Transboundary Water Troubles in Africa

An Interdisciplinary Case Study of the Grand Ethiopian Renaissance Dam and its Influence on the Nile Basin

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January 2020

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Course: Scriptie: Interdisciplinair onderzoek II (LA3V11003)

Liberal Arts and Sciences

Utrecht University

Abstract

The recent tensions in the Nile Basin are due to the construction of the Grand Ethiopian Renaissance Dam (GERD) in the upstream area. Although, Ethiopia's need for a better economic position is satisfied by the building of this dam. Egypt is worried it might reduce the supply of fresh water to Egypt and thus result in a downfall of its economy. The complex nature of this conflict and its possible dramatic outcomes (i.e. war) demand an interdisciplinary analysis bringing together the perspectives of Environmental Sciences, International Relations and Economics. Together these disciplines will formulate an integrated answer to the following research question: How does the Grand Ethiopian Renaissance Dam influence the transboundary water interactions in the Nile Basin between Egypt and Ethiopia?

After a short introduction of the conflict, the disciplinary analyses will follow first in separate chapters. Towards the end of this thesis the disciplinary insights will be brought together according to the interdisciplinary method of Repko and Szostak (2017) in order to create a more comprehensive understanding which will serve as an answer to the research question.

In Chapter one, the Environmental Sciences uses the Driver-Pressure-State-Impact-Responses (DPSIR) framework to identify the impact of the GERD on the water supply of Egypt, consequences of a changed water supply and resolutions these consequences. In the second chapter, International Relations reviews the asymmetrical power relations by combining two frameworks of hydro-politics. In Chapter three, Economics applies Game Theory (a cooperative and a non-cooperative framework) and compares them to come up with different potential solutions.

The insights provided by the disciplines are the following. Negative impacts of the GERD on the water supply of Egypt are likely to occur during the filling period of the reservoir and possibly during operation after the filling is completed. Impacts can be reduced by a collaboration between Egypt and Ethiopia regarding the filling and operation policies of the GERD. The GERD is a challenge to the existing status quo with Egypt as hegemonic power and Ethiopia as non-hegemonic power. It might result in a peaceful change of the regional order, but could also be the starting point of conflict and war. This potential conflict can be solved when the countries work together under the circumstances of a Grand coalition or by the influence of an international community.

In Chapter four, the separate insights are integrated into a more comprehensive understanding: the Transformative Disruption Model. The final conclusion is that there are several outcomes possible on a scale from harmony to conflict, depending on how Egypt will react to the construction of the dam. When Egypt harmonizes with the building of the GERD, a more peaceful situation will occur benefiting all countries involved. When Egypt retaliates, the political relations worsen which might lead to war in the region. This influences the flow of the Nile originating from Ethiopia and therefore creating economic decline.

Keywords: Interdisciplinarity, Transboundary water interaction, Nile Basin, Grand Ethiopian Renaissance Dam, Egypt, Ethiopia, Water allocation, conflict.

Acknowledgements

The authors would like to thank the people that contributed to this thesis and who brought this thesis to a higher level. First of all, we would like to thank Dennis Kerckhoffs, MA, who supervised the thesis and whose feedback has been valuable, especially to the integration. Furthermore, we would like to thank the three disciplinary advisors who formed a vital part in establishing the disciplinary insights: Dr. Paul. Schott, Dr. John Hogan and Dr. Martijn Huysman. Last, we would like to thank L.J.Q. van Rooden for proofreading and Tim Kramer for his help with the website that was used to communicate and present this thesis. The authors would like to note that where sources of information by other authors have been used, they have been acknowledged and that all errors in this work are our own.

Utrecht, January 2020

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Table of Contents

Abbreviations list

Abbreviation	*Explanation*
AHD	Aswan High Dam
BBC	British Broadcasting Corporation
BCM	Billion Cubic Metres
CFA	Corporate Framework Agreement
DPSIR	Drivers-Pressures-State-Impact-Responses model
DTWIF	Dynamic Transboundary Water Interaction Framework
EEA	European Environment Agency
FHH	Framework of Hydro-Hegemony
GAMS	General Algebraic Modelling System
GERD	Grand Ethiopian Renaissance Dam
GMCR	Graph Model for Conflict Resolution
GWH	Giga What per Hour
IR	International Relations
NATO	North Atlantic Treaty Organization
NBI	Nile Basin Initiative
NISRG	National Independent Scientific Research Group
OECD	Organization of Economic Cooperation and Development
SES	Social-Ecological System
WEF nexus	Water-Energy-Food nexus

Introduction

"The 'water war' brewing over the new River Nile dam" (BBC, 2018).

