Building Adaptive Capacity into Transboundary Water Regimes

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INTRODUCTION

When turbulent floodwaters finally receded back into the confines of the banks of the Ganges-Brahmaputra Rivers in August 2004, Bangladesh, Nepal, and India were reeling from one of the worst floods in recent memory. Some 2,000 people had been killed and as many as 63.85 million people across the region were affected—outbreaks of diarrhea and pneumonia spread rapidly. New cases of diarrhea increased at a rate of 9,000 cases a day in Bangladesh while shelters in India swelled with a population of close to 2 million displaced flood victims (WHO 2004). The tide of human suffering caused by the flood of 2004 is by no means unique in history; 90% of all disaster related deaths during the period between 1975 and 2001 were water related (ISDR 2004: 14).

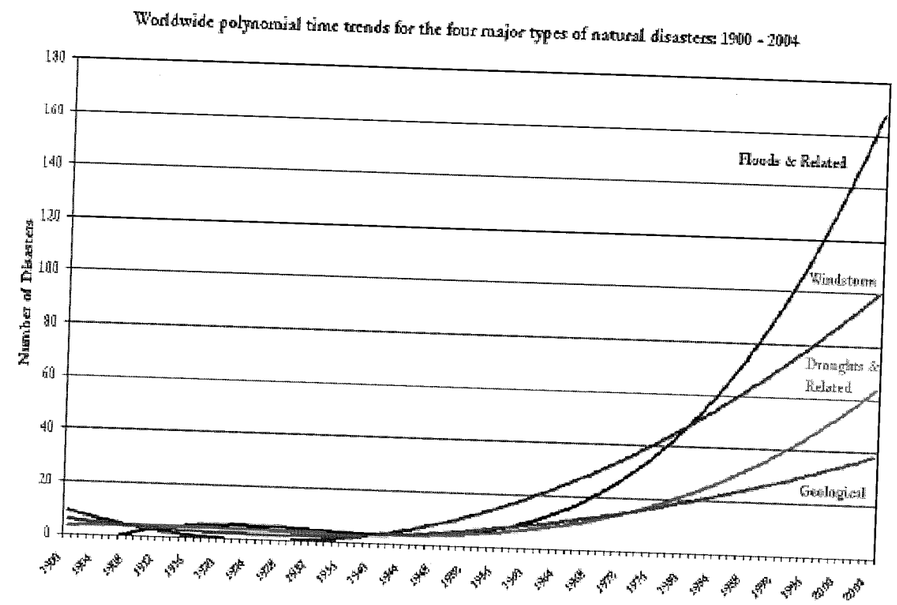


Figure 1. Disaster Trends 1900-2004
Source: CRED Disaster Database

Current trends show that the occurrence of floods over the last century has increased dramatically (See Figure 1) and experts predict that the trend will continue in part due to the increasing hydrological variability associated with climate change (WWAP 2006: 181). In 2005, floods killed 6,135 people and more than 74 million were displaced globally (See Figure 2) (CRED Disaster Database). The problems associated with water related disaster exacerbate human suffering through increased risk of water born disease epidemics, contaminated water supplies, as well as destruction of agricultural crops and homes.

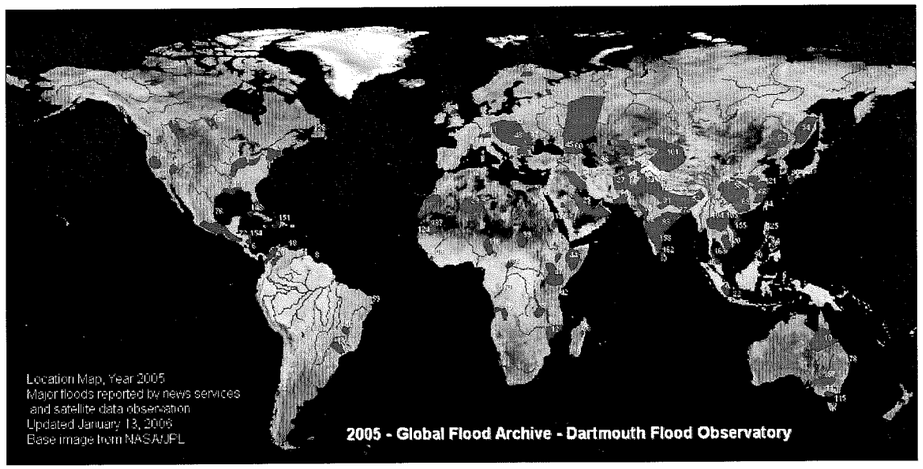


Figure 2. Major Floods, 2005
Source: Dartmouth Flood Observatory

Effective and coordinated response to flood risk is critical to minimize loss of life and human suffering, yet such management remains elusive particularly in transboundary river basins. In order to address the issue of water related risk, this paper advocates the use of an adaptive process to build a system of risk management that is both flexible and integrated. This paper builds an integrated and adaptive model to transboundary water management with the purpose of creating a regime capable of addressing water related risk including flood, drought, and technological failure through the development of a regime structure that strengthens local management of water resources within a cross-scale system capable of holistic and integrated governance. Recognizing that the creation of an adaptive system through a flexible process will allow the development of governance organizations capable of addressing local and basin specific risk factors within the cultural context of the basin, the paper does not advocate a specific outcome of the adaptive process but rather envisions what such a system would look like.

The paper provides a brief overview of the layers, and the structure of a governance framework, as well as how such an adaptive system would potentially function in the Ganges-Brahmaputra Basin in the year 2025. Then the paper examines important linkages between units within an adaptive governance framework. In Section 5 the paper proposes an adaptive process for the creation and implementation of adaptive systems such as the one described in Section 4, in several "regions at risk," which represent the highest proportion of water related disasters.

2. GOVERNANCE SYSTEM FOR WATER RISK MANAGEMENT

I propose a modification of the current systems governing transboundary watercourses in order to better manage water related risk. River Basin Organizations are useful structures in the governance of watercourses, yet they have thus far failed to develop from narrow basin-wide level institutions into a more holistic approach to water resources management. It is important to

recognize that the process of creating an adaptive approach to water related risk management will be driven by the regional, national, and local cultural and political context and will be unique to individual transboundary rivers.

However there are several basic characteristics representative of all adaptive basin management systems. These include: (1) the governing of water resources in a sustainable manner through a process of policy experimentation; as well as the ability to adapt to changing realities and needs within the natural and social systems; (2) an integration of river basin, local, national, and international resource management; and (3) reducing vulnerability by aggregating and/or reducing risk associated with hydrological extremes and man-made disaster by improving system resilience. An adaptive system of water governance for transboundary water resources includes institutional and functional changes at the local, national, river basin, and international level. Specific suggestions are listed below (See Figure 3).

- **Local**
  - **Strengthen management institutions and stakeholder participation**
  - **Create a *Catchment Council* and *Response Group***

The system aggregates local management units into a coherent institution—a *catchment council* (*catchment congress* in large basins)—across national boundaries to enable local involvement in the transboundary governance process. Local stakeholders are also organized into a *response group* to coordinate action in response to hydrological or man-made disaster.

- **State**
  - **Decentralization of water management to appropriate level**
  - **Goal setting**

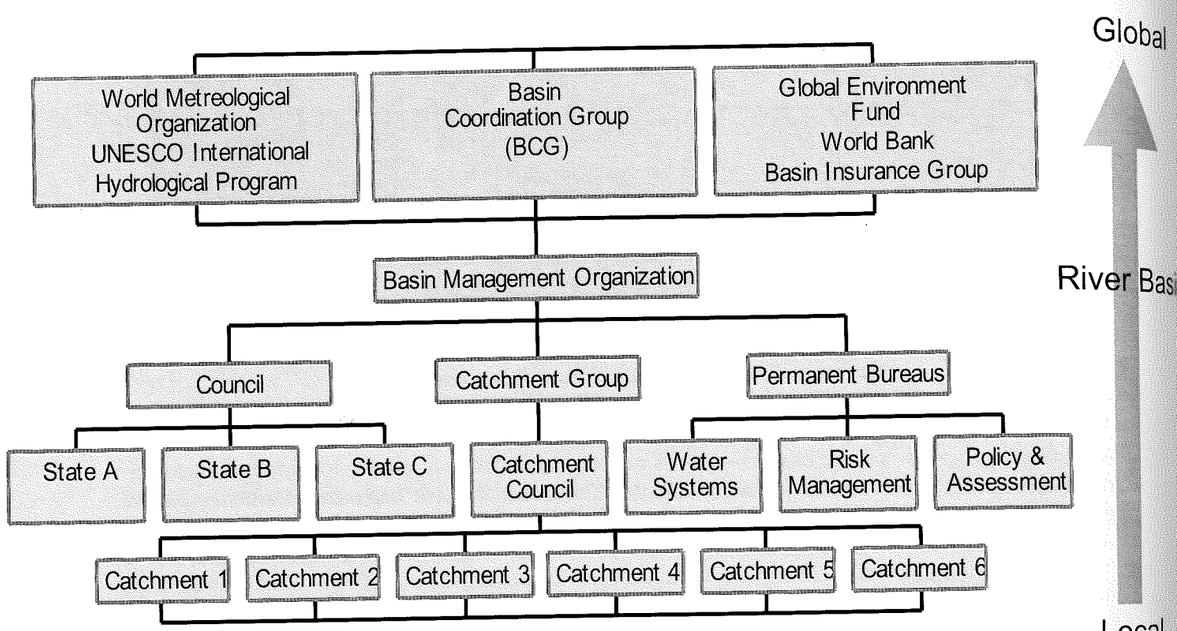
At the state level, the system requires the decentralization of water management decisions from the national to the local level while using the knowledge, enforcement capability, and technical capacity available at the national level to develop goals and objectives for the system within the context of national needs and interests.

