6 Water allocation in transboundary river systems in times of climate change

P. Michael Link

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Table of Contents

1 Introduction: Research on climate change and security in Hamburg 1
Michael Brzoska and Jürgen Scheffran

2 Climate change and weather extremes as risk multipliers 19
Tipping points, cascading events, and societal instability
Jürgen Scheffran

3 Agrofuel expansion and black resistance in Brazil 49
Energy landscapes as materialized unequal power relations
Martina Neuburger, Rafaela Rau, and Tobias Schmitt

4 Interaction between wind energy, climate vulnerability, and violent conflict in Northern Kenya 67
Janpeter Schilling and Luise Werland

5 The roadmap to energy security in Egypt 83
Mostafa Shaaban

6 Water allocation in transboundary river systems in times of climate change 103
P. Michael Link

7 Managing water-related vulnerability and resilience of urban communities in the Pearl River Delta 121
Liang Emlyn Yang

8 Challenges and opportunities for historical irrigated agricultural systems in Mediterranean regions 143
Technical, cultural, and environmental assets for sustainable rural development in Ricote (Murcia, Spain)
Andrea L. Balbo, José María García Avilés, Johannes Hunink, Francisco Alcón, Juan Esteban Palenzuela Cruz, Julia Martinez-Fernández, Arnald Puy, Juan Miguel Rodriguez Lopez, Katharina Heider, Rodrigo García Abenza, and Jürgen Scheffran

9 Sustainable access to rural and urban land by integrating local perspectives 163
The potential of using Information and Communication Technologies
Juan Miguel Rodriguez Lopez, Katharina Heider, Andrea L. Balbo and Jürgen Scheffran

10 Drought, flight, conflict: "climate migration" as a driver for conflict? 175
Christiane J. Fröhlich

11 Disrupting the knowledge-power politics of human mobility in the context of climate change 195
Questioning established categories
Sarah Louise Nash

12 Explaining the diversity of resilience in the climate change and security discourse 209
Resilience in translation
Delf Rothe

13 Climate change and planning for the military 229
Michael Brzoska

14 How does path dependence affect the climate change-conflict nexus? 251
Jasmin S. A. Link

15 Critical evaluation of the implementation of the concept of environmental security 263
Case study of the Environment and Security Initiative (ENVSEC)
Judith Nora Hardt

16 The Anthropocene: an opportunity for transdisciplinary and inclusive science? 287
Andrea L. Balbo, Delf Rothe, and Jürgen Scheffran

About the authors 297

6 Water allocation in transboundary river systems in times of climate change

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Abstract

Rivers are the lifelines for large shares of the global population Now climate change adds uncertainty to water availability in many transboundary river systems, making it hard or impossible for some countries to comply with existing treaties and affecting societal stability. In our research within CliSAP, we have developed a theoretical framework for the assessment of water conflict and cooperation in times of climate change. The framework links environmental change to altered water availability. This in turn has effects on individual human wellbeing in the riparian countries.

One case study that has been our particular focus is the Nile River Basin. Results indicate that Egypt's water allocation goals can not be met in a business-as-usual scenario, increasing the likelihood of the downstream countries engaging in conflicting strategies with their upstream neighbors.

KEYWORDS: *Transboundary rivers, water management, climate change, Nile River Basin, agent-based modeling.*

Introduction

Since the beginning of civilization, humans have settled close to rivers to use their water for consumption, agriculture, provision of food, and as means for transportation. The first cities have developed along large rivers and even today, transboundary rivers are of particular economic and strategic importance. However, pronounced growth of metropolitan areas along rivers has created challenges in recent decades that have made water a scarce resource in some river basins, particularly where other sources of freshwater are lacking. This has led to diminishing per capita water availability, a trend that is presumably intensified by the effects of climate change, which impact the water availability in river systems by affecting precipitation patterns and evaporation rates (Field and Van Aalst 2014; Stocker et al. 2014)

The necessity to share river water among several riparian countries creates additional caveats as downstream countries are dependent on sufficient fresh water inflow from the upstream riparians both quantitatively and qualitatively. There are 263 transboundary river systems in the world that serve as freshwater source for more than 40 % of the world's population (Wolf 1998). Adequate water allocation schemes usually require some kind of agreement between riparians and indeed agreements exist for practically all transboundary river systems. Nonetheless, conflict potentials remain if the riparians have distinctly different water use interest and histories of conflict and distrust.