"Egypt still at odds with Ethiopia over giant Nile dam" (Al-Jazeera, 2019).

These newspaper headlines show the presence of serious transboundary water resource tensions in the Nile Basin, mainly between Egypt, Sudan and Ethiopia. The direct cause is the building of the hydroelectric Grand Ethiopian Renaissance Dam (GERD) by Ethiopia. Ethiopia claims the building of the GERD is necessary due to the construction of industrial parks, creating the need for a large electricity resource. The goal is to become a middle-income country (BBC, 2018). The realization of the GERD would improve its industry and thus it economic and political position in the region.

Egypt, however, is worried: 85% of the Nile river comes from the Ethiopian highlands and Ethiopia controls the amount of water that is available for Egypt, a downstream country (Al-Jazeera, 2019). Egypt fears that their share of fresh water from the Nile will be reduced, although Ethiopia denies this. If there is less fresh water, Egypt can produce less food and their amount of job losses will increase to one million. According to Al-Jazeera (2019), this means the economic output decreases with $1.8 billion annually. Ethiopia claims that the GERD will stimulate economic development in both Ethiopia and Egypt.

Negotiations regarding the dam between Egypt and Ethiopia are difficult (BBC, 2018). Ethiopian prime minister Abiy Ahmed said that "no force can stop Ethiopia" (BBC, 2019). Moreover, in 2013 secret recordings were spilled of Egyptian politicians proposing hostile acts towards Ethiopia (BBC, 2019). Such statements give rise to serious concerns about the situation escalating into conflict and potentially causing a war.

War would cause severe damages ecologically, politically and economically. It is the least desirable outcome of the changing transboundary water interactions. To prevent the conflict from escalating, it is necessary to identify the potential impacts of the GERD. Therefore, the research question of this thesis is: How does the Grand Ethiopian Renaissance Dam influence the transboundary water interactions in the Nile Basin between Egypt and Ethiopia? Transboundary

water management is an extremely complex subject. The building of the dam can have an impact in multiple areas ranging from the climate to the economy to the political situation of both countries. It is therefore crucial to have several diverse insights into the mechanisms of transboundary water interactions, how this can lead to problems and offer insights into potential mechanisms to prevent or solve conflicts.

According to Tayia (2019), a prominent researcher on transboundary water interactions, resolution mechanisms for transboundary water conflicts that are offered by a single discipline are not able to handle all dimensions of transboundary water conflicts; they simply lack the analytical capacity. It is therefore desirable, if not necessary, to have an interdisciplinary approach. The disciplines that will contribute to this interdisciplinary research are the disciplines Environmental Sciences, International Relations and Economics. Repko and Szostak (2017), leading academics in the field of interdisciplinary research, introduced four criteria for conducting useful interdisciplinary research.

First, the problem must be complex (Repko and Szostak, 2017). It has to be studied from different disciplines. According to Tayia, there are five types of conflict issues: "natural resources, sovereignty, survival, honour and ideology" (2019, p. 6). Transboundary water conflicts concerns three of these: natural resources, sovereignty and survival (Tayia, 2019). This excludes other disciplines such as religion studies that could possibly be involved in conflicts. Furthermore, Tayia (2019) states that the mechanisms to resolve transboundary water conflicts are predominantly rooted in the disciplines Environmental Sciences, International Relations and Economics.

Second, every discipline needs to offer different insights or theories for the problem (Repko and Szostak, 2017). The disciplines can be used to strengthen one another where needed and come up with an answer to the research question. Environmental Sciences is vital when examining the effects of the GERD on the environment and water availability, but lacks the competency to assess social, economic or political consequences. The disciplines International Relations and Economics can cover this area of the problem. International Relations can explain political actions and reactions but does not analyse individual behaviour and environmental consequences preceding politics. Economics shows how individuals make rational decisions about scarce resources, in this situation about water. However, Economics does not examine it from a macro perspective in this case, only from an individual perspective.

Third, no single discipline can explain or solve the problem (Repko and Szostak, 2017). Consequences and solutions regarding the conflict involved with the building of the Grand Ethiopian Renaissance Dam have been investigated by all three disciplines involved in this research. Not one discipline however has created a suitable answer to this intricate and elaborate research question, because they focus on different aspects of the problem (Tayia, 2019).

