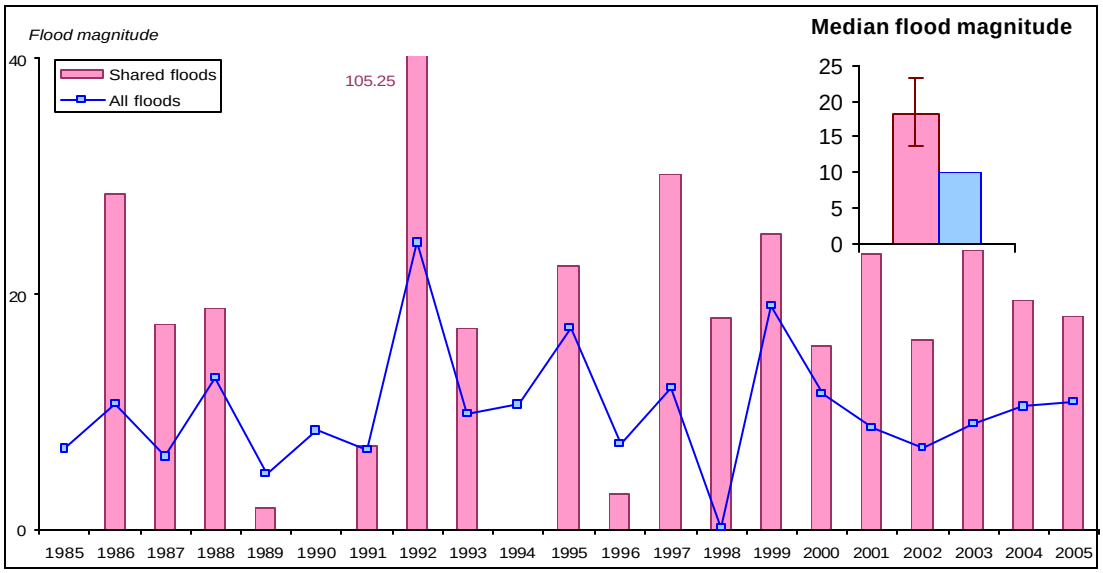


Figure 2.5: graphing the flood magnitude per year shows that shared floods are higher than those of all river floods, indicating that transboundary river floods are more severe than non-transboundary events. This is amplified by the fact that even the median values of the different types of events show a considerable difference.

When we look at the average affected area (thus not only the flooded areas but also the extent of geographic regions affected by flooding), we see that on average, shared floods affect larger areas than all river floods combined do: shared floods influence on average 222,000 km^2 while all river floods affect an average area of about half that size (128,000 km^2, see figure 2.6).

Thus on a global scale, we have now established that shared floods are more severe than all river floods combined. We continued the analysis by looking at the flood magnitude for shared floods and all floods per country. Again, it is unmistakable that the shared floods are much more severe than all the river floods combined. Plotting the median values of the high, medium and low HDI countries shows a threshold around a flood magnitude of 13; under it fall all the river floods, above it are all the shared river floods. The high HDI countries experience only slightly less severe shared and non-shared floods than the medium developed countries do, while the low developed countries on average experience the most severe transboundary and non-shared floods (see figure 2.7).

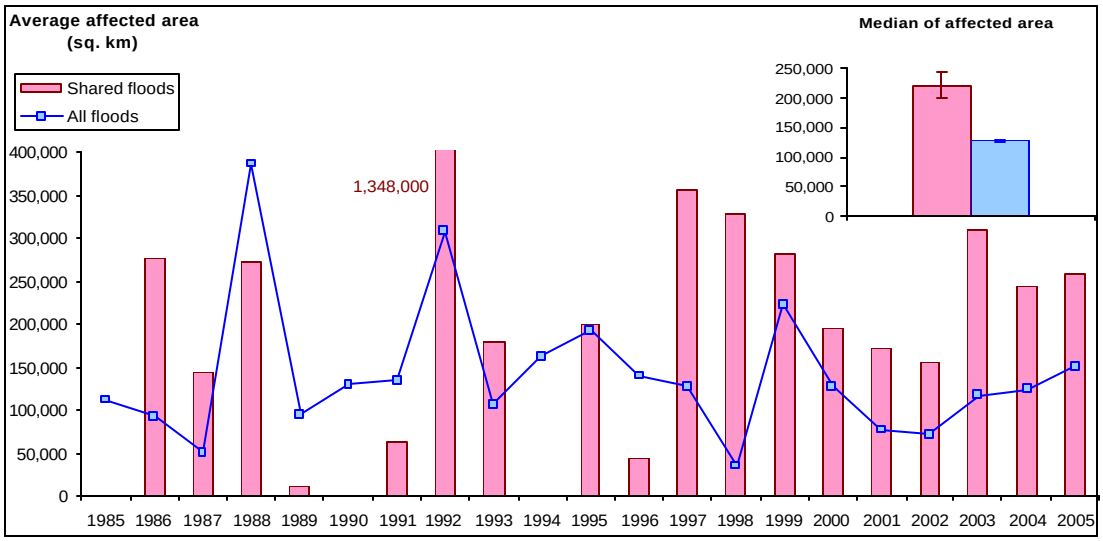


Figure 2.6: the average affected area per year and per type of flood shows that transboundary floods affect larger areas than non-transboundary floods do. Again, these findings are strengthened by plotting the median values of both types of flood events.

Thus, when looked at the severity and affected area, shared floods are far harsher than all river floods combined but it is not yet established whether this results in a relatively higher number of casualties, affected people or the total amount of financial damages .

The graph of the death toll divided by the number of floods of all river floods versus the death toll divided by the number of shared floods (figure 2.H in appendix, page 185) shows a clear separation especially between high developed countries and low developed countries; the high developed countries experience higher death tolls relative to their population during all river floods, while the low developed countries experience higher death tolls relative to their population during shared floods. The medium developed countries also on average experience higher death tolls during shared floods When we execute the same analysis, only now looking at the displacement toll, we can again see that the majority of all the river floods together have higher displacement tolls than the shared floods do (figure 2.I in appendix, page 186). The high developed countries on average, though, have higher displacement tolls for shared floods. Lastly, we compare the financial damage relative to the GNI of a country. We can distinguish that the majority of the financial damage of the shared floods is higher than the financial damage caused by all floods (figure 2.J in appendix, page 187).

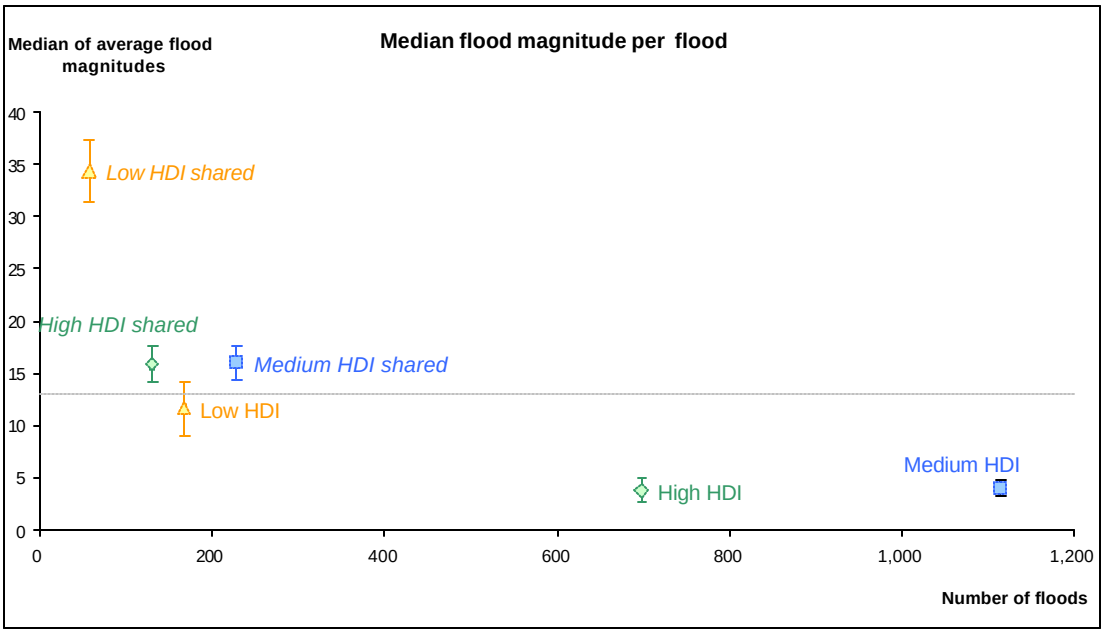


Figure 2.7: when we take the median of the severities per country, a threshold around the flood magnitude of 13 appears; under it fall all the river floods, above it are all the shared river floods.

Global Analysis of Transboundary River Floods and related Socio-Economic Variables

We have now established that transboundary floods significantly differ from non-shared events, which justifies a closer look at these events. Similar to the overview of all river floods, we will first look at a possible relationship between the level of development and the number of (shared) river floods a country experiences. Hypothetically, one could argue that the more developed countries are technically more advanced and have more resources to predict or prevent floods and notify neighboring countries, which might decrease the number of shared river floods. Lesser developed countries that share river basins might not be able to predict floods, be less prepared for them and unable to contain or lessen floods starting in their own country. The data, however, shows a great deal of spread which indicates that a variety of influences are important when looking at complex relationships like this: there is no apparent pattern. There are a few remarkable, but logical outliers. India and Bangladesh for instance are the two medium-developed countries that both have a relatively high share of transboundry river floods. This makes sense, since both countries are notorious for the fact that they experience large amount of floods on a regular basis, and consequently are plotted on the right side of the x-axis. In addition, Bangladesh is part of four IRBs and more than 80% of its land surface lies within these basins. India is part of 6 IRBs, with about 45% of its land surface within these basins. This explains why both countries experience a higher than average amount of shared floods. The United States is the only high developed country with a relatively high river floods, compared to the other high developed countries. This can be attributed to the large surface of the country inside river basins (more than 62%) and the amount of river basins (19 in total).

When we look for a relationship between transboundary floods, the resulting casualties and the level of development (figure 2.8) we notice that, with the exception of one year and similar to non-shared floods (figure 2.2) the developed countries experience fewer casualties than the developing countries.

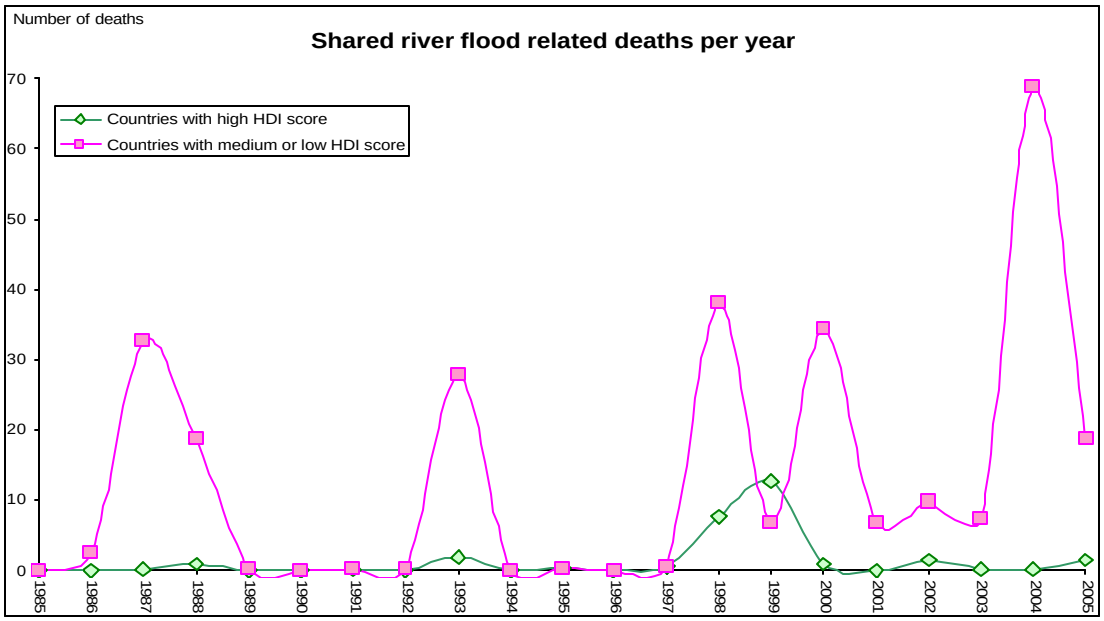


Figure 2.8: the average number of casualties divided by the amount of countries in that class per year shows us that transboundary floods cause more casualties on average in the less developed countries than they do in the developing countries.

When we investigate the displacement toll of transboundary floods (figure 2.K in appendix, page 188), we see no apparent pattern between the level of development and the displacement toll. The annual economic losses associated with shared flood events (figure 2.L in appendix, page 198, similar to figure 2.F in appendix, page 183) are always lower for the low HDI scoring countries, with the exception of the year 2000, in which a catastrophic flood hit Mozambique and surrounding countries (see chapter four).

If we look at the medians of the financial damages and casualties per HDI class, but now for shared floods only (figure 2.9), we see the same theory-confirming trend as figure 2.3 showed for all river floods: compared to the less developed countries, high developed countries experience the highest amount of financial damage per flood and the least amount of casualties.

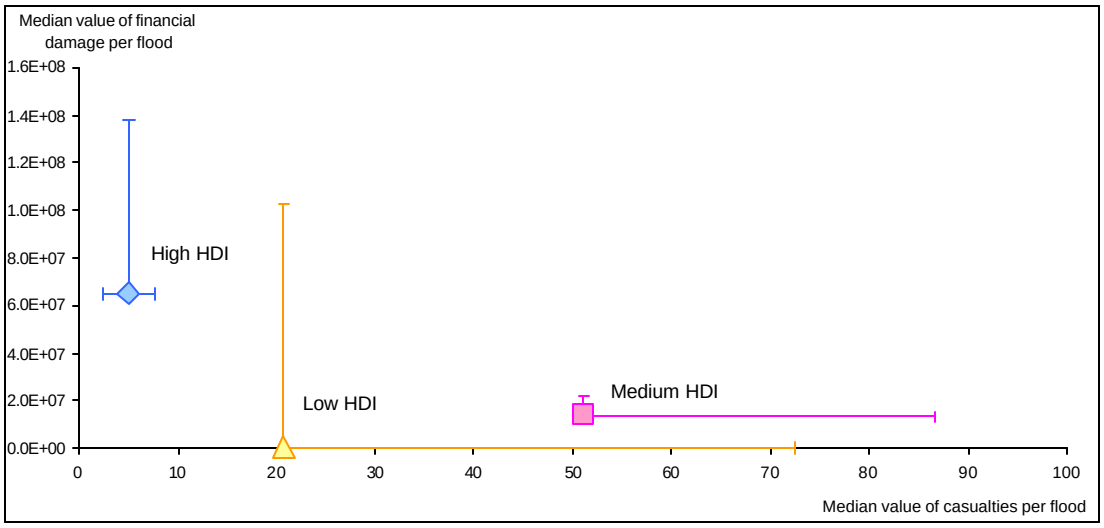


Figure 2.9: the median values of financial damages per flood accumulated for all high, medium and low scoring HDI countries, plotted against the median values of casualties per flood. As with non-shared floods, high developed countries have the least amount of casualties, but the highest amount of financial damage.

Analysis by Continent

We will further explore transboundary events and narrow the analysis down to the actual IRBs per continent to find out what the most vulnerable IRBs are when it comes to transboundary flooding. 27% (76 of the 279) of all IRBs have experienced transboundary flooding over the past 21 years. Transboundary floods do not take place every year on every continent, but it does appear that they have become more frequent over the past ten years, especially in Asia, South America and Europe (see figure 2.10).

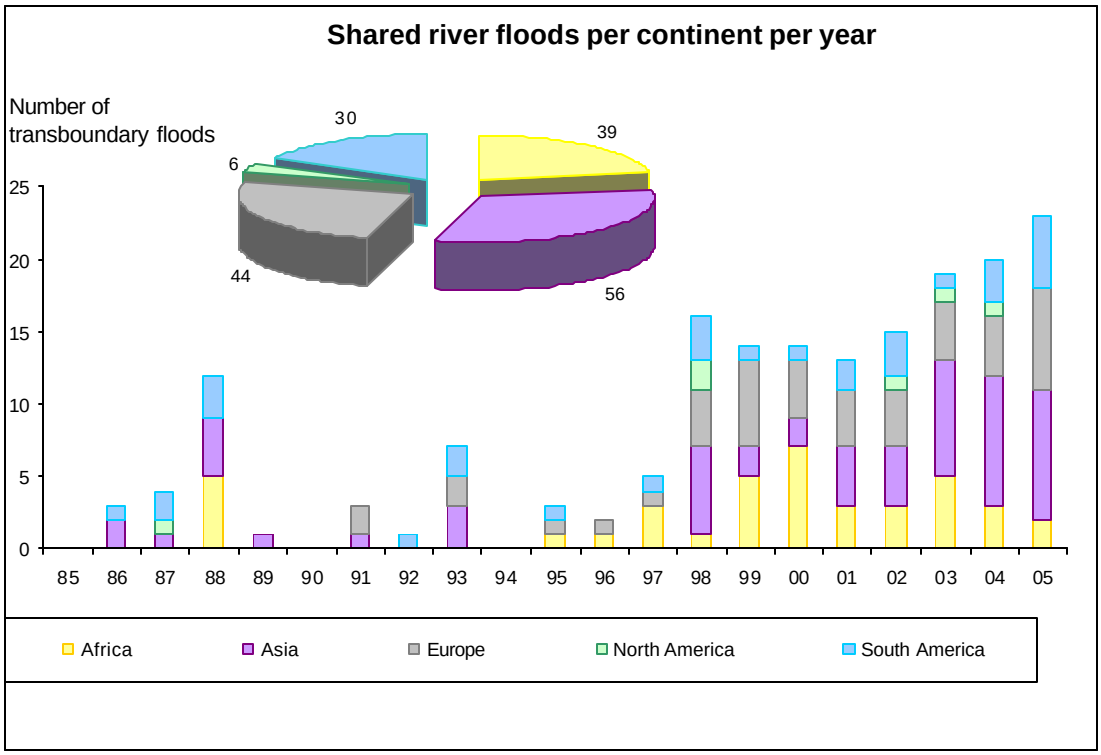


Figure 2.10: Shared river floods per year per continent show a steady increase of transboundary floods over the years globally, but especially on the Asian and European continents. Both these continents also dominate the total amount of shared river floods.

When we look at the median flood magnitude for shared floods per continent, we see that, even including the standard error, African and South American countries experience the most severe floods (see figure 2.11), while the other three continents are in roughly the same category between 7 and 9.5.

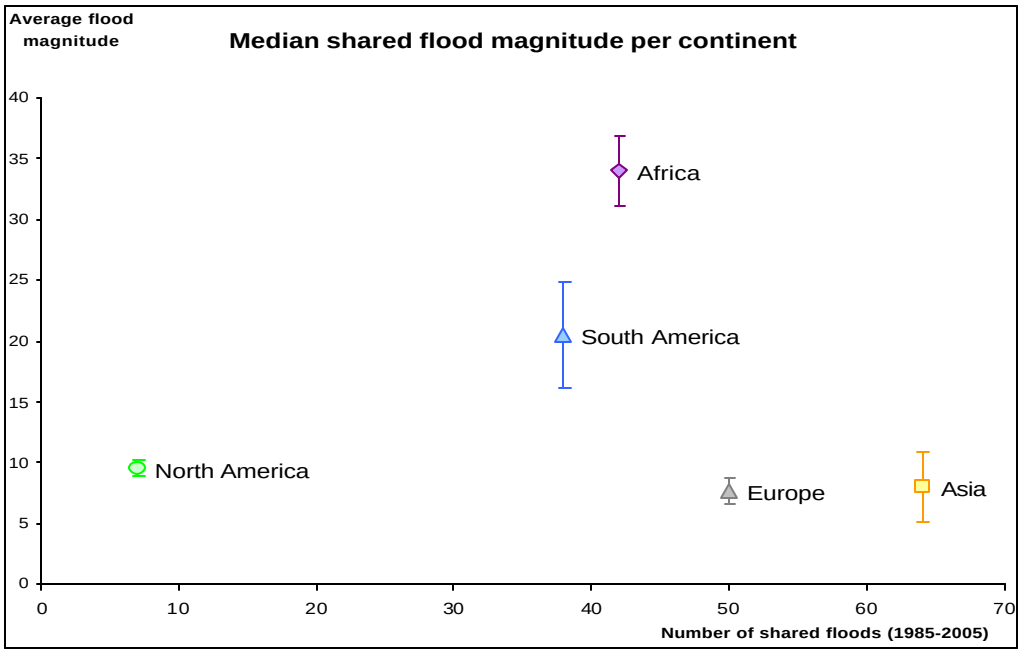


Figure 2.11: the median of all shared flood events per continent show that Africa experiences the most severe floods, while transboundary floods in Europe are the least severe.

When looking at the statistics categorized per continent and only look at the IRBs that have experienced transboundary floods over the past 2 decades (see figures 2.12 and 2.13), it is evident that Asia is the continent with IRBs that have had the most transboundary floods, causing the highest amount of affected amount of people. North America has experienced the least amount of transboundary floods, and has the lowest scores on all three variables. Europe has the second most quantity of transboundary floods, but the second lowest amount of casualties.

When we look at the amount of financial damage caused by shared floods, Europe by far has had the most accumulated damages. Their total of almost 90 billion US dollars is 90 times larger than the damages in North America, 40 times larger than the damages in Africa, 9 times higher than the financial damages in South America and still 4 times higher than the financial damages in Asia (see figure 2.13). Even when we divide the total amount of damages done by the total amount of floods, Europe is still leading with 1.8 billion US dollars damage per flood. The second runner up is Asia, with almost 0.4 billion US dollars per transboundary flood. Shared floods in South America result in almost 0.3 billion US dollars and in North America, the damages are around 0.14 billion US dollars. Africa comes in last with 5.4 million US dollars per shared flood.

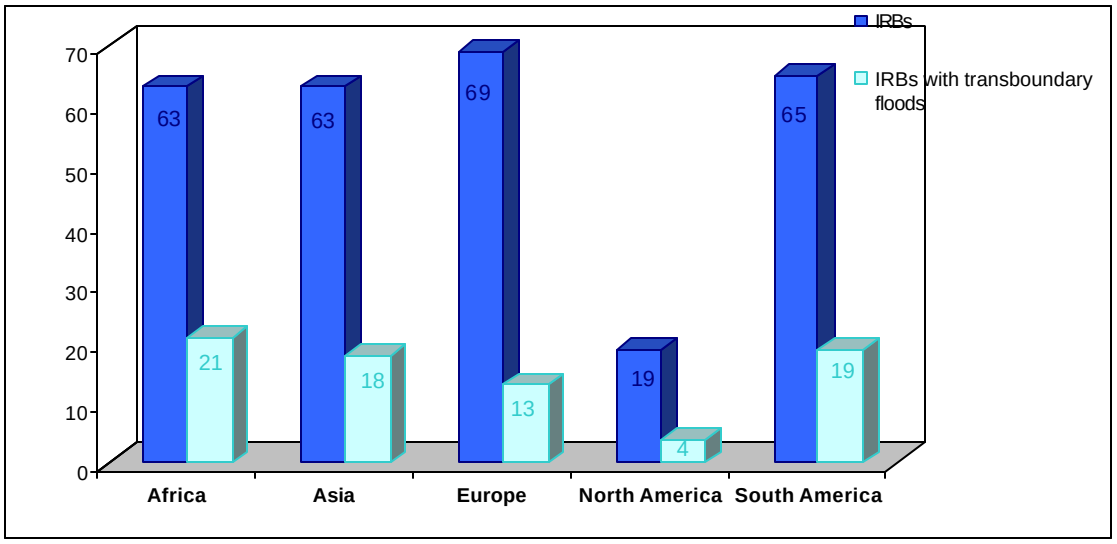


Figure 2.12: The largest share of IRBs that experience transboundary flooding can be found on the African continent (33%), followed by South American IRBs (29%), Asian IRBs (29%), North American IRBs (21%) and European IRBs (19%). Please note that in this paper, the South American continent includes the countries of Central America. Central America has 27 IRBs.

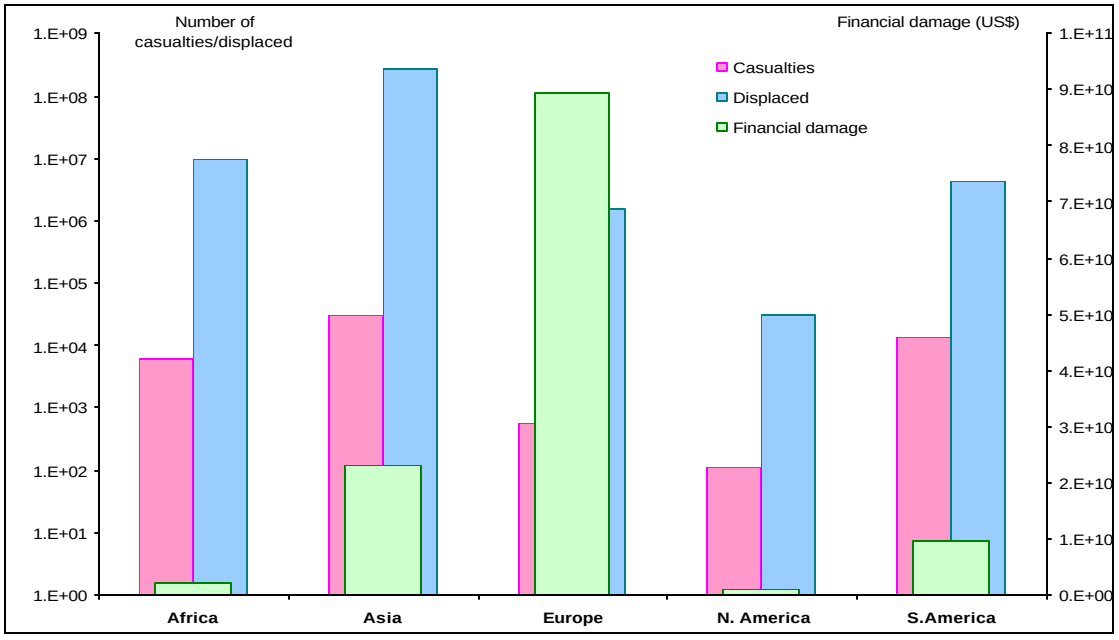


Figure 2.13: Transboundary flood statistics for all three variables, per continent. Europe by far has had the most financial damage, while Asia has experienced the highest amount of casualties and displaced/affected individuals. The financial damages experienced by North America are even lower than that in Africa.

Lastly, we looked at whether the number of countries that share an IRB influences the amount of shared flood events that take place. Hypothetically, chances for shared flood events increase when there are more countries in an IRB. However, the data shows that this relationship is not as apparent as expected; IRBs that experienced one flood have 2 countries in it at minimum, but a maximum of eight countries (the Lake Chad river basin). This is visible for every amount of transboundary floods, indicating that the number of countries that share a river basin does not guarantee more or less transboundary flood events to occur within that basin.

Analysis by International River Basin

In order to identify IRBs that have proven to be relatively vulnerable to transboundary floods, we will shift our focus from continents to individual IRBs. The number of transboundary floods occurring over the past 21 years in an IRBs ranges from a high of 24 in the Danube river basin in Europe and the Ganges-Brahmaputra-Meghna river basin in Asia, to lows in 45 basins of only one shared flood in the last two decades. The graphs below (figure 2.14 and 2.15) show the top 12 IRBs rated according to how many transboundary floods took place in the basin (only IRBs with 4 or more transboundary floods). Noticeable at first sight is the fact that even though the Danube and Ganges have seen the most shared floods in the past 21 years, they do not automatically rank first and second when it comes to the number of casualties, or the number of affected people. If the other variables are taken into consideration, the top changes. There are IRBs that not incorporated in the graph, that have higher amount of casualties than the top 12 IRBs; the most casualties and affected amount of people were in the Ganges, Irrawaddy and Indus basins, but the Irrawaddy, the Pedernales, the Lempa, the Coatan Achute, the Dasht, the Limpopo, and the Incomati river basins all have less than 4 transboundary flood events, yet are also in the top 12 of casualties. Same goes for the number of affected people; the Ganges, Indus, Mekong, Nile and Zambezi river basin are included in the top 12, but the Irrawaddy, the Coatan Achute, the Karnaphuli, the Limpopo, the Lempa, the Incomati and the Umbelezi river basins experienced fewer than 4 floods, yet in this top 12. Looking at the total amount of financial damages per IRB, the top 12 does include the Danube, the Ganges, the Rhine, the Indus, La Plata, Mekong and Han river basins, but the Elbe, Coatan Achute, Irrawaddy, Amazon and Tijana river basins all have less than 4 transboundary flood events, yet are included in the top 12 of financial damages resulting from shared flood events. Looking at the average death toll (relative to the population in the basin), the Pedernales, Coatan Achute and Sembakung river basins have proven to be the most vulnerable, although the number of transboundary river floods in these basins was one, two and one respectively.

Even though it can be misrepresentative to average the HDI scores of all the countries within a basin[14], it does provide a bit more insight. For instance, the top 12 of displaced/affected

[14] For instance, the La Plata basin has a HDI range from 34 (Argentina), which would represent a high developed country, to 113 (Bolivia) representing a medium developed country; the average for the entire basin is 69 (medium developed). The Danube has Switzerland it in, rank #7, but also Moldova, rank #115, but the average is 46 for the entire basin.

persons and casualties, only medium and low developed basins are represented. However, the top 12 of highest death tolls and financial damage does not include low developed basins. The medium developed basins are represented the most in all five top 12s.

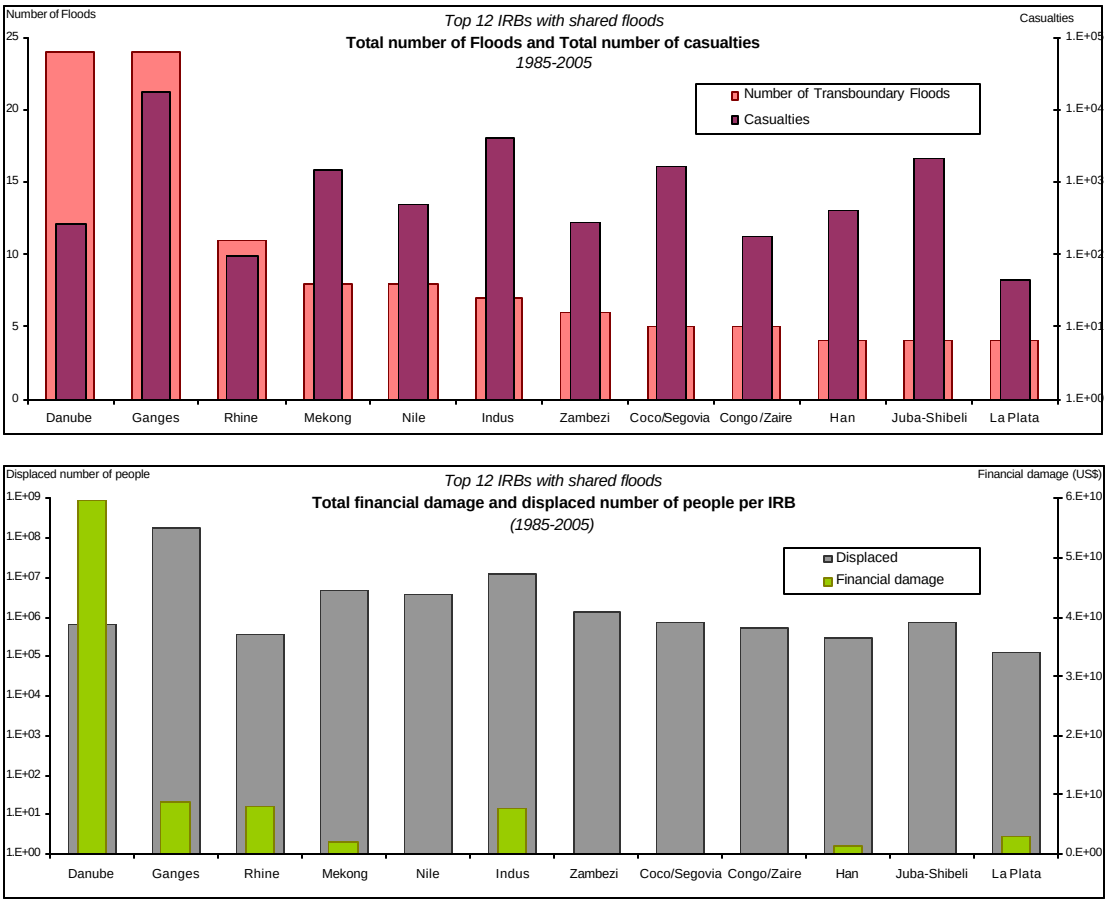


Figure 2.14 and 2.15: IRBs ranked according to the amount of transboundary river floods they have experienced over the period 1985-2005. Evident is that the high numbers of transboundary floods do not necessarily result in corresponding high numbers of financial damage, casualties or displaced/affected individuals.

When we rank the average flood magnitude per international river basin, we see that 6 of the top 12 are African basins, 4 of them are South American (see figure 2.M in appendix, page 190). The IRB with the highest flood magnitude is the Irrawaddy in Asia. This basin has experienced one class II shared flood in 2004 that lasted 110 days and affected over 1,163,000 km^2, which explains the extremely high flood magnitude.

With a few exceptions, countries with higher population tend to have more people occupying shared river basins. This can be attributed to the fact that people have always been attracted to

water and river locations, although in the less developed countries it more an issue of survival while in the developed countries it can also be an aesthetical consideration. Some IRBs are more densely populated than others, resulting in more people being vulnerable to flooding, thus it is more precise to relate the number of casualties to the number of people living in the IRBs. We have therefore plotted the amount of floods experienced by an IRB against the average death toll per million basin population (figure 2.N in appendix, page 191). Highly impacted IRBs will be found in the upper regions, where many deaths occur and those deaths are in high proportion to basin population. It might be expected that IRBs with a high number of transboundary floods, are also the IRBs that are most impacted. However, as the graph shows, there are a considerable amount of IRBs with less than 5 shared floods that are highly impacted, especially compared to the IRBs with the highest amount of floods (the Danube basin and the Ganges basin). The Pedernales river basin is the IRB that has experienced the highest death toll per million basin population. This basin has only experienced one flood, which caused about 3,300 casualties, but with a basin population of only 17,920 people, the relative impact is immense: per million basin population, 187,000 people lost their lives. Basins that have experienced considerably more floods, like the Danube and the Ganges, show much lower impacts; although the Ganges basin has over 580 million people living in it, and experienced 24 shared floods, almost 18,000 people lost their lives due to floods, which is about 30 people per million. The Danube also experienced 24 floods, but with a basin population of 78 million, it only lost 274 people during the last two decades, which is about 3.5 people per million population. Although there is substantial scatter in the data, the individual numbers per IRB suggest that if a country experiences more than the average amount of 2.6 (i.e. three) floods, the spread of the average death toll per million basin population seems to stabilize per continent; Asian IRBs do not fall below 19, while European IRBs do not exceed 4.

Most IRBs have death tolls below 10 people per million basin population (figure 2.O in appendix, page 192), underlining just how extreme the Pedernales death toll was. However, when we look at the average death toll per million basin population per continent (figure 2.16), only Europe comes close to this average. This is because all 13 IRBs that have experienced transboundary floods are below ten casualties per million basin population, Nestos being the exception with a value of 15. The average death toll for South America is the highest of all the continents although only North America has experienced fewer floods (figure 2.11). However, outliers strongly influence the average death toll (not only for South

America), for instance one flood event in the Pedernales basin, previously mentioned, and another one in the Tumbes basin, resulting in 364 casualties, which is relatively high on a basin population of 154,070. When these two extreme outliers are taken out of the equation, the average death toll plunges down to 707 - still the highest. This might be because half of the basins experienced more than one flood, which means that half of the IRBs have populations living in them without a lot of flood-related experience, resulting in more casualties. However, there are three IRBs with one flood event and no reported casualties (Hondo, Rio Grande and Lake Titicaca), although this in turn might also be the result of a low population density in the flood-affected area.

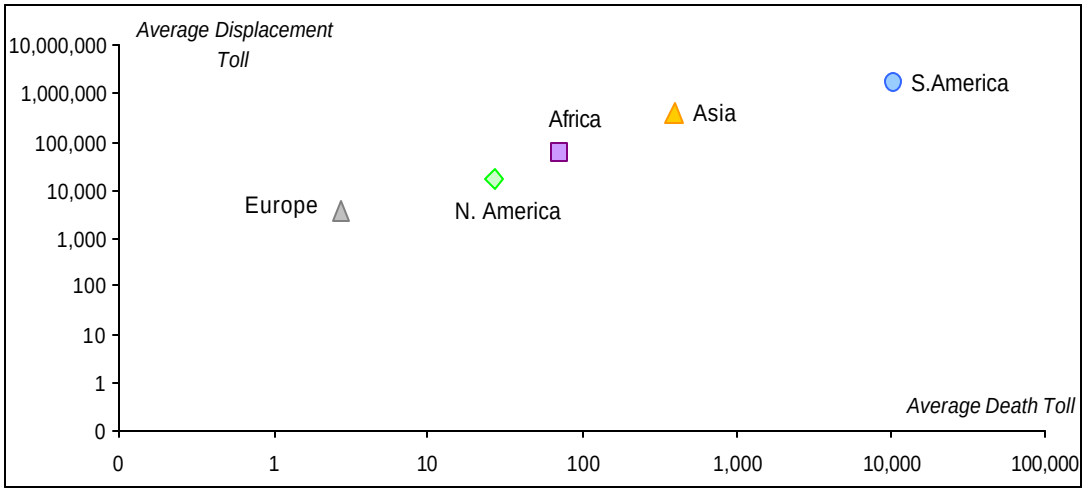


Figure 2.16: The average death toll plotted against the average displacement toll per million population, split up per continent. This visualization immediately shows the ranking of continents for these two variables; Europe has the lowest score for both, while South America has the highest for both. Note that outliers strongly influence the average death toll, especially for South America.

Surprisingly, the average death toll of the African IRBs combined is not the highest; there are 14 basins (out of the 20 total) that only experienced one flood event, but none of these resulted in an excessive amount of casualties[15]. Although all three basins with 5 or more floods have death tolls below 10, the theory that experienced communities have less flood-related casualties does not seem to hold up when it with respect to the African IRBs, or it must be attributed to the fact that either the floods in these basins were not severe or sudden enough to cause large amounts of casualties relative to the basin population, or took place in sparsely

[15] A possible explanation, not further explored in this paper, might be an oral tradition of the early recognition of the severity of floods or the social-cognitive factors that affect human behavioral response to them.

populated areas. Lastly, in Asia 7 (of a total of 19) IRBs had one transboundary flood event. The outliers are yet again the basins with the least amount of transboundary floods, and thus the least amount of experience. The Dasht and Sembakung basin both experienced one flood, with death tolls of 2300 and 4300 respectively, resulting in an average death toll for the Asian IRBs of almost 400 individuals per million basin population.

When we look at the number of affected/displaced individuals per IRB (figure 2.P in appendix, page 193), we see that, on average, the South American IRBs have the highest displacement tolls relative to the basin population, followed by Asian IRBs, African IRBs, North American IRBs and European IRBs with the lowest average displacement tolls. The displacement toll for European IRBs does not have nearly as much spread as the other four continents. When we plot the displacement tolls against the death tolls per IRB, categorized per continent, the relationship between the two is not immediately apparent (figure 2.Q in appendix, page 194), although it is clear that the European IRBs have far less scatter than the other IRBs. When plotted on a linear scale (figure not included), however, it becomes clear that the displacement toll rises quickly, while the death toll does not follow this increase up until a certain threshold around 10,000. After that, the death toll rises along with the displacement toll. This implies that the location and/or severity of the flood event causes more victims if the number of displaced/affected people exceeds 10,000.

Discussion and Conclusions

This study looked at loss of life, flood-related affected/displaced individuals and financial damage statistics for national and transboundary river flood events, while focusing on the continents with international river basins (IRBs). Available information from the OFDA/CRED International Disaster Database (Em-Dat) and the Dartmouth Flood Observatory (DFO) were combined to identify transboundary flood events and have more precise indications of the casualties and financial damage for both transboundary and national floods.

The following can be concluded:

- *Statistics on (Transboundary) Floods*

In the period 1985-2005 a total of 1760 worldwide river flood events killed over 112,000 people, affected more than 354 million persons, and caused around 687 billion US dollars in damage. 175 out of the total 1760 river flood events were transboundary river floods and caused almost 37,000 people their lives, affected about 210 million people and caused more than 97 billion USD financial damage. These figures indicate the massive impacts of national and transboundary flood events on a global scale.

- *Floods and the National Level of Development*

Countries, societies and people can face similar patterns of natural hazards, but often experience widely differing impacts when floods occur. Besides the type, severity and location of the flood, the impacts depend in large part on the kind of development choices a country has made (or was able to make) previously. For example, as countries become more thriving, they are often better able to afford the investments needed to protect people from floods, like dikes and levees. At the same time, the rush for growth can trigger chaotic urban development in flood-prone areas that increases risks of large-scale fatalities during floods. The essential difference between floods in more developed countries as opposed to less developed countries is the loss of lives and wealth: loss of life is high and economic loss is low in developing countries and vice versa in developed countries. On a worldwide scale and for the considered period, developed countries have lesser flood-related casualties per million population per year. In general, lesser developed countries experience more casualties on average than the more developed countries do. The spread increases when analyses include only the population

living in the river basins of the countries. This indicates that the number of flood-related casualties is not only linked to the level of development of a country. Based on the significant scatter in the findings, it must be concluded that a variety of factors are important when looking at complex relationships like this one. Nevertheless, it still indicates that there is a relationship between the HDI of a country and flood vulnerability and this correlation might even be codependent: while vulnerability is an outcome of the level of development, it is likely a cause as well. Although not tied to pollution, social sciences might describe this as an element of 'environmental injustice' (Shrader-Frechette, 2002) because, like any other disaster, flood hazards tend to affect the disadvantaged more than other groups; it is the elderly and those with low health status, who are likely to suffer the worst effects from flooding. The less well-off or poor members of societies are also likely to suffer proportionately more than the well-off members, even though in absolute terms the tangible flood damages of the latter group are likely to be higher. Poorer members of society tend to have less or no insurance cover, fewer financial reserves and less financial resilience to enable them to recover. Estimates of financial loss can therefore be very misleading because they underestimate the impacts of such problems, and the total distributional effects of floods on society tend to be higher for the less well-off. Lesser developed countries often have fragile infrastructure or infrastructure in state of retrogression; while more developed countries have higher levels of (improving) infrastructure that are able to cope with natural disasters like floods. Furthermore, lower developed countries in the front line of floods are more likely to get stuck in poverty, and are particularly hard hit and the most likely to be at the mercy of floods. Lastly, the poorest often have few choices available to adapt to variations in natural conditions; they may not be able to move to less stressed regions, or provide disaster-resilient infrastructures. Development and implementation of preventive and mitigation measures specifically aimed at the low(er) developed countries are thus of the utmost importance.

- *Floods and the Number of Displaced / Affected People*

Simply looking at how many floods a country has experienced and how many people were affected by this flood shows no apparent pattern, indicating that there are more factors at play. The average flood-related affected amount of individuals per million population increases when the average annual number of river flood-related displacements increases. It appears that this relationship is not linked to the level of development of a country, although the low scoring HDI countries are always above the invisible threshold around 1,000. China is the country that has experienced the highest amount of average annual flood-related

displacements, in high proportion to the population. In general, it seems that for the higher developed countries, the death toll decreases as displacement toll increases. Lower developed countries display the opposite trend. This might point to the fact that whenever a flood is severe and / or takes place in a densely populated area, the number of casualties and victims is high. Is the event less severe and / or not unexpected, the amount of victims will be lower, but the number of affected people higher. It can also indicate that countries with adequate flood warning and communication systems and the human and financial resources to get people out of harm's way on time, i.e. having high displacement tolls, appear to lower the amount of flood-related victims.

- *Floods and Financial Damages*

The damages done by a flood will be influenced by its physical characteristics and its impacts on human attributes such as assets, lives, etc. These include the hydraulic characteristics of the flood, such as water depth, flow velocities and rate of rising of the waters. Also the predictability of the flood, determining the possibilities for evacuation, is a key factor in the final loss of life. The type of flood largely determines these factors. Having said that, our research shows that medium developed countries experience higher financial losses relative to their GNI than the more developed or the less developed countries do. On average, the total amount of damage per year for the medium developed countries is higher than that of the high developed countries and accumulated over the 21 years, the medium scoring countries have the most financial damage. This indicates that the developed countries seem to either have structures that can withstand floods better and/or are able to protect structures from harm caused by floods. Medium developed countries have less costly structures, possibly not as able to withstand flood damage and/or less sufficient protective constructions. Low scoring HDI countries do not have costly structures built in the floodplains and therefore have relatively less financial impacts. However, numbers alone fail to adequately capture the impact of the disaster on the poor who often bear the greatest cost in terms of lives and livelihoods, and rebuilding their shattered communities and infrastructure. For instance, it may be reasonable to measure a Dutch householder's relatively minor flood damage in thousands of dollars. But a flood in Bangladesh may entirely dispossess a farming household; they may even lose their farmland by erosive effects of floods. Their loss may be measured in only hundreds of dollars, but they may not receive aid or insurance payments.

- *Comparison of River Floods and Transboundary River Floods*

Over the considered period, almost one tenth (175 out of the total of 1760) of all river floods were shared by two or more countries, but globally accounted for 32% of all casualties, almost 60% of all affected individuals and 14% of all financial damage. Our data furthermore shows that transboundary floods are more severe in their magnitude, they affect larger areas, result in higher death tolls (except in the high developed countries) as well as higher displacement tolls in high developed countries, and cause more financial damage than non-shared river floods do. On a global scale as well as a per country scale, we clearly see that shared floods are more severe than all river floods combined. Lastly, the majority of financial damage of the shared floods is higher than the financial damage caused by all floods.

- *Transboundary River Floods and the National Level of Development*

The data shows no apparent relationships between the number of river floods and the number of shared river floods; lesser developed countries do not necessarily experience more transboundary floods than more developed countries, so technical advancements or abilities to predict or prevent floods, all supposedly better developed mechanisms in high developed countries, do not seem to influence the number of transboundary floods. Further research is needed to explore why this is the case.

- *Transboundary River Floods by Continent*

The data shows that transboundary events are becoming more frequent on every continent, especially Asia. African and South American countries experience the most severe floods, while the other three continents are in roughly the same category between 7 and 9.5. Although Asia does not have the most IRBs out of all continents, it is the continent with the most transboundary floods (56), followed by Europe (44), Africa (39), South America (30) and North America (6) respectively. The number of countries sharing an IRB does not influence the number of transboundary flooding taking place in that basin. Asian IRBs have the most casualties and the most affected quantity of individuals. European IRBs have had the lowest death tolls over the period 1985-2005; South American IRBs the highest. Transboundary floods in the European IRBs have caused the most financial damage. The earlier discussed HDI-list indicated that the low development countries are mostly found in Africa and the high development countries can be found typically in countries of northern and western Europe, Australia, New Zealand, Canada, United States, Japan, Israel and East Asian Tigers. Thus these findings suggest that the low development countries experience less

material loss than the more developed countries. Communities in developing countries will have fewer capital resources to spend on sustainable protection strategies and will not be able to buy flood insurance. More developed communities might be more vulnerable to tangible flood losses, but they have the ability to obtain better protection systems and have the possibility to obtain flood insurance.

- *Transboundary River Floods by International River Basin*

76 of the presently known 279 IRBs have experienced shared floods in the period 1985-2005. The top 12 of IRBs with the most transboundary floods have seen four or more floods – the remaining IRBs (64) have seen three or less floods. For the considered period, the Ganges-Brahmaputra-Meghna and the Danube river basin have experienced the most transboundary flood events, 24 to be exact. The Rhine River basin comes in second, with 11 floods, followed by the Mekong with eight. Based on this single variable, the Ganges, Danube and Rhine river basins are the top 3 IRBs. When we rank the 12 river basins with the highest severity score on average, six of the top 12 are African basins, 4 of them are South American. The IRB with the highest flood magnitude is the Asian Irrawaddy river basin. While taking the scatter of the data points into account, the individual death toll numbers per IRB suggest that if a country experiences more than the average amount of 2.6 floods (i.e. three), the spread of the average death toll per million basin population seems to stabilize per continent; Asian IRBs do not fall below 19, while European IRBs do not exceed four. Not only is this an effect of fewer data points (lesser IRBs experiencing more than the average amount of floods), it also indicates that societies as a whole might be more adapted to floods, and less vulnerable to floods, if they experience them on a regular basis, like in the Danube or the Ganges, regardless whether they live in a developed or less developed country. Communities with experience with past floods and a strong social, structural and environmental coping capacity might be more resilient to floods than communities that experience floods on a very irregular basis. Obviously, the number of casualties is influenced by the type and severity of the flood event, whether it was predicted or a total surprise, and whether or not this flood took place in a densely populated area (a city, for instance) or not. The latter may explain the lower impacted IRBs in less developed countries. Average death tolls per continent are lowest for European and highest for South American IRBs. However, outliers on all continents (except Europe) heavily influence the average death tolls. The outliers are often basins with the least amount of flood events, strengthening the theory that experience with flood events lowers the death toll in IRBs. When the average death toll per IRB is plotted against the average displacement toll per IRB,

categorized per continent, the average death toll does not nearly climb as fast as the average displacement toll does. Around 10,000 displaced people per million basin population, the average death toll suddenly begins to rise more quickly. This indicates that when the average displacement toll rises above 10,000, the flood is apparently so severe, that it causes comparatively more victims than floods that do not displace that many people.

- *Most Vulnerable IRB and Continent to Transboundary River Floods*

Depending on the definition of 'vulnerability', there are several answers to the question which IRB is the most vulnerable to transboundary flooding. When the average death toll is taken into consideration, the Pedernales, Coatan Achute and Sembakung river basins have proven to be the most vulnerable IRBs of all. If IRBs are ranked according to the most casualties or number of affected people, the Ganges, Irrawaddy and Indus basins are the top three. Looking at the total amount of financial damages per IRB, the top three is the Danube, Elbe, and Ganges. The Danube, Ganges and Rhine river basin are the basins where the most shared floods took place in the last 21 years. Lastly, the basins that experienced the floods with the highest average magnitude are the Irrawaddy, Okavango and Chamelecon. Vulnerable IRBs are found mostly in South America and Asia; the minority of vulnerable IRBs is located in North America and Europe.

These conclusions point to the fact that vulnerability to floods is a complex phenomenon and cannot be explained using three variables. Future research could discover more statistically relevant linkages if each and every unique event was looked at more closely, taking into consideration the type, severity, geographical location, size and population density of the location. Area characteristics such as population magnitude, land-use, and warning- and emergency-systems differ on a regional scale and influence the impacts caused by a flood. Other important socio-economic factors that influence these impacts are the level of flood protection and the organization of flood defense and disaster management. Communities in developing countries might be more resilient to floods than industrialized countries due to experience with past floods and a strong social, structural and environmental coping capacity.

This paper comprises a wide-ranging analysis based on publicly available data. However, several issues are key to further understanding the results. As indicated previously, the data used in this study has several limitations; the records of casualties and displaced/affected persons per flood event have considerable variation and uncertainty. Therefore, the presented

results should not be used as a predictor for the loss of life or the amount of affected people to be expected in a specific basin or country. Rather, the results are to regarded as a more detailed picture of the world of (transboundary) flood events and have allowed us to formulate relative comparisons. The result may be helpful for policy-makers to identify and evaluate potential vulnerability to (transboundary) floods for future water management and international cooperation over shared floods. The other issues mentioned previously about the accuracy of the reported numbers, the temporal aggregation of events, the disaster type categorization, and the fusion of the two databases are all important issues resulting in the recommendation to develop a consistent categorization methodology for flood events.

This study has made a careful start with providing more insight in the relations between flood losses (human and financial) and vulnerability factors, including developmental characteristics. Such insights provide a basis for formulation and (cost) effective prioritization of mitigation strategies and policies. Floods have huge impacts on every society making it necessary to introduce new creative preventive and mitigating policy actions on a global scale. But since the greatest impact of floods is still on the poorer countries in the world exerting an enormous toll on future development, it is highly recommended to help decrease the vulnerability of those who are most exposed, first.

CHAPTER THREE: TRANSBOUNDARY RIVER FLOODS, INTERNATIONAL RIVER BASIN INSTITUTIONS, FLOOD-RELATED EVENTS AND INTERNATIONAL FRESHWATER TREATIES[16]

Author: Marloes H. N. Bakker

Abstract

Transboundary flood events have become more frequent over the last two decades, yet seem to be overlooked in the international river basin cooperation arena. In this paper, we examine the current state of existing transboundary river institutions, international water events and international fresh water treaties related to shared flood events. These geopolitical measures are complemented with biophysical and socio-economic variables (see chapter two) to identify which international river basins (IRBs) have sufficient institutional capacity focused on transboundary floods and which basins will have to strive to decrease their vulnerability to shared floods and are recommended to enlarge their institutional capacity.

Of the 279 known IRBs, 78 are represented by shared rivers institution of some form. Most of them are set up for joint management. Out of the 153 transboundary institutions worldwide, only eight are principally concerned with flooding, five of which are located in Africa, two in Europe and one in Asia. Over the years 1948-2004, almost three % of the events are related to flood control or flood relief. Overall, 87% of the events related to transboundary floods fall in the range from 'neutral' to 'single most cooperative'. Only nine events fall in the 'conflictive range'. However, next to a general increase of flood-related events, a slightly alarming trend of less cooperative events over the past 15 years is also noticeable and indicates that there might be more need for official international institutions dealing with transboundary flood-events. Globally, no more than 11 basins have international freshwater treaties with floods as their principal issue.

[16] Part of this article has been presented at the International Conference of the Network of International Commissions and Transboundary Basin Organizations (INBO) & the African Network of Basin Organizations (November 03-06, 2004, Dakar, Senegal). The data on river basin institutions has been incorporated in the UNEP five-part series on 'Hydropolitical Vulnerability and Resilience along International Waters: Africa' (UNEP, 2006) and will be incorporated in the other parts for the remaining continents.

Overall, 43 basins in which transboundary floods took place in the period 1985-2005 have no type of institutional capacity in the form of international institutions or organizations for international river basins, let alone institutions specifically aimed at shared flood events. The average death and displacement tolls relative to the million population living in the IRBs are lower in the 37 basins that do have such institutional capacity and, in seven cases also flood-related institutional capacity, despite the fact that the flood magnitudes (see chapter two) are always significantly higher. This could be an important indication that institutional capacity i.e. international cooperation before, during and after the flood events might play an important role in the reduction of flood-related casualties and affected individuals.

Based on our vulnerability variables, there are 12 basins[17] that have experienced more than one shared flood in the past 21 years, but have not set up any institutions for such events, nor signed any treaties focusing on floods. These basins are recommended to increase their institutional capacity aimed at transboundary flood events. The IRBs that already have set up institutions to cooperate over their shared waters, but have not focused on flood-events, should consider including flood-related issues in their mandate, in order to be better prepared when disaster strikes.

[17] The Juba-Shibeli in Africa, with four transboundary floods, the Han, Kura-Araks and Ma in Asia (four, two and two transboundary floods), the Maritsa and Po in Europe (three and two transboundary flood events) and six basins in South America: the Coco/Segovia, Grijalva, Artibonite, Changuinola, Coatan Achute and Orinoco river basins.

Introduction

Flood disasters are among the world's most frequent and damaging types of disasters and affect the lives of millions annually. Impacts of floods continue to increase worldwide as river basins continue to be urbanized and as floodplains continue to attract more human activities. In addition, predictions are that global climate change will increase storminess and precipitation in some parts of the world, which may increase flood risk. This is why there is an ongoing search for better ways of protecting human life, land, property and the environment by improved flood management. Flood management is difficult in river basins controlled by a single authority, and becomes even more challenging when dealing with transboundary floods, which may originate in one country or jurisdiction and then propagate downstream to another country, or jurisdiction. Under such circumstances, the demands on international cooperation and management in all aspects of flood management are particularly important, especially because institutional capacity in an international river basin should be able to absorb changes in the basin in order to decrease the changes for conflict (Wolf *et al.*, 2003).

Previous studies have focused on water or flood management per country (Arnell, 1998; Olsthoorn, 2001; Dixit, 2003; Enserink, 2003; van Steen, 2004), and integrated water resource management (IWRM) (Biswas, 2004; Blomquist, 2005) or water institutions in general (Gopalakrishnan *et al.*, 2005) but few and only recently, researchers looked at the phenomenon of shared floods (Marsalek *et al.*, 2006). However, these studies only focus on a specific shared river basin (Beaumont, 1998; Feitelson, 2000; Middelkoop, 2001; Muckleston, 2003, Maganga *et al.*, 2003). Hazard and vulnerability vary from place to place, but equally significant are the institutional, social, economic and policy frameworks: these represent the rock on which the adoption of floodplain management so frequently flounders. This study will include all the currently known international river basins to see if and how transboundary floods are dealt with. In particular, this research will aim to:

- Produce a database that lists the institutional capacity per basin (i.e. international river basin organizations and commissions) which will be used to
- Determine whether transboundary flood events are in the list of priorities of transboundary river institutions
- Examine how many international freshwater treaties deal with shared flood events
- Investigate whether transboundary floods have caused a disproportional amount of conflicts over water or deteriorated international relations.

Combined with the biophysical variables and socio-economic variables from chapter two, the geo-political variables mentioned above will shed more light on the level of vulnerability of IRBs to shared river floods. To answer the above questions, we will use global data compiled by the author and combine it with the findings of the Transboundary Freshwater Dispute Database (TFDD) research group (TFDD, 2006, including unpublished data). The assumption is that transboundary floods are underrepresented in treaties and institutions, because floods are either not frequent enough to warrant putting time, effort and financial resources into or that such events do take place often but are just too complicated to capture in international institutions and international fresh water treaties. However, we further hypothesize that an apparent lack of flexibility in institutions has not caused and will not cause a relative disproportional amount of conflicts over water or deteriorate international relations, because the situations are dealt with in an unofficial yet efficient and cooperative way. The answers to the questions above will clarify which international river basins (IRBs) have sustainable institutions, and which basins will have to strive to increase their institutional capacity when it comes to shared floods.

This paper can be broken down in two major components. Because flood hazards are ultimately a product of society and social change and an inherent part of the past, the first part describes the history of floods, explains the physical flood-producing processes, how floods affect different countries in different ways, and proceeds to discuss human impacts and strategies for managing floods. The second part of the paper will focus on finding the answers to the questions posed above. We will end with a discussion and cautious recommendations.

Humans, Rivers and Floods

Humans have always been attracted to water and river locations. Apart from the obvious source of drinking water, rivers supported a food source, provided a means of transportation, and eventually supplied power to mills. Because of these life-giving characteristics of water, people have lived along the edge of rivers and lakes since earliest times. It is no coincidence that Hamoukar, the world's oldest excavated city[18], can be found in the Khabur river basin. Other great cities are found along the banks of rivers like the Nile, the Tigris and the Rhine. Proximity to rivers has been proven to be both a source and a reward of strength. Stronger and wealthier societies tend to live close to rivers, while weaker, poorer ones are forced away from rivers, where water is harder and more costly to obtain, and food supplies are less secure. Similarly, in the less developed parts of the world today, stronger and wealthier groups tend to live close to abundant clean water sources or water supply systems, while the poorest are forced to travel significant distances to obtain water of generally lesser quality at greater cost. Rivers are thus as closely linked with the economic and political fabric of human society as they are with the landscape. It has only been since the past century that technology has allowed permanent human colonization and settlement further away from water (Sadoff and Grey, 2002).

The acceptance of a certain risk of flooding has always been a price for living close to rivers, because often, when excessive or uncontrolled water intrudes in the form of floods into areas reserved for other human purposes, the proximity to water has proven to be an inconvenience at least, but catastrophic at most. The reality of floods and their effects is not something of the last couple of decades, but goes back to the beginning of history of the earliest civilizations. In both western and eastern civilizations, people have recounted legends of floods engulfing the entire earth. Native global flood stories are documented as history or legend in almost every region on earth. Ancient civilizations in China, Babylonia, Wales, Russia, India, America, Hawaii, Scandinavia, Sumatra, Peru, and Polynesia all have their own versions of a giant flood.

[18] The 6,000-year-old city discovered in 1999 in the northeast corner of Syria is challenging long-cherished notions about the beginnings of civilization in the cities of southern Mesopotamia (Lawler, 2006).

Floods in Numbers

Most of the world's people live in coastal areas or on floodplains (Ward, 2002) and few floodplains are untouched by human activity. Precisely because they were settled early, floodplains are typically integrated into existing agricultural and economic activities. Unfortunately, there is no comprehensive global data bank to examine estimates of the numbers of people and properties located in flood-prone areas. However, some estimates (Parker, 1996) have been produced for a small number of countries revealing widely varying proportions of total country populations which are flood-prone. These are 3.5 % in France, 4.8 % in the United Kingdom, 9.8 % in the United States, over 50 % in the Netherlands and 80% in Bangladesh. The UNDP estimated that in 2004 about 196 million people [19] in more than 90 countries were exposed on average every year to catastrophic flooding (UNDP, 2004). Many more are exposed to minor or localized flood hazards that can have a cumulative dampening impact on development, but do not cause major human losses in single events. Consequently, very few countries and very few parts of the world's population are spared the effects of floods. More areas are becoming increasingly exposed and vulnerable to floods. Over the last 21 years, only 29 of a total of 194 countries have not had some type of flood-event in the years 1985-2005 (see figure 3.1) – that indicates that a little more than 85% of all countries have experienced one or more flood events in the last two decades. On a global scale, flood losses are increasing dramatically, mainly because of population and capital moving into harm's way (Mitchell, 2003). The flood events of last year (excluding flash floods) caused 4240 fatalities worldwide (four % of the total amount of casualties) and accounted for USD 16 billion of losses (seven % of the total). The total amount of river floods differ per year, but a steady increase is visible. In the period 1985-2005, river floods alone (1760 in total), caused over 112,000 people their lives, affected more than 354,000,000 people and resulted in USD $6{,}9 \times 10^{11}$ of financial damage (see chapter two).