Water conflicts can be caused by a variety of factors, including unilateral utilization of water by upstream countries (Bernauer and Siegfried 2012; Fischhendler, Dinar, and Katz 2011) or generally increasing water stress (Wolf 1999b). However, it has to be noted that despite recurring tensions and disputes over water resources in transboundary rivers, there has been only one interstate war over water in recorded history, which already dates back several millennia (Wolf 1998). Currently, water disputes are usually embedded in tensions and disagreements about other political or economic issues, so they play only a marginal role at the interstate level. Instead, cooperative use of water resources may benefit all riparians and could serve as foundation for cooperation with regard to other aspects as well (Conca 2002).

In order to be able to assess the interaction of physical and socio-economic aspects of water use in transboundary river systems, we have developed an integrated conceptual framework of water conflict or cooperation that takes into account issues of water management and changes in environmental conditions. It is applied exemplarily to the Nile River Basin, one of the key case study areas in the work of the Research Group Climate Change and Security on water resources. Possible development pathways can be identified not only by theoretical analyses but also by model simulations. Key insights are discussed and summarized in the conclusion.

Management of transboundary river systems

The distribution of river water among the riparians is no trivial matter in many of the world's transboundary river systems. History shows that conflicts have arisen in all river basins that could only be solved by some kind of agreement. The Transboundary Freshwater Dispute Database contains information on historic water conflicts and allows for detailed assessments of causes and consequences (Wolf 1999a).

With regard to the case study area, the Nile River Basin, it becomes evident that there is no simple relationship between the various physical and socio-economic drivers, water availability, and the potential for conflict. Environmental change can lead to altered resource abundance affecting economic wealth, which in turn could translate into a higher potential for conflict onset (Link et al. 2012). First of all, climate change is an external forcing that impacts the availability of key resources such as water or land for agricultural production. This affects human wellbeing and – due to the transboundary nature of the river basin – interstate relationships, which can be affected either cooperatively or in a conflictive manner. The likelihood of conflict onset can be limited as long as all riparians have an adequate adaptive capacity to deal with the external change.

Already existing agreements on water use can provide a useful setting for further cooperation among riparians or be a burden as in the case of the Nile River, where water agreements are outdated and neglect a majority of the riparians of the river basin. Egypt has historically established itself as a hydro-hegemon, requiring the majority of the river water (Zeitoun and Warner 2006). Because of substantial external support by Great Britain in colonial times, Egypt became the dominating country in the region with regard to power and exploitation potential, offsetting its inferior geographic position.

Current water allocation in the Nile River Basin is based on two key treaties, one from 1929 between the colonial United Kingdom, Egypt, and Sudan (Cascão 2009) and one from 1959. The latter became necessary due to the construction of the Aswan High Dam and allocated practically all water of the Nile River to the countries of Sudan and Egypt, implicitly leaving no water to the upstream countries. This agreement has sparked substantial disputes between the upstream countries, particularly Ethiopia, and the downstream countries that want to maintain this agreement as long as possible (Link et al. 2012).

Strong economic development in the upstream countries of the Nile River Basin and the construction of the Grand Renaissance Dam in Ethiopia are substantial challenges to Egypt's status as hydro-hegemon. After completion, the reservoir can take up considerable amounts of water from the Blue Nile, potentially significantly reducing Nile water flows downstream (Link and Scheffran 2015). Furthermore, energy production from the dam is supposed to make Ethiopia less dependent on energy from the

surrounding countries and it should provide Ethiopia with additional income from energy sales to its neighbors. Egypt strictly opposes any reductions in water availability but it is unlikely that this dispute will cause a war for water, as such a military conflict could not be financed by Egypt and the result would be questionable at best (Gebreluel 2014). Instead, the shift in power balance in the Nile River Basin could be a basis for new kinds of cooperation. Initially, a new agreement considering the capacities of all reservoirs could be drafted, which could be subsequently extended for further cooperation among riparians (Bastawesy 2014).