Fourth, the problem deals with an unresolved societal issue, therefore it needs problem-based research (Repko and Szostak, 2017). No agreement regarding the conflict has been reached yet and there are real concerns about the escalation of the conflict. It is thus crucial to perform interdisciplinary research in this case.

This thesis will proceed in four parts. It begins with three disciplinary chapters that will be integrated in the last chapter resulting in a more comprehensive understanding of the problem.

The first chapter will focus on the discipline Environmental Sciences. This discipline studies the physical environment and possible solutions to environmental problems. It perceives the earth as a large-scale system consisting of the atmosphere, biosphere hydrosphere and lithosphere[1] and searches to understand interactions within or between these systems with the use of observation, experimentation and modelling. This discipline is relevant for answering the interdisciplinary research question, as it can analyse the effect of the GERD on the water supply in Egypt, consequences of a changed water supply and responses to these consequences.

The discipline of International Relations is central in the second chapter. In general, it provides insight into interactions between different actors (e.g. state and non-state actors) at different levels (e.g. supranational, national and regional) with a main focus on politics, organizations, law and culture. Politics is the governance of people and managing power in a certain area. It explains how decision-making can influence interaction between actors. This makes the transboundary struggle for the same resource, i.e. water, by definition a political one. The focus of this second chapter will thus be on how disruptions, e.g. the Grand Ethiopian Renaissance Dam, influence the hydro-hegemonic structure and counter-hegemonic processes in the Nile Basin between Egypt and Ethiopia. This chapter will start from the basic idea of structuralism and introduces hydro-hegemonic frameworks and ideas. This will then be applied to the present

[1] The atmosphere is the air which consists of a mixture of gasses; the biosphere refers to all living things; the hydrosphere consists of all bodies of water; the lithosphere refers to the mantle and the crust, the two outermost layers of the earth.

situation in the Nile Basin. International Relations is therefore necessary to identify the political aspect of the transboundary water interaction in the Nile Basin.

The last disciplinary chapter is about the economical aspect of the transboundary water interactions. The building of the GERD is caused by economic drivers. The aim is for Ethiopia to become a middle-income country. First, the chapter will focus on how the economy contributes to the existence of the transboundary water resource conflict. Then, the focus will be on how the issue can be solved, viewed from the behavioural economic perspective. In this type of research, Economics will contribute to the interdisciplinary research question by applying Game Theory in the search for potential solutions. Game Theory, which is not only focused on economic variables, but also involves other aspects of the issue, such as environmental and political preferences of the countries.

Following these chapters is chapter four on integration. The different disciplinary aspects of transboundary water interactions in the Nile Basin between Egypt and Ethiopia will be integrated into a more comprehensive understanding, thereby giving a more complete insight in 1) how these interactions within the context of the GERD occur, 2) why these interactions create potential problems and 3) how these problems might be solved. It will integrate the different disciplinary insights by connecting, redefining, extending and organizing different concepts (i.e. creating common ground). As Repko and Szostak explain, without integration, these different perspectives would lead to mere multidisciplinary work: integration is “the cognitive process of critically evaluating disciplinary insights and creating common ground among them to construct a more comprehensive understanding” (2017 p. 221). This can be a valuable contribution to the existing academic literature regarding this subject and help to better understand and improve the current situation in Northern Africa.

1. Impact of the GERD on the Water Supply of Egypt

Environmental Sciences - Whitney Frederiks

Introduction

One of the main drivers of the transboundary water conflict between two riparian states of the Nile, Egypt and Ethiopia, are the potential impacts of the hydroelectric Grand Ethiopian Renaissance Dam (GERD) on the downstream countries. Egypt claims that its share of fresh water from the Nile River will be reduced as a result of the GERD and claims that this is a threat to the water security of Egypt (Al-Jazeera, 2019. The cause of this concern is whether the GERD will lower the water supply downstream of Ethiopia and this is one of the main points of disagreement between Egypt and Ethiopia causing the tensions between these countries (Al-Jazeera, 2019). Egypt relies heavily on the Nile River as a resource for their fresh water; 85% of fresh water in Egypt is derived from the Nile. Ethiopia, however, claims that the construction of the GERD will only influence downstream water supply in a positive way, namely regulate the unreliable water flow in the downstream countries (BBC, 2018). These uncertainties surrounding the effect of the GERD on water supply in Egypt and the disagreement between Egypt and Ethiopia are the cause of transboundary water management tensions between Egypt and Ethiopia.