[19] The global population is approximately 6,6 billion - and counting - so on average, about three per cent of all people are exposed every year to flooding.

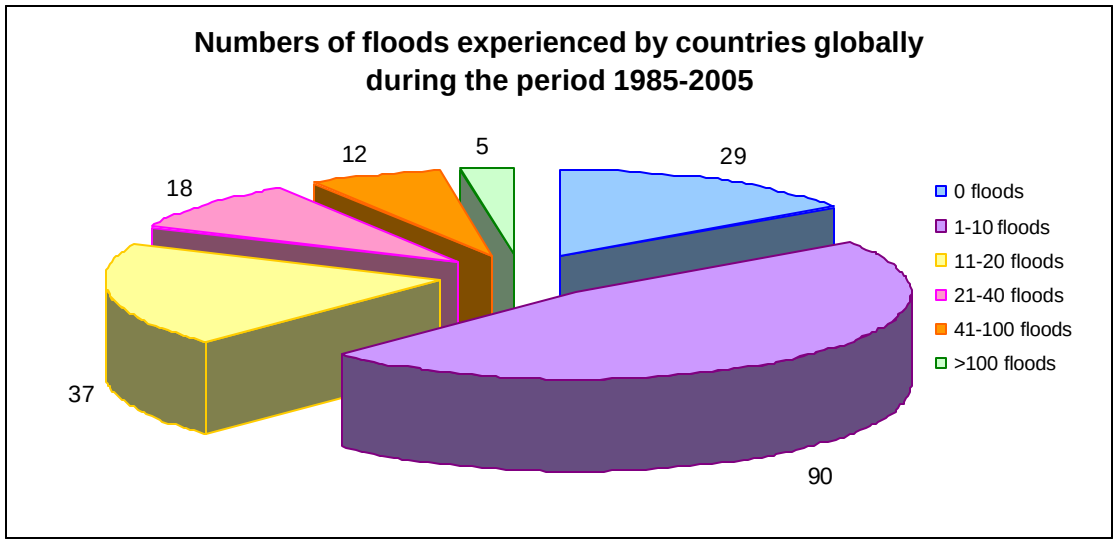


Figure 3.1: During the period 1985-2005, 127 countries have experienced at least one type of flood event; only 29 countries have not.

The Hydrology of Floods

Flood events have been defined in many ways:

> 'a relatively high flow which overtaxes the natural channel provided for the runoff' (Chow, 1956); 'extremely high flows or levels of rivers, whereby water inundates flood plains or terrains outside of the water-confined major river channels' (Yevyevich, 1994); and 'a body of water which rises to overflow land which is normally not submerged' (Ward, 1978)

are just a few of many. Flood plains are defined as 'areas of low lying land that are subject to inundation by lateral overflow water from rivers or lakes with which they are associated' (Junk and Welcomme, 1990). This definition includes fringing flood plains of lakes and rivers, internal deltas and the deltaic flood plains of estuaries. But regardless of the definitions used to describe floods and that are affected by floods, the events are always linked to the flow regime of a river and will always be an essential part of the hydrologic cycle. The ultimate source of all river flow is rainfall or snowmelt, collectively called precipitation, over the catchment area of the river. The catchment area or river basin is the area that the river drains. The flood-producing potential of a river basin depends on its natural setting (for instance climate, soils, geology, geography), on the land (forests, crops, roads, buildings), and on the land-use (agriculture, forestry, towns, cities). Rain and water from melting snow reaching the soil surface can infiltrate into the soil or run off directly into streams and rivers. Soils have an infiltration capacity – the maximum rate at which they can absorb rainfall – and once this has

been exceeded the excess water runs off as a direct, or fast-response, runoff or overland flow. Direct runoff is the major cause of most floods. The infiltration capacity depends on the soil type and the amount of water already held by the soil. The geology of the underlying rocks has a direct control on the deep percolation and may indirectly control infiltration because the soils are often derived from the rocks below.

Floods are considered to be independent events and are characterized by their magnitude, their duration, and their frequency. The magnitude of a flood is defined in either of two methods. One is the flow rate of the flood peak, usually expressed as volume per unit time. The second is flood stage, which is usually expressed as a height above a specified reference flood stage. The duration of a flood is defined as its length of time above flood stage. The frequency of a flood is defined as a probability of its occurrence during a given period, which is generally taken to be a year. That is, a flood which is designated as a 'one in a hundred years' event has a one per cent chance of occurring during any given year[20]. In analyzing the statistics of floods, hydrologists usually study the largest flood in each year, the so-called annual flood. From the analysis of these annual floods, it is possible to estimate the probability that a certain flood would be exceeded in any year. This flood can be expressed either as water level or as discharge, the two being related by the properties of the river channel. The frequency of a flood of a given size is often described by the recurrence interval or return period[21].

Although floods are natural phenomena, they are believed to be intensified by human alteration of the environment. The surface of the earth has been significantly modified by human activities over at least the past 6000 years[22]. These activities, whether they are greenhouse gas emissions, deforestation, urbanization, or dam building for water management purposes, have affected the hydrological, geomorphic, atmospheric and physical flood-

[20] Thus the term "a one-hundred year flood" is actually a misnomer, since it does not mean that the flood occurs every 100 years (see footnote 21). In fact, two 100-year floods could occur a year apart or even a month apart. This causes a great deal of confusion to the general public.

[21] An example: if a flood of 2500 m^3/s is said to have a return period of 100, then there is a 1% chance that the river discharge will be 2500 m^3/s (or higher) in any year. It is a graphic way of describing the rarity of the flood. The mean annual flood, the average of the annual floods, gives a measure of the magnitude of floods for a particular river basin and is used to scale the floods of different return periods for a catchment. The mean annual flood is a very common flood and has a return period of only 2 to 2.5 years. In many rivers it is approximately the flow that the river channel can carry when running bankful.

[22] The earliest modification probably occurred when Mesolithic peoples used fire to clear woodland for hunting.

producing processes. One of the most common ways in which human activity causes floods is through the process of urban growth within river catchments (Jones, 2000). In rapidly urbanizing catchments in particular, the driving force behind growing flood discharges and worsening flood hazards is development – not just in the floodplain but everywhere in the catchment. Urban development results in permeable natural surfaces being replaced by artificial impermeable ones so that runoff accumulates more completely and rapidly in stream and river channels rather than infiltrating into the soil and percolating into groundwater. At the same time, the density and efficiency of drainage channels are increased. Sources of flood flows are thus everywhere where development is occurring and it is here that runoff retarding and flood storage measures are required.

The overall effect is that flood peaks are increased because of increased runoff related to reduced infiltration capacity. The frequency of flooding may also increase, and the lag time between precipitation and flooding may decrease, making it more difficult to provide timely flood warnings. Human deforestation is also often accused of causing and intensifying flood hazards. However, the scientific evidence relating to the worsening effects of urbanization on floods is clearer than for deforestation, and instead, it is now the draining of wetlands that is widely acknowledged to have exacerbated floods. Other modifications too have intensified the flood hazards, for instance removal of the natural vegetation tends to reduce evapotranspiration losses and exposes the soil surface to the full kinetic energy of the falling rain, causing breakup of the soil, clogging pores, reducing infiltration capacity. However, some human modification may have actually reduced flood hazards; all the activities that increase the transmission time or reduce the net water surplus within a basin and any activity that increases evopatranspirational losses or infiltration capacity, improves soil structure, exports water from the basin or consumes it, all of which will reduce river discharges.

The verdict is still uncertain about the general effects of global warming on flood risks (van Aalst, 2006). In theory, though, climate change can cause a change of precipitation patterns, which can lead to change in the distribution, intensity and duration of extreme rainfall events and higher frequency of heavy precipitation, resulting in more floods. Other projected impacts of such changes in climate are an increased flood runoff which could increase recharge of some floodplain aquifers, increased soil erosion and increased pressure on government and private flood insurance systems and disaster relief.

It must be noted that there is not yet a full understanding in the literature about floods, the causes of flood impacts (Pielke, 1999) and the manner in which impacts transfer and ripple through economies and communities. Currently, flood researchers are hindered by incomplete understandings and evaluations of flood effects, incomplete and poor-quality data, data which are not comparable and therefore not capable of being combined, difficulties of tracing secondary and tertiary effects on individuals, communities and economies, inadequate means of modeling flood impacts and a variety of methodological and measurement problems.

Types of Floods

Every flood is a unique phenomenon, but several types of floods can be distinguished (see table 3.1). The most common type is where a river overflows its banks due to a large input of rainfall or snowmelt. These are types of flood that can be predicted and explained in terms of catchment physical characteristics and climatic inputs (Arnell, 2002). When one looks at the size of the affected area and the duration of precipitation (or, in other words, the spatial[23] and temporal scale of the flood events), there are two categories of floods (Waggoner, 1990; Bronstert, 2003). The first category includes extensive, long-lasting floods (plain floods). These describe the flooding of larger areas that is almost invariably caused by rainfalls lasting several days or weeks in connection with high antecedent soil saturation. Flooding caused by extensive and long-lasting rainfalls, partly connected with the melting of snow and ice, occurs mostly in plain areas when the dikes along the big rivers can no longer contain the flood discharges. This can lead to flooding of wide areas, as, for example, during the flooding of the European Rhine/Meuse rivers in December 1993 and in January and February 1995. The second category is local, sudden floods, or flash floods, which describe flooding in small catchments that is mainly caused by short and highly intensive precipitation (e.g., thunderstorm). Flash floods occur primarily in hilly or mountainous areas due to prevailing convective rainfall mechanisms, thin soils, and high runoff velocities. The warning time for these events is short. In general, the duration of the flood events is also short, but this flood type is also frequently connected with severe damages. Flash floods are in fact the number one weather-related killer in the United States of America, killing about 200 people every year, with most deaths caused by drowning (Ohl and Tapsell, 2000).

[23] Note that catchment size is always an important parameter when discussing floods since unit area flow in floods of the same risk decreases with an increase of catchment area, influencing forecast, warning, response, defense and coping with floods.

Table 3.1: types of floods and their causes. Partly adapted from Jonkman, 2005 and Green et al., 2000.

Cause	Type
Rainfall	Riverine or non-riverine
	Slow-onset or flash flood
	Convectional/frontal/orographic
	Torrential rainfall floods
Snowmelt	Riverine
	Overland flow
Ice melt	Glacial melt water (rise in air temperature)
	Glacial melt water (geothermal heat source) - e.g. Jokulhlaup Spate floods
Flooding during freeze-up	Riverine
Flooding by ice breakup	Riverine (also called ice-jam floods)
Mud floods	Floods with high sediment content
	Induced by volcanic activity
Coastal/sea/tidal floods	Storm surge (tropical or temperate induced)
	Ocean swell floods
	Tsunamis or seismic sea waves (induced by geological process)
Dam	Dam-break flood (can be deliberate acts of war or terrorism)
	Dam overtopping
	Failure of natural dams e.g. moraines
Drainage problems	Failure of regular drainage systems

Although heavy rain is the prime initiator of flooding worldwide, it does not follow that all floods are necessarily caused by an excess of rainfall or snowmelt. For instance, rivers can overflow because ice-dammed lakes are released. Some massive landscape-forming floods were caused in North America and the Himalaya in this way during deglaciation (Arnell, 2002), and much smaller floods occur still from the periodic release of water stored behind or within glaciers. Landslides too can create temporary dams which produce floods when breached. Lastly, floods can also be caused by an unusually high rise in groundwater levels, such that the water table reaches the surface (Arnell, 2002). Similarly, a rise in lake levels can lead to inundation of the surrounding land. Both these types of floods are generated by prolonged heavy rainfall or snowfall. Finally, floods can also be generated by humans (Vevjevich in Rossi *et al.*, 1994), for instance when structures built by society break (e.g., break of a levee, break of a dam or dike), or by errors in operation (such as mismanagement of flood control gates or equipment).

Flood types are not necessarily mutually exclusive; convectional rainfall may generate flash floods; and frontal rainfall may be influenced by topography to generate orographic rainfall floods.

Floods in Developed and Lesser Developed Countries

Countries and people can face similar patterns of natural hazards, but often experience widely differing impacts when disasters occur. The impact of a flood depends in large part on the kind of development choices a country has made (or was able to make) previously. For example, as countries become more thriving, they are often better able to afford the investments needed to protect people from floods, like dikes and levees. At the same time, the rush for growth can trigger chaotic urban development in flood-prone areas that increases risks of large-scale fatalities during floods. Disasters in general, floods being no exception have the greatest impact on the poorer countries in the world and exert an enormous toll on development. About 85 percent of the people exposed to natural disasters like earthquakes, tropical cyclones, floods and droughts live in countries that either score medium or low on the United Nations (UN) Human Development Index or the HDI[24] (UNDP, 2004) and only 11% of the people exposed to natural hazards live in low-development countries, but they account for 53% of the people who lose their lives (UNDP, 2004). When we look at river flood-related casualties only (figure 3.2), we clearly see that since 1985, the medium and low developed countries have had far more casualties on average each year compared to the high developed countries; the high developed countries account for only 7.7% of the total amount of riverflood-related victims over the considered period.

It should be stressed is that where there is a risk of flooding, it is commonly very high relative to that from other hazards. Outside of the Netherlands and some other countries for instance, it is unusual for a flood alleviation project to be designed to protect against a flood more severe with than that with a return period of 200 years. Consequently, the risk to life from flooding is likely to be higher than those levels of risk which are deemed to be acceptable or tolerable in regard to such hazards as nuclear power stations or chemical plants. For those other hazards, a general rule of thumb has been adopted that an individual risk of death per year of one in one million is a threshold value.

[24] The UN Human Development Index (HDI) is a comparative measure of poverty, literacy, education, life expectancy, childbirth, and other factors for countries worldwide. It is a standard means of measuring well-being, especially child welfare.

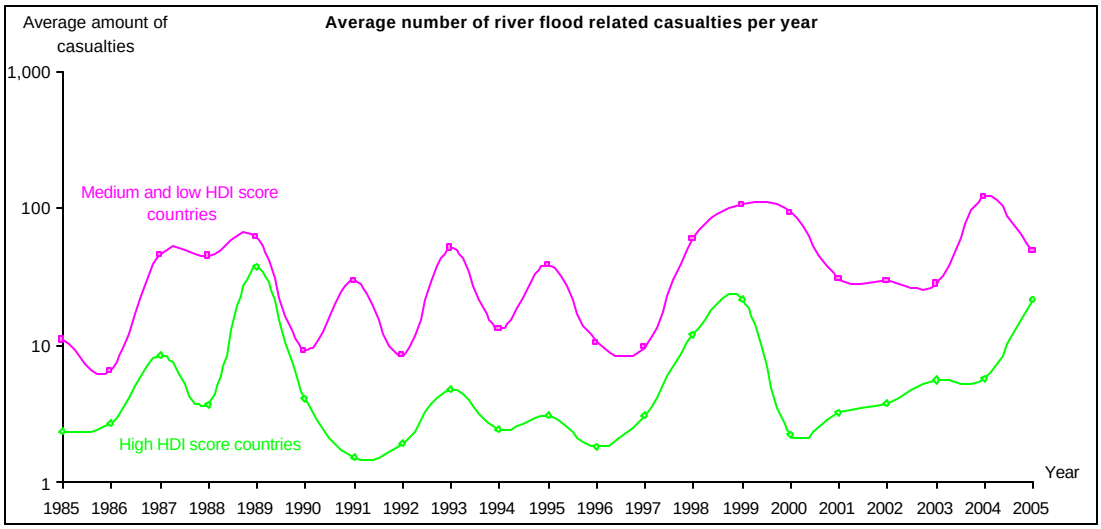


Figure 3.2: the average number of river flood-related casualties clearly shows that high developed countries suffer far less victims per year than the medium and low developed combined do.

In general, the relationship between numbers of deaths and economic loss by floods can be expected to approximate an inverse one: where economic growth takes place within flood-prone areas, it is reasonable to expect that whenever per capita incomes rise, so will property value at risk and average annual flood losses in real terms. As time passes, floods may lead to increased losses as compared to impacts of flood events in the past with the same characteristics, because of the general trends to increase investment and population in flood plains with time in many river valleys of the world. Indeed, data shows that annual economic losses associated with disasters in general averaged USD 75.5 billion in the 1960s, and rose steadily to more than eight times that amount in the 1990s (see figure 3.3) (UNDP, 2004). In 2005, the total amount of damage was over 212 million USD. About 7.5% (or USD 1,6 billion) of that amount was caused by floods (Munich Re, 2006).

Individual floods can cause significant losses to the economic capacity of a country because the costs of replacing damaged or destroyed infrastructure may absorb the resources that would otherwise be available for economic or social development. Governments and individuals may alternatively have to borrow heavily to fund these replacements and repairs.

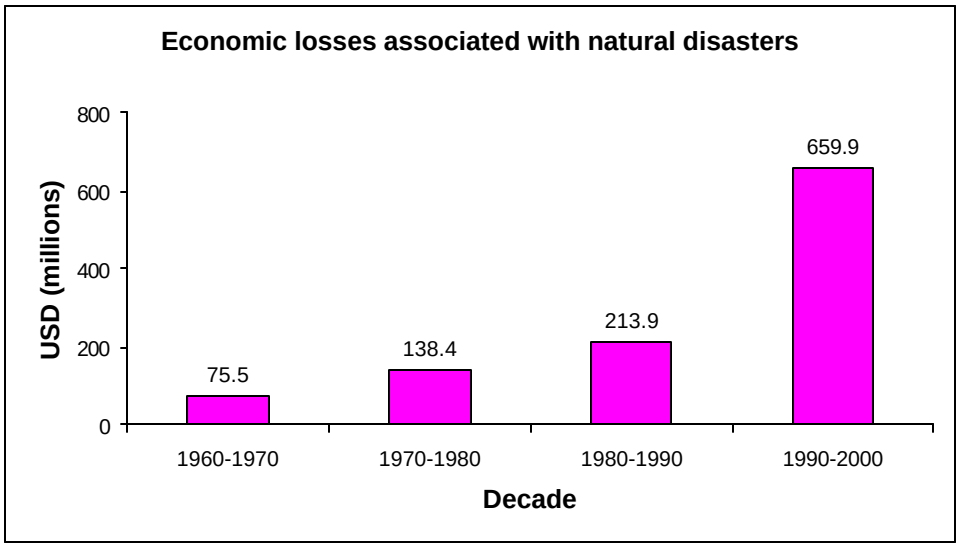


Figure 3.3: Annual economic losses associated with natural disasters show a steady increase over the last 4 decades. Adapted from UNEP, 2004.

In absolute terms, richer nations bear the greater proportion of losses, but poorer countries suffer more when economic loss is measured as a proportion of gross national income (GNI[25]) (see chapter two) or gross domestic product (GDP) (Schipper and Pelling, 2006). However, numbers alone fail to adequately capture the impact of the disaster on the poor who often bear the greatest cost in terms of lives and livelihoods, and rebuilding their shattered communities and infrastructure. For instance, it may be reasonable to measure a Dutch householder's relatively minor flood damage in thousands of dollars. But a flood in Bangladesh may entirely dispossess a farming household; they may even lose their farmland by erosive effects of floods. Their loss may be measured in only hundreds of dollars, but they may not receive aid or insurance payments.

It is important to realize that people in developing countries do not live in conditions that are vulnerable to floods out of ignorance about the hazard or incorrect perceptions of risk. The unplanned and unmanageable large-scale migration from rural to urban areas is a feature of many developing countries of the world, especially in Africa. Most have little freedom to choose how and where they live. Often, they have no option except vulnerable locations such

[25] The GNI, previously known as Gross National Product (GNP), comprises the total value of goods and services produced within a country (i.e. its GDP), together with its income received from other countries (notably interest and dividends), and less similar payments made to other countries. For operational and analytical purposes, it is the World Bank's main criterion for classifying economies.

as flood plains (Dixit, 2003). They are forced to live there not because land use planning is poor, but because the prevailing agrarian relation in their society, or because the processes of social and economic exclusion make them unable to own property in safer areas. As a result, in many developing countries the most serious flood-related risks are associated with widespread floods in remote areas and in unplanned settlements within urban areas (Alexander, 2000). Sadly, the people at the margins of a country's social, economic and political system frequently find it hardest to reconstruct their livelihood after a disaster. In addition, many developing countries do not have the financial resources to implement structural flood control measures.

Perceptions of Flood Risks

Although flood risks are increasing more and more, especially since the latter part of the 20th century, people have continued to be drawn to and occupy floodplains; sometimes because there are no other places to live, sometimes because of aesthetic and prestigious considerations, but almost always knowingly in spite of potential peril. What, if anything, explains this apparent contradiction?

Firstly, it has been documented that people confronted with fears in general for which they have no ready means of coping, simply deny the threat altogether (Schulz *et al.*, 1973). The best known, although outdated, of these threats is the nuclear bomb, arguably comparable to threats of terrorist attacks or Weapons of Mass Destruction (WMDs[26]). It is hardly ever discussed, but if pressed, people may move from denial to a special kind of interpretation; everyone will get hurt, except for oneself. This is the '*it can't happen to me'* syndrome, in which people deny the existence of a risk for which they have been warned (Mileti, 1994). When this syndrome is translated to flood events, the general mode is to fasten on to deterministic explanations such as: 'floods occur every ten years'. That does a great deal to reduce tension and stress. At the same time, strengthening social resilience capacity could reduce vulnerability (Folke *et al.* 2002). Theoretically, communities build in a floodplain, i.e. exposed to regular disturbances, and may have developed organizational and infrastructural responses to absorb disturbances more easily than other societies.

Kates (1962) looked in more detail at the differences in the perceptions of individuals as to the nature and magnitude of the flood problem, and he showed that their perceptions often differ considerably from those of the engineer or the scientist. Often, flood plain occupants do not spend much time thinking about the potential dangers of flooding; it may be only one of many problems that concern him in his daily life. As a logical result, only a small part of the time is spend to deal with flood matters. Kates furthermore noted that floodplain occupants often perceive the flood hazard and its potential effects rather imperfectly. As can be expected, those who have experienced a flood in the past tend to have more accurate perceptions of the hazard than those who have not had such experience, which can create issues if a region has not experienced a flood event in decades. Prior flood experience, like flood location or

[26] Today, the term 'Weapons of Mass Destruction' means different things to different people. The most widely used definition is that of nuclear, biological or chemical weapons (NBC).

proximity to the threat, structure the perceptions of risk that people form. As people learn more about various flood protection structures there is a corresponding decrease in their expectation of future flooding. Prior disaster experience, however, might also backfire when people escaped the damage in previous events; 'the water never got my house, so I am safe this time too'. But it does not necessarily follow that even when there is accurate perception of the hazard that there will be effective action to deal with it; floodplain occupants may feel that they will not suffer any damage in the future and even if they do, it will not be serious. In addition, the typical individual is mostly unaware of the wide range of actions he can take to reduce potential flood losses (Derrick Sewell, 1971). So for the most part there tends to be a lack of concern about flood hazards and action seems to await a crisis.

White was the first who sought to understand why people live and, more importantly, continue to live in disaster-prone floodplains even if they have the means to relocate. In his influential dissertation entitled "Human adjustment to floods", published in 1945, White argued that flood protection in any form tends to develop a false sense of security among floodplain occupants (White, 1945; Kates, 1962). Floodplain occupants may take the construction of a dike or dam to mean that there will never be any more flooding. Consequently, more and more people move in, and activity in the floodplain intensifies. A recent example of the impacts of false-confidence on structural works was seen when Hurricane Katrina hit New Orleans, during the summer of 2005[27]. Some may misinterpret White's theories that development should have never occurred in floodplain areas like New Orleans, but White himself noted the benefits that structural flood protection has brought to this particular city.

[27] A significant portion of New Orleans is located in coastal floodplains, protected by structural mitigation mechanism (floodwalls and levees.) Supposedly the structural mechanisms were built to withstand a category III hurricane design standard. Hurricane Katrina, a category III hurricane when it hit New Orleans, did not exceed the design standards of the structural mitigation mechanisms.

Coping with Floods

The History of Flood Plain Management

Since the establishment of the earliest civilizations along rivers, efforts have been made to protect urban settlements and cultured lands against flooding. Mainly due to an increase of population and investment in flood plains and flood prone areas, it has become more and more urgent to protect citizens from the risks of flooding. And, in all probability, governments like to increase the average standard of living of their citizens by better protection of important occupied flood plains. It is safe to state that people will always have to cope with flood events and flood problems will be on societies' agendas as long as civilizations exist.

Worldwide, the principal way of local defense was the construction of flood dikes or flood walls[28] (Starosolszky, 1994) and flood levees[29]. These structures remained the most common flood control measures for several centuries, with flood levees being the most widespread and at the same time the most important method of flood protection. In fact, Egyptian levees on the Nile are still in use today. In most parts of the world simple indigenous flood adjustments made at the individual household level can be found. Communities which have occupied flood-prone areas for many generations have typically adapted to their situation and developed small-scale, local adaptations to make them less vulnerable and more resilient to flood hazards and disasters. Such adjustments are ones which societies have evolved over centuries through accumulation of flood knowledge and an understanding of what works and what does not. Flood embankments were part of these indigenous approaches; communities banding together to construct dike systems, partly in order to convert wetlands to arable land. Such actions started quite early and were widespread over Western Europe (Wagret, 1967), these systems being constructed and maintained through a system of Common Property Resource management (Ostrom, 1990). Conversely, Wittfogel (1957) has argued that the large scale works of the Middle East and Asia were the consequence of strong central governments. Other indigenous adaptations vary from the raised earth mounds constructed in Zeeland (the Netherlands) as flood refuge areas, to raising housing on stilts in Malaysia to the practice of taking refuge on roof areas in Bangladesh. In Setubal, Portugal, residents have adapted to frequent flooding by closing off their front door with either a steel door or a concrete wall. In

[28] A flood wall is a man-made primarily vertical barrier designed to temporarily contain the waters of a river or other waterway which may rise to unusual levels during seasonal or extreme weather events. Nowadays, these constructions are made out of concrete materials.
[29] A levee is made by piling dirt to varying heights and ten to 20 feet wide at the base or more.

some cases, a similar wall has been constructed across the door between the living area and the bathroom so that when the toilet overflows in a flood, the living area is protected (Penning-Rowsell and Fordham, 1994). Other examples of indigenous adaptations to floods using coconut leaf flood walls, removable flood shields in doorways and home-made 'flood shields', placed across entrances to prevent flooding. The Cajun or Acadian population that joined the Native American communities in the coastal swamps and marshes of Louisiana in the eighteenth century also adapted their dwellings to floods. The base floor of the dwelling construction typical of this area was set upon cypress pilings (or stilts) sunk into the silt deposited by spring and summer flooding (Laska and Wetmore, 2000). The most extreme form of adaptation is perhaps that of the char dwellers of Bangladesh. Here, the rivers are constantly changing their courses, creating and eroding islands and the char dwellers retain title to land whether or not it is currently part of the river channel (Schmuck-Widmann, 1996). Furthermore, not only are some dwellings deliberately constructed on higher ground, but some are dismantled in times flood and moved to the top of earthen flood embankments. In addition, the agricultural economy is adapted to flooding through, for example, the use of flood-tolerant rice crops and the use of boat-craft instead of roads since these and bridges may be washed away. In short, many populations are highly adapted to the routine pattern of flooding. However, indigenous approaches are often only relatively effective in rural areas, but some floods are so extreme that they easily overwhelm the traditional coping responses.

Experience suggests that as modernization takes place (i.e. through urbanization and economic growth) indigenous approaches seem to be forgotten (Chan and Parker, 1996): as time passed, the application of modern science and technology to the problem of flooding resulted in the introduction of non-traditional flood adjustments into societies. These adjustments include high-technology flood forecasting and flood control systems, such as those used along the Dutch coastline. Lately, a combination of indigenous and technological adjustments is being accomplished by letting local people participate in designing strategies to combat flood hazards. This approach is recognized more and more as very valuable. Effective indigenous approaches are no longer pushed out through the process of urbanization and it is no longer automatically modern technologies that take over.

Coping Measures

Coping with floods is defined here as taking measures, with necessary policies and strategies of implementation, which a society may apply to alleviate the consequences of flood events.

In essence, there are four types of measures that societies all over the world have used and still use when coping with floods (Rossi *et al.*, 1994), see table 3.2. The variety and uniqueness of geographical sites, and vast differences in the economic status, social mores and institutional arrangements from one country to another, weigh against the provision of a universal solution to the global flood problem. For any floodplain location, the range of available mitigation options and their mix is large, and optimal solutions are unique to each community. Which particular adjustments and designs will be favored by a country or region will depend on a variety of factors, including geophysical conditions, climate and variability, land use patterns, economic conditions, and, last but not least, socio-political conditions.

Table 3.2: four types of measures for coping with floods, all supposed to reduce exposure and vulnerability to floods if working effectively. The most widespread modifications are the structural and non-structural measures. Adapted from Rossi et al., 1994.

Name	***Description***	***Examples***
Structural measures	These types of measures are intensive and extensive physical measures which change a flood generating environment (reservoirs, levees, dikes, new flood-related channels or extensive measures usually spread over the catchment). Structural or engineering means usually involve large-scale, capital-intensive construction of levees and floodwalls, or modifying the river channel (through deepening, widening and straightening) by increasing its capacity to take flood flows, in order to constrain floodwaters and to limit the extent to which they can flow across floodplains. Structural measures are usually designed to reduce flood risk by changing the probability of flooding and by reducing the exposure of properties and people to floods.	Reservoirs, levees and floodwalls, channelization
Non-structural measures	This is mainly done by regulating the way of using flood plains and other flood-prone land, carrying out flood defense, and, when feasible, using insurance to distribute flood risks. Non-structural flood adjustments are those which are based upon:	Flood proofing, flood insurance, regulation of land use, public relief, emergency action, keep people away from floods
	* Controlling and limiting the use of floodplains, through a variety of planning or regulatory mechanisms;	
	* Reducing the extent to which people and property are in the path of floods through flood forecasting and warning; and	
	* Reducing the effects of floods on communities through flood insurance, flood relief and other social security measures.	
A combination of structural and non-structural mitigation measures	Any combination of structural and non-structural additions, changes or adjustments to buildings which reduced or eliminate flood damage to the buildings and their contents.	
Do nothing except educate	No implementation of (non) structural measures; only investments in raising awareness about flood risks.	Education would basically consist of reminding people only to adjust in some way to flood phenomena, such as leaving flood plains mainly to agriculture.

Roughly, there are two ways of thinking about protection from floods. There are people who argue that the best way to deal with floods is to control them where they form. On the opposite side are those who believe that the most efficient way to deal with floods is to control them by means of structural measures close to the place where they are likely to do the most damage. The omnipresent capital structures designed to alter the hydrologic cycle in almost all nations containing considerable portions of the nation's wealth show that the latter opinion has been by far the most popular one over time (Moser, 1994). Such structural measures are specifically designed to control water in order to prevent flood events, modify the height, quantity, duration and/or frequency of flooding in an area by means of dams, levees, channels, movable barriers and diversion tunnels.

Structural Adjustments

In general, there are three types of structural adjustments:

- Reservoirs (i.e. dams, impoundments).

These structures are the principal type of structural measures. Basically, they impound water during periods of high flows to reduce downstream floods. Dams collectively represent what are possibly the most significant interventions in the terrestrial hydrological cycle (Acreman *et al*., 2000). These kinds of changes to the channel are done not only in order to prevent inundation of the floodplain, but also to increase navigation potential, extract gravel, and, increasingly and for instance in the Netherlands, to restore river channels to their earlier form.

- Levees and floodwalls.

These structures prevent all flood damages until water reaches the top of the structure. Sometimes, flood embankments are build out of the river channel while leaving the channel unmodified (Arnell, 2002). However, it ultimately alters the relationship between river and floodplain since the frequency of inundation will be altered (under 'natural' conditions, the floodplain may be inundated to some degree most years, and some floodplain wetlands are much more closely connected to the river), which will affect floodplain vegetation, as will reduce river water levels and lower the floodplain water table.

- Channelization.

Channel modifications include channel alignment, relining the channel with some other material, and excavations within the channel (Arnell, 2002). It increases the hydraulic capacity of the stream, thus decreases the flood stages for the same rate of flow. The channel may be widened, deepened, diverted, or obstructions may be cleared. The main physical effects of channel modifications include not only the obvious changes to the channel itself, but also the

separation of the channel from the floodplain and previously mentioned effect on the floodplain vegetation. River channel modifications that change the shape of the channel are generally designed to change the shape of the flow hydrograph – to move water more quickly and to prevent it overflowing on to the floodplain. As a general rule, the hydrograph peak increases, and the lag-time between rainfall and response falls. The greatest effect of separating the river from its floodplain tends to be noticed for larger events, because the effect of the lost storage is greatest; the greater the change in capacity of the modified channel, the greater the effect on flood magnitudes (Arnell, 2002).

Although flood control works may have been and still are important tools for reducing damages to existing development in flood hazard areas, they also encourage additional floodplain development and thereby increased rather than decreased property and people at risk from flooding. In fact, given the choice, existing flood-prone communities would select structural measures as the favored option to reduce flood risk. In addition, once a commitment is made to major flood control works, as was done in the Netherlands, the precedent is set for any future shortcoming to be remedied by additional flood control mitigation measures. This is called the levee paradox or 'hydro-illogical cycle' (Wilhite *et al.*, 1987; Smith, 2000): a town develops on a floodplain, no major floods have occurred in recent collective memory thus there is a general apathy towards flood risk, and the community lacks flood awareness. A major flood occurs which creates a dramatic increase in community awareness and a cry for flood protection will soon be heard. Thus a levee is constructed and the community relapses into an awareness of stupor. Development of all kinds proceeds in the area under the misconception that it is now flood-free. Abruptly, and unexpectedly, crisis returns when the levee is overtopped; community outrage is greater than before, also because there are more people, too. The levee is extended upwards and outwards and apathy returns once again. Years pass, an even bigger flood occurs and the cycle continues.

While physical structures may have successfully protected and continue to protect areas, they can and have engender(ed) a false sense of security (White, 1945) and the realization that structures are not infallible, is missing or sometimes conveniently ignored. It is recognized in many developed countries that to completely control floodwaters is not the optimal flood management strategy (see chapter four). In addition, all structures require maintenance, particularly dikes, which can erode over time or become saturated and fail during extended periods of high flow. Furthermore, no matter what level of flooding structures is designed,

there may come a time when the flood levels will exceed the design flood. Whatever the reason, once a structural system fails the damage form the flooding will be greater than if the structures had never been put in place.

Non-structural Adjustments

Until the late 1970s, when it came to protection from floods, structural measures were preferred (Gruntfest, 1994). More and more, however, these large scale capital intensive projects were being questioned both on technical and environmental grounds. In addition, many development experts wondered whether large scale flood control projects are economically suitable for the lesser developed countries (Cuny, 1983), since they increase the country's debt significantly for little economic return, and some flood control projects may be counterproductive It seems that in spite of the historic merits of structural adjustments, their importance has decreased in the last decades, and non-structural measures have received increasing attention.

Non-structural adjustments modify the susceptibility of flood plain activities to flood damage (Moser, 1994) rather than altering the nature of the river, or the flood itself, like structural adjustments do. Non-structural approaches are most applicable in 'formal' societies and although they have greatest potential when they are introduced before flood disasters occur, they have usually been implemented after flooding problems have arisen. Examples of non-structural measures include but are not limited to:

- Flood proofing measures.

Flood proofing[30] is essentially a combination of structural change and emergency action. It concentrates on the adoption of certain measures that can be put into action as soon as a flood warning is received. Just like structural measures, flood proofing tends to foster and encourage human occupancy of floodplains, but it also places part of the responsibility for taking action on the shoulders of the individual. Flood forecasting systems are a different type of flood proofing. This strategy acknowledges that floods will occur, and concentrates on minimizing the opportunities for damages.

- Flood insurance.

[30] Flood-proofing is a planned approach to modifying buildings to make them more resilient to flooding. Basic approaches to flood proofing are: relocation, elevation, floodwalls, dry flood proofing, and wet flood proofing.

Flood insurance provides a means of reimbursement of damage costs, allowing victims to recover from loss. It spreads the cost of irregular and geographically confined flood losses over both time and space. And lastly, it can be used to encourage actions, at individual and collective levels, to reduce exposure to flood loss. By concentrating on creating sources of innovation and renewal, it is a way of managing for resilience. Flood insurance is provided in several countries, but in different ways, reflecting different institutional arrangements and flood experience (for examples see Arnell, 2000). Flood insurance is rarely an integral part of flood management, with the significant exception of the U.S.A., and to a lesser extent, France. Insurance as well tends to encourage increased occupancy selectively and allows or encourages property owners to remain on the floodplain, particularly if the insurance is subsidized. This means that insurance has the potential to increase both the losses during a flood and exposure to the flood hazard.

- Regulation of land use.

Floodplain occupancy can be regulated by states through statutes, ordinances, subdivision regulations, government purchase of property, and subsidized relocation. National policies to regulate how land is used, especially in flood zones, generally include:

- Land-use zoning to discourage or prevent building in flood-prone areas;
- The control of settlement expansion into floodplains;
- Controls on development density in floodplains such as locational permits; and
- Specified design standards (for instance minimum building construction standards for floodplains or sea-flood areas, such as minimum property floor levels)

Such regulatory policies are often enacted or otherwise introduced by the central government and implemented and enforced by local authorities, and they strongly build and rely on sound mapping of flood-prone areas. The success depends on the extent to which they are enforced; unsound enforcement is often the proverbial Achilles' heel. Thus clearly, regulatory approaches have greatest potential in a formal society. Regulation of land use has a number of advantages. The most important perhaps is that it encourages careful weighing and consideration of the costs against the benefits of floodplain occupancy versus location elsewhere.

- Public relief.

Catastrophic flood disasters, especially those in which lives are lost, often lead to a direct public response, whether their scale is large or small. Often, an immediate reaction to the announcement of a flood disaster is the establishment of a national relief fund to assist flood victims. Large-scale catastrophic floods may even lead to direct international public response,

through relief and internationally funded programs, like the devastating floods in Mozambique of 2000 did (see chapter four). The principal justification for the various forms of relief is that they help to ease the immediate distress, and to support initial rehabilitation. Also, it may be politically unacceptable to do nothing following extreme events. However, it can remove the incentive to avoid future flood losses, and therefore encourages persistent human occupancy of the floodplain.

- Emergency action.

This response consists mainly of removing persons or property from the area subject to flooding. Generally, the local authority or the central government assumes responsibility for overall organization. The effectiveness of emergency action usually depends upon the extent of preparation before the flood occurs. Again, emergency action tends to encourage persistent human occupancy of floodplains.

- Keep people out of the way of floods.

If it is realized that any structure to contain floods will at some point be overcome by a flood of greater magnitude, the way is open for the adoption of the strategy 'keep the people out of the way of the flood'. This means avoid development in flood-prone areas. However, on a practical level, this option is mostly impossible since there are already many valuable developments (cities for instance) in flood plains that cannot be removed and in addition, the flood plain provides many valuable services, even despite the ever-present danger. In the same line of thought is the removal of towns in harm's way of potential floods, a solution the United States has applied[31], but its attainability depends heavily on the size of the town and the absence or presence of valuable developments. As one can imagine, costs for moving towns are substantial, but in the end might outweigh the costs of chronic flood-relief or the maintenance and/or production of flood-related structural measures.

As was mentioned before, several of the options mentioned require a well-functioning society because enforcement if a large part of the execution of the measures. Also, other social guides, like national laws, historical precedents, jurisdictional constraints, and government policies,

[31] The small town of Soldiers Grove, Wisconsin, was one of the first towns to move out of harm's way (Clement, 2001). After decades of floods from the Kickapoo River forced the town to rebuild time after time, often with federal money, the U.S. Army Corps of Engineers proposed a $3.5 million levee to protect the town. The village rejected the levee plan and instead proposed moving homes and the business district to higher ground. After years of bureaucratic delays and another huge flood, the town was moved in a five-year process completed in 1983.

condition to an important extent the adjustments that are chosen. For instance, if only flood relief or flood protection are seen as possible responses to flood situations, then only these are written into the legislation. Consequently, other alternatives as flood insurance, flood proofing, and so on may not be considered at all in actual decision-making, even though they may be much more effective in dealing with flood problems than the latter.

The Four Phases of Flood Management

Historically, four phases of floodplain management can be distinguished (Green *et al.*, 2000; Parker, 2000): 'no organized flood management', 'keeping the river away from the people', 'keeping the people away from the river' and 'learning to live with floods'. The phase a country is in varies per nation and is linked to the specific culture and history. Political acceptability considers the dominant world views that the designs of the paths follow. A hierarchical government will choose a policy in which flood control structures dominate. Due to shifting pressures such as anthropogenic pressures, climate, the failure of current flood management policy (van Ogrop, 2005), or the emergence of a dominant worldview, society will evolve or modify a system to cope with floods. Primarily, society adapts to the natural flood conditions and develops the land in accordance with the prevailing natural conditions.

The first phase is characterized by lack of knowledge of flood hazards, and any attempts at managing floods are tentative or based dominantly on the experience and actions of individual floodplain occupants.

Progressively, this first phase was replaced by the second phase: the state begins promoting and implementing structural flood control measures. This approach, characteristic of the late nineteenth and most the twentieth century, was the 'engineering' or scientifically rational approach to river management. It was often marked by state promotion of structural (i.e. large-scale engineering) measures although many of the works of this time where undertaken by provincial or local governments. The philosophy was strongly rational: rivers were being 'trained' or 'improved' (or 'economically more productive' as Worster (1985) describes this process in the United States) to become efficient and to stop floods from interfering with human activity. There was a strong emphasis on building flood embankments designed and constructed to engineering standards, constructing flood relief channels and sometimes constructing a series of flood control dams. The language used during this phase reflects this struggle to make rivers efficient servants of human purposes: floods were to be 'controlled'

and ‘defenses’ were to be prepared against floods. Unfortunately, structural approaches have a number of disadvantages, including that flood control structures may encourage further floodplain development (false sense of security); flood embankments may be only partly effective in exceptional floods (i.e. they may be overtopped or breached); structural approaches may have adverse or damaging environmental consequences (Brookes, 1988; Purseglove, 1988) and perverse impacts on downstream areas (worsening their flood problems); and flood control may only address part of the problems which cause flood disasters (i.e. flood control does not address people’s vulnerability to flood hazards).

Eventually, the strategies which rely solely or primarily on structural flood control measures subsequently tend to go through a transition resulting in greater emphasis on non-structural measures. These non-structural approaches were originally proposed as part of an integrated strategy for the good management of floodplains (White 1945, 1974), and frequently came to be offered as an alternative to the traditional engineering solutions. Whereas the second phase defined the problem as the rivers, and the solution being to keep the rivers away from the public, non-structural approaches were argued on the basis that the public should be kept away from the rivers. Rather than engineering the rivers to be ‘efficient’, the approach characterizing the third phase centered upon making people behave. The idea behind this phase was that people should not be on the floodplain in the first place; and, if they insisted upon occupying the floodplain, they should bear the consequences of their choice. Non-structural approaches include small-scale ‘structural’ modifications of individual buildings (designed-in or retrofitted adaptations; new buildings should be flood proofed against some design standard flood) and measures designed to move people away from floods. In this phase, communities could deliberately be designed and planned to adapted to floods in a variety of ways, but can also include planning controls to prevent the spread of communities on to the floodplains. Flood-proofing builds upon indigenous flood adaptation approaches and this may be promoted, as may improved flood forecasting and warning schemes to allow people and property to be evacuated from a flood-prone area in advance of a flood. There may also be an effort to encourage purchase of flood insurance. In extreme cases entire communities or parts of communities have been moved from flood-prone to flood-free land. This third wave was characterized by the same optimism as the second wave of approaches. Non-structural approaches were generally assumed to offer an alternative and be a replacement for traditional engineering approaches.

The fourth and final phase can be characterized as a holistic approach: learning to live with floods. The original idea behind the third phase, the non-structural approach was often already expressed in the terms of 'coping with floods' or 'living with floods' and the holistic approaches may be seen as a return to this original idea. The holistic approach is not a single strategy, but rather a variety of strategies, resulting from the evaluation of the successes and failures of the previous phases in combination with the recurrence of exceptional and highly damaging floods. The emerging holistic approach addresses the basic causes of floods and flood disasters and talks in terms of 'flood alleviation', and 'flood mitigation', rather than in terms of flood control, and of 'flood hazard management' or 'flood risk management'. The concept of sustainable development (United Nations, 1992) is one of the drivers of this approach, especially the requirement to think about a catchment as a whole, including the inter-relationships between land and water. In addition, not only is economic development taken into account, but also human development, including increasing public involvement in decision making. This fourth wave is more critical and less optimistic than either of the previous phases.

The Netherlands is a textbook example of all these phases and is in the final one: after hundreds of years of anthropocentric modification of the land surface and channel networks, a gradual dawn of a philosophy of protection and restoration has started with the country wide water management concepts entitled 'Living with Floods' and 'Giving Room to the Rivers' ('*Ruimte voor de Rivier*'). See chapter four for more details.

Flood Policy: Institutions , Roles and Responsibilities

Flood policies and management are culturally constructed phenomena: people's understanding of floods and how to deal with them derives from their unique environmental and cultural conditions. Therefore, the respective roles and responsibility of the individual and state regarding response to flood hazards are defined according to the different traditions and institutions present in a country; the strategy of flood management is shaped by history and reflects the culture of that country and local flood conditions[32].

Generally, the goal of public flood policy often translates into reducing risk, exposure and/or vulnerability to the hazard, but this may be done in different ways and the goals will relate to what is believed to be economically, socially, politically, environmentally and morally desirable for the specific country. For example, an ancient principle underlying English flood legislation is that responsibility for drainage of land and avoidance of flooding rests primarily with the individual riparian owner[33], and a complex history of case law has accumulated to help settle disputes between riparian owners. Only in the lowest-lying areas, historic organizations to address flood problems emerged (Darby, 1983). In other countries, flood hazards may be recognized as a national threat inviting state response. This used to be the case in the Netherlands where flooding is a strategic threat to the nation, and the constitution states that the inhabitability of the country and the protection and improvement of the environment are public tasks (Huisman *et al.*, 1998), resulting in a more collective and consensual approach. Members of the public could be required to join a *dijkleger* (literally meaning a 'dike army') and equipment could be requisitioned by the state in flood emergencies[34]. In the People's Republic of China, voluntary labor is mobilized and 'organic cadres' involving tens of thousands of citizens under the leadership of the Communist Party of China to construct and defend flood dikes (Parker, 2000). In other countries, flood alleviation measures are

[32] See for instance Reisner (1986) who gives a detailed description of the water projects in the U.S.A. and provides insight in American politics.
[33] The responsibility for maintenance and renewal of flood and tidal defenses rests with the riparian owner except where there is specific agreement to the contrary. In effect, where tidal defenses are assessed with a residual life of 5 years or less, the Environment Agency (EA) may contribute to the cost of renewal. It should be noted that this is a permissive power; the EA has a duty to enforce against riparian owners but not to contribute to the cost of the required works (Grant *et al.*, 2005).
[34] The last *dijkleger* stopped functioning in October of 2002 because the Dutch government deemed them no longer necessary. In addition, there were problems with motivation and availability of the 'recruits'.

viewed as public goods (goods which are not marketed), the proper responsibility for provision of which lies with public agencies through public policy. The regulation of a river such as the Rhine to reduce flooding risks throughout a large river basin, and the construction of a major flood embankment project along hundreds of kilometers of rivers in Bangladesh are examples of this; such large-scale adjustments could not be promoted other than by public agencies. In some cases, it even calls for important international cooperation. Lastly, economies and standards of living of sub-regions within states can be repeatedly weakened by flooding, resulting in public policies aimed at reducing the impact of floods within the context of regional development policy. The large-scale, multi-purpose dam-building projects starting in the 1930s in the Tennessee valley in the USA are an example of publicly funded flood-control projects undertaken within such a regional development context.

When it comes to public policies directly relevant to flood hazards, the number of levels of government, and the nature of these levels of government, also varies between countries (Tobin and Montz, 1997). For instance, in the USA, it is common to distinguish between federal (i.e. central), state and local government flood policy. In the Netherlands, the interrelationships within these three-tiers have been important in the 1995 floods, but the local-level decisions were of similar and crucial importance. In Bangladesh, the Flood Action Plan is centrally driven, but there are also tiers of local and district government which are particularly involved in flood relief and food allocation.

Strong societal and institutional forces can also influence and sometimes dominate flood policy-making. These forces include the power structure of society, institutional arrangements and traditions, and national economic and political trends. In England for instance, the agricultural lobby and the landowning classes were driving forces for the flood policy. In India, the tradition of bureaucratic manipulation and corruption in government seeps through in flood management. And in Argentina, the private interests are sometimes superior to the public good, which can have adverse affects on public flood policy.

There are numerous issues, be it rational or not, that can constrain public flood policy in any country, at any time (see table 3.3 for a summary): issues of technical and physical character, financial and economic issues, legal and administrative issues, environmental issues and last, but certainly not least, political issues. Political issues especially are of importance for the

Table 3.3: Five issues that have the potential to constrain the public flood policy of any country. As indicated, phase II appears to be the most vulnerable phase during flood policy development, and political issues always have the possibility to hamper the process.

Issues	***Potential to constrain during***	***Explanation***
Technical and physical	Phase II	This applies mainly to engineering or constructional approaches to reducing flood hazards and related disaster potential.
Financial and economic	Phase II and phase III	Public policy is often constrained by availability of financial resources. Severe shortage of finance and high levels of foreign debt can seriously affect the pace of restoration of flood-damaged infrastructure and communities. Developing countries are often caught in such circumstances.
Legal and administrative	Phase III	In some countries, there is a firm belief in individual property, for instance in Costa Rica and Turkey. These citizens of such countries would challenge land-use zoning policies. In poor nations, enforcement problems are likely to be widespread because of the existence of a large informal sector in which decisions are taken with no regard to any constraints imposed by public regulations, and monitoring for compliance is weak. Furthermore, institutional arrangements can constrain and narrow effective implementation of public flood policy and policy choice because agencies commonly seek to operate only within their boundaries of responsibility and find it more difficult to form alliances for broader inter-institutional policy promotion. It is often easier to approach a flood hazard problem by implementing a narrow, engineering based project than developing a broader and diverse program of projects promoting social change to reduce flood hazards.
Environmental	Phase II and phase IV	The environmental constraints on public flood policy became increasingly significant during the latter quarter of the 20th century, especially in developed nations. The environmentally adverse effects of economically efficient engineered flood control structures became widely evident and major changes in the philosophy of flood hazard reductions were made. Flood management agencies began to employ more biologists, environmentalists and environmental economists. It became recognized that floodplains have real value in a lots of other ways; they are important in 'absorbing' floods' through reducing their peaks and velocities, and in maintaining water quality through processing and filtering wastes and moderating water temperatures; they support breeding and feeding grounds and provide sites of recreation and aesthetic value. So now, designing flood management policy with regard to these beneficial values and to be consistent with sustainable development objectives have become important goals.
Political	All phases	Flood events can be either small scale or large scale, but they will always be cross-scale in both space and time. A flood in one area generates feedback elsewhere, and since rivers often form political boundaries between countries, or may flow from one country to another, reducing flood hazards along such rivers usually requires cross-border cooperation. As a result, these events have to be tackled simultaneously at several levels, at times in several countries, and the power of centralized management agencies should be redistributed and balanced.

remainder of this paper since these are not only linked to troubles on a regional and national scale when it comes to the design, formulation, and implementation flood policy, but also have to potential to generate (and caused) troubles in many regions of the world when it comes to reaching agreement over flood measures and policies with neighboring countries. The ecological, economical and physical interconnectedness of river basins naturally calls for collaboration between countries even though flood management at root will be a national endeavor. A flood in one area by definition generates feedback elsewhere, and since rivers often form political boundaries between countries, or may flow from one country to another, reducing flood hazards along such rivers usually requires cross-border cooperation. As a result, these events have to be tackled simultaneously at several levels, possibly in several countries, and thus, hypothetically, the power of centralized management agencies should be redistributed and balanced, making the need for international coordination great, and larger-scale controls, not only nationally but also internationally, often necessary (Hilborn and Walters, 1992; Hilborn and Gunderson, 1996). Co-management systems and the decentralization of power are tools that can be used to deal with such cross-scale effects. Next, we will take a closer look at institutions that deal with transboundary flood events.

Institutions: An Introduction

By definition, institutions are humanly devised constraints that shape human interaction or, less formally, the rules of the game in society (North, 1990). Institutions are often defined as the expressions of the terms of collective human experience (Scott, 1995) and consisting of cognitive, normative and regulative structures and activities that provide stability and meaning to social behavior. At any rate, institutions provide the means by which societies can act on their knowledge and use it to produce a livelihood from the resources in their environment. Each institution has its own history, its own time-dependent line of development (Scott, 1995); and how a system develops and operates affects its structure and capacities for action. Thus by its very nature, institutions are constantly subjected to pressures for change as a country's economic and social demands change (Frederiksen, 1992) resulting in the tight link between the social values of a country and its institutions.

The broadest definitions of institutions include both formal institutions, such as administrative structures, and informal institutions, such as customs and practices (Olsson, 2003). However, in the remainder of this paper the term ‘institutions’ is used only in the sense of formal institutions only. As a result, whenever the term ‘institutions’ is used, it will point to formal,

government-based institutions specifically designed for the management of -inter-national river basins.

The quantity of literature on institutions is impressive, and it would be impossible to synthesize all the theories concerning institutional research in this paper. However, it seems appropriate to introduce crucial findings, agreed upon theories and general terms used when discussing institutions.

Institutional Inertia

Of specific importance, when talking about institutions that deal with (transboundary) water issues, is stability, or 'institutional inertia', a quality most institutions display. A general characteristic of conventional water resource management is that it is often primarily predisposed to eliminate the disturbance by blocking it out (Holling *et al.*, 1995), even though disturbances are part of the natural cyclic processes of ecosystems. This holds especially true for systems that have not experienced crises in the past decades, which tends to create the conditions for a larger-scale and widespread crisis later on. A significant example of this form of institutional inertia is the '*waterschappen*' (water boards) in the Netherlands (see paper on case studies for more details). Another reason for conservatism or inflexibility in institutions is caused by the fact that institutions are political by nature. Genschel (1997) already recognized that rather than confronting the extremely uncertain event of a complete institutional overhaul, policy actors will choose to patch up existing institutions with new structures or transpose them to new functions as long as possible, because these two strategies of institutional change are arguably less costly, less risky, and less politically disruptive in the short run. Lastly, institutional inertia can also be caused by intellectual inertia. Ideas in agreement with current policy practices and accepted political doctrine benefit from a considerable comparative advantage over untried proposals based on unconventional ideas. This explains, for instance, why the holistic concept of 'Living with Floods' took years before it could actually be implemented in the Netherlands.

This does not mean that institutional change is neither impossible nor uncommon. It is however believed to be periodic. Under stable conditions, policy makers lean heavily on the existing institutional arrangement and make incremental adjustments only at the margin in order to accommodate changes in the world around them. History has shown that only at moments of crises, politics can overrule institutions rather than the other way around (Visser

and Hemerijck, 1997; Gunderson *et al.*, 1995) like an unexpected flood event with far-reaching unacceptable consequences. Indeed, in the past new types and arrangements of water institutions were often created after a catastrophe, for instance the Dutch Delta Commission, created right after the devastating storm in 1953, and the change in national flood management after the extreme high waters in 1993 and 1995 (for more details, see chapter four).

Path Dependency, Lock-In and Institutional Breakout

Values of the past created the institutions of the present, while changing social values will affect the institutions of the future. Or, in other words, history matters when one looks at the creation of institutions or the evolution of ideas. This concept is termed 'path dependency'. Clear definitions for path dependency are rare. A narrow definition has been suggested by Levi (1997, 28):

> "Perhaps the better metaphor is a tree, rather than a path. From the same trunk, there are many different branches and smaller branches. Although it is possible to turn around or to clamber from one to the other - and essential if the chosen branch dies - the branch on which a climber begins is the one she tends to follow."

In other words, the direction and scope of institutional change cannot be separated from its earlier course or past history. When this concept is specifically applied to institutions, it generally refers to situations in which decision-making processes (partly) depend on earlier choices and events (Woerdman, 2004). Therefore, no institution can be properly understood apart from its wider social, historical and cultural context. For example, during the age of enlightenment (18^{th} century), humans were removed from their environment; nature and society were separated. This became the foundational principle of Western thought and provided the management structure for, among other things, dealing with floods. Boldly stated, men took control over nature and tamed the rivers by building dikes and levees and it was not until recently that this form of protection, gridlocked in a form of institutional inertia, has been pushed aside in favor of other forms of protection. In the Netherlands, for instance, people have been protected from floods by dikes and levees which in a way disconnected them from their natural surroundings. Recently, the Dutch have chosen another branch, or left their path that they have been walking on for hundreds of years, by introducing the new water management concept of 'Living with Floods' (Visser and Hemerijck, 1997). Steadily, this concept will transform the Dutch way of how to cope with floods (for more details, see chapter four).

A lock-in (Scott, 1995) is another important term and can be defined as the dominance of a sub-optimal situation in the presence of a superior alternative (Woerdman, 2004). A sub-optimal arrangement can be a (set of) inefficient policy instrument(s), for instance. The superior alternative may be present in theory; it might have been developed or thought of but is not (yet) adopted and implemented. Alternatively, this innovation may already have been adopted and implemented in a particular institutional setting, but not in the setting under consideration. In that case, the alternative is used in another policy area and/or in another country.

Path dependence and a lock-in do not necessarily imply inevitability but can be remediable. Or, as Woerdman (2004) puts it: an institutional breakout may occur. Woerdman states that for a breakout to occur, there must be a known superior alternative or the dominant institutional arrangements have become unattractive. Institutional change may arise from planned and conscious action, but external shocks, as was said earlier, can also provide strong pressures for such change. Furthermore, a loss of trust in governance can provide the crisis needed for organizational change as part of a democratic process. An example of areas in which this loss of trust has triggered new approaches includes the management of floods but also forest fires and the control of lake eutrophication and pests (Holling, 2004). Typically, management becomes somewhat more complex, open, and integrative across scales of variables (Gunderson *et al*. 1995).

Water Management Institutions

The previous sections clarified why the institutions found all around the world devised specifically for the development and management of a nation's water resources are not the same everywhere; history has created the form of the government and the legal system of a country, which in turn form the basic structure for water- and land-use legislation, particularly in such matters as delegation of government responsibilities. An example is the major difference in water management displayed by unitary republics and federated republics, primarily due to the extent of state/provincial autonomy in resources ownership and management. But besides the history of a country, some general characteristics of water influence the nature of national water institutions as well, and these characteristics were specified by Frederiksen (1992). First of all, the quantity of water present in a nation influences the arrangements, because when there is sufficient water, there is no need for tight arrangements among users and conflicts and environmental concerns are minimal. Another

influence on the structure of institutions is the speed at which resources problems (have) come up. Has it been at a rate to which the institutions could adjust in an orderly manner or did they occur at such a pace that institutional changes were made in response to crises? A third influence is the relative population density. In well managed, densely populated areas, many management decisions reside in local units where people readily cooperate and work together to solve conflicts and maximize mutual benefits. Problems can arise where central or state governments have taken over these long-established arrangements. A fourth influence is climate, most notably the amount, pattern and nature of precipitation, because this variable basically determines the extent of major commitments to irrigation, drainage and flood control. Related to this are findings by Stahl (2005), who showed that hydroclimatic variability and population density are most influential in arid to sub-humid basins, while socioeconomic and political factors seem to be more important in determining water-related international relations in humid basins.

Due to the unbiased nature of water events ignoring humanly drawn boundaries, together with the mostly uncontrollable and unpredictable nature of water, water management institutions need to be flexible in order to be able to react to short-term, extreme occurrences like floods. At the same time, and albeit that flood management at root will be a national endeavor, the ecological, economical and physical interconnectedness of river basins naturally calls for collaboration between countries. These two arguments seem to contradict each other, because large, centralized resource management agencies, perhaps what international river basins institutions end up being, are susceptible to making large mistakes and do not (cannot) have the variety of response capabilities that complex, polycentric, multi-layered governance systems can have (Gunderson *et al.*, 1995; Ostrom, 1998). Regional bodies can be potentially more flexible to respond to the water flow fluctuations in their transboundary rivers than an international outfit. Floods, especially transboundary ones, pose a monumental challenge to local public officials who must be prepared to cope with demands encompassing every aspect of community life (Drabek and Hoetmer, 1991), but at the same time, it is precisely the local-level institutions that can learn and develop the capability to respond faster than do centralized agencies. Being 'on the ground', they are physically closer to the resources, there is no separation of the user from the manager, and there is more learning-by-doing in accumulating a base of practical ecological knowledge (Berkes and Folke, 1998).