In other transboundary river systems, challenges to existing power structures have generally led to increased efforts for cooperation as well. It will be interesting to see whether this trend can be upheld if water stress increases considerably by possible reductions in supply due to climate change – by effects on precipitation and evaporation – and concurrent increases in demand due to population growth and further economic development.

Implications of climate change

Changes in environmental conditions in transboundary rivers occur as a combination of impacts of climate change as well as economic development and demographic change in many parts of the world, not only affecting water supply and demand but also water quality (de Stefano et al. 2012; Schellnhuber et al. 2013). Global warming may not only limit the water supply to river systems but also increase demand by affecting the amounts needed for human consumption and agricultural irrigation (Tir and Stinnett 2012). Increased evaporation with concurrent reductions in rainfall is likely to cause declines in river flows, reduced percolation into aquifers, and degradation of soils. In the long run, the frequency and amplitude of extreme events such as floods or droughts is expected to increase, which places an additional strain on the adaptive capacities of countries to cope with such changes (Field and Van Aalst 2014). Particularly, the melting of glaciers affects the water balance of rivers, increasing their flow in the coming years while declining substantially afterwards.

When water availability changes as a consequence of climate change, impacts will not be homogeneously distributed among all riparians of transboundary rivers. Countries with a geographic disadvantage, i. e. the downstream countries, are likely to be affected to a larger extent than their upstream neighbors. Already existing conflicts about water distribution may be aggravated, possibly increasing the frequency and intensity of disputes. Nonetheless, it is still possible for riparians to cooperate on water utilization, particularly if the necessary institutional setting is already in place (Brochmann and Hensel 2011; Mianabadi, Mostert, and van de Giesen 2015; Tir and Stinnett 2012). These include new approaches in the design of water treaties,

which include adjustable allocation strategies, the focus on water quality as well as on quantities, strategies to address extreme events, review procedures, and joint institutions for water management (Cooley and Gleick 2011).

However, it has to be noted that the interactions in the water-security nexus are complex and climate change adds to already existing fears of growing water scarcity in many transboundary river systems. This may prompt a continued securitization or militarization of water resources, eventually inducing new water conflicts in the future (Feitelson, Tamimi, and Rosenthal 2012; McDonald 2013). In contrast, it is also conceivable that policy makes use of climate change in general – regardless of the actual regional impact on the hydrological setting – to promote cooperative measures among riparians by fostering trust, mutual understanding, and reconciliation (Amster 2013; Ide and Scheffran 2014).

Framework for the assessment of water conflicts

A conceptual framework of the water-security nexus can be a helpful tool to assess the complexity of the interactions between the physical and socio-economic aspects of water supply and the political and institutional dimensions of water use. All of these affect societal stability and possible conflict onset at multiple scales (Scheffran et al. 2012a, 2012b). The framework developed by the Research Group Climate Change and Security considers the linkages between environmental and demographic change, their impacts on water resources, the relationship between water stress and human security, the responses of key actors, and the institutional setting of water management and conflict resolution (Link, Scheffran, and Ide 2016). Key pathways and cascades of effects connect the three main compartments that are interlinked by causal relationships and feedback loops (Fig. 1). Based on the development of the physical drivers on water resources that interact with socio-economic drivers, impacts on security are assessed. This includes both individual human security as well as international security. The framework also addresses how water security actually translates into effects on the relationships between societies or countries, which may range from full scale war to neutral behavior to major cooperation.

