Cooperation and Adaptation to Climate Change in the River Nile Basin

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ABSTRACT

In this paper we explore potential limits, barriers or opportunities for adaptation to climate change in the River Nile Basin. The extent to which the transboundary nature of water resources in internationally shared river basins limits the ability of states and their national water management institutions to adapt to climate change is uncertain. We investigate whether climatic drivers lead to conflictual or cooperative interactions between states and how these interactions influence adaptation policies and outcomes. The research focuses on institutions of water resources management including national policies, bilateral or multi-lateral agreements, and uni-lateral or collaborative actions taken by the institutions of different basin states in response to experienced extreme climate events or the threat of future climate change. The analysis is based on 70 semi-structured interviews conducted during 2007 and 2008 with stakeholders in the Nile Basin in Egypt, Ethiopia, Kenya, Sudan and Uganda, including decision makers and water resources managers in government ministries and the Nile Basin Initiative. The results suggest that extreme climate events and the threat of climate change are now more likely to lead to cooperation between basin states than conflict. However, responses to climatic and non-climatic drivers of water resource policies and developments can be either cooperative or unilateral. It is hypothesised that cooperative actions between states and their institutions are more likely to provide better adaptation for the majority of the basin states than unilateral actions. Nevertheless, there are indications that some unilateral actions are perceived as being key adaptations for particular states or regions. The findings highlight the benefits of supporting cooperation amongst riparian states and suggest that factors that limit cooperation may also limit future adaptation to climate change.

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, the changes in demand and the effects of climate change. However, planned adaptation may be complicated by the

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transboundary nature of the water resources. An estimated 90 percent of all Africa's surface freshwater resources are located in international (or transboundary) river basins and lakes, defined as those 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 percent 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).

In this paper we use the term climate variability to refer to variations in climate on a seasonal to decadal time scale, which includes extreme climate events such as floods and droughts. Climate change refers to: variation in mean climate conditions on a multi-decadal or longer time scale, although climate change can also be associated with changes in climate variability. Adaptation refers to adjustments to systems in response to a sudden or gradual change or stimulus that modify its impacts.

Transboundary Rivers in Africa pose particular management challenges because of competing national interests and few 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); the Manantali Dam in Senegal (Magistro and 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 transboundary river basins have histories of both cooperation and indeed conflict over water resources (Yoffe et al. 2003).

There are several models that have been used to conceptualise conflict and cooperation, for example the Conflict Intensity Frame shown in Figure 1, developed by Zeitoun and Warner (2006). Conflict is used to refer to a range of types of negative interaction that encompass mild verbally-expressed discord and cold interstate relations (-1 to -3 on Yoffe et al.'s Water Event Intensity scale, 2003) to hostile military acts or declarations of war between states or their representatives and institutions (-5 to -7 on Yoffe et al.'s Water Event Intensity scale, 2003). Cooperation encompasses a range of positive interactions that can take many forms from mild verbal support (+1) to the signing of an international freshwater treaty (+6) and voluntary unification into one nation (+7, Yoffe et al. 2003). In addition a useful typology of cooperation has been developed by Mirumachi (2007) from work by Tuomela (2000), which describes five levels of cooperation: confrontation of an issue; ad hoc collaboration; technical collaboration; risk-averting cooperation and risk-taking cooperation (Figure 2).

Research on international river basins has shown that: conflict does not only manifest as violent conflict but that less intense forms of conflict are still conflict; conflict and cooperation can coexist, are dynamic over time and can vary in degrees of intensity; and conflict or cooperation can occur at different scales and over different issues (Wolf 1998; Wolf et al. 2003; Kistin 2006; Zeitoun and Warner 2006). Keohane (2005) states that "Cooperation should not be viewed as the absence of conflict, but rather as a reaction to conflict or potential conflict" (p54). All these observations point to the need to avoid a simple dichotomy of conflict and cooperation (Kistin 2006).

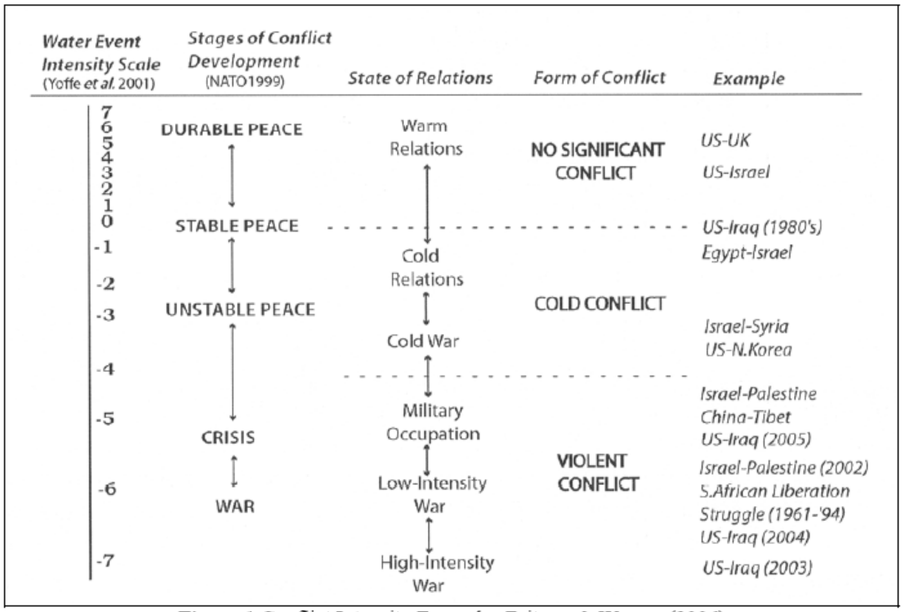

Figure 1 Conflict Intensity Frame by Zeitoun & Warner (2006)