So can we now actually pinpoint qualities that make for good water institutions? To start with, it makes sense that basin wide cooperation so should have all riparians in it. Although there are examples of institutions that have evolved after a long conflict and with only a few of the riparians committing to it (i.e. in the Nile, Mekong, Indus and Ganges basins), such commissions can be seen as starting points and are therefore by no means deemed worthless. Thus, initiatives excluding riparians should not be encouraged, nor should they be ignored. In addition, Millington (2002) distilled four principles that can be observed in international river basins that seem to be doing the best job at managing the basin. These four common attributes are:

- An institutional framework exists which is both robust and flexible, and includes modern legislation and an integrated policy framework.
- Planning and management is knowledge driven. Strategic assessment of water and related resources receives high priority, and does not stop at mere data management, but actively pursues the generation of strategically focused information and knowledge.
- Integration is built into institutions, resource management, and policy. There is recognition of the holistic nature of ecosystems, and all policies, decisions and projects are evaluated against this background.
- Community participation is built into all processes. It is seen as the normal way of doing business. It recognizes also that the natural resources of a country belong to its people, and they have a right to participate in its management – with the flow-on effects that community participation leads to government efficiency, ownership of policies and actions by the community, and to more readily accepted principles of cost sharing.

River Basin Organizations

Introduction

Managing rivers effectively has long been a goal of societies and states, not in the last place because managing rivers was and is viewed as something that is necessary for the common good. So not only did rivers play a remarkable part in defining the structure of human societies, they also have long been a feature of the global political environment, because politics, by definition, is a process by which collective decisions are made within groups.

As described, early societies in alluvial basins had great opportunities, but at the same time, had to face great risks. They had to learn to live with floods and, if at all feasible, benefit from these events. This took ingenuity and physical structures, but most of all, required the organization and cooperation between a large number of people, as well as rules and institutions for overall water management. And thus bureaucracies and hierarchies, some still functional today, were born which helped civilizations and cities deal with these issues and foster cooperation between all of those involved[35]. Societies in upland headwaters did not face the same incentives as did societies located downstream, and historically these societies appear to have more often been characterized by smaller, less structured social groupings (Sadoff and Grey, 2002). Hence, one fundamental lesson of universal and historical experience widely accepted today is that a river is best managed as a basin unit. Furthermore, since any action in one part of the basin has impacts in another, joint and cooperative management of water resources is a desirable goal sought by many governments, policy experts, and water management professionals (Ostrom, 1990; Dellapenna, 2001; Kliot *et al*. 2001; Turton and Henwood, 2002; Jagerskog, 2002; Philips *et al*., 2006). Fortunately, countries throughout the world have recognized that water management is indeed an important issue that cannot be ignored and have created various special purpose agencies to develop and manage the waters locally, regionally or for international river basins (IRBs). Managing IRBs complicates water management. Control of international rivers that cross political boundaries indiscriminately is tangled with power issues, economic opportunity, national security, society and culture. Since an institution influences behavior and thus the amount of conflict arising

[35] See also Wittfogel's *"Oriental Despotism"* (1957). Wittfogel argued that control of water for irrigation was central to the Asian system of economic production, and had a major impact on the organization of what he coined ' hydraulic societies'. The control of water could be seen a source of power and be exploited by a central bureaucracy theory that came to be known as 'hydraulic monopoly'.

over behavior differences, a dominant role of a water institution is to reduce conflict (Lynne *et al*., 1990). Giordano and Wolf (2001) indeed showed that where relatively strong, sustainable institutions are in place, international water disputes do get resolved, even among enemies.

However, no quantitative global data exists on the number of water institutions that deal specifically with transboundary issues, let alone the number of water institutions that deal with boundary crossing floods. There are case studies about national endeavors (for instance by Kemper *et al.*, 2005) but these logically focus on national cooperation and not on cooperation efforts for international river basins (IRBs). This next section addresses this gap in current research by creating a global database of river basin organizations (RBOs) and river basin commissions (RBCs), collectively called international river basin institutions (IRBIs) principally erected for international river basins (IRBs).

The following section will specifically look at IRBIs that are used to bring stakeholders together and deal with transboundary water issues like shared floods.

River Basin Organizations and River Basin Committees: Global Facts & Figures

At present, there are 279[36] rivers around the world that cross the boundaries of two or more nations. The catchment areas that contribute to these rivers comprise approximately 42% of the land surface of the earth[37], include 40% of the world's population, and contribute almost 80% of freshwater flow (Wolf *et al.* 2003; TFDD unpublished data, 2006). All the 279 international rivers, without exception, create some degree of tension among the societies that

[36] New basins have been 'discovered' or were created since the last update of the TFDD, but not yet published; a manual count of the IRBs resulted in an increase of basins from the reported 263 on the TFDD website to 279 basins when writing this paper. The 'new' basins in Asia are: the Johore, Tebrau, and Scudai (shared between Malaysia and Singapore), the Loes (shared by Indonesia and Timor L'Este), and the Shu and Talas (shared between Kazakhstan and Kyrgyzstan). In Latin or Central America, six more basins were found: the Temash and Moho (shared between Guatemala and Belize), the Corredores/Colorado, the El Naranjo and Conventillos (shared between Costa Rica and Panama), the Chamelecon (shared between Guatemala and Honduras). In Africa, four more basins were added: the Thukela (between Lesotho and South Africa), the Sanaga (between the Central African Republic, Cameroon and Nigeria), the Pungwe (shared between Mozambique and Zimbabwe), and the Pangani (shared betweenTanzania and Kenya). There is indication of the existence of more basins between Timor L'Este and Indonesia, but there is not yet enough spatial information to confirm this.

[37] Numbers used for calculation: land area of the Earth: 147,142,344 km^2, and the land area of all the 279 international river basins combined is 61,852,500 km^2.

they bind[38] because hydrologic needs can get sidetracked by other concerns. The resulting tensions, and their responses, are linked with many other characteristics of societies – history, culture, environment and economy - that affect relations between neighboring nations. Therefore, completely decoupling water's role from the complex dynamics of relationships between states is not possible (Sadoff and Grey, 2002).

Methodology

Over a 6-month period (July-December 2004), we have attempted to summarize the number and nature of multilateral institutions which deal with international waters issues like floods. To this end, data was collected by conducting interviews, and searching the internet in order to compile an empirical database of institutions and organizations which added to some type of institutional capacity in the IRBs around the world. The types of international water collaboration were categorized as either being a 'commission', meaning a bilateral or multilateral body, comprised of officials appointed by national governments to participate in dialogue, discourse, negotiations and the like regarding the international water body for which it was created, or an 'organization', meaning a bilateral or multilateral body, comprised of officials acting on behalf of their government (ministerial, technical or other) to conduct coordinated and/or informed management of the international water body. An organization differs from a commission in that it involves the implementation of bilateral or multilateral programs concerning for instance information sharing, joint management and so on. Note that this is merely an attempt to define the concepts of 'commission' and 'organization' since these concepts are somewhat fuzzy throughout the literature; both terms are used loosely and possibly even interchangeably[39]. Consequently, any categorization that uses such concepts is subjective and will not be seen as an important distinction when discussed in the remainder of the paper. We will therefore use the term international river basin institutions (IRBIs) to refer to both of the concepts. The results are discussed in the remainder of this paper.

Results: Global Database

In total, 153 IRBIs were found around the world. When categorized per continent (figures 3.4 and 3.5), we see that South America has the least amount of amount of institutions that deal with shared river basins resulting in more than 80% (or 53) of their IRBs without a form

[38] The word 'rival' has the same root as 'river', derived from the riparian concept of dwellers on opposite riverbanks.

[39] An example taken from the findings is the Niger Basin Authority (NBA) labeled as an organization but formerly called the River Niger Commission.

of organization specifically designed to deal with transboundary water issues. Africa, Asia and Europe do slightly better: 25%, 27% and 29% of their IRBs are represented by an RBO or an RBC, while the 37 institutions in North American represent all IRBs. Note that a higher number of IRBSs does not automatically result in better management or relative better international cooperation in the specific basins, if such a thing can be gauged at all. Furthermore, the presence of an RBO or RBC in an international river basin does not imply that all riparian countries are parties to the institution; some forms of international water collaboration include all the riparian states, while others do not. See the summary per continent for specific examples of this (appendix table 3.A-3.E, page 216 and further).

Globally, 78 of all IRBs (almost 28%) are represented by an RBO or RBC. The data furthermore revealed that some IRBs have more than one IRBI (figure 3.5): 34 IRBs, or a bit more than 12% have more than one institutions that deals with shared water issues. Note that a value of zero do not necessarily reflect an absence of an RBO/RBC, it merely means that no RBO or RBC was found at the time of the search.

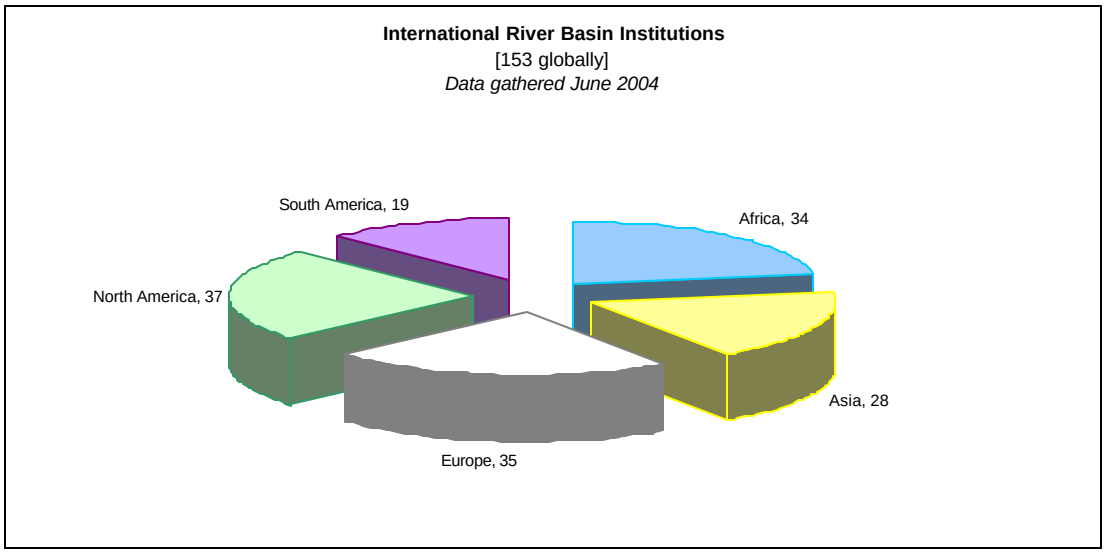


Figure 3.4: the number of international river basin institutions per continent. For a complete list of all IRBIs per continent, see appendix tables 3.A-3.E (page 216 and further)

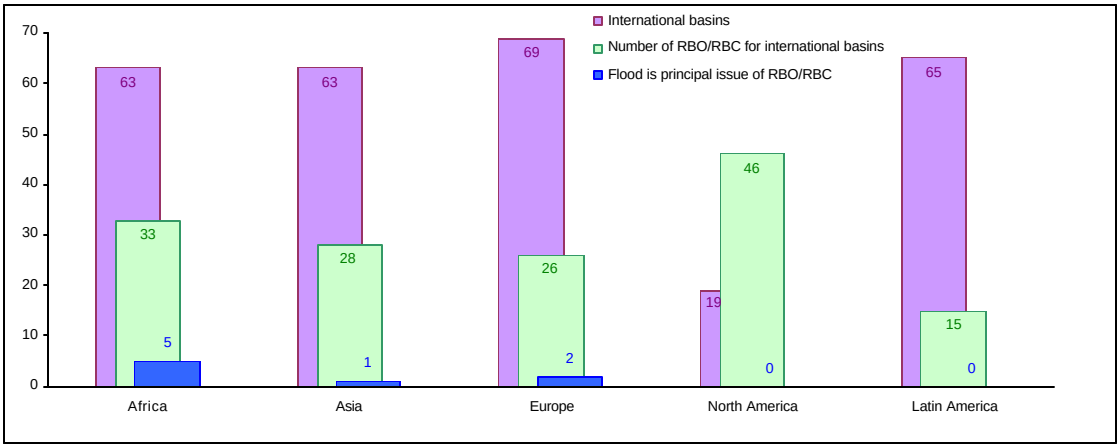


Figure 3.5: The number of International River Basins (IRB) per continent, followed by the basins that have an International River Basin Institution (IRBI), and the number of institutions that have transboundary floods listed as a principal issue in their mandate.

Summary per Continent

Africa

We found 34 institutions in Africa that are specifically set up for an international river basin on that continent. These 34 organizations represent 16 out of the total 63 IRBs present in Africa (see figure 3.6). They are mostly specifically aimed at one international basin, or a subbasin within that basin, although there are also organizations established for more than one IRB. For instance, the *Organisation pour la Mise en Valeur du Fleuve Gambie* (The Gambia River Basin Development Organization or OMVG) not only covers the Gambia, as the name suggests, but also the rivers Koliba/Corubal and Géba. Another example is the *Autorité du Liptako-Gourma* (Liptako-Gourma Authority or ALG); a sub-regional institution for the Liptako-Gourma river basin, covering the international basins of the rivers Volta and Niger.

Some forms of international water collaboration in Africa include all the riparian states, while others do not. The Limpopo basin, for instance, covers Botswana, Mozambique, South Africa, and Zimbabwe but the Joint Water Commission only has members of South Africa and Mozambique. Another example is the Congo / Zaire basin; a total of four initiatives are found here but not one includes all the riparian countries. The Limpopo basin illustrates another form of cooperation that excludes certain riparians: the basin covers Botswana, Mozambique, South Africa, and Zimbabwe. However, the Joint Water Commission established for the basin only has representatives from South Africa and Mozambique in it.

Issues covered by the African shared water institutions are understandably 'joint management', directly followed by mostly economic concerns: technical cooperation & assistance, infrastructure and development and economic development (see figure 3.A in appendix, page 205). Surprisingly, border and territorial issues are not high on the list of principal issues, nor are water quantity and fishing. Four organizations have incorporated flood control as (one of) their objectives: the Organisation pour la Mise en Valeur du bassin du fleuve Senegal (OMVS), the Commission Internationale du Bassins Congo-Oubangui-Sangha (CICOS), the Organisation pour la Mise en Valeur du Fleuve Gambie / Gambia River Basin Development Organization (OMVG), and the Niger Basin Authority (NBA).

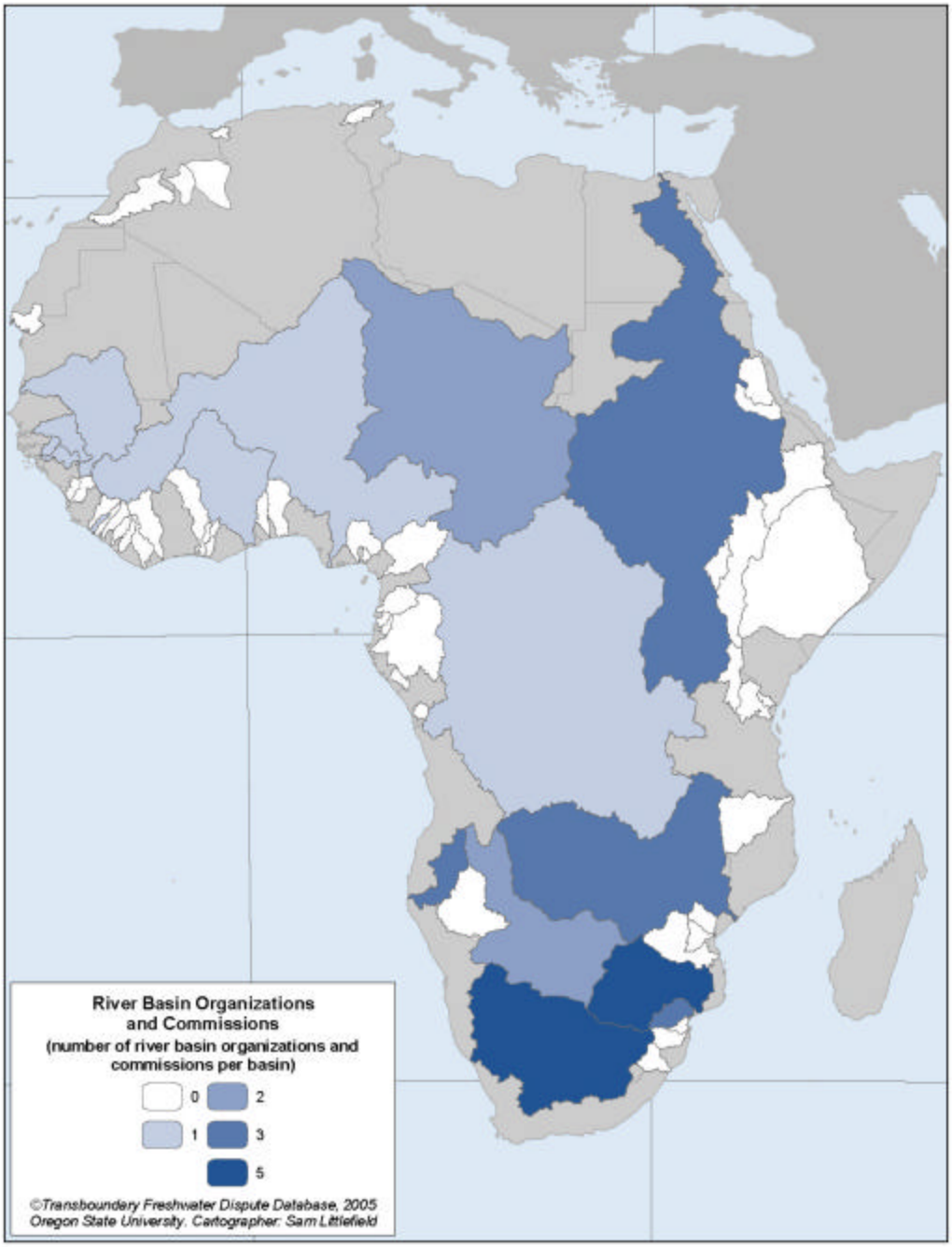


Figure 3.6: River basin organizations and commissions in Africa mapped per IRB (TFDD, 2006, unpublished data; UNEP, 2005) not only clearly shows the dominance for transboundary water institutions for the Limpopo and Orange River Basins (both with 5 IRBIs), but also the absence of such institutions for 77% of African IRBs.

The average age[40] of the African IRBIs is 19 years, the youngest being two years, the oldest 76 years (the Zambezi Watercourse Commission, or ZAMCOM, and the Lesotho Highlands Development Authority, or LHDA, respectively).

Asia

Our data shows that Asia has set up 28 IRBIs for 17 out of the 63 IRBs found on this continent; 73% of the Asian IRBs do not have a shared water institution (see figure 3.7). Six IRBs have multiple institutions set up for them, for instance the Aral Sea with the International Fund for saving the Aral Sea and the Interstate Coordination Water Commission (ICWC). However, the Aral Sea basin also illustrates a form of cooperation that excludes certain riparian states, because neither of these two initiatives includes all the 8 riparians. Another example of a basin with more than one institution yet excluding certain riparians is the Mekong River Basin with five different institutions. Most of the Asian IRBIs are set up for one IRB, but exceptions can be found. The Indo-Bangladesh Joint Rivers Commission for instance is not set up for a specific international river, but rather for the cooperation on joint waters between India and Bangladesh, thereby covering three IRBs (the Fenney, the Ganges-Brahmaputra-Meghna and the Karnaphuli river basins). However, except for the Fenney, these IRBs have more than these two riparians, thus although this seems like a cooperative initiative, it simultaneously excludes several stakeholders, namely China, Nepal, Myanmar and Bhutan. Issues covered by the Asian IRBIs are mainly joint management and water quantity (see figure 3.B in appendix, page 206). The Mekong River Commission is the only transboundary water institution that has flood control as one of its objectives.

The average age of Asian international water institutions is 23 years. The youngest institution has recently started operating on July 26 of 2006 (the preparations for the Commission for the Rivers Chu and Talas started in 2001); the oldest is the Mekong River Commission which has been functional for almost 50 years.

[40] The average age of the institutions is the sum of the years of existence of all the institutions divided by the total number of institutions.

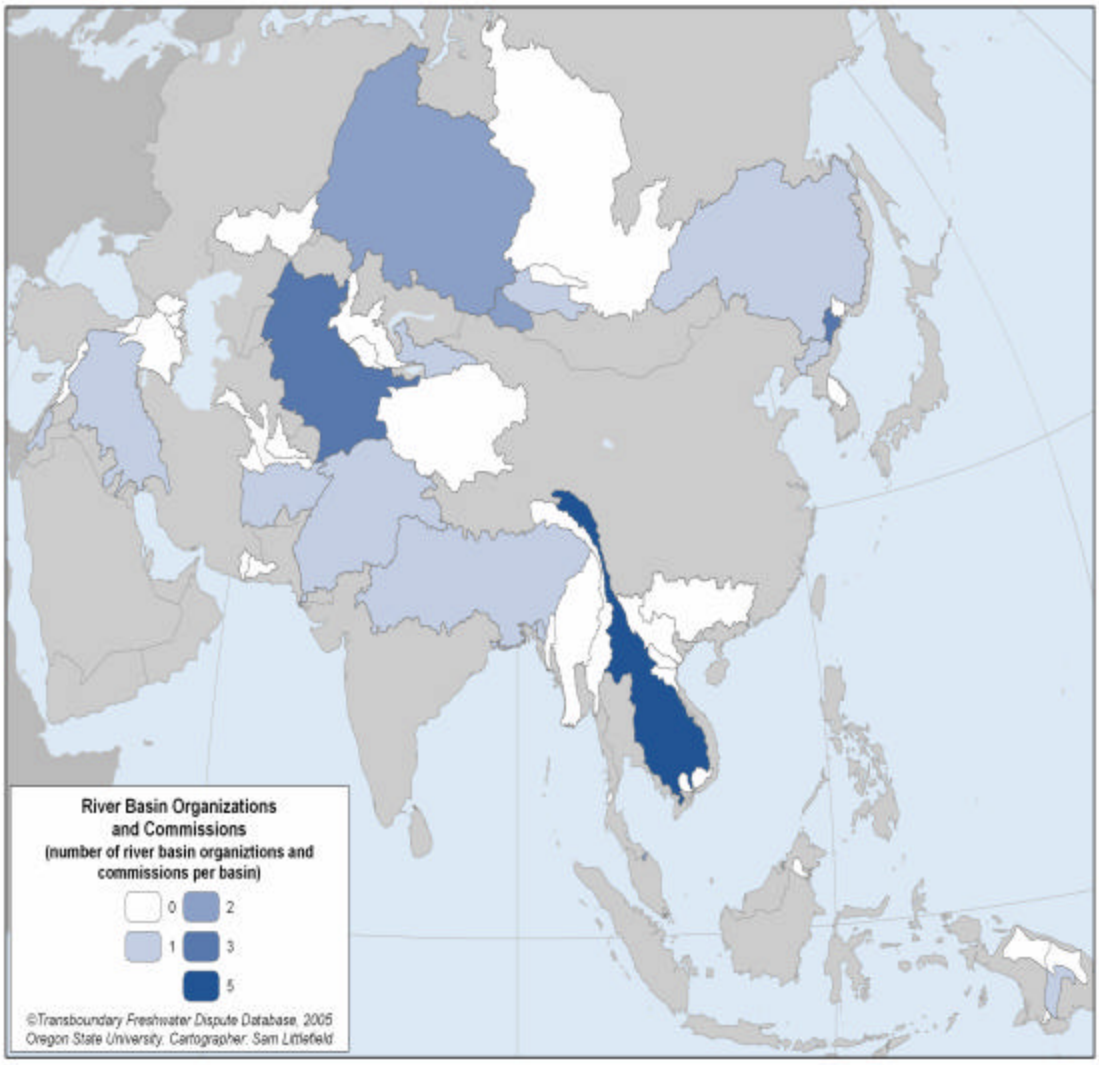


Figure 3.7: map showing the RBOs and RBCs in Asia (TFDD, 2006; unpublished data). The Mekong River Basin has the most institutions (5), followed by the Aral Sea and Tumen River Basin (both 3). Immediately apparent is the fact that many of the Asian IRBs (72.6%) do not have an institution set up for them.

Europe

There are 35 RBOs and RBCs found in Europe[41], representing 20 out of the 69 IRBs present on this continent (see figure 3.8). Nine of these were erected especially for subbasins, for instance the Peipsi Center for Transboundary Cooperation for Lake Peipsi (a subbasin of the Narva River Basin), the International Sava River Basin Commission (a subbasin of the Danube), and the International Meuse Commission (IMC) (a subbasin of the Rhine). The remaining 26 European international water institutions are aimed at one basin. The exceptions are the Finnish-Russian Joint Commission on the Utilization of Frontier Waters and the Finnish-Norwegian Transboundary Water Commission, targeted at the multiple shared river basins between Finland and Russia and Finland and Norway.

Issues covered by the European RBOs and RBCs are primarily joint management and water quality (see figure 3.C in appendix, page 207). There are two organizations that have flood incorporated as one of their principal issues: the International Commission for the Protection of the Oder River against Pollution (ICPOAP) and the International Commission for the Protection of the Rhine (ICPR).

The average age of European IRBIs is 31 years. The International Sava River Basin Commission has been functional for two years while the Central Commission for Navigation on the Rhine (CCNR) has been set up 191 years ago.

[41] This EU Directive utilizes the river basin as the natural unit for water management and states that each river basin within a Member State must be assigned to a river basin district (RBD) and the Member State must arrange for co-ordination of administrative arrangements for water management in relation to each RBD lying within its territory. The Directive furthermore requires that river basins which cross national frontiers must be assigned to an international RBD and the Member States involved must together ensure the co-ordination of measures for its implementation. However, the data was gathered before the deadline of assigning river districts to basins passed, and therefore the resulting 'competent authorities' are excluded from the total count of international water institutions found in Europe.

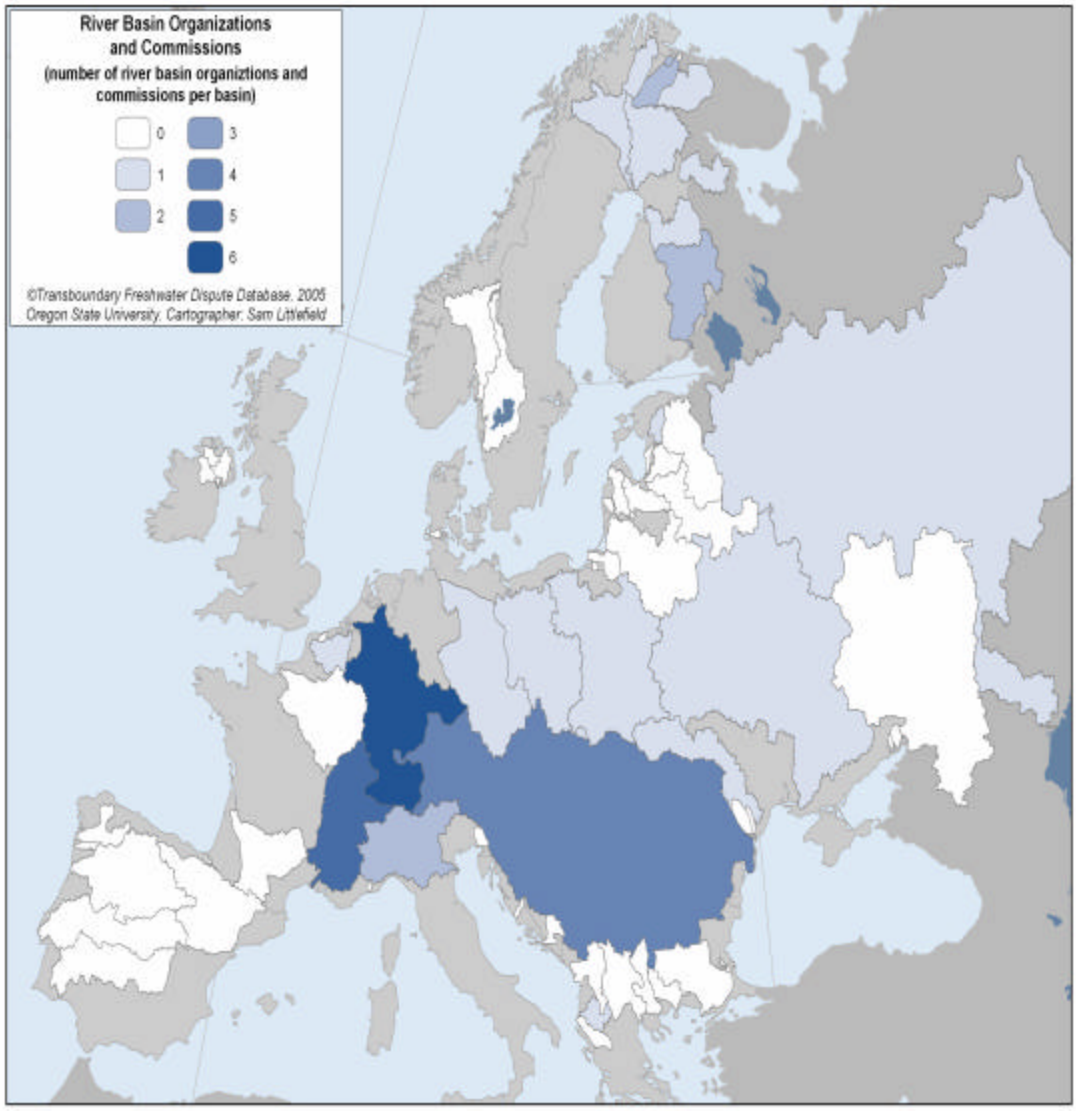


Figure 3.8: a map of the European shared water institutions make visible that the Rhine and Rhone River Basins have the most institutions set up for them (six respectively five), but 71% of the European IRBs do not have a transboundary water institution.

North America

The North American continent has 37 water institutions aimed at international river basins and they cover all the 19 IRBs (see figure 3.9). Some international river basins have multiple institutions set up for them; the St. Lawrence River Basin, for instance, has 11 institutions, mainly resulting from the directives of the Great Lakes Commission. There are several institutions set up specifically between countries, thereby covering more than one IRB; the Transboundary Watershed Alliance (TWA) and the International Joint Commission (IJC), both between Canada and the USA, and the International Boundary and Water Commission (IBWC) between Mexico and the USA, are examples of this.

Issues covered by the IRBIs are primarily joint management, water quality and border issues (see figure 3.D in appendix, page 208). There are no institutions that have flood as one of their principal issues.

The average age of the North American transboundary water institutions is about 68 years. The youngest has been set up in 2002 (the Lake Huron Binational Partnership (LHBP)) while the oldest was created back in 1889 (the International Boundary and Water Commission (IBWC)).

South America

We found 19 transboundary water institutions on the South American continent. These represent 11 IRBs out of a total of 65[42] (see figure 3.10). The La Plata River Basin has seven institutions set up for it, but not all of them include all the riparians of this basin. There are three binational institutions between Argentina and Uruguay (the Comisión Administradora del Río de la Plata or the Administrative Commission for the Río de la Plata (CARP), the Comision Binacional Punte Buenos Aires Colonia or Buenos Aires - Colonia Bridge Binational Commission (COBAICO) and the Comision Technica de Mixta de Salto Grande (CTMSG)). Another example of an institution set up between countries is the Binational Commission of Economical Cooperation and Physical Integration between Chile and Argentine, covering more than one IRB.

[42] Central America, the inset of figure 3.11, has 27 IRBs and is regarded as part of the South American continent in this paper.

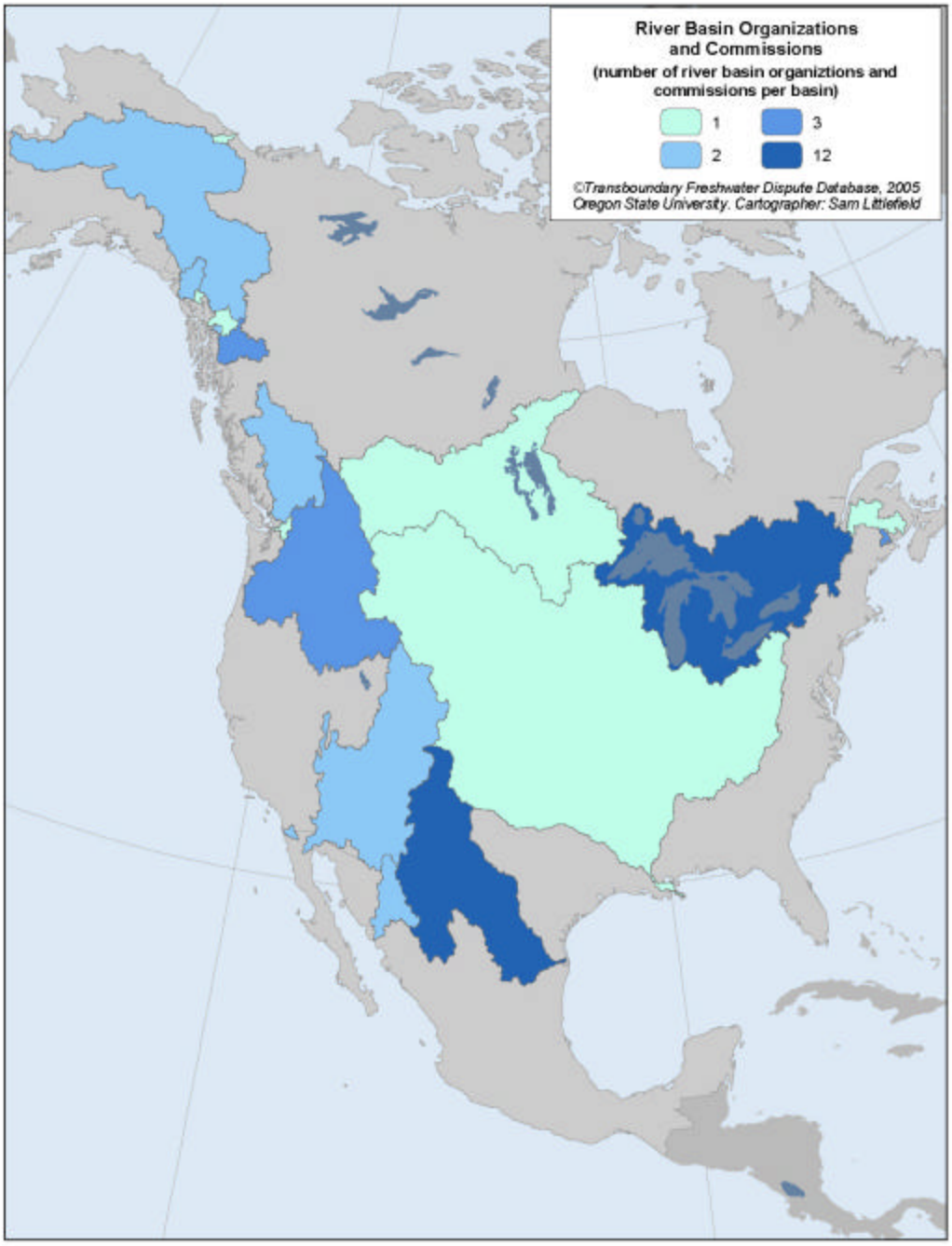


Figure 3.9: a map of the shared water institutions on the North American continent show the dominance of such institutions in the St. Lawrence River Basin. There are no white basins on this map, indicating that all IRBs have some sort of transboundary water institution set up for them.

Issues covered by the IRBIs are mainly (see figure 3.E in appendix, page 209) joint management and economic development. There are no institutions that have flood incorporated as one of their principal issues.

The average age of shared waters institutions in South America is 26 years. The youngest is about ten years (the Binational Autonomous Authority of the Lake Titicaca (ALT), while the oldest has existed for over 60 years (the Comision Technica de Mixta de Salto Grande (CTMSG)).

Principal Issues Worldwide

When we look at the principal issues on a global scale, transboundary water institutions are mostly although may be not surprisingly, set up for joint management (see figure 3.F in appendix, page 210). Water quality and technical cooperation/assistance are two other important issues, while territorial issues are not a high priority. Out of the 153 transboundary institutions, only eight are principally concerned with flooding, five of which are located in Africa, two in Europe and one in Asia. North America and South America do not have any form of institution that has been created specifically for floods (see figure 3.5).

Flood-related Events

Yoffe (2001) looked at what kind of issues sparked water events during the period 1948-1999 (either cooperative or conflictive), and reported that water quantity far outweighed the other issues, followed by infrastructure and joint management. For the highest form of cooperation (treaties concerning international waters), she found that the emphasis lay on water quality and quantity, hydropower, joint management and economic development. The most extreme conflictive events (i.e. extensive military acts) only concerned quantity and infrastructure. We did a search based on Yoffe's protocol, but included more search terms, and found that for the period 2000-2004, joint management, water quality and water quantity were the main issues of water-related events[22]. However, as indicated, except for water quality, these issues were not found to be of primary interest to the shared water institutions.

Does that mean that transboundary floods never have been nor will be a concern? In chapter 2, and summarized in figure 3.11, we clearly showed that transboundary floods take place on every continent and have even increased over the past two decades, especially in Asia.

Figure 3.10: a map of the South American shared water institutions clearly shows that the La Plata River Basin has the most institutions, but 83% of the South American IRBs do not have an transboundary water institution set up for them.

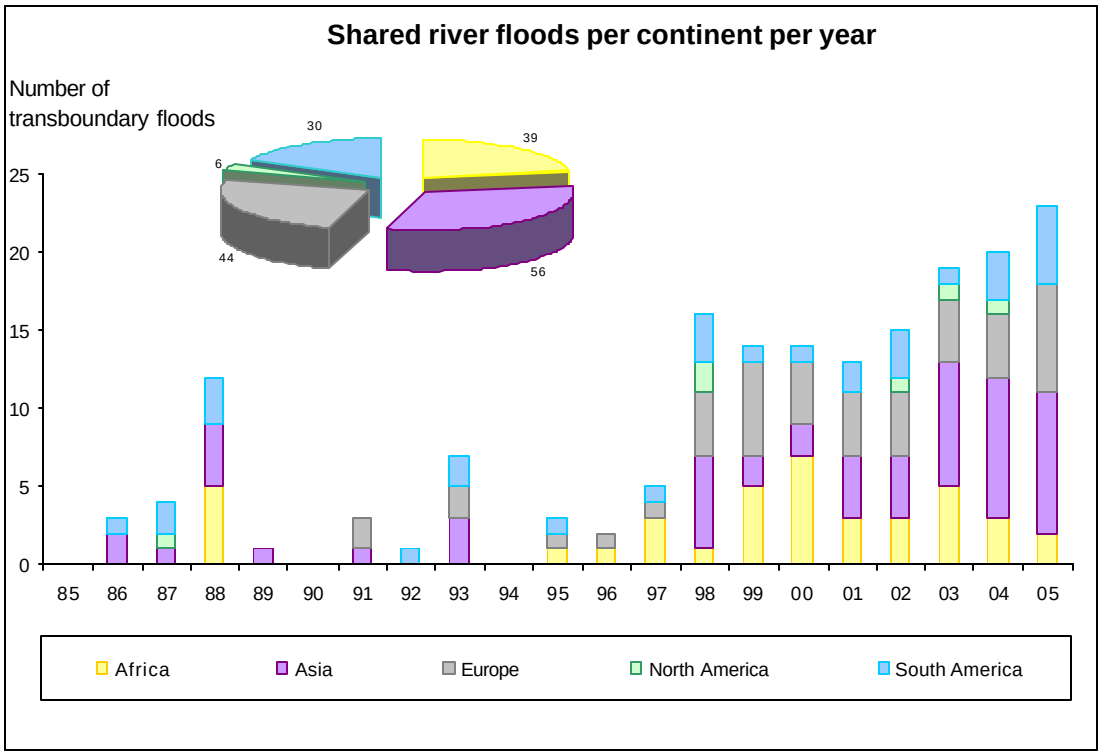


Figure 3.11: Shared river floods per year per continent show a steady increase of transboundary floods over the years, especially on the Asian and European continents.

So is there perhaps simply no need for official institutional cooperation over shared flood events? If we look back to the years 1948-2004[43] to see how many water events[44] took place in IRBs over the years (Yoffe, 2001, to which we added our data), we see that almost three per cent (59 out of a total of 2269) of the events are related to flood control or flood relief. Figure 3.12 shows how these events are divided per continent; Africa, the continent with the highest

[43] As noted, Yoffe (2001) looked at the period 1948-1999; we used a more inclusive protocol (i.e. more search terms) to find water-related events for the period 2000-2004. Due to a lack of time, our search excluded the IRBs of South America and Africa. Despite these two excluded continents, 22 (or 32%) of the 59 flood-related events were found for the period 2000-2004 and 408 water-related events (or 18%) were found of the total 2269 event. This might indicate that our more comprehensive protocol either resulted in finding more events or that relative more events took place or were reported to take place in the first years of the 21st century then in the second half of the 20th century.

[44] A water event is defined as 'instances of conflict and cooperation that occur within an international river basin, that involve the nations riparian to that basin, and that concern freshwater as a scarce or consumable resource (e.g., water quality, water quantity) or as a quantity to be managed (e.g., flooding or flood control, managing water levels for navigational purposes). Incidents that did not meet the above criteria were not included as events in the analyses (e.g., third-party (i.e., non-basin country) involvement, delineation of rivers as boundaries, fisheries, issues internal to a country, construction of ports or waterfront facilities).' (Yoffe, 2001)

amount of institutions that have floods as one of their principal issue, has had the least events with flood (two events back in 1988), while Asia and Europe, with one respectively two institutions that deal with floods, have experienced the most (16 respectively 24 events). North America experienced 13 events, South America 12, but neither has institutions with floods as principal issue.

As figure 3.12 and figure 3.G in the appendix (page 211) illustrate, most of the flood-related events took place in Europe, in the Danube River Basin. The La Plata River Basin is second, with ten events and the Ganges-Brahmaputra-Meghna basin has had eight events related in some degree to floods during the period 1948-2004.

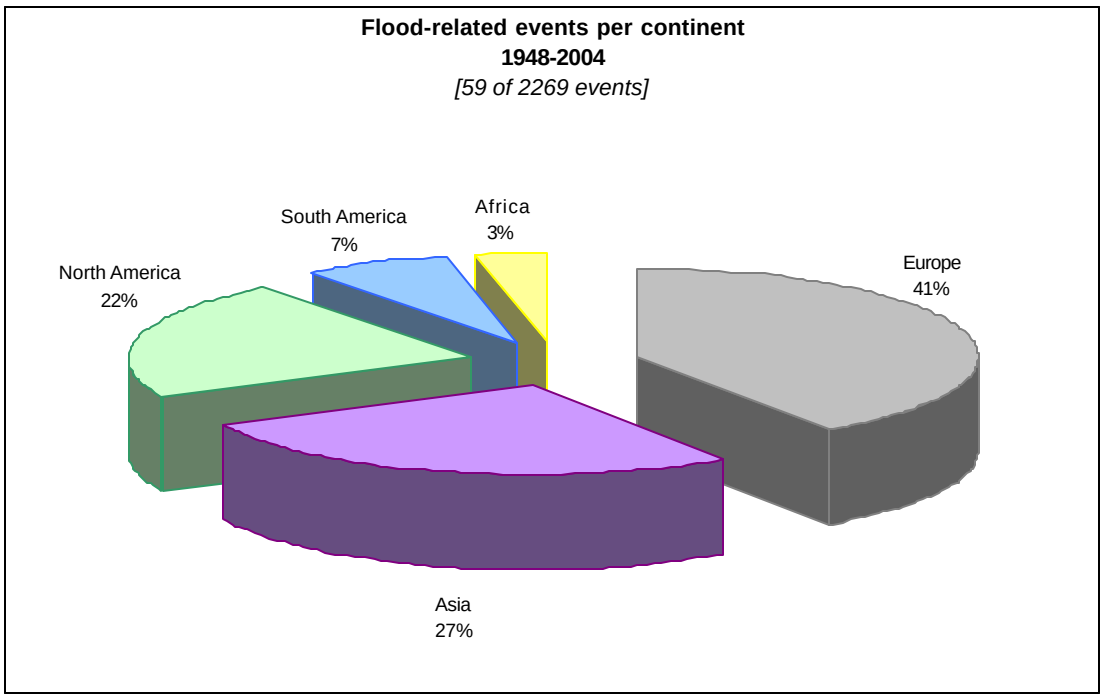


Figure 3.12: the number of flood-related events over the period 1948-2004, per continent. Data for the period 1948-1999 is adapted from Yoffe (2001). Note that South America and Africa were not included for the period 2000-2004.

If the events are broken up by continent and by decade (figures 3.13 and 3.H in appendix, page 212), it seems that flood-related events are especially increasing on the Asian and European continent. Figure 3.I in the appendix (page 213) shows that events in North America had the broadest range, while events happening on the European and South American continent were all cooperative. Furthermore, we see that on the African continent, flood-related events rarely make the news, although 39 transboundary flood events took place on

that continent. The figures also show that, after a rather rapid decline in events related to floods, there has been an increase from 1980 onwards; it appears that the number of flood-related events has increased the last 25years. Especially since the last bar is only for the period 2000-2004, instead of a full decade. When categorized using Yoffe's BAR scale[45] (2001), we see that the found flood-related events are mostly 'BAR 2', which stands for '*Official verbal support of goals, values, or regime'*, followed by 'BAR 3' (*Cultural or scientific agreement or support (non-strategic); agreements to set up cooperative working groups*) and 'BAR 1' ('*Minor official exchanges, talks or policy expressions--mild verbal support*') (see figure 3.14). There are nine incidents that have been ranked under 'BAR 6' or '*Major strategic alliance (regional or international) - International Freshwater Treaty'*; note that all of these took place before 1970. Thus all flood-related events are overwhelmingly cooperative, although the degree of cooperation has declined. We do see an alarming increase of less cooperative incidents over the past 15 years. The topics of the cooperative flood-related events are mostly assistance during or after floods, agreements on data-sharing and agreements to jointly study how to control floods. Less cooperative events are events related to placing the blame on each other for floods, or criticizing constructions that affect other riparians.

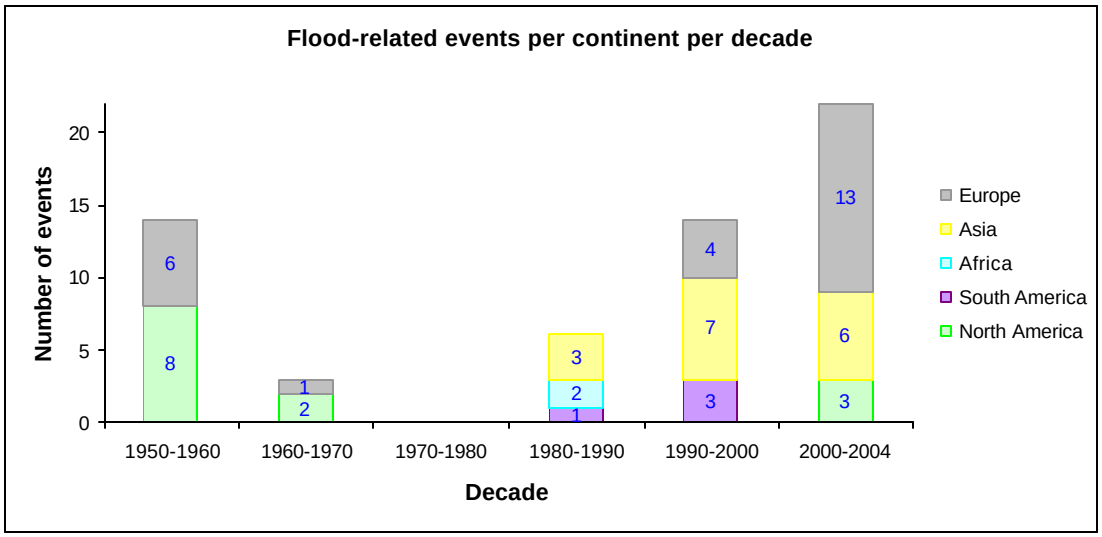


Figure 3.13: flood-related events categorized per continent and per (half) decade show that transboundary flood-related events are relatively new on the Asian continents, and have been increasing on the European continent since the beginning of the 21st century. African and South American flood-related events appear to be rather exceptional, although this might be due to poor or missing data.

[45] The BAR scale is a measurement of the intensity of an event. The BAR scale ranges from –7 to +7, with –7 denoting the most conflictive events, 0 denoting neutral events, and + 7 denoting the most cooperative events.

International Freshwater Treaties and Transboundary Floods

Using Yoffe's findings one last time to see how transboundary floods are being dealt with in the international water treaty arena, we ranked the treaty data on the TFDD website according to continent and IRB. There are 269 international water treaties in the database; 24 of these deal with flood-related issues. Globally, no more than 11 basins (or 3.6%) have international freshwater treaties with floods as their principal issue. These basins are all, on average, high developed basins. Note that we did not update this database – the numbers found for international water treaties only apply to the period 1948 to 1999. In addition, the database is being adjusted by lawyers to more accurately depict the nature and consequences of the different structures of international treaties. Figure 3.J in the appendix (page 214) shows that Europe has the most international water treaties that deal with flood issues, while in Africa and Asia, despite the fact of having a substantia l amount of international freshwater treaties, none of the treaties have floods as their principal issue. Except for one treaty drafted for the Rhine basin, all of the treaties related to floods are bilateral. Although Europe has the highest amount of freshwater treaties dealing with flood events, percentage wise, the North American IRBs have the highest coverage (figure 3.K in appendix, page 315). However, a noteworthy observation is that seven out of the eleven IRBs with flood-related international treaties, did not experience any shared flood events during the last 21 years.

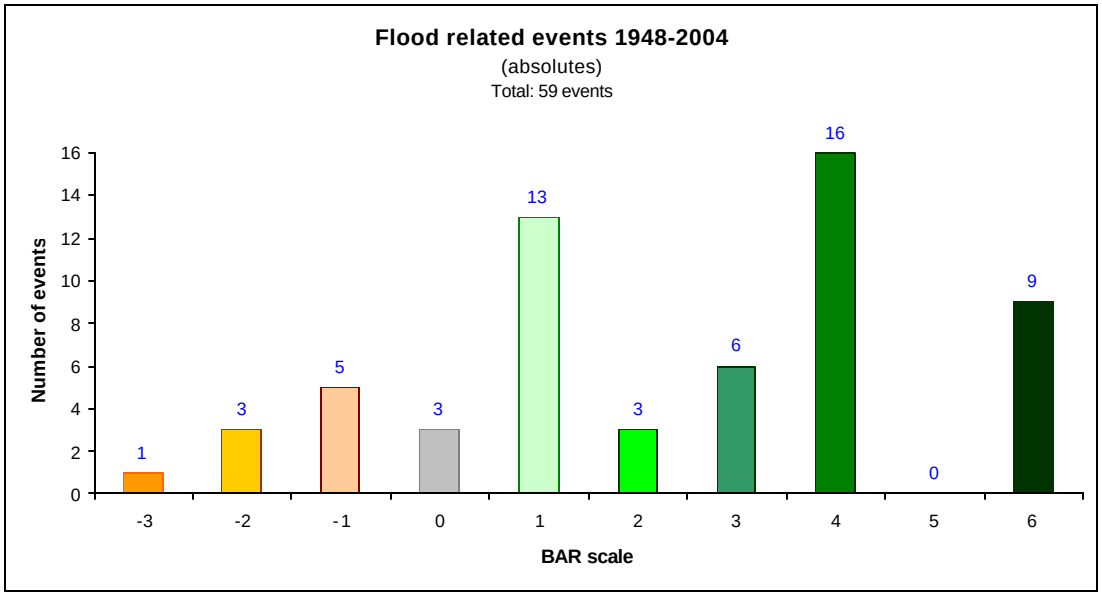


Figure 3.14: when all the flood-related events are ranked on the BAR scale, it is evident that most of the events are in the cooperative range, and only 13.2% have been ranked as conflictive.

Only the Danube, Nelson-Saskatchewan, Po and Rhine river basins have experienced transboundary floods, the others have not. But all of the above does not yet establish that institutions make a difference when it comes to transboundary floods. When we use the previously explained variables of vulnerability (see chapter two, page 13) completed with the geo-political measure of presence of institutions and compare basins that have some kind of institutional capacity to deal with transboundary flood events, to those who do not have such capacity (figures 3.15 through 3.18; compiled with data from chapter two), we clearly see that the average death and displacement tolls relative to the million population living in the IRBs are lower in the basins with flood-related institutional capacity, despite the fact that the flood magnitudes (see chapter two) are always significantly higher. In addition, we see that the basins with institutional capacity on average have more countries in the basin, while the basins that have not set up institutions to deal with transboundary water issues, typically have two or three countries in the basins. Besides the fact that the floods are more severe, the number of countries present in a basin could as well clarify that the basins with institutional capacity have higher average financial damages. The general trends visible per continent are also visible on a global scale.

When we look at all the basins that have experienced transboundary flooding and combine that with the data found on institutional capacity and international water treaties (see table 3.4), we clearly see that on the African continent, the Juba-Shibeli river basin could profit from institutional capacity to deal with the phenomena of shared floods; such events took place in this basin multiple times, yet no institution is set up, nor are any treaties signed. The Zambezi and Nile river basins have set up international cooperation over shared waters, but none of these forms of cooperation deal with transboundary flooding, although shared flood events take place on a rather regular basis in these basins. On the Asian continent, the same holds true for the Kura-Araks basin, where we did not find any institutional capacity. The Aral Sea, Ganges, Golok, Han and Indus River Basins all have shared water institutions, but none are focusing on shared floods. In Europe, the Maritsa basin has no flood-related institutional capacity, and while the Danube basin has institutions, none of them deal with flood issues, although there are 7 treaties that are flood-related, which is also the case for the Po River Basin. In North America, the five basins that have experienced transboundary floods, all have shared water institutions set up for them, but none of them has flood as a principal issue, and only the Nelson-Saskatchewan has one flood-related treaty. However, two basins experienced

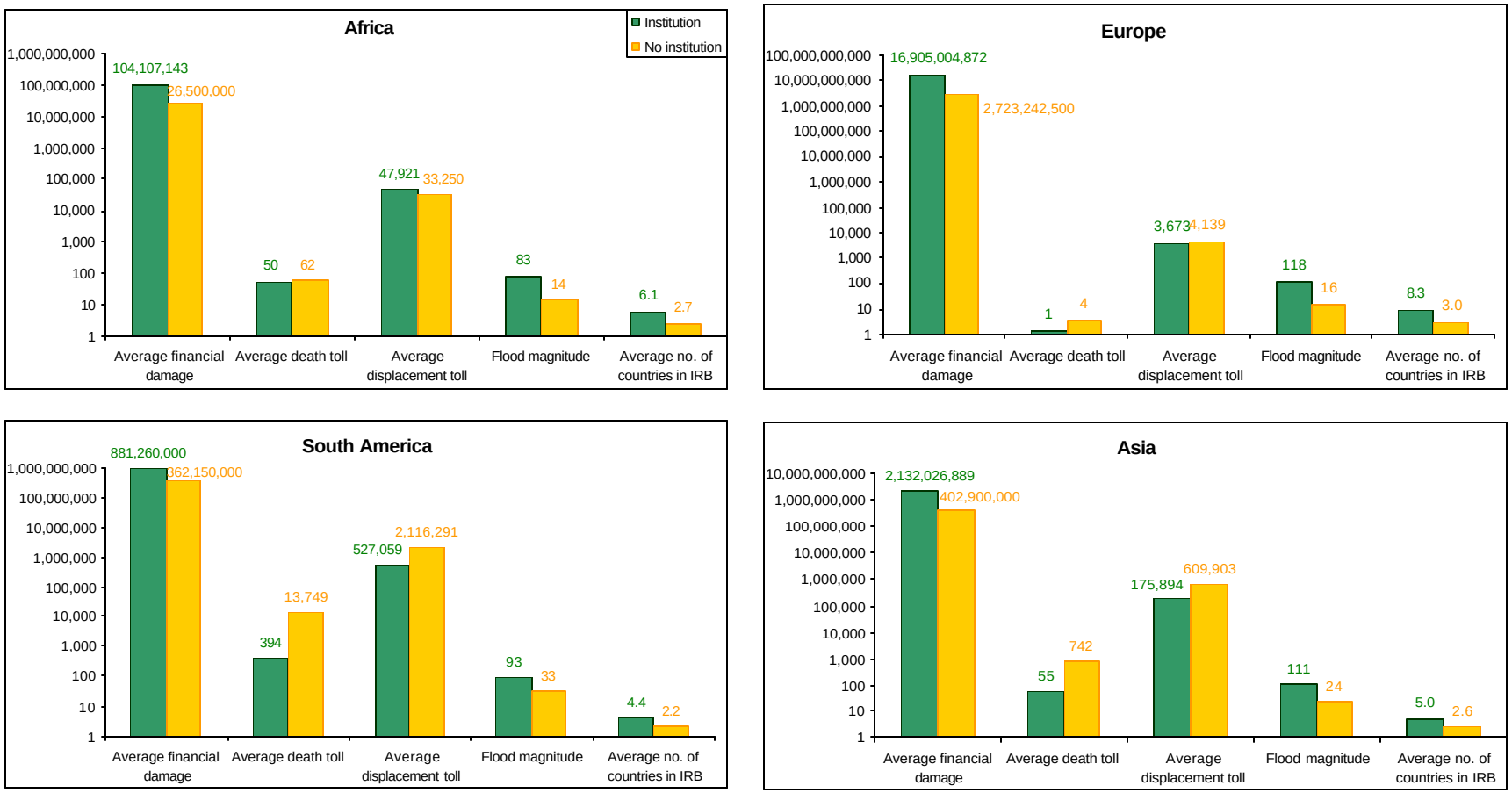


Figure 3.15-3.18: flood-related institutional capacity present in the IRB seems to result in lower death and displacement tolls, although the flood magnitudes are significantly higher in these basins. Severity and the number of countries present in the basin may both be responsible for higher average financial damages. The same trends are visible on a global scale. Also, note that the values for North America are not compared, because all IRBs have institutional representation, making an assessment impossible.

Table 3.4: summarizing table on all the IRBs that have experienced transboundary floods. In red are the vulnerable basins; those with more than one shared flood in their past but without international water institutions or any other form of institutional capacity to deal with transboundary floods.

Continent	Floods in IRB	International River Basin	Institution?	Number of institutions	Flood principal issue?	Flood related treaties?
Africa	5	Congo/Zaire	Y	1	Y	N
	1	Gambia		1		
	1	Geba		1		
	2	Niger		1		
	1	Senegal		1		
	1	Incomati		3	N	
	1	Kunene		3		
	1	Lake Chad		2		
	2	Limpopo		5		
	8	Nile		3		
	1	Okavango		2		
	1	Orange		5		
	2	Volta		1		
	6	Zambezi		3		
	1	Gash	N			
	1	Guir				
	4	Juba-Shibeli				
	1	Oueme				
	1	Sabi				
	1	Umbeluzi				
Asia	8	Mekong	Y	5	1	N
	3	Aral Sea		3	N	
	24	Ganges-Brahmaputra-Meghna		1		
	3	Golok		2		
	1	Ili/Kunes He		1		
	7	Indus		1		
	1	Jordan		1		
	1	Karnaphuli		1		
	1	Tigris-Euphrates/Shatt al Arab		1		
	1	Bei Jiang/Hsi	N			
	1	Dasht				
	4	Han				
	1	Irrawaddy				
	2	Kura-Araks				
	1	Loes				
	2	Ma				
	1	Salween				
	1	Sembakung				
	1	Terek				

Continent	Floods in IRB	International River Basin	Institution?	Number of institutions	Flood principal issue?	Flood related treaties?
Europe	11	Rhine	Y	6	1	4
	24	Danube		4	N	7
	3	Maritsa		1		N
	1	Ebro		1		
	2	Po	N			3
	2	Dnieper				N
	1	Douro/Duero				
	2	Elbe				
	1	Neretva				
	1	Nestos				
	1	Seine				
	1	Vardar				
N. America	1	Nelson-Saskatchewar	Y	1	N	1
	2	Rio Grande		4		N
	1	Skagit		1		
	1	St. John		1		
	2	Tijuana		2		
South America	3	Amazon	Y	1	N	N
	4	La Plata		7		
	1	Lake Titicaca-Poopo		3		
	3	Lempa		1		
	2	Sixaola		1		
	2	Artibonite	N			
	1	Chamelecon				
	2	Changuinola				
	1	Choluteca				
	2	Coatan Achute				
	5	Coco/Segovia				
	1	Corredores/Colorado				
	3	Grijalva				
	1	Hondo				
	1	Negro				
	2	Orinoco				
	1	Pedernales				
	1	Rio Grande				
	1	San Juan				
	1	Tumbes				

only two shared floods, the remaining three only one, indicating that shared flood events are probably not a priority due to the rarity of such events. In South America, the Amazon, Grijalva, Coco/Segovia, La Plata and Lempa River Basins all have experienced five or less transboundary flood event but no flood-related treaties are in place for any of the basins. The Amazon, Plata and Lempa do have transboundary water institutions, but none of these focuses on shared flood events.

Discussion

This study attempted to find out if extreme hydrological conditions like transboundary floods are under- or overrepresented in international river basin institutions in an effort to shed light on which IRBs have sustainable institutions when it comes to transboundary flood events, and which basins will have to strive to increase their institutional capacity when it comes to shared floods. To this end, available information from the TFDD (2006) was expanded and updated, and combined with data compiled by the author to create a global picture of the existing transboundary flood institutions, past events and international fresh water treaties related to shared flood events.

The following can be concluded:

- *Institutions and Water*

Path dependency recognizes the impact history has on the creation of institutions and policies, and shows that an evolution over time to the most efficient alternative not necessarily always occurs. With this theory in mind, water management institutions should be able and willing to renew themselves following crises like floods. They should be willing to embrace uncertainty and systematically learn from earlier (re)actions. They furthermore should be able and willing to generate new, unconventional, out-of-the-box and novel solutions in order to avoid institutional inertia or lock-ins, which might be defined as a pragmatic adaptation.