- **River Basin**
  - **Strong institution with well developed institutional feedback from all other levels.**

At this level, there is a need for the development of a strong organization that has the institutional capacity to drive the management of the river basin as an integrated unit yet shows sensitivity to the needs of local and national stakeholders.

- **International**
  - **Technical assistance**
  - **Financing and insurance**
  - **Creation of RBO umbrella organization**
  - **Insurance**

Figure 3. Structure to Operationalize Adaptive Capacity in Transboundary Water Governance



At the international level, existing mechanisms and institutions such as the World Meteorological Organization (WMO), UNESCO, the Global Environment Facility (GEF), and the World Bank should focus their efforts around a joint initiative to finance and develop adaptive water management. Such an effort would include technical assistance, a financing scheme to help basin States in less developed river basins, and the sponsorship of an international umbrella organization for basin management organizations (BMOs) to foster the transfer of knowledge and experiential learning among international river basins. In addition, a mechanism for the purchase of insurance against transboundary water risks must be developed.

2.1 Why Adaptive Capacity?

The fundamental characteristics of natural disaster and water related risk lend themselves to an adaptive process of management. Adaptive systems have two unique aspects that are necessary to address risk in transboundary water systems: 1) resilience; and 2) change over time. Resilience is the capacity within the system mitigating the impacts of extreme events and increasing the ability of society to respond to risk in a sustainable manner (Adger 2000; Folke, Carpenter,

Elmqvist, Gunderson, Holling, and Walker 2002: 13; Berkes, Colding, and Folke 2003: 14). Change over time is a constant process achieved through the relational networks and feedback within the adaptive system leading to the assessment of outcomes (Holland 1995; E Ostrom 1999; Berkes et al. 2003; Berkes 2006). Adaptation emerges from a system encouraging policy experimentation and change to achieve effectiveness and maximize system resilience.

The challenge in an adaptive system is to integrate management of the resources across the scales—local, national, river basin, and international—taking advantage of the unique properties of each scale. Berkes (2006) examines the challenge presented by cross-scale regimes in the management of straddling fish stocks. Looking at the International Commission for the Conservation of Atlantic Tuna (ICCAT) he demonstrates that the lack of a connection between local and international management institutions results in policies that do not consider the needs of the local level. The disconnection between international policy and conditions experienced at the local scale leads to the perception that the international regime is both unresponsive and unnecessarily restrictive. Berkes concludes at the international level the governance of common resources are characterized by: "(1) the failure to recognize important scale and level interactions; (2) the persistence of mismatches between the levels and scales in human-environment systems, and (3) the failure to recognize heterogeneity in the way scales are perceived and valued by different actors" (2006: 2). These failures result from the static nature of international regimes and the lack of an integrated adaptive approach to management.

There are several systems for achieving integrated or adaptive management in systems requiring cross-scale management that address the scaling-up problem faced when transferring the commons regimes from local to global (Berkes 2006; Young 2002). Co-management (Pinkerton 1989; Jentoft, McCay, and Wilson 1998; Berkes 2002; Carlsson and Berkes 2005) is essentially the joint management of a resource by multiple institutions at different scales, typically local and national (Carlson and Berkes 2005: 1). The World Bank defines co-management as "the sharing of responsibilities, rights, and duties between primary stakeholders, in particular, local communities and the nation state; a decentralized approach to decision-making that involves the local users in the decision making process as equals with the nation-state" (1999: 21). The structure of co-management could be scaled-up to work at the river basin level to govern transboundary water resources.

Polycentric governance builds upon the concept of co-management (V Ostrom, Tiebout, and Warren 1961; V Ostrom 1987; 1991; 1997; E Ostrom 1999; Baer and Marando 2001) and consists of a series of overlapping management units, which may have horizontal connections and vertical linkages to other management scales forming a cohesive system of governance for complex resources (V Ostrom et al. 1961: 831). Baer and Marando emphasize two key characteristics of polycentric governance including the tendency of decision and action to locate at the best scale and level to meet the needs of actors within the system and the potential for constant reorganization of management units to better accomplish their tasks (2001: 722). There are several advantages to polycentric governance: (1) higher layers of governance protect the rights of the others in the system; (2) higher layers are able to see and address larger scale impacts and system-wide vulnerabilities; (3) system of overlapping management units allows successful management strategies to be shared with others in the system (E Ostrom 1999: 36). Polycentric systems are also beneficial because they also aggregate risk, which in turn reduces vulnerability, if one part of the system fails another part can compensate (Carlsson and Berkes

2005: 8). Local response is often going to remain the most effective way of responding, however, in a complex and interconnected system—such as an international river basin—it is critical that local responses are coordinated across jurisdictional boundaries.

3. 2025 MASSIVE FLOODING IN GANGES-BRAHMAPUTRA: A HYPOTHETICAL SITUATION

July 5, 2025: Forecasts issued by the Ganges-Brahmaputra Basin Management Organization (GBBMO) predict heavy and extended monsoonal rains over much of Nepal, North Eastern India, and Bangladesh causing the risk management bureau to elevate flood risk to extreme, triggering activation of the flood mitigation and disaster response plans at local, national, and basin-wide levels. An emergency videoconference between members of the Catchment Council, composed of local management units, allows the GBBMO to disseminate information including the assessment that widespread flooding is likely, an overview of resources within the basin available for response, and a review of the extreme event response plan that was modified in 2023 after a previous flood event in 2022 but never used in its current form. Local management units activate locally developed flood mitigation plans preparing to move millions of people to higher ground if necessary, while continuing to constantly collect hydrological data on flow levels and rainfall data and sending it to the GBBMO to incorporate into a rapidly changing picture of flood risk within the basin. Officials are confident that ongoing programs that encouraged those living in the lowest lying areas most vulnerable to flood to move their homes have reduced the population in the direct path of an immediate threat. Extensive flood education has also improved responsiveness of the population to evacuation notices.

10 July 2025: The Ganges and Brahmaputra river flows have reached a trigger stage identified in the flood mitigation plan. With no expected end to the rain a staged evacuation begins, moving those in the lowest lying areas and those most vulnerable i.e. families with young children and the elderly, to higher elevations. After this is complete, the evacuation of areas farther from the flood waters progresses. Evacuees are housed in pre-designated shelters on higher ground stocked with food and sanitation supplies.

17 July 2025: Continuous and heavy rains have caused the river to rise dramatically past flood stage. Measurements indicate that it is a 100-year flood. This activates contingency payments on a flood insurance policy held through the GBBMO. U.S. $500 million is released by the insurance agency to the GBBMO and is distributed to the worst affected catchment areas under guidelines established by the Insurance Implementation Section of the Disaster Response Plan. Funding is used to help prevent outbreak of disease in crowded shelters, sanitize water, relocate evacuees in any shelters under threat from floodwaters, and support efforts to keep the waters from destroying critical infrastructure.

15 August 2025: The floodwaters have largely receded and evacuees are returning home. Local management units use the fresh memory of the flood to educate those returning and, in an effort to mitigate impacts of future floods, offer reconstruction aid to those willing to rebuild in less vulnerable areas. The GBBMO begins an assessment of the disaster and the response in the hopes of understanding whether forecasts were accurate; whether communication and information exchange worked in a timely and efficient manner; and whether the distribution of

contingency funds was fair and that it went to areas with the most critical need. Local management units undertake a similar assessment of their own responses and the effectiveness of their flood mitigation and disaster response plans.

At the end of September 2025, the Catchment Council holds a meeting reporting on the effectiveness of local response to the July/August flood and provides input to the GBBMO. The Council of Ministers conducts an assessment of the national responses to the disaster to determine strengths and weaknesses and reports these to the GBBMO. The Assessment Bureau of the GBBMO synthesizes the GBBMO internal self-assessment with the reports of the Catchment Council and Council of Ministers. An examination of the response reveals gaps in the system, which can be addressed through modification of the system and policy.

4. AN ADAPTIVE REGIME FOR TRANSBOUNDARY WATER GOVERNANCE

Creating international watercourse regimes that have adaptive capacity presents both practical and theoretical challenges. Such a regime must successfully integrate local stakeholders into international governance and develop necessary horizontal and vertical linkages among actors within the system. Moving from the current static mechanisms currently governing international watercourses to a dynamic system, requires action at four levels: 1) local, 2) national, 3) river basin, and 4) international. Change at these levels is galvanized through the adaptive process to enhance and coordinate interaction among stakeholders at the local level, while increasing their input into the watercourse regime and their access to both information and resources, allowing them to respond to change within the hydrologic system more effectively. The national level focuses on changing the harmonization of water regulations and local governance systems across the transboundary basin. The process includes the transformation of the role of the State in the transboundary regime from rigidly defined cooperation to a network of interrelations with other basin States and local management units while maintaining the role of the State in developing national level policy input into the risk management process. The emergence of adaptive institutions through the adaptive process described in Section 5 envisions a BMO with a strengthened secretariat, increased autonomy from the member States and strong linkages to the local, national, and international levels that are developed through a process of network building. At the international level, the author envisions an enhanced role for existing institutions such as the World Meteorological Organization (WMO) and the UNESCO International Hydrological Program (IHP). In addition, an umbrella organization, the Basin Coordination Group (BCG), for transboundary water regimes will facilitate the exchange of ideas and solutions across the boundaries of individual river basins.