Egypt and Ethiopia agreed in 2015 to have an expert panel assessing the environmental consequences of different policies on the timetable of the construction of the GERD: the National Independent Scientific Research Group (NISRG). However, Egypt has involved the United States of America as mediator in 2019, before the NISRG could produce a consensus report and recommendations (Nature, 2019). Therefore, no operation policy of the GERD has been established yet by Ethiopia and the effect of the GERD on the water supply of Egypt is still unclear at the time of writing.

The aim of this thesis is to assess the impact of the GERD on Egypt from different disciplinary perspectives. This chapter focuses on Environmental Sciences and studies the potential effects of the Grand Ethiopian Renaissance Dam on the water supply in Egypt after its expected completion in 2022. Moreover, possible solutions to these impacts will be researched. Negm and Abdel-Fattah (2019) stress that only Egypt's water share will be affected, since the Blue Nile travels from Ethiopia to Sudan and lastly to Egypt so that Sudan can still hold back their share of fresh water using their dams before the Nile reaches Egypt. The effect on water supply is therefore studied solely in Egypt.

1.1 Method

This research is qualitative; data will be collected by means of literature research. Sources were gathered using two methods. First, sources were found using the keywords ‘Nile’ and ‘Grand Ethiopian Renaissance Dam’ in Google Scholar and Scopus. Articles were filtered for the discipline Environmental Sciences and date. Second, more sources were found using the snowball sampling approach where sources were selected from references in the already selected papers.

The research will be conducted using the Driver-Pressure-State-Impact-Responses (DPSIR) framework . This framework consists of five interacting components, as presented in Figure 1. The DPSIR framework has been developed by the Organization of Economic Cooperation and Development and the European Environment Agency and is one of multiple frameworks that has been developed for the adaptive management of Social-Ecological Systems (SES) (Gari, Newton, & Icely, 2015)[2]. According to Gari et al. (2015), the DPSIR framework is used to analyse systems that are subject to anthropogenic influence and the corresponding ecological problems.

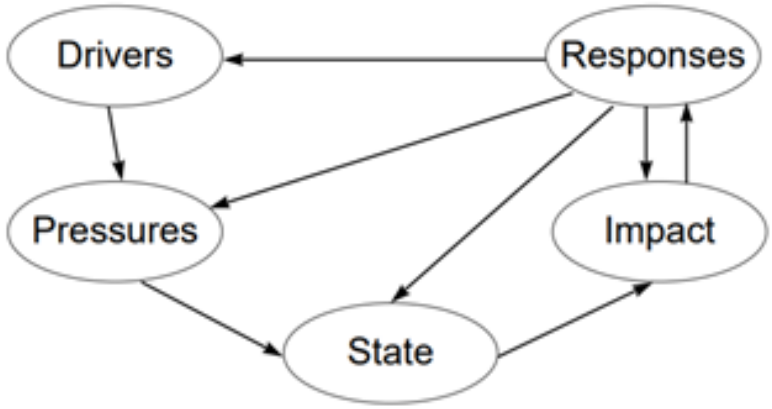

Figure 1: Model of the DPSIR framework (European Environment Agency, 1999).

[2] A SES is a system defined by regular interactions between the biophysical and social factors. It thus comprises an ecological and social system wherein the ecological system is affected by the social system.

The first element of the model, ‘Drivers’, consists of social and economic processes that drive production and consumption in a society (European Environment Agency, 1999). This driver causes pressure on a natural resource; the component ‘Pressures’. The third component, ‘State’ is affected by the pressure and represents the quantity and quality of the natural resource. The state can change due to the pressure, for example the global increase in temperature due to air pollution, and cause change to the ecological or social system; the ‘impact’ (European Environment Agency, 1999). Lastly, the component ‘Responses’ consists of measures taken to manage the impact. Measures can be adaptive, preventive or compensative and apply to every prior component of the DPSIR framework (European Environment Agency, 1999).

The DPSIR framework is used in this chapter since identifying the different components of the DPSIR framework provides an accessible means to analyse the effect of the GERD on the water supply of Egypt. This chapter will first discuss the study area. The DPSIR framework will then be applied by identifying the different components of the DPSIR framework. First, by assessing the driver and pressure causing the potential change in water supply in Egypt. Second, the change in state, the water supply in Egypt, will be discussed. Third, potential impacts of this change in water supply in Egypt to agriculture, hydroelectricity production and seawater intrusion in Egypt will be summarized. Subsequently, responses to these impacts will be discussed.