- *Global Statistics on Transboundary Water Institutions*

There are 279 international river basins around the world, 78 of which are represented by shared waters institution of some form. 12% (34 basins) have more than one institution that deals with shared water issues in the basin. In total, we found 153 transboundary water institutions. The IRBs in South America have the least amount of institutions that deal with international river basins; more than 80% (53 IRBs) do not have some form of organization specifically designed to deal with transboundary water issues. Africa, Asia and Europe do slightly better: 25%, 27% and 29% of their IRBs are represented by some form of institution. All of the North American IRBs are represented in some way. However, not all forms of international water collaborations include all the riparian states.

- *Principal Issues of Transboundary Water Institutions*

The transboundary water institutions found are mostly set up for joint management. Water quality and technical cooperation/assistance are two other important issues, while territorial issues are not a high priority. Out of the 153 transboundary institutions, only eight are principally concerned with flooding, five of which are located in Africa, two in Europe and one in Asia. North America and South America do not have any form of institution that has been created specifically for transboundary floods.

- *Water-related Events Globally (1948-2004)*

For the period 1948-1999, the issues that sparked water events in general were mainly water quantity, followed by infrastructure and joint management (Yoffe, 2001). For the highest form of cooperation (treaties concerning international waters), Yoffe found that the emphasis lay on water quality and quantity, hydropower, joint management and economic development. The most extreme conflictive events (i.e. extensive military acts) only concerned quantity and infrastructure. For the period 2000-2004, joint management, water quality and water quantity were the main issues of water-related events. Based on these findings, one would expect that transboundary water institutions would be mainly set up for the quality and quantity of the shared water body, the infrastructure and forms of hydropower. However, as indicated, except for water quality, these issues were not found to be of primary interest to the shared water institutions. This might be because many existing water institutions were created in times and eras when the problems of developing and managing water resources were very different from what they are experienced to be today (Jury and Vaux, 2005). For example, a number of the institutions in the arid and semiarid western United States were devised at a time when water was treated as an important instrument of settlement. As protection of the environment, water quality and water pollution became more pressing problems, institutions have been developed to jointly combat those concerns.

- *Flood-related Events Globally (1948-2004)*

Over the years 1948-2004, almost three % (59 out of a total of 2269) of the events are related to flood control or flood relief. The extent of cooperation ranged from the highest form of cooperation (“Major strategic alliance (regional or international); International Freshwater Treaty “) to less extreme conflictive events (“Diplomatic-economic hostile actions; Unilateral construction of water projects against another country’s protests; reducing flow of water to

another country, abrogation of a water agreement")[46]. Overall, the events related to transboundary floods were mostly cooperative; almost 85% falls in the range from neutral to single most cooperative. Only nine events fall in the 'conflictive range'; one event being rated with a -3 as the most negative score. There are nine incidents that have been ranked under 'BAR 6' or 'major strategic alliance (regional or international) - International Freshwater Treaty'; note that all of these took place before 1970. All the flood-related events are overwhelmingly cooperative, although the degree of cooperation has declined. We do see an alarming increase of less cooperative incidents over the past 15 years. This might be due to the fact that not only floods have been increasing steadily over the last couple of decades, but more importantly, the amount of shared river floods has also increased all around the globe (see also chapter two). The occurrence of more shared floods in the past 10 years than 20 years ago logically results in more interactions between countries that share this flood event. The slightly alarming trend of less cooperative events over the past 15 years furthermore indicates that there might be more need for official international institutions dealing with transboundary flood-events. A future research endeavor could investigate the reasons behind the increase of less cooperative flood-related events.

- *Flood-related Events per Continent and per International River Basin (1948-2004)*

Africa, the continent with the highest amount of institutions that have floods as one of their principal issue, has had the least events with floods (two events back in 1988), although 39 transboundary flood events took place on this continent. The lack of events making the news might therefore also be due to poor or missing data. Asia and Europe, with one respectively two institutions that deal with floods, have experienced the most (16 respectively 24 events). North America experienced 10 events, South America four, but neither has institutions with floods as principal issue.

- *International Freshwater Treaties related to Floods*

Globally, no more than 11 basins (or 3.6%) have international freshwater treaties with floods as their principal issue. There are three European basins (Danube, Po and Rhine) and one North American basin (Nelson-Saskatchewan) with treaties that actually experienced transboundary floods in the last 21 years, while the other seven did not.

[46] For the period 2000-2004, none of these were extreme conflictive, nor extreme cooperative, but ranged from -1, which is mild verbal expression displaying discord in interaction. Both unofficial and official, including diplomatic notes of protest) to +2, which stands for official verbal support of goals, values, or regime.

In summary, 43 basins in which transboundary floods took place in the period 1985-2005 have no type of institutional capacity in the form of international institutions or organizations for international river basins, let alone institutions specifically aimed at shared flood events. The average death and displacement tolls relative to the million population living in the IRBs are lower in the 37 basins that do have institutional capacity and, in seven cases also flood-related institutional capacity, despite the fact that the flood magnitudes (see chapter two) are always significantly higher. Remarkable is that the basins with institutional capacity on average have more than three riparians in them, while the basins without institutional capacity are mostly those with three or two riparians. This indicates that more riparians do not necessarily complicate or even get in the way of creating such international institutions – based on this database, it seems to be just the opposite: when more countries share a basin, it is more likely that a river basin institution is present. This could all be a sign of the fact that institutional capacity i.e. international cooperation before, during and after the flood events, might play an important role in the reduction of flood-related casualties and affected individuals.

Except for the Po and the Rio Grande (in South America) River Basins, these 43 basins also do not have international water treaties focused on floods. Resilience is enhanced by the presence of international agreements and institutions, thus, the absence of these characteristics hypothetically increases the changes for conflict in these basins: if a transboundary flood in one of these basins occurs, the institutional capacity to absorb this change does not seem to be present, thus increasing the likelihood of conflict between the riparians (Wolf *et al.*, 2003).The majority of these 43 basins only experienced one transboundary flood in the past 21 years, which partly clarifies the absence of transboundary flood-related institutional capacity – the policymakers might not prioritize flood-related institutions or flood-related water treaties because these events appear not to be a regular threat. It can also be argued that the relative absence of flood-related international agreements is due to the fact that obligation in case of flood-related emergencies are inherent to the rules of *bona fides* between riparian states. However, several basins have experienced two or more shared floods, indicating that the phenomena of transboundary floods is something to be taken seriously in these basins, especially when one wants to enhance resilience to change and promote the human and environmental security in international river basins. The fact that no aggressive water-related floods were documented for these basins implies that people were probably inclined to cooperate over flood-related-issues, if there were issues at all, but this does not automatically mean that future shared flood-events in these basins can be solved in an efficient and

cooperative way with without existing institutional capacity. The basins that have experienced more than one shared flood in the past 21 years, but have not set up any institutions for such events, nor signed any treaties focusing on floods, are therefore recommended to increase their institutional capacity aimed at transboundary flood events. These 12 basins are: the Juba-Shibeli in Africa, with four transboundary floods, the Han, Kura-Araks and Ma in Asia (four, two and two transboundary floods), the Maritsa and Po in Europe (three and two transboundary flood events) and six basins in South America: the Coco/Segovia, Grijalva, Artibonite, Changuinola, Coatan Achute and Orinoco river basins. Transboundary flood events are frequent enough in these 12 basins to justify creating specialized institutions for such events. Although this apparent lack of flexibility has probably not caused major conflicts over these events in the past, it cannot be assumed that this will always be the case. But while it is complicated to capture the nature of these events in rigid agreements, history has proven that international institutions and international fresh water treaties related to shared floods have been successfully implemented. Therefore, we recommend that flood-related issues are put on the agenda of not only the 12 most vulnerable basins distilled in this research, but all the international river basins where transboundary floods can take place. The IRBs that already have set up institutions to cooperate over their shared waters, but have not focused on flood-events, should consider including flood-related issues in their mandate, in order to be prepared for such events. The IRBs that as of yet have not set up any official form of international cooperation over their transboundary rivers, are greatly encouraged to do so. This will increase the institutional capacity which in turn will decrease the likelihood of future flood-related conflicts.

CHAPTER FOUR: TRANSBOUNDARY RIVERFLOOD MANAGEMENT: A CASE STUDY COMPARISON BETWEEN THE NETHERLANDS AND MOZAMBIQUE[47]

Author: Marloes H. N. Bakker

Abstract

Flood management is difficult enough in national river basins controlled by a single, national authority, but becomes even more challenging when dealing with transboundary floods. Nonetheless, vulnerability and adaptation to shared floods is poorly understood. This study acknowledges the significance of shared flood events and examines the differences or similarities in responses, measures taken, international water treaties signed and institutions created of a developed downstream country prone to flooding (the Netherlands) and a lesser developed yet relative equally exposed country (Mozambique) – what are the lessons learned?

History shows that existing institutions should be able to absorb and manage any change – which includes shared flood events - that occurs in the basin's physical setting. This requires that sound, comprehensive institutions to deal with these events are in place, but also that these institutions and organizations should be flexible enough to adapt to uncertainty. The ecological, economical and physical interconnectedness of river basins naturally calls for collaboration between countries but flood management at root will be a national endeavor. However, since local or national flood protection measures can have negative affects both downstream and upstream, national flood protection measures should always take into account their possible impact on the other riparian states.

In the Netherlands, it has become clear that, although some past investments in flood control structures proved to be sensible, many structural and non-structural strategies have failed to be sufficiently effective, and recently, rigorous readjustments of the model of flood control management so strongly advocated by the Dutch for hundreds of years (Changnon, 1996; Mileti, 1999; Myers and Passerini, 2000) were put into practice. This transition is accompanied by a shift in emphasis from controlling floods to living more in harmony with them and renewed emphasis avoidance of damage, rapid recovery after floods and on self-

[47] Parts of this article have been presented at the 3rd Asia Pacific Association of Hydrology and Water Resources (October 16-18, 2006, Bangkok, Thailand).

help. Mozambique's flood management approach mostly still resembles the old Dutch (and many other developed countries') approach of fighting against water and trying to prevent floods with massive flood-containment and landscape altering constructions. Changing climate conditions and population growth rates are likely to demand a less rigid water management strategy. Therefore, the choice for future flood management in Mozambique should be for the most flexible strategy, a more resilient pathway of living with floods. Compared to the Netherlands, very little needs to be undone in order to implement this alternative strategy, not only because there is still more faith and reliance on traditional flood risk warnings and indigenous approaches than the traditional engineering structures, already very compatible to the holistic approach of flood management, but also because very little needs to be undone in order to adhere to this alternative strategy. Hence, Mozambique can even end up leading the way and setting an example for developed countries for postmodern flood management.

Introduction

Shared floods have been responsible for 32.7% of all the river flood-related deaths worldwide during the period 1985-2005 (see chapter two) and when looking ahead, it is not unreasonable to expect flood frequency and severity to increase in many parts of the world due to climate variability. Over time, population growth, climate-related factors aggravated by urbanization, and social, economic and political processes have massively increased and will continue to increase human exposure and vulnerability to floods. Nonetheless, vulnerability of societies to floods, let alone transboundary floods, is still poorly understood. River basin management is directly related to the mitigation of the risks involved with flooding and is therefore increasingly important issue for authorities in many countries. Flood management is difficult enough in national river basins controlled by a single, national authority, but becomes even more challenging when dealing with transboundary floods, which may originate in one country or jurisdiction and then propagate downstream to another country, or jurisdiction. Under such circumstances, the demands on international cooperation and management in all aspects of flood management are particularly important, especially because institutional capacity in an international river basin should be able to absorb changes in the basin in order to decrease the likelihood for conflict (Wolf *et al.*, 2003).

Previous studies have focused on water or flood management per country (Arnell, 1998; Olsthoorn, 2001; Dixit, 2003; Enserink, 2003; van Steen, 2004), but few and only recently, researchers looked at the phenomenon of shared floods (Marsalek *et al.*, 2006). However, these studies only focus on a specific shared river basin (Beaumont, 1998; Feitelson, 2000; Middelkoop, 2001; Muckleston, 2003, Maganga *et al.*, 2003). This study acknowledges the significance of shared flood events and will investigate how such stresses influence societies and what the institutional responses to these events were. We assume that the choice of flood management and strategies differs per country and is highly influenced by the social, economic and political processes. Disasters are the unresolved problems of societies during 'normal' times, and these problems affect the way people are impacted by disasters. Analyzing these processes and organizations over time would expose these conditions and help identify the root causes of disasters. We hypothesize that floods strike the developed and less developed countries alike, and people may face the same potential risks, but they may not equally vulnerable because they may face different consequences to the same hazard. This presumably results in different responses, measures taken and institutions created. We will

therefore look concretely at a developed downstream country prone to flooding (the Netherlands) and a lesser developed yet relative equally exposed country (Mozambique) for differences or similarities in responses, measures taken, international water treaties signed and institutions created. Looking at historical perspectives, we hope to uncover what influenced or triggered societies to take certain flood-related decisions, learn from particular national experiences, the strategic choices made and identify lessons learned. Borrowing the biophysical, socio-economic and geo-political variables of chapters two and three, but now solely applied to the two case studies, will provide additional insight in the level of vulnerability of both countries to transboundary floods.

After a general introduction to floods and societies, we will talk about the two case study areas, the Netherlands and Mozambique, in detail. We will end with conclusions and a discussion.

Floods and Societies

Flooding are natural phenomena. However, no uniform, rigorous, and broadly agreed upon, definition of the term 'flood' exist (Kundzewicz *et al*., 2001). In general, flooding is associated with harm and damage and considered an undesirable occurrence. But it is the nature of a society and the worldview of that society that determines not only what is meant by a 'flood' but also how floods should be managed, what choices are based on and what approaches are adopted.

Countries and people can face similar patterns of natural hazards, but often experience widely differing impacts when disasters occur. This is also true for the impact of a flood; it depends in large part on the kind of development choices a country has made (or was able to make) previously. For example, as countries become more prosperous, they are often better able to afford the investments needed to protect people from floods, like dikes and levees. At the same time, the rush for growth can trigger chaotic urban development in flood-prone areas that increases risks of large-scale fatalities during floods. Disasters in general, floods being no exception, have the greatest impact on the poorer countries in the world and exert an enormous toll on development. About 85 percent of the people exposed to natural disasters like earthquakes, tropical cyclones, floods and droughts live in countries that either score medium or low on the United Nations (UN) Human Development Index or the HDI[48] (UNDP, 2004) and only 11% of the people exposed to natural hazards live in low-development countries, but they account for 53% of the people who lose their lives (UNDP, 2004). When we look at river flood-related casualties only (figure 4.1), we clearly see that since 1985, the medium and low developed countries have had far more casualties on average each year compared to the high developed countries; the high developed countries account for only a little bit less than 87% of the total amount of river flood-related victims over the considered period.

[48] The UN Human Development Index (HDI) is a comparative measure of poverty, literacy, education, life expectancy, childbirth, and other factors for countries worldwide. It is a standard means of measuring well-being, especially child welfare.

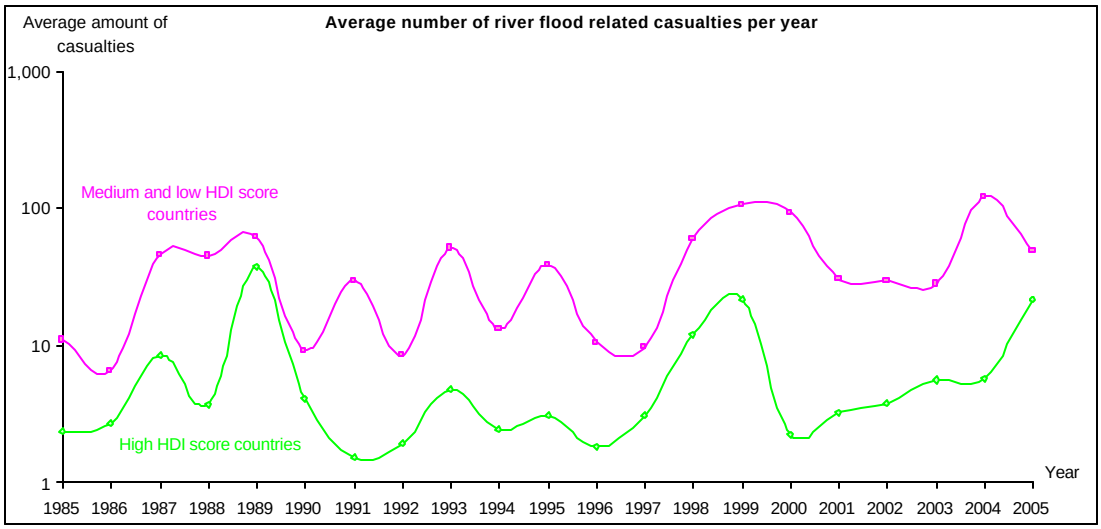


Figure 4.1: the average number of river flood-related casualties clearly shows that high developed countries suffer far less victims per year than the medium and low developed combined do. Data from chapter two.

It should be stressed is that where there is a risk of flooding, it is commonly very high relative to that from other hazards. Outside of the Netherlands and some other countries for instance, it is unusual for a flood alleviation project to be designed to protect against a flood more severe than that with a return period of 200 years. Consequently, the risk to life from flooding is likely to be higher than those levels of risk which are deemed to be acceptable or tolerable in regard to such hazards[49]. For those other hazards, a general rule of thumb has been adopted that an individual risk of death per year of one in one million is a threshold value.

In general, the relationship between numbers of deaths and economic loss by floods can be expected to approximate an inverse one; where economic growth takes place within flood-prone areas, it is reasonable to expect that whenever per capita incomes rise, so will property value at risk and average annual flood losses in real terms. As time passes, floods may lead to increased losses as compared to impacts of flood events in the past with the same characteristics, because of the general trends to increase investment and population in flood plains with time in may river valleys of the world. Indeed, data shows that annual economic losses associated with disasters in general averaged USD 75.5 billion in the 1960s, and rose steadily to more than eight times that amount in the 1990s (see figure 4.2 (UNDP, 2004). In

[49] For instance, floods in the Netherlands form a bigger risk than the risk of a chemical disaster, a nuclear hazard and a train accident taken together.

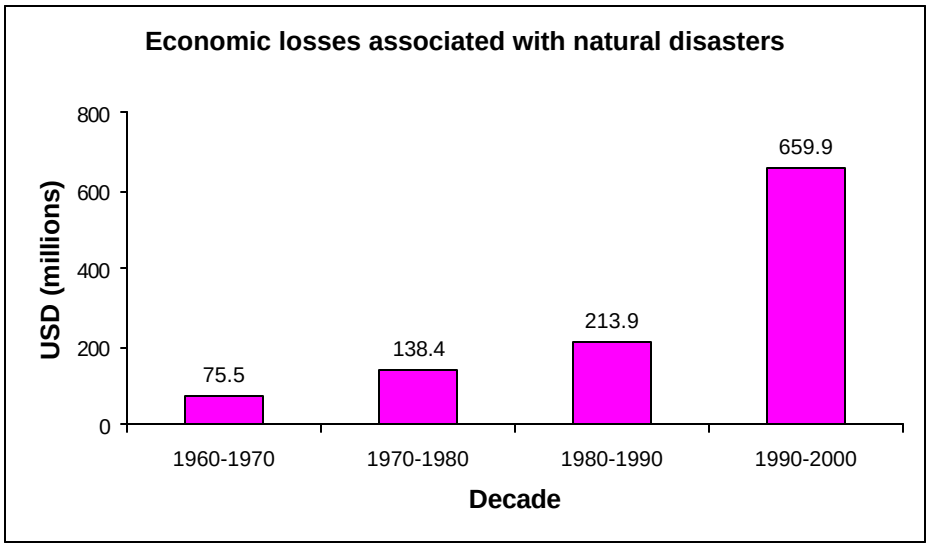


Figure 4.2 (adapted from UNEP, 2004). Annual economic losses associated with natural disasters show a steady increase over the last 4 decades.

2005, the total amount of damage was USD 212,127 million. About 7.5% (or USD 1,6 billion) of that amount was caused by floods (Munich Re, 2006). Individual floods can cause significant losses to the economic capacity of a country because the costs of replacing damaged or destroyed infrastructure may absorb the resources that would otherwise be available for economic or social development. Governments and individuals may alternatively have to borrow heavily to fund these replacements and repairs.

In absolute terms, richer nations bear the greater proportion of losses, but poorer countries suffer more when economic loss is measured as a proportion of gross national income or GNI[50] (see chapter two) or gross domestic product or GDP (Schipper and Pelling, 2006). However, numbers alone fail to adequately capture the impact of the disaster on the poor who often bear the greatest cost in terms of lives and livelihoods, and rebuilding their shattered communities and infrastructure. For instance, it may be reasonable to measure a Dutch householder's relatively minor flood damage in thousands of dollars. But a flood in Bangladesh may entirely dispossess a farming household; they may even lose their farmland

[50] The GNI, previously known as Gross National Product (GNP), comprises the total value of goods and services produced within a country (i.e. its GDP), together with its income received from other countries (notably interest and dividends), and less similar payments made to other countries. For operational and analytical purposes, it is the World Bank's main criterion for classifying economies.

by erosive effects of floods. Their loss may be measured in only hundreds of dollars, but they may not receive aid or insurance payments.

It is important to realize that people in developing countries do not live in areas that are vulnerable to floods out of ignorance about the hazard or incorrect perceptions of risk. The unplanned and unmanageable large-scale migration from rural to urban areas is a feature of many developing countries of the world, especially in Africa. Most have little freedom to choose how and where they live. Often, they have no option except vulnerable locations such as flood plains (Dixit, 2003). They are forced to live there not because land use planning is poor, but because the prevailing agrarian relation in their society, or because the processes of social and economic exclusion make them unable to own property in safer areas. As a result, in many developing countries the most serious flood-related risks are associated with widespread floods in remote areas and in unplanned settlements within urban areas (Alexander, 2000). Sadly, the people at the margins of a country's social, economic and political system frequently find it hardest to reconstruct their livelihood after a disaster. In addition, many developing countries do not have the financial resources to implement structural flood control measures.

Case Study Areas: the Netherlands and Mozambique

The next section will describe the two selected case study areas, namely the Netherlands and Mozambique. For each country, we will first give a general overview and provide relevant background information. We will then discuss the history of water management in the countries, zoom in on flood management and transboundary flood events and end with an overview of the water-related and transboundary-flood specific institutional capacity present in each country.

The Netherlands: General Background Information

The Netherlands is a European country and borders the North Sea to the north and west, Belgium to the south, and Germany to the east. With 395 inhabitants per km^2 (or 484 people per km^2 if only the land area is counted, since 18% is water), it is the 23rd most densely populated country in the world, and most intensely populated country in Europe.

The Netherlands is the downstream riparian for two major European international river basins[51] – the Rhine and the Schelde (see figure 4.3). 28% of the Netherlands is part of these international river basins and almost 4.5 (of the 16.5 million) people live in them. Approximately 24% of the land lies below sea-level, but half of the country is below sea-level or river-level. When exposure to flooding is ranked, the Netherlands is the number one country in Europe; if the Dutch were to stop pumping and unman their dikes, half of the Netherlands would disappear, precisely the half where $^3/_4$ of the population lives. The population in the flood-prone areas protected by the dikes, the land use intensity, and the capital investment have all rapidly increased. As a result, the adverse economic and emotional consequences of a flood, or even an evacuation due to flood risk, have increased substantially.

Today, thanks in part to its location in the Rhine Delta, the Netherlands has a prosperous and open economy, which depends heavily on foreign trade and is noted for stable industrial relations, moderate unemployment and inflation, and an important role as a European transportation hub. Industrial activity is predominantly in food processing, chemicals,

[51] The TFDD (2006) defines a "river basin" as being synonymous with what is referred to in the U.S. as a "watershed" and in the UK as a "catchment," or: all waters, whether surface water or groundwater, which flow into a common terminus. By this definition, the Meuse river basin, often referred to as a separate international river basin, is part of the Rhine River Basin.

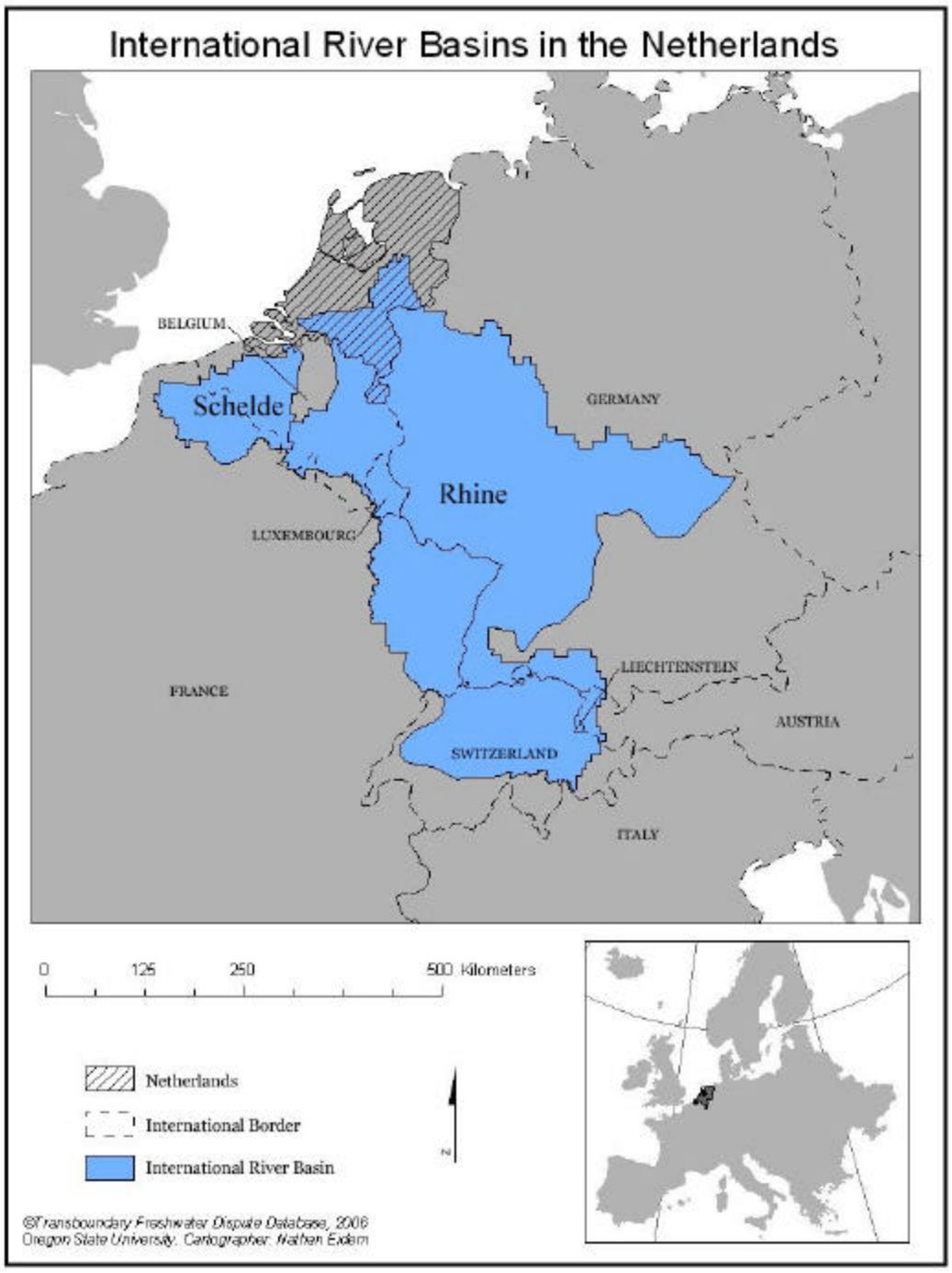


Figure 4.3: an illustration of the geographical location of the Netherlands and the international river basins it is part of.

petroleum refining, and electrical machinery. A highly mechanized agricultural sector employs no more than 2% of the labor force but provides large surpluses for the food-processing industry and for exports. Presently, the Netherlands is the 16th largest economy of the world and number 12 on the HDI country list, thus considered a country of high development.

Water Management in the Netherlands through the Ages

When it comes to water management and flood protection, probably no country in the world has as much experience as the Netherlands. It resulted in a country where humans have exerted one of, if not the, greatest influences in shaping the landscape[52]. The Dutch have been fighting the North Sea and the Rhine and Schelde rivers for millennia. Roman generals Nero Drusus (38-9 BC) and Gnaeus Domitius Corbulo[53] (7-67 CE) built the earliest canals in the Netherlands in the first century of the Christian era. In addition, Roman-era farmers began draining the marshlands to plant crops; the peat lost most of the water it had once absorbed, it compacted down and the ground level fell until it approached the groundwater level. Irreversible intervention did not really begin until about thousand years ago, as the growing population pushed into marshes and peat bogs along the North Sea. The more water farmers drained, the more the peat settled, the more the ground level fell and the more water had to be drained, etcetera. The Dutch built sea dikes to keep the seawater out and interior dikes to protect their fields. They dug drainage ditches and dammed tidal inlets and creeks where the sea intruded into the countryside. But eventually, a water management system was required to keep the water out. Gullies were dug out, which were bound near a river with a sluice. The sluice could prevent high water levels from flowing into the polder and drain the redundant water into the river. The latter could only be done when the water level in the river was not too high. When water levels were high for a long period, the water would eventually flow back into the polder. Therefore, every field was enclosed by a dike, each with its own sluice. This was known as the 'polder-outlet pool' system: an area with a number of polders, cut off from the river. The area between the polders, which was also cut off from the river, was called the

[52] It was supposedly the French philosopher Voltaire (1694-1778) who once stated that 'God created the world, but the Dutch created the Netherlands', now an often proudly uttered Dutch saying.

[53] In 47 AD, he was commander of the Germania Inferior armies. During his stay in Germania, he ordered the construction of a canal between the rivers Rhine and Meuse. Parts of this engineering work, known as 'Fossa Corbulonis' or Corbulo's Canal, have been found at archeological digs. Its course is identical to the Vliet.

drainage or outlet pool ('*boezem*'). During times of continually high water levels, water could and can be stored in this outlet pool, without flooding the fields.

By the end of the 12th century, a new system of caring for the dikes was evolving. Each landowner was required to maintain his portion of a dike[54]. Local societies elected representatives to oversee the care and building of larger waterworks that were beyond the means of local landowners. These elected water guardians formed regional and provincial *waterschappen* (water boards) headed by a dike revee or dike lord. The water boards levied taxes, administered water matters, and gave out fines. At least one farmer was put to death for failing his duty. The right of the society was regarded as being greater than the right of the individual (Ward, 2002). Every year, there were four inspections ('*schouwen'*); the dike lord would ride his horse over the dike and inspected the separate portions. If the dike was not maintained properly, he would stop his inspection and the one responsible would have to repair the dike. The lord would go into the nearest pub, where he could drink and eat all he wanted for as long as the repairs lasted – the landowner would have to pay for this and the stay of the lord and his company for as long as the repairs lasted. Many landowners went broke because of this (Wegereef, 2006).

As early as the mid-14th century, a nearly completed connected system of dikes arose that created the landscape of the Netherlands up to the present day. However, land in the northern, southern, and western parts of the Netherlands had subsided so greatly that that the *boezem*-system no longer worked. The soil remained marshy. So the Dutch began to pump. From the 15th century onwards, a new technological development provided a new solution: wind drainage. Mills were placed on the sluices between the polder and the outlet pool. These mills were able to pump water upwards and therefore pump water from the polder into the outlet pools, regardless of the river's water level. Unfortunately, one problem remained: what if the outlet pool became full? Pumping water from the outlet pool and back into the river would have been an expensive solution in the Middle Ages. Individual farmers were unable to build and maintain all these dikes, sluices and mills. To share the costs, small settlements or hamlets were established, which can be considered as precursor of the current local water management

[54] In extreme cases, a rigid protocol called 'Law of the Spade' (Ward, 2002) was evoked; when a landowner could or would not manage his portion, he was required to put his spade in the ground and leave his own lands forever. Neighbors of the scofflaw would then appoint someone else to take over the land and maintain the dike that the previous owner had so studiously ignored.

organizations. Within a hamlet, every farmer was responsible for a small part of the dike. Later, the hamlets had their own management. Farmers and citizens became the local 'government' and they had to agree amongst themselves how high they would built the dikes, how to control the water heights and so on. They were also given permission to collect taxes themselves, in order to pay for their work related to these activities. In some areas, the water management organizations remained small, but in for instance the south of Holland, three very large water management organizations were established, the so called dike or polder boards, or *hoogheemraadschappen'* of Delft land, Schie land and Rhine land. These umbrella organizations had a high status and became very wealthy. They attracted scientific staff, and coordinated the hamlets. In many polders, however, water management continued to be divided. This partition of power had some negative consequences. Only the polders that bordered onto a river or the sea were responsible for the maintenance of the river or sea dikes. Although other polders benefited from the dikes too, they did not have to contribute to the maintenance. The financial support for the water management was therefore not optimal. A flood in the year 1675 demonstrated the weaknesses of the system and the states introduced an annual check, to prevent the district water boards from neglecting their duties.

The crumbling of this form of water management also implied that the local organizations developed at their own pace. Cooperation was difficult, because each organization had its own problems and its own way of dealing with them. Additionally, there was no defined standard to determine whether the dikes were the correct size. In the 16th and 17th centuries (the latter also known as the Dutch Golden Age), trade brought prosperity and wealthy merchants could invest in new canals that went deeper and helped finance the reclamation of hundreds of thousands of acres of land. Many district water boards switched over to a new system. Instead of farmers, the boards maintained the dikes themselves, financed by levying taxes. The more powerful the district water boards were, the more interested the government was. The states of Holland governed the projects and ensured different water boards did not interfere with each other. Moreover, the states wanted to ensure that the water boards' interests did not conflict with the military interests of the states. The government could flood strips of land as a defense line if necessary.

In 1795, the French army of Napoleon attacked the Netherlands (Mokyr, 1999). The Dutch elite welcomed the French and started a debate about how the Dutch States could be reformed in pursuant to a real united nation, like that of the French. The central theme of this debate was

centralization and thus the district water boards would have to be centralized too, although when half of a country has to be protected from water, the need for a single administrative body to oversee all the affairs of water in the country is logical and irrefutable. One of the consequences was that a central institute had to take responsibility of all the water ways and public works. In 1798, this became the '*Bureau voor den Waterstaat'* (Bureau for Water Management, named '*Rijkswaterstaat*' after 1815). After the Napoleon armies were defeated in 1815, the Netherlands became an autonomous, sovereign state once again, with King William I on the throne. During his reign, a great deal was done to improve the nation's waterways[55].

During the second half of the 19th century and the first half of the 20th century, *Rijkswaterstaat* developed into a large and powerful organization that intervened in a growing number of affairs. Since the major flood of 1953, *Rijkswaterstaat* has been occupied with the design, construction and maintenance of the Delta Works but furthermore also manages and maintains all polders, dikes, sluices, and pumping-stations and is responsible for flood protection, taking care of the main roads, encouraging traffic safety and developing durable and efficient water systems. It is now the most efficient national water agency in the world.

Flood Management in the Netherlands through the Ages

In the Netherlands the emphasis of national flood management has been almost exclusively on containment and prevention. Less attention was given to the consequences of floods, evacuation decisions and plans, or changes in land use in risky regions. The traditional flood risk management strategy in the Netherlands is based on preventing floods by constructing dikes and other structures. The alternative states of this flood management system therefore vary between either no flood or a catastrophe (Klijn *et al*., 2004). Because the Netherlands had the wealth and the technology to continue building even larger dikes, the dikes were raised after each flood so people felt safe and investments in the area increased, causing a further need to prevent flooding (de Bruijn and Klijn, 2001). As a result, about one third of the Netherlands needs and has artificial protection against floods from the sea or the major rivers. In this area millions of people live and large industries have settled, making flood risk management an important issue for the Netherlands. In the Netherlands, the constitution has been interpreted as requiring the State to defend the citizens against flooding. Hence, the

[55] Not without reason, William I was nicknamed 'The Channel King'. The North-Holland channel, for instance, was the largest channel in 1824 for ocean shipping in the world.

fixed design standards of protection that are applied across the major polders, varying by the nature of the risk, follow logically from the Dutch worldview.

The flood protection in the Netherlands is based mainly upon a risk concept. Following the 1953 flood, legally prescribed public safety standards are indirectly linked to potential damages. The flood defense infrastructure in the country now meets these prescribed standards. A regular safety assessment is a key element of management and control of this infrastructure. Longer term social and economic development however, is recognized to change the perception of and acceptance of flood risk. Thus it has been proposed to adapt high level policy and strategies to take account of these socio-economic factors.

Along the Rhine and Meuse rivers, the flood frequency is once per 1250 years, or a probability of 0.0008 of being exceeded in any given year. Of course, there is no guarantee that such a storm could not happen two successive years in a row. The frequencies of occurrence, or risk levels, are determined by the national Parliament. These so-called design floods also constrain all landscape planning projects in the floodplain. Proposed river works for nature restoration, sand mining or other purposes, need formal approval as stated in the River act. The condition of flood control works, levees and fairways is monitored regularly. Every five years, a formal report on flood safety is made.

Dikes along the rivers have regularly collapsed. This happened 152 times between 1750 and 1800 alone. However, after the establishment of the previously mentioned *Bureau voor den waterstaat* (*Rijkswaterstaat* or the Directorate-General of Public Works and Water Management) in 1798, this happened much less frequently. Since the end of the 18th century, the major rivers have reached very high levels eight times. On six of those occasions, it led to major dike collapses and flooding (see table 4.1).

In 1953, 400 dikes were breached and inundated the land almost as far north as Rotterdam. Nearly two thousand people died and more than 150,000 hectares of land were flooded. It proofed a defining moment for the Netherlands. Twenty days after this catastrophic flood, the Delta commission was sworn in. Within three years the *Rijkswaterstaat* executed a plan that made sure this would never happen again[56]. Forty years later, in 1993 and again in 1995,

[56] The Delta Works took ten years to complete and is sometimes referred to as the eighth Wonder of the World and has been declared one of the modern Seven Wonders of the World

Table 4.1: Chronological list of river floods in the Netherlands since 1100 shows that river floods primarily occurred along the Rhine and Meuse rivers (adapted from Ministry of Housing, Spatial Planning and the Environment, Ministry of Agriculture, Nature and Food Quality, 2001 and Ministry of Transport, Public Works and Water Management, 2004).

History of floods in the Netherlands since 1100		
Year	Location / River	Details
1163	Meuse River	no details
1214	Everywhere in the Netherlands	no details
1277	Formation of the Dollart River	Partly in Germany: first documented transboundary flood
1530	Flanders, Zeeland	400,000 deaths
1781	Wamel and Dreumel	no details
1784	Betuwe, Tielerwaard, Maas and Waal, Ooijpolder	10 to 20 deaths
1799	Waal River	no details
1805	Weurt	no details
1809	From Ooijpolder to Alblasserwaard	275 deaths
1855	Betuwe, Country of Meuse and Waal	13 deaths
1861	Bommelerwaard	37 deaths
1880	Country of Heusden and Altena	2 deaths
1926	Meuse River	no details
1993	Rhine and Meuse Rivers	Dikes did not breach
1995	Rhine and Meuse Rivers	30 deaths; 250,000 evacuated

extremely high discharges occurred in the Rhine and Meuse rivers. The one in January of 1995 was the highest since 1926. Although the dikes held, about 250,000 people were evacuated within one week, including complete livestock of the farmers in the threatened area. After these events dike improvement were carried out much faster than planned and the design once-in-1250-year discharge that must be contained or controlled within the flood plain is higher than it was prior to these events. Without further measures, this meant heightening the already considerable high dikes. However, it was realized that increasing the heights of dikes further and further would at one point not be possible anymore from a technical point of view. In addition, the public started to oppose to increasing dike heights, because they began feeling boxed in. After all these centuries of protecting themselves against water, it was realized that, although some past investments in flood control structures proved to be sensible, many structural and non-structural strategies have failed to be sufficiently effective, and that the model of flood management, considered for hundreds of years to be the one and only correct way to deal with floods and therefore, always strongly advocated in the Netherlands, requires

---

by the American Society of Civil Engineers. It reduces the risk of flooding to 1:4,000 a year in the delta area and the north, and 1:10,000 a year (which is unique in the world) in the *Randstad*.

rethinking (Changnon, 1996; Mileti, 1999; Myers and Passerini, 2000). In other words, the Dutch realized that the 'hydro-illogical cycle[57]' (Wilhite *et al.*, 1987; Smith, 2000) needed to be broken and a structural change to the Dutch water management was necessary to survive the next few centuries. The course of water management was drastically altered by the government. This transition was and still is accompanied by a shift in emphasis from controlling floods to living more in harmony with them and renewed emphasis on self-help. It can therefore be seen as entering the fourth or holistic phase of flood management (see chapter three, page 77 and further). The holistic approach is not a single strategy, but rather a variety of strategies, resulting from the evaluation of the successes and failures of the previous phases in combination with the recurrence of exceptional and highly damaging floods. The holistic approach addresses the basic causes of floods and flood disasters and talks in terms of 'flood alleviation', and 'flood mitigation', rather than in terms of flood control, and of 'flood hazard management' or 'flood risk management'. In addition, not only is economic development taken into account, but also human development, including increasing public involvement in decision making. So instead of making the dikes higher and stronger, the government started to look at ways to give the rivers more room and take into account changes in the societal preferences and views on flood risks and technological flood protection. The thought behind it is that it is better to allocate areas that could be set under water now, before it is too late. The project was titled "Making room for the River" (*Ruimte voor de Rivier*) and it envisions surrendering the hard-fought land back to the water. This new introduced strategy will allow the rivers to flood more naturally, rather than trying to force them into artificial channels. 600,000 acres of dry land are now becoming lakes, wetlands and floodplain forests. The aim is that by 2050, 90,000 hectares of land[58] will be surrendered to increase the size of floodplains, which will be allowed to turn into natural forests and marshlands. Thousands of farmers are abandoning agriculture to become paid stewards of their own naturalized land. Further adaptation visions focus on a further widening of the floodplains and the planning of 'green rivers'. These 'green rivers' (floodplains between dikes) will only be used during floods. In the upstream sections in Germany the focus is on landscape planning so that water will flow less quickly to the river. Critics or non-believers of this policy argue that Germany will never heighten or strengthen their dikes to withstand the high water levels necessary to flood these

[57] Once the commitment was made to major flood control works, as was done in the Netherlands, the precedent is set for any future shortcoming to be remedied by additional flood control mitigation measures.

[58] The surface of the Netherlands is 41,500 km^2 (CIA, 2006), or 4,150,000 hectares, thus 2.2% of land will be surrendered. This percentage includes $^1/_{10}$ of the country's farmland.

cleared areas, and Germany will be flooded before the water will reach the Netherlands, making the Dutch overflow areas unnecessary.

In the densely populated Netherlands, sacrificing land has proven difficult. Not surprisingly, people currently living in these potentia l flooding areas do not agree with the government's plans. Especially because due to successful history of combating floods and the subsequent false sense of security, the flooding issue is still perceived as less acute and relatively easy to solve and for many, it is counter-intuitive that soil, which was claimed over centuries, is given back to the sea or a river. Some towns and villages are already told that they cannot build new infrastructure, because their surroundings will be given back to the rivers in the coming decades. More recently, some towns got permission to build along rivers again, but only if they take increasing water heights into account; the municipality Nederlek is now considering building houses on stilts and recreational development of their area in the form of harbors, for instance. Business opportunities are seized as well: one company has started designing giant floating farms, houses, commercial parks and towns that could be stationed in flood-storage areas.

Theory behind Dutch Water and Flood Management

The traditional approach in water management in the Netherlands is the based on the 'Polder model' which in turn is based on the notions of solidarity and equality. In the Polder model, parties strive for consensus; confrontation is not an option. In many liberal democratic societies attempts are made to institutionalize multi-stakeholder processes in strategic environmental decision-making. In the Netherlands, this has resulted in the so-called 'Green Polder model' which is the Polder model concept applied to environmental policies. In it, social organizations and interest groups are given the opportunity to air their views and present their arguments at an early stage in the decision-making process, including decisions related to flood management. In the past, the Polder model (or striving for consensus) has lead almost automatically to heightening the dikes. When the crises of the high river discharges of the Rhine and Meuse in 1993 and 1995, took place, they could not be addressed by the existing rules or systems. Therefore, the initial response was close to a denial of the need and it was soon decided that the dikes needed to be heightened. Fortunately, it was realized that this could only be a short-term solution. Today, the Polder model is used to shift paradigms – instead of combating the water; people are learning and accepting how to live with water.

Table 4.2: the details on the shared floods during the period 1985-2005 in the international river basins the Netherlands is part of. Data from chapter two.

Year	IRB	Severity class	Affected area (sq. km)	Flood magnitude	Countries involved	Casualties	Displaced	Damage (USD)
1993	Rhine	2	261,100	24.5	Netherlands	1	13,000	$52,000,000
					France	no data	8,000	$510,000,000
					Belgium	1	2,000	no data
					Czech Republic	no data	no data	no data
					Germany	5	25,000	$580,000,000
1995	Rhine	3	341,200	48.6	Netherlands	0	0	$1,760,000,000
					France	37	294,100	$221,100,000
					Germany	4	no data	no data
					Belgium	6	0	$29,000,000
					Luxembourg	no data	no data	no data
1998	Rhine	2	26,850	3.6	Netherlands	0	0	$20,000,000
					Belgium	1	400	no data
2003	Rhine	1	167,000	8.5	Netherlands	0	0	$3,840,000
					Germany	7	1,500	$675,000,000
	Seine				Belgium	no data	no data	no data
					Romania	2	no data	no data
	Elbe				France	10	no data	no data
					Czech Republic	no data	no data	no data

Transboundary Floods in the Netherlands

The Schelde River has not experienced any shared river floods during the period 1985-2005[59], but the Rhine River Basin has experienced 11 transboundary floods; four of them reached the Netherlands (see table 4.2) and caused 100% of the river-flood-related casualties, displaced people and financial damage. These four floods intensified the international cooperation between the Rhine (and Meuse) riparians; in 1998, action plans for both the Rhine and later on the Meuse were agreed upon by all riparians. The Rhine Action Plan specified, among other things that damage resulting from transboundary floods should be decreased by means of, for instance, spatial planning projects, retaining and storing water when water levels are extremely high, giving room (back) to the rivers, and improving the warning systems. The Action Plan for the Meuse basically states similar objectives, except the measures are not as specifically mentioned as in the Rhine Action plan (Ministry of Transport, Public Works and Water Management, 2005). The Dutch government furthermore officially acknowledges that international coordination is an important factor to reduce the changes and results of floods. Cooperation is especially necessary with Germany (Rhine) and Belgium (Meuse). The Netherlands has officially promised to Germany that whatever measures they will implement, will not harm or intensify flood-related consequences for them. The options for actual international cooperation, with regards to transboundary flood-containment-constructions and policies, has yet to be figured out; several studies are carried out to work out the options every country can agree upon (Ministry of Transport, Public Works and Water Management, 2005).

[59] For methodology and additional background information, see chapter two.

International Water Institutions related to Transboundary Floods

Cooperation over shared water resources started with collaboration over fishing and transportation – issues that are equally important to both the upstream and downstream riparians. Later on, environmental issues became important and the quality of the water was reason to combine forces with the other riparians. The floods of 1993 and 1995 made everybody realize that cooperation over shared floods should no longer be ignored. The international institutions already set up for the international river basins to deal with the previous mentioned issues are now being used to integrate transboundary flood management issues. The institutional capacity present in the international river basins that the Netherlands are part of and that can absorb flood-related changes in the basin is summarized in tables 4.A and 4.B in appendix (page 258 and 259).

Of the six river basin organizations present in the Rhine River Basin, one of them, the International Commission for the Protection of the Rhine (ICPR) has flood events as a principal issue and all the riparians including the Netherlands are members of this commission. It was initiated by the Netherlands, and started as a common forum for all the riparian states of the Rhine in 1950, where questions relating to the pollution of Rhine water were discussed and solutions were sought. In the ICPR, decisions are taken jointly and each country, land or regional government adopts the ensuing measures. The ICPR is not an international administrative institution, but more of an advisory body and committee of negotiation. Efforts to protect the Rhine from pollution and to recover the health of its ecosystem have resulted in the signing of the Convention of the Protection of the Rhine in 1998 by its five riparian countries and the European Union. One of the main goals of the new Convention is holistic flood prevention and protection, while taking into account ecological requirements. The Convention considers the drainage basin as one unit and takes into account the interconnectedness between different parts of the ecosystem.

One of the consequences of the great floods of the Rhine in 1993 and 1995 was that riparians realized that their cooperation should be intensified. Therefore, the Ministers of the Rhine riparians adopted the ICPR "Action Plan on Floods" on the 22nd of January, 1998. The ICPR has produced an action plan for flood defense which provides an assessment of flood retention effects on the flooding in the Rhine basin. This considers effects both local to the immediate surroundings of the protection measure and the broader impact of the whole river (see http://www.iksr.org/ for further details).

When it comes to the Rhine River Basin, much of the Water Framework Directive (see page 137) elements have been incorporated into the goals and tasks of the ICPR, which are:

- Decrease damage risks
- Decrease levels of high water
- Increase awareness of high-water
- Improver high-water warning systems

The Rhine-riparians have agreed to share the responsibilities; every country must do its share to realize the EC and ICPR goals. The German states are responsible for high-water protection and high-water prediction and transboundary cooperation takes place between German and Dutch national and regional water authorities. They work together in order to coordinate and optimize retention measures in the border areas. The Germans do not want to interfere in the Dutch way of dealing with national flood risks and there seems to be no other variables to hinder further organizational cooperation, although more intensified cooperation is necessary.

The Rhine has become an example in the field of international cooperation over water. Viewed from a global perspective of conflicts and cooperation in the water sector, during the last 200 years the Rhine basin and its riparians has not seen conflictive events on an international scale, and from a historical long-term perspective, transboundary cooperation has advanced very strongly.

The international cooperation for the Meuse river basin is not yet as complete and certain as it is for the Rhine. The cooperation for the Meuse river basin is complicated by the fact that the riparians all have different levels that define 'high water' – the Netherlands is the country that aims higher than all the other two countries. In order to comply completely with Dutch safety standards, the Flemish part of Belgium has to intervene in a relatively big way by means of constructing more gullies, widening canals etc. The most concrete international agreement is that Belgium measures cannot have negative consequences for the Netherlands. The decision has been made to tackle the high-water levels together, and this will be used to initiate conversations with the other riparians (Ministry of Transport, Public Works and Water Management, 2005). It seems a joined research about the Meuse discharge is a necessary missing element.

International Flood-related Freshwater Treaties signed by the Netherlands

There are 44 international freshwater treaties specifically drafted for the Rhine River Basin, but only three of these are flood-related[60] and not signed by the Netherlands (see table 4.A in appendix, page 258). Probably the best-known treaty in Europe, the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (or UNECE Water Convention, drafted 17 March 1992), drawn up under the auspices of the Economic Commission for Europe (ECE), went into force on 06 October 1996 and has 35 parties, none of which part of the African continent. It is intended to strengthen national measures for the protection and ecologically sound management of transboundary surface waters and groundwaters (for more information, see http://www.unece.org/env/water/).

On an even more encompassing international level, the UN Convention on the Law of the Non-navigational Uses of International Watercourses (adopted by the General Assembly of the United Nations on 21 May 1997[61]) has one article that relates to floods: article 27, Prevention and mitigation of harmful conditions, states that:

> 'Watercourse States shall, individually and, where appropriate, jointly, take all appropriate measures to prevent or mitigate conditions related to an international watercourse that may be harmful to other watercourse States, whether resulting from natural causes or human conduct, such as flood or ice conditions, water-borne diseases, siltation, erosion, salt-water intrusion, drought or desertification' (UN, 1997).

In addition, the Guidelines on Sustainable Flood Prevention were adopted by the parties to the Convention in March 2000. These guidelines aim to 'recommend measures and best practices to prevent, control and reduce the adverse impact of flood events on human health and safety, on valuable goods and property, and on the aquatic and terrestrial environment'. Most recently, the Joint meeting of the Legal Board and the Flood Task Force took place in Geneva on 20-21 June 2006, and drafted model provisions on transboundary flood protection, prevention and mitigation. It drew inspiration from the UN 1997 Watercourses Convention;

---

[60] Namely: the treaty between Switzerland and Austria-Hungary for the straightening of the Rhine from the mouth of the Ill until Lake Constance (1892); Exchange of notes constituting an agreement concerning the execution of improvement works on the River Gander at Mondorff (France) and at Mondorf-les-Bains (Luxembourg), Paris (1986) and the Agreement between the government of the French Republic, the government of the Federal Republic of Germany, and the government of the Grand Duchy of Luxembourg on flood warning for the catchment basin of the Moselle (1987).

[61] Status of ratification relevant for this chapter: Belgium and Tanzania abstained; Swaziland, Zaire and Zimbabwe were absent during the vote.

article I states that the riparian parties ‘shall take all appropriate measures to prevent, control and mitigate flood risks’.

Current developments on the European scale have opened the door for more international cooperation. On 22 December 2000 the European Water Framework Directive (WFD) was officially published and thereby entered into force. The WFD establishes a framework for water management in Europe and complements the many water directives that already exist. The WFD is mainly oriented at improving the quality of the water and (to some part) the use of the water for socio-economic purposes. The backbone of the Water Framework Directive is a system of river basin management. Member states are obliged to identity their river basins and assign these to "river basin districts". For all districts, national and international, six-yearly river basin management plans and programs of measures need to be developed. To ensure the necessary national and inter national co-ordination, member states need, among others, to identity a "competent authority" (art. 3, 11, 13, 14, 15, Annex VI, VII). Flooding is mentioned (article I states the aim to contribute to mitigating the effects of floods and droughts) but the WFD provides hardly any provisions in this field. The reason for not including flooding (and quantity aspects in general) is political. Several countries felt that including possibilities to extend quantity in the WFD would restrict them in their planned developments of the resource. Consensus could be reached on quality only. Initiatives are taken to include flooding in a later stage. However, in 2004, the European Commission (EC) announced via the ‘Flood risk management program’ that a coordinated and integrated approach to flood protection is necessary to decrease the size and chance of flood disasters in Europe. With this, the EC created the conditions necessary to realize cooperation on a river basin scale. The EC proposed that the member states and the commission work together to draft and execute a coordinated program to prevent, protect and soften the consequences of floods. The most important elements of that action program are:

- Improved cooperation and coordination by creating and executing flood risks management plans;
- Establish and use flood risk maps as planning and communication instruments;
- Improve the exchange of information, experiences and coordinated development and improvement of good practices;
- Strengthen the ties between the water management institutions and flood protection authorities and scientific researchers, and
- Strengthen the communication and awareness of flood risks by involving all stakeholders.

Mozambique: General Background Information

Mozambique can be found in South-eastern Africa, bordering the Mozambique Channel, between South Africa and Tanzania. The country is situated on Africa's largest coastal plain (half the territory is no more than 230 meters above sea level) and shares land borders with South Africa and Swaziland in the south; Malawi, Zambia, and Zimbabwe in the west; and Tanzania in the north. With about 800,000 km^2, Mozambique is about 23 times the size of the Netherlands.

Mozambique has over 100 rivers, nine of are shared with other countries to which it is the downstream riparian to: the Buzi, the Incomati, the Limpopo, the Maputo, the Pungwe, the Rovuma, the Save, the Umbeluzi and the Zambezi (see figure 4.4). All these rivers, except for the Rovuma, have their floodplains inside of Mozambique. 57.9% of the Mozambican territory is part of these international river basins and about 7.7 million (of the 19.7 million) people live in them. More than 50% of the total annual runoff is generated outside Mozambique, making Mozambique extremely dependent on these shared rivers.

Since independence in 1975, Mozambique has been going through a period of transition and the past three decades have been tumultuous on a political, social and economic scale, going from one extreme to another: from Portuguese colonial rule, with a system of suppression and colonial capitalism, to a revolutionary phase with a one-party socialist system and centrally planned economy, which eventually led to a brutal civil war that devastated the countryside, national infrastructure and displaced millions. In 1978, Mozambique embarked on a new course aimed at transforming the planned economy into a market economy and moved to a multi-party democracy, but only at the end of the civil war in 1992 and the first democratic elections in 1994 supervised by the UN, stability was restored. Mozambique became one of the fastest growing economies in the world, and the economic outlook is favorable. However, as number 168 on the HDI list, Mozambique is still among the world's ten poorest countries of the world; about $^1/_3$ of the urban people and $^2/_3$ of the rural population lives in absolute poverty.

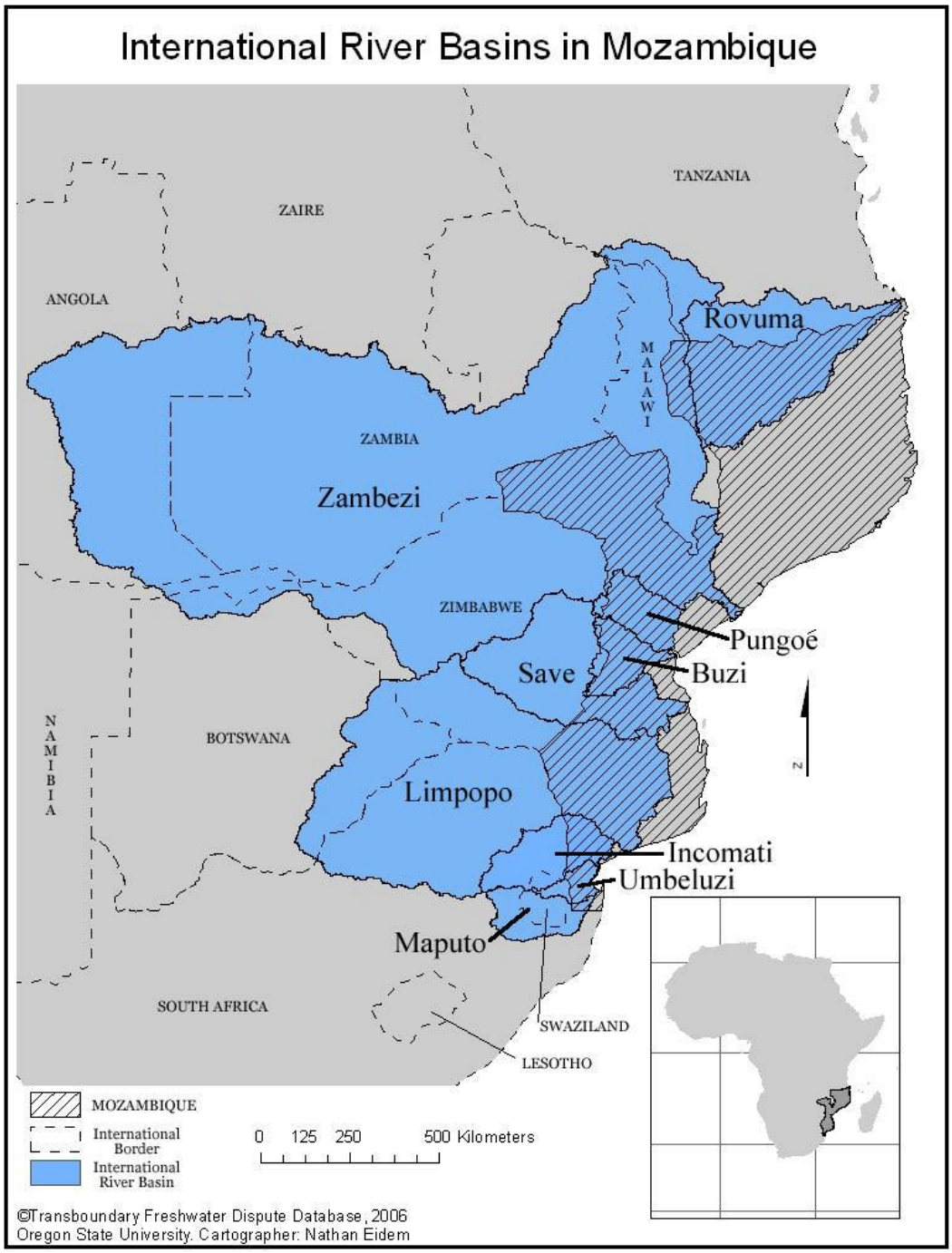


Figure 4.4: map illustrating the nine river basins Mozambique shares with its neighboring countries.

Thus in many ways, Mozambique is a 'transition country' moving from socialism to capitalism. In different parts of the world, periods of transition from one-party socialist rule towards a multi-party democracy and a market economy have tended to provide an environment that is conducive to the expansion of organized crime. The same occurred in Mozambique. The social control mechanisms introduced under socialist rule, which included measures that encouraged people's participation in the decision-making process and held government officials accountable for their actions, collapsed and were replaced by weak state structures that could provide only symbolic safety and security to a population that was left to fend for itself. Today there is a lack of political will to fight organized crime and corruption, and a general perception that some of the political elite are either involved in or are connected with organized crime. There is a general fear that Mozambique is very close to becoming a criminalized state (Gastrow and Mosse, 2002). Basically, there are two very different images of Mozambique. One is of rapid GDP growth and growing exports and of transparent and clear management of donor money. The other is of worsening poverty in rural areas and of state capture, with a predatory elite that robs banks and non-donor resources, smuggles and kills, and maintains a corrupt justice system.

Mozambique's once substantial foreign debt has been reduced through forgiveness and rescheduling under the International Monetary Fund's Heavily Indebted Poor Countries (HIPC) and Enhanced HIPC initiatives, and is now at a manageable level. However, Mozambique remains dependent upon foreign assistance[62] for much of its annual budget, and the majority of the population remains below the poverty line. Subsistence agriculture continues to employ the vast majority of the country's work force. Mozambique is mainly a rural society; about 85% of the people is self-supplying and lives from their own harvest.