Drivers of water availability

Water supply in a given watershed depends on the hydro-meteorological setting and geographic characteristics, such as precipitation patterns, evaporation rates, aquifer recharge, soil characteristics, and drainage to the sea. These are affected by climate

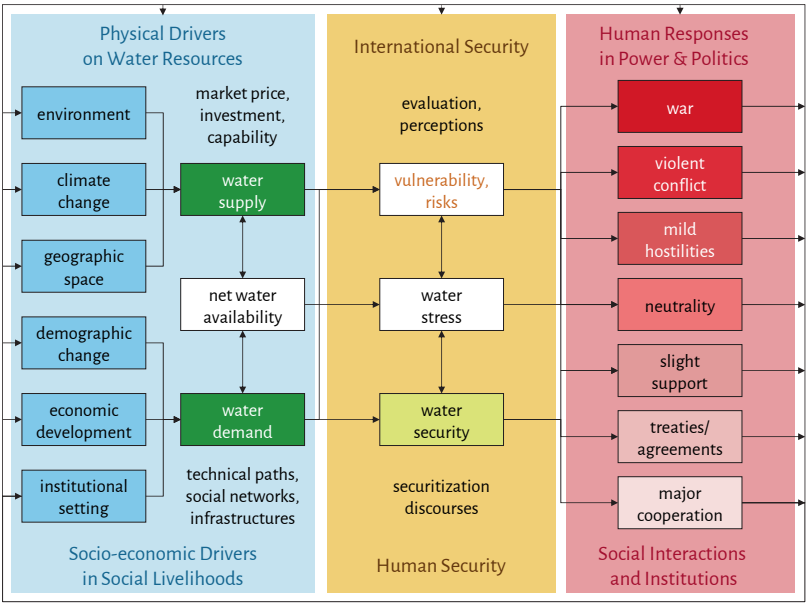

Figure 1: The conceptual framework of the water-security nexus. Source: Link, Scheffran, and Ide 2016.

change. On the other hand, socio-economic variables like economic development, demographic change, water-related infrastructure, and the institutional setting in a given river basin drive water demand and water-related investments.

Of course, both demand and supply need to remain balanced. Trends in livelihoods such as population growth and changes in human needs have a profound influence on the amount of water withdrawn in a given geographic location (Gassert et al. 2013). The technical potential to withdraw and store water and the economic setting with regard to water use govern the degree to which countries can actually fulfill their own water needs and thus the level of water stress experienced by the given riparian.

Water stress and water security

Human perceptions and values determine whether the amount of water allocated to a riparian is considered to be abundant, sufficient, or scarce. Different actors can have substantially differing perceptions, which may give rise to heated political debates (Harris and Alatout 2010). Furthermore, water also has symbolic meanings, connecting water to religious ideas such as purity, or concepts of national development or state building (Fröhlich 2012; Hansson 2001; Jacobs 2002).

It is not clear whether increasing water stress and insufficient supply raise security concerns. This depends on the agents involved and their value perceptions, individual vulnerabilities, and security concepts applied. The security dimensions in the framework range from concerns about individual human security to national security threats to risks for international relations (Zeitoun 2011). Water stress can drive political decisions or discourses that aim at increasing water availability to reduce potential dissatisfaction and security concerns. There are numerous examples of research on the securitization of water, in which the amounts of water allocated to the riparians, water development projects, or the causes of water problems have led to heavy disputes among politicians, scientists, engineers, and local people (Murtinho et al. 2013; Waintraub 2009).

Conflictive and cooperative human responses and social interactions

The third part of the framework addresses the collective responses and social interactions to the given state of water security, which may lead to either conflict or cooperation. The perception of water scarcity, together with increasing levels of insecurity and the securitization of water, can create an environment that is dominated by fear, anger, and hostilities, increasing the likelihood of onset of violent conflict (Stetter et al. 2011). Depending on the reply to such conflictive behavior, a self-reinforcing cycle of violence may ensue.

Generally, the escalation of conflicts due to water stress requires not only on the motivation of the agents but also on their capabilities and opportunities to act. There are only some examples in the literature, in which a considerably weaker party engaged in violent conflict nonetheless (Assies 2003). Climate change may cause the overall water availability to increase in some parts of the world (e. g. due to glacial melting or altered rainfall patterns). This may relieve some of the pressures of water demand, creating new chances for cooperation on water. In this context, it is important to note that the motivation and opportunity for cooperation (or conflict) are the product of social interaction (Ide and Fröhlich 2015) that is shaped considerably by securitization, identity constructions, and politics of scale.