1.2 Study Area

The Nile River is the longest river in Africa, covering approximately 6700 km in length and a drainage basin of 3,4 million square kilometres (Abtew & Dessu, 2019). Eleven countries are located in the Nile Basin, as can be seen in Figure 2: Egypt, Sudan, Ethiopia, Eritrea, South-Sudan, Uganda, Kenya, Rwanda, Democratic Republic of the Congo, Burundi and Tanzania (Negm & Abdel-Fattah, 2019). The Nile is a north-flowing river, discharging into the Mediterranean Sea in Egypt, and has multiple tributaries of which the White Nile and the Blue Nile are the most important (Abtew & Dessu, 2019). The Blue Nile comes from the highlands of Ethiopia, beginning in Lake Tana and flowing into Sudan to join the White Nile near Khartoum and it flows into Egypt towards the Nile delta (Negm & Abdel-Fattah, 2019). 85% of the water arriving in Egypt originates from the Blue Nile in Ethiopia and the other 15% originates from the White Nile (Mulat & Moges,

2014). The water supply of Egypt is thus mostly fed by the Blue Nile Basin, which will be the study area of this chapter.

Ecosystems and climate vary greatly along the length of the Nile River; the northern part of the Nile in Egypt and Sudan flows mainly through desert, but the Nile also flows through mountainous areas, wetlands, tropical forests and savannas (Abtew & Dessu, 2019). Large seasonal and inter-annual variability characterize the flow regime of the Nile River (Digna et al., 2018). The average discharge of the Nile River is relatively low, on average 2640 m^3/s. In comparison, the Mississippi River has a comparable catchment size (3,3 million square kilometres) and discharges 17358 m^3/s (Schramm, 2004).

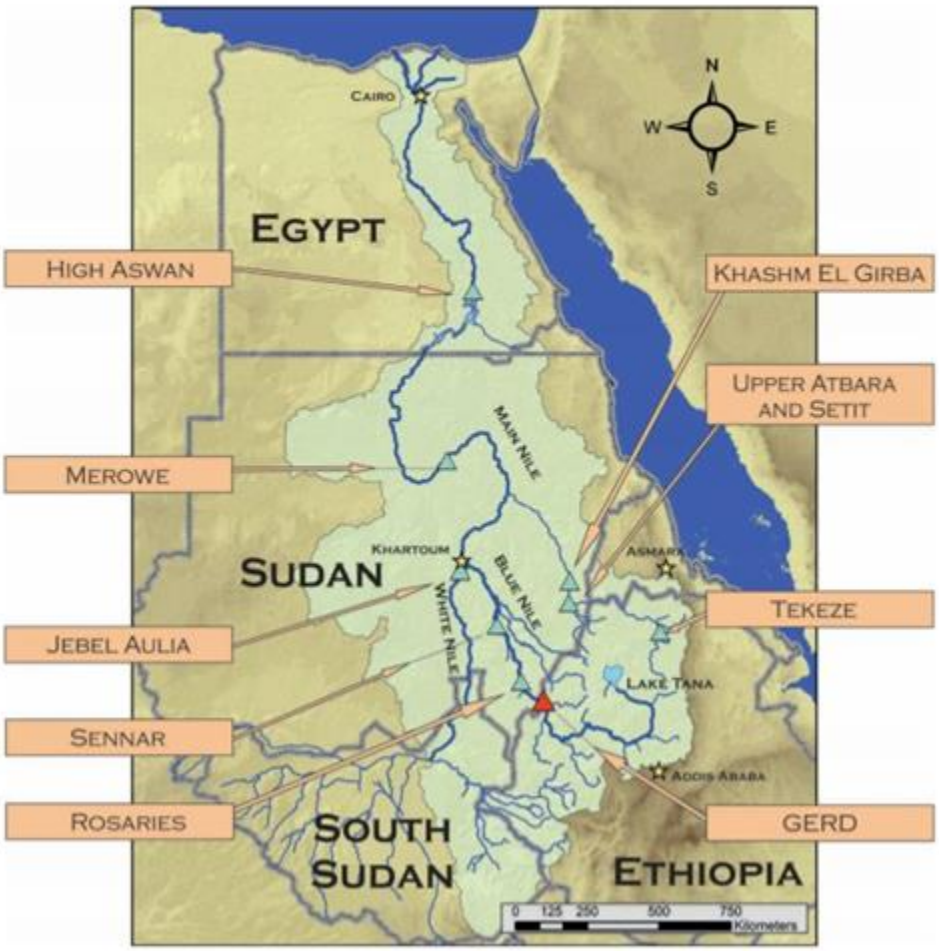

Figure 2: Location of the GERD and other major dams in the Blue Nile Basin (Wheeler et al., 2016).