In December 2004, Mozambique underwent a delicate transition as Joaquim Chissano stepped down after 18 years in office. His newly elected successor, Armando Emilio Guebuza, has promised to continue the sound economic policies that have encouraged foreign investment. Until now, he seems to focus on stimulating the private sector and poverty reduction, which is encouraging. Political analysts however wonder if the democratic system will be sustained; there is no political opposition so far, therefore any critical political dialogue is absent.

[62] The country receives enormous amounts of development funds. For instance, it has received 35 million Euros as bilateral development cooperation aid from the Netherlands in 2004.

Water Management in Mozambique through the Ages

During the colonial times in Mozambique, policies were designed to benefit Portuguese immigrants and the Portuguese homeland, thus little attention was paid to Mozambique's national integration, its economic infrastructure, or the skills of its population. The first colonial legislation concerning inland waters was enacted in 1901 and established a dual regime of water property. Based on the Portuguese Civil Code, water flowing on private lands, including those originating from rain, were considered private as long as they were confined within the limits of that land; the remaining was public water and its administration was assigned to the colonial Public Works Department. This regime was revoked in 1975 by the first Constitution of Mozambique which ruled that all inland waters were to be considered state property and therefore public. Management of all water resources and the provision of water and sanitation services were taken over by the Central Government.

Today, the government of Mozambique has central responsibility for overall water management. There is a traditional dependence on centralized command and control administrations for water resources development and management and an over-reliance on government agencies to develop, operate and maintain water and sanitation systems. At the central level, the Ministry of Public Works and Housing (MOPH) houses the National Directorate of Water (DNA), the central institution in charge of policy making and implementation. However, authority and responsibility are dispersed among numerous public entities at both the national and local levels. Consequently, there are neither well-structured central goals nor controls. In addition, there is an insufficient number of experienced staff and a lack of financial resources. DNA has created the so-called Regional Water Authorities (ARAs), five in total, which are organized on hydrographic basis:

- ARA – South: includes all the basins south of the Save, and the Save river basin itself;
- ARA – Centre: covers all the basins between the Save and Zambezi basins;
- ARA – Zambezi: corresponds to the Zambezi river basin;
- ARA – Centre-North: covers the Zambezi basin as far as Lúrio river, including the Lurio basin, and
- ARA – North: covers all the basin north of the Lurio basin.

The main functions of these basin authorities are to prepare and implement hydrological basin development plans, maintain and operate hydrological infrastructures (dams, water ways), maintain a register of water users, collect water user taxes and fees, issue water use and effluent licenses and operate the hydrological measurement network. However, the water

organizations are neither completely centralized nor decentralized. Furthermore, the ARA-South, ARA-Centre and ARA-Zambezi are the only operational ARAs and only the ARA-South has slowly developed into a full-fledged regional water management authority. This decentralization process brings greater flexibility to react to unexpected events and provides the planning authorities at central level with data that are more realistic. The main constraint of the decentralization process is posed by the scarcity of technically qualified personnel and financial resources (Carmo Vaz and Pereira, 2000).

Mozambique introduced its current water law in 1991, following years of reform of many other constitutional issues of the country and approved a new National Water Policy in 1995. This water law pays special attention to issues of shared river basins. The water law refers to the need for Mozambique to cooperate with the other watercourse states and adds emphasis on integrated water resources management. The following objectives are mentioned:

- Adoption of coordinated management measures for the shared river basins, taking into account the interests of all the watercourse states
- Equitable utilization of common water resources
- Preparation and/or joint realization of projects and construction of hydraulic infrastructures
- Control of water quality, prevention of pollution and soil erosion and
- Exchange of information on issues of common interest.

The government concretized this by creating the *Gabinete de Rios Internacionais* (GRI or International Rivers Office), in 1999, installed in the DNA, and charged specifically with transboundary issues. The GRI is already contributing to a significant improvement in the relationships, communications and discussions between DNA and the water authorities of the other riparian countries. Their responsibilities are entirely focused on the urgent day-to-day issues driven by the scope of the SADC water sector activities, negotiations related to the establishment of joint river commissions and coordination within some line ministries.

Flood Management in Mozambique through the Ages

Mozambique has a history of floods and natural conditions for periodic occurrences of extreme hydrological extremes (see figure 4.5). Decennia of living along the riverbanks have given inhabitants of the area a wealth of knowledge of the river's behavior. People occupy the floodplains in the drier times in lightweight huts that they can disassemble and remove. When the floods come the inhabitants move their huts to higher ground. Locals possess methods for

predicting floods and in general, there is a historic reliance on these traditional warning systems and experience, and less faith in engineering structures. This has caused problems in the past; there are indications for instance that in the case of the 2000 flood, the traditional authorities did not believe in the flood warnings because it went against their experiences. In other cases, the warnings were too technical for common people to understand.

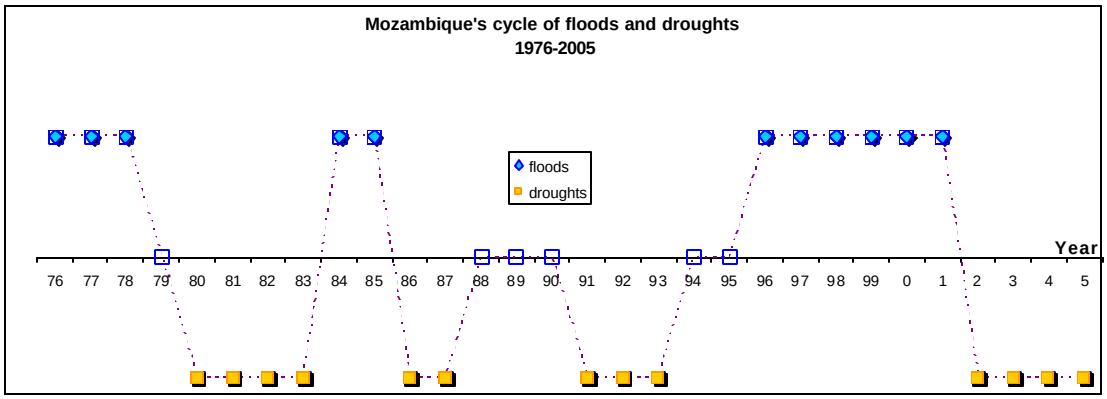


Figure 4.5: the cycle of floods and droughts Mozambique has gone through since 1976.

The general Mozambican disaster strategy is to include disaster prevention and mitigation measures as integral parts of any development plan. Mozambique has tried to minimize the negative impacts by constructing and implementing mostly structural measures (see chapter three). Due to a lack of financial resources, Mozambique has been able to built only five dams[63] with sufficient storage capacity to have an impact on large floods, although three of them are built on tributaries (Carmo Vaz, 2000). All the reservoirs incorporate in their operating rules a flood reserve during the rainy season. Levees for protection against floods are used in irrigation areas seem to be a good solution, but on a local scale only. The levees are designed for return periods of five to 20 years. However, the heights of some stretches of levees are at lower levels than initially designed and constructed due to erosion. The responsibility as to who must maintain, repair or inspect the levees is not clearly defined (Carmo Vaz, 2000). In June of 1999, a national policy on disasters management was formulated and the *Instituto Nacional de Gestao das Calamidades*[64] (INGC or Institute of Disaster Management) was created, marking a substantial change in the philosophy of dealing

[63] The Pequenos Libombos (1988), Corumana (1989), Massingir (1977), Chicamba (1968) and Cahora Bassa (1975) (Carmo Vaz, 2000).
[64] According to the National Policy on Disaster Management the objective of the INGC is disaster management and the coordination of prevention activities, relief to disaster victims and the rehabilitation of affected infrastructure.

with disasters and the need for an integrated long-term plan of managing disasters. The INGC was established as a national coordinating entity with the legal authority to call on all partners to plan and implement responses and prevention measures. Thus necessary policies seem to be in place. However, at present, flood management infrastructure is incomplete, not maintained, or simply broken. This makes the creation of an effective flood management plan a highly challenging task.

Mozambique has no experience with the possible impacts in terms of flood reduction. None of the flood prone basins in Mozambique, for instance, have defined flood areas to where part of the floodwater could be channeled or temporarily stored. Recently, the notion that floods cannot be avoided, and people have to learn to live with floods has entered into the Mozambique field of water policy, although it has not yet been conceptualized or concretized in new policies (DNA, 2000). Each basin though has areas which are normally flooded and not occupied for any particular use.

Floods and Foreign Development Aid

Droughts and floods are a priority for Mozambique's disaster reduction, because it faces a regular cycle of these; see figure 4.5. But at the same time, it suffered (and suffers) from a wide range of natural and man-made disasters. Since its independence in 1975, it has been victim to cyclones, massive war-provoked population displacements, coastal oil spills, erosion and landslides, wildfires, pests, epidemics (cholera, bubonic plague, meningitis, HIV/AIDS), forest fires, and large transportation accidents. Disasters hurt developing countries and poor people disproportionately because poverty and disasters are mutually reinforcing and undermining incentives for development (Gruntfest, 1994; Anderson, 1991). This is no different for floods; the effects of floods in the lesser-developed countries are often more serious compared to effects of floods in more developed countries, especially since recovery is much more difficult. As stated previously, Mozambique is still highly dependent on foreign aid development funds, even more so when it comes to disaster relief. Development assistance for ongoing projects or projects in pipeline have USD 6.1 billion committed to them (OdaMoz, 2006), but of all development aid projects sponsored by foreign donors, most of them are in the 'Government and Civil Society' and 'Health' sectors (see figure 4.6). There are ten ongoing projects related to floods, nine of them initiated by the EC, one by the USA,

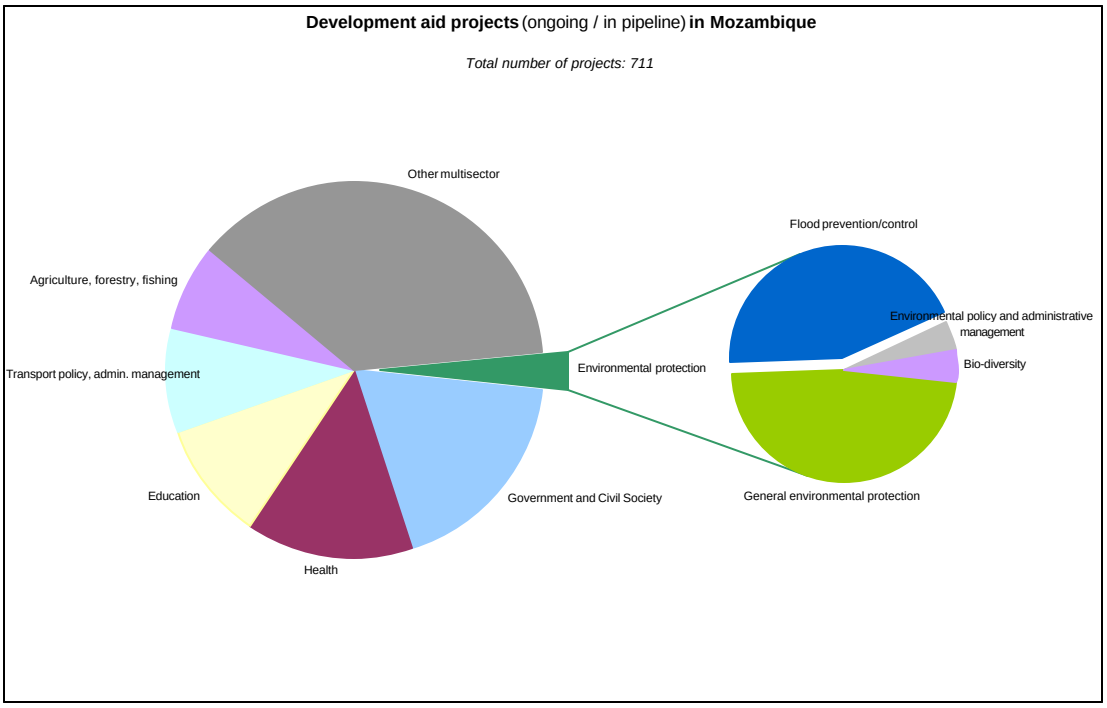


Figure 4.6: of all the 711 development aid projects ongoing or in pipeline in Mozambique, only ten are dedicated to flood/prevention or control, for a total around USD 74 million. These projects, however, are all post-flood reconstruction projects; none of them address flood prevention or mitigation options. Data from OdaMoz, 2006.

for a total of USD 74 million (1.2% of the total amount committed), but these are all post-flood reconstruction projects. None of them focuses on flood mitigation, adaptation or reduction. No doubt relief and rehabilitation are crucial from the point of view of supporting the households and families hit by floods, and humanitarian action to relief the impact of disasters will always be vitally important (UNDP, 2004), but equally and arguably in the long run even more important are long-term provisions such as insurance, and mitigation measures. Next to *post-facto*, *pre-facto* aid should be offered in the form of building more institutional capacity: training qualified people for the DNA, the GRI and the ARAs in the various disciplines that deal with flood management. Additionally, the national Mozambican flood warning systems still need strengthening while the equipment and models used for flood warning in the country are old and need updating.

Theory behind Mozambique Water and Flood Management

In Mozambique, the water law's history is following the Portuguese Water laws until independence in 1974. In 1991, a new water law was introduced and considered all water as

state owned, a public good, and all infrastructure, bridges, dams and canals build by the state. The concept is that all water resources are to be governed by the state for the benefit of the population. Water is seen as free for all. Only the large-scale users need permits and concessions. The 1991 law has characteristics of a revolutionary time, using the concept of rational use, which implies a set of non-stated values.

Transboundary Floods in Mozambique

Mozambique has a long history of floods and major floods have been recorded in all international river basins, with the exception of the Rovuma. During the period 1985-2005, Mozambique has experienced 15 river floods, six of which were transboundary (see table 4.3) and accounting for 85% of all the river flood-related casualties, 66% of all displaced people and 91% of all financial damage pointing to the massive human and financial impact transboundary floods have on this country.

The impacts of the 1997 flood in the Zambezi were felt only locally, but the one in 2001 was the second most severe flood since 1975 for Mozambique. The floods in 2000 in the Umbeluzi basin were quite serious, but damages and casualties were reduced by the *Pequenos Libombos* reservoir and a flood warning system.

The floods in February of 2000 were, according to the Mozambique officials, the worst floods on record. The Limpopo, Incomati and Umbeluzi rivers exceeded all recorded water levels since 1937. DNA and ARA-Sul issued flood warnings, although it became clear that the flood propagation model that was used was inadequate and unable to make reasonable forecasts of water levels at the Lower Incomati. There was an effective flood warning mechanism between the Government of South Africa and Mozambique on the Limpopo River, which was used to warn Mozambique. However, the Mozambican government failed to move the communities from affected areas because of insufficient capacity (logistics, flood hazard maps etc). In addition, the inhabitants refused to move out of the area, as they did not comprehend the magnitude of the floods. The degree of vulnerability of their settlements was not known to the population, nor safe havens and refugees been identified. As a result, the floods caused enormous destruction and losses; it killed 800 people and affected 1,500,000 (about 12% of the nation's people). The floods triggered immediate assistance by South Africa and a watershed of relief support by the international community and emphasized once more the

Table 4.3: the details on the shared floods during the period 1985-2005 in the international river basins Mozambique is part of. Data from chapter two. Note that differences in development of the structures for reporting disaster damage might play a role when it comes to the reliability of this data, as well as the availability and accuracy of demographic data, and misrepresentation of events for political reasons.

Year	IRB	Severity class	Affected area (sq. km)	Flood magnitude	Countries involved	Casualties	Displaced	Damage (USD)
1988	Limpopo	1	388,500	13.0	Mozambique	11	18,000	*no data*
	Orange				Botswana	8	6,000	*no data*
	Zambezi				Zimbabwe	*no data*	*no data*	*no data*
					South Africa	*no data*	*no data*	*no data*
1997	Zambezi	1	211,800	17.5	Mozambique	35	*no data*	*no data*
					Malawi	0	80,000	*no data*
2000	Limpopo	2.00	436,000	54.5	Mozambique	800	634,800	$419,200,000
					South Africa	103	200	$39,400,000
	Incomati				Botswana	3	32,000	$0
					Zimbabwe	70	66,000	$72,900,000
	Umbeluzi				Malawi	0	0	$0
					Swaziland	0	0	$0
2001	Zambezi	nd	202,300	nd	Mozambique	113	485,000	$36,000,000
					Malawi	59	200,000	$0
					Zambia	5	30,000	$0
					Zimbabwe	13	15,000	$3,600,000
2003	Zambezi	1	354,400	23.0	Mozambique	4	*no data*	*no data*
					Malawi	8	400,000	*no data*
2003	Sabi	1	116,900	8.5	Mozambique	8	8,300	*no data*
					Zimbabwe	*no data*	*no data*	*no data*

need for further regional cooperation. In the following year, 2001, the country was flooded again in the central region, as well as in 2003 in the northern region.

It is important to raise awareness of people in relation to floods and to promote education programs, at all levels, so that the population in general becomes more prepared to face large floods and react adequately when they occur. Women play a key role in the Mozambican household livelihood systems (DNA, 2000) and without an understanding of their roles and responsibilities an appropriate flood protection and mitigation strategy cannot be formulated. The problem of floods cannot be resolved without public participation. There is a need to work with the people who are affected by floods. In general, public participation enables informed and innovative decision-making and building citizenship for joint disaster mitigation. People's contribution and ownership of flood protection measures are considered key and no steps should be taken by the government unless people are willing to participate in the maintenance of the infrastructure that is developed.

International Water Institutions related to Transboundary Floods

Mozambique shares nine rivers with other countries. Some of the basins have international freshwater treaties, but none of these are specifically drafted for hydrological extremes like floods. There are also several transboundary water institutions for the Incomati, Limpopo and Zambezi (three, five and three) and Mozambique is a member of all of them except for two of them for the Zambezi (see table 4.C and 4.D in appendix, page 260 and 261), but again, none of these institutions deal partly or completely with transboundary floods.

At the time of independence, Mozambique inherited a situation in which there were almost no agreements on sharing water resources and its management in common river basins. Nowadays, international cooperation in the Limpopo River Basin is present in the form of an agreement for the establishment of the river basin commission (to be called LIMPCOM), which was signed in 2003 and the four riparians have agreed to establish a Joint Limpopo forecasting system for the entire basin. In addition, the hydrometric stations have been upgraded, and a telemetric network has been installed.

In the Zambezi River Basin, the riparians have signed an agreement in July 2004 for the establishment of the river basin commission (to be named Zambezi River Commission or ZAMCOM). Since 1987, the establishment of ZAMCOM has been given full priority by SADC and final draft consensual text was reached early in 2003 and a ratification process will Follow. There already is a Joint Operational Technical Committee, a coordinated body for exchange of data on management of Kariba and Cahora Bassa, which played a crucial role in the reduction of the floods in 2001.

In the Incomati River Basin, the inequality of the three riparian countries in terms of geographic position, economy and technological know-how is salient. The upstream country, South Africa, is the most powerful, whereas the downstream country, Mozambique, is comparatively weak[65]. In such a situation the upstream country may be tempted to ignore the interests of other riparians. This would provide fertile ground for open conflict to emerge. Up to 1991, South Africa indeed developed its water resources largely without considering the needs of Mozambique, while taking a more careful approach with regard to Swaziland. Yet at

[65] The geographical location of a riparian does not guarantee the amount of power a country holds – the upstream country can also be the weakest party, as is the case with the riparians Nepal, Bhutan and India that share the Ganges-Brahmaputra-Meghna river basin (Baillat, 2004).

various crucial moments in the history of water sharing, South Africa also took Mozambique's interests, which it could have ignored, into account. In the late 1980s and early 1990s, South Africa announced that it intended to construct the Driekoppies Dam, which, together with the Maguga Dam, was erected with the purpose of utilizing floodwaters not used by Mozambique. Mozambique in response stated that "serious shortages of water are expected to occur along the Incomati river in Mozambique" and demanded that South Africa would guarantee a minimum flow in the Incomati at the border. Swaziland needed World Bank funding for the construction of the Maguga dam, and the World Bank demanded a declaration of 'no objection' from Mozambique, forcing Swaziland and South Africa to address Mozambique's conditions. A water use arrangement was therefore the central issue of the Tripartite Permanent Technical Committee (TPTC) meeting on 14 February, 1991. A day later, the ministers responsible for water agreed that, pending future agreements resulting from a Joint Inkomati Basin Study, the base flow at the border between South Africa and Mozambique should be maintained at no less than 2 m^3 /s. The minister of water affairs personally guaranteed the minimum flow at the border at Ressano Garcia in 1997. Subsequent developments show that South Africa remains committed to considering downstream interests, also explicitly stated in its National Water Act of 1998. This commitment has been reconfirmed with the signing of the Tripartite Interim Agreement in 2002. By the same token, Mozambique showed its commitment to recognize upstream interests, relying in return on South African investments (e.g. Maputo corridor and Mozal) as a cornerstone of its new pragmatic policy of economic reconstruction (van der Zaag and Carmo Vaz, 2003).

Mozambique is member of the Southern African Development Community (SADC), an organization that aims to promote Southern African regional cooperation in economic development. The other eight founding members are Angola, Botswana, Lesotho, Malawi, Swaziland, Tanzania, Zambia and Zimbabwe. Namibia, South Africa, Mauritius, the Democratic Republic of the Congo and Madagascar have joined since. SADC has a Disaster Management Strategy. The main objective of this strategy is to reduce the vulnerability of the people in the region to threats of floods (and droughts) and pool resources to address preparedness and response to these phenomena. Some relevant features of the strategy are: building and promoting potential and complementary synergies, avoiding duplication of efforts in the area of floods (and drought) management, defining clear roles of those involved and addressing issues of preparedness, early warning, mitigation, response and recovery. In addition, the organization has a website that:

> 'aims at providing up-to-date information on development and impacts of floods, drought and adverse weather in the Southern Africa region' and 'intended to facilitate the exchange of technical and other useful information that can be used by the disaster and technical communities in preparing for and responding to the occurrence of cyclones, floods and droughts' (see http://gisdata.usgs.net/sa_floods/).

At the political level, SADC states acknowledge water resources as a key factor in regional development and strive to minimize disputes over scarce resources through implementation of the protocol and promotion of bi- and multinational negotiations in transboundary river basins. Since 1987, SADC has made tremendous efforts to develop a common understanding of the management of its water resources. These efforts culminated in the signing of the first Protocol on Shared Water Courses in 1995 which was met with reservation from the beginning, particularly from the so-called downstream countries like Mozambique. This protocol underwent extensive revision until a revised protocol was signed in 2000 and came into force in 2003 after ratification by more than two-thirds of its member states, as is mandated by the SADC treaty.

Lessons Learned

When the compare the vulnerability variables (see chapter two) of both case study countries (see figure 4.7; compiled with data from table 4.2, 4.3, and data from chapter two and three), we clearly see that, although the flood magnitudes are about the same, the death and displacement toll in the most developed country, with the most institutional capacity, are much lower than in the less developed country. In addition, the global trend that river basins with more riparians in it, on average have more institutional capacity (chapter three) also holds true when comparing these two countries.

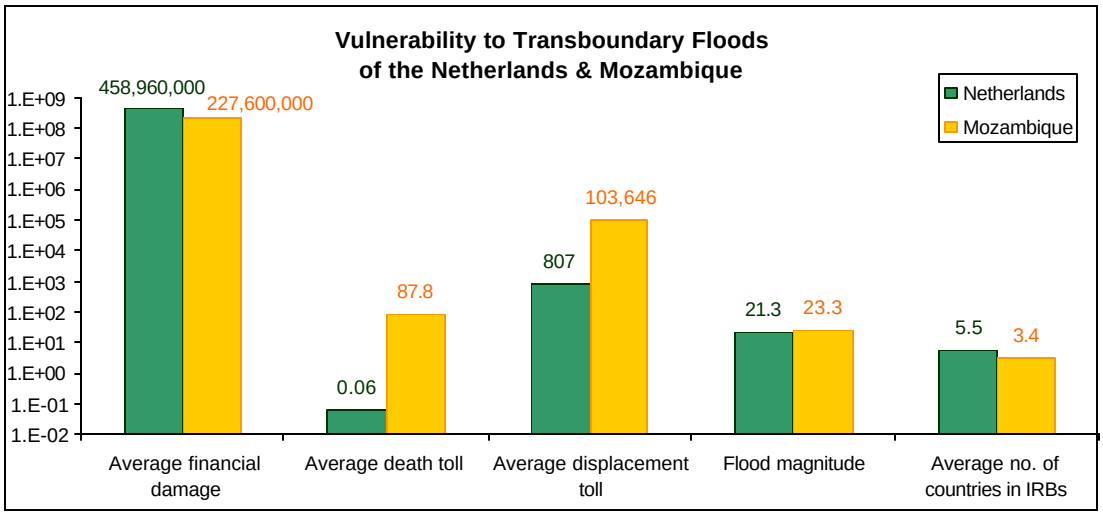


Figure 4.7: the average death and displacement tolls for transboundary floods are lower in the Netherlands than in Mozambique, while the flood magnitudes are in the same severity class. Data from chapter two.

This can partly be explained by the obviously enormous (historical) differences between the two countries: the Rhine and Schelde riparians are all countries with a smooth running, profitable economy, modern societies, high levels of knowledge and high population densities. The catchments have adequate, border-crossing flood-warning systems and all riparians have more than enough human and financial resources should catastrophe strike. The catchments that Mozambique is part of, on the other hand, have much less developed countries. The economies are far less profitable and flood-problems are just one of many life-threatening natural events for the majority of the population. In addition, one of the main features of the SADC region is that the pace and depth of development across the SADC countries have been uneven, making the riparians much less comparable on a political, economical and cultural level than the West-European countries are.

Table 4.4: summary of some of the geographical, historical and cultural factors that have shaped flood management practices in the two case study countries. Additional data from the CIA World Factbook, 2006 and TFDD, 2006.

	Netherlands	Mozambique
History		
General	From Republic (1648) to present constitutional monarchy (1815)	Colonial history; independence in 1975
Politics	Parliamentary democracy since 1848	Multi-party democracy since 1990; first democratic elections held in 1994
Economy		
Agriculture	2%	21%
Industry	25%	32%
Services	73%	47%
Social		
Population density	High	Low
Population growth rate	0.53%	1.48%
Population in IRBs	27%	39%
Institutional capacity		
National water management	High	Medium
Transboundary waters	High	Low
Geography		
Landscape	Result of past human activity	Large areas essentially untouched by human activity
Reclamation	Most of the country is reclaimed form sea and floodplains	No reclamation projects
Water issues		
Scarcity	No	High
Flood management	Historic reliance on dikes as engineering approach to flood alleviation	Historic reliance on traditional warning systems and experience, less faith in engineering structures

Not only do these differences result in differences in quantities as figure 4.7 shows, but they also clearly illustrate varying bases for governmental intervention in flood hazard management. The specific conditions, like the level of socio-economic development and the level of established international cooperation, but also the historical, social, geographical and cultural factors (table 4.4) influenced the way international water problems were tackled. Overall, though, both countries clearly demonstrate that cooperation in the management of shared water resources is possible and in general, water has driven them towards cooperation.

National Flood Policy

In Mozambique (and for that matter, in China, Bangladesh, Cambodia, Poland, Germany, the United States, and Chili), flood management strategies are still based on a resistant system, where there is no damage at all. However, the problem with resistant systems is that if the system fails, there is chaos. Thus in Mozambique, floods still cause disasters partly because of this utilization of the traditional flood risk management strategy. However, Mozambique is at a point in history where it still has to decide upon a national future flood management strategy. It is hard to say what direction it will take, but it seems that there are only two realistic alternatives: the traditional path of dike systems, or living with floods. In general, the Mozambican people are practically forced to live with floods, but there is an understandable drive to further develop the region[66]. Van Ogtrop (2005) looked at the advantages and disadvantages these two options might have and concluded that the sustainability of one or the other pathway depends strongly on the future conditions within the river basins. If conditions do not change much, the traditional approach will be the sustainable way to go, just as was done in the Netherlands. However, anthropogenic and climatic pressures can change the riverine environments significantly, making it necessary to have a more flexible system of flood management in place that can absorb fluctuating conditions. This path is the more flexible of the two options. Thus, in summary, the choice for future flood management must consider the current speculations on changing climate conditions, as well as the population growth rates and choose the most sustainable path accordingly. It is now recognized that totally controlling floodwaters may not be the optimal flood management strategy. Therefore, it is highly recommended that strategies other than those traditionally adopted in developed countries be considered. Furthermore, current understandings of climate change together with the already highly naturally fluctuating conditions in all the IRBs of Mozambique all seem to suggest that the more flexible pathway is the most sustainable choice for future flood management. However, there needs to be a willingness to review and consider the possibilities for the implementation of alternative flood management strategies on all political measures. Compared to the Netherlands, very little needs to be undone in order to adhere to this alternative strategy. Hence, it can even lead the way toward postmodern flood management and set an example for developed countries where it proofs to be difficult to revert back to a system whereby nature is again given space.

---

[66] The construction of the Moamba major dam in the Lower Incomati basin is an example of this (van Ogtrop, 2005).

International Cooperation

The level of symmetry between the riparians influences the way cooperation takes place – the 'stronger' (not always the upstream) state can dominate decision making and cooperation. It is recommendable that transboundary water management should try to eliminate upstream-downstream thinking which often is equal to acting on strong and weak positions. In general, it is mostly the downstream country that has the most to lose, and thus has to work hardest to guarantee the other riparians take his best interest into account. The downstream countries are often put in a position of responding and reacting to upstream *faits accompli*s, and find it difficult to influence the agenda. The case of the Netherlands indicate that it pays of to take on a very dynamic attitude and combat the tendency of large impact decisions being taken in each country individually. When riparian countries take individual decisions that can potentially damage another country's interests, without it being the result of negotiations and agreements, it is worth it to voice protests firmly and consistently until a change in attitude is adopted. In addition, the general public should be duly informed of what is happening and why. This has not been the case in Mozambique. Therefore, Mozambique in general, and DNA in particular, should be more active, as was the Netherlands, in face of the developments taking place in the other countries, and be the most interested and pro-active party in encouraging negotiations and agreements.

Flood-related Events, Treaties and Institutional Capacity

Our research revealed the absence of flood-related treaties and flood-related institutional capacity but also the absence flood-related conflictive events (see also chapter three) in international river basins of both the Netherlands and Mozambique. The absence of flood-related treaties might be explained by the fact that these events are not regular enough to guarantee a high placement on governments' priority lists, because they are too difficult to capture in official language or because it is considered taken care of under the IWRM-umbrella. Still, the apparent lack of institutional capacity did not result in conflictive interactions between the riparians. Globally, cooperation over water is much more common than fighting over water (Wolf *et al.*, 2003), but for the Rhine and Schelde River Basins, this might also be explained by the fact that there is no serious water shortage problem and there are advanced standards of transboundary cooperation and international law in Western Europe. Also the inherent pressure for nation states to behave as good neighbors might play a role when catastrophes hit. As for Mozambique, history also proofs that this country rather cooperates over water than start wars over it: the country realizes its vulnerable downstream

position and participated in international water initiatives during their civil war, although the political circumstances did decrease the amount of trust between the riparians[67]. Now, water management forms one of the foundations for cooperation in the Southern African region, via SADC, although it has been argued that each country started out promoting only its own water own water developments (Carmo Vaz and Lopes Pereira, 2000), without taking the needs of the other riparians into account.

[67] For instance, it was agreed in 1991 by Mozambique, South Africa and Swaziland to do a joint study on the Incomati River that would serve as a basis for future negotiations on water sharing; but Mozambique did not participate in the study because the required environment of trust was lacking. This undermined the study itself, but also Mozambique's negotiating position (Carmo Vaz and Lopes Pereira, 2000)

Discussion and Recommendations

General

One-tenth of all river floods experienced worldwide in the period 1985-2005 were shared between two or more countries. This 10% is responsible for 32% of all river flood-related casualties, almost 60% of all affected individuals and 14% of all financial damage (see chapter two), indicating that transboundary floods cannot be ignored.

Flood Institutions and Transboundary Water Management

Governments and flood-related institutions and policies should be flexible enough to adapt to changing streams of ideas. They must be able to keep pace with, and remain responsive to, changing understandings of the causes of flood hazards and changing interpretations of the relationships between society and environment. They should be able to constantly reassess, and be prepared to rethink and adjust, their flood hazard reduction policies in the light of the changing stream of ideas, evidence and proposals for new emphases, paradigms and approaches. This is the only way paradigms can be shifted, as they were in the Netherlands.

The ecological, economical and physical interconnectedness of river basins naturally calls for collaboration between countries. In addition, riparian countries share a common resource, a common history, and a common future, which creates an inherent pressure for nations to behave as good neighbors, even when political ideologies diverge. Furthermore, there are outside pressures on nation states to act responsibly and to honor existing regional and international conventions. A holistic approach therefore has to be based on multilateral and, if necessary, international co-operation, including interdisciplinary planning for the whole catchments areas. If a river basin covers more than one country, the national authorities should provide the necessary support for a joint river basin authority or committee with responsibility for the integrated management of the water resources in the basin. At the very least, a central authority needs to provide a system of linkages between existing organizations dealing with water resources with a view to harmonizing approaches and policies. Nevertheless, flood management at root will be a national endeavor, but because local or national flood protection measures can have negative affects both downstream and upstream, national flood protection measures should always take into account their possible impact on the other Riparian States.

Furthermore, national efforts need to maintain synergy with those at bilateral and regional levels. Lastly, the crucial sovereignty principle [68] should not be ignored.

The Netherlands: National Level

The Netherlands experienced four floods in the period 1985-2005, all of which were transboundary and in the Rhine basin, thus accounting for 100% of all flood-related casualties, displacements and financial damage. Historically, individuals were responsible for the maintenance of the dikes, but over the years, responsibility for action shifted from the individual to the public at large to a national institution, called *Rijkswaterstaat*, at present arguably the most efficient governmental water institution in the world and responsible for the safety of all the Dutch citizens.

The case study of the Netherlands showed that a traditional flood management approach, coinciding with a hierarchist management style (or total control) can change in part because the views of people influenced a radical shift in management style. For hundreds of years, the Dutch have tried reasonably successfully to tame the rivers, and spend millions of dollars protecting their people by means of dikes and levees. However, the many technical solutions that have been implemented have actually exacerbated flood vulnerability. Now, it turns out that it is more efficient and safer in the long run to give this land back to the rivers and learn to live with the reality of floods. So recently, the Dutch shifted paradigms. They do not focus on prevention of floods, but rather on avoiding damage and rapid recovery after floods. In other words, they have accepted the reality of floods and are learning to live with them.

The Netherlands: International Cooperation

The Netherlands is a member of the International Commission for the Protection of the Rhine (ICPR), a joint institution of which all Rhine-riparians are members, and that deals with the transboundary water issues, including transboundary flood events, of the Rhine River basin. The history of the development of the ICPR supports the idea that non-legally binding norms, such as work programs defining common concerns are worth considering as an initial step to establish mutual trust and co-operation practices. However, it should be kept in mind that much of the ICPRs progress was achieved because of unique regional circumstances, namely

[68] The sovereignty principle tells us that each nation has the right to develop its own policies, laws and institutions and their own strategies for natural resources development and utilization principles.

in the aftermath of the Sandoz crisis[69] which created a lot of public concern and windows of opportunity. There is also a joint commission for the Schelde River basin, the *Commission internationale pour la protection de l'Escaut* (CIPE or International commission for the protection of the Schelde), the other international basin the Netherlands is a part of. However, this commission has as of yet not incorporated transboundary flood events into their mandate. This might be due to the fact that the Schelde has never seen any huge flood disasters, and thus so far, no windows of (political) opportunity were present. In addition, the quality of the Schelde waters is of little to no importance to the riparians, because it is not being used for drinking water or agricultural purposes. Hence, there is no immediate incentive for the Schelde riparians to work together on issues of quality, let alone quantity. The EU wide Water Framework Directive (WFD) mentions transboundary floods, but quantity aspects could not yet be agreed upon due to political tensions

Mozambique: National Level

In total, Mozambique has experienced six (out of a total of 15) transboundary river floods that accounted for a disproportionate 85% of all the river flood-related casualties, 66% of all displaced people and 91% of all financial damage, indicating that transboundary floods are significant events in this country. Historical and present records show that the Mozambican government is officially responsible for the protection of the Mozambican people, but in reality, the responsibility lies with the individual, since the country has significant constraints in terms of financial and qualified human resources and its weak economic infrastructure is aggravated by the other frequent natural disasters such as cyclones, droughts, bush fires, and various epidemics. For instance, the responsibility as to who must maintain, repair or inspect the levees is not clearly defined. This indicates the need for strengthening of the institutional capacities in Mozambique in the field of water resources and flood management at both the central and local level. A promising start has been made with the creation Regional Water Authorities (ARAs), five in total, which are organized on hydrographic basis. However, the ARAs all have different perceptions of the local problems in their region and view irrigation as a more pressing issue than floods.

[69] On November 1, 1986, a fire broke out at a Sandoz storehouse near Basel, Switzerland. The storehouse contained about 1,300 tons of at least 90 different chemicals. The majority of these chemicals were destroyed in the fire, but large quantities were introduced into the atmosphere, into the Rhine River through runoff of fire-fighting water (about 10,000 to 15,000 m^3), and into the soil and groundwater at the site.

At present, flood management infrastructure is incomplete, not maintained, or simply broken. This makes the creation of an effective flood management plan a highly challenging task. In addition, there is an overall lack of qualified staff at DNA and GRI, the war situation and lack of financial resources resulted in an insufficient amount of attention paid to the management of the country's water resources. In addition, Mozambique has multiple other pressing challenges, including the need to consolidate democracy, continue the fight against corruption and extreme poverty, and progressively reduce the country's dependency on high levels of external aid by promoting economic growth through export diversification and enhancing a favorable business environment. However, since 2002, institutional strengthening through 'process analysis' has started in order to support and strengthen the DNA, and in particular the GRI, but the key area of institutional weakness within these institutions is still the lack of expert resources to analyze the strategic impact of the water-related agreements on the economy of Mozambique. There is an urgent need to develop decisions support systems, evaluation tools, and access to data and information for input to the analysis. Mozambique will therefore have to strengthen its own financial resources, as well as its human resources capacity.

There is an urgent need for a more comprehensive national flood strategy that need to be incorporated into the National Water Policy (DNA, 1995), in which there is as of yet not mention of flood-related mitigation policies. However, corruption at various levels of the administration is one of the barriers to more effective institutional capacity related to international river basins. Other significant constraints in terms of effective flood management are lack of financial and qualified human resources.

Mozambique: International Level

As the last downstream riparian of nine major international rivers basins that discharge through Mozambique, the nation is dependant on sound transboundary resource management. In addition, as the development of the water resources in the riparian countries is continuing, some might say accelerating, Mozambique will probably not only receive less but more polluted water in the future, but also larger floods. The Incomati, Limpopo and Zambezi River Basins have joint institutions set up for the basin, but the other six international river basins Mozambique is a riparian to (the Buzi, Maputo, Pungwe, Rovuma, Save and Umbeluzi,) have not. The experience with ZAMCOM reveals that when the number of riparian countries is high, it has been more difficult to reach a common understanding about development priorities

owing to the wide range and multiplicity of water users and goals in question. Regardless of the fact that the effectiveness and quality of these agreements can be questioned (Carmo Vaz and van der Zaag, 2003), they do represent a hopeful indication of willingness to cooperate over water. None of the institutions have transboundary flood events as one of their principal issues, although both the Limpopo and Zambezi river basins have experienced several shared floods in the past, which should put the management of these shared river basin and reaching agreements with the other riparian countries on water floods high on the priority list of Mozambique. Note however that the Mozambican capacity to negotiate transboundary water agreements is not strong and needs strengthening particularly when it comes to legal and technical aspects.

Most SADC countries have flood disaster and mitigation units, but these are generally ill equipped and have inadequate staff. It was telling that, though some SADC countries came to the aid of Mozambique's flooding in 2000, comprehensive assistance only came from outside the SADC region. The countries in the SADC region are not only connected by their geographical position; whatever happens in one of the countries, will inevitably have repercussions for the entire SADC region as far economic stability, democratic governance, and the investment environment is concerned. This should be enough of a stimulus to develop a more comprehensive flood disaster and mitigation institution build up from national units for the SADC countries. Strong cooperation and support from the other SADC countries with which it shares various river basins would include but is not limited to a free and smooth flow of data, collaboration between the responsible meteorological institutions for forecast of extreme meteorological events. The Mozambican ARAs, the Catchment Management Agencies in South Africa and the proposed River Basin Authorities in Swaziland (van der Zaag and Carmo Vaz, 2003), will all presumably facilitate necessary data sharing and coordination of action and aid during a shared flood event.

The lack of hydrological data and scientific knowledge on floods as well as insufficient human and institutional capacity, i.e. a lack of efficient national water management institutions, not only in Mozambique, but in the other riparians as well, are major obstacles that have to be overcome in order for international water cooperation initiatives to be implemented. Vital steps towards the integration shared flood management into joint riparian management strategies are to have human and institutional capacity building programs, to establish monitoring programs for quality and quantity of the water resources, and to promote research

on floods. This can be aided by shifting the goal of foreign aid assistance projects to *pre-facto* aid and focus more on institutional capacity and governance. Responses to flooding must be made part of daily governance, not only *post-facto* relief. In other words, the institutional capacity to respond to floods whenever and wherever they occur must be strengthened.

Lessons Learned

The respective roles and responsibility of the individual and state regarding response to flood hazards are defined according to the different traditions and institutions present in a country, while the definition of an appropriate flood management strategy is shaped by history and reflects the culture of that country and local flood conditions. As expected, differences in GNI, the proportion of the population living in the international river basins, the history and the average spending of a household on food[70] are all reflected in the flood management policy adopted in different countries and the consequences of transboundary floods in terms of financial damages, and death and displacement tolls.

The structure of the institutions created in both countries is influenced by, first of all, the quantity of water present; when there is sufficient water, as in the Netherlands, there is no immediate need for tight arrangements among users and conflicts and environmental concerns are minimal. Another influence on the structure of institutions is the speed at which water problems have come up. In the case of the Netherlands, an umbrella-organization was present for hundreds of years when catastrophe hit in 1953 – the institutional capacity was present to respond, adjust and change in response to this crisis. Mozambique on the other hand, has to deal with catastrophic flood events nearly every year, while institutional capacity is virtually absent. Mainly due to its chaotic history and turbulent past three decades, it does not have the financial nor human resources to adjust or make drastic institutional changes in an orderly manner. A third influence is the relative population density. In well managed, densely populated areas, like the Netherlands, many management decisions reside in local units where people readily cooperate and work together to solve conflicts and maximize mutual benefits. The local water management organizations in the Netherlands have had hundreds of years to

[70] An industrialized country is likely to have about 4% of the population engaged in agriculture, with agricultural production contributing less than 7% of national income; the average household is likely to spend less than 25% of their income on food. Conversely, developing countries are characterized by 60-70% of the population living in rural area, with 30% of national income coming from agriculture and by the poor spending 60-70% of their income on food. Agriculture in the developed countries is typically heavily subsidized whereas in developing countries it is a net contributor to the national exchequer (Green, 2006).

fine-tune their communication, while the regional water management agencies in Mozambique were just erected and, except for one, are not even operational yet.

In the developed world, the past is largely a history of mending failures in water management and much of the current investment in those countries is devoted to seeking to recover from the damage done to rivers and catchments over the last one hundred years. Consequently if we look backwards, it should only be to learn lessons for the future. Limitations of current knowledge will always be a problem, but the weaknesses of the past approaches can be avoided. Perhaps the most useful of those lessons is about attitudes, rather than about technologies adopted. Past approaches were characterized by technology driven solutions, while ignoring alternatives and believing that the problem could be fixed.

In general, lack of scientific assessment of vulnerabilities, weakness and corruption in governance structure, and inadequate required technical, human and financial resources exacerbate vulnerability to floods along international waters. So in the less-developed countries, like Mozambique, where there is a lack of access to resources, to education and to decision-makers, and poverty generates vulnerability amongst people, societies are particularly vulnerable to floods, even exacerbating the lasting effects of these events (Green *et al.*, 2000, Blaikie *et al.*, 1994). In these areas, shared flood events need to be addressed systemically through stimulating social and economic development rather than only through flood alleviation schemes. Noteworthy is the consideration that less developed countries often have highly variable environmental conditions[71]. Hence, flood management policies that are successful in Europe are not necessarily effective in countries with more extreme or variable climates.

This (and the previous) chapter showed that the greatest impact of floods is still on the poorer countries in the world, which exerts an enormous toll on future development. It is therefore highly recommended to help decrease the vulnerability of those who are most exposed. This would include searching for alternative flood management strategies to decrease overall vulnerability. If recommending an alternate or additional flood management plan for

[71] Savenije (1995) suggests that developed countries are not more developed because of a higher state of knowledge, but they are developed because of the robust nature of the environment where these societies have formed, suggesting that the European environment is better able to absorb or adapt to shifting forces such as increasing precipitation or population pressure (Mudelsee *et al.*, 2003).

Mozambican (shared) river basins, it would be very tempting to adopt flood management policies that have been implemented in developed countries that have helped allow developed countries like the Netherlands to evolve into highly structured and powerful societies. However, it is now recognized in many developed countries like the Netherlands that to completely control floodwaters is not the optimal flood management strategy. In addition, years of living along the riverbanks have made the inhabitants learn to live with and predict future floods. This knowledge is essential and should be regarded as valuable while forming the basis of future flood management policies (Van Ogtrop *et al.*, 2005). Thus, it is highly recommended that strategies other than those traditionally adopted in developed countries be considered, especially because in Mozambique (and for that matter, in China, Bangladesh, Cambodia, Poland, Germany, the United States, and Chili) flood management strategies are still based on a resistant system, and floods still cause disasters partly because of this utilization of this traditional approach. The choice for future flood management in Mozambique ought to consider the current speculations on changing climate conditions, as well as the population growth rates and choose the most sustainable path accordingly. Overall, it seems that the alternative flood management approach is the most flexible thus most sustainable choice for future flood management. In addition, increasing resilience can lessen the impact of or even prevent catastrophes. Compared to the Netherlands, very little needs to be undone in order to adhere to this alternative strategy, not only because there is still more faith and reliance on traditional flood risk warnings and indigenous approaches than the traditional engineering structures, which is already very compatible to the holistic approach of flood management, but also because very little needs to be undone in order to adhere to this alternative strategy. Hence, Mozambique can even end up setting an example for developed countries when it comes to post-modern flood management.

Chapter Five: Conclusions

Floods are among the world's most frequent and most destructive of all natural disasters and annually affect the lives of millions all over the globe. The dramatic reality of floods and their effects goes back to the beginning of history of the earliest civilizations. The force of excessive or uncontrolled water, or its intrusion into areas reserved for other purposes, represents a hazard to the majority of the global population's way of life and their social well-being. River floods, the type of flood examined in this research, have become more frequent over the last 25 years. However, not much is known about vulnerability of societies to floods. The international community has responded to this concern with an increase in research activities, but seem to ignore the fact that floods do not recognize national boundaries; the phenomena of shared, or transboundary floods occurring in international river basins (IRBs) is rarely touched upon. Consequently, vulnerability and adaptation to shared floods is poorly understood. The primary purpose of the present work therefore is to fill this gap in knowledge and explore transboundary river flood events in more detail.

To meet this objective, global data was combined to assess how many of all floods were riverine and how much of these were shared between two or more countries. The results show that in the period 1985-2005 a total of 1760 worldwide river flood events killed over 112 thousand people, affected 354 million individuals, and caused 687 billion US dollars of damage. Almost one tenth, 175 of the 1760, of all river floods were shared by two or more countries, but globally accounted for 32% of all casualties, almost 60% of all affected individuals and 14% of all financial damage. These numbers point to the massive impacts of both national and transboundary river flood events on a global scale. Our data furthermore shows that transboundary floods are more severe in their magnitude, affect larger areas, result in higher death tolls (except in the high developed countries) as well as higher displacement tolls in high developed countries, and cause more financial damage than non-shared river floods do. On a global scale as well as a per country scale, we clearly see that shared floods are more severe than all river floods combined. However, selecting the one country, continent or river basin that is the most vulnerable to –transboundary– floods, is impossible since the answer heavily depends upon the specific definition of vulnerability. This indicates that vulnerability to floods is a complex phenomenon which cannot be explained by using the results of this study only.

The research furthermore revealed an alarmingly low institutional capacity related to transboundary river floods. Although almost 30% of the IRBs have some form of shared rivers institutions, only eight of these institutions are dealing with transboundary flooding, five of which are located in Africa, two in Europe and one in Asia. Globally, no more than 11 basins have international freshwater treaties with floods as their principal issue. However, a slightly alarming trend of less cooperative events related to floods over the past 15 years is noticeable. More than 15% of the IRBs have experienced transboundary floods but do not have any type of institutional capacity in the form of international institutions or organizations for international river basins, let alone institutions specifically aimed at shared flood events. Their average death and displacement tolls relative to the million population living in the IRBs are higher than in the basins that do have such institutional capacity, despite the fact that the flood magnitudes are always significantly higher. This could be an important indication that institutional capacity, i.e. international cooperation before, during and after the flood events, might play an important role in the reduction of flood-related casualties and affected individuals. Collectively, these results indicate that there may be more need for official international institutions dealing with transboundary flood-events, especially in those basins that have experienced more than one transboundary flood in the past, nor signed any flood-related treaties[72]. Those IRBs that already have set up institutions to cooperate over their shared waters, but as of yet have not focused on flood-events, should seriously consider including flood-related issues in their mandate.

History shows that existing institutions should be able to absorb and manage any change – which includes shared flood events – that occurs in the basin's physical setting. This requires that sound, comprehensive institutions to deal with these events are in place, but also that these institutions and organizations should be flexible enough to adapt to uncertainty. Flood management is difficult enough in national river basins controlled by a single, national authority, but becomes even more challenging when dealing with transboundary floods. We therefore examined the differences or similarities in vulnerability to transboundary floods by looking at the responses, measures taken, international water treaties signed and institutions created of a developed downstream country prone to flooding (the Netherlands) and a lesser developed yet relative equally exposed country (Mozambique). The comparison indicated that

[72] The Juba-Shibeli in Africa, the Han, Kura-Araks and Ma in Asia, the Maritsa and Po in Europe and six basins in South America: the Coco/Segovia, Grijalva, Artibonite, Changuinola, Coatan Achute and Orinoco river basins.

Mozambique's flood management approach mostly still resembles the old Dutch approach (and many other developed countries') of trying to prevent floods by fighting the water with massive flood-containment and landscape altering constructions. However, it is now recognized that controlling floodwaters is not the optimal flood management strategy. Thus while it would be very tempting to adopt flood management policies that have been implemented in developed countries and have helped allow developed countries like the Netherlands to evolve into the highly structured and powerful societies they are today, it is not recommendable. The choice for future flood management in Mozambique should be for the less rigid strategy, since changing climate conditions and population growth rates will most likely demand flexibility. Therefore, to decrease the vulnerability of those who are most exposed, the pathway of living with floods would be the most sustainable choice for future flood management. Compared to the Netherlands, very little needs to be undone in order to adhere to this alternative strategy, not only because there is still more faith and reliance on traditional flood risk warnings and indigenous approaches than the traditional engineering structures, already very compatible to the holistic approach of flood management, but also because very little needs to be undone in order to adhere to this alternative strategy. Hence, Mozambique can even end up leading the way and setting the example for developed countries when it comes to post-modern flood management.

This study provides unique qualitative and quantitative data on the phenomenon of transboundary river flood events on a global, continental, IRB and country scale. It is hoped that the findings are considered by water policy makers around the world during the design or readjustment of international flood policies.

Bibliograhpy

Adger, W. N. 2000. Social and ecological resilience: are they related? Progress in Human Geography 24:347-364.

Alexander, W. J. R. 2000. Flood risk reduction in developing countries. An African perspective. Pages 260-270 in: D. J. Parker, editor. Floods. Routledge, London.

Anderson, Mary. 1991. Which costs more: prevention or recovery? In: Managing Natural Disasters and the Environment, Alcira Kreimer and Mohan Munasinghe, editors. World Bank.

Arnell, N. W. 1998. Climate change and water resources in Britain. Climatic Change 39:83-110.

Arnell, N. W. 2002. Hydrology and Global Environmental Change. Pearson Education Limited, Essex.

Baillat, A. 2004. Hydropolitics in the Himalayan Kingdoms. Two cases of Cross-Asymmetry: the Kingdom of Nepal and the Republic of India and the Kingdom of Bhutan and the Republic of India. In: Fifth Pan-European Conference. Standing Group on International Relations, The Hague.

Beaumont, P. 1998. Restructuring of water usage in the Tigris-Euphrates Basin: the impact of modern water management policies. In: J. Coppock, Miller, J.A., editors. Transformations of Middle Eastern natural environments: legacies and lessons. Yale University, New Haven.

Berkes, F., Colding, J., Folke, C., editors. 2003. Navigating Social-Ecological Systems. Building Resilience for Complexity and Change. Cambridge University Press, Cambridge.

Berz, G., Kron, W., Loster, T., Rauch, E., Schimetschek, J., Schmieder, J., Siebert, A., Smolka, A., Wirtz, A. 2001. World map of natural hazards - a global view of the distribution and intensity of significant exposures. Natural Hazards 23:443-465.

Birkes, F., Folke, C., Colding, J., editors. 1998. Linking social and ecological systems. Cambridge University Press, Cambridge.

Biswas, A. K. 2004. Integrated Water Resources Management: A Reassessment. A Water Forum Contribution. Water International 29:248-256.

Blaikie, P., Cannon, T., Davis, I., Wisner, B. 1994. At risk: natural hazards, people's vulnerability, and disasters. Routledge, New York.

Blomquist, W., Schlager, E. 2005. Political Pitfalls of Integrated Watershed Management. Society and Natural Resources 18:101-117.

Brookes, A. 1988. Channelised Rivers: Perspectives for Environmental Management, Chichester: John Wiley.

de Bruijn, K. M., Klijn, F. 2001. Resilient flood risk management strategies. In: IAHR Congress.

De, U. S., Khole, M., Dandekar, M. M. 2004. Natural hazards associated with meteorological extreme events. Natural Hazards 31:487-497.

Bronstert, A. 2003. Floods and climate change: interactions and impacts. Risk Analysis 23:545-557.

Carmo Vaz, A. 2000. Coping with floods - the experience of Mozambique. In: 1st WARFSA/WaterNet Symposium: Sustainable Use of Water Resources, Maputo.

Carmo Vaz, A., Lopes Pereira, A. 2000. The Incomati and Limpopo international river basins: a view from downstream. Water Policy 2:99-112.

Chan, N. W., Parker, D.J. 1996. Response to Dynamic Flood Hazard Factors in Peninsular Malaysia. Geographical Journal 162:313-325.

Changnon, S. A., editor. 1996. The Great Flood of 1993: Causes, Impacts and Responses. Westview Press, Boulder, CO.

Chow, V. T. 1956. Hydrologic studies of floods in the United States. International Association of Scientific Hydrology 42:134-170.

Christie, F., Hanlon, J. 2001. Mozambique and the Great Flood of 2000. James Currey, Indiana University Press, Oxford, Bloomington, Indianapolis.

CIA 2006. The World Factbook. Online country information available at: https://www.cia.gov/cia/publications/factbook/index.html (last accessed 29 November 2006).

Cuny, F. C. 1983. Disaster and development. Oxford University Press, New York.

Cutter, S. L., Mitchell, J. T. and Scott, M. S. 2000. Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. Annals of the Association of American Geographers 90:713-737.

Darby, H. C. 1983. The changing Fenland. Cambridge University Press, Cambridge.

Dellapenna, J. W. 2001. The customary international law of transboundary fresh waters. International Journal of Global Environmental Issues 1:264-305.

Derrick Sewell, W. R. 1971. Human responses to floods. In: R. J. Chorley, Kates, R.W., editors. Introduction to geographical hydrology. Spatial aspects of the interactions between water occurrence and human activity. Methuen & Co Ltd, London.

Dixit, A. 2003. Floods and vulnerability: need to rethink flood management. Natural Hazards 28:155-179.

DNA (Direcção Nacional de Águas (DNA) [National Directorate of Water]), 1995. National Water Policy.

DNA (Direcção Nacional de Águas (DNA) [National Directorate of Water], 2000. Recommendation by Panel of Experts. International Conference for Mozambique Flood. 25-28 October 2000, Maputo.

Drabek, T. E. 2000. Social factors constraining responses to warnings. Pages 361-376 in: D. J. Parker, editor. Floods. Routledge, London.

Enserink, B., Kamps, D., Mostert, E. 2003. Public participation in river basin management in the Netherlands: (not) everybody's concern. RBA-Centre, Delft University of Technology, Delft.

Feitelson, E. 2000. The upcoming challenge: transboundary management of the hydraulic cycle. Water, Air and Soil Pollution 123:533-549.

Follke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, CS, Walker, B. 2002. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Ambio 31:437-440.

Frederiksen, H. D. 1992. Water Resources Institutions. Some Principles and Practices. World Bank Technical Paper 191, World Bank, Washington, D.C.

Genschel, Philipp. 1997: The Dynamics of Inertia: Institutional Persistence and Change in Telecommunications and Health Care. In: Governance 10(1): 43–66.

Giordano, M., Wolf, A.T. 2001. Incorporating equity into international water agreements. Social Justice Research 14:349-366.

Gopalakrishnan, C., Tortajada, C., Biswas, A.K., editors. 2005. Water Institutions: Policies, Performance and Prospects.

Grant, P., Glynn, J., Spaliviero, F., Cooper, J., Conroy, A., Finlinson, B., Wallace, S., Jarritt, N. 2005. Thames Gateway London Partnership. Strategic Flood Risk Assessment of East London. Entec UK Limited.

Green, C. 2006. The social construction of floods. Pages 519-536 in: D. W. Knight, Shamseldin, A. Y., editors. River Basin Modelling for Flood Risk Mitigation. Taylor & Francis Group, Leiden.

Green, C. H., Parker, D.J., Tunstall, S.M. 2000. Assessment of Flood Control and Management Options. Prepared for the WCD. Flood Hazard Research Centre, South Africa.

Gruntfest, E. 1994. Flood disaster relief, rehabilitation and reconstruction. In: G. Rossi, Harmancioglu, N., Yevjevich, V., editors. Coping with floods. Kluwer Academic, Dordrecht; Boston.

Guha-Sapir, D., Hargitt, D., Hoyois, P. 2004. Thirty years of natural disasters 1974-2003: the numbers. Centre for Research on the Epidemiology of Disasters, Louvain-la-Neuve.

Gunderson, L. H., Holling, C.S., Light, S.S., editors. 1995. Barriers and Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press, New York, NY.

Haque, C. E. 2003. Perspectives of Natural Disasters in East and South Asia and the Pacific Island States: Socio-economic Correlates and Needs Assessment. Natural Hazards 29:465-483.

Hesselink, A. W. 2002. History makes a river. Morphological changes and human interference in the river Rhine, the Netherlands. Utrecht University, Utrecht.

Hilborn, R, D Gunderson.1996. Chaos and paradigms for fisheries management. Mar. Pol. 20:87-89.

Hilborn, R. and C. J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York.

Holling, C. S. 2001. Understanding the Complexity of Economic, Ecological, and Social Systems. Ecosystems 4:390-405.

Holling, C. S. 2004. From Complex Regions to Complex Worlds. Ecology and Society 9.

Hossain, F., Katiyar, N. 2006. Improving Flood Forecasting in International River Basins. EOS (AGU) 87:49-50.

Hoyois, P., Guha-Sapir, D. 2003. Three decades of floods in Europe: a preliminary analysis of EMDAT data. Working paper (draft). CRED.

Huang, G. H. 2005. Living with Flood: A Sustainable Approach for Prevention, Adaptation, and Control. Water International 30:2-4.

Huisman, P., Cramer, W., van Ee, G., Hooghart, J.C. 1998. Water in the Netherlands. Netherlands Hydrological Society, Delft.

Jagerskop, A. 2002. Contributions of regime theory in understanding interstate water cooperation: lessons learned in the Jordan river basin. In: A. Turton, Henwood, R., editors. Hydropolitics in the Developing World: Southern African Perspective. University of Pretoria, African Water Issues Research Unit, Pretoria.

Jonkman, S. N. 2005. Global Perspectives on Loss of Human Life Caused by Floods. Natural Hazards 34:151-175.

Junk, W. J., Welcomme, R.L. 1990. Floodplains. Pages 491-524 in: B. C. Patten, editor. Wetlands and shallow continental water bodies. Vol. 1: Natural and human relationships. SPB Academic Publishing bv, The Hague.

Kates, R. W. 1962. Hazard and Choice Perception in Flood Plain Management. Research paper no. 78, University of Chicago, Department of Geography.

Kemper, K., Dinar, A., Blomquist, W., editors. 2005. Institutional and policy analysis of river basin management decentralization. The principle of managing water resources at the lowest appropriate level - when and why does it (not) work in practice? World Bank, Washington DC.

Klijn, F., Buuren, M., van, van Rooij, S.A.M. 2004. Flood-risk management strategies for an uncertain future: living with Rhine river floods in the Netherlands? Ambio 33:141-147.

Kliot, N., Shmueli, D., Shamir, U. 2001. Development of institutional frameworks for the management of transboundary water resources. International Journal of Global Environmental Issues 1:306-328.

Klise, G. T., Neir, A. M., Campana, M.E. forthcoming. Hydrovulnerability in the Middle East. In: A. T. Wolf, editor. Hydropolitical resilience and vulnerability, Corvallis.

Knight, D. W., Shamseldin, A. Y., editors. 2006. River Basin Modelling for Flood Risk Mitigation. Selected Papers. Taylor & Francis Group / Balkema, Leiden.