Cooperation can only be achieved if stakeholders recognize their options that may reduce water stress or increase their economic welfare (Norman, Bakker, and Cook 2012). If people affected by water stress do not act, water issues remain neutral (i. e. they are neither conflictive nor cooperative) as they remain below a critical threshold and thus do not lead to extraordinary responses.

In transboundary watersheds, the political institutions of the riparians have a profound influence on whether water scarcity leads to conflict or cooperation. They have

the ability to mitigate possible disputes before they escalate into violent conflicts (Gizelis and Wooden 2010; Tir and Stinnett 2012). Basinwide agreements or adaptation measures offer additional chances for cooperation than individual riparian's responses at the country level, which may become particularly important if environmental conditions become strained under climate change (Pelt and Swart 2011). However, current water management schemes in transboundary river systems are generally only bilateral (Mirumachi 2015).

Linkages within the framework

There are interactions and feedbacks between the three compartments of this framework of the water-security nexus that can affect conflict or cooperation through different pathways. The value-security dimension is at the center of this scheme, connecting the supply-demand balance, which is based on the given hydrological setting, with the resulting societal responses, either leading to conflict or cooperation. The links between the compartments are determined by the political setting. Water security and securitization discourses interact mutually with the vulnerabilities to water scarcity and to conflict, regardless of the causal relationship between the two (Link, Scheffran, and Ide 2016).

Matters are further complicated by the fact that actions to facilitate cooperation on water at the international scale may create a conflictive reaction at the national or subnational scale (Norman, Bakker, and Cook 2012). Water management solutions at the national scale tend to more readily lead to conflict whereas solutions at the watershed level or at the subnational scale are more likely to create cooperation (Feitelson and Fischhendler 2009; Harris and Alatout 2010). An example is the Jonglei channel in the Nile River Basin, which was a cooperative effort between the countries of Egypt and Sudan that led to intrastate conflict within Sudan that eventually eased the secession of South Sudan (Mason et al. 2009).

Despite all these complications the framework allows for a systematic assessment of water-related conflict and cooperation in transboundary river systems. In the following, this framework is applied to the Nile River Basin, which essentially supplies Northeast Africa with water and that is expected to experience increasing water stress due to possibly unfavorable changes in meteorological patterns due to climate change with concurrent increases in population and continuing economic development, leading to considerable growth in regional water demand.

Case study: The Nile River

Northeast Africa and the Nile River Basin have been one of the research foci of the Research Group Climate Change and Security. The Nile River Basin is one of the regions that can be considered a climate hot spot and it is likely that altered environmental conditions will have an effect on the likelihood of conflict onset (Scheffran, Link, and Schilling 2012). With regard to water allocation, based on scenarios of change in water allocation, an agent-based model of the main riparian countries was developed that simulates possible strategies to meet individual countries' goals of water supply (Link and Scheffran 2019). In general, research results point to a substantial increase in water stress and additional societal pressures in the coming decades, which necessitates new and innovative water allocation schemes if conflicts among riparians are to be avoided.

Water availability in times of climate change: The Nile River is the principal water source for more than 230 million people in the region (Nile Basin Initiative 2013). Based on the current trend, more than 300 million people are expected to live in the Nile River Basin in the late 2020s. The downstream countries are particularly dependent on the water from the river as there are practically no other water sources in the country (Link et al. 2012). Currently, approximately 85 % of the water in Egypt originates in the Ethiopian Highlands and flows through the Blue Nile (Arsano 2010). However, Ethiopia now increases its own water use substantially, culminating in the construction of the Grand Renaissance Dam, which will withhold an amount of water equivalent to the annual flow of the Blue Nile from the downstream countries during the time period when the reservoir of the dam is filled (Bastawesy 2014). So far, Egypt can use the share of water allocated to Sudan in the 1959 Nile water agreement, which Sudan does not utilize for itself. But with Sudanese water demand growing concurrently as well, the remaining share for Egypt is likely to stagnate at best (Taha 2010), making it difficult for Egypt to meet its own goals.