4.1 Local Change

Two institutions are created within the proposed risk management framework at the local level: the formation of a Catchment Council and a coalition for rapid response (Response Group). Actors within the system include the technical staff of the management units and civil society participants, and both stakeholders and NGOs involved in participatory processes related to adaptive management at the local level. The involvement of civil society must occur at the beginning of the adaptive process in order to create transboundary water management institutions. Both the Catchment Council and the Response Group provide a link among actors

within the transboundary basin at the local and national levels. The second fundamental role of the Catchment Council is to provide a mechanism for local participation in the adaptive and integrated management of the basin as a whole. Through the aggregation of management units into a coherent voice, the Catchment Council and Response Group are composed of members from local water governance units directly responsible to water allocation decisions and the collection of hydrologic data and observations from the field. However, while the makeup of these groups will necessarily vary from basin to basin there are several basic functions that the Catchment Council must fulfill. These include: 1) providing a forum for discussion and communication, 2) data aggregation, 3) modeling and forecasting, 4) training and technical assistance, and 5) assessment of actions, policy, and critical response.

The Catchment Council is responsible for addressing and responding to issues within defined normal operating conditions in the basin, such as mild drought, flood, and routine pollution—that which falls within levels permitted by regulation. The Response Group is activated to respond to critical situations that require the rapid deployment of resources or invocation of special regulatory measures to mitigate the problems such as severe or persistent drought, flood, industrial accidents, and ecological catastrophes within the watercourse. The horizontal linkage of local management units in response to a challenge will allow the efficient distribution of resources throughout the basin and allow resources from unaffected areas of the basin to be use in response to disasters in other areas. Given the task of the Response Group it necessarily has a different construction than the Catchment Council. The Response Group includes local technicians from individual sub-catchments, members of the State ministries in charge of emergency response, and staff of the BMO in charge of forecasting and response. The group has the responsibility to create basin wide response plans for different crisis scenarios as well as the autonomy to implement these plans in the event that pre-defined thresholds are crossed. Assessment of the responses coordinated by the Response Group will be undertaken at local, national, and regime level and may be used as case study presentations to the BCG. Feedback about the success or failure of a response to minimize system vulnerability will form the nexus for the development of new policies, approaches, and adaptations to regime structure in order to improve system resilience.

In large international basins with either a large geographic scope or large number of basin States, it is impractical to have every local manager meet regularly to discuss water management. However, it is possible to form a system of sub-catchment representation into a Catchment Congress. In a large transboundary watershed with numerous tributaries feeding into the watercourse, it is possible to break the basin up into catchments or sub-catchments within larger catchments until the geographic scale is such that local management units can communicate effectively and meet on a regular basis. Within this regime, each sub-catchment would meet regularly to discuss challenges to management, changes within the system, and current and future challenges. In addition, the sub-catchment would then nominate a representative to the catchment meetings who would in turn have similar discussions and nominate representatives to the Catchment Congress. With a similar process in all catchments and sub-catchments, the Catchment Congress would represent the geographic and hydrologic diversity of the basin as well as any upstream and downstream challenges to allocation and management. The formulation of a Catchment Congress regime in a large transboundary basin does present cross-scale issues. While the system successfully aggregates local needs and concerns, it is critical that

flow and feedback networks integrate local stakeholders into the decision making process through the constant flow of information and knowledge both up to the Catchment Congress and down to local management units.

4.2 National Level

States have an altered role in a transboundary water regime designed to enhance adaptive capacity. Within the system, States have two primary functions—1) meeting of the parties, and 2) legal reform decentralizing water management, emphasizing local governance, and regulatory harmonization. First, the meeting of the parties (MOP) within the transboundary regime forms the core of State input at the basin level. The MOP provides for cooperation among basin States at the ministerial level with the purpose of developing the general goals and objectives of the regime. In addition, the MOP is a forum for the discussion of regulatory harmonization at the State level within the basin. Legal reform at the State level must be undertaken at the inception of the new adaptive management institutions to maximize the effectiveness of the regime. The first step is the decentralization of water management to the local level—allowing stakeholders at the sub-catchment level significant autonomy over water allocation and monitoring. The second step is transboundary harmonization of regulatory standards.

4.3 Regime

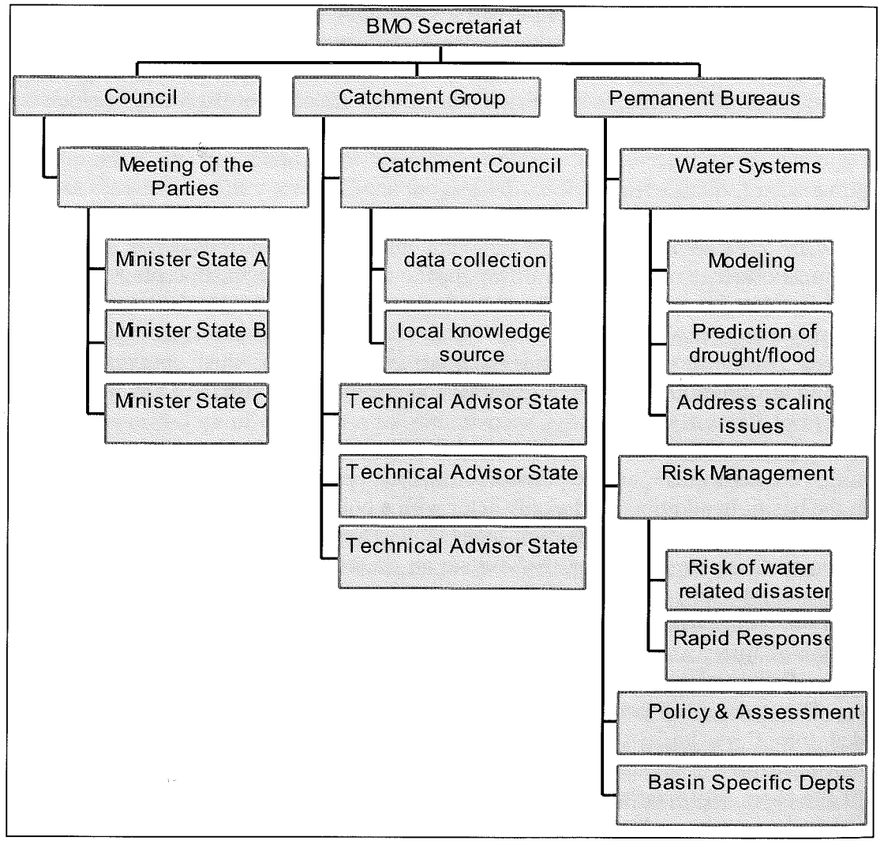
Transboundary watercourse regimes are not uncommon today, however, they are frequently static organizations that are incapable of response to climatic changes, hydrological extremes, or man-made disaster. The proposed adaptive management organization at the basin level has both a significantly stronger and more dynamic secretariat and vertical linkages with international organizations, local stakeholders, and national governments, which provides the critical resources and information necessary for change and adaptive response (See Fig. 3 and Fig. 4).

Within the organization, expanded institutional functions include the development of models and forecasting; risk assessment; and response coordination between national, international, and local actors in the basin. In addition, as the only actor with a holistic view of the basin, the BMO is the ideal driver of adaptation and adaptive management within the system. Therefore the basin organization is driven by structures to facilitate an adaptive management process including the continual assessment of responses and outcomes as well as the examination of social needs and climatic trends within the watershed. The primary role of the organization and the secretariat is the synthesis of information and action from the local and international level into a coherent policy that reflects at least in part the goals and objectives of water management as defined by the States. The structure of the secretariat reflects the role it is designed to fulfill. The Secretariat is divided into three basic sections including the Council, the Catchment Group, and the Permanent Bureaus. These three groups form the functional basis of the regime and conscribe the ability of the basin organization to manage the river basin in an adaptive manner that is defined by holistic system-wide goals yet driven by local needs, resources, and knowledge.

4.3.1 Council

The Council, composed of the basin States, primarily defines broad objectives within the basin. For instance, if food security is of importance to all basin States, a goal might include increasing the proportion of water dedicated to irrigation within the water resource system. Broad goals might also include mitigating the impact of seasonal variability of water resources, hydrological extremes such as drought or flood, or reducing the likelihood of man-made disasters. Such goals define the priorities of the basin organization, but need to be continually reassessed to determine if they accurately reflect the needs of basin States and the local stakeholders living within the region. Reassessment should be done at least once every six months, which requires regular meetings of the basin States at the ministerial level.

Figure 4. Basin Management Organization (BMO) Structure



4.3.2 Catchment Group

The composition of the Catchment Group is slightly more diverse than the Council, including both technical experts from the basin States as well as the Catchment Council (or Catchment Congress in a large basin) and stakeholders from local management units. The purpose of the

Catchment Group is to provide a vehicle for the inclusion of local knowledge and basin specific experience within the decision making structure of the secretariat. It is a means of aggregating local perspectives on water management in the basin into a coherent and active voice in the adaptive management process at the basin level. In addition, the group will also provide a means of rapidly disseminating information and resources from the secretariat to local management structures, and vice versa, as well as serving as a conduit for feedback within the adaptive governance system.