Kovacs, P. J. E. 2004. Increase community protection from extreme weather events. Isuma 2:4 (57-61).

Kramer, A. 2003. Managing Freshwater Ecosystems of International Water Resources - The Case of the Maputo River in Mozambique. Working paper 07/2003. Institute for Landscape and Environmental Planning, Berlin.

Kundzewicz, Z. W., Budhakooncharoen, S., Bronstert, A., Hoff, H., Lettenmaier, D., Menzel, L., Schulze, R. 2001. Floods and droughts: coping with variability and climate change. In: conference proceedings of the International Conference on Freshwater, Secretariat of the International Conference on Freshwater, editor, Bonn, Germany.

Laska, S., Wetmore, F. 2000. Reducing Flood Loss Potential by Flood proofing in the USA. In: D. J. Parker, editor. Floods. Routledge, London.

Lawler, A. 2006. North Versus South, Mesopotamian Style. Science 312:1458-1463.

Lynne, G. D., Milon, J.W., Wilson, M.E. 1990. Identifying and measuring potential conflict in water institutions. Water Resources Bulletin 26:669-676.

Levi, M. 1997. A Model, a Method, and a Map: Rational Choice in Comparative and Historical Analysis. Comparative Politics: Rationality, Culture and Structure. M. I. Lichbach, Zuckerman, A. S. Cambridge, Cambridge University Press: 19-41.

Maganga, F. P., Kiwasila, H.L., Juma, I.H., Butterworth, J.A. 2003. Implications of customary norms and laws for implementing IWRM: Findings from Pangani and Rufiji basins,Tanzania. In: 4th WaterNet/Warfsa Symposium: Water, Science, Technology & Policy Convergence and Action by All.15-17 October 2003. WaterNet/Warfsa, Tanzania.

Marjanovic, P., Nimpuno, K. 2003. Living with Risk: Toward Effective Disaster Management Training in Africa. In: A. Kreimer, M, Arnold, A. Carlin (2003) Building Safer Cities. The Future of Disaster Risk. The World Bank, Washington DC.

Marsalek, J., Stancalie, G., Balint, G., editors. 2006. Transboundary Floods: Reducing Risks Through Flood Management. Proceedings of the NATO Advanced Research Workshop on Transboundary Floods: Reducing Risks and Enhancing Security Through Improved Flood Management Planning, Baile Felix (Oradea), Romania, 4-8 May 2005. Springer, Berlin.

Middelkoop, H., Kwadijk, J.C.J. 2001. Towards integrated assessment of the implications of global change for water management - the Rhine experience. Phys. Chem. Earth (B) 26:553-560.

Mileti, D. S. 1999. Disasters by design: a reassessment of natural hazards in the United States. Joseph Henry Press, Washington D.C.

Mileti, D. S. 1994. Public response to flood warnings. Coping with floods. G. Rossi, Harmancioglu, N., Yevjevich, V. Dordrecht, Boston, Kluwer Academic: 549-564.

Millington, P. 2002. Internationalising the Murray Darling Basin experience. Paper presented at: Mekong Dialogue Workshop: "International Transfer of river basin development experience: Australia and the Mekong Region", Brisbane Australia, 2 September 2002.

Ministry of Housing Spatial Planning and the Environment. 2001. Third Netherlands' national communication on climate change policies. Prepared for the Conference of Parties under the Framework Convention on Climate Change. The Hague, Ministry of Housing, Spatial Planning and the Environment: 132.

Ministry of Housing Spatial Planning and the Environment, Ministry of Agriculture, Nature and Food quality. 2001. De wegen van het water. Waterbeheer in de 21e eeuw. The Hague, Ministry of Housing, Spatial Planning and the Environment, Ministry of Agriculture, Nature and Food quality.

Ministry of Foreign Affairs. 1998. The Management of Shared River Basins, experiences from SADC and EU. The Hague, SDU.

Ministry of Transport, Public Works and Water Management. 2005. Tussenrapportage onderzoeksprogramma Rampenbeheersingsstratgegie overstromingen Rijn en Maas. The Hague, Ministry of Transport, Public Works and Water Management.

Ministry of Transport, Public Works and Water Management. 2004. Methode voor de bepaling van het aantal slachtoffers ten gevolge van een grootschalige overstroming. Onderbouwing van de slachtofferfuncties voor de Standaardmethode Schade en Slachtoffers als gevolg van overstromingen. The Hague, Ministry of Transport, Public Works and Water Management.

Ministry of Transport, Public Works and Water Management. 2000. Anders omgaan met water. Waterbeleid voor de 21e eeuw. The Hague, Ministry of Transport, Public Works, and Water Management.

Mokyr, J. 1999. The Industrial Revolution and the Netherlands: Why did it not happen? Prepared for the 150th Anniversary Conference of the Royal Dutch Economic Association, 10-11 December 1999, Amsterdam, the Netherlands.

Moser, D. A. 1994. Economics of selection of flood mitigation measures. In: Coping with floods. G. Rossi, Harmancioglu, N., Yevjevich, V. Dordrecht; Boston, Kluwer Academics: 585-596.

Muckleston, K. W. 2003. International Management in the Columbia River system. Oregon State University, Corvallis.

Mudelsee M, B. M., Tetzlaff G, Grünewald U. 2003. No upward trends in the occurrence of extreme floods in central Europe. Nature 425: 166-169.

Munich, Re. 2006. Topics Geo - Annual review: Natural catastrophes 2005. Munich Re, Munich.

Mutter, J. C. 2005. The Earth Sciences, Human Well-Being, and the Reduction of Global Poverty. Eos 86:157, 164-165.

Myers, M.-F., Passerini, E. 2000. Floodplain management: historic trends and options for the future. Pages 244-253 in: D. J. Parker, editor. Floods. Routledge, London.

North, D. 1990. Institutions, Institutional Change, and Economic Performance. Cambridge University Press, Cambridge.

OdaMoz. 2006. Overseas Development Assistance to Mozambique. Online database available at http://www.odamoz.org.mz/

Ohl, C. A., Tapsell, S. 2000. Flooding and human health. The dangers posed are not always obvious. BMJ 321:1167-1168.

Olsthoorn, A. A., Tol, R.S.J., editors. 2001. Floods, flood management and climate change in the Netherlands. Institute for Environmental Studies, Amsterdam.

Olsson, M. R. 2003. The construction of the meaning and significance of an 'author' among information behaviour researchers. A social constructivist approach. Doctoral dissertation, University of Technology, Sydney, Australia.

Ostrom, E. 1998. A Behavioral Approach to the Rational Choice Theory of Collective Action. Presidential Address, American Political Science Association 1997. American Political Science Review 92 (1). 1-22.

Ostrom, E. 1990. Governing the commons. Cambridge University Press, Cambridge.

Parker, D. J. 1996. International Experience with Flood Hazard Management: Key trends and General Lessons. In: 6th BRAND 96 European Congress, Amsterdam, the Netherlands.

Parker, D. J., editor. 2000. Floods. Routledge, London.

Penning-Rowsell, E. C., Fordham, M., editors. 1994. Floods across Europe. Middlesex University Press, London.

Phillips, D., Daoudy, M., McCaffrey, S., Ojendal, J., Turton, A. 2006. Trans-boundary Water Cooperation as a Tool for Conflict Prevention and for Broader Benefit-sharing. Prepared for the Ministry of Foreign Affairs, Sweden. Phillips Robinson and Associates, Windhoek.

Pielke, Jr., R. A. 1999. Nine fallacies of floods. Climatic Change 42:413-438.

Pierson, P. 2000. Increasing returns, path dependence, and the study of politics. American Political Science Review 94:251-267.

Purseglove, J. 1988. Taming the Flood, Oxford: OUP

Reisner, M. 1986. Cadillac Desert. Pimlico, London.

Rossi, G., Harmancioglu, N., Yevjevich, V., editors. 1994. Coping with floods. Kluwer Academic Publishers, Dordrecht.

Sadoff, C. W., Grey, D. 2002. Beyond the river: the benefits of cooperation on international rivers. Water Policy 4:389-403.

Savenije, H.H.G. 1995. Man and Water, Friends or Foes. UNESCO/IHE Institute for Water Education Press, Delft, the Netherlands.

Schipper, L., Pelling, M. 2006. Disaster risk, climate change and international development. Disasters. The Journal of Disaster Studies, Policy and Management 30:19-38.

Schulz, E.F., Koelzer, V.A., Mahmood, K., editors. 1972. Floods and Droughts. Proceedings of the Second International Symposium in Hydrology. Second International Symposium in Hydrology., Fort Collins, Colorado, USA, Water Resources.

Schmuck-Widmann, H. 1996. Living with floods: survival strategies of char-dwellers in Bangladesh. Hilbert and Posger, Berlin.

Scott, W. R. 1995. Institutions and organizations. SAGE Publications, Inc., Thousand Oaks. Semadeni-Davies, A. 2004. Urban water management vs. climate change: impacts on cold region waste water inflows. Climatic Change 64:103-126.

Shrader-Frechette, K. 2002. Environmental Justice: Creating Equity, Reclaiming Democracy (Environmental Ethics and Science Policy). Oxford University Press, New York.

Smith, D. I. 2000. Floodplain management: problems and opportunities. Pages 254-267 in: D. J. Parker, editor. Floods. Routledge, London.

Stahl, K. 2005. Influence of Hydroclimatology and socioeconomic conditions on water-related international relations. Water International 30:270-282.

Starosolszky, O. 1994. Flood control by levees. Pages 617-636 in: G. Rossi, Harmancioglu, N., Yevjevich, V., editors. Coping with floods. Kluwer Academics, Dordrecht; Boston.

Steel, B. S., Clinton, R.L., Lovich, N. P. 2003. Environmental politics and policy. A comparative approach, 1st edition. McGraw-Hill, New York.

Tobin, G.A. and Montz, B.E. 1997. Natural Hazards: Explanation and Integration, New York, N.Y: The Guilford Press.

Tol, R. S. J., van der Grijp, N., Olsthoorn, A. A., van der Werff, P. E. 2003. Adapting to climate: a case study on riverine flood risks in the Netherlands. Risk Analysis 23:575.

Transboundary Freshwater Dispute Database (TFDD). 2006. Online database at http:www.transboundarywaters.orst.edu

Turton, A., Henwood, R., editors. 2002. Hydropolitics in the Developing World: Southern African Perspective. University of Pretoria, African Water Issues Research Unit, Pretoria.

United Nations (UN). 1997. United Nations Convention on the Law of the Non-navigational Uses of International Watercourses.

United Nations (UN). 1992. Agenda 21. New York, United Nations.

United Nations Development Programme (UNDP). 2005. Human Development Report 2005. International cooperation at a crossroads. Aid, trade and security in an unequal world. New York, United Nations Development Programme.

United Nations Development Programme (UNDP). 2004. A Global Report: Reducing Disaster Risk, A Challenge for Development. New York, UNDP.

United Nations Environmental Programme (UNEP). 2006. Hydropolitical Vulnerability and Resilience along International Waters: Africa.

United Nations Environmental Programme (UNEP). 2004. Understanding Environment, Conflict and Cooperation.

United Nations Development Programme (UNDP). 2004. A Global Report: Reducing Disaster Risk, A Challenge for Development. United Nations Development Programme. Bureau for Crisis Prevention and Recovery. New York, UNDP.

van Aalst, M. K. 2006. The impacts of climate change on the risk of natural disasters. Disasters. The Journal of Disaster Studies, Policy and Management 30:5-18.

van der Zaag, P., Carmo Vaz, A. 2003. Sharing the Incomati waters: cooperation and competition in the balance. Water Policy 5:349-368.

van Ogtrop, F. F., Hoekstra, A. Y., van der Meulen, F. 2005. Flood management in the Lower Incomati river basin, Mozambique: Two alternatives. Journal of the American Water Resources Association 41:607-619.

van Steen, P. J. M., Pellenbarg, P. H. 2004. Water management challenges in the Netherlands. Tijdschrift voor Economische en Sociale Geografie 95:590-598.

Visser, J., Hemerijck, A. 1997. A Dutch Miracle. Job growth, welfare reform and corporatism in the Netherlands. Amsterdam University Press, Amsterdam.

Waggoner, P. E., editor. 1990. Climate change and U.S. water resources. John Wiley & Sons, New York.

Walker, B., Meyers, J.A. 2004. Thresholds in Ecological and Social-Ecological Systems: a Developing Database. Ecology and Society 9.

Ward, D. R. 2002. Water Wars. Drought, Flood, Folly, and the Politics of Thirst. Riverhead Books, New York.

Ward, R. 1978. Floods: A Geographical Perspective. Macmillan, London.

Wagret, P. 1967. Polderlands. London, Methuen.

Wegereef, S. 2006. Een kleine geschiedenis van de dijkschouw in het Rivierengebied. In:. Regionaal Archief Rivierenland.

White, G. 1945. Human adjustment to floods. Research paper # 29. University of Chicago, Chicago.

White, G. F., editor. 1974. Natural Hazards: Local, National, Global. Oxford University Press, New York.

Wind, H. G., Nierop, T. M., de Blois, C.J., de Kok, J.L. 1999. Analysis of flood damages from the 1993 and 1995 Meuse floods. Water Resources Research 35:3459-3465.

Wittfogel, K. A., editor. 1957. Oriental despotism: a comparative study of total power. Yale University Press, New Haven.

Woerdman, E. 2004. The institutional economics of market-based climate policy. Elsevier, Amsterdam.

Wolf, A. T., Yoffe, S., Giordano, M. 2003. International Waters: Identifying Basins at Risk. Water Policy 5:31-62.

Wolf, A., J. Natharius, J. Danielson, B. Ward, and J. Pender. 1999. International River Basins of the World, International Journal of Water Resources Development 15(4) 387-427.

World Bank. GNI ranking 2004. Washington, World Bank. http://www.worldbank.org

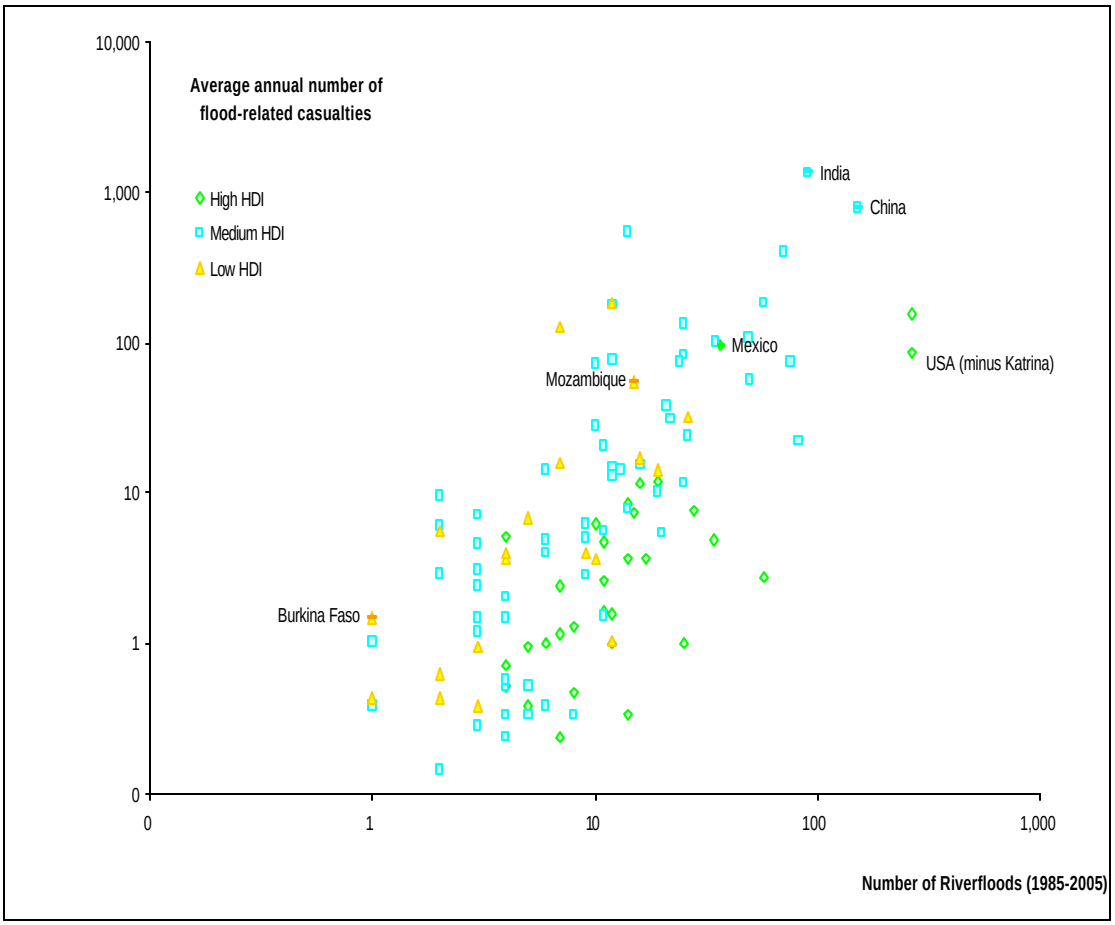
World Health Organization (WHO). 2002. Floods: climate change and adaptation strategies for human health. Report on a WHO meeting. London, WHO.

Worster, D. 1985. Rivers of Empire: Water, Aridity, and the Growth of the American West. Pantheon Books, New York.

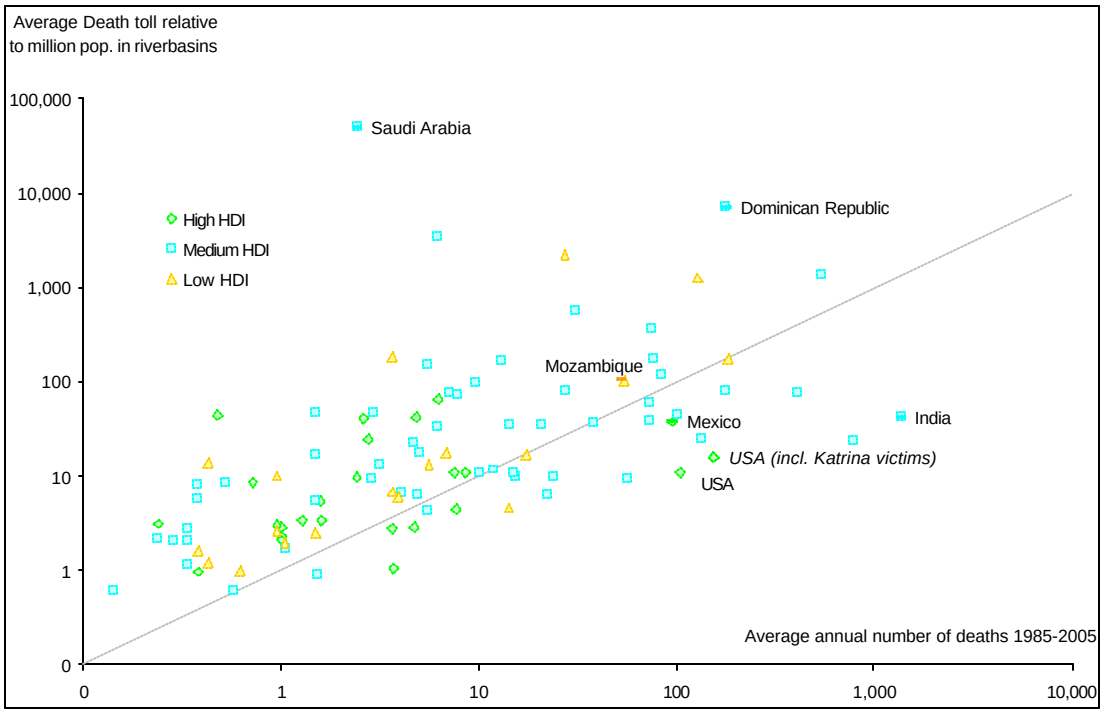
Yevjevich, V. 1994. Technology for coping with floods. Pages 35-46 in: G. Rossi, Harmancioglu, N., Yevjevich, V., editors. Coping with floods. Kluwer Academic, Dordrecht; Boston.

Yoffe, S. B. 2001. Basins at Risk: Conflict and Cooperation over International Freshwater Resources. Ph.D. dissertation. Oregon State University, Corvallis, USA.

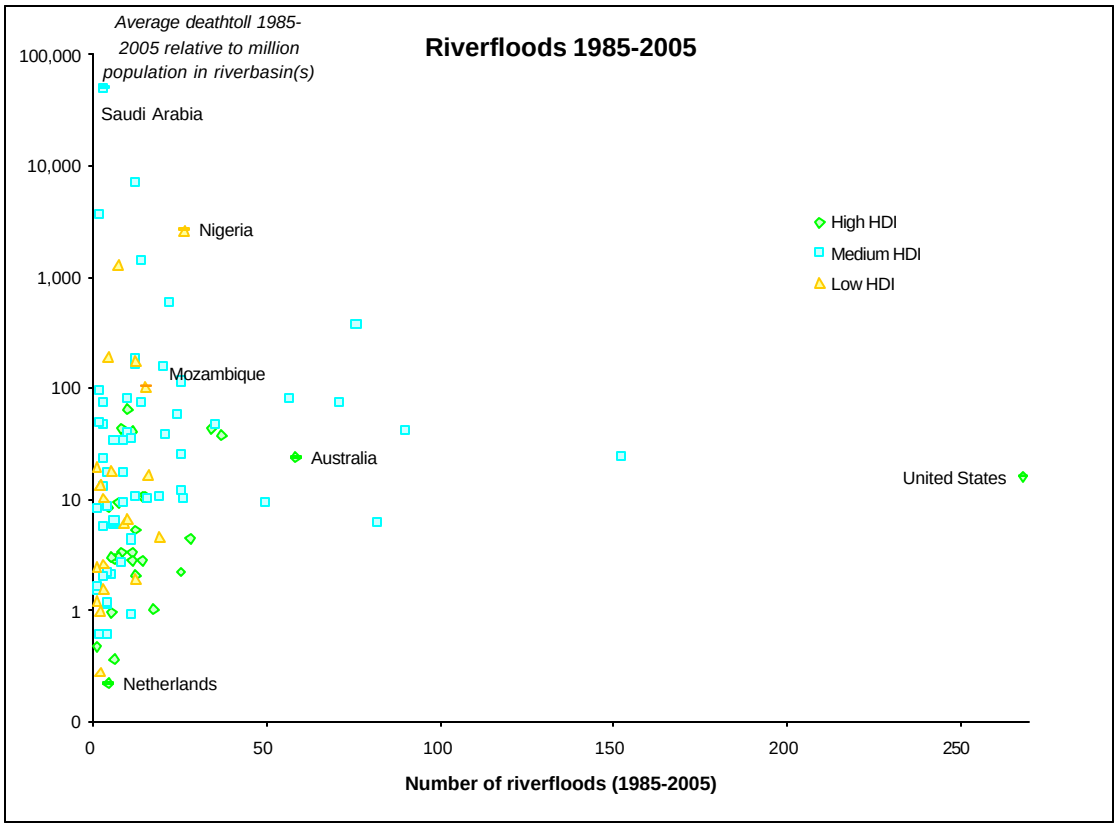
APPENDICES



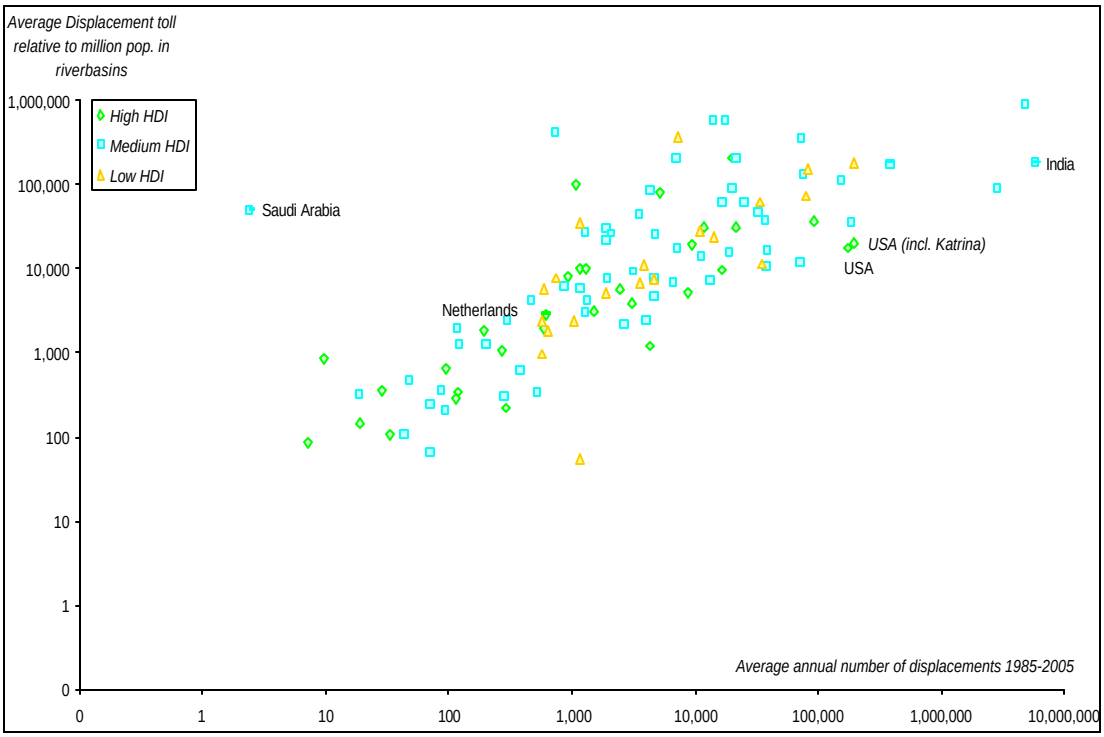
Appendix 2A: The average annual number of flood related casualties per country plotted against the total number of river floods that country has experienced during the period 1985-2005. Countries in the upper right have experienced many floods and have had high casualties on average.



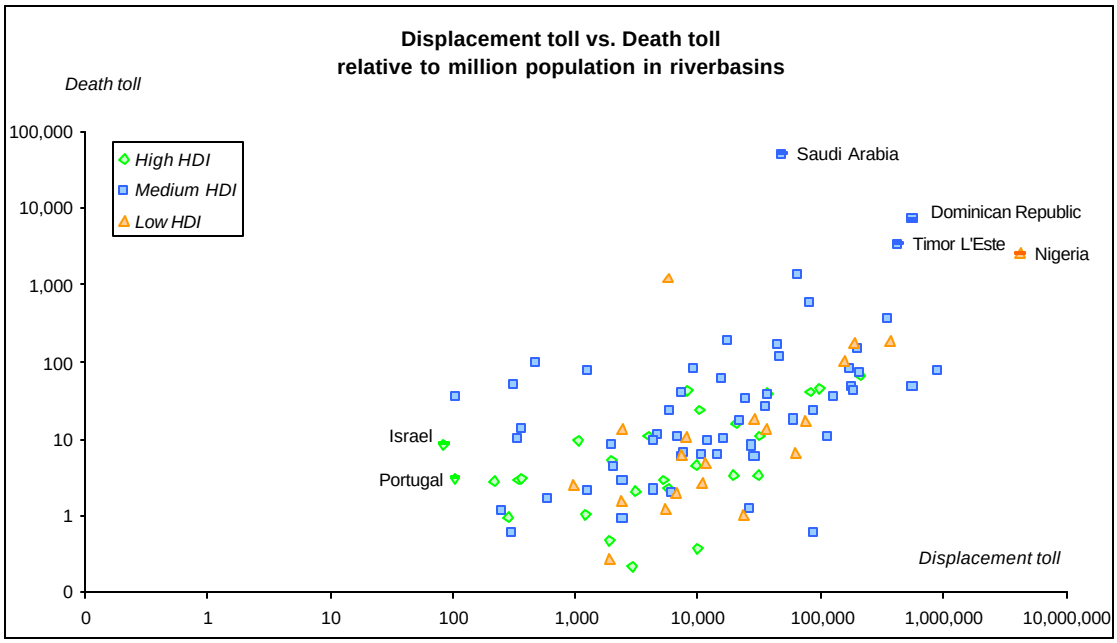
Appendix 2B: The average death toll relative to the million population living in the river basins plotted against the average annual number of flood-related deaths shows no apparent pattern, indicating that vulnerability to river floods cannot only be described by looking at these factors.



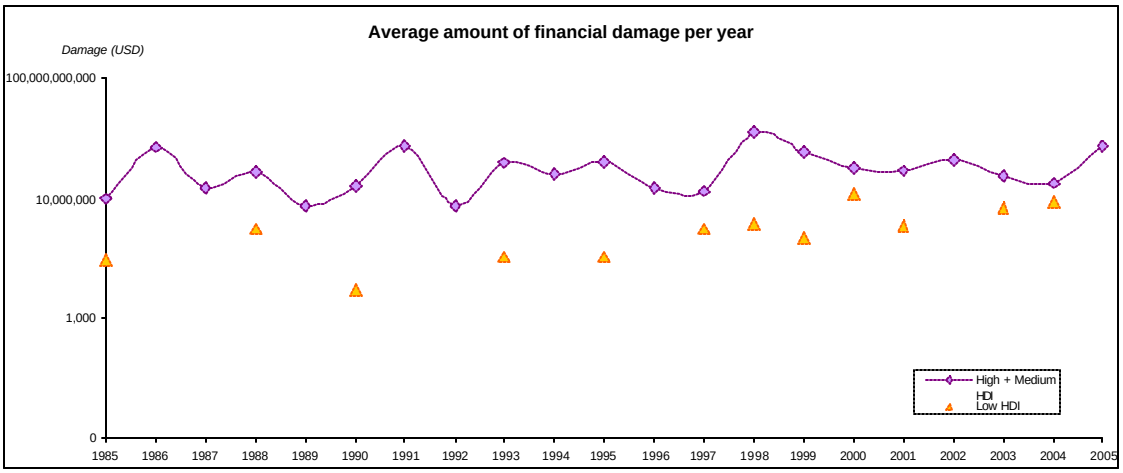
Appendix 2C: The average river flood related death toll relative to the million population living in the river basins plotted against the number of floods a country has experienced over the period 1985-2005.



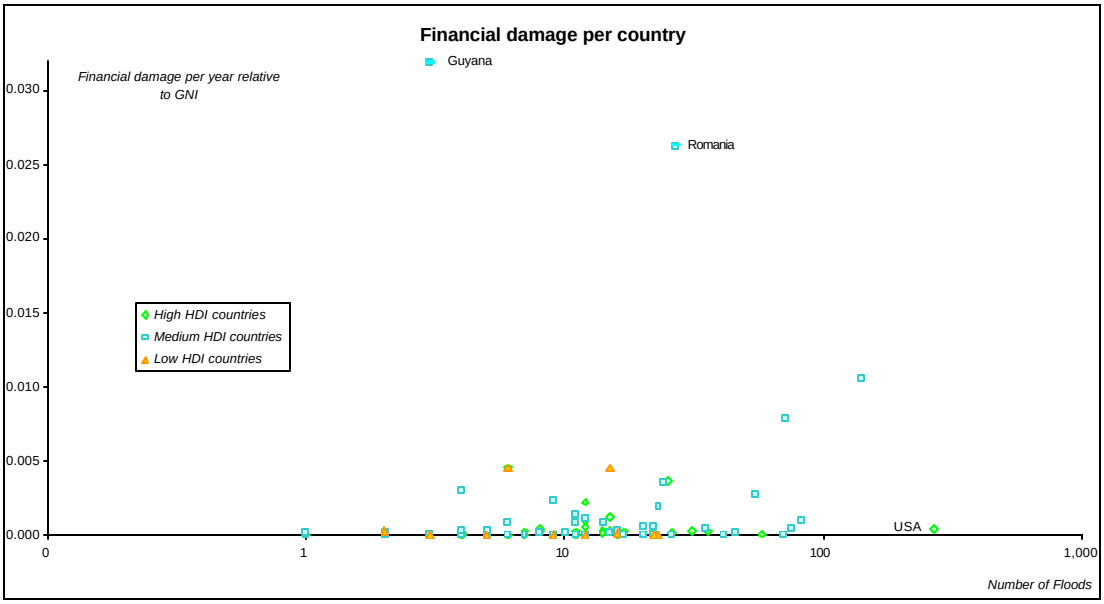
Appendix 2D: Average displacement toll relative to million population in the river basins plotted against the average annual number of displacements during the period 1985-2005. The trend that can be found when including the entire population of a country disappears when we only look at those fractions actually living in the river basins and therefore directly vulnerable to river floods.



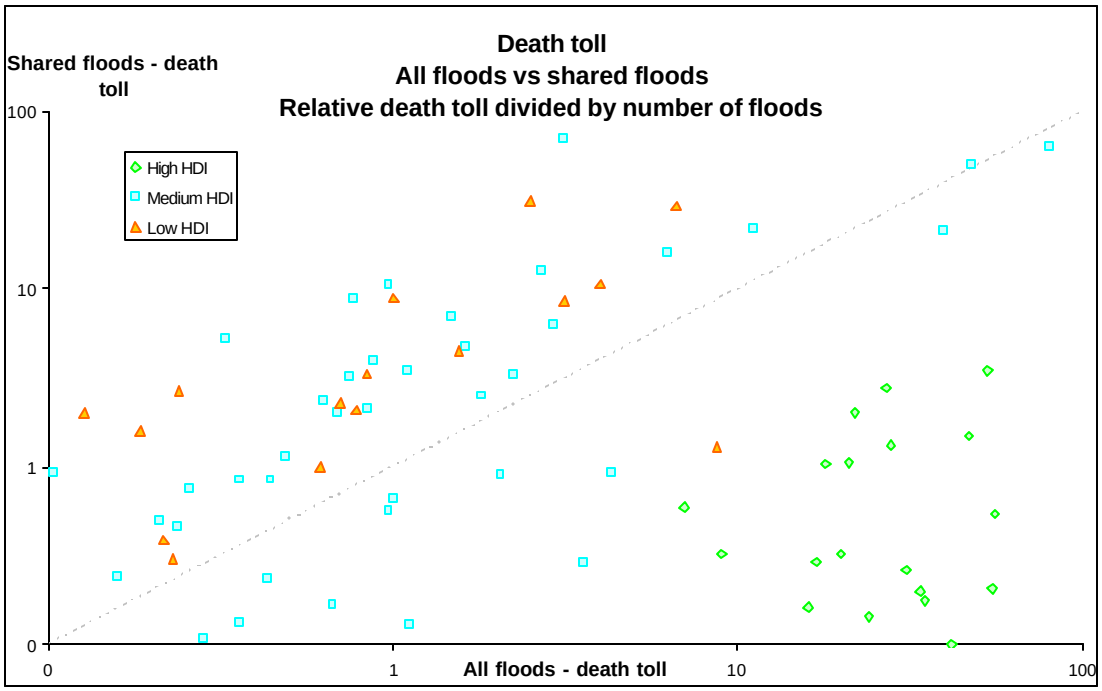
Appendix 2E: When we plot the average displacement toll and the average death toll per country (both relative to the million population in the river basins), we see that there is no distinct tendency of high displacement tolls resulting in lower death tolls.



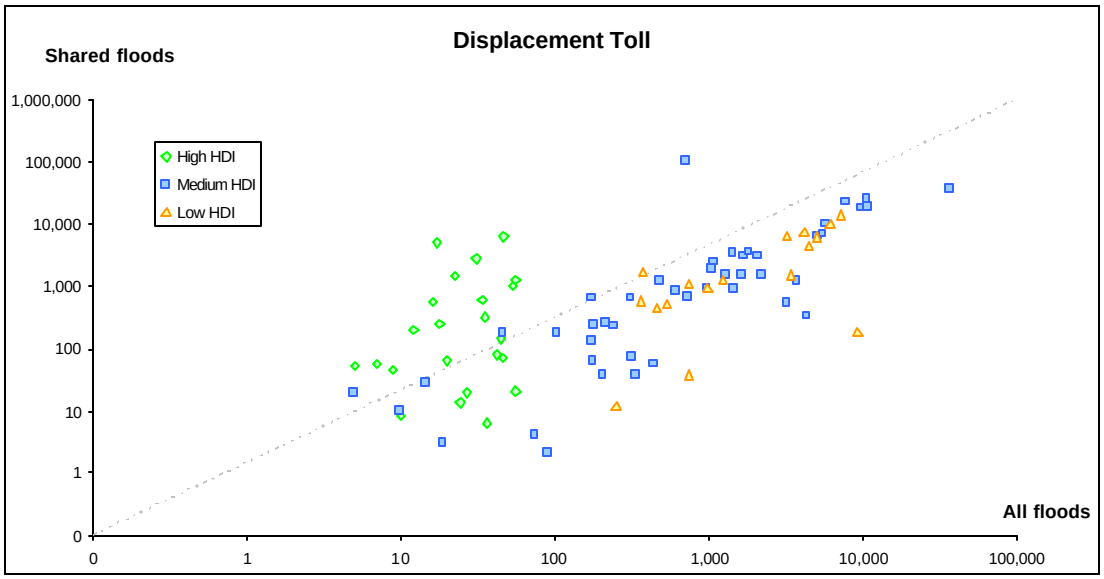
Appendix 2F: The average amount of financial damage per year, divided by the number of countries in that HDI class, with the purple line representing the high and medium HDI score countries, and the orange cones representing the low HDI score countries.



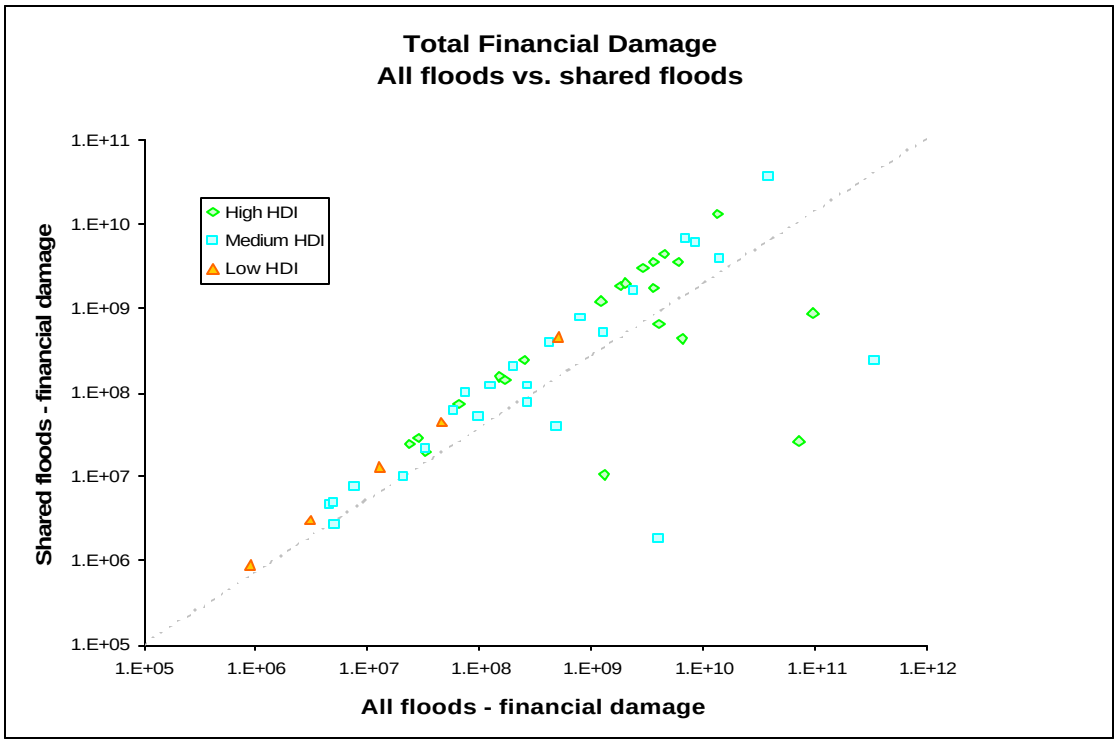
Appendix 2G: The number of floods and the financial damage per year relative to the GNI of a country clearly shows that it is mostly the medium developed countries that suffer the most financial damage relative to their GNI.



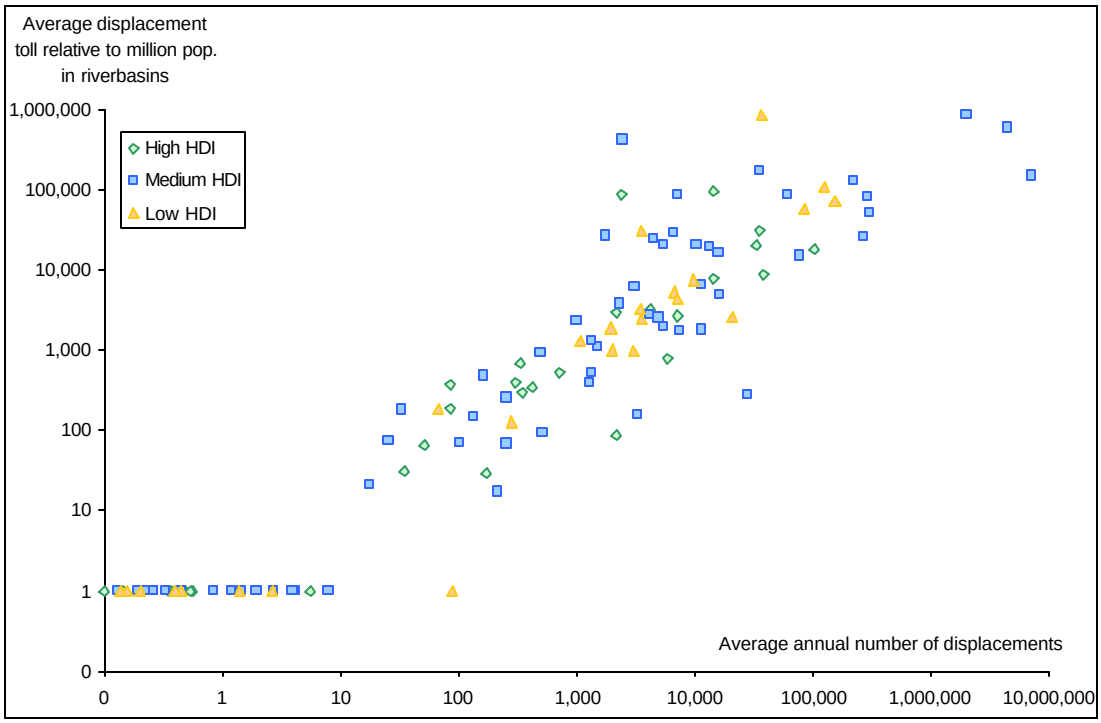
Appendix 2H: the high developed countries experience higher death tolls relative to their population during all river floods, while the low developed countries experience higher death tolls relative to their population during shared floods.



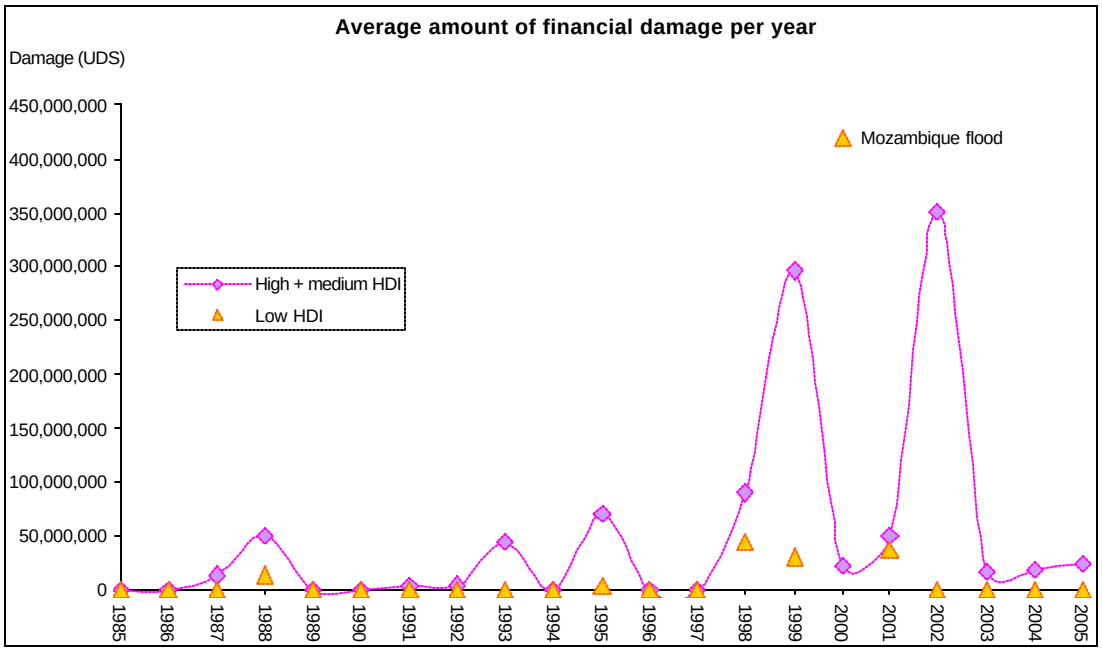
Appendix 2I: comparing the displacement tolls per types of floods shows that on average, transboundary river floods have lower displacement tolls.



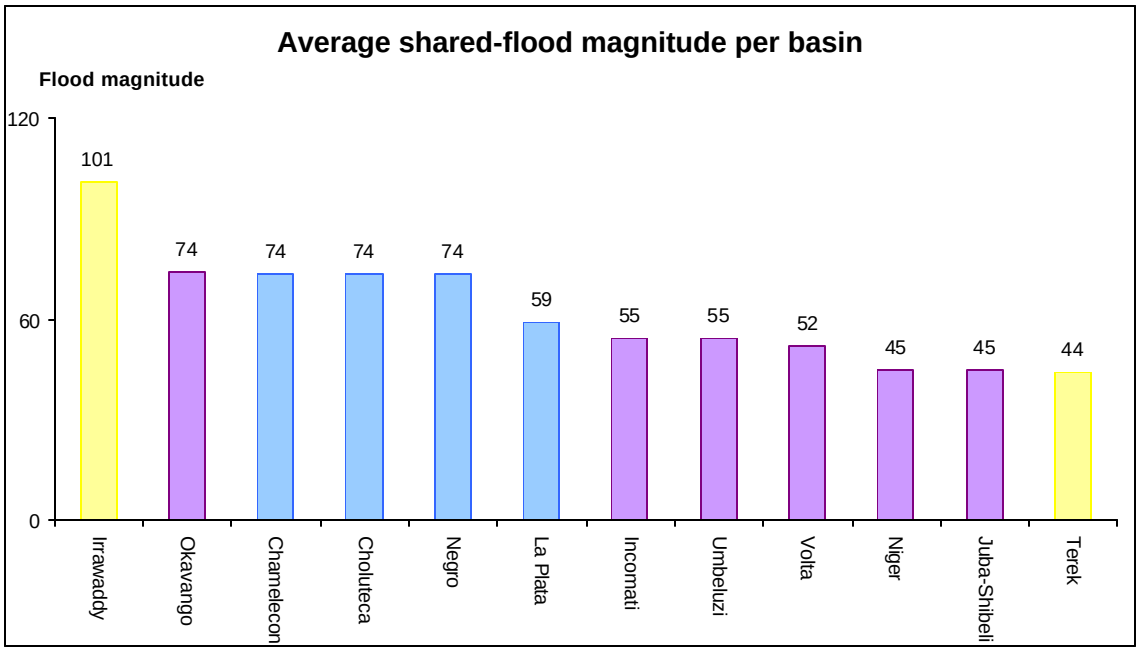
Appendix 2J: shared floods results in higher financial damages relative to a country's GNI than non-shared floods do.



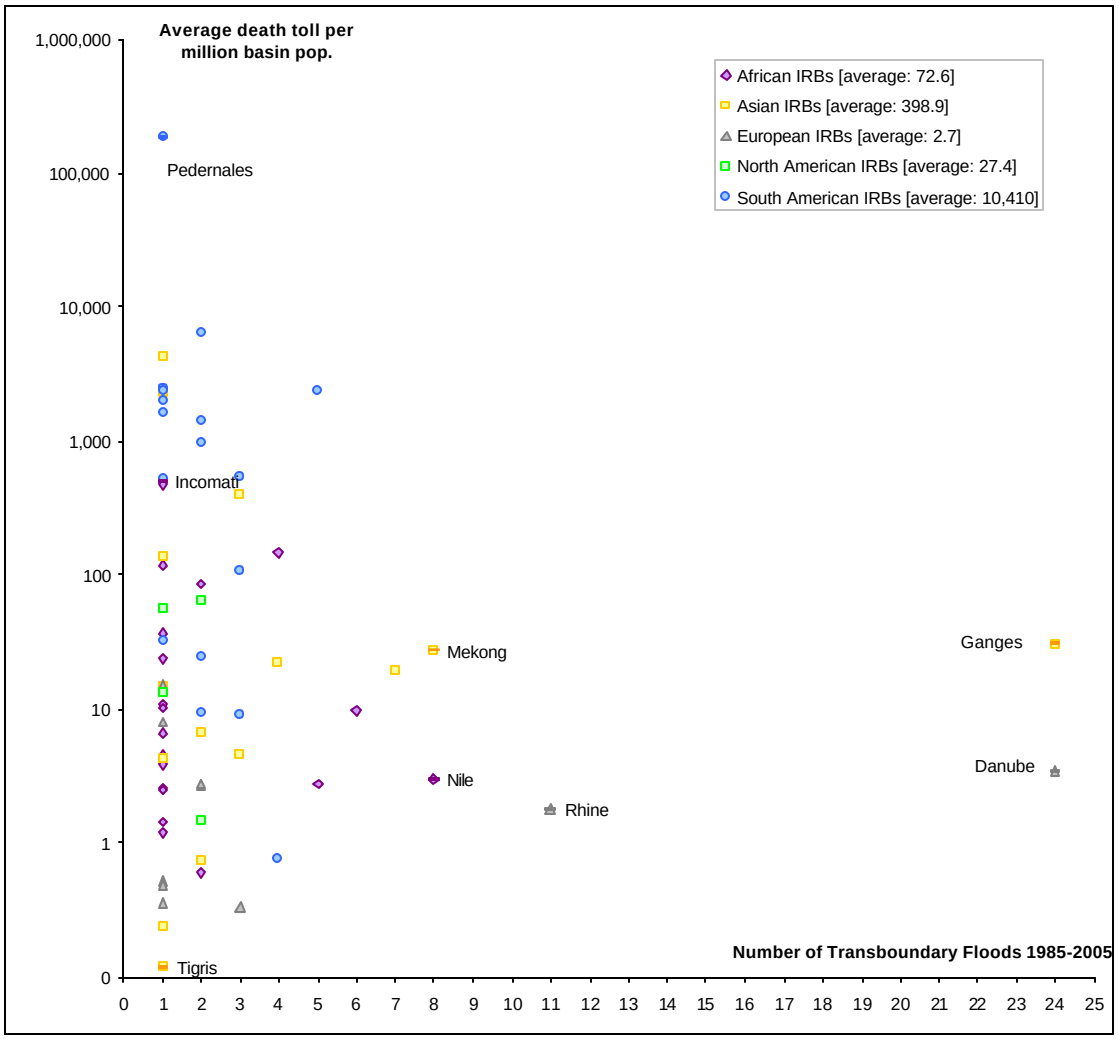
Appendix 2K: average displacement toll relative to million population in the river basins plotted against the average number of annual number of displacements during the period 1985-2005.



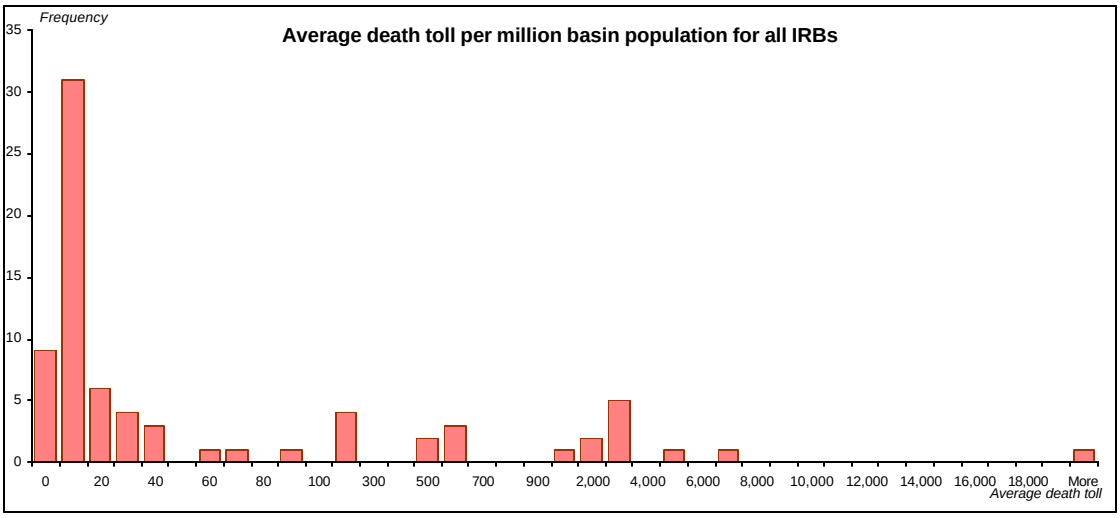
Appendix 2L: The average amount of financial damage per year, divided by the number of countries in that HDI class, show that the low developed countries almost every year experience lower financial damages related to shared flood events than the more developed countries do.



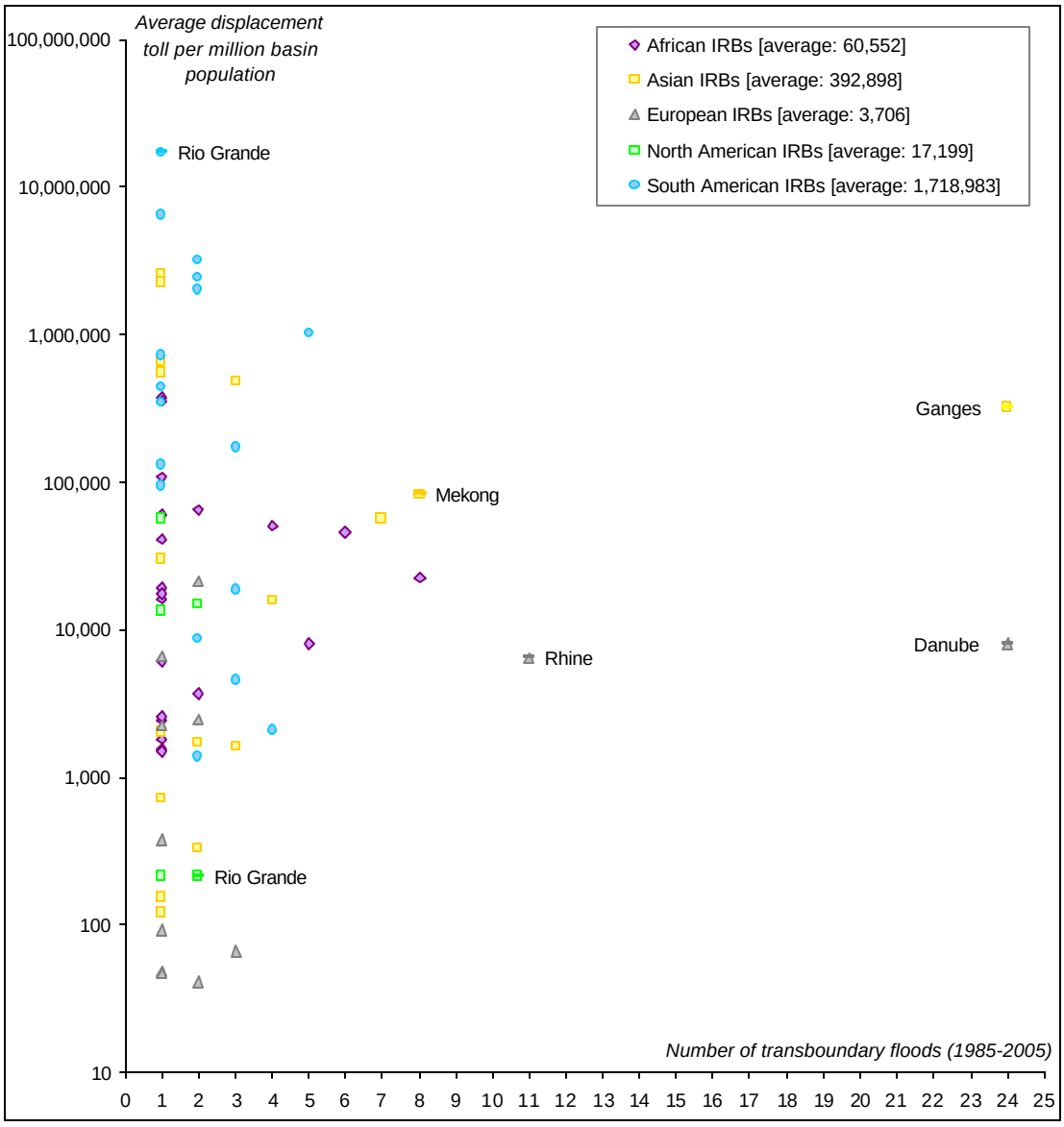
Appendix 2M: the top 12 of the IRBs with the highest average flood magnitude show the dominance of African and South American IRBs.



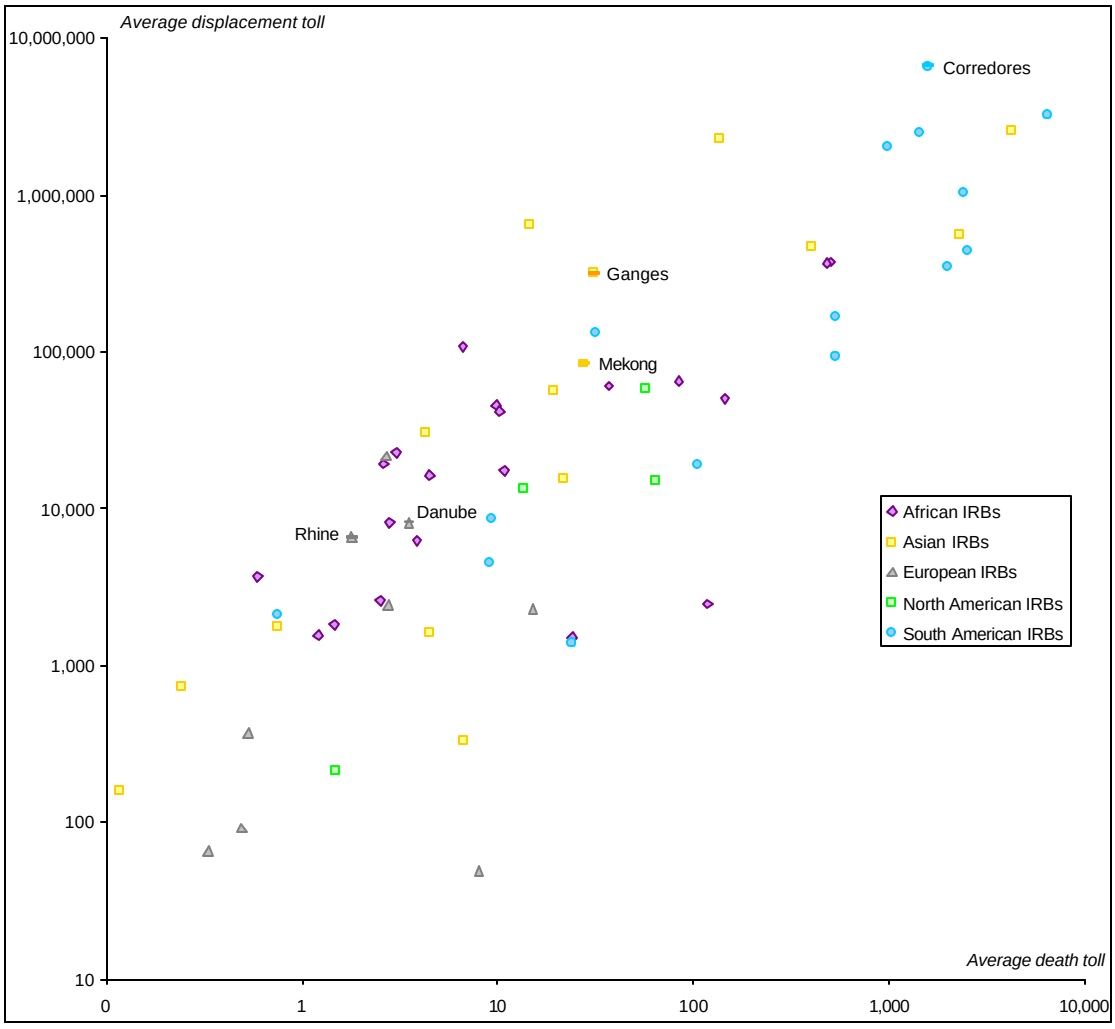
Appendix 2N: When the amount of floods experienced by an IRB is plotted against the average death toll per million basin population, the Pedernales river basin is by far the most impacted river basin. For basins that have experienced more than the average amount of transboundary floods, the death toll seems to stabilize on the European and Asian continents, and slightly less for African IRBs. The average death tolls for the South American IRBs have the broadest range, with no apparent pattern.



Appendix 2O Frequency graph of the average death toll for IRBs. The highest frequency is found in the classes below 10 deaths per million river basin population. Unmistakably, the Pedernales death toll of 187,000 (represented in the class 'More') is an extreme outlier.



Appendix 2P: The amount of floods experienced by an IRB against the average displacement toll per million basin population shows that the Rio Grande in South America is the river basin that has seen the highest impact of all IRBs.