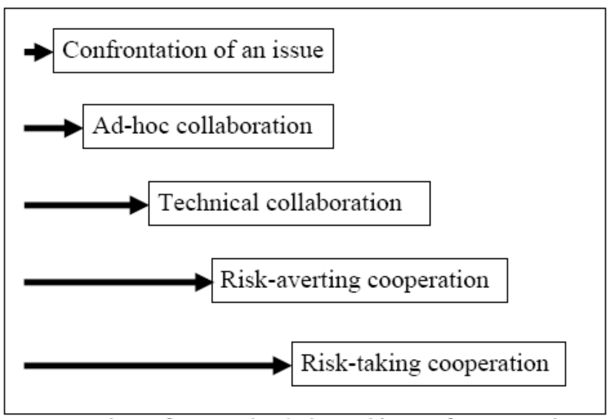

Figure 2 Typology of cooperation (Mirumachi, 2007 from Tuomela, 2000)

Despite the benefits proposed from cooperation over shared water resources (Sadoff and Grey 2002) there are many barriers to this cooperation. These barriers are political, social, institutional, physical and geographical. Goulden et al. (2008) reviewed evidence for climate change and its possible impacts on water resources in Africa and the challenges of adaptation to climate change impacts on water resources in transboundary river basins. They concluded that the transboundary nature of the resource and its role in adaptation to climate variability and climate change is poorly understood and suggest that research is needed to examine the factors and processes that are important for cooperation between river basin states to lead to positive adaptation outcomes and increasing adaptive capacity of water management institutions.

The aim of this paper is to examine the role of specific extreme climate events in triggering cooperation or conflict in one of the larger transboundary river basins in Africa, the River Nile Basin, and the ways in which cooperation or conflict provide opportunities for or potentially limit adaptation to climate extremes and future climate change.

In this introduction to the paper we have explained the background and aim to the research and explained some of the key concepts used in the paper. In the next section we introduce some key characteristics of the Nile Basin case study including projections of future climate change for the Nile Basin. In the following sections we describe our research approach, followed by some results and then a discussion and some conclusions.

THE NILE BASIN CASE STUDY

The River Nile and its tributaries flow through eleven countries (Egypt, Ethiopia, Eritrea, Sudan, Uganda, Kenya, Tanzania, Burundi, Rwanda, Democratic Republic of Congo and Central African Republic[137]) and provide water and livelihoods for many of the 160 million people living within the 3.1 million km^2 of the basin[138]. River waters are used by upstream countries predominantly for hydropower, and by the downstream countries of Sudan and Egypt predominantly for irrigation and intensive cultivation, but also for hydropower production. Egypt is reliant on the river water almost entirely for its water resources. Around 70 to 84 percent of the flow of the main Nile in Egypt is estimated to originate in the Ethiopian highlands from the Blue Nile, Sobat and Atbara tributaries and most of the remainder is from the White Nile, which flows from Lake Victoria through Uganda and into Sudan, through the Sudd swamps of Southern Sudan and then joins the Blue Nile at Khartoum before flowing North as the main Nile into Egypt (Sutcliffe and Parks 1999; Conway 2005; Block et al. 2008). The Lake Victoria basin is shared by Uganda, Tanzania, Kenya, Rwanda and Burundi (see Figure 3).

There are important geographical variations in the distribution of water resources and human populations within the Nile Basin. Figure 3 shows how precipitation varies across the Nile Basin, from over 1600 mm per year in parts of the Ethiopian highlands to less than 25 mm a year in much of Egypt. By contrast the highest population densities are to be found along the Nile valley and in the Nile delta in Egypt. Egypt's reliance on the River Nile for water resources is extremely high. Water resources are most highly developed in Egypt, where there are a number of dams, barrages and canals used for hydropower production and irrigation, the largest of which is the Aswan High Dam completed in 1964. These dams are used to regulate water supply and allow Egypt to fully use the Nile waters it receives (Arab Republic of Egypt: Ministry of Water Resources and Irrigation 2005). Sudan has several dams used for both, irrigation and hydro-power and Uganda has the Owen Falls Dam at the outlet of Lake Victoria for hydro-power, but the other countries in the basin currently have few major dams or other large scale water infrastructure in the basin although a number are under construction or recently completed (for example the Tekeze dam in Ethiopia and the Sondo Miriu hydropower plant in Kenya). A number of studies have been done to identify potential projects in different basin countries, but many of these schemes may have transboundary consequences and there have been reports of tensions between countries

[137] The eleventh country, the Central African Republic, has a small area and population in the basin of about 1000 people in 1000 km^2 (Wolf, A. (Accessed 2008)). For this reason it is often excluded from the list of basin countries and has not participated in any basin wide initiatives to date.
[138] http://www.waterandfood.org/basins/nile-river-basin.html

because of proposed and constructed projects in the past[139]. Development of Nile water resources is seen by many of the Nile Basin governments as necessary for economic development and meeting the growth in demand for food, water resources and electricity as economic development progresses in the region and populations continue to grow at a high rate (El-Fadel et al. 2003; Mason 2004). The development or improvement of infrastructure for water storage and flood protection, in particular, may become increasingly important for adaptation to climate change in the future, but can also have a role in mitigating current vulnerabilities to climate variability (Millar 2007; Commission for Africa 2008). However, as Adger et al. (2003) point out, there will be both winners and losers from such adaptations. Hydropower also potentially has a role to play in mitigating climate change because of its ability to reduce demand for fossil fuel powered electricity generation (Davidson et al. 2003). However, climate change and climate variability have important implications for hydropower and irrigation infrastructure investments (Block et al. 2008). The uncertain impacts of climate change have been suggested as a reason to enhance cooperation over water resources in shared river basins (Sadoff et al. 2008). However, before considering future water resource developments and the role of cooperation it is important to understand the current patterns of use of Nile waters and the historical determinants of these, including treaties and existing institutions of water management.