It has to be noted that the overall amount of water available in the Nile River system critically depends on the long-term development of rainfall amounts in the Ethiopian Highlands. Climate models are still inconclusive about the trend of precipitation in the upstream countries of the Nile (Stocker et al. 2014). In the recent past, the flow in the White Nile has decreased while there has been an increase in the Blue Nile (Bushara and Abdelrahim 2010) but it is unclear if this trend will hold up. Further uncertainties may arise from changes in evaporation in the Sudd Swamps in South Sudan, where the flow velocity of the river is substantially lower than in the rest of the river system.

Water-security discourses in the Nile River Basin: The uncertainty associated with the development of river flow rates and the concurrent increasing demand in all riparian countries makes it harder for the individual countries to meet their own water needs.

If public perception or the views of political decision makers suggest that the national security is threatened because of an insecure water supply, they may turn to protective (conflictive) measures to secure their own interests. The people may pressure the governments to take a tougher stance on water issues, thus making cooperative solutions harder to achieve (Feitelson 2002). The situation is aggravated if harvest failures, insufficient sanitation, declines in water quality or increasing food prices adversely affect human livelihoods (Deligiannis 2012), giving rise to the possibility of uprisings such as the Arab Spring in 2011. At present, Egypt feels particularly challenged by the emancipation of the upstream countries who have formed initial coalitions to secure their own interests against the still-hydro hegemon Egypt. When the Grand Renaissance Dam in Ethiopia is brought into service, this will substantially shift the power relationships between the three main riparians of the Nile River (Egypt, Sudan, and Ethiopia) in favor of the upstream region, making it necessary to devise new agreements between the riparians to avoid an intensification of water-related disputes (Link and Scheffran 2015).

Conflictive and cooperative interactions among riparians: The increasing vulnerability of the downstream countries may cause them to take unilateral actions to secure their share of the Nile waters, thus facilitating the onset of new water-related conflicts (Link et al. 2012). This tendency is countered by a growing effort to increase the combined adaptive capacity of the riparians by fostering cooperative measures. However, there are also developments that are complicating matters: the construction of the Grand Renaissance Dam will lead to a substantial strengthening of the Ethiopian bargaining position in the region (Link and Scheffran 2015), which is likely to force Egypt to give up its hydro-hegemonial status (Gebreluel 2014). Furthermore, cooperative projects that have been launched in the past such as the Jonglei Channel have turned out to be inadequate and have led to increased tensions within the country of Sudan instead of fostering cooperation, ultimately resulting in the failure of the project (Mason et al. 2009).

Nonetheless, the institutional basis for basinwide cooperation has been established with the founding of the Nile Basin Initiative. Cooperative projects in the Nile River Basin have received substantial external financial support from e. g. the USA and the World Bank, i. e. agents who have a strong interest in cooperation in the Nile River Basin mostly for economic reasons (Paisley and Henshaw 2013). One key project of the Nile Basin Initiative has been the drafting of a Cooperative Framework Agreement that has already been signed by six riparians and has been ratified by three.

Linkages within the water-security nexus: The variable climate conditions in the Nile River Basin already pose a considerable challenge to water security. This challenge is likely to substantially grow in the next few decades. Even a favorable development of overall water availability in the river system may be inadequate to meet the strongly