1.3 Drivers and Pressures

Ethiopia pursues ambitious plans to develop hydropower in order to reduce poverty and stimulate economic development. 83% of the Ethiopian population is presently without access to electricity (Mulat & Moges, 2014). As a result, the GERD is under construction with the sole purpose of hydroelectric power generation. Ethiopia started constructing the GERD in 2011 and the dam is presently due to be completed in 2022, although the completion has already been postponed on multiple occasions (Abd-Elhamid, Abdelaty, & Sherif, 2019). It is located on the Blue Nile in Ethiopia close to the border with Sudan. The location of the GERD is presented in Figure 2 above. Other major dams in the Blue Nile Basin are the Aswan High Dam (AHD) in Egypt and the Sudanese Merowe and Rosaries dams.

The GERD reservoir covers 1800 square kilometres and the height of the GERD itself is approximately 140 meters, making it the largest hydropower dam in Africa (Abd-Elhamid et al., 2019). It is expected to produce approximately 15 GWH/year (Tan, Erfani, & Erfani, 2017). To accomplish this, the GERD reservoir will have a storage capacity of 74 billion cubic metres (BCM) of which 60 BCM is active storage; water that can actually be used for flood control or electricity generation (Abd-Elhamid et al., 2019). The remaining 14 BCM consists of water that cannot physically be drained by gravity through the spillway of the GERD: the inactive storage. To fill this reservoir at the start and to produce power, water has to be retained in the reservoir and this causes pressure on the water supply in Egypt by decreasing the amount of water passing the GERD, as will be discussed in the next section.

1.4 State

According to Egypt's claim, the GERD causes a change in the water supply of the Nile River. The water supply of the Nile River downstream of Ethiopia is the state according to the DPSIR framework and changes as a result of the GERD. There are two aspects to this potential reduction of water supply in Egypt that will be discussed below: the time period where the reservoir of the GERD has to be filled and the daily operation of the GERD once the reservoir is sufficiently full.

First, the reservoir of the GERD has to be filled before the GERD can be operated and a vast majority of researchers agree that filling the reservoir will have a negative impact on water supply in Egypt (see for example Abtew & Dessu, 2019; Bastawesy, Gabr & Mohamed, 2015; Kahsay, Kuik, Brouwer, & van der Zaag, 2015; Liersch, Koch, & Hattermann, 2017; Negm & Abdel-Fattah, 2019). However, the impact on Egyptian water supply is highly dependable on Ethiopia's filling policy of the reservoir. A shorter filling period of the GERD, for example 2 years, would cause a relatively larger reduction of water supply in Egypt compared to a longer filling period of for instance 6 years (Abtew & Dessu, 2019). However, a shorter filling period is for Ethiopia economically more beneficial compared to a longer filling period (Abtew & Dessu, 2019). No official policy has been established yet because of these conflicting interests. For instance, Ethiopia rejected the proposal of Egypt concerning the filling period of the GERD in August 2019 (Al-Jazeera, 2019). This proposal stated a five phases period of filling the reservoir that should be extended when drought occurs (Al-Jazeera, 2019). According to Abdelhaleem and Helal (2015), the filling period of the GERD reservoir is expected to be between 3-7 years. The amount of years it takes to fill the reservoir and the average water flow released by the GERD are fundamental to the impact on Egypt and Ethiopia during the filling period. The importance of finding the optimal filling period is highlighted by Negm and Abdel-Fattah (2019): "If Ethiopia decided to fill the lake in just 3 years, it means deducting 25 BCM per year, which means major destruction to Egypt" (p. 13). This 25 BCM is the amount of water that is stored in the reservoir and thus deducted from the water flow, which is on average 84 BCM in the Nile River (Negm & Abdel-Fattah). A filling period of 5 years would deduct less; 15 BCM (Negm & Abdel-Fattah, 2019). According to Liersch et al. (2017), the filling of the dead storage (14 BCM) may take 0,5-8 years. Water supply in Egypt could be reduced by 12%-25% during a filling of 3-7 years (Abdelhaleem & Helal, 2015). Thus, it is of importance to find an optimal filling policy for the GERD that is economically beneficial for Ethiopia while reducing Egyptian water supply minimally. However, the results of studies on the optimal filling period are extremely diverse. Abtew and Dessu (2019) found that the optimal policy would be to retain 20% of the annual discharge to fill the reservoir in approximately 8 years and according to Mulat and Moges (2014) a filling period of 6 years would be sufficient to not cause a significant reduction of the water supply in Egypt. Moreover, Negm and Abdel-Fattah (2019) found that the optimal filling policy would be to retain 5 BCM/year for a duration of at least 3,8 years. The total storage capacity of the GERD when using this policy would be 19 BCM,

instead of its full potential of 74 BCM. Liersch et al. (2017) underline accordingly that the maximum storage capacity of the GERD will not be reached and that the storage will on average be half full.

