Adaptation to climate change in international river basins in Africa: a review*

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Abstract

This paper reviews current knowledge of the potential impacts of climate change on water resources in Africa and the possible limits, barriers or opportunities for adaptation to climate change in internationally shared river basins. Africa faces significant challenges to water resources management in the form of high variability and regional scarcity, set within the context of generally weak institutional capacity. Management is further challenged by the transboundary nature of many of its river basins. Climate change, despite uncertainty about the detail of its impacts on water resources, is likely to exacerbate many of these challenges. River basins and the riparian states that share them differ in their capacities to adapt. Without appropriate cooperation adaptation may be limited and uneven. Further research to examine the factors and processes that are important for cooperation to lead to positive adaptation outcomes and the increased adaptive capacity of water management institutions is suggested.

Key words
Climate change, adaptation, water resources, Africa, transboundary rivers, international river basins, conflict, cooperation

INTRODUCTION

Africa's fresh water resources are vital to the support of livelihoods (particularly agriculture and fisheries-based livelihoods), food security and power generation as well as growing domestic and industrial needs. Water resources are under pressure

from increasing demand and competing uses. Climate change threatens to put further pressure on water resources due to a possible increase in the already high variability in rainfall and river flows and changes to the geographical distribution of water resources, some areas possibly becoming drier, whilst others becoming wetter (Kundzewicz *et al.*, 2007). Water users and water resource management institutions have to adapt to this variability, changes in demand and the effects of climate change, which whilst they may be significant in the future they are also uncertain.

Adaptation may be complicated by the transboundary nature of water resources. An estimated 90% of all Africa's surface freshwater resources are located in river basins and lakes that are shared between two or more countries (United Nations Development Programme, 2006). There are 60 international river basins within the African continent, covering 62% of the continent's area. There are five river basins in Africa that are shared by eight or more countries (Congo, Niger, Nile, Zambezi and Lake Chad) and 30 are shared by more than two countries (Wolf *et al.*, 1999).

International rivers in Africa pose particular management challenges because of competing national interests and limited mechanisms for cooperative action between nations that share major river basins. There are many examples in Africa where water management has been compromised by climate variability and competing transboundary needs for water (or power generation from water); for example, the Manantali Dam in Senegal (Magistro & Lo, 2001), the Mtera Dam in Tanzania (Lankford *et al.*, 2004) and the current low levels in Lake Victoria (Pearce, 2006).

The transboundary nature of many of the World's great rivers and increasing water scarcity has led to ideas of 'water wars' or conflict over water resources (Gleick, 1993). However, nations that share international river basins have histories of both conflict and cooperation over water resources (Yoffe *et al.*, 2003). Despite the benefits proposed from cooperation over shared resources there are many barriers to cooperative action. These barriers are political, social, institutional, physical and geographical.

In this paper we use the term conflict not just to refer to armed violent conflict between nations, but also to a range of types of negative interaction that encompass mild verbally-expressed discord and cold interstate relations to hostile military acts or declarations of war between states or their representatives and institutions (Yoffe *et al.*, 2003). Conflict can also refer to negative interactions between societal groups at a sub-state scale. Similarly the term cooperation encompasses a range of positive interactions that can take many forms (see Yoffe *et al.* 2003) and occur between a number of different actors at different scales. Keohane (2005) describes how "cooperation occurs when actors adjust their behaviour to the actual or anticipated preferences of others, through a process of policy coordination"(p51) and distinguishes it from harmony, where no adjustments are needed. He goes on to say that "cooperation should not be viewed as the absence of conflict, but rather as a reaction to conflict or potential conflict" (p54).

This paper reviews literature on climate change and its impacts on water resources in Africa, literature on adaptation to climate change for water resource management and literature on conflict and cooperation in international or transboundary river basins. The review is used to identify the challenges that climate change represents to water

resources management in the context of cooperative and non-cooperative behaviour of river basin nation states and their institutions. The aims of the paper are:
i) to identify what is known about the need and the potential for adaptation to climate change in international river basins, and the processes and factors that may either constrain or enhance adaptation, and
ii) to identify opportunities for further research to enhance our understanding of how to promote appropriate adaptation to both current climatic variations and future climate change in international river basins.
The next section reviews current understanding of water resources in Africa, how they change as climate changes and interactions between climate change impacts and socio-economic change. The following section explores processes of managing change in river basins, framed around ideas of adaptation to climate change. There then follows a section that sets adapting to climate change (vis-à-vis barriers and opportunities) in the context of theory and observation of cooperative and conflictual behaviour around water resources in international river basins. The final section uses insights from the review to identify areas of understanding and highlight opportunities for further study.