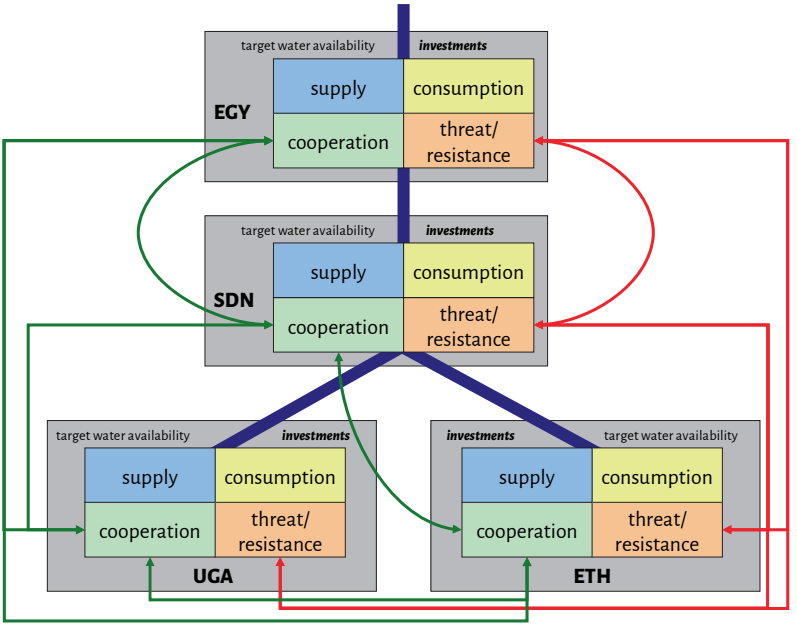

Figure 2: Interactions between the countries in the simulation model.

growing demand for water, particularly in the downstream countries (Link et al. 2012), further increasing the already high vulnerability to climate change in Egypt and Sudan (Brooks, Adger, and Kelly 2005). The Arab Spring has caused the economic and political destabilization of Egypt, reducing its capacity to properly address its water problems. The transition from a quasi-hegemonial system to a state with three more or less equally powerful riparians (Egypt, Sudan, Ethiopia) in the region may create new chances for durable cooperation in the Nile River Basin as it will become necessary to negotiate and sign new fundamental agreements on the allocation of water and energy from hydropower in the region.

Modeling of possible water allocation schemes

The interactions of the main riparians of the Nile River Basin with regard to fulfilling their own water needs can be simulated in a simulation model that focuses on four key riparians (Egypt, Sudan, Ethiopia, and Uganda). The countries may invest financial resources in strategies to increase water supply, make water use more efficient,

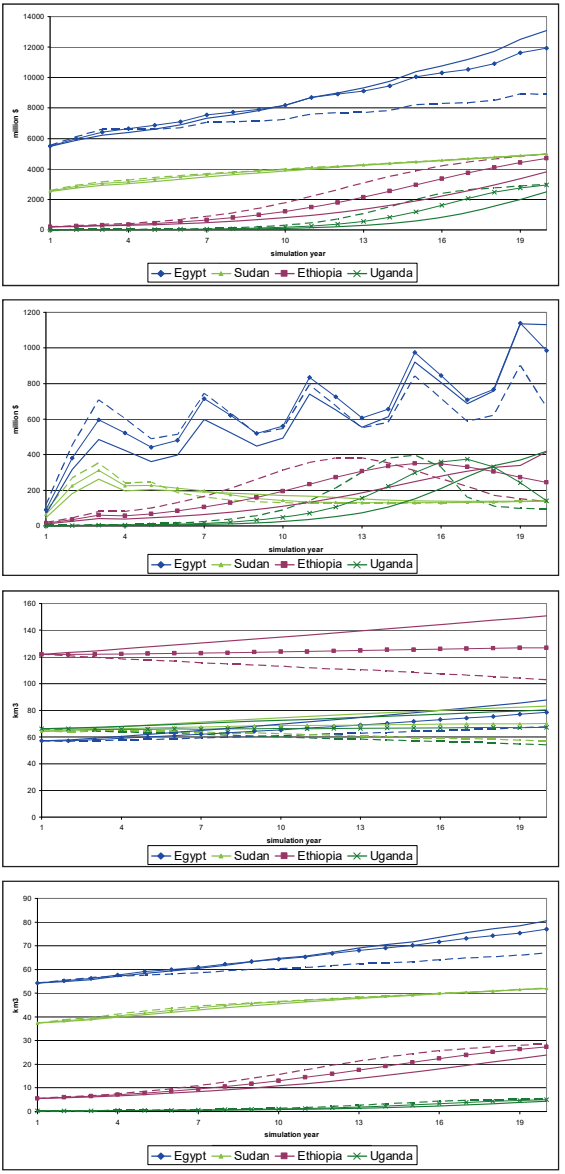

Figure 3: Total investments into water resources (first panel), investments into the acquisition of additional water resources (second panel), water supply (third panel), and water consumption (fourth panel) in each country. *Note: The thick solid lines denote the case of a climate change induced overall increase of water resources of 20 % by the end of the simulation period, the dashed line a decrease of 20 %. The lines with symbols denote a reference scenario with no climate change.*

engage in cooperative measures, or threaten neighboring riparians to use less water (who may then resist that threat). Figure 2 shows a scheme of possible interactions.