There is also an important role for the Catchment Group as an advisor and participant in the development and adaptation of the hydrological models and forecasting methods developed by the Permanent Bureaus of the BMO Secretariat. It is critical for effective management to have accurate means of predicting hydrological variation and the effects of climatological change. The group has an essential role in addressing issues of scale within the risk prediction process—in other words, how to apply forecasts, hydrological, and climatological predictions developed at the regional or basin level to the local scale. Through the constant input of locally collected data the group helps the permanent bureaus of the secretariat refine the modeling systems and make them increasing reliable and useful at the local level within the basin. Finally, the Catchment Group provides horizontal linkage among local management units and technical experts within the national level water management institutions, providing a powerful means of communication across the jurisdictional boundaries circumscribed on the basin.

4.3.3 Permanent Bureaus

The permanent bureaus of the secretariat form the core of institutional memory, adaptive response, and communication with the international, national, and local actors involved in adaptive basin management. There are three bureaus that an adaptive watercourse regime must include: (1) Water Systems, (2) Risk Management, and (3) Policy & Assessment—along with any other bureaus deemed necessary on a basin specific level. These bureaus correspond to the outputs and processes needed to ensure that adaptive management is successful.

4.3.3.1 Systems Bureau

First, the Water Systems bureau is primarily tasked with modeling the hydrological and climatological systems that affect the quantity and quality of water within the basin and then creating forecasts and predictions, given the indicators generated through modeling. The Water Systems bureau must have a strong relationship with the catchment group, which will provide the Systems bureau with data and observations from within the individual local management jurisdictions. The Systems bureau will in turn provide the Catchment Group with forecasts and predictions. Through the constant circular flow of information—data and observations up from the local level, and forecasts and predications down from the bureau level—the system will provide a powerful mechanism for the constant assessment of the accuracy and usefulness of the output of the Systems bureau as well as the quality and utility of the data being collected at the local level. It will then be possible to change the modeling and forecasting processes to more accurately reflect what will in fact occur within the basin, and to collect data and observations at the local level that will maximize the ability of the bureau to create accurate models of the system processes (hydrological, climatological, ecological) in the basin.

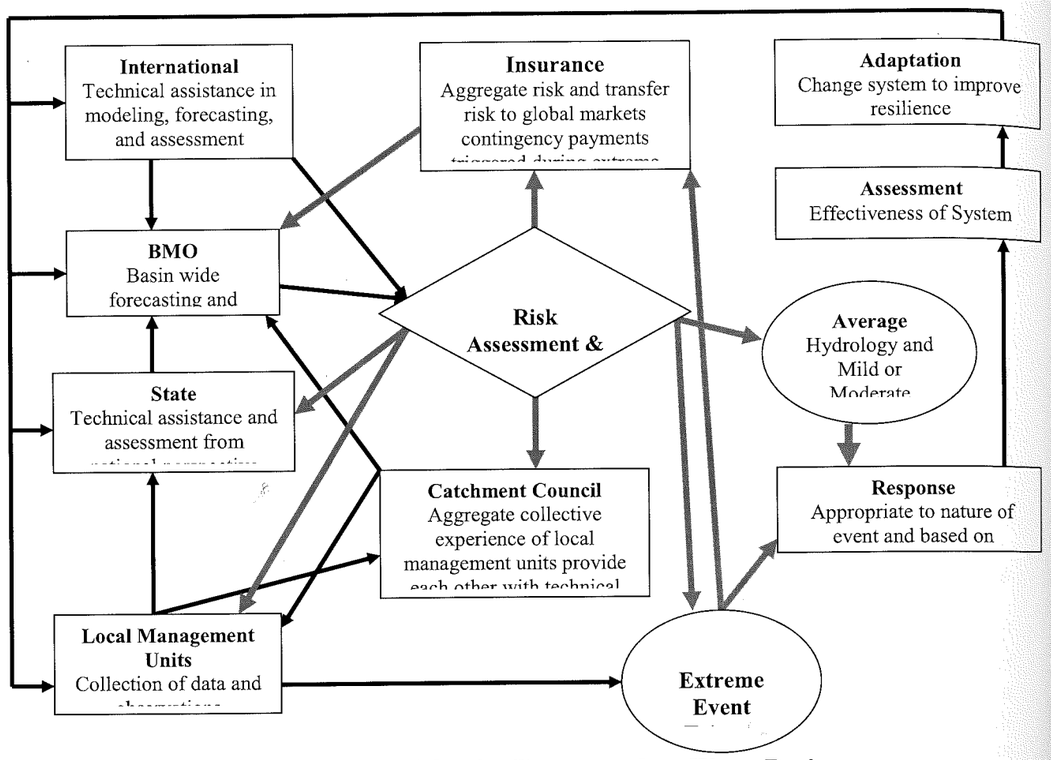


Figure 5. Flow and Feedback in the Adaptive Transboundary Water Regime

4.3.3.2 Risk Management

The Risk Management bureau is responsible for the implementation of policy at the national and local levels as well as risk assessments based on models and forecasts developed by the Water Systems bureau. As such, the bureau is composed of both technical experts, in charge of assisting in local and state level implementation, and monitoring staff. In addition, the bureau coordinates the response to critical events when the watercourse regime determines that there is a high risk of an extreme event occurring. The bureau of Management and Response must have a strong relationship with the Catchment Group in order to manage a cooperative adaptive response by the river basin as a whole. Particularly critical to assure adaptive responses is the regular assessment of responses at the local, national, and regime levels.

4.3.3.3 Policy and Assessment Bureau

The Policy and Assessment Bureau is tasked with the planning and assessment necessary to achieve the broad goals established by the council, and to address the crosscutting issues defined

by the Catchment Group. Planning focuses on two states: 1) *steady state* defined by average seasonal variability, and 2) *extreme state* during periods of acute variability, systems failure, or man-made disaster. During *steady state* planning, the emphasis is on creating a system of allocation that meets the needs of basin States and local stakeholders, as well as establishing policy that accounts for the normal temporal and spatial variability within the hydrological system. While *steady state* policy is going to be relatively more stable over time than *extreme state*, the Policy and Assessment Bureau must have the capacity to reassess the changing needs and hydrological and climatological realities within the basin and adapt the *steady state* policy accordingly. In addition, the *steady state* policy must consider minor drought, flood, and background pollution within the system's defined normal range.

Extreme state policy, in turn, identifies critical thresholds for hydrological extremes and disasters that would automatically invoke defined response procedures. Both the critical thresholds and the response procedures will necessarily be different for various crisis scenarios within the basin. For instance a sustained drought will require a much different systemic response than a flood or large chemical spill. The goal of *extreme state* policy is to recognize the potential natural and man-made challenges within individual river basins. Decision making procedures and mechanisms for responding when these or other disasters occur can then be created to facilitate an adaptive response, reducing vulnerability and minimizing risk within a resilient system.

In addition, the Policy and Assessment Bureau will also need to develop risk assessments based on the forecasts from the Systems Bureau that will allow targeted response to problems. The other responsibility of the bureau is the integration of inputs from the basin State members, as well as information and knowledge from the local stakeholders, and the communication of policies and process to the Catchment Group and Council. It is critical that management units at the State and local level have an integral role in the development of policy, as such ownership will improve implementation of the policy at the national and local levels.

4.4 International

There are also several changes at the international level needed to facilitate the transition to adaptive management of transboundary water resources. These include an increased role for the WMO and the UNESCO IHP, creation of an umbrella organization for river basin regimes, and an international financing mechanism.

4.4.1 Technical Assistance

The role of the WMO and IHP as technical experts and sources of climatological data make these organizations a critical component of an international support system for individual basin regimes. In addition, both organizations can be adapted to the purpose of regime support without significant change to their existing charters and by-laws. The WMO has a broad purpose to facilitate the collection of meteorological data as well as promote the creation of systems for the exchange of information (WMO Charter 2003). Already in existence is the WMO Commission for Hydrology (CHy), which is a nexus for technical expertise and information related to hydrological phenomena, including drought, flood, and man-made disaster (WMO Regulation 2003). UNESCO IHP takes a holistic approach to the study and development of expertise in the

areas of science, hydrology, and society (UNESCO IHP). The knowledge base developed by IHP is therefore useful in the management of resources in an adaptive manner. The collective knowledge of the WMO and UNESCO IHP, among other possible participants, is critical to the successful creation of the accurate models and forecasting systems critical to adaptive management. Technical assistance is to be undertaken on a basin-by-basin case as well as through the BCG.

4.4.2 Basin Coordination Group

The creation of an umbrella organization, the BCG, composed of individual river basin regimes will disseminate information and aggregate knowledge across river basin boundaries. The development of technical capacity, knowledge, and innovative solutions is critical to the success of adaptive management at the river basin level. The BCG is the mechanism at the international level for the dissemination of accumulated wisdom among BMOs. The joint UNESCO and WMO Hydrology for the Environment, Life, and Policy (HELP) program could be emulated as an international model for the BCG. Indeed, HELP could easily be modified to fit the needs of the BCG. While the HELP program is composed mostly of domestic river basins (UNESCO HELP 2005), its basic goals are similar, such as the development of science for use in the creation of water policy and the creation of a network of basins utilizing a similar management mechanism to strengthen the depth of international knowledge. The central roles of the BCG involve the transfer of knowledge between basin regimes, discussion of ideas and innovative solutions to challenges, and the aggregation of technical expertise and experience in adaptive transboundary water governance.