CLIMATE CHANGE AND WATER RESOURCES IN AFRICA

Water resources in Africa

Africa is characterised by a wide variety of climate systems ranging from humid equatorial, through seasonally-arid tropical, to sub-tropical Mediterranean type climates. Annual precipitation in Africa is estimated at about 20 360 km^3 (Aquastat Survey, 2005). Disparities between countries and regions are very important. With more than 7500 km^3/year, the central region receives 37% of all precipitation in Africa in an area that accounts for less than 20% of the total. In contrast, the northern region, with an area similar to the central region, receives less than 3% of total precipitation (Aquastat Survey, 2005). Although a dry regime (rainfall < 400 mm/yr) covers 41% of the continent, the intermediate regime (>400 <1000 mm/yr) covering 25% of the continent attracts greater concern than the other regimes as changes in precipitation would result in serious changes in surface water supply. The intermediate regime shows high seasonality and includes three densely populated regions: Southern Africa (including the Orange and Limpopo basins); most of East Africa, (including a large section of the upper Nile basin); and the East-West band stretching from Senegal to Sudan (broadly similar to the Sahel) which crosses a number of important river basins (including Lake Chad, the Niger, the Upper Volta, and the Senegal).

This review concentrates primarily on surface water resources in international river basins, whilst recognizing the importance of groundwater which currently represents 15% of Africa's water resources and is used by 75% of the population, mainly in North Africa (AfDB *et al.*, 2000). Green water, present in soil moisture reserves and evaporated to the atmosphere from soil and vegetation (Falkenmark, 1995), is vital in supporting natural ecosystems and rainfed agricultural production systems. Potential evaporation rates are high throughout Africa and, along with precipitation patterns, are important for determining seasonal variations in soil moisture and surface water availability. In some instances riparians in international basins may use basin

precipitation as the basis for calculating total water availability so that accounting for green and blue water flows (and changes thereof) is relevant to discussions and agreements on water allocation. The hydrological monitoring network for surface water in Africa is poorly developed with generally sparse coverage and short fragmentary records, although some long reliable records exist for strategic locations in parts of the Nile Basin and on major rivers in West Africa (Senegal, Niger, Congo; Conway *et al.*, in press). Monitoring networks for groundwater are currently inadequate (Groundwater and Climate in Africa, 2008), whilst soil water is not generally monitored.

African water resources are not evenly distributed throughout the continent and are often not located where there is the greatest demand. Africa has 17 rivers with catchment areas greater than 100 000 km^2 and 11 over 250 000 km^2 in area (see Table 1). It has more than 160 lakes larger than 27 km^2, most of which are located around the equatorial region and sub-humid East African highlands within the Rift Valley (AfDB *et al.*, 2000). River channels and basin watersheds make up almost 40% of Africa's international borders and all of the major African rivers traverse one or more international boundaries (de Wit & Stankiewicz, 2006). Table 1 shows the number of countries sharing and total area of each of the 11 largest international river basins in Africa (all over 250 000 square kilometres in area and shared by between three and 13 countries). The basin discharge varies greatly according to region and specific characteristics of the rivers, with the highest discharge being in the Congo basin and lowest in the Orange basin in Southern Africa. All of these river basins have high levels of variability, in particular the rivers of west and Southern Africa for which the coefficient of variation at the gauging stations shown in Table 1 were over 20% for the period 1961 to 1990. Three basins can be described as experiencing water stress (defined by United Nations Development Programme, 2006 as less than 1700 cubic metres per person per year) whilst two of these, the Orange and the Limpopo, both in Southern Africa experience water scarcity (defined as less than 1000 cubic metres of water per person per year, United Nations Development Programme, 2006). The Nile and Volta basins have the highest average population densities and are approaching situations of water stress. These statistics mask considerable variability within the basins and only refer to renewable water resources and not to people's ability to access water (Rijsberman, 2006).

The high levels of variability in rainfall and river flows in Africa across a range of spatial and temporal scales have important consequences for the management of water resource systems (Peel *et al.*, 2004; Conway *et al.*, in press). Throughout Africa this variability brings significant implications for society and causes widespread acute human suffering and economic damage (Conway & Hulme, 1996). Although most of the African population (roughly 69%) lives, on average, in conditions of relative water abundance, this does not reflect the poor access to clean drinking water and sanitation (Vorosmarty *et al.*, 2005). Only 62% of African's had access to improved water supply in 2000 despite the considerable improvements during the 1990s (WHO/UNICEF, 2000). Current population trends and patterns of water use indicate that more African countries will exceed the limits of their "economically usable, land-based water resources before 2025" (Ashton, 2002).