Interactions between the countries are simulated for a time period of two decades, in which the overall water availability in the river system either increases or decreases due to effects of climate change. Link and Scheffran (2019) provide a detailed model description and simulation results for an extended model version that focuses on five countries.

The results show that the countries' strategies are highly dependent on the long-term trend of overall water availability. Investments are intensified in times of increasing water scarcity (Fig. 3, first panel). The marked increase in total investments for Egypt in the scenario of an expansion of water availability is caused by the particularly pronounced growth of water demand in this scenario that is attempted to be met. Since water use is already close to total supply, additional growth causes an increase in consumption costs, leading to such uncharacteristic trend in total investments.

The oscillations in Egyptian investments into new water resources are related to switches between cooperative and conflictive strategies (Figure 3, second panel). The fact that investment costs are much higher in times of conflict leads to a decline in the incentive to threaten and makes the country turn towards cooperation instead. In case of a more pronounced difference in unit costs between conflictive and cooperative strategies, Egypt would refrain from the conflictive strategy as there would be too little reward for the effort put in.

The expansion of water supply generally follows the underlying climate scenarios (Figure 3, third panel). Without climate change, there is hardly any expansion, as this would be fairly expensive to realize. In contrast, the climate effect is much more pronounced: if there is more water available in the Nile River Basin, supply can grow substantially without great efforts while it shrinks more than can be offset by investments into any new resources if water generally becomes even scarcer in times of climate change. However, consumption in the upstream countries is largely unaffected by climate trends (Figure 3, fourth panel), mainly because water use is initially quite low and water goals are substantially higher. So investments are made regardless of the overall development of water availability. Consumption in Egypt is much more sensitive to changes in the hydrological system and any negative changes in environmental conditions are practically impossible to offset even by massive investments into the expansion of water infrastructure.

Summary and conclusions

The assessments regarding water allocation in times of changing environmental conditions show that the water-security nexus consists of numerous complex interactions and that there are not merely simple relationships. In the past, water conflicts have often not only had an environmental and an economic dimension – very often other aspects such as culture and religion have been important, highlighting the vital role of water for people in transboundary river systems all over the world. Water stress is likely to increase as a consequence of the joint effects of climate change, population growth, economic development, and growing inequities in water distribution. This may give rise to new conflicts as disagreements among riparians on water-related issues mount.

The conceptual framework of the water-security nexus considers the important security pathways and reflects the diversity of water conflicts for all possible spatial extents. Not only does it look at the physical conditions for water disputes, it also addresses the possibility of feedbacks between social change and the environmental system, the role of institutions affecting water use, and possible strategies to deal with growing water scarcity. This framework can be translated into agent-based research models to study the effects of concrete scenarios of environmental change on the ability of individual riparians of transboundary river systems to meet their own desired goals of water consumption.

Assessments of water-related conflicts indicate that the actual distribution of water is rarely the key issue for water disputes. Often, divergent political views are channeled into concurrent struggles for hegemonial power, energy production, the maintenance of water quality, and the preservation of societal values. Many transboundary conflicts that also involve water could not be solved by merely increasing the overall amount of water available to the conflict parties (Bichsel 2009), as is prominently the case in the water conflict between Israel and Palestine that could not be resolved despite substantial increases in water availability from wastewater recycling and desalination (Aviram, Katz, and Shmueli 2014). Instead, the resolution of water conflicts also requires the recognition of the associated political, economic, societal, and cultural settings and discourses. Recent research on water conflicts has increasingly focused on the latter, broadening our understanding of these parts of the water-security nexus that will hopefully facilitate the increasingly successful mediation of water conflicts despite the additional challenges arising from the impacts of climate change.

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