Appendix 2Q: When the average death toll per IRB is plotted against the average displacement toll per IRB, categorized per continent, we see that, even though the average death toll does not nearly climb as fast as the average displacement toll does, the two variables do seem to be linked. Noticeable is that the European IRBs are the only IRBs that are less scattered; the average death toll does not exceed 15.6 and the average displacement toll does not exceed 21,454, whereas the ranges of the other IRBs are far more spread throughout the entire Appendix. When plotted on a linear scale, a threshold will appear. Where this Appendix only revealed that both variables climb, a linear Appendix clearly shows that around 10,000 displaced people per million population, the average death toll suddenly begins to rise more quickly. This indicates that when the average displacement toll rises above 10,000, the flood is apparently so severe, that it causes comparatively more victims than floods that do not displace that many people [or the other way around: floods that cause less than 10,000 displacements per million population, do not cause many victims]. Clearly visible is that the European IRBs have not crossed this threshold.

Table 2A: List of transboundry river flood events 1985-2005

Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
1985	*No transboundary riverfloods this year*					
1986	1	Peru and Bolivia	Lake Titicaca region	Lake Titicaca	February 1, 1986	90
	2	India and Bangladesh	Ganges	Ganges-Brahmaputra-Meghna	June 15, 1986	67
	3	India and Bangladesh	Teesta, Ganges and Jamuna	Ganges-Brahmaputra-Meghna	September 22, 1986	19
1987	4	Argentina and Paraguay	Bermejo and Rio Pilcomayo	La Plata	January 15, 1987	22
	5	United States and Canada	Piscataquis, Androscoggin, Kennebec, St. John, Aroostook,	St. John	March 31, 1987	10
	6	Bangladesh and India	Ganges, Brahmaputra, Jumna and Teesta	Ganges-Brahmaputra-Meghna	July 23, 1987	63
	7	Guatemala and Mexico	Usumacinta River valley	Grijalva	October 1, 1987	8
1988	8	Costa Rica and Panama	Changuinola and Sixaola	Basin: Changuinola and Sixaola	January 30, 1988	7
	9	Botswana, Mozambique, Zimbabwe, and South Africa	Pungoe, Limpopo and Honde	Limpopo, Zambezi, and Orange	March 8, 1988	8
	10	Rwanda, Congo, Democratic Republic of, and Uganda	Mubuku, Rubiriha	Congo / Zaire	May 6, 1988	10
	11	India and Bangladesh	Bramaputra, Barak and tribuatries and Surma and Kushiara	Ganges-Brahmaputra-Meghna	May 23, 1988	20
	12	India and Nepal	Ravi, Yamuna, Chenab, Jehlum, and Duri Rapti	Ganges-Brahmaputra-Meghna and Indus	July 4, 1988	36
	13	Sudan and Ethiopia	Blue Nile, White Nile, Atbara, and Baro	Nile	August 5, 1988	37
	14	Chad and Cameroon	Chari , Elghazal	Lake Chad	August 20, 1988	18
	15	India and Nepal	Brahmaputra valley, Ganges, Kosi, Bagmati, Adhwara, Burhi, Gandak, and Churani	Ganges-Brahmaputra-Meghna	August 23, 1988	24
	16	Honduras, El Salvador, Guatemala, and Nicaragua	Rio Grande and Lempa	Lempa	August 25, 1988	5
	17	Nigeria and Benin	Erinle, Niger, Oeme and Niger	Niger Basin	September 14, 1988	13
	18	India and Pakistan	Beas, Yamuna, Jelum, Tawi, Chenab, Ravi, Sutlej, Chenab and Ravi	Indus	September 21, 1988	18
	19	Nicaragua, Panama, and Costa Rica	Alferez, San Juan, Colorado, Coto	San Juan and Corredores / Colorado	October 18, 1988	8
1989	20	Vietnam, Bangkok, and Thailand	nd	Mekong	nd	nd
1990	*No transboundary riverfloods this year*					
1991	21	Austria and Germany	nd	Danube	July 18, 1991	4
	22	Poland and Hungary	nd	Danube	August 2, 1991	4
	23	Laos and Vietnam	Ma	Ma	August 12, 1991	1
1992	24	Argentina and Brazil	Rio Grande Do Sul	La Plata	April 1, 1992	93
1993	25	Mexico and United States	Tijuana, Mojave, Gila, Salt and San Francisco	Tijana	January 6, 1993	15
	26	India and Bangladesh	Brahmaputra, Barak, Singra, Kathkal, Manu, Khowai, Manu, Dhalai, Kushyara, Surma	Ganges-Brahmaputra-Meghna	June 4, 1993	19
	27	India, Nepal and Pakistan	Ravi, Beas, Satluj, Ghaghhar, Yamuna, Jhelum, Narayani, Trishuli, Bagmati, Palung, Manahara, Meghna, Padma, Jamuna, Chenab, Ravi and Sutlej	Indus	July 8, 1993	37
	28	Nicaragua and Honduras	Escondido, Kurinwas, Kamas, Rio Grande, Coco, Cruta and Segovia.	Coco / Segovia	August 7, 1993	6
	29	India and Nepal	Rapti	Ganges-Brahmaputra-Meghna	September 9, 1993	9
	30	France, Italy and Switzerland	Arc, Garonne, Lez, Rhone. Areas of Como and lake Maggiore	Rhone	September 22, 1993	17
	31	Germany, France, Belgium, Netherlands, and Czech Republic	Seine and its tributaries, the Oise and Marne, Mosel, Saar, Rhine, Neckar, Aisch, Nahe, Meuse, Houille, Oise, Moselle, Aisne, Sambre	Rhine	December 21, 1993	11

Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
1994	*No transboundary riverfloods this year*					
1995	32	France, Germany, Netherlands, Belgium, and Luxembourg	Salado River	Rhine	April 6, 1995	6
	33	Guatemala and Mexico	Ulua River	Grijalva	September 9, 1995	4
	34	Togo and Benin	Oueme	Oueme	September 21, 1995	8
1996	35	Ethiopia and Somalia	Shabelle	Juba-Shibeli	November 6, 1996	5
	36	Greece and Bulgaria	Kosthinos and Nestos	Nestos	December 1, 1996	3
1997	37	Malawi and Mozambique	Zambezi Pungue Buzi	Zambezi	January 15, 1997	45
	38	Brazil and Uruguay	Parana, Itaqu, and Uruguay	Rio Grande	October 15, 1997	8
	39	Somalia, Kenya, and Ethiopia	Tana	Juba-Shibeli	October 19, 1997	30
	40	Spain and Portugal	Guadiana	Douro	November 5, 1997	8
	41	Tanzania, Congo	Congo	Congo	December 20, 1997	12
1998	42	Kenya, Somalia, Zambia and Tanzania	Mkondoa, Tanzania Lake, Victoria Lake, Lake Tanganyika, Tana	Congo, Nile and Juba-Shibeli	January 1, 1998	20
	43	United States and Mexico	Pajaro, Napa, San Diego, Cuyama and Ventura	Tijuana	February 3, 1998	19
	44	Peru and Ecuador	Tumbes, Zaramilla and Chancay	Tumbes	February 10, 1998	34
	45	Pakistan and Iran	Kech and Dasht	Dasht	March 2, 1998	4
	46	Bangladesh and India	Brahmaputra	Ganges-Brahmaputra-Meghna	June 9, 1998	4
	47	Bangladesh and India	Ganges, Morapagladiya	Ganges-Brahmaputra-Meghna	July 5, 1998	80
	48	Kyrgyzstan and Uzbekistan	Shakhimardan-Sai and Ak-Suu	Aral Sea	July 8, 1998	1
	49	North Korea and South Korea	Han	Han	July 31, 1998	2
	50	United States and Mexico	Rio Bravo, Del Rio Ciudad, Acura	Rio Grande	August 22, 1998	6
	51	China and Nepal	Andhi and Bhod	Ganges	August 28, 1998	4
	52	Mexico and Guatemala	Chiapas San Lucar Pikikipan and Coatan	Coatan Achute	September 3, 1998	10
	53	Belgium and Netherlands	Haringvliet	Rhine	September 14, 1998	3
	54	Germany and Czech Republic	Rhine	Rhine	October 31, 1998	nd
	55	Ukraine, Slovakia, Romania and Hungary	Tisza	Danube	November 5, 1998	nd
	56	Peru and Ecuador	Ica Ica, Guayas, El Oro, Manabi, Los Rios.	Amazon	November 15, 1997	90
	57	Bulgaria and Turkey	Sofia, Meric and Tunica	Maritsa	December 14, 1997	65

Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
1999	58	Romania, Hungary, and Ukraine	Tisza, Danube, Sava, and Timsa.	Danube	February 21, 1999	26
	59	Switzerland, Germany, Austria, France	Rhine and Aare.	Rhine	May 12, 1999	6
	60	Germany, Austria, and Switzerland	Danube, Iller, Lech Wertach, Loisach, Ammer, Isar and Inn and Rhine.	Danube, Rhine	May 22, 1999	8
	61	Romania, Slovakia, Czech Republic, and Poland	Moravia and Ipel	Danube	June 22, 1999	10
	62	Romania and Hungary	Siret, Somes, and Riul Mare	Danube	July 9, 1999	8
	63	Bangladesh and India	Brahmaputra, Jamuna, Padma, Meghna, Gomti, Surma and Khowai.	Ganges-Brahmaputra-Meghna	July 11, 1999	24
	64	North Korea and South Korea	Pampanga and Han.	Han	July 30, 1999	10
	65	Bangladesh and India	Matamuhuri	Ganges-Brahmaputra-Meghna	August 11, 1999	5
	66	Romania and Bulgaria	Tisza	Danube	September 4, 1999	5
	67	El Salvador, Mexico, Guatemala, Costa Rica, Nicaragua, Panama, and Colombia	Grijalva, Carrizal, Usumacinta, Lempa, Ulua, Sulaco, Humuya, Ixpats, Samala, Platanitos and Botas.	Grijalva, Negro, Lempa, Choluteca, Chamelecon	September 12, 1999	31
	68	Ghana and Togo	Niger, Kaduna and Benue	Volta	September 15, 1999	27
	69	Hong Kong and China	Pearl	Bei Jian / His	September 15, 1999	4
	70	India and Bangladesh	Padma, Mahananda	Ganges-Brahmaputra-Meghna	September 24, 1999	6
	71	Congo, Democratic Republic of, and Congo Republic	Congo	Congo / Zaire	November 29, 1999	nd
2000	72	Mozambique, South Africa, Botswana, Zimbabwe, Malawi and Swaziland	Incomati, Umbeluzi, Limpopo, Sabie, Save, Lucite, Buzi, Jukskei, Klip, Crocodile, Metsimotlhabe , Mutirikwi, Runde and Songwe	Limpopo, Incomati, and Umbeluzi	January 26, 2000	62
	73	Argentina, Bolivia and Peru	Rimac, Pirai, Grande and Vermejo.	La Plata	March 9, 2000	9
	74	Czech Republic, Romania and Slovakia	Elbe, Tisza, Iza and Viseu	Danube	March 9, 2000	3
	75	Romania, Hungary, Serbia and Montenegro and Ukraine	Lapus, Cavnis, Iza, Viseu, Tisa, Cris, Olt, Mures, Somes, Bega, Crisul Alb, Timava Mica, Timis, Bodrog, Tisza, Takta, Theiss, Koeroes, Rata and Sokolia.	Danube	April 5, 2000	21
	76	Timor l'Est and Indonesia	Beneneai	Loes	May 16, 2000	9
	77	Thailand, Vietnam and Cambodia	Mekong, Red	Mekong	July 11, 2000	31

Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
2000	78	India, Bangladesh, Bhutan, and Nepal	Brahmaputra and its tributaries, Jamuna and its tributaries, Padma, Surma and Kushiyara, Varsha, Ratuwa, Narayani, Karnali.	Ganges-Brahmaputra-Meghna	August 2, 2000	29
	79	Cambodia, Vietnam, Thailand and Laos	Mekong, Bassac and Tonle Sap	Mekong	August 28, 2000	nd
	80	China, Russia, North Korea, and South Korea	Imjin	Han	August 30, 2000	12
	81	India and Bangladesh	Ganges, Kosi, Bagmati, Burhi Ganduk, Hoogly, Kharia, Ichamati, Jamuna, Damodar, Mayurakshi and Ajoy	Ganges-Brahmaputra-Meghna	September 18, 2000	34
	82	Italy and Switzerland	Po and Ticino	Po	October 14, 2000	9
	83	Algeria and Morocco	nd	Guir	October 22, 2000	4
	84	Malaysia and Thailand	Sungai Bata, Sungai Kampung Telok Malik, Sungai Pantai Johor, Sungai Baru, Sungai Golok, Sungai Padang Terap.	Golok	November 21, 2000	11
	85	Croatia and Serbia and Montenegro	Neretva, Zeta	Neretva	December 28, 2000	3
2001	86	Mozambique, Malawi, Zambia and Zimbabwe	Zambezi, Nhamadzi, Dziwedziwe, Nipiode , Pungue, Buzi , Save, Shire, Luangwa, Kafue and Gwayi.	Zambezi	January 1, 2001	117
	87	France and Belgium	Meuse and its tributaries.	Rhine	January 5, 2001	3
	88	Indonesia and Malaysia	Manyang, Bone, Rejang, Bengawan Solo and Bolango	Sembakung	February 4, 2001	15
	89	Ukraine, Hungary, and Romania	Tisza, Tur, Latoritsa, Somes and Viseu	Danube	March 4, 2001	14
	90	India and Bangladesh	Khowai, Manu, Kushiara, Muhuri, Dharla, Kabatakh, Matamuhuri and Bakkhali.	Karnaphuli	June 5, 2001	18
	91	Bosnia Herzegovina, Serbia and Montenegro and Romania	Bosna, Spreca and Obnica	Danube	June 19, 2001	4
	92	Bangladesh and India	Dhalai, Surma, Dharla, Ganges, Brahmaputra, Padma, Mahananda, Mahananda and Fulahar.	Ganges-Brahmaputra-Meghna	July 31, 2001	nd
	93	Sudan and Ethiopia	Nile, Blue Nile, Upper Nile, Omo, Baro and Awash	Nile	August 6, 2001	39
	94	Cambodia and Vietnam	Mekong, Tien, Hau and Tonle Sap	Mekong	August 15, 2001	97
	95	Guinea and Mali	Niger and tributaries	Niger	August 18, 2001	53
	96	Argentina and Uruguay	Salado and tributaries, Olimar	La Plata	October 1, 2001	62
	97	Honduras and Nicaragua	Toa and Sagua	Coco / Segovia	October 26, 2001	21
	98	France and Germany	nd	Rhine	December 29, 2001	2

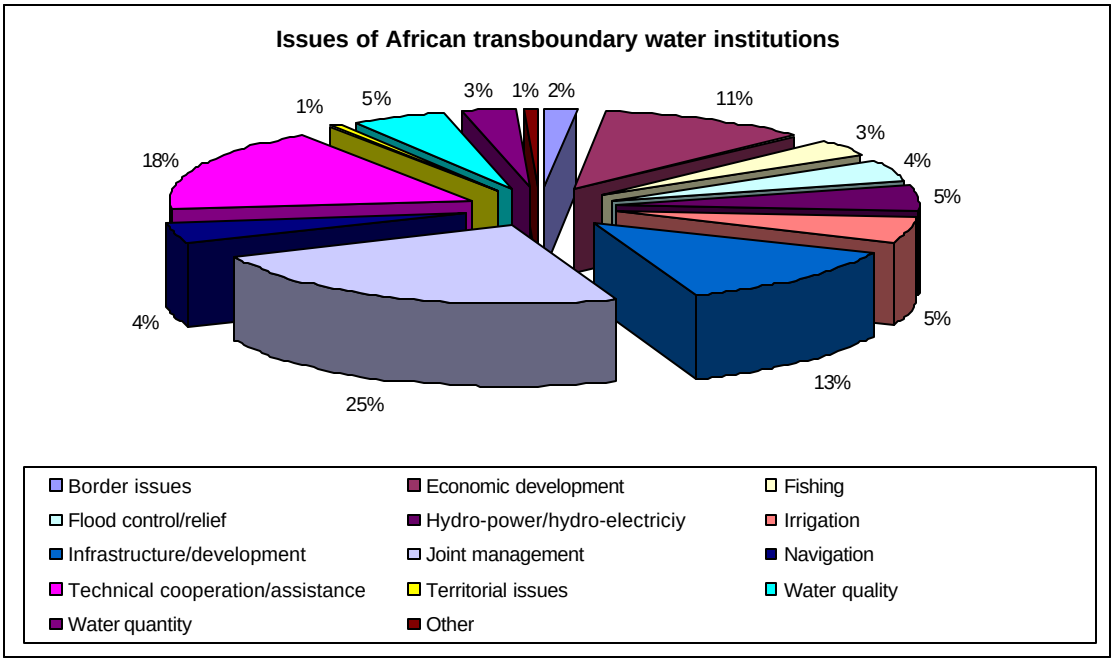
Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
2002	99	Romania and Hungary	Tisza	Danube	January 2, 2002	3
	100	Kenya, Nairobi, Uganda, Rwanda, and Tanzania	Mara, Tana, Sabaki, and Semliki	Nile	April 26, 2002	33
	101	Honduras and Nicaragua	Juticalpa	Coco / Segovia	May 23, 2002	14
	102	Germany, Switzerland, France, Italy, and Austria	Drome, Cervo	Po and Danube	June 6, 2002	4
	103	India and Bangladesh	Ganga-Padma, Brammaputra-Jumuna and the Meghna	Ganges-Brahmaputra-Meghna	June 21, 2002	69
	104	Colombia and Venezuela	Aruca	Orinoco	July 5, 2002	4
	105	South Korea and North Korea	Han, Naktong and Saenae.	Han	August 5, 2002	7
	106	Austria, Germany, Czech Republic, Romania, and Hungary	Danube, Salzach, Kamp, Elbe, Mulde, Vltava, Blanice, Malse, Berounka, Slavkovsky, Uhlava, Luznice, Otava, Labe and Sazava.	Danube and Elbe	August 7, 2002	22
	107	Thailand and Cambodia	Mekong	Mekong	August 18, 2002	101
	108	Thailand and Myanmar (Burma)	Salween	Salween	August 17, 2002	35
	109	United States and Mexico	Rio Grande, Medina and Guadeloupe	Rio Grande (North America)	October 10, 2002	6
	110	Congo, Republic of and Congo, Democratic Republic of	Lower Congo and Tributaries	Congo	November 10, 2002	1
	111	Uganda and Kenya	Awash	Nile	November 16, 2002	10
	112	Costa Rica and Panama	Banano, Santa Clara, Indio and Sixaola	Sixaola	November 23, 2002	21
	113	Greece and Macedonia	Vardar	Vardar	December 6, 2002	5
2003	114	Germany, Belgium, Romania, France, Netherlands, and Czech Republic	Moselle, Main, Saale, Itz, Rhine, Elbe. Agueda, Douro. Bistrita . Meuse, Dender. Seine and its tributaries Oise and Aisne. Meuse, Vltav, Berounka, Mrlina, Elbe	Rhine, Seine, Elbe, and Douro	January 1, 2003	8
	115	Malawi and Mozambique	Shire, Meluli, Mutivaze, Monapo, Licungo, Revubue, Muaguide, Montepuez, Messalo.	Zambezi	January 1, 2003	48
	116	Zambia, Angola and Namibia	Upper Zambezi and tributaries	Zambezi	January 15, 2003	168
	117	Turkey, Greece and Bulgaria	Meric and Ergene	Maritsa	January 17, 2003	46
	118	Spain and France	Ebro, Adour and Gironde	Ebro	February 5, 2003	9
	119	Pakistan and Afghanistan	Indus	Indus	February 16, 2003	7
	120	Lebanon and Israel	Jordan	Jordan	February 21, 2003	4

Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
2003	121	Mozambique and Zimbabwe	Save, Runde, Tokwe, Mazari, Gwanazuva, Mutirikwi.	Sabi	March 5, 2003	12
	122	Belarus and Ukraine	Pripyat and tributaries	Dnieper	March 22, 2003	45
	123	Azerbaijan and Armenia	Kura delta, Alazan, Kura, Araks, Tovuz, Zegam, Shamkir-Chai, Dasagli, Amirvar, Debed, Araz, Akhstev, Haram.	Kura-Araks	April 7, 2003	11
	124	Dominican Republic and Haiti	Gurabo, Fajardo and Nagua	Artibonite	April 16, 2003	7
	125	Kenya and Uganda	Nyando, Awach, Migori and Kuja. Kositei, Cheptokwo, Nginyang, Iriri, Kimondi, Chesita, Mururni, Swam, Orwa. Nzoia, Ombeyi. Turkwel, Kerio, Tinganga. Tana, Sabaki. Lak Dara and tributaries. Amaler and Namalu .	Nile	April 21, 2003	45
	126	Bangladesh and India	Bramaputra and Ganges and their tributaries. Padma, Khowai, Dhalai, Monu, Teesta, Dharla, Jamuna, Muhuri, Banglali, Gumti, Ganges, Brahmaputra, Dukhkumar, Shitalakhya, Balu and Buriganga. Brahmaputra and its tributaries: Jiadhol, Kushiara, Singla, Longai, Pagladiya, Pagladia, Mora-pagladia, Noona, Khuthimari, Puthimari, Kuhiyara, Singla, Jiabhoroli. Ganges. Adhwara group of rivers. Koshi, Kamala, Balan, Bagmati, Gandak, Burhi Gandak, Mahananda, Sone, Burhigandak and Pupun. Fenni, Mahurir, Gomati, Mahananda, Ganges, Sai, Sharda, Ganga, Ghaghra, Gomati.	Ganges-Brahmaputra-Meghna	June 11, 2003	122
	127	Pakistan and India	Indus and tributaries, Jhelum, Chenab, Satluj	Indus	July 15, 2003	49
	128	Sudan and Eritrea	Gash, Atbara and Siteet	Gash	July 28, 2003	25
	129	Senegal, Mauritania, Gambia and Guinea-Bissau	Senegal and tributaries, Gambia and tributaries, Geba	Senegal, Gambia and Geba	August 9, 2003	89
	130	Burkina Faso and Mali	Niger and tributaries. Volta Noire, Oti, White Volta	Niger and Volta	August 10, 2003	71
	131	Malaysia and Thailand	Ketil, Selama, Muda, Lembu, Baling, Bongkok, Teroi Bukit, Sedim, Kepala Batas, Taman Aman, Pantai Johor. Pinang.	Golok	October 3, 2003	23
	132	Canada and United States	Squamish, Cheakamus, Lillooet, Sooke, Chilliwack, Ryan. Rutherford Creek. Skokomish, Nooksack, Skagit, Stillaguamish, Sauk, Stehekin.	Skagit	October 17, 2003	10

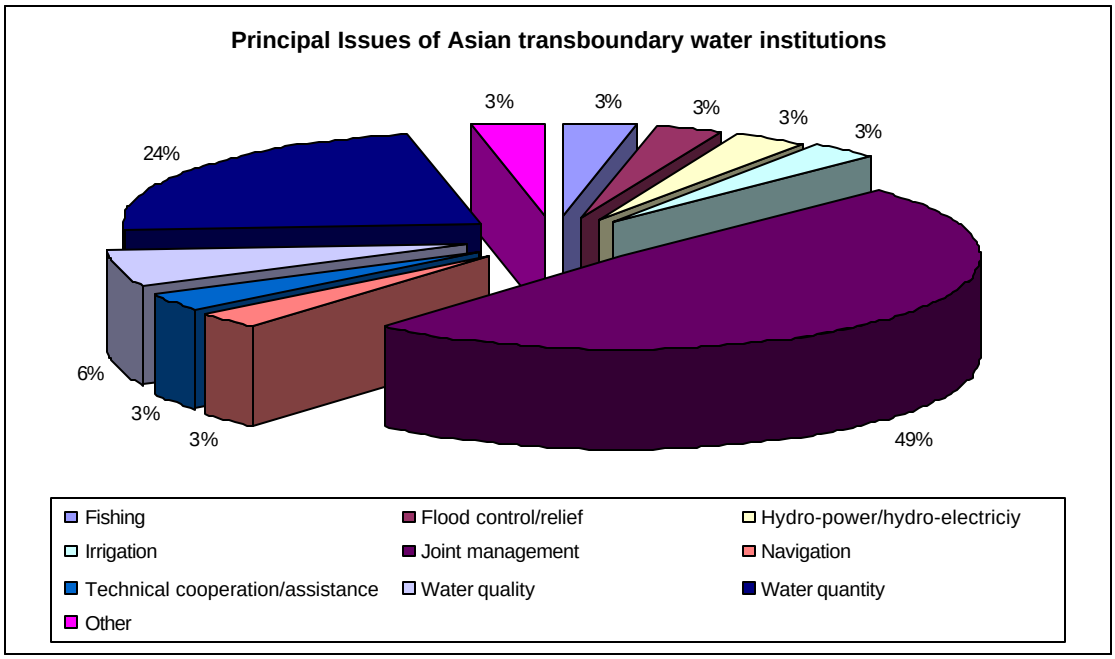
Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
2004	133	Iran and Iraq	nd	Tigris-Euphrates / Shatt al Arab	January 10, 2004	10
	134	Angola and Namibia	Kunene	Kunene	January 27, 2004	35
	135	Namibia, Zambia, Angola and Botswana	Okovango (Kavango), Zambezi and tributaries, Cuando, Zambezi	Okovango and Zambezi	February 1, 2004	123
	136	Bolivia and Brazil	Mamore, Itonamas, Baures, Guapore and tributaries.	Amazon	February 23, 2004	39
	137	Turkey, Armenia and Georgia	Goksu, Pular, Carsamba, Cokelez, Forkun. Kura, Hrazdan	Kura-Araks	March 5, 2004	5
	138	Bosnia-Herzegovina and Croatia	Sava, Vrbas and Trebisnjica	Danube	March 23, 2004	12
	139	United States and Canada	Park, Forest, Pembina, Tongue, Spring Brook, Red , Fisher	Nelson-Saskatchewan	March 28, 2004	15
	140	Russia and Belarus	Dnepr tributaries. Desna, Bolva, Bersuat, Obsha, Oka, Polist, Moksha, Ural, Pripyat	Dnieper	March 30, 2004	37
	141	Bosnia-Herzegovina, Croatia and Romania	Vrbas, Lasva, Sava, Sana, Bosna, Una, Drava, Pliva, Jezero, Mrkonjic Grad, Doboj, Prnjavor, Modrica, Travnik, Bugojno, Gornji and Donji Vakuf, Zenica, Maglaj, Lukavac, Zivinice, Gracanica, Sanski Most, Bihac, Kljuc, Mostar, Zdena, Mures and Crisu and their tributaries	Danube	April 12, 2004	21
	142	Kenya and Uganda	Nyando, Mahenya, Sondu-Miriu, Sio, Awach, Ombeyi, Migori and Kuja, Tonde, Chemoron, Endao, Miriu, Athi, Nzoia, Thirikwa, Ndarugu, Thiriku, Ruamuthambi, Kirichwa, Ruaraka	Nile	April 9, 2004	33
	143	Bangladesh and India	Surma, Kushiyara, Goain, Piain, Sari, Dholai, Khowai, Bheramohona, Bahsira, Donu and Khangsa, Nambul, Imphal, and Thoubal	Ganges-Brahmaputra-Meghna	April 14, 2004	20
	144	Dominican Republic and Haiti	Soleil and Yuna	Perdernales	May 23, 2004	10
	145	India, Bangladesh and Myanmar (Burma)	Sarda. Kiul, Bagmati, Adhawara, Lakhandai, Sakri, Bhutahi Balan, Kosi, Gandak, Burhi. Brahmaputra and tributaries. Pakke, Bordikrai, Hulengi, Satrang. Bhagirathi and Ichhamati. Fulohar, Lish, Mansai, Bhairav, Gomati, Muhuri, Fenni, Howra, Kabatakh, Gomoti, Khowai, Dhalai, Muhuri, Gumti, Burma. Ganges, Padma, Brahmaputra, Jamuna and Meghna, Dharla. Irrawaddy and Chindwin and tributaries. Salween and Shweli. Tenasserim.	Ganges-Brahmaputra-Meghna and Irrawaddy	June 20, 2004	110

Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
2004	146	Nepal and Bhutan	Bagmati, Lal Bakaiya and Jhanjh. Tawa, Rapti, Samari, Koshi	Ganges-Brahmaputra-Meghna	July 5, 2004	38
	147	Slovakia, Poland and Hungary	Hornad, Bodrog, Torysa and Ondava, Hernad	Danube	July 27, 2004	15
	148	India and Pakistan	Narmada, Mahi, Kailash, Bayal, Ghaggar, Indus tributaries, Tavi	Indus	August 1, 2004	39
	149	Vietnam and Cambodia	Mekong (Cuu Long), Tien	Mekong	August 24, 2004	59
	150	India and Bangladesh	Krishnai, Rongjuli and Dudhnoi, Hugli, Atrai, Chhoto Jamuna, Surma	Ganges-Brahmaputra-Meghna	October 7, 2004	12
	151	Paraguay and Argentina	Tebicuary, Paraguay, Parana, Uruguay tributaries.	Amazon	November 7, 2004	39
	152	Malaysia and Thailand	Kelantan, Lebir, Golok, Semerak, Tambatan Diraja, Dungun, Galas, Temala, Sungai Kolok and Saiburi	Golok	December 10, 2004	9
2005	153	Costa Rica and Panama	7 rivers (unidentified)	Changuinola	January 11, 2005	8
	154	Colombia and Venezuela	Lebrija, Oro, Frio, Tachira, Mocoties, Chama, Tachira. Escalante, Tama, Zulia.	Orinoco	February 11, 2005	16
	155	Greece, Bulgaria and Turkey	Evros (or Meric) Arda, Maritsa, Tundja and Arda	Maritsa	February 17, 2005	36
	156	Kazakhstan and Uzbekistan	Syr Darya	Aral Sea	February 24, 2005	28
	157	China and Kazakhstan	Ili	Ili / Kunes He	March 11, 2005	12
	158	Poland, Romania, Hungary, Czech Republic and Slovakia	Tributaries of the Odra . Wolborka. Tributaries to the Vistula, Czarna, Wisla, Wislok. Pasleka, Kaczawa, Somes, upper Tisza, Koros, Danube, Sazava, Morava, Torysa, and Sava valley.	Danube	March 17, 2005	23
	159	Romania and Serbia and Montenegro	Timis, Mures, Bega, Cerna, Barzava, Ialomita and Tamis.	Danube	April 18, 2005	48
	160	Ethiopia and Somalia	Wade Shabelle, Hargeysa, Bilate, Ashewa, Genale, Dawa, Fafen, Sile, Sego and Jubba.	Juba-Shibeli	April 23, 2005	53
	161	Georgia and Russia	Mtkvari, Rioni, Tskhenistskali, Ladzhanuri, Terek, Kuma, Podkumok, Tamlyk, Dzhemukha, Kalaus, Darya and Surkul, Sunzha, Volga, Kama and Ural and tributaries.	Terek	April 25, 2005	36

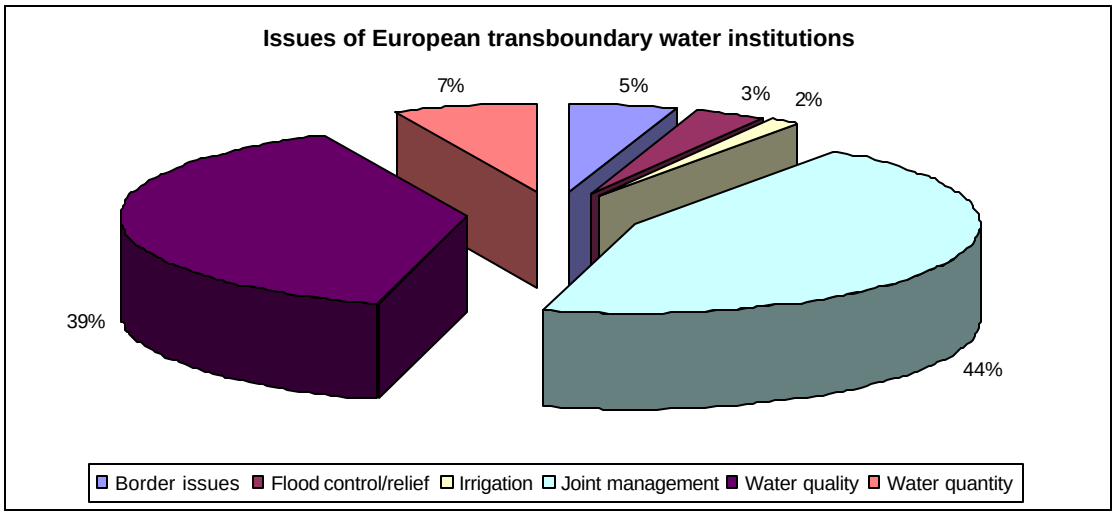
Year	#	Countries involved	Rivers	International River Basin(s)	Start	Duration (days)
2005	162	Kenya and Uganda	Nyando, Kibos, Awattende, Maugo. Ombeyi, Athi, Ewaso Nyiro. Oluch, Mango and Awach Kagan. Nyamasaria and Mahenya, Namatala, Ijara and Tala.	Nile	May 3, 2005	32
	163	Tajikistan, Afghanistan and Kyrgyzstan	TUpper Amu Darya and tributaries, Panj, Pyandzh, and Panjshir.	Aral Sea	June 15, 2005	37
	164	Pakistan and Afghanistan	Upper Indus tributaries. Kabul, Swat, Shalam, Kunar, Chitral, Panjkora. Khatayan, and Alingar.	Indus	June 21, 2005	46
	165	Romania and Bulgaria	Olt, Vedea and Teleorman, Yantra, Vit, Osam, Baniska and Jantra, Suhata, Iantra, Kamchia, Russenski Lom.	Danube	July 2, 2005	15
	166	Pakistan and India	Indus and tributaries, Chenab, Jhelum, Tavi, Ravi, Naullah Dek, Chenab, Ravi, Beas, Pabbar, Tawi and Ujh, Jhelum and Sindh.	Indus	July 5, 2005	41
	167	India, Bangladesh and Nepal	Brahmaputra and tributaries. Lohit, Dikhow, Jai Bharati, Puthimari, Subansairi, Dhansiri, Durra, Burhi-Dehing, Kundli, Jiyadhol, Lali and Siang, Barak. Ganges and tributaries. Baghmati, Ganga, Sharda, Gandak, Yamuna, Varuna, Nagwa nullah, Kane, Kosi, Bagmati, Kamla, Budi Gandak, Rapti, Ghaghra, Gomti, Ken, Budhi Rapti. Brahammaputra-Jamuna and Ganges-Padma-Meghna basins.Teesta, Dharla, Brahmaputra, Kortoa, Ghagot. Rapti, Bagmati and Lalbakaiya, Saptakosi	Ganges-Brahmaputra-Meghna	July 7, 2005	21
	168	Romania, Moldova, Hungary and Bulgaria	Upper Siret and tributaries, Prut and Chevcar.	Danube	August 14, 2005	20
	169	Switzerland, Austria, and Germany	Danube and tributaries including Isar, Enns and Inn. Rhine tributaries including Landquart, Aare.	Danube and Rhine	August 21, 2005	6
	170	Vietnam and Cambodia	Mekong (Cuu Long), Tien, Hau	Mekong	September 8, 2005	55
	171	Romania and Bulgaria	Prahova, Ialomita and Arges.	Danube	September 21, 2005	19
	172	China, Vietnam and Thailand	Ping, Chi, Korn and Lao, Kok, Wang, Ca	Mekong	September 26, 2005	11
	173	El Salvador, Guatemala, Honduras, Nicaragua and Mexico	Acelhuate, Lempa, Paz, Coatan, Jamapa, Tlalixcoyan, Atlahuilco, Motozintla and Ulúa	Lempa, Coatan Achute and Coco / Segovia	October 1, 2005	16
	174	Haiti and Dominican Republic	Riviere Froide	Artibonite	October 23, 2005	4
	175	Nicaragua and Honduras	Rio Grande of Matagalpa, Coco, Cangrejal , Wampu	Coco / Segovia	October 30, 2005	17



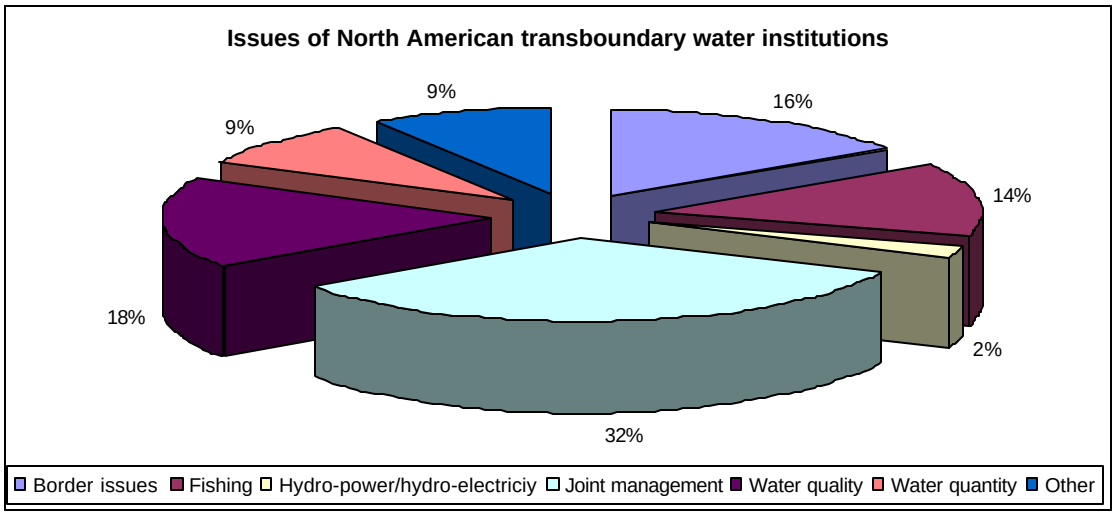
Appendix 3A: the principal issues of transboundary water institutions found on the African continent.



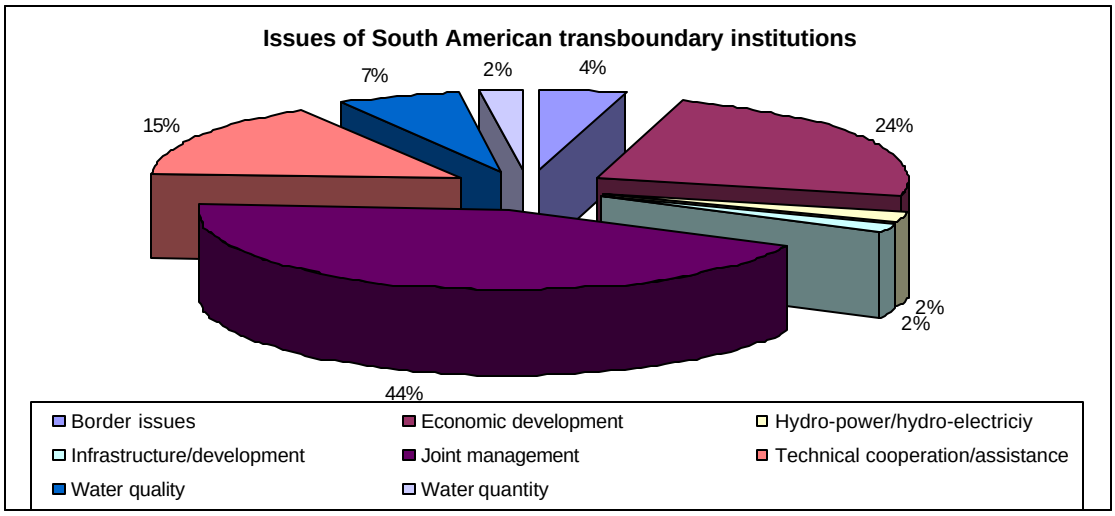
Appendix 3B: the principal issues of transboundary water institutions found on the Asian continent.



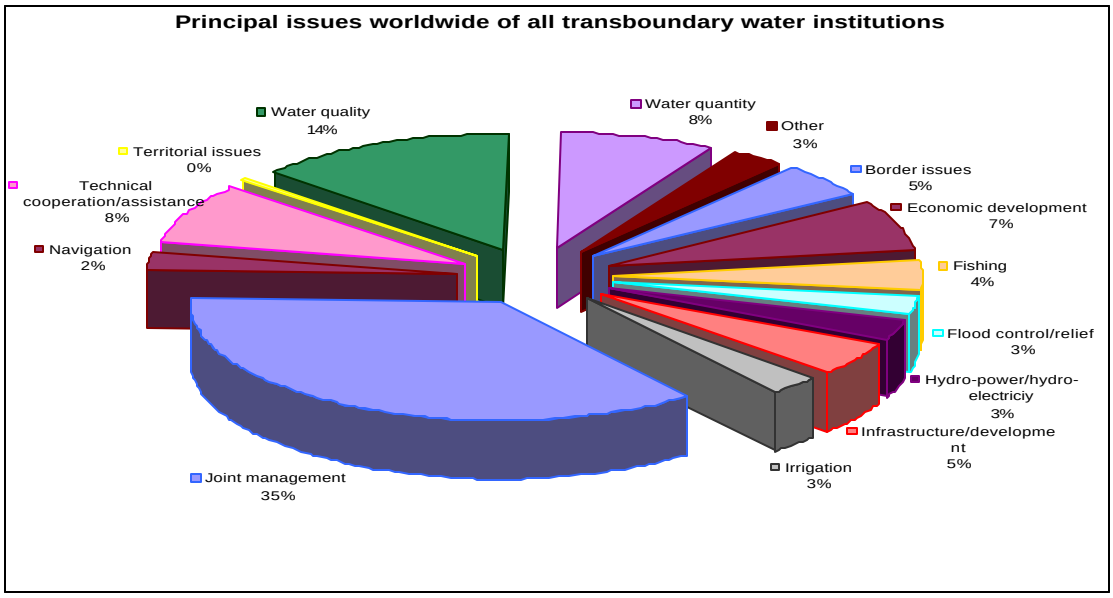
Appendix 3C: the principal issues of transboundary water institutions found on the European continent.



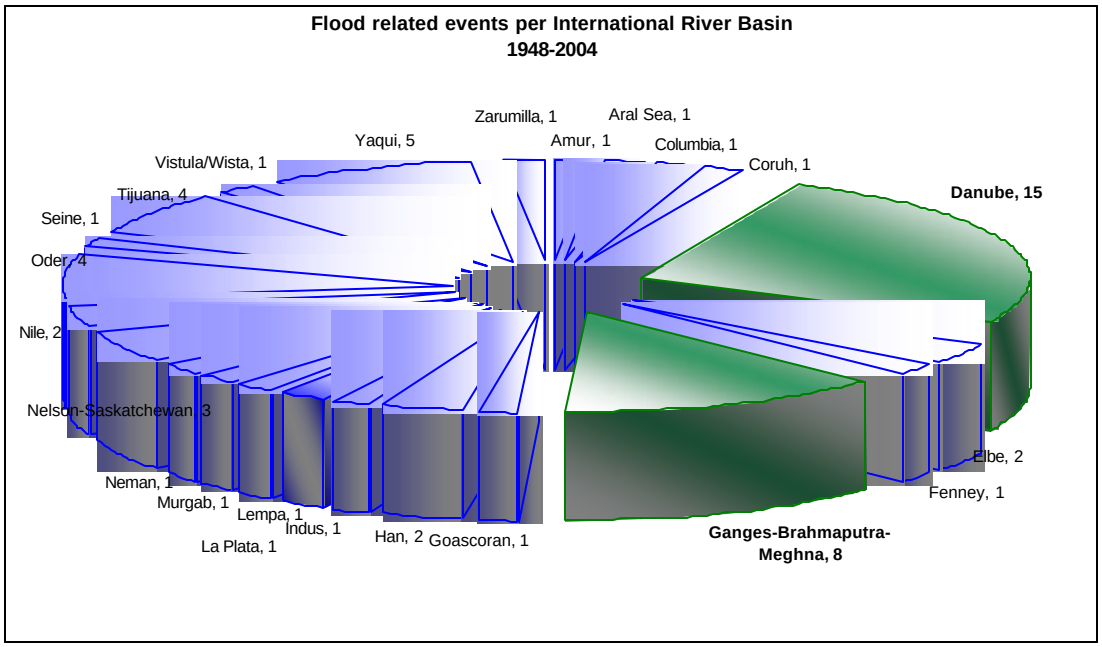
Appendix 3D: the principal issues of transboundary water institutions found on the North American continent.



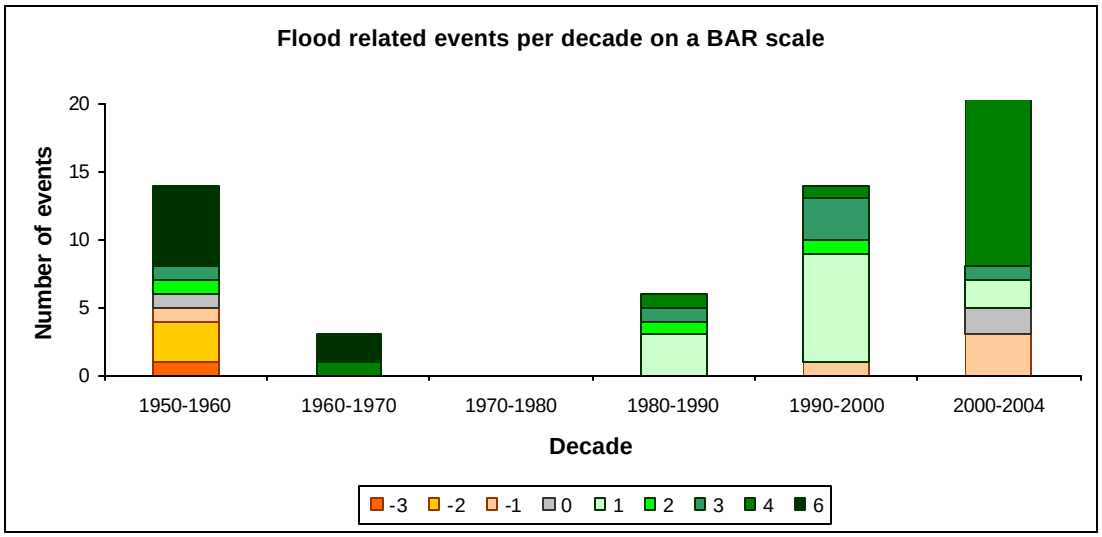
Appendix 3E: the principal issues of transboundary water institutions found on the South American continent.



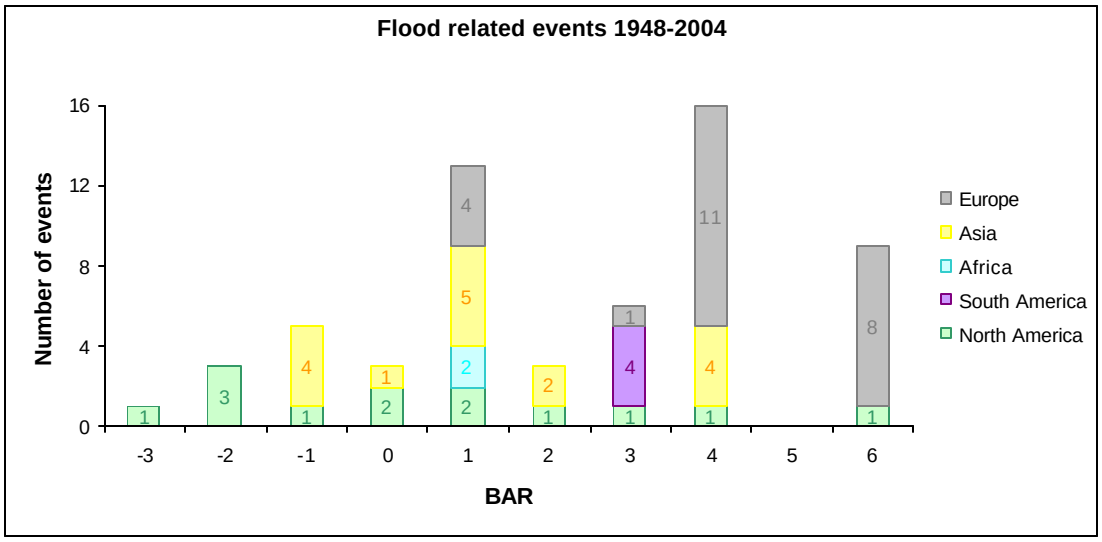
Appendix 3F: summarizing the principal issues of all institutions concerned with transboundary water issues clearly shows that joint management is the overall top priority, followed by water quality and technical cooperation/assistance. Of all the 14 issues, flood control/relief comes in on a shared tenth place (together with irrigation), mentioned only 9 times as a principal issue of the transboundary institution.



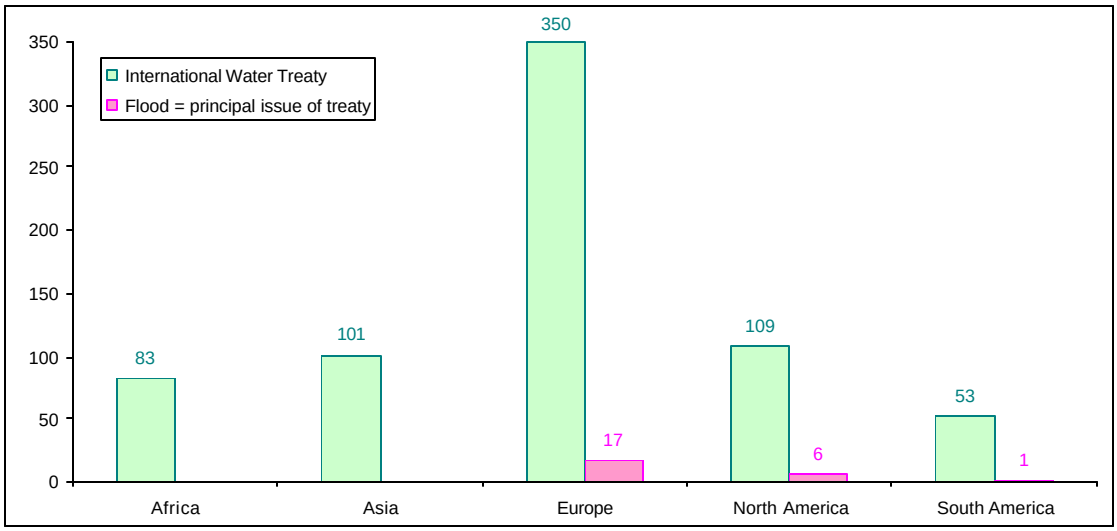
Appendix 3G: Flood related events per basin. Data for the period 1948-1999 was adapted from Yoffe (2001). Globally, there are 23 International River Basins that have experienced one or more flood-related events, but it is the European Danube River Basin that has experienced the most (15), followed by the Asian Ganges-Brahmaputra-Meghna River Basin with eight incidents.



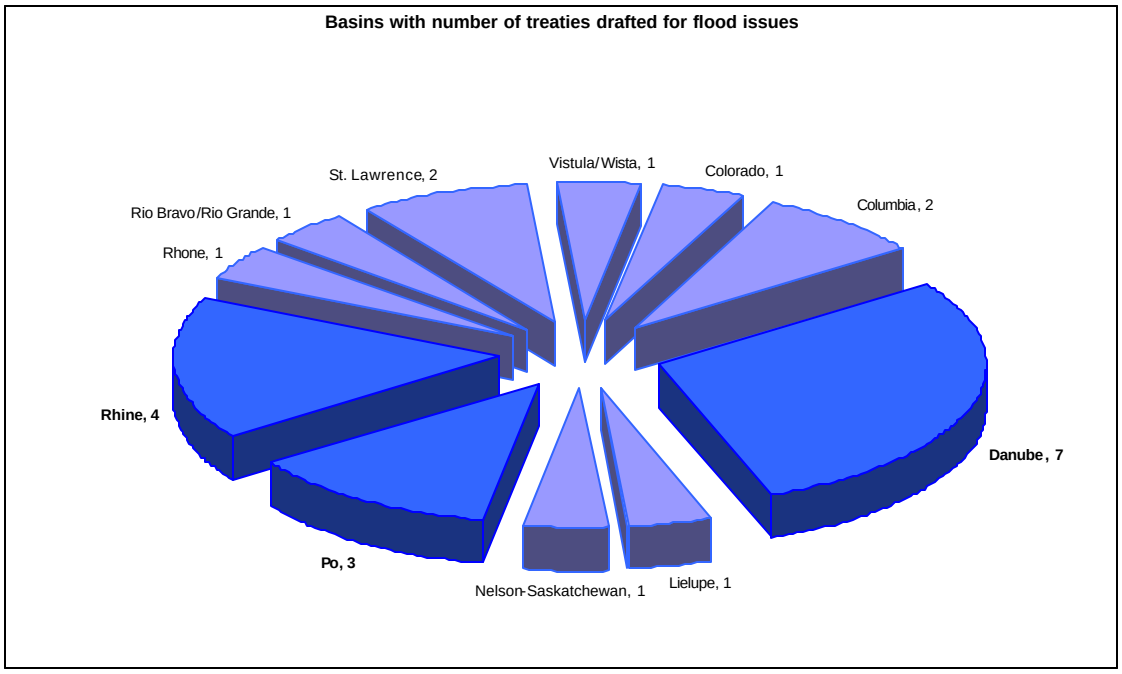
Appendix 3H: the number of flood related events per decade (and the period 2000-2004) on a BAR scale (Yoffe, 2001). The BAR scale runs from -7, representing 'Formal declaration of war' to +7, representing 'Voluntary unification into one nation', but the events related to floods can be plotted on a BAR scale from -3 to +6.



Appendix 3I: flood-related events ranked by BAR-scale and by continent show us that events that have happened on the North American continent have the broadest range, while events happening on the European and South American continent were all cooperative.



Appendix 3J: every continent has international water treaties, but these are rarely principally drafted for transboundary flood issues. Appendix adapted from Yoffe (2001); note that the data covers 1948-1999 only.



Appendix 3K: of the 279 international river basins known today, only 11 have treaties that deal with transboundary flood issues. Europe might score highest when it comes to absolute numbers, but when solely looking at basins, flood issues are dealt with in 4 out of 19 basins in North America, covering 21% of its basins, while Europe with 6 out of 69 only has 8.7% of its basins covered, and South America, with 1 out of 65, merely 1.5%.