There are a number of treaties or agreements on the use of the Nile waters but none exist that are agreed on by all river basin states (Waterbury 2002). Some of these agreements were made by Great Britain on behalf of it's then protectorates, and some have since been rejected by the post-colonial governments of Kenya and Tanzania but are still observed by Egypt and Sudan (for example the 1959 treaty on the 'Full Utilisation of the Nile'[140]). Recent bilateral or multilateral agreements include the 2003 Protocol for the Sustainable Development of Lake Victoria Basin, between Kenya, Tanzania and Uganda and the establishment of the Lake Victoria Basin Commission under the auspices of the East African Community (EAC)[141]. There are currently no basin wide institutions for managing the river but in 1999 the Nile Basin Initiative (NBI) was formed by the ten basin countries with support from the World Bank and other international donors. The NBI consists of meetings of the Council of Water Ministers, meetings of technical advisors from the water ministries of each country and a number of projects and programmes. The aim of the NBI is to build trust between the basin countries and lead to establishment of a Nile Basin Commission. A basin wide Nile Basin Framework Agreement is being negotiated under the auspices of the NBI, however negotiations are currently stalled because of differences between countries with respect to references to existing contentious treaties such as the 1959 treaty between Egypt and Sudan.

[139] For example Egypt objected to the Finchaa Dam on a tributary to the Blue Nile in Ethiopia and Ethiopia objected to Egypt's Toshka project and Peace Canal (Waterbury 2002).

[140] The 1959 treaty was agreed between Egypt and Sudan on completion of the Aswan High Dam and divided the average flow into Lake Nasser between Egypt (55.5 bcm/yr) and Sudan (18 bcm/yr) and allowed 10 bcm/yr for evaporation. The Permanent Joint Technical Committee between Egypt and Sudan was set up to implement this treaty.

[141] http://www.unhabitat.org/downloads/docs/Protocol%20for%20Development%20Lake%20Victoria%20Basin%20EAC%202003.pdf

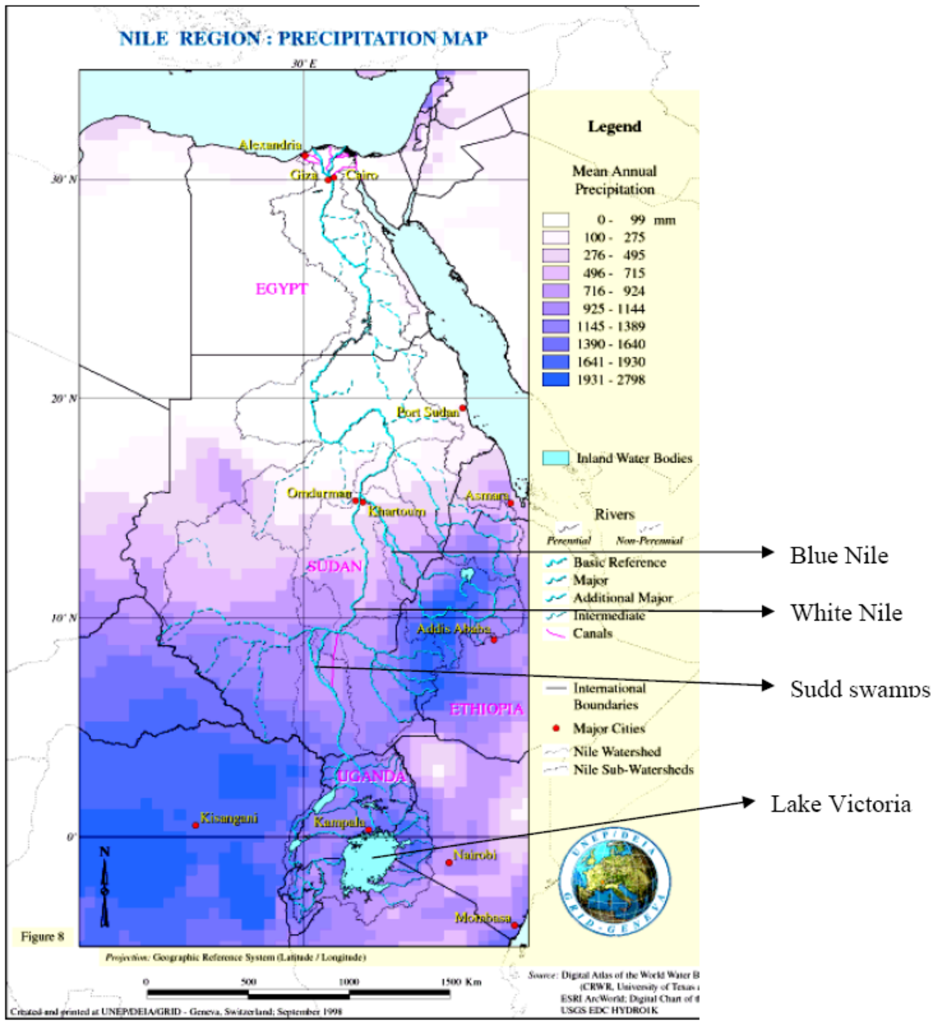

Figure 3 Map of the Nile Basin showing precipitation variation (www.grid.unep.ch)

Climate variability, climate change and impacts on water resources in the Nile Basin

The climate of the Nile basin is temporally as well as spatially variable. Variability in rainfall during the twentieth century has resulted in fluctuations in Nile flows and the levels of lakes in the Nile Basin. In particular the levels of Lake Victoria and runoff in the Ethiopian highlands are extremely sensitive to variation in rainfall (Conway 2005). Notable recent climate extremes include a prolonged dry period in the 1970s and 1980s where Blue Nile flows were much reduced and the levels of Lake Nasser reached record low levels and periods of above average rainfall and sharp rises in the level of Lake Victoria and other lakes in East Africa in the early 1960s and again in 1997/1998 (Conway and Hulme 1993; Nicholson 1993; Conway and Hulme 1996; Sene 1998; Conway 2005; Conway et al. 2005; Conway et al. in press).