4.4.3 Insurance

It is important to ensure that financial resources are available for prompt response to crisis events to secure the success of transboundary adaptive management. Therefore I propose the use of insurance as a means of regularizing costs and managing risk to BMOs through the aggregation of risk. The model for aggregating large-scale climatic risk is the World Food Program (WFP) catastrophic drought insurance project in Ethiopia (WFP 2005; 2006). While the use of insurance at the international level has been limited thus far, following the first full year of the Ethiopian Drought Insurance Program, the WFP concluded that "Low probability, high-consequence risk such as catastrophic drought is suitable for transfer to global markets where it can be pooled and where diversified risk portfolios can be put together to reduce the cost of coverage" (2006: 6). The project uses competitively bid commercial insurance contracts, which provide contingency funding to the government of Ethiopia, to be used for drought intervention in the event of extreme drought. The system sets a payment trigger level based on the country's extreme drought history.

A weather monitoring program tracks whether or not this trigger has been reached. An Implementation Rule Book creates a comprehensive structure of rules designed to mitigate drought before the trigger level is reached and provides a system of allocating contingency funding once an insurance payment has been released (2006: 5). Contingency funding is distributed based on impact assessments that ensure that the funding goes only to the worst hit areas. The WFP would like to expand the program to include increased insurance, coordination

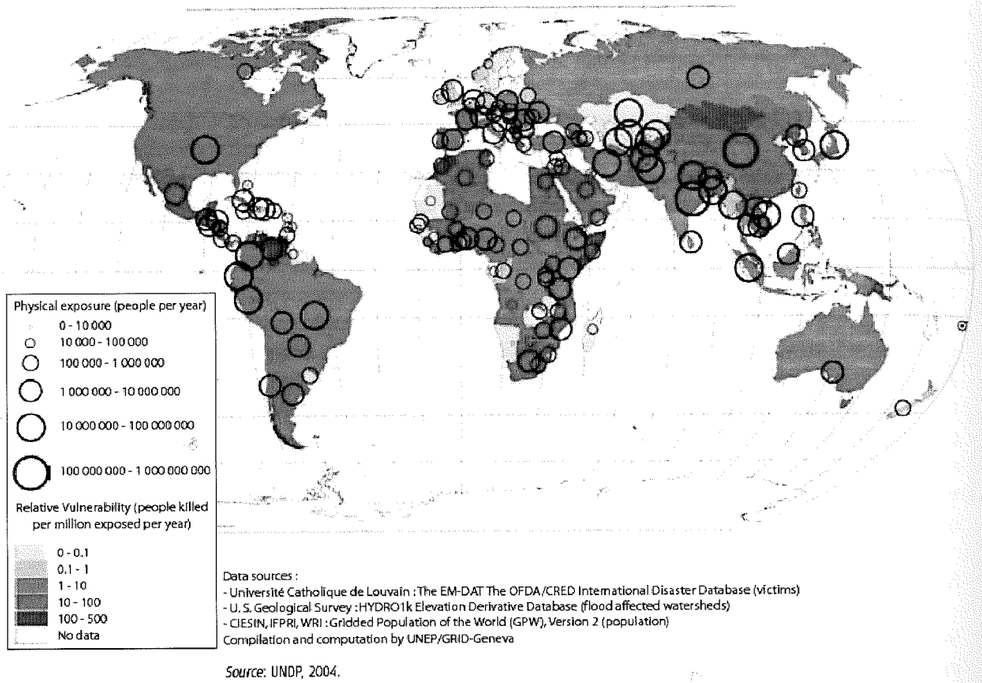
with other safety net programs, capacity building, and increased monitoring and evaluation (2006: 5). Potential benefits related to the availability of disaster contingency funds are an incentive to develop response time leading to earlier action in the event of a catastrophe (2006: 5). The WFP does expect that long-term effectiveness of the program will be contingent on combining insurance with a comprehensive approach to drought risk allowing effective response to mild and moderate drought events (2006: 6).

Insurance has similar possibilities, as a way of aggregating risk, in the adaptive transboundary water management regime. Once a BMO is established and an effective monitoring, modeling, and forecasting system is in place collecting and assessing hydrological and climatological data, the Risk Management Bureau should begin preparing risk assessments (for drought, flood, and other potential water related catastrophes) and developing catastrophe trigger points with the assistance of the WMO and UNESCO IHP. The basin would then be ready to purchase insurance to provide them with contingency funding in the event of extreme hydrological events. Funding should be made available at the international level through the World Bank and GEF to developing basins to ensure that these basins are able to afford insurance. The BMO, through its permanent bureaus, will have to develop comprehensive rules for the allocation of contingency funding during extreme events, which might fall within their *extreme state* planning. One of the primary responsibilities of the BMO is the development of planning to facilitate basin wide response to hydrological events that fall within a defined average range and so the organization will have the capacity to coordinate the use of insurance with ongoing monitoring, capacity building, mitigation efforts, and cooperative management.

5. IMPLEMENTATION

While catastrophe related to hydrological variability including both drought and flood is a global problem there are regions that are more vulnerable and therefore initial funding should be targeted to specific transboundary basins in these "regions at risk." This section will examine the "regions at risk" and propose initial projects for implementation beginning with those basins with the highest level of flood or drought related risk in order to maximize the effect of limited funding.

Figure 6. Flood Exposure and Relative Vulnerability to Flood
Source: WWAP 2006: 354



Source: UNDP, 2004.

5.1 Regions at Risk

Flood risk including mortality, economic loss, and number of people affected, while existing across all regions, is concentrated in South East Asia (See Figures 6, 7, and 9). High concentrations of population, poverty, large transboundary rivers, and heavy seasonal rain due to monsoons lead to a high magnitude of human suffering and economic devastation as seen in the 2004 Ganges-Brahmaputra floods. Initial efforts to reduce flood risk should therefore be concentrated in South East Asia with focus particularly on the Ganges-Brahmaputra Basin and the Mekong Basin reflecting two transboundary river basins with the highest economic losses as a proportion of GDP (see Figure 7.c) as well as higher likelihoods of flooding on an annual basis due to monsoon cycles.

Figure 7. Flood Risk

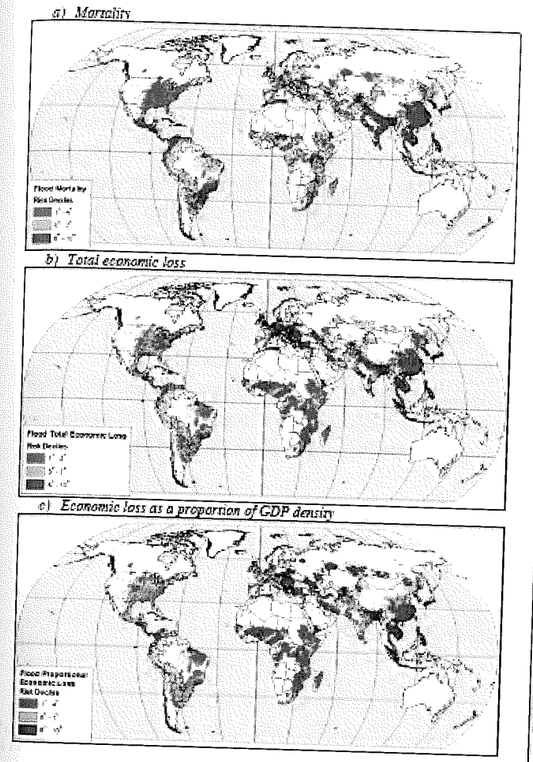


Figure 8. Drought Risk

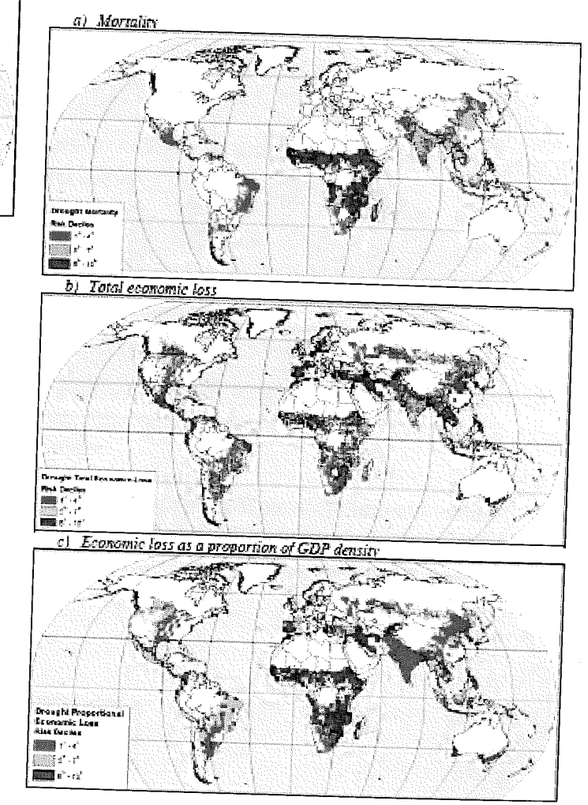
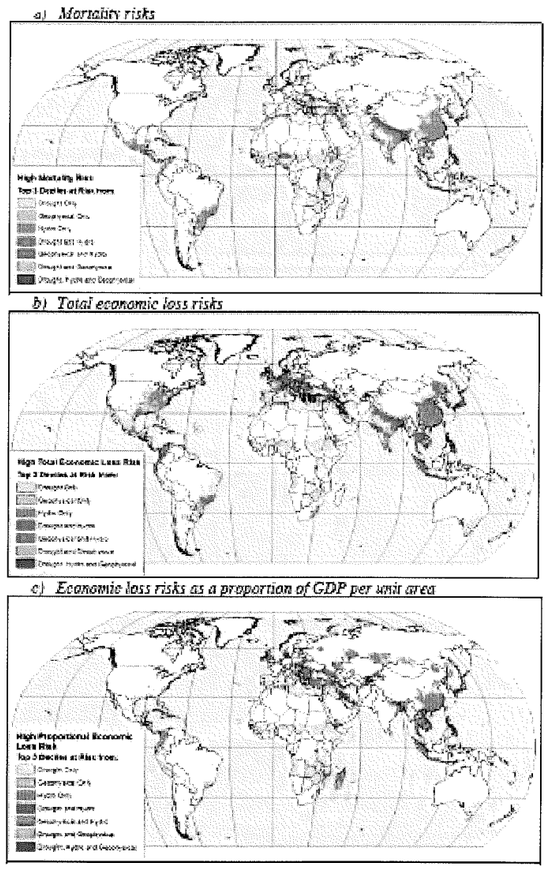