Table 3A: List of international river basin commission on the African continent

Congo/Zaire						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Cameroon, Central African Republic, Congo, Republic of the (Brazzaville), Congo, Democratic Republic of (Kinshasa)	Official	Commission	Water quality, navigation, flood control/relief, infrastructure/development	November 6, 1999, effective since November 23, 2003	Commission Internationale du Bassins Congo-Oubangui-Sangha (CICOS).	TFDD
Corubal						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Guinea, Guinea-Bissau	Official	Organization and economic program	Hydro-power/hydro-electriciy, flood control/relief, irrigation, infrastructure/development	1978	Organisation pour la Mise en Valeur du Fleuve Gambie / Gambia River Basin Development Organization (OMVG). The three principal thrusts of OMVG concern energy, food security and communications. OMVG has carried out studies which have resulted in the recommendation of four sites of potential development as hydro-electric power projects. These are at Sambangalou on the River Gambia, Fello Sounga and Saltinho on the River Koliba/Corubal and Gaoual on the River Géba. The main objective of OMVG, is to promote socio-economic integration of its members States.	TFDD
Geba						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Guinea, Guinea-Bissau, Senegal	Official	Organization and economic program	Hydro-power/hydro-electriciy, flood control/relief, irrigation, infrastructure/development	1978	Organisation pour la Mise en Valeur du Fleuve Gambie / Gambia River Basin Development Organization (OMVG). The three principal thrusts of OMVG concern energy, food security and communications. OMVG has carried out studies which have resulted in the recommendation of four sites of potential development as hydro-electric power projects. These are at Sambangalou on the River Gambia, Fello Sounga and Saltinho on the River Koliba/Corubal and Gaoual on the River Géba. The main objective of OMVG, is to promote socio-economic integration of its members States.	TFDD

Incomati						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Mozambique, South Africa, Swaziland	Official	Commission	Joint management, infrastructure/development, technical cooperation/assistance	February 15,1991	Tripartite Permanent Technical Commission (TPTC).	TFDD
South Africa, Swaziland	Official	Commission	Joint management, infrastructure/development, technical cooperation/assistance	March 13, 1992	Joint Water Commission (JWC). The Joint Water Commission was established as a technical advisory commission to advise the Governments of the Kingdom of Swaziland and the Republic of South Africa on water resources of common interest. The JWC was formed through the JWC treaty signed in 1992. There are three commissioners appointed by each Government for a period determined by each Government. The JWC monitors the activities of KOBWA on behalf of the governments of Swaziland and South Africa.	TFDD
Mozambique, South Africa, Swaziland	Official	Organization and economic program	Joint management, infrastructure/development, technical cooperation/assistance	1993	Komati Basin Water Authority (KOBWA). A bi-national company formed in 1993 through the treaty on the Development and Utilization of the Water Resources of the Komati River Basin signed in 1992 between the Kingdom of Swaziland and the Republic of South Africa. The purpose of KOBWA is implement Phase 1 of the Komati River Basin Development Project. Phase 1 comprise the design, construction, operation and maintenance of Driekoppies Dam in South Africa (Phase 1a) and the Maguga Dam in Swaziland (Phase 1b). Additional party involved: Mozambique which shares the same river system and is participating through TPTC.	See http://www.kobwa.co.za/

Kunene						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Angola, Namibia	Official	Commission	Economic development, joint management, infrastructure/development, technical cooperation/assistance	1996	Angola Namibian Joint Commission of Cooperation (ANJCC)	TFDD
Angola, Namibia	Official	Organization	Economic development, joint management	Data not available	Joint Operating Authority	TFDD
Angola, Namibia	Official	Commission	Joint management, technical cooperation/assistance	Data not available	Permanent Joint Technical Commission	TFDD
Lake Chad						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Cameroon, Central African Republic, Chad, Niger, Nigeria,	Official	Commission	Water quality, water quantity, navigation, fishing, economic development, joint management, irrigation, infrastructure/development, technical cooperation/assistance, border issues	May 22, 1964	Lake Chad Basin Commission (LCBC). The Commission is a Regional Government Organization, designed to manage the basin and to resolve disputes that might arise over the lake and its resources. The aims of the Commission are to regulate and control the utilization of water and other natural resources in the basin; to initiate, promote and coordinate natural resources development projects and research within the basin area; to examine complaints; and to promote the settlement of disputes, thereby promoting regional cooperation. Note: the Central African Republic joined in 1994 and Sudan was admitted as an observer by the 10th Summit held in N'Djamena in July, 2000. It will become the sixth member state after ratifying the convention and statute which created the Commission.	http://www.cblt.org/ [HACKED] and http://www.imf.org/external/np/sec/decdo/lcbc.htm and http://dup.esrin.esa.it/users/summaryu85.asp
Cameroon, Central African Republic, Chad, Niger, Nigeria	Official	Organization	Economic development, joint management, infrastructure/development, technical cooperation/assistance	Data not available	Basin Committee for Strategic Planning (BCSP); created through LCBC, for local initiatives.	TFDD

Limpopo						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Botswana, Mozambique, South Africa, Zimbabwe	Official	Commission	Economic development, joint management, infrastructure/development, technical cooperation/assistance	November 1, 2003	Limpopo Watercourse Commission (LIMCOM). This commission was negotiated by the Limpopo Basin Permanent Technical Committee. The Commission between South Africa, Botswana, Mozambique and Zimbabwe is to manage the Limpopo River and must facilitate the building of capacity within the four countries to manage the water resource.	See http://www-dwaf.pwv.gov.za/Communications/PressReleases/2003/MINISTER%20KASRILS%20MP%20SIGNS%20AN%20IMPORTANT%20RIVER%20AGREEEMENTS%20IN%20MOZAMBIQUE.doc
Botswana, Mozambique, South Africa, Zimbabwe	Official	Commission	Economic development, joint management, infrastructure/development, technical cooperation/assistance	1995	Limpopo River Basin Commission (LRC). Institutional arrangement to manage water. Operating on a river-catchment basis, rather than by national boundaries, this body provides an appropriate institutional vehicle to guide the development in the basin.	http://www.sadcwscu.org.ls/ [not working]
Botswana, Mozambique, South Africa, Zimbabwe	Official	Organization	Economic development, joint management, infrastructure/development, technical cooperation/assistance	1986	Limpopo Basin Permanent Technical Committee (LBPTC). In 1986, Limpopo Basin States signed in Harare, Zimbabwe, a multilateral agreement establishing a Limpopo Basin Permanent Technical Committee (LBPTC), which was set up to advise the parties on issues regarding the river. The LBPTC did not however function during its first ten years. LBPTC's second meeting was held in South Africa in 1995. At the meeting, it was agreed to activate the LBPTC, which was a dead organization, and discussions concentrated on mutual interest regarding the common river.	See http://www.riob.org/ag2002/LimpopoOrange.pdf
Botswana, Mozambique, South Africa, Zimbabwe	Official	Organization	Joint management, technical cooperation/assistance	1983	Joint Permanent Technical Committee (JPTC). The JPTC was established in 1983 to make recommendation on matters concerning common interest in the Limpopo.	TFDD
Mozambique, South Africa	Official	Commission	Joint management, technical cooperation/assistance	1996	Joint Water Commission (JWC). In 1996, after South Africa's political change, the two countries signed in Mozambique, an agreement establishing a Joint Water Commission (JWC), with advisory functions on technical matters relating their common rivers, including the Limpopo.	TFDD

Mana-Morro						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Guinea, Liberia, Sierra Leone,	Official	Organization	joint management	October 3, 1973	Mano River Union (MRU). The MRU was established in 1973 to constitute a customs and economic union between the member states in order to improve living standards. Decisions are taken at meetings of a joint ministerial committee. The governments of all three 'Mano River Union' countries recognise that their individual future prosperity depends on increasing dialogue and co-operation between them, and moves to revitalise the Mano River Union are likely to resume as soon as peace has returned to Sierra Leone and to the respective border regions of the three countries.	See http://www.manoriver.com/mano/projects/country_overview.shtml
Niger						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Algeria, Benin, Burkina Faso, Cameroon, Chad, Guinea, Ivory Coast, Mali, Niger, Nigeria, Sierra Leone	Official	Organization	Water quality, hydro-power/hydro-electriciy, navigation, fishing, flood control/relief, economic development, joint management, irrigation, infrastructure/development, technical cooperation/assistance	1980	Niger Basin Authority (NBA), formerly the Niger River Commission (RNC). The NBA is one of the oldest African Intergovernmental Organization as its creation dates back to 1964 when it was called River Niger Commission. The River Niger Commission functioned for seventeen years and the results achieved were deemed insufficient. Consequently, the member states decided to replace it with a new organization, the Niger Basin Authority which became heir to all the assets, liabilities and programs initiated by the River Niger Commission. The aim of the Niger Basin Authority is to promote cooperation among the member countries and to ensure integrated development in all fields through development of its resources.	http://www.abn.ne/homepg.html
Nile						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Burundi, Central African Republic, Egypt, Egypt (administered by Sudan), Eritrea, Ethiopia, Congo, Democratic Republic of (Kinshasa), Sudan, Tanzania, United Republic of, Uganda, Kenya, Rwanda, Sudan (administered by Egypt).	Official	Organization and economic program	Economic development, joint management, other: poverty eradication	1999	Nile Basin Initiative (NBI). The NBI is a transitional mechanism that includes nine Nile riparian countries as equal members in a regional partnership to promote economic development and fight poverty throughout the Basin. The vision of the NBI is to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources.Within the framework of Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE), a Nile River Basin action plan was prepared in 1995 with support from CIDA. In 1997, the World Bank agreed to a request by the Council of Ministers of Water Affairs of the Nile Basin States (Nile-COM) to lead and coordinate donor support for their activities. In 1998, recognizing that cooperative development holds the greatest prospects of bringing mutual benefits to the region, all riparians, except Eritrea, joined in a dialogue to create a regional partnership to facilitate the common pursuit of sustainable development and management of Nile waters.	http://www.nilebasin.org/

Nile - continued						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Burundi, Central African Republic, Egypt, Egypt (administered by Sudan), Eritrea, Ethiopia, Congo, Democratic Republic of (Kinshasa), Sudan, Tanzania, United Republic of, Uganda, Kenya, Rwanda, Sudan (administered by Egypt)	Official	Organization and environmental program	Joint management, technical cooperation/assistance	1993	Technical Cooperation Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE). Formed in an effort to focus on a development agenda.	TFDD
Nile (Lake Victoria subbasin)						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Prinicipal Issue**	**Date**	**Description**	**Source**
Kenya, Tanzania, Uganda,	Official	Organization and environmental program	Water quality, fishing, joint management	June 30, 1994	Lake Victoria Fisheries Organization. Objectives: To foster co-operation amongst the Contracting Parties in matters regarding Lake Victoria; To harmonize national measures for the sustainable utilization of the living resources of the Lake; To develop and adopt conservation and management measures to assure the health of the Lake's ecosystem and the sustainability of its living resources. The Lake Victoria Fisheries Organization was established by a Convention (mandate) signed on 30th June 1994, in Kisumu, Kenya by the "Contracting Parties" who consist of the Governments of the Republic of Kenya, the Republic of Uganda and the United Republic of Tanzania.	http://www.inweh.unu.edu/lvfo/
Okavango						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Angola, Botswana, Namibia,	Official	Commission	Joint management	September 15, 1994	The Permanent Okavango River Basin Commission (OKACOM). OKACOM is a regional, high-level committee that was formed to ensure the water resources of the Okavango River system are managed in appropriate and sustainable ways and to foster co-operation and co-ordination between the three Basin states; Angola, Namibia, and Botswana.	PPT show at http://www.sharingwater.net/acrobat/Gen%20background%20OKACOM%20-%20I.%20Pinheiro%20(OKACOM).ppt#2
Botswana, Namibia	Official	Commission	Joint management	November 13, 1990	Joint Permanent Water Commission (JPWC). JPWC focus is on the bilateral management of the Okavango River and the Kwando-Chobe-Linyati reach of the Zambezi River.	See http://www.savannas.net/botswana/ruhydro.htm and http://www.gci.ch/GreenCrossPrograms/waterres/pdf/WFP_Okavango.pdf

Orange						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Botswana, Lesotho (Kingdom of), Namibia, South Africa	Official	Commission	Joint management	November 3, 2000	Orange/Senqu River Commission (ORASECOM). ORASECOM is the first RBO to be established in terms of the SADC Protocol on Shared Watercourse Systems. The secretariat was established in 2003.	See http://www.riob.org/ag2002/LimpopoOrange.pdf
Lesotho (Kingdom of), South Africa	Official	Organization and economic program	Water quantity, Hydro-power/hydro-electriciy, economic development, joint management, technical cooperation/assistance	1930	Lesotho Highlands Development Authority (LHDA): The LHDA was set up to implement and operate that part of Lesotho Highlands Water Project (LHWP) that falls within the borders of Lesotho.	http://www.lhwp.org.ls/default.htm and See http://www.lhda.org.ls/
Lesotho (Kingdom of), South Africa	Official	Commission	Joint management, technical cooperation/assistance	October 24, 1986	Lesotho Highlands Water Commission (LHWC). The signing of the Lesotho Highlands Water Project Treaty by the Government of Lesotho and of the Republic of South Africa on the 24th October 1986 established the Joint Permanent Technical Commission (JPTC) to represent the two countries in the implementation and operation of the LHWP. The Joint Permanent Technical Commission (JPTC), was later renamed the Lesotho Highlands Water Commission (LHWC) with a secretariat in Lesotho to monitor and oversee the Treaty.	See http://www.riob.org/ag2002/LimpopoOrange.pdf and See http://www.lhwp.org.ls/ and http://www.lhwp.org.ls/overview/default.htm
Namibia, South Africa	Official	Commission	Joint management, technical cooperation/assistance	1992	Permanent Water Commission (PWC). In a bilateral agreement in 1992, Namibia and South Africa established a Permanent Water Commission (PWC). PWC was to act as a technical adviser to the Parties on matters relating to the development and utilization of the Orange water resources.	See http://www.riob.org/ag2002/LimpopoOrange.pdf
Namibia, South Africa	Official	Organization and economic program	Joint management, irrigation, technical cooperation/assistance	1992	Joint Irrigation Authority (JIA). Countries signed in 1992 another agreement establishing a JIA, administering an existing irrigation scheme along the riverbanks under the auspices of the PWC.	See http://www.riob.org/ag2002/LimpopoOrange.pdf
Senegal						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Mali, Mauritania, Senegal	Official	Organization and economic program	Water quality, water quantity, hydro-power/hydro-electriciy, navigation, flood control/relief, economic development, joint management, irrigation, infrastructure/development, technical cooperation/assistance	March 11, 1972	Organisation pour la Mise en Valeur du bassin du fleuve Senegal (OMVS). In 1963, shortly after independence, Guinea, Mali, Mauritania, and Senegal signed the Bamako Convention for the Development of the Senegal River Basin that declared the Senegal River to be an "International River" and create an "Interstate Committee" to oversee its development. In 1968, the Labe Convention created the Organisation of Boundary stares of the Senegal River (OERS - Organisation des Etats Riverains du Sénégal). In 1972 the OMVS, a river management organisation, was created replacing the OERS which broke up after the withdrawal of its fourth member, Guinea.	http://www.omvs.org, http://www.ifrance.com/omvs-soe/, case study report at http://www.up.umnw.ethz.ch/de/teaching/Pruefung_Aquatische_Systeme/papers_bernauer_f2004/Case%20study%20Senegal%20River.pdf and http://www.gm-unccd.org/FIELD/Multi/OMVS/Profile.htm and http://www.omvs-hc.org/

Volta						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Burkina Faso, Mali, Niger	Official	Organization and economic program	Hydro-power/hydro-electriciy, navigation, fishing, economic development, irrigation, infrastructure/development	December 3, 1970	Liptako-Gourma Integrated Authority or Autorite de developpement integre de la region du Liptako-Gourma (ALG). The ALG, a sub-regional institution has the primary mission to promote the integrated development of the Liptako-Gourma region with a view to improving the living conditions of the population.	See http://www.afdb.org/knowledge/pressreleases2003/adf_57_2003e.htm
Zambezi						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Angola, Congo, Democratic Republic of (Kinshasa), Malawi, Mozambique, Tanzania, United Republic of, Botswana, Namibia, Zambia, Zimbabwe	Official	Commission	Border issues, territorial issues	July 13, 2004	Zambezi Watercourse Commission (ZAMCOM). Commission to manage and develop the Zambezi river's water resources. Besides managing the Zambezi's resources, the Commission, consisting of three organs - a council of ministers, a technical committee and a secretariat drawn from all eight countries - will advise member countries on planning, utilisation, protection and conservation issues around the river. Country representatives will also protect national interests in actual or potential disputes. Signing the agreement is expected to bring benefits across all sectors, including trade, industry, energy production, food security, transport and communication, tourism, regional security and peace. Additional parties involved: SADC and the ZRA. The formation of ZAMCOM as by the Watercourse protocol is part of the ongoing Project 6 of the ZACPLAN. The sixth project is considered as a key part of the ZACPLAN formulate a development strategy and simulate various development scenarios for the Basin.	See http://www.plusnews.org/report.asp?ReportID=42174&SelectRegion=Southern_Africa and http://www.eawag.ch/research_e/apec/seminars/Case%20studies/2003/Zambezi.pdf
Zambia, Zimbabwe	Official	Organization and economic program	Water quality, economic development, joint management, technical cooperation/assistance	1987	Zambesi River Authority (ZRA). The Zambezi River Authority is governed by a Council of Ministers consisting of four members, two of whom are Ministers in the Government of the Republic of Zambia and two of whom are Ministers in the Government of Zimbabwe. Mission: to co-operatively manage and develop in an integrated and sustainable manner the water resources of the Zambezi River in order to supply quality water, hydrological and environmental services for the maximum socio-economic benefits to Zambia, Zimbabwe and the other Zambezi River basin countries. Promoting regional co-operation in integrated water resources management; Providing hydrological and environmental services to the entire Zambezi River countries; Efficiently, equitably and sustainably managing and operating the Kariba Complex and other future dams on the common Zambezi River.	http://www.zaraho.org.zm/ and http://www.eawag.ch/research_e/apec/seminars/Case%20studies/2003/Zambezi.pdf
Botswana, Namibia	Official	Commission	Joint management	November 13, 1990	Joint Permanent Water Commission (JPWC). JPWC focus is on the bilateral management of the Okavango River and the Kwando-Chobe-Linyati reach of the Zambezi River.	See http://www.savannas.net/botswana/ruhydro.htm and http://www.gci.ch/GreenCrossPrograms/waterres/pdf/WFP_Okavango.pdf

Table 3B: List of international river basin commission on the Asian continent

Amur						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
China, Mongolia, Russia	Official	Commission	Joint management	2004	Amur River Coordination Committee	http://www.panda.org/about_wwf/where_we_work/asia_pacific/news/successes/index.cfm?uNewsID=16173
Aral Sea						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan	Official	Commission	Water quantity, water quality, joint management	February 18, 1995	Interstate Coordination Water Commission (ICWC). On February 18, 1992 the five Ministers of Water Resources of Central Asian states signed an "Agreement on cooperation in joint management, use and protection of interstate sources of water resources" and this agreement founded the ICWC. Executive bodies of ICWC are River Basin Authorities (BWOs) SyrDarya and AmuDarya. BWOs are in charge of planning and managing water flow schedules and water resources distribution, as well as direct implementation of the decisions made by ICWC relevant to water allocation, schedules of water flow and releases, water quality control.	http://www.icwc-aral.uz/index.htm
Kazakstan, the Kyrgyz Republic, the Republic of Tajikstan, Turkmenistan, and the Republic of Uzbekistan	Official	Organization	Other: research and education	1994	International Fund for saving the Aral Sea (IFAS). An interstate organisation established in order to fund and credit joint regional environmental and research programmes and projects aimed at saving the Aral Sea and improving the environmental situation in the areas affected by the disaster as well as solving regional socio-economic problems. Primary goals include: stabilising and improving the environment of the Aral Sea Basin, rehabilitating the disaster zones, improving water resource management, and increasing the capacity of local and state institutions for planning and implementing programs.	

Aral Sea - continued						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Israel, Jordan	Official	Commission	Water quality, water quantity, joint management	1994	A Joint Water Committee (JWC) - to jointly manage water resources of the West Bank; for the purposes of monitoring, planning, study, information sharing, and dispute resolution. The Joint Water Committee is to manage mutual water resources, operate jointly established monitoring stations to monitor the quality of water along their boundary, and to develop plans to supply Jordan with an additional 50 mcm/yr. of drinking water.38 Article 6 of the Jordan Israel Peace Treaty provides for mutual assistance in the alleviation of water shortagesThe JWC served as an institutional mechanism for the interim period, mainly to oversee the implementation of Article 40 (of the agreement deals with water allocation but refers to the immediate needs of the Palestinians without considering the principle of equitable and reasonable utilization of the water resources by both sides).	See http://www.wws.princeton.edu/~wws401c/aliya.pdf and http://law.gonzaga.edu/borders/water.htm
Coruh						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Turkey, former USSR	Official	Commission	Joint management	1973	Joint Boundary Water Commission.	See http://www.akdeniz.edu.tr/muhfak/publications/gap.html
Fenney						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
India and Bangladesh	Official	Commission	Joint management	March 19, 1972	Indo-Bangladesh Joint Rivers Commission. Mission: to develop the waters of the rivers common to the two countries on a cooperative basis (specifically excluding issues of Ganges development).	See http://www.transboundarywaters.orst.edu/projects/casestudies/ganges.html
Fly						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
	Official	Commission	Joint management	1978	Fly River Provincial Boundaries Commission. Established in accordance with the Fly River Constituencies Act.	See http://www.paclii.org/pg/cases/PNGLR/1980/140.html

Ganges-Brahmaputra-Meghna						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Prinicipal Issue**	**Date**	**Description**	**Source**
India and Bangladesh	Official	Commission	Joint management	March 19, 1972	Indo-Bangladesh Joint Rivers Commission. Mission: to develop the waters of the rivers common to the two countries on a cooperative basis (specifically excluding issues of Ganges development).	See http://www.transboundarywaters.orst.edu/projects/casestudies/ganges.html
Helmand						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
	Official	Commission	Water quantity, joint management		Helmand River Delta Commission. Task: to measure and divide the river flows between the two signatories.	
Indus						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
India, Pakistan	Official	Commission	Water quantity, joint management	1960	Indus Water Commission or Permanent Indus Commission. Regulates the allocation of waters from the Indus River basin between India and Pakistan.	See http://wrmin.nic.in/international/industreaty.htm
Karnaphuli						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
India and Bangladesh	Official	Commission	Joint management	19-Mar-72	Indo-Bangladesh Joint Rivers Commission. Mission: to develop the waters of the rivers common to the two countries on a cooperative basis (specifically excluding issues of Ganges development).	See http://www.transboundarywaters.orst.edu/projects/casestudies/ganges.html
Kura-Araks						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Georgia, Turkey				is being set up	Joint Commission	

Mekong						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Cambodia, Lao PDR, Thailand and Vietnam	Official	Commission	Hydro-power/hydro-electricity, irrigation, navigation, fishing, flood control/relief, joint management	1957	Mekong River Commission (formerly known as Mekong Committee; name change in 1995). A coordinating mechanism between the four countries. Original aim was development of large scale water-resource developments, but this has never been realized. Now objections include hydropower, irrigation, flood control, collection and distribution of hydrological data. Also, the MRC serves as focal point for donor organizations and countries. MRC maintains regular dialogue with the two upper states of the Mekong River Basin, China and Myanmar.The MRC member countries agree to co-operate in all fields of sustainable development, utilisation, management and conservation of the water and related resources of the Mekong River Basin, such as navigation, flood control, fisheries, agriculture, hydropower and environmental protection.	See http://www.mrcmekong.org/ and http://waterpartners.geo.orst.edu/news/OSU2003v3.ppt#9
Talas						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Kazakstan, Kyrgyzstan	Official	Commission	Joint management	January 21, 2000	Article 5 of the international agreement between the Government of the Kazakh Republic and the Government of the Kyrgyz Republic on the Use of Water Management Facilities of Intergovernmental Status on the Rivers Chu and Talas states that "in order to ensure safe and reliable work of water management facilities of intergovernmental status, the Parties shall create permanent commissions to determine the working regimes and the range of necessary expenses for exploitation and maintenance".	See http://www.talaschu.org/index.php?ID=basis,agree,en
Tigris-Euphrates/Shatt al Arab						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Iraq, Turkey	Official	Commission	Water quantity, technical assistance/cooperation, joint management	1980	Joint Technical Committee on Regional Waters. Formed on the basis of a former protocol (1946) concerning the control and management of the Euphrates and the Tigris. Set up in 1980 by both countries for discussing regional water matters.	See http://www.fao.org/ag/agl/aglw/aquastat/countries/turkey/index.stm

Table 3C: List of international river basin commission on the European continent

Danube

Participating countries	Level of Collaboration	Principal Issue	Type of Collaboration	Date	Description	Source
Albania, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Italy, Moldova, Poland, Romania, Slovakia, Slovenia, Switzerland, Ukraine, Yugoslavia (Serbia and Montenegro)	Official	Commission	Water quality, joint management	October 22, 1998	International Commission for the Protection of the River Danube (ICPDR). The ICPDR is an international organisation consisting of 13 cooperating states and European Union, implementing the Danube River Protection Convention. It is the institutional frame not only for pollution control and the protection of water bodies but it sets also a common platform for sustainable use of ecological resources and coherent and integrated river basin management. The ICPDR is the body charged to implement the "Convention on the Protection and Sustainable Use of the Danube River" (Danube River Protection Convention, DRPC).	See http://www.icpdr.org/pls/danubis/danubis_db.dyn_navigator.show
Ukraine, Slovakia	Official	Commission	Joint management		Joint Commission. For the regulation of water supply.	TFDD

Daugava

Participating countries	Level of Collaboration	Principal Issue	Type of Collaboration	Date	Description	Source
Russian Federation, Republic of Belarus and Republic of Latvia				Draft agreement May 2003	Draft agreement includes the establishment of a joint commission ("To accomplish the aims of the present Agreement the Parties shall establish a joint Russian-Byelorussian-Latvian Commission on the use and protection of water resources of the Zapadnaya Dvina/Daugava River Basin").	See http://www.unece.org/env/water/cwc/legal/Daugava_e.pdf

Dnieper

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Belarus, Russian Federation and Ukraine	Official	Commission	Joint management, border issues	2003	International Dnieper Basin Council. In 2003, Ministers of Belarus, Russian Federation and Ukraine signed a statement on ecological rehabilitation of the Dnieper River, leading to the creation of the International Dnieper Basin Council. The creation of this Council was facilitated within the framework of the UNDP-GEF Dnieper Basin Environment Programme. The Council is consultative in nature and will function as a coordinating body to ensure effective international cooperation focused on the environmental rehabilitation of the Dnieper basin. It will play an active role in the development and implementation of both the regional Strategic Action Plan as well as the three countries' National Action Plans. It will also aim to ensure the development of stable transboundary monitoring systems, encourage sustainable exchange of environmental information and facilitate wide participation of interested stakeholders in river basin management.	See http://www.grid.unep.ch/product/publication/freshwater_europe/dniepr.php

Elbe						
Participating countries	**Level of Collaboration**	**Prinicipal Issue**	**Type of Collaboration**	**Date**	**Description**	**Source**
Czech Republic, European Union, Germany	Official	Commission	Water quality, joint management	1990	International Commission for the Protection of the Elbe (ICEP). The contracting parties shall cooperate in the International Commission for the Protection of the Elbe to prevent the pollution of the Elbe and its drainage area.The main goals are the possibility to produce drinking water from water pumped from the river acompanying groundwater, possibility to use the water and sediments for agriculture, return to a close to natural ecosystem with a healthy species diversity, and reducing the bad effects of Elbe river basin on the North Sea.	See http://rod.eionet.eu.int/show.jsv?id=182&mode=S and http://www.ikse.de/
Kemi						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Norway	Official	Commission	Water quality, joint management	1980	Finnish-Norwegian Transboundary Water Commission. The Commission acts as a body for cooperation and communication between the two states. Its aim is to preserve the transboundary watercourses and their unique natural conditions. It also safeguards the environmental interests of both states and the residents of the border region. The Commission has an advisory role. It submits proposals and motions and issues statements on matters related to water management. Many actions need preparatory work, for example, monitoring of the state of the environment and activities influencing the catchments, as well as hearing experts before (recommendations) decisions can be made by the Commission.	See http://www.ymparisto.fi/default.asp?node=9813&lan=en
Lake Ohrid (subbasin of Lake Prespa)						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Albania, Macedonia	Official	Organization	Border issues	January 15, 2000	Alliance for Lake Cooperation in Prespa and Ohrid. The alliance focuses on promoting and supporting the cross-border activities in the protection of the environment in the Region of Ohrid and Prespa Lakes aiming at sustainable development of the region. The approach includes development of cross border cooperation and co-ordination between the relevant states and above all local government and NGOs in order to ensure the active participation of the local population.	See http://allcoop.org.mk/ALLCOOP.html

Naatamo						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Norway	Official	Commission	Water quality, joint management	1980	Finnish-Norwegian Transboundary Water Commission. The Commission acts as a body for cooperation and communication between the two states. Its aim is to preserve the transboundary watercourses and their unique natural conditions. It also safeguards the environmental interests of both states and the residents of the border region. The Commission has an advisory role. It submits proposals and motions and issues statements on matters related to water management. Many actions need preparatory work, for example, monitoring of the state of the environment and activities influencing the catchments, as well as hearing experts before (recommendations) decisions can be made by the Commission.	See http://www.ymparisto.fi/default.asp?node=9813&lan=en
Narva						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Estonia, Russia	Official	Commission	Joint management	1997	Estonian – Russian Joint Transboundary Water Commission	See http://www.envir.ee/jc/eng/index.php
Neman (Nemunas) (subbasin Sesupe)						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Lithuania, Poland	Official			being set up	Joint Commission.	TFDD
Russian Federation, Poland	Official			being set up	Joint Commission.	TFDD
Oder/Odra						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Poland, the Czech Republic, Germany	Official	Commission	Water quality, flood control/relief, joint management	April 26, 1999	International Commission for the Protection of the Oder River against Pollution (ICPOAP). The objectives of the ICPOAP are: 1. to prevent the pollution of the Oder and the Baltic Sea by contaminants and to achieve a reduction in the pollution thereof; 2. to achieve the most natural aquatic and littoral ecosystems possible with the corresponding species diversity; 3. to permit utilisation of the Oder, in particular the production of drinking water from bank filtrate and the use of its water and sediments in agriculture; 4. to provide for precautions against the risk of flood damage and achieve a sustained reduction thereof; and 5. to coordinate implementation of the Water Framework Directive in the Oder river basin.	See http://www.mkoo.pl/

Olanga						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Russia	Official	Commission	Water quality, joint management	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm
Oulu						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Russia	Official	Commission	Water quality, joint management	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm
Pasvik						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Norway	Official	Commission	Water quality, joint management	1980	Finnish-Norwegian Transboundary Water Commission. The Commission acts as a body for cooperation and communication between the two states. Its aim is to preserve the transboundary watercourses and their unique natural conditions. It also safeguards the environmental interests of both states and the residents of the border region. The Commission has an advisory role. It submits proposals and motions and issues statements on matters related to water management. Many actions need preparatory work, for example, monitoring of the state of the environment and activities influencing the catchments, as well as hearing experts before (recommendations) decisions can be made by the Commission.	See http://www.ymparisto.fi/default.asp?node=9813&lan=en
Finland, Russia	Official	Commission	Water quality, joint management, border issues	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm

Rhine						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
European Union, France, Germany, Luxemburg, the Netherlands, Switzerland	Official	Commission	Water quality, flood control/relief, joint management	1950	International Commission for the Protection of the Rhine (formerly: International Commission for the Protection of the Rhineagainst Pollution) (ICPR). Targets: 1. Sustainable development of the entire Rhine ecosystem 2. Guarantee the use of Rhine water for drinking water production 3. Improvement of the sediment quality in order to enable the use or disposal of dredged material without causing environmental harm. 4. Overall flood prevention and environmentally sound flood protection 5. Improvement of the North Sea quality in accordance with other measures aimed at the protecton of this marine area.	See http://www.iksr.org/
Switzerland, Austria, Germany, France, Luxembourg and the Netherlands	Official	Commission	Other: research and education	1970	International Commission for the Hydrology of the Rhine Basin (CHR). An organisation where the scientific institutes of the Rhine riparian states formulate joint hydrological measures for sustainable development of the Rhine basin. Mission: 1) Expansion of the knowledge of the hydrology in the Rhine basin and 2) making a contribution to the solution of cross-border problems.	See http://www.chr-khr.org/
Germany, France, Luxembourg and the Netherlands	Official	Commission	Water quality, other: research and education	2002	The International Meuse Commission (IMC). The main goals of the IMC are: - to coordinate the implementation of the European Water Framework Directives - to give advice and recommendations to the parties to prevent and protect against high waters - to give advice and recommendations to the parties to prevent and combat water pollution (prevention and detection systems) NGOs can participate in the IMC meetings.	See http://www.cipm-icbm.be/default.asp
Netherlands, Belgium, Germany, France, and Switzerland	Official	Commission	Navigation	1815	Central Commission for Navigation on the Rhine (CCNR). The Commission passes resolutions unanimously in line with its terms of reference as follows: ● proposals concerning the prosperity of navigation on the Rhine ● adoption of technical and administrative regulations (and their amendments) concerning the safety of vessels ● complaints arising from the application of the Mannheim Convention.	See http://unesdoc.unesco.org/images/0013/001333/133303e.pdf

Schelde						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Belgium, France, Netherlands	Official	Commission	Water quality, joint management	1995	International Scheldt Commission (ICBS). International cooperation in order to protect the waters of the Scheldt river.	See http://www.isc-cie.com/default.asp
Tana						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Norway	Official	Commission	Water quality, joint management	1980	Finnish-Norwegian Transboundary Water Commission. The Commission acts as a body for cooperation and communication between the two states. Its aim is to preserve the transboundary watercourses and their unique natural conditions. It also safeguards the environmental interests of both states and the residents of the border region. The Commission has an advisory role. It submits proposals and motions and issues statements on matters related to water management. Many actions need preparatory work, for example, monitoring of the state of the environment and activities influencing the catchments, as well as hearing experts before (recommendations) decisions can be made by the Commission.	See http://www.ymparisto.fi/default.asp?node=9813&lan=en
Torne/Tornealven						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Norway	Official	Commission	Water quality, joint management	1980	Finnish-Norwegian Transboundary Water Commission. The Commission acts as a body for cooperation and communication between the two states. Its aim is to preserve the transboundary watercourses and their unique natural conditions. It also safeguards the environmental interests of both states and the residents of the border region. The Commission has an advisory role. It submits proposals and motions and issues statements on matters related to water management. Many actions need preparatory work, for example, monitoring of the state of the environment and activities influencing the catchments, as well as hearing experts before (recommendations) decisions can be made by the Commission.	See http://www.ymparisto.fi/default.asp?node=9813&lan=en
Tuloma						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Finland, Russia	Official	Commission	Water quality, joint management	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm

Vistula/Wista

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Ukraine, Poland	Official	Commission	Water quantity, irrigation, joint management	1996	Joint Commission. For the cooperation in the field of water management in frontier waters; irrigation, regulation, water supply.	TFDD

Volga

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Kazakhstan, Russia	Official	Commission	Water quality, water quantity, joint management	Data not availabe	Joint Russian-Kazakhstan Commission for Utilization and Protection of Transboundary Waters.	www.iucn.org/themes/law/pdfdocuments/EPLP55EN.pdf

Vuoksa (subbasin Lake Saimaa)

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Russian Federation, Finland	Official	Commission	Joint management	October 26, 1989	Joint Commission. For regulation of the rules for the lake Saimaa and the Vuoksa rivers.	See http://www.unece.org/env/water/documents/transbwatcoopnis_fin_e.pdf
Finland, Russia	Official	Commission	Water quality, joint management	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm

Yser

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
	Non-official	International initiative	Other: research and education	1994	European Rivers Network (ERN). ERN, the European Rivers Network, is a non profit NGO and is supported by IRN (International Rivers Network), S.O.S. Loire Vivante, EURONATUR (European Foundation for Natural Heritage), DUH (Deutsche Umwelthilfe) and many others. The aim of ERN, is to link groups, organisations and persons working for the protection of rivers and to improve communication between them. ERN also links organisations from different working fields such as environment, culture, education and human rights. ERN seeks to promote the sustainable wise management of living rivers in opposition to the exploitation, pollution and degradation that has occurred in the past.	See http://www.rivernet.org/ern.htm

Torne/Tornealven

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Finland, Norway	Official	Commission	Water quality, joint management	1980	Finnish-Norwegian Transboundary Water Commission. The Commission acts as a body for cooperation and communication between the two states. Its aim is to preserve the transboundary watercourses and their unique natural conditions. It also safeguards the environmental interests of both states and the residents of the border region. The Commission has an advisory role. It submits proposals and motions and issues statements on matters related to water management. Many actions need preparatory work, for example, monitoring of the state of the environment and activities influencing the catchments, as well as hearing experts before (recommendations) decisions can be made by the Commission.	See http://www.ymparisto.fi/default.asp?node=9813&lan=en

Tuloma

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Finland, Russia	Official	Commission	Water quality, joint management	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm

Velaka

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
	Non-official	International initiative	Other: research and education	1994	European Rivers Network (ERN). ERN, the European Rivers Network, is a non profit NGO and is supported by IRN (International Rivers Network), S.O.S. Loire Vivante, EURONATUR (European Foundation for Natural Heritage), DUH (Deutsche Umwelthilfe) and many others. The aim of ERN, is to link groups, organisations and persons working for the protection of rivers and to improve communication between them. ERN also links organisations from different working fields such as environment, culture, education and human rights. ERN seeks to promote the sustainable wise management of living rivers in opposition to the exploitation, pollution and degradation that has occurred in the past.	See http://www.rivernet.org/ern.htm

Vistula/Wista

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Ukraine, Poland	Official	Commission	Water quantity, irrigation, joint management	1996	Joint Commission. For the cooperation in the field of water management in frontier waters; irrigation, regulation, water supply.	TFDD

Volga						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Kazakhstan, Russia	Official	Commission	Water quality, water quantity, joint management	Data not availabe	Joint Russian-Kazakhstan Commission for Utilization and Protection of Transboundary Waters.	www.iucn.org/themes/law/pdfdocuments/EPLP55EN.pdf
Vuoksa (subbasin Lake Saimaa)						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Russian Federation, Finland	Official	Commission	Joint management	October 26, 1989	Joint Commission. For regulation of the rules for the lake Saimaa and the Vuoksa rivers.	See http://www.unece.org/env/water/documents/transbwatcoopnis_fin_e.pdf
Finland, Russia	Official	Commission	Water quality, joint management	1964	Finnish-Russian Joint Commission on the Utilization of Frontier Waters. This cooperation provides an example of the benefits of sustained activities between two countries sharing common resources. Geographical Scope: The lakes, rivers, and streams intersected by the frontier line or along which the frontier line runs.	See http://www.inwent.org/ef-texte/vilnius/rep1199e.htm
Wiedau						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
					European Rivers Network (ERN). ERN, the European Rivers Network, is a non profit NGO and is supported by IRN (International Rivers Network),	
	Non-official	International initiative	Other: research and education	1994	S.O.S. Loire Vivante, EURONATUR (European Foundation for Natural Heritage), DUH (Deutsche Umwelthilfe) and many others. The aim of ERN, is to link groups, organisations and persons working for the protection of rivers and to improve communication between them. ERN also links organisations from different working fields such as environment, culture, education and human rights. ERN seeks to promote the sustainable wise management of living rivers in opposition to the exploitation, pollution and degradation that has occurred in the past.	See http://www.rivernet.org/ern.htm
Yser						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
	Non-official	International initiative	Other: research and education	1994	European Rivers Network (ERN). ERN, the European Rivers Network, is a non profit NGO and is supported by IRN (International Rivers Network), S.O.S. Loire Vivante, EURONATUR (European Foundation for Natural Heritage), DUH (Deutsche Umwelthilfe) and many others. The aim of ERN, is to link groups, organisations and persons working for the protection of rivers and to improve communication between them. ERN also links organisations from different working fields such as environment, culture, education and human rights. ERN seeks to promote the sustainable wise management of living rivers in opposition to the exploitation, pollution and degradation that has occurred in the past.	See http://www.rivernet.org/ern.htm

Table 3D: List of international river basin commission on the North American continent

Alsek

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management, fishing	1999-2008	Joint Transboundary Technical Committee (TBRTC). Provision of the Pacific Salmon Treaty (1999). The Committee shall: - assemble and refine available information on migratory patterns, extent of exploitation and spawning escapement requirements of the stocks; - examine past and current management regimes and recommend how they may be better suited to achieving preliminary escapement goals; and - identify enhancement opportunities that: a) assist the devising of harvest management strategies to increase benefits to fishermen with a view to permitting additional salmon to return to Canadian waters; and b) have an impact on natural transboundary river salmon production.	See http://www.oceanlaw.net/texts/psc-ch1.htm
Canada, United States of America	Official	Commission	Joint management, border issues	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Chilkat

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission		1999-2008	Joint Transboundary Technical Committee (TBRTC). Provision of the Pacific Salmon Treaty (1999). The Committee shall: - assemble and refine available information on migratory patterns, extent of exploitation and spawning escapement requirements of the stocks; - examine past and current management regimes and recommend how they may be better suited to achieving preliminary escapement goals; and - identify enhancement opportunities that: a) assist the devising of harvest management strategies to increase benefits to fishermen with a view to permitting additional salmon to return to Canadian waters; and b) have an impact on natural transboundary river salmon production.	See http://www.oceanlaw.net/texts/psc-ch1.htm

Chilkat - continued						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Commission	Joint management, border issues	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm
Colorado						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Commission	Water quantity, joint management	1950	International Water and Boundary Commission (IBWC). The two Governments through the IBWC jointly administer the terms of the 1944 Water Treaty relating to the Colorado River, which provides that of its waters there are allotted to Mexico, (a) a guaranteed annual quantity of 1,500,000 acre-feet (1,850,234,000 cubic meters) and (b) any other quantities arriving at the Mexican points of diversion with certain conditions stipulated in the 1944 Treaty. The application of these terms began in 1950. The operations are performed in collaboration with the United States Bureau of Reclamation, Department of the Interior.	See http://www.ibwc.state.gov/html/colorado_river.html

Columbia

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management, border issues	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm
Canada, United States of America	Official	Organization	Water quantity, joint management	1941	IJC Board: International Columbia River Board of Control. The Board keeps the Commission apprised of streamflow and water-level data on both sides of the international boundary and reports to the Commission each April. Established by Order of the International Joint Commission (IJC) dated 15 December 1941 to ensure the implementation of the provisions of that Order—which granted approval for the United States to construct and operate the Grand Coulee dam and reservoir (Frankin D. Roosevelt Lake)—and to continue to study the effect of the operation of the Grand Coulee dam and reservoir upon water levels at and above the international boundary.	See http://www.ijc.org/conseil_board/columbia/en/columbia_home_accueil.htm

Firth

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Fraser

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Mississippi

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Mexico, United States of America	Official	Commission	Joint management	1889	International Boundary and Water Commission (IBWC). Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties.	See http://www.ibwc.state.gov/

Nelson-Saskatchewan

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Rio Grande						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Mexico, United States of America	Official	Organization	Joint management, water quality	1994	Río Grande/ Río Bravo Basin Coalition. The mission of the Río Grande/ Río Bravo Basin Coalition is to facilitate local communities in restoring and sustaining the environment, economies, and social well being of the Río Grande/ Río Bravo Basin.	See http://www.rioweb.org/
Mexico, United States of America	Official	Commission	Joint management	1889	International Boundary and Water Commission (IBWC). Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties.	See http://www.ibwc.state.gov/
Skagit						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

St. Croix

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm
Canada, United States of America	Official	Organization	Joint management	1915 (2000)	International St. Croix River Board. On September 26, 2000, the International Joint Commission formally combined its existing International St. Croix River Board of Control (founded in 1915) and its International Advisory Board on Pollution Control - St. Croix River and established the International St. Croix River Board. It's mandate is to assist the Commission in preventing and in resolving disputes regarding the boundary waters of the St. Croix River, to monitor the ecological health of the St. Croix River boundary waters aquatic ecosystem, and to ensure compliance with the Commission's Orders of Approval for structures in the St. Croix River.	See http://www.ijc.org/conseil_board/st_croix_river/en/stcroix_home_accueil.htm

St. John

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

St. Lawrence						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Commission	Joint management	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm
Canada, United States of America	Official	Commission	Joint management	1955	Great Lakes Commission. The Great Lakes Commission is a binational public agency dedicated to the use, management and protection of the water, land and other natural resources of the Great Lakes-St. Lawrence system.	See http://www.glc.org
Canada, United States of America	Official	Commission	Joint management, fishing	1955	The Great Lakes Fisheries Commission. The Commission was established in 1955 by the Canadian/U.S. Convention on Great Lakes Fisheries. The commission coordinates fisheries research, controls the invasive sea lamprey, and facilitates cooperative fishery management among the state, provincial, tribal, and federal management agencies. The Commission has two major responsibilities: 1. To develop coordinated programs of research on the Great Lakes, and, on the basis of the findings, to recommend measures which will permit the maximum sustained productivity of stocks of fish of common concern; and 2. To formulate and implement a program to eradicate or minimize sea lamprey populations in the Great Lakes.	See http://www.glfc.org/home.asp
Canada, United States of America	Official	Organization	Other: research and education	1978	Great Lakes Science Advisory Board. Provides scientific advice to the International Joint Commission and the Great Lakes Water Quality Board and is responsible for developing recommendations on all matters related to research and the development of scientific knowledge pertinent to Great Lakes water quality.	See http://www.ijc.org/conseil_board/science_greatlakes/en/glsab_home_accueil.htm

St. Lawrence - continued						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Organization	Water quality	1978	Great Lakes Water Quality Board. The principal advisor to the IJC with regard to all functions, powers and responsibilities regarding water quality.	See http://www.ijc.org/conseil_board/water_greatlakes/en/glwqb_mandate_mandat.htm
Canada, United States of America	Official	Organization	Water quality	1990	Integrated Atmospheric Deposition Network (IADN). Established by the United States and Canada for conducting air and precipitation monitoring in the Great Lakes Basin.	See http://www.msc-smc.ec.gc.ca/iadn/Overview/index_e.html
Canada, United States of America	Official	Organization	Joint management, water quality, water quantity, other: research and education	1914	IJC Board: International Lake Superior Board of Control. The Board's duties include setting Lake Superior outflows, and overseeing the operation of the various control works. Activities related to these responsibilities include: conducting studies to develop and improve the regulation plan; monitoring repairs and maintenance of the control facilities; and directing flow measurements in the St. Marys River for the purpose of determining the discharge capacities of the various control works.The Board provides the Commission with advice on matters related to: adverse hydrologic conditions on the lakes; modification of the control facilities; and levels and flows in the St. Mary's River, including the environmentally sensitive St. Mary's Rapids.	See http://www.ijc.org/conseil_board/superior_lake/en/superior_mandate_mandat.htm
Canada, United States of America	Official	Organization	Water quantity, hydro-power/hydro-electricity, joint management.	1950	IJC Board: International Niagara Board of Control. The Board's main duties are to oversee water levels regulation in the Chippawa-Grass Island Pool and installation of the Lake Erie-Niagara River Ice Boom. The Board also collaborates with the International Niagara Committee, a body created by the 1950 Niagara Treaty to determine the amount of water available for the Falls and power generation.	See http://www.ijc.org/conseil_board/niagara/en/niagara_home_accueil.htm
Canada, United States of America	Official	Commission			International Niagara Committee	
Canada, United States of America	Official	Organization	Joint management, water quantity, other: research and education	1952	IJC Board: International St. Lawrence River Board of Control. Its main duty is to ensure that outflows from Lake Ontario meet the requirements of the Commission's order. The Board also develops regulation plans and conducts special studies as requested by the Commission. Outflows are set by the Board under the regulation plan.	See http://www.islrbc.org/new-Version/engmain.html

St. Lawrence - continued						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Organization	Water quality, joint management, other: research and education	2002	Lake Huron Binational Partnership (LHBP). In 2002 the federal, state and provincial agencies that manage binational environmental activities under the 1987 Great Lakes Water Quality Agreement formally endorsed the formation of a Lake Huron Binational Partnership in order to prioritize and coordinate environmental activities in the Lake Huron basin. The federal and state/provincial environment agencies and the state/provincial natural resource agencies form the core of the Partnership by providing leadership and coordination. This partnership builds upon the efforts begun by the Michigan Office of the Great Lakes in their Lake Huron Initiative. The Partnership facilitates information sharing and priority setting for binational environmental protection and restoration activities of importance in the Lake Huron basin and also the development of partnerships to undertake efforts that can not be accomplished by individual agencies alone. One of the purposes of the Partnership is to develop an action-oriented process for addressing Lake Huron concerns to help identify priority issues and future efforts needed to ensure a he	See http://cfpub.binational.net/huron/intro-e.cfm
Stikine						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Commission	Joint management, fishing	1999-2008	Joint Transboundary Technical Committee (TBRTC). Provision of the Pacific Salmon Treaty (1999). The Committee shall: - assemble and refine available information on migratory patterns, extent of exploitation and spawning escapement requirements of the stocks; - examine past and current management regimes and recommend how they may be better suited to achieving preliminary escapement goals; and - identify enhancement opportunities that: a) assist the devising of harvest management strategies to increase benefits to fishermen with a view to permitting additional salmon to return to Canadian waters; and b) have an impact on natural transboundary river salmon production.	See http://www.oceanlaw.net/texts/psc-ch1.htm
Canada, United States of America	Official	Commission	Joint management, border issues	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality, and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Taku						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Canada, United States of America	Official	Commission	Water quality, fishing	1999-2008	Joint Transboundary Technical Committee (TBRTC). Provision of the Pacific Salmon Treaty (1999). The Committee shall: - assemble and refine available information on migratory patterns, extent of exploitation and spawning escapement requirements of the stocks; - examine past and current management regimes and recommend how they may be better suited to achieving preliminary escapement goals; and - identify enhancement opportunities that: a) assist the devising of harvest management strategies to increase benefits to fishermen with a view to permitting additional salmon to return to Canadian waters; and b) have an impact on natural transboundary river salmon production.	See http://www.oceanlaw.net/texts/psc-ch1.htm
					International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty	
Canada, United States of America	Official	Commission	Joint management, border issues	1909	of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm
Tijuana						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Mexico, United States of America	Official	Commission	Joint management, border issues	1889	International Boundary and Water Commission (IBWC). Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties. The IBWC is an international body composed of the United States Section and the Mexican Section,	See http://www.ibwc.state.gov/

Whiting

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management, border issues	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Yaqui

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
					International Boundary and Water Commission (IBWC). Has the responsibility for applying the boundary and water treaties between the United States and Mexico and settling differences that may arise out of these treaties. The IBWC is an international body composed of the United States Section and the Mexican Section.	
Mexico, United States of America	Official	Commission	Joint management, border issues	1889		See http://www.ibwc.state.gov/

Yukon

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Canada, United States of America	Official	Commission	Joint management, border issues	1909	International Joint Commission (IJC). The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions. In particular, the Commission rules upon applications for approval of projects affecting boundary or transboundary waters and may regulate the operation of these projects; it assists the two countries in the protection of the transboundary environment, including the implementation of the Great Lakes Water Quality Agreement and the improvement of transboundary air quality; and it alerts the governments to emerging issues along the boundary that may give rise to bilateral disputes.	See http://www.ijc.org/en/home/main_accueil.htm

Table 3E: List of international river basin commission on the South American continent

Amazon						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Brazil, Peru, Bolivia, Colombia, Ecuador, Venezuela, Guyana, Suriname, French Guiana	Official	Organization	Water quality, economic development, joint management	July 3, 1978	The contracting parties of the Organization of the Amazon Cooperation Treaty (OTCA). OTCA has agreed to undertake joint actions and efforts to promote the harmonious development of their respective Amazonian territories in such a way that these joint actions produce equitable and mutually beneficial results and achieve also the preservation of the environment, and the conservation and rational utilization of the natural resources of those territories	See http://www.otca.org.br/en/institucional/Amazon_Cooperation_Treaty.php
Cullen						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Argentina, Chile	Official	Commission	Economic program, joint management	Data not available	Binational Commission of Economical Cooperation and Physical Integration	
La Plata (Del Plata)						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Argentina, Uruguay	Official	Commission	Joint management, border issues	November 19, 1973	Comisión Administradora del Río de la Plata or the Administrative Commission for the Río de la Plata (CARP) is an an international organism, of binational character, that offers the legal frame and enables dialogues between its the Argentine Republic and the Eastern Republic of Uruguay, for the negotiation in matters of interest common to both nations concerning the Rio de la Plata.	http://www.comisionriodelaplata.org/
Argentina, Uruguay	Official	Commission	Economic development, joint management, technical cooperation/assistance	1985	Comision Binacional Punte Buenos Aires Colonia or Buenos Aires - Colonia Bridge Binational Commission (COBAICO). This commission was based on a common interest in increasing commerce between Argentina and Uruguay. In order to facilitate this commerce, a bridge was created across the Plata River which runs between the two national territories. One of the responsibilities of COBAICO is overseeing the sustainable management and preservation of the Plata River.	See http://www.cobaico.com.ar

La Plata (Del Plata) - continued						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Brazil, Argentina, Uruguay, Paraguay, Bolivia	Official	Commission	Joint management	1969	The permanent Intergovernmental Co-ordinating Committee (CIC) is responsible for ongoing administration ot the La Plata Basin Treaty (1969). The committee is composed of representatives of each country and has a secretariat with responsibility for coordination promotion, and control of the multinational efforts.The 1969 treaty provides an umbrella framework for several bilateral treaties between the riparian, and a direction for joint development of the basin. The treaty requires open transportation and communication along the river and its tributaries, and prescribes cooperation in education, health, and management of 'non-water' resources (e.g., soil, forest, flora, and fauna). The foreign ministers of the riparian states provide the policy direction.	TFDD
Argentina, Uruguay	Official	Commission	Water quantity, hydro-power/hydro-electricity, economic development, joint management, technical cooperation/assistance	December 30, 1946	Comision Technica de Mixta de Salto Grande (CTMSG). The Salto Grande River Basin forms an international sub-basin within the La Plata River Basin.The CTMSG was set up for the production of electrical energy, using the rapids of the Salto Grande between Argentina and Uruguay. Work began in 1974, actual electricity generation starting in 1979. Now the commission manages, operates and maintains the turbines. Argentina and Uruguay have their power markets totally integrated; these turbines contributes 60% of Uruguay's energy demand and covers 10% of the Argentina market.	http://www.saltogrande.org/saltogrande/Principal.html
Argentina, Paraguay, Brazil?	Official	Organization	Economic development, joint management, technical cooperation/assistance	1971	Comision Mixta del Rio Parana or Joint Commission of the Parana River (COMIP). The Parana forms an international sub-basin within the La Plata River Basin. COMIP was agreed to by both Paraguay and Argentina in 1971. This agreement legally binds both countries to a set of laws regulating the shared use of the Paraná River as a natural resource. COMIP functions as an international organization, as such it is responsible for conducting evaluations in such areas as industrial, agricultural and recreational use of Paraná River.	TFDD
Argentina, Bolivia	Official	Commission	Economic development, joint management, technical cooperation/assistance	June 9, 1995	Binational Commission for the Development of the upper Bermejo River and Grande de Tarija River Basins. The Bermejo and Tarija River Basin forms an international sub-basin within the La Plata River Basin. This Commission is responsible for the administration of the Upper Bermejo River and Grande de Tarija River Basins, in order to promote sustainable development in its area of influence, optimize its natural resources development, contribute to its socioeconomic development, and allow rational and equitable management of water resources.	http://www.cbbermejo.org.ar/indexeng.htm

La Plata (Del Plata) - continued

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Argentina, Bolivia, Paraguay	Official	Organization	Joint management	February 9, 1995	Comisión Trinacional para el Desarrollo de la Cuenca del Río Pilcomayo – Tri-national Commission for the Development of the Pilcomayo River Basin. The Pilcomayo River Basin forms an international sub-basin within the La Plata River Basin. The Commission is responsible for the study and execution of joint projects in the Pilcomayo River.	See http://www.pilcomayo.org.py/comision.html

Lagoon Mirim

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Uruguay, Brazil	Official	Commission	Joint management	April 26, 1963	Commission for the Development of the Mirim Lagoon Basin (CLM). Set up to perform joint initiatives in the Mirim Lagoon, with Brazilian and Uruguayan agents. It acted satisfactorily to address the problems and issues inherent in the proposal of regional development. However, attempts at integrated institutional actions were frustrated, and over the years, each country has established its own agenda. In June 2002, a unilateral legal instrument to help reactivate the Commission was signed.	See http://www.bioone.org/bioone/?request=get-document&issn=0044-7447&volume=033&issue=01&page=0068.

Lake Fagnano

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Argentina, Chile	Official	Commission	Economic development, joint management	data not available	Binational Commission of Economical Cooperation and Physical Integration	TFDD

Lake Titicaca-Poopo System

Participating countries	Level of Collaboration	Type of Collaboration	Principal Issue	Date	Description	Source
Bolivia, Peru, Chile	Official	Organization	Water quality, economic development, joint management, technical cooperation/assistance	May 29, 1996	Binational Autonomous Authority of the Lake Titicaca (ALT). The ALT is an entity of international public right with autonomy in its decisions and administrations in technical and economic fields; ALT's political functioning is associated with the Peruvian and Bolivian State Secretaries. ALT's General Objective is to promote and conduct actions, programs and projects, to dictate norms of management control and protection of the water resources in the Hydrologic System of the Lake Titicaca, the Desaguadero river, lake Poopo and The Coipasa Salt Lake (TDPS), under the framework of the Master Plan of the TDPS system.	http://www.pnud.bo/biodiversidad/dips/alt/alt.html
Bolivia, Peru	Official	Organization	Joint management	1987	Joint Subcommittee for the Development of the Lake Titicaca Integration Zone (SUBCOMILAGO).	See http://www.oas.org/usde/publications/Unit/oea31e/ch03.htm
Bolivia, Peru	Official	Organization	Joint management	July 1, 1993	The Autonomous Binational TDPS System Authority for the TDPS.	TFDD

Lempa						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
El Salvador, Honduras, Guatemala	Official	Commission	Water quality, economic development, joint management, technical cooperation/assistance	1992	Comisión Trinacional del Plan Trifinio or Trinational Commission of the Trifinio Plan (CTPT). The CTPT is the entity in charge of overviewing the execution of the Trifinio Plan, and its continuous updating, with administrative, financial, and technical autonomy, and its own legal status. Also, the Plan Trifinio forms part of the Central American integration process, and is attached to the Central American Integration System (SICA).	TFDD
Paz						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Guatemala, El Salvador	Official	Commission	Joint management	Data not available	Comisión Binacional del Río Paz	TFDD
Guatemala, El Salvador	Official	Organization	Economic development, joint management, infrastructure/development, technical cooperation/assistance, border issues	1971	International Waters and Borders Committee (CILA). Main task: to advice and assist the governments of both countries on border issues, while enabled to carry out research and studies, as well as to execute works previously approved by the Governments. CILA's tasks include: providing an opinion on any construction projects intended to be executed in the terrestrial boundaries, or in the basins of international rivers and lakes, and supervising their construction, to guarantee the rights of any of the countries are not jeopardized. All matters and issues related to defense works, and to the use of international waters shall be dealt with on the basis of the rules and principles recognized by International Law, which international organizations have promoted, and which allow for the greater benefit of the population and interest of both countries.	TFDD
San Martin						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Chile, Argentina	Official	Commission	Joint management	Data not available	Binational Commission of Economical Cooperation and Physical Integration	TFDD

Sixaola						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Costa Rica, Panama	Official	Organization	Joint management	Data not available	Comité de la cuenca del río Sixaola (CCRS).	TFDD
Zapaleri						
Participating countries	**Level of Collaboration**	**Type of Collaboration**	**Principal Issue**	**Date**	**Description**	**Source**
Chile, Argentina, Bolivia	Official	Commission	Economic development, joint management	Data not available	Binational Commission of Economical Cooperation and Physical Integration	TFDD

Table 4A: summary of the institutional capacity related specifically for transboundary floods in the Netherlands. Data from chapter 2.Note that the data related to treaties comes from a database over the years 1945-2000, therefore excluding recent EC-based decisions.

The Netherlands		
IRB	Rhine	Schelde
Countries that share IRB	Austria	Belgium
	Belgium	
	France	
	Germany	France
	Italy	
	Liechtenstein	
	Luxembourg	Netherlands
	Netherlands	
	Switzerland	
% of NL in basin	27.8	0.2
Treaties	44	6
Flood-related treaties	3	0
Flood-related treaties with NL as signatory	0	
RBOs	6	1
RBO's with NL as member	4	1
RBOs with flood as principal issue	1	0
RBOs with flood as principal issue and NL as member	1	
Transboundary Floods 1985-2005	11	
Floods involving NL 1985-2005	4	

Table 4B: summary of the international water institutions the Netherlands is a member of. Only the IKSR has transboundary flood issues listed as a principal issue.

Date	IRB	Signatories	Description	Source
2002	Meuse (subbasin of Rhine)	Germany, France, Luxembourg and the Netherlands	The International Meuse Commission (IMC). The main goals of the IMC are: - to coordinate the implementation of the European Water Framework Directives - to give advice and recommendations to the parties to prevent and protect against high waters - to give advice and recommendations to the parties to prevent and combat water pollution (prevention and detection systems) NGOs can participate in the IMC meetings.	See http://www.cipm-icbm.be/default.asp
1950	Rhine	European Union, France, Germany, Luxemburg, the Netherlands, Switzerland	International Commission for the Protection of the Rhine (formerly: International Commission for the Protection of the Rhineagainst Pollution) (ICPR). Targets: 1. Sustainable development of the entire Rhine ecosystem 2. Guarantee the use of Rhine water for drinking water production 3. Improvement of the sediment quality in order to enable the use or disposal of dredged material without causing environmental harm. 4. Overall flood prevention and environmentally sound flood protection 5. Improvement of the North Sea quality in accordance with other measures aimed at the protecton of this marine area.	See http://www.iksr.org/
1970		Switzerland, Austria, Germany, France, Luxembourg and the Netherlands	International Commission for the Hydrology of the Rhine Basin (CHR). An organisation where the scientific institutes of the Rhine riparian states formulate joint hydrological measures for sustainable development of the Rhine basin. Mission: 1) Expansion of the knowledge of the hydrology in the Rhine basin and 2) making a contribution to the solution of cross-border problems.	See http://www.chr-khr.org/
1815		Netherlands, Belgium, Germany, France, and Switzerland	Central Commission for Navigation on the Rhine (CCNR). The Commission passes resolutions unanimously in line with its terms of reference as follows: ● proposals concerning the prosperity of navigation on the Rhine ● adoption of technical and administrative regulations (and their amendments) concerning the safety of vessels ● complaints arising from the application of the Mannheim Convention.	See http://unesdoc.unesco.org/images/0013/001333/133303e.pdf
1995	Schelde	Belgium, France, Netherlands	International Scheldt Commission (ICBS). International cooperation in order to protect the waters of the Scheldt river.	See http://www.isc-cie.com/default.asp

Table 4C: summary of the institutional capacity related specifically to transboundary floods in Mozambique. Data from chapter 2. Note that the data related to treaties comes from a database over the years 1945-2000, therefore excluding newer decisions and agreements.

Mozambique					
IRB	Buzi	Incomati	Limpopo	Maputo	Pungwe
Countries part of IRB	Mozambique Zimbabwe	Mozambique South Africa Swaziland	Botswana Mozambique South Africa Zimbabwe	Mozambique South Africa Swaziland	Mozambique Zimbabwe
% of MZ in basin	3.12	1.86	11.05	0.20	3.63
Treaties	0	5	1	2	0
Flood-related treaties		0	0	0	
Flood-related treaties with MZ as signatory					
Treaties with MZ as signatory		2	1	1	
RBO		3	5	0	
RBO's with MZ as member		2	5		
RBOs with flood as principal issue		0	0		
RBOs with flood as principal issue and MZ as member					
Transboundary Floods 1985-2005		1	2		
Floods involving MZ 1985-2005		0	2		

Mozambique				
IRB	Ruvuma	Sabi	Umbeluzi	Zambezi
Countries part of IRB	Malawi Mozambique Tanzania	Mozambique Zimbabwe	Mozambique South Africa Swaziland	Angola Botswana Malawi Mozambique Namibia Tanzania Zaire Zambia Zimbabwe
% of MZ in basin	12.55	3.84	0.92	20.73
Treaties	0	0	1	8
Flood-related treaties			0	0
Flood-related treaties with MZ as signatory				
Treaties with MZ as signatory			1	2
RBO			0	3
RBO's with MZ as member				1
RBOs with flood as principal issue				0
RBOs with flood as principal issue and MZ as member				
Transboundary Floods 1985-2005		1	1	5
Floods involving MZ 1985-2005		1	0	3

Table 4D: summary of all the international water institutions Mozambique is part of; none of them have transboundary flood issues listed as a principal issue.

Date	IRB	Signatories	Description	Source
1993	Incomati	Mozambique, South Africa, Swaziland	Komati Basin Water Authority (KOBWA). A bi-national company formed in 1993 through the treaty on the Development and Utilization of the Water Resources of the Komati River Basin signed in 1992 between the Kingdom of Swaziland and the Republic of South Africa. The purpose of KOBWA is implement Phase 1 of the Komati River Basin Development Project. Phase 1 comprise the design, construction, operation and maintenance of Driekoppies Dam in South Africa (Phase 1a) and the Maguga Dam in Swaziland (Phase 1b). Additional party involved: Mozambique which shares the same river system and is participating through TPTC.	See http://www.kobwa.co.za/
February 15,1991		Mozambique, South Africa, Swaziland	Tripartite Permanent Technical Commission (TPTC).	TFDD
November 1, 2003	Limpopo	Botswana, Mozambique, South Africa, Zimbabwe	Limpopo Watercourse Commission (LIMCOM). This commission was negotiated by the Limpopo Basin Permanent Technical Committee. The Commission between South Africa, Botswana, Mozambique and Zimbabwe is to manage the Limpopo River and must facilitate the building of capacity within the four countries to manage the water resource.	See http://www-dwaf.pwv.gov.za/Communications/PressReleases/2003/MINISTER%20KASRILS%20MP%20SIGNS%20AN%20IMPORTANT%20RIVER%20AGREEEMENTS%20IN%20MOZAMBIQUE.doc
1996		Mozambique, South Africa	Joint Water Commission (JWC). In 1996, after South Africa's political change, the two countries signed in Mozambique, an agreement establishing a Joint Water Commission (JWC), with advisory functions on technical matters relating their common rivers, including the Limpopo.	TFDD
1995		Botswana, Mozambique, South Africa, Zimbabwe	Limpopo River Basin Commission (LRC). Institutional arrangement to manage water. Operating on a river-catchment basis, rather than by national boundaries, this body provides an appropriate institutional vehicle to guide the development in the basin.	http://www.sadcwscu.org.ls/ [not working]
1986		Botswana, Mozambique, South Africa, Zimbabwe	Limpopo Basin Permanent Technical Committee (LBPTC). In 1986, Limpopo Basin States signed in Harare, Zimbabwe, a multilateral agreement establishing a Limpopo Basin Permanent Technical Committee (LBPTC), which was set up to advise the parties on issues regarding the river. The LBPTC did not however function during its first ten years. LBPTC's second meeting was held in South Africa in 1995. At the meeting, it was agreed to activate the LBPTC, which was a dead organization, and discussions concentrated on mutual interest regarding the common river.	See http://www.riob.org/ag2002/LimpopoOrange.pdf
1983		Botswana, Mozambique, South Africa, Zimbabwe	Joint Permanent Technical Committee (JPTC). The JPTC was established in 1983 to make recommendation on matters concerning common interest in the Limpopo.	TFDD
July 13, 2004	Zambezi	Angola, Congo, Democratic Republic of (Kinshasa), Malawi, Mozambique, Tanzania, United Republic of, Botswana, Namibia, Zambia, Zimbabwe	Zambezi Watercourse Commission (ZAMCOM). Commission to manage and develop the Zambezi river's water resources. Besides managing the Zambezi's resources, the Commission, consisting of three organs - a council of ministers, a technical committee and a secretariat drawn from all eight countries - will advise member countries on planning, utilisation, protection and conservation issues around the river. Country representatives will also protect national interests in actual or potential disputes. Signing the agreement is expected to bring benefits across all sectors, including trade, industry, energy production, food security, transport and communication, tourism, regional security and peace. Additional parties involved: SADC and the ZRA. The formation of ZAMCOM as by the Watercourse protocol is part of the ongoing Project 6 of the ZACPLAN. The sixth project is considered as a key part of the ZACPLAN formulate a development strategy and simulate various development scenarios for the Basin.	See http://www.plusnews.org/report.asp?ReportID=42174&SelectRegion=Southern_Africa and http://www.eawag.ch/research_e/apec/seminars/Case%20studies/2003/Zambezi.pdf