Against a backdrop of existing high levels of variability, climate change will alter the timing, distribution and quantity of water resources (Goulden et al. 2008). Table 1 summarises climate model projections of changes in temperature and precipitation from the present day to the end of this century (2080 to 2099) for East Africa, the main source region for the Nile. The projections are based on the results of 21 climate models using the A1B emissions scenario[142], published in the IPCC Fourth Assessment Report (Christensen et al. 2007). Warmer conditions can be expected in the 2080s, with the model mean showing an increase of 3.2°C and all models showing an increase of between 1.8 and 4.3°C. Nearly all models project wetter conditions in East Africa (with a model mean of +7 percent, and individual models projecting a range of between 3 percent reduction in precipitation up to a 25 percent increase).

In addition to changes in mean climate conditions, climate change is expected to cause changes in climate variability, in particular to the frequency and severity of extreme climate events, such as floods and droughts. However projections of changes in extreme events for the tropics remain uncertain (Christensen et al. 2007). Variability of the climate in East Africa is currently driven largely by the behaviour of ENSO and circulation patterns in the Indian Ocean, but climate models do not show clear tendencies in the future behaviour of these large-scale drivers (Merryfield 2006; Conway et al. 2007).

Surface water resources in the Nile Basin will be impacted by increased evaporation due to higher temperatures and also due to changes in rainfall. Nile flows and levels of the lakes in the Nile basin may be reduced unless increases in rainfall outweigh the effect of evaporation increases. Projections of future Nile water resources are highly sensitive to the particular climate scenarios and models used. Table 2 shows a range of results from a number of studies that show both increases and decreases in Nile water in the future. In addition to the effect of climate change on water resource availability in the Nile Basin, if projected increases in annual rainfall are experienced as more extreme events, then we can expect more frequent and/or more extreme and damaging flooding events.

The Nile Basin countries differ to some extent in the nature of their vulnerability to climate change impacts. For example, in Egypt a key vulnerability is its long-term water security given the rapidly rising demand for water with a growing population (Conway et al. 1996; Hefny and Amer 2005). Ethiopia is vulnerable in terms of food security for the population (Webb 1993). Sudan is vulnerable in terms of the impacts of extreme events and to some extent food security, whilst the Lake Victoria basin region is vulnerable to the impacts of extreme events and the impacts of variability on, hydropower generation and livelihoods, for example (Conway et al. 2005).

[142] Emissions scenario A1B represents a mid-range emission profile for a future world scenario characterised by rapid economic growth, a global population that peaks in the mid-21st century and then declines and with technology based on a balance of fossil fuel and non-fossil fuel energy sources (Nakicenovic 2000). Although A1B has been chosen as a 'best-guess' scenario there are already indications that we are currently above this and the higher emissions scenarios used by the IPCC in terms of emissions (Raupach et al. 2007).

Table 1. Changes in mean temperature and precipitation between the present day (1980 to 1999) and the period 2080 to 2099 for East Africa. Multi-model means and model range shown, based on Christensen et al. (2007), summarised in Goulden et al. (2008)

Region	Temperature		Precipitation	
	Annual	Seasonal	Annual	Seasonal
East Africa (12S,22E to 18N,52E)	+3.2°C with an inter-model range of +1.8°C to +4.3°C.	Warming in all seasons ranging from +3.1°C (DJF, SON) to +3.4°C (JJA).	Increase of 7% with an inter-model range of -3% to +25%.	Increase in all seasons ranging from 4% (JJA) to 13% (DJF).

Table 2. Summary of studies of climate change impacts on surface water resources in the Nile (adapted from Goulden et al. 2008).

Projected changes in water resources	Authors
Runoff in Eastern Africa is projected to possibly increase by 2050.	(Strzepek and McCluskey 2006)
Future **Nile** discharge (up to 2100) will decrease slightly (-2%) or will remain relatively stable compared to the current situation (average over 1750–2000 AD).	(Aerts et al. 2006)
Increase in runoff of 20 to 40% by 2050 in Eastern equatorial Africa.	(Milly et al. 2005)
Lake Tana: if the temperature is increased by 2°C and: 1) no change in rainfall → decrease in annual flow by 11.3%; 2) decrease in rainfall by 10% to 20% → decrease in runoff by 29.3% to 44.6%; 3) increase in rainfall by 10% to 20% → increase in runoff by 6.6% to 32.5%.	(Tarekegn 2000)
Significant reduction in runoff in **Nile** by 2050	(Manabe et al. 2004)
Runoff in Eastern and Northern Africa is projected to possibly increase by 2050.	(Arnell 2003)
By 2025, propensity for lower **Nile** flows (in 8 out of 8 scenarios).	(Strzepek et al. 2001)
Five out of six climate models produced an increase in **Nile** flows at Aswan, with only one showing a small decrease.	(Yates and Strzepek 1998)
Range (due to differences between GCM scenarios) of –9% to +12% changes in mean annual **Nile** flows for 2025.	(Conway and Hulme 1996)
Divergence between climate model results for the **Nile** basin; two produced increases and two produced decreases in flows.	(Strzepek and Yates 1996)
By 2050, the combined effects of 3 driving forces (climate change, land-use change, water resources management) on future water availability in **Egypt** range from a large water surplus to a large water deficit.	(Conway et al. 1996)