Figure 9. Global Risk Hotspots by Disaster



Source: Natural Disaster Hotspots: A Global Risk Analysis, CHRR, Columbia University, 2005

The number of people affected by hydrological events is high within both of these basins (see Figures 10 and 11) with flood and drought accounting for nearly all of the people affected by disaster in India, Bangladesh, Nepal in the Ganges-Brahmaputra Basin; and Thailand, Laos, Cambodia, and Myanmar in the Mekong Basin. Drought, on the other hand, is critical primarily in Africa (see Figures 11, 12, and 13) from an economic and human suffering perspective. The problem is concentrated in Southern Africa, the Horn of Africa, and West Africa. The issues of drought, while affecting fewer people than flooding, is the second most frequent type of natural disaster, and as with floods, are increasing in frequency (see Figure 10). The process for choosing transboundary basins is more challenging because severe episodic drought is widespread in these regions. Possible initial projects include the Niger Basin, Volta Basin, or the Zambezi Basin all of which have a recent history of severe drought resulting in famine.

5.2 Adaptive Process for Implementation

The creation of an adaptive system for transboundary water risk management is complex and should be undertaken through an adaptive process allowing basin States and local stakeholders to create a system that is uniquely theirs. The process should be phased to ensure that all involved have the time and resources to implement the critical steps.

Figure 10. People Affected

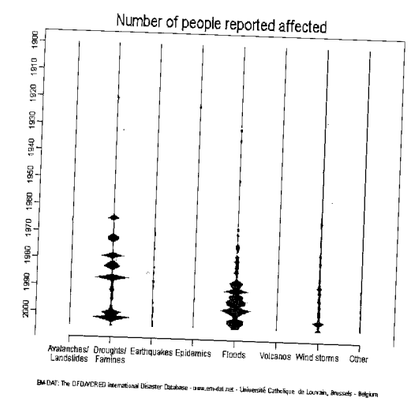


Figure 11. People Affected by Disaster South Asia

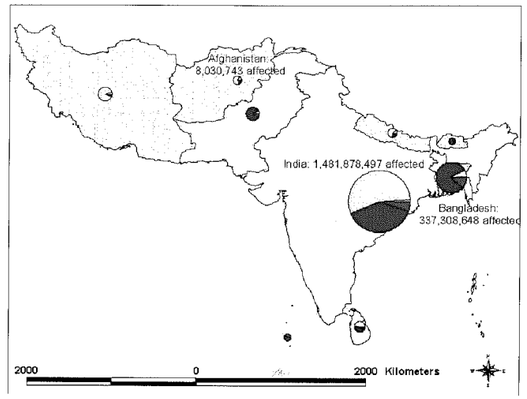


Figure 12. People Affected by Disaster South East Asia

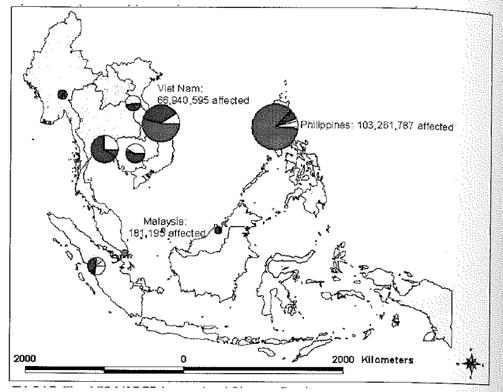
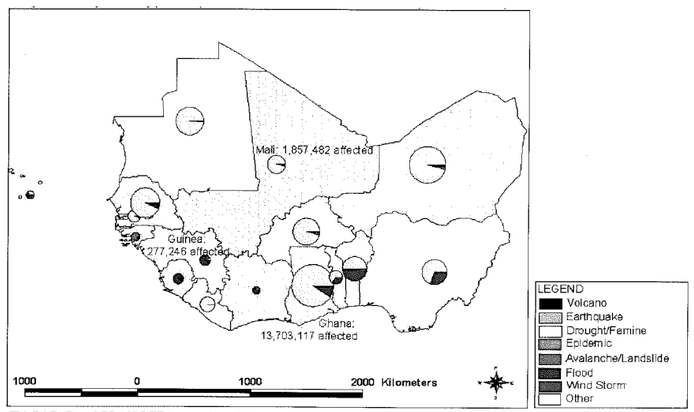


Fig 13. People Affected by Disaster West Africa



EM-DAT: The OFDA/CRED International Disaster Database
(http://www.cred.be ; email: cred@epid.ucl.ac.be)

5.2.1 Phase I

Phase I of the project involves three steps including: 1) Decentralization and Harmonization; 2) Information Exchange and Technical Cooperation; and 3) Capacity Surveys and Capacity Building. Decentralization and Harmonization are legal processes undertaken by the basin States.

Management of water resources is decentralized through the creation or reinforcement of local management units that may take a variety of forms but which should involve local stakeholders, civil society, and NGOs in a participatory dialogue on local water management as well as water related risk. Harmonization involves a negotiated process between basin States to ensure that water related regulation and laws are similar and not contradictory making these regulations and laws more transparent and easier for basin stakeholders to understand. Information Exchange and Technical Cooperation also take place at the State-to-State level, building networks between the State water ministries and technical experts working within the basin. Regular meetings between ministers and technical experts at a basin wide level should take place. Although a number of face-to-face meetings are critical for building rapport between participants, the use of technology such as video conferencing will reduce costs and minimize the time requirement such meetings will entail. Technology will also facilitate communication during periods of crisis.

Capacity is critical to the success of both the adaptive process and the emergent institutions. During Phase I, one of the first undertakings is a capacity survey examining institutional, technical, and human capacity existing in the basin, as well as identifying gaps. The foundation for training and the development of human technical capacity and knowledge should as far as possible rest upon existing human capital in the system to create shared knowledge and understanding within the system. Utilizing human resources already existing in the basin is more efficient than bringing in outside resources because these individuals are a part of the local culture and in addition, have experience working within the context of the area. The capacity survey should include civil society and local management units since these resources represent a collective knowledge and experience that can provide unique sources of wisdom to the process. Also critical is determining gaps in knowledge and technical capacity.

Once the Capacity Surveys are undertaken, two tangential processes of capacity building are necessary. The first involves technical capacity in order to develop accurate forecasting and monitoring. It is critical to build upon existing capacity to ensure the existence of a data collection network that includes hydrological and climatological monitoring stations for river levels and precipitation and everything in between. In addition, a communications system must be established to ensure the networks function effectively over large distances and across national boundaries. Finally, capacity building will extend to the development of local management units and processes for regional participation where none exist or where they are not functional.

The second process involves the development of human capacity using resources that exist within the basin and external resources where gaps in knowledge exist. Using the knowledge base within the basin, networks between individuals with similar information bases should be forged through meetings to form knowledge groups. Following the creation of these knowledge groups, workshops should be developed to disseminate the collective knowledge available within the basin as broadly as possible. The advantage of this strategy is that the process will help build connections and create synergy between local management units and civil society as they share information and create horizontal connections throughout the system as individuals interact across jurisdictional boundaries. This enhances the potential for cooperation and facilitates future steps toward adaptive management.

5.2.2 Phase II

Phase II should begin following the decentralization of management and harmonization of the water laws within the basin. Capacity building is seen as an ongoing process and will continue throughout the development of the adaptive system. However, by the beginning of Phase II, the capacity survey should be finished and knowledge sharing should be underway. Phase II consists of three processes: 1) networking to create a critical mass; 2) development of basin goals; and 3) creation of local risk management plans. Networking remains critical during Phase II. Also critical throughout this time, is building upon the relationships created during the knowledge sharing process in Phase I. Connectivity of basin wide networks at the local management unit level should be achieved initially through aggregation. Individual management units should share information and knowledge with each of the management units directly adjacent to themselves through regular meetings. As the relationships, knowledge, and understanding increase between local management units, it is possible to move to higher levels of connectivity within the system, bringing local management units into a larger dialogue about goals and objectives and institutional frameworks to facilitate their participation in the management of the basin as a whole.