Second, there is currently no consensus yet about the impact of the GERD on downstream water supply once the GERD is operational after the reservoir is full, but most studies find no significant negative effect of the GERD on downstream water supply (see for example Abtew & Dessu, 2019; Digna et al., 2018; Jeuland,Wu & Whittington, 2017; Kahsay et al., 2015). Jeuland et al. (2017) found that water supply in Egypt will not be significantly affected by the GERD in a regular year without extensive droughts (only 0%-4%). Kahsay et al. (2015) also show that negative impacts on Egypt during the filling policy will be reversed during operationalisation of the GERD. Nevertheless, if drought prolongs for multiple years or if Ethiopia does not take the needs of Egypt into account and retains too much water, Egypt might experience critical water shortage (Liersch et al., 2017).

1.5 Impacts

The potential decrease in water supply in Egypt as a result of the GERD affects Egypt in multiple ways. These will be summarized below.

First, irrigated agriculture in Egypt is affected by a decrease in water supply in Egypt. Approximately 80-85% of the water supply in Egypt is used for irrigation purposes and will thus be negatively affected if water supply in Egypt decreases as a result of the GERD (El-Nashar & Elyamany, 2018). Donia and Negm (2019) found that a filling period of 5 years and total GERD storage would cause a high loss in economic income of Egypt by decreasing crop return value[3] with 15%. A filling period of 10 years would cause a decrease of 6% (Donia & Negm, 2019).

Second, the Nile flows into Lake Nasser once it reaches Egypt, the reservoir of the AHD. This water is used by the AHD for electricity generation. However, the amount of water stored in Lake Nasser decreases as a result of the decreased inflow of water. There is no consensus about

[3] Crop return value is the profitability of a crop, taking the production costs and financial returns into account. Crop return is influenced by water supply through water scarcity (Donia & Negm, 2019).

the exact extent of the impact on the Lake Nasser reserve, but there is agreement that the active storage of Lake Nassar will decrease (Abdelhaleem & Helal, 2015; Donia & Negm, 2019; Negm & Abdel-Fattah, 2019). This damages the ecosystem of the lake and causes a reduction in energy generation by the AHD (Negm & Abdel-Fattah, 2019). According to Mulat and Moges (2014), hydroelectricity generation at AHD will decrease 12% during the filling period of the GERD and 7% during operation once the reservoir is sufficiently filled.

Third, the potential retention of water in the GERD reservoir causes a decreased flow in the Nile River and reduces the surface water table of the Nile Basin (Abd-Elhamid, Abdelaty, & Sherif, 2019). The reduced surface water level, in combination with the pumping of groundwater for irrigation purposes, causes a decrease in groundwater levels of the Nile aquifer (Negm & Abdel-Fattah, 2019). The result is a lower groundwater table (Aziz et al., 2019). The combination of a lower groundwater table and groundwater pumping at current levels would allow increased intrusion of salty seawater into the groundwater of the Nile delta (Abd-Elhamid, Abdelaty, & Sherif, 2019). According to Negm and Abdel-Fattah (2019), a lowering of the groundwater table of 2 meters would cause an area of 2677 km^2 to cope with seawater intrusion and a decrease of 5 meters would increase the area to 4675 km^2. This could cause soil salinization, ground subsidence and possibly the collapse of buildings (Mohamed & Elmahdy, 2017). Furthermore, it could cause a lower quality of the groundwater in Egypt, which could cause degradation of agricultural land (Mohamed & Elmahdy, 2017; Negm & Abdel-Fattah, 2019).

1.6 Response

To resolve negative impacts on water supply in Egypt, finding the optimal filling and operation policy for the GERD is fundamental. Additionally, to prevent the electricity generation at the AHD from dropping too much, AHD and GERD operation strategies should be in accordance. AHD reserves should at least be 10 BCM at all times and there should be a reserve of 20 BCM reserved in the GERD reservoir for the use of downstream countries during dry periods (Negm & Abdel-Fattah, 2019).