EXAMINING ADAPTATION: RESEARCH APPROACH

The conceptual framework and research questions (shown in Figure 4) draw on the literature on international relations in transboundary rivers (Wolf 1998; Yoffe et al. 2003; Zeitoun and Warner 2006) collective action and governance of commons resources (Sadoff and Grey 2002; Waterbury 2002) and the climate change adaptation literature (Tompkins et al. 2005; Arnell and Delaney 2006; Penning-Rowsell et al. 2006; Kundzewicz et al. 2007; Moser in press). The conceptual framework proposes that a number of different drivers or factors, including experienced extreme climate events and the threat of climate change, lead to interactions between states and their institutions that might involve cooperation, non-cooperation or conflict over water resources (or a mixture of these types of interaction) and that these interactions in turn shape policy for adaptation to climate change and the adaptation outcomes for different nations. Social, political and economic factors will shape these relationships. Several qualities of adaptation outcomes are considered: *who* is adapted or not adapted?; *what types* of adaptation are used? And are there *barriers or limits* to adaptation? Based on this conceptual framework the paper attempts to answer three research questions:

i) Do climate events and the threat of climate change lead to interactions that are conflictual or cooperative (by providing a window of opportunity)?
ii) How does the nature of interactions (cooperative or conflictual) influence adaptation policy and adaptation outcomes?
iii) Is cooperation necessary for adaptation to climate change and does conflict or lack of cooperation provide a limit to adaptation in international river basins?

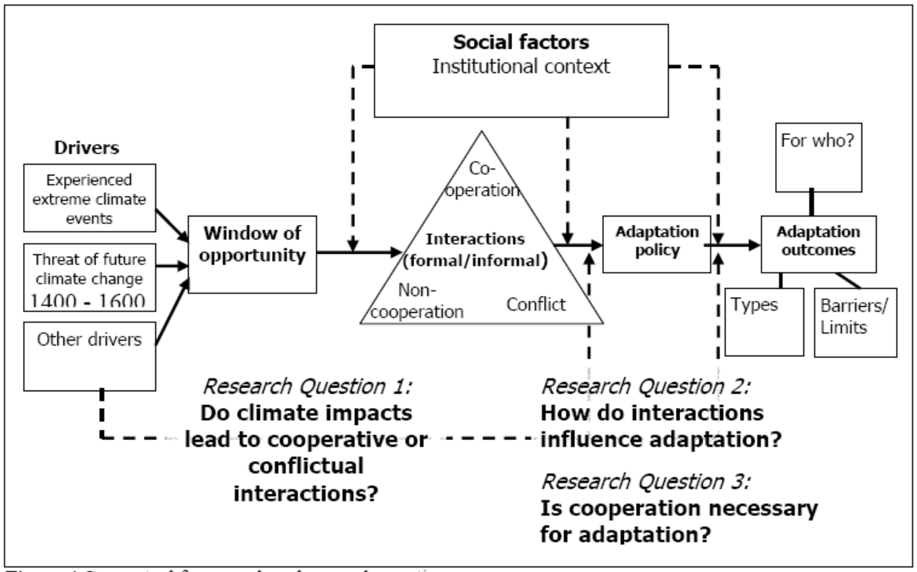

Figure 4 Conceptual framework and research questions

An interdisciplinary approach has been used for this research using case studies of specific drought and flooding related climate events in the recent past in the River Nile basin, as well as the consideration of current cooperative efforts and plans for future water resource developments and climate change adaptations within the basin. The unit of analysis is the state and sub-basin. The analysis is based on 70 semi-structured interviews conducted during 2007 and 2008 with stakeholders in Egypt, Ethiopia, Kenya, Sudan and Uganda, including representatives of government ministries and agencies, donors and international bodies (e.g. World Bank, UN agencies), civil society organisations, academics, and project or programme staff of the NBI. The interviews were conducted and the analysis carried out with reference to the list of key variables shown in Table 3.

Table 3 Key variables for data collection and analysis

Climate event and projections of climate change	Institutional setting/ regime history	Interactions	Adaptations
Timing , duration, chronology and magnitude of impact (e.g. impact on river flows, economic impact, lives and livelihoods)	*Chronology of formation and changes in key institutions* Different types/role of institutions over time.	*Type* (e.g. treaty, agreement, formal statement, informal statement, joint activity, ad hoc, risk-averting etc.) Between *who*? - which states and which actors? *Intensity/ typology* of interaction: Water Event Intensity Scale of Yoffe et al. 2003: • -7 formal declaration of war, • 0 Neutral or non-significant act, • 7 voluntary unification into one nation *Typology of cooperation* (Mirumachi, 2007)	*Action, type and goal*: what was the adaptation action? Taken by whom? What was its goal? What type? (e.g. with respect to purposefulness, timing duration, and location) *Effectiveness*: adaptation outcome/ adaptedness/ adaptive capacity, effective for whom and over what timescale, sustainability of adaptation. *Barriers or limits to adaptation*

RESULTS

Learning from the past: extreme climate events and inter-state interactions

Climate change will be experienced partly as extremes of climate, therefore one can learn something about adaptation to future climate change by looking at responses to extreme events in the past (Glantz 1991). Periods of high and low rainfall lead to impacts such as drought and food insecurity[143], low lake levels (with impacts on hydropower, domestic water supply for urban areas and irrigated agriculture) and flooding (with livelihood and health impacts and impacts on infrastructure such as roads, bridges and buildings). In recent decades in the Nile Basin there have been a number of different events that were caused or exacerbated by climate variability over which interactions have occurred between two or more Nile basin states, for example those listed in Table 4. Data collected from interviews and from the literature about responses to the three events were analysed and are described below, paying particular attention to inter-state interactions and the institutions involved in these.

Table 4. Climate related events used as case studies

Case	Year	Climate related event and impacts	Main countries involved	Interactions
1	1980s	Low Blue Nile flows, low levels of Lake Nasser, drought and food security problems in Ethiopia, water security in Egypt	Ethiopia, Sudan, Egypt	Mainly unilateral responses by Egypt and Ethiopia.
2	1998-2000	High rainfall, blockage formation and flooding of Lake Kyoga	Uganda, Egypt	Egypt funding and participating in cooperative project with Uganda to remove blockage.
3	2005-2006	Low levels of Lake Victoria (partially climatically driven)	Uganda, Kenya, Tanzania	Low level conflict (tension) followed by cooperation under the auspices of the EAC.