The development of basin goals is partially achieved at the local level through network building. However, it is also a conversation that must occur between basin States and between local management units and the States. The development of goals will directly feed into the process to follow, which is the development of institutional frameworks to facilitate what, until this point, have been less formal networks. Envisioned in the institutional framework for adaptive capacity outlined in section 3, this includes the development of the BMO to assume a coordinating role: concentrate forecasting and modeling that resided within basin States into one location in order to develop a basin-wide hydrological picture ; coordinate communication across scales in order to facilitate input from the State and local management levels into a unified process of policy development, risk minimization, and disaster response. The Catchment Council is included to facilitate the maintenance of networks between local management units and to provide them with a strong mechanism for input into the policy making process. The Catchment Council also provides a powerful instrument for assessment as problems within the system are likely to emerge at the local level and provide an important check within the system as local management units will be able to express difficulties with implementation and policy approaches. In addition the Council would serve as a forum for introducing innovative strategies and successes.

5.2.3 An Adaptive Process

The process of creating an adaptive system will necessarily take time as networks are created, connectivity within the system is increased, capacity is built, and dialogue is fostered. The adaptive forces within the system extend from the reality that the process does not exist within a vacuum but will inherently be affected by hydrological events, even catastrophes—particularly in the initial target basins which are, more than most, subject to high levels of water related risk. The existence of ongoing hydrological risk during the inception of the adaptive system is positive, as it will serve to maintain political will within the basin and support new and innovative systems at the local levels. These events will necessarily shape the process into one of experimentation, assessment, and adaptation, allowing the system to be changed to meet specific

needs within the basin, address context specific problems, and to effectively represent the cultures present in the basin.

5.3 Financing

Financing is important to the success of creating an adaptive system and the system itself. The initial inception of the transboundary water risk management system will be costly and require significant financial commitment from the international community. However, in the long-term, the risk management system will be self-sustaining as capturing a proportion of that reduction for maintenance of the system minimizes economic loss due to hydrological risk. The cost of economic losses due to flood is currently $50 to 60 billion per year with these losses sharply concentrated in developing countries (UNU 2004). Economic loss in Asia between 1987 and 1997 exceeded $136 billion dollars. While response to the 1998 flooding in the Ganges-Brahmaputra Basin in Bangladesh included $700 million distributed by the government and $288 million distributed by NGOs, a total of nearly $1 billion to assist with recovery in one disaster (Paul, 2003, 3-6). The critical element in financing the development of adaptive risk management systems is a transition of dollars away from response to mitigation and preparation. Currently the ratio of dollars spent on response to dollars for mitigation is around 100/1 (UNU 2004). Yet unlike disaster response, the cost benefit ratio of forecasting and monitoring systems is 10 to 15 to 1, while construction of flood resistant buildings adds only 2 to 12% to the cost of construction (UNU, 2004). Significant savings can be achieved through the development of adaptive risk management systems, which can ultimately be used to sustain the system.

Financing is of critical importance to the success of adaptive management. While basin States will finance BMOs governing developed river basins, less developed areas will require external financing and technical assistance to implement transboundary adaptive water management and the creation of a BMO. The Global Environment Facility (GEF) and the World Bank (WB) currently finance projects related to water resources and should designate funding for capacity building related to the development of transboundary adaptive institutions and the development of technical capacity for hydrological monitoring with the assistance of the WMO and UNESCO IHP.

5.4 Benefits

The development of transboundary adaptive risk management systems in basins prone to transboundary flooding provide striking benefits, particularly in developing countries in Asia with international river basins. Between 1900 and 2006 in Asia alone, 6.7 million lives were claimed, 1.2 million were injured, 99.5 million people lost their homes, 2.7 billion people were affected, and $205 billion dollars worth of damage was inflicted by floods (CRED Database 2006). By focusing on disaster mitigation, preparedness, and adaptive response to catastrophe, the transboundary water risk management system can reduce the cost of floods both in terms of human suffering and economic loss. The reduction of cost will provide significant benefits to the countries involved in adaptive systems by freeing resources for development and providing stability and security for their citizens. Global benefits can be maximized by focusing international resources on basins with the highest potential risk of flooding and drought.

6. CONCLUSION

To conclude, this paper develops the concept of adaptive capacity into a prescription for the development of transboundary adaptive watercourse management through the creation of a BMO, and the integration of local management units, basin States, and the international community into a resilient system of both decentralized management and aggregating risk. It is critical to recognize that the success of building adaptive capacity into transboundary river basins is dependent on a calculated strategy of support by key members of the international community. There are several aspects upon which success will hinge:

1) **Targeted Roll-Out**—Introduction of the program of adaptive risk management in basins identified as having high water related risk and high potential benefit, such as the Ganges-Brahmaputra Basin.

a. There is limited international funding available for water governance and water-related risk management in transboundary basins. Therefore such finances should be targeted to basins with the most critical need for systems to manage risk.

b. Targeting high-risk basins will help bring basin states to the negotiating table because of the corresponding high potential benefit from risk management. Basins experiencing regular water-related catastrophes are more likely to agree to such a program in the absence of demonstrated success.

c. Establishing a series of case studies and lessons learned will allow expansion of the program to basins with lower water-related risk as they will see the demonstrated benefits.

2) **Financing**—critical is a shift in international funding imperatives from disaster response to prevention and mitigation. The benefits of this shift are clear both in reduced economic loss to basin states facing water related risk and the lower costs of mitigation as opposed to disaster response.

a. As noted above the limited amount of international funding should be focused on specific targeted basins in the short term.

b. There must be a recognition that the building of adaptive regimes requires time and will not succeed without long-term commitments by donors and basin states.

c. Development of the insurance program is critical to ensure that the shift of international funding from response to mitigation is possible. Insurance will provide contingency funding in the event that a disaster occurs, freeing the international community and the basin states to focus on the development of the adaptive system.

3) **Technical Assistance**—the critical added value of this system is access to expertise and technology that basin states would otherwise not have had access to.

a. Capacity building, the transfer of both skills and knowledge, is critical to improve the skill sets and local capacity within the basins.

b. The development of technical networks to collect information is critical to forecasting and disaster mitigation.

c. International organizations with technical expertise should develop close relationships with basins undertaking adaptive management to provide specialized modeling, forecasting, and climatology expertise. By centralizing this knowledge at the international level, the international community and transboundary basins can benefit from economies of scale while still enjoying the benefits of a technically skilled and capable scientists and risk managers.

d. It is important to ensure that basins agreeing to undertake adaptive management efforts have priority access to technical assistance, knowledge sharing, and financing.

The system relies on an adaptive process of phased regime development that will result in locally resilient and adaptive institutions while proposing what a regime for adaptive management of water risk might look like. Adoption of adaptive management within transboundary basins will allow for the efficient development of water resources. In addition, it will reduce the vulnerability of those within the basin to hydrological extremes, climate change, and man-made catastrophe through the aggregation of risk, coordinated response, and contingency payments through insurance during extreme events. This approach is designed to be applied first in "basins at risk" as the human and economic cost of water related risk within those basins are disproportionately high and the potential benefits of adaptive management are equally great.

Bibliography

Adger, W. Neil. "Adaptation to Climate Change in the Developing World." *Progress in Development Studies*. V 3, N 3 (2003).

-----. "Social and Ecological Resilience: Are They Related?" *Progress in Human Geography*. V 24, N 3 (2000).

Anderies, John. "A Framework to Analyze the Robustness of Social-ecological Systems from an Institutional Perspective." *Ecology and Society*. V 9, N 1 (2004).

Baer, Susan and Vincent Marando. "The Subdistricting of Cities: Applying the Polycentric Model." *Urban Affairs Review*. V 36, N 5 (May 2001).

BBC. "Concern Over Mozambique's Floods." BBC News. (20 Feb 2001) *Available at* http://news.bbc.co.uk/2/hi/africa/1180717.stm. *Accessed* (19 Nov 2006).

-----. "Europe Counts Cost of Flood Damage." BBC News. (15 Aug 2002) *Available at* http://news.bbc.co.uk/2/hi/business/2194038.stm. *Accessed* (19 Nov 2006).

-----. "Map: The World's Water Hotspots." BBC News. (20 Oct 2004) *Available at* http://news.bbc.co.uk/2/hi/science/nature/3754520.stm#top. *Accessed* (19 Nov 2006).

-----. "China Apologizes for River Spill." BBC News. (26 Nov 2005) *Available at* http://news.bbc.co.uk/2/hi/asia-pacific/4474284.stm. *Accessed* (19 Nov 2006).

-----. "High Danube Sparks Europe Floods." BBC News. (14 Apr 2006) *Available at* http://news.bbc.co.uk/2/hi/europe/4910126.stm. *Accessed* (19 Nov 2006).

Berkes, Fikret. "From Community-Based Resource Management to Complex Systems: The Scale Issue and Marine Commons." *Ecology and Society*. V 11, N 1 (2006).

Berkes, Fikret, Colding, and Folke, eds. Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge, UK: Cambridge University Press (2003).

Bourne, Charles. International Water Law: Selected Writings of Professor Charles B. Bourne. (Patricia Wouters, ed.). London: Kluwer Law International (1997).

Brooks, Nick. "The Determinants of Vulnerability and Adaptive Capacity at the National Level and the Implications for Adaptation." *Global Environmental Change*. V15 (2005).

Carlsson, Lars and Fikret Berkes. "Co-management: Concepts and Methodological Implications." *Journal of Environmental Management*. V 75 (2005).

Carpenter, Stephen, and Lance Gunderson. "Coping with Collapse: Ecological and Social Dynamics in Ecosystem Management." *Bioscience*. V 51, N 6 (June 2001).