[143] Drought and crop failure does not always lead to famine or food insecurity. Famine results from an inability of the population to purchase or exchange goods for food and can be triggered by natural disasters including drought or floods, civil conflict and/or market fluctuations, for example (Sen 1999).

1. **Low flows in the Blue Nile during the 1970s and 1980s**
   A prolonged trend of drying in the Ethiopian highlands and across much of East Africa led to exceptionally low levels of lake Nasser in the mid 1980s (Figure 5) and contributed to the 1980s famines of Ethiopia. The responses to this drying 'event', indicated in Figure 5, have been largely unilateral (i.e. non-cooperative: not involving cooperation with other Nile Basin countries). For example, Egypt was forced to take emergency measures to implement drought contingency plans as a response and this also triggered an adaptation in the form of the development of Egypt's capacity for longer term forecasting and management (Conway 2005). Ethiopia's experience of food insecurity, in particular during this period, has influenced its current policy of (mostly unilateral) development of its water resources. It is hypothesised that the severity of the famines in Ethiopia may have led to a reduced resistance by Egypt to Ethiopia's plans to develop Nile waters and the experience of low levels in Lake Nasser may have prompted increasing efforts on Egypt's part to enhance cooperation within basin. Further analysis of interview data is needed to test these hypotheses. More recently Egypt's response to increasing demand for water within Egypt, population growth and the high water levels experienced in lake Nasser during the 1990s has been to expand irrigation into desert regions outside the Nile valley and delta area (for example the Toshka project). Conway (2005) expressed concerns that this may be maladaptive (i.e. poorly adapted) in the long term as climate variability means Egypt is likely to experience reduced Nasser levels at some point, possibly enhanced by climate change (although the impact of climate change is uncertain and may result in increased average levels of Lake Nasser in the future).

2. **Uganda – blockage and flooding on Lake Kyoga, 1998-2000**
   An exceptionally high rainfall event in late 1997 and early 1998 caused widespread flooding around Lakes Victoria and Kyoga in Uganda, as well as many other East African lakes. In Lake Kyoga the flooding was exacerbated by the formation of a blockage of floating vegetation that caused the lake to rise a further one metre in addition to the initial one metre rise (see Figure 6). A project to mitigate the flooding around the shores of Lake Kyoga was instigated by the Uganda Ministry of Water with cooperation from the Egyptian Ministry of Irrigation. The Egyptians provided technical advice and equipment to cut through the papyrus blockage at the outlet of the lake in the River Nile to allow the flood waters to recede and return the water into the Nile river system. This cooperative action was bilateral between Uganda and Egypt and provided a clear benefit to both countries. It also avoided the need for diversion of Nile water away from the lake, which would have been a consumptive use not favoured by Egypt. The type of cooperation this case represents is an 'ad-hoc collaboration' (Mirumachi 2007) with a score of 3 or 4 on the Water Event Intensity Scale (Yoffe et al. 2003).

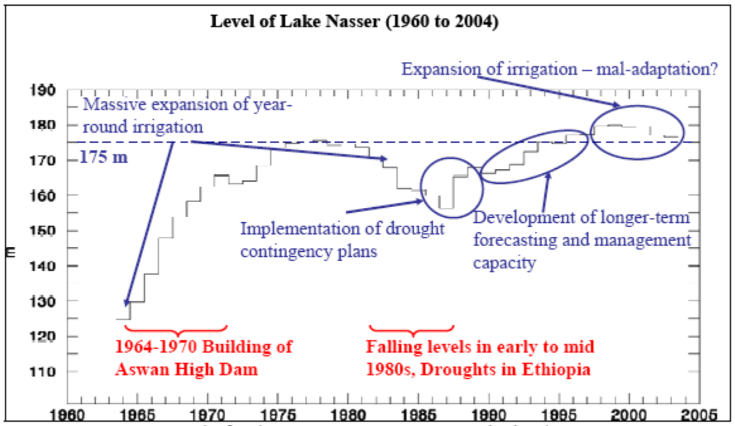

Figure 5 Level of Lake Nasser 1960 to 2004 and adaptive responses

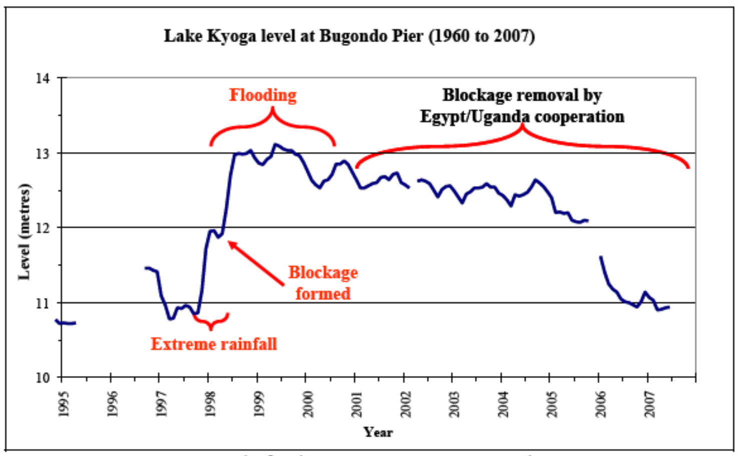

Figure 6 Level of Lake Kyoga 1995 to 2007 and responses

3. Lake Victoria – low levels in 2005/6.

Lake Victoria has a history of fluctuation in lake levels with variation in the rainfall over the catchment and the direct rainfall into the lake (Tate et al. 2004). Large increases in lake level and flooding occurred following exceptionally high rainfall in the early 1960s and again at the end of 1997 and early 1998. Since 1998 there has been a declining trend in lake levels (see Figure 7) possibly indicating a return to pre 1960 lake levels, which were lower on average than post 1960 levels. In addition to climatic factors, lake levels have also been controlled since 1956 by the Owen Falls Dam at the outlet of Lake Victoria at Jinja in Uganda, which has been operated approximately according to an 'Agreed Curve'[144] which models the natural relationship between water level and outflow (Sutcliffe and Parks 1999). Since 1997 there has been some departure from this agreed curve for the purposes of flood