Cortner, Hanna. "Institutions Matter: the Need to Address the Institutional Challenges of Ecosystem Management." *Landscape and Urban Planning*. V 40 (1998).

CRED (Centre for Research on the Epidemiology of Disasters) Disaster Database. *Available at* http://www.cred.be/.

Dietz, Thomas, et al. "The Struggle to Govern the Commons." *Science*. V 302 (2003).

Folke, Carl et al. "Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformation." Scientific Background Paper on Resilience for the process of the

World Summit on Sustainable Development, Environmental Advisory Council to the Swedish Government (Apr 2002).

Frank, Bernard, and Anthony Netboy. "Water, Water, Everywhere but…" *The Scientific Monthly*. V 68, N 6 (June 1949).

Gerlak, Andrea. "One Basin At a Time: The Global Environmental Facility and Governance of Transboundary Water." *Global Environmental Politics*. V 4, N 4 (Nov 2004).

------. "The Global Environmental Facility and Transboundary Water Resources Management: New Institutional Agreements in the Danube River and Black Sea Region." *Journal of Environment & Development*. V 13, N 4 (Dec 2004).

Gibson, Clark et al. "The Concept of Scale and the Human Dimensions of Global Change: A Survey." *Ecological Economics*. V 32 (2000).

Giordano, Mark et al. "International Resource Conflict and Mitigation." *Journal of Peace Research*. V42, N 1 (2005).

Giordano, Meredith and Aaron Wolf. "Sharing Waters: Post-Rio International Water Management." *Natural Resources Forum*. V 27 (2003).

Gleick, Peter. "Water and Conflict: Freshwater Resources and International Security." *International Security*. V 18, N 1 (Summer 1993).

Gunderson, Lance. "Ecological Resilience—In Theory and Application." *Annual Review of Ecology and Systematics*. V 31 (2001).

Hart, Henry. "Crisis, Community, and Consent in Water Politics." *Law and Contemporary Problems*. V 22, N 3 (Summer 1957).

Holland, John. Hidden Order: How Adaptation Builds Complexity. Addison-Wesley Publishing Company: Reading (1995).

Holms, John. "Coping with Drought in Botswana: An African Success." *The Journal of Modern African Studies*. V 23, N 3 (Sept 1985).

Imperial, Mark. "Institutional Analysis and Ecosystem-Based Management: The Institutional Analysis and Development Framework." *Environmental Management*. V 24, N 4 (1999).

Jackson, Robert, et al. "Water in a Changing World." *Ecological Applications*. V 11, N 4 (Aug 2001).

Jentoft, S., B. J. McCay, and D. C. Wilson. "Social Theory and Fisheries Co-management." *Marine Policy*. V 22 (1998).

Karr, James. "Biological Integrity: A Long-Neglected Aspect of Water Resource Management." *Ecological Applications*. V 1, N 1 (Feb 1991).

Kessler, Winifred, et al. "New Perspectives for Sustainable Natural Resources Development." *Ecological Applications*. V 2, N 3 (Aug 1992).

Kliot, N., et al. "Institutions for Management of Transboundary Water Resources: Their Nature, Characteristics, and Shortcomings." *Water Policy*. V 3 (2001).

Koberg, Christine. "Resource Scarcity, Environmental Uncertainty, and Adaptive Organizational Behavior." *The Academy of Management Journal*. V 30, N 4 (Dec 1987).

Malnes, Raino. "Imperfect Science." *Global Environmental Politics*. V 6, N 3 (Aug 2006).

McDaniels, Timothy, et al. "Democratizing Risk Management: Successful Public Involvement in Local Water Management Decisions." *Risk Analysis*. V 19, N 3 (1999).

Mitchell, Ronald. "Part Two: The Effectiveness of International Environmental Regimes—Problem Structure, Institutional Design, and the Relative Effectiveness of International Environmental Agreements." *Global Environmental Politics*. V 6, N 3 (Aug 2006).

Myint, Tun. "Managing Complexities in Global Environmental Governance: Issues-Interests-Actors Network Model for the Transnational Environmental Governance in the Mekong River Commission and the International Commission for the Protection of the Rhine" in *Proceedings of the 2001 Berlin Conference on the Human Dimensions of Global Environmental Change "Global Environmental Change and the Nation State*. (Frank Beirmann, et al. eds) Potsdam Institute for Climate Impact Research: Potsdam (2002).

Olsson, Per. "Adaptive Comanagement for Building Resilience in Social-Ecological Systems." *Environmental Management*. V 34, N 1 (2004).

Ostrom, Elinor. "Coping with Tragedies of the Commons." *Annual Review of Political Science*. V 2 (1999).

Ostrom E, et al. The Drama of the Commons. National Research Council. National Academy Press, Washington, DC (2002).

Ostrom, Vincent. The Political Theory of a Compound Republic: Designing the American Experiment. Institute for Contemporary Studies Press: San Francisco, 2nd Rev. Ed. (1987).

-----. The Meaning of American Federalism: Constituting a Self-Governing Society. Institute for Contemporary Studies Press: San Francisco (1991).

-----. The Meaning of Democracy and the Vulnerability of Democracies: A Response to Tocqueville's Challenge. University of Michigan Press: Ann Arbor (1997).

Ostrom, Vincent, et al. "The Organization of Government in Metropolitan Areas: A Theoretical Inquiry." *The American Political Science Review*, V 55, N 4 (Dec 1961).

Paul, Bimal Kanti. "Relief Assistance to 1998 Flood Victims." *Geographical Journal*. V 169, N 1 (2003).

Pinkerton, E. In E. Pinkerton (ed.), Cooperative Management of Local Fisheries: New Direction in Improved Management and Community Development. University of British Columbia Press, Vancouver, British Columbia (1989).

Rosenthal, Uriel, and Alexander Kouzmin. "Crises and Crisis Management: Toward Comprehensive Government Decision Making." *Journal of Public Administration Research and Theory*. V 7, N 2 (Apr 1997).

Sadoff, Claudia, and David Grey. "Cooperation on International Rivers: A Continuum for Securing and Sharing Benefits." *Water International*. V 30, N 4 (Dec 2005).

Sagar, Amduj, and Stacy VanDeveer. "Capacity Development for the Environment: Broadening the Scope." *Global Environmental Politics*. V 5, N 3 (Aug 2005).

Sparks, Richard. "Need for Ecosystem Management of Large Rivers and Their Floodplains." *Bioscience*. V 45, N 3 (Mar 1995).

Stakhiv, E. Z. "Policy Implications of Climate Change Impacts on Water Resources Management." *Water Policy*. V 1 (1998).

UN International Strategy for Disaster Reduction. "Guidelines for Reducing Flood Losses." UN/ISDR: (2004).

UNESCO. "HELP: Hydrology for the Environment, Life, and Policy." UNESCO: IHP SC-2005/WS/5 (2005).

UN University. "Two Billion Will Be in Flood Path by 2050, UNU Expert Warns." Newsletter of UNU. V32 (Aug 2004).

Vinogradov, Sergei, et al. Transforming Potential Conflict into Cooperation Potential: The Role of International Water Law. UNESCO PC→CP Publications (2003). *Available at* http://unesdoc.unesco.org/images/0013/001332/133258e.pdf. *Accessed* 20 Nov 2006.

WWAP, UN. Water A Shared Responsibility: The United Nations World Water Development Report 2. World Water Assessment Program, UNESCO (2006).

Weigele, Thomas. "Decision-making in an International Crisis: Some Biological Factors." *International Studies Quarterly*. V 17, N 3 (Sept 1973).

Wiseberg, Laurie. "An International Perspective on the African Famines." *Canadian Journal of African Studies*. V 9, N 2 (1975).

WFP. "Pilot Development Project—Ethiopia Drought Insurance: Projects for Executive Board Approval" World Food Program: Rome, WFP/EB.2/2005/8-A (Oct 2005).

-----. "Operation Reports: Ethiopia Drought Insurance Update and 2007 Weather Risk Management Program." World Food Program: Rome, WFP/EB.2/2006/10/1 (Oct 2006).

WMO. Basic Documents No 1. World Meteorological Organization. WMO-No 15 (2003 Edition).

Wolf, Aaron. "Conflict and Cooperation along International Waterways." *Water Policy* V 1 (1998).

World Health Organization (WHO). "Emergency and Humanitarian Action: South East Asia Region Highlights N. 4 15 July to 31 August 2004 Summary Report." WHO: (30 Aug 2004).

Wouters, Patricia. "Geneva Strategy and Framework for Monitoring Compliance with Agreements on Transboundary Waters: Elements of a Proposed Compliance Review Procedure." United Nations Economic and Social Council, UN DOC MP.WAT/2000/5, The Hague, Netherlands (17 Dec. 1999).

------. "Present Status of International Water Law" *Editor's Forward to* International Water Law, Selected Writings of Charles B. Bourne. London, UK: Kluwer Law International (1997).

-------. "An Assessment of Recent Developments in International Watercourse Law through the Prism of the Substantive Rules Governing Use Allocation." *Natural Resources Journal,* V 36 (1996).

Yohe, Gary, and Richard Tol. "Indicators for Social and Economic Coping Capacity—Moving Toward a Working Definition of Adaptive Capacity." *Global Environmental Change*. V 12 (2002).

Young, Oran. The Institution Dimensions of Environmental Change: Fit, Interplay, and Scale. MIT Press: Cambridge, MA (2002).