[144] Several agreements between Great Britain on behalf of the Government of Uganda and the Government of Egypt made in 1949, 1950 and 1952 established the financing and policy of operation of the dam (see http://ocid.nacse.org/tfdd/treaties.php).

management and also to accommodate the increased capacity and demand for electricity generation since the opening of additional turbines in the extension to the Owen falls dam in 2000 (DWD 2004; Goulden 2006). The accelerated decline in levels between 2004 and 2007, which can be seen on the far right hand side of Figure 7, has been the subject of much concern and debate in the region. Different people have blamed this decline on a number of different factors including the excess releases of water at the dam, climate change causing increased evaporation, drought and land use change. From a number of studies it appears that both climatic and non-climatic causes have contributed to declining water levels. According to studies by Sutcliffe and Peterson (2007) and Kull (2006), approximately half of the drop in level between 2000 and 2006 can be explained by excess releases at the outflow of the lake made in order to meet power generation demands, whilst the other half appears to be due to climatic factors.

The decline in lake level has reduced the generating capacity of Uganda's hydroelectric facilities and also had an impact on infrastructure and livelihoods around the lake in Uganda, Kenya and Tanzania, for example disrupting water supplies for towns and transport and fishing infrastructure. Tensions resulting from these impacts were apparent as accusations against the Ugandans and counter accusations and denials that appeared in the media during 2006. These accusations also occurred informally in scientific and technical meetings, including meetings of the EAC. The result of these tensions was a move by the EAC to instigate cooperation between the water departments of the three countries (Kenya, Tanzania and Uganda) to study the water balance of the lake and suggest a water release policy to be adopted through consultation with the NBI[145]. This example can be interpreted as mild discord or conflict followed by cooperation of the type described by Mirumachi (2007) as 'confrontation of an issue' followed by an 'ad-hoc collaboration' and possibly also a factor in prompting a longer term 'technical collaboration' under the auspices of the Lake Victoria Basin Commission established by the EAC. Applying the Water Event Intensity Scale (Yoffe et al. 2003) to this example we see interactions with a score of -1 being followed by interactions scores of 1, 2 and 3.

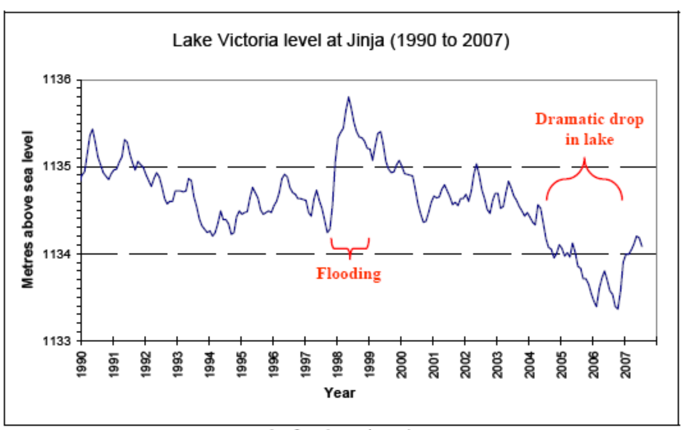

Figure 7 Level of Lake Victoria 1990 to 2007

[145] Egypt's position on this initiative is not clear, although recent media reports have suggested that bilateral discussions on the water releases from Lake Victoria have occurred between Ugandan and Egyptian officials during 2008 (Doya 2008).

Prospects for adaptation: the role of cooperation in water resource planning

Currently in the Nile Basin there is much activity with respect to water resource developments across the basin. Some water resource developments can be considered as adaptations to climate variability whilst others are principally adaptations to increasing demand for water and electricity for economic development purposes. Some of these developments are cooperative and being planned under the auspices of the NBI, for example the Baro-Akobo multi-purpose water resources project in the Eastern Nile region[146] (on the border between Sudan and Ethiopia) and the Rusumo Falls Hydroelectric Power Development project in the Kagera river basin[147] (shared between Tanzania, Rwanda and Burundi). There are also many unilateral water resource development projects being planned or implemented across the basin, for example: the Toshka irrigation project in Egypt, the Meroe Dam in Sudan, the Tekeze Dam in Ethiopia, the Bujagali Dam in Uganda, water supply infrastructure in the Shinyanga region in Tanzania, and the Sondu Miriu Dam in Kenya. Some of these unilateral projects have more implications for Nile water sharing than others and some are potential sources of tension between Nile basin countries.

There is much talk of the importance of cooperation in the Nile Basin amongst politicians, advisers and Ministry of Water officials. Interviews revealed that some officials link the need for cooperation to potential competition over water resources in the future either due to increasing demand and/or due to the potential impacts of climate change, for example in the quotation below:

> "So inevitably cooperation is important because clearly we will soon go into competition for the resource, real competition. For now it is more of a perception. It's perceived, but I think it is going to be real. So cooperation is necessary, I think, to plan together."
> *Interview participant, Uganda, October 2007*

Despite a widespread perception of the importance of cooperation, conversations with Water Ministry employees in the different countries, and a review of policy documents, revealed how many of the unilateral projects being currently undertaken are seen as very important for each countries development and adaptation needs. A key question remains unanswered as to whether these unilateral developments will impede the adaptation of other Nile Basin countries.

DISCUSSION

The first research question asked whether climate events and the threat of climate change lead to interactions that are conflictual or cooperative. In some of the examples presented the experienced extreme climate events prompted cooperation (e.g. Lake Kyoga and Lake Victoria), whilst in others responses were often unilateral (non-cooperation, e.g. Lake Nasser) and occasionally involved low-level (non-violent) conflict or tension (Lake Victoria initially). The Lake Victoria case highlights the important role regional institutions such as the EAC can play in mitigating tensions and encouraging cooperative interactions. In addition the Permanent Joint Technical Committee (PJTC) between Egypt and Sudan is important for responding to extremes in levels of Lake Nasser. Up until now the only basin wide regional

[146] See http://ensap.nilebasin.org/index.php?option=com_content&task=view&id=39&Itemid=131
[147] See http://nelsap.nilebasin.org/index.php?option=com_content&task=view&id=37&Itemid=89

institution, the NBI, has just been used to a limited extent as a medium for cooperation in response to extreme climate events, for example for exchange of information about current and predicted flooding events during 2007 in the Eastern Nile region. However, several of the projects once fully implemented are likely to have the potential for reducing vulnerability to climate impacts by helping to predict and/or respond to future extreme climate events and climate change, for example the Decision Support System in the Water Resources Planning and Management project and the Flood Preparedness and Early Warning project for the Eastern Nile basin[148]. To achieve their maximum possible benefit it will be essential that these projects become fully integrated in national decision making institutions such as the Ministries of Water/Irrigation of the basin countries.

It is not clear that the threat of climate change is yet influencing interactions between states in the Nile Basin. Many of the people interviewed revealed that climate change is a subject that is only recently being examined in institutions within the basin and most respondents considered there to be insufficient expertise or capacity to respond to climate change within their country. During 2008 the NBI began to incorporate climate change issues into some of its programmes, but this has yet to be fully implemented.

This paper also asks how the nature of interactions influences adaptation policy and adaptation outcomes and whether cooperation is necessary for adaptation to climate change. This has proved more difficult to answer since specific policies for adaptation to climate change in the water resource sector do not yet exist. However, many of the water resource developments being planned or taking place are likely to have consequences for adaptation to climate change. Unilateral or cooperative water resource developments could turn out to be either good or bad adaptations depending on the time frame and from which country's perspective they are considered, as well as from the differing perspectives of stakeholders within a country. For example, unilateral actions such as Egypt's expansion of irrigation in the desert has caused some tensions in the Nile basin and it may leave Egyptians vulnerable should Nile flows reduce in the future.

Uncertainty, on the one hand, over the direction and magnitude of changes in rainfall and Nile flows with future climate change and, on the other hand, uncertainty over future sharing of water by the Nile countries mean that it is difficult to predict the impact of future adaptations or the capacity to adapt to climate change. As a way of addressing these uncertainties, we have suggested some indicative scenarios in Table 5. Under a scenario where Nile flows reduce in the future and where the status quo of current usage patterns is maintained, the upstream riparians are limited in their ability to adapt to decreasing Nile flows. In contrast if upstream countries increase their use of water, in particular through unilateral developments, these could provide adaptation possibilities for upstream riparians but impede downstream adaptation, in particular for Egypt, which would be increasingly water stressed. In contrast, if Nile flows increase in the future, adaptation to increased flood risk will be necessary in mid and upstream countries and downstream Egypt will have more water available to adapt to increasing water demand as temperature and populations increase.

[148] See http://www.nilebasin.org/ for project descriptions

Table 5 Example scenarios of climate and water use for discussion by Nile stakeholders

		Future Climate Change impact on water resources	
		Decrease in Nile flows	**Increase in Nile flows**
Hydro-political situation	**Maintenance of status-quo**	**A** Adaptation necessary throughout basin, reduced options for adaptation for upper basin riparians	**B** Positive adaptation possible for Egypt and Sudan (need for mid/upper basin to adapt to flood risk)
	Increasing use of water by upstream countries	**C** Adaptation options of upper basin countries may disadvantage adaptation of downstream countries	**D** Adaptation options available to all riparians?

This is an example of the types of scenario that could be developed in more detail in a participatory manner by Nile Basin stakeholders to help discuss the future impacts of climate change and the role of cooperation in suitable adaptive responses. A key concern is that some unilateral developments (planned or already occurring) may impede the ability of other countries to adapt to climate change. However, this needs to be studied further. It can be seen that either of the extreme outcomes suggested in boxes A and C disadvantage some of the basin countries. Cooperative development of the Nile water resources may be able to achieve an outcome that avoids these extreme outcomes, but it is suggested that cooperative planning may need to expand beyond existing NBI projects to take account of existing unilateral developments. There is a widespread belief within the basin that cooperation will be necessary to meet the challenges of water resources management at the basin scale, and some interview participants implied that competition over Nile resources is already prompting cooperation. If competition over water resources is expected to increase in the future any limits to cooperation may be a threat to some or all of the Nile basin countries.

CONCLUSIONS

The results presented here suggest that extreme climate events and the threat of climate change can lead to both conflict and cooperation between riparian states, however currently cooperation appears a more likely outcome than prolonged conflict. Responses to climatic and non-climatic drivers of water resource policies and developments can be either cooperative or unilateral. Cooperation can assist responses to climate extremes and potentially to future climate change but the benefits may not be equally distributed between states and unilateral actions can cause tensions. It is hypothesised that cooperative actions between states and their institutions are more likely to provide better adaptation for the majority of the riparian states than unilateral actions taken by different states. Nevertheless, there are indications that some unilateral actions are perceived as being key adaptations for particular states or regions. This points to a potential limit to the ability of cooperation to contribute to climate change adaptation. Regional institutions (e.g. PJTC, EAC, NBI) are important for cooperation and potentially also for climate change adaptation. The findings highlight the benefits of supporting cooperation between riparians through appropriate institutions and suggest that factors that limit cooperation may also limit future adaptation.

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