Allam and Eltahir (2019) identify a clear trade-off between the production of hydropower in Ethiopia and the use of freshwater for irrigation purposes in Egypt. This trade-off is subject to

the Water-Energy-Food nexus (WEF nexus). This nexus considers the interrelations between water security, energy security and food security and their trade-offs. To produce food, water and energy are both required and to generate energy, water is often a direct or indirect input. Therefore, it is important to consider and integrate these three aspects in policy making for basin-wide management (Allam & Eltahir, 2019). According to Allam and Eltahir (2019), the optimal operation policy for the GERD would be to release three to four CBM per month and to increase water storage in the reservoir during wet seasons and decrease storage during dry seasons. This policy provides the most optimal distribution of water for irrigation in Egypt and hydropower generation in Ethiopia (Allam & Eltahir, 2019). Fundamental to this policy however, is an effective collaboration between Egypt and Ethiopia. Current collaboration between the 10 riparian states takes place through the Nile Basin Initiative (NBI), launched in 1999 (Negm & Abdel-Fattah, 2019). However, Negm and Abdel-Fattah (2019) state that the NBI fell short when no agreement between mainly Egypt and Ethiopia could be reached regarding the GERD, provoking Ethiopia to start constructing the GERD by itself. Wheeler (2016) emphasises that collaboration and communication between the two riparian states reduces downstream risk. In addition, Basheer et al. (2018) developed a model using 120 different WEF nexus scenarios to quantify the impact of collaboration between Ethiopia and Sudan on the WEF nexus and found that intensifying the collaboration increases the economic gains of the allocation of freshwater in the Blue Nile Basin.

It was discussed in section 1.6 that seawater intrusion takes place as a result of a combination of reduced water levels in the Nile because of the GERD and groundwater pumping. Armanuos et al. (2017) used a three-dimensional groundwater model with different scenarios for groundwater pumping and found that the pumping of groundwater has a more significant effect on seawater intrusion in groundwater compared to the GERD. Continuing groundwater pumping at current rates is thus unsustainable and should be reduced to compensate for the GERD. Abd-Elhamid et al. (2019), using SEAWAT, a digital program developed for the simulation of three-dimensional groundwater flows, found that for a GERD filling period of 3 and 6 years, groundwater pumping would have to be reduced by 60% and 30%-40% respectively to avoid increased seawater intrusion.

Conclusion

This chapter presents pressing effects of the Grand Ethiopian Renaissance Dam on the water supply in Egypt, consequences of this changed water supply and responses to this problem. Literature research was conducted and presented using the DPSIR framework. Results show that the need for a large energy resource drives Ethiopia to build the GERD. To fill the reservoir and during operation of the GERD once the reservoir is sufficiently filled, water from the Nile River will be retained and therefore pressures water supply in Egypt. The GERD will have a negative influence on the water supply of Egypt during the filling of the reservoir. However, this effect will decrease once the GERD becomes operational after the filling of the reservoir is completed, but to which extent is presently unsure. This uncertainty is a result of the lack of official filling and operation policies by Ethiopia at the time of writing. The decrease of water supply in Egypt will decrease water availability for irrigation, decrease electricity generation of the Aswan High Dam and in combination with increasing groundwater pumping would cause accelerated seawater intrusion in the Nile delta in Egypt, causing soil salinization, lower water quality, degradation of agricultural land and ground subsidence. In response to these negative effects of the GERD, it is necessary for Egypt and Ethiopia to collaborate on water allocation between the two countries and for Ethiopia to take the needs of Egypt into account when establishing the filling policy and operation policy of the GERD. Using the WEF nexus for this cause could prove valuable since collaboration between Ethiopia and Egypt could improve overall benefits for the Blue Nile Basin.

Discussion

The results show that the GERD can have extensive effects on the water supply of Egypt and therefore on electricity production and seawater intrusion in Egypt. However, there are multiple uncertainties and limitations to this research. First, the results of this research are based on models to predict the effect of the GERD. The Ethiopian government has not published any details yet on the filling policy or operation policy of the GERD. This causes the need to make assumptions when modelling the potential effects of the GERD (see for example Liersch et al., 2017), which

could partly explain the highly diverse findings by Environmental Scientists as has been addressed in this chapter. The extent to which the water supply in Egypt will be affected is also highly dependent on multiple factors, primarily the amount of years taken to fill the reservoir and seasonal variability. Moreover, despite not being discussed in this chapter because of the limited extent of the research, climate change also affects the future water supply in Egypt (Abtew & Dessu, 2019; Liersch et al., 2017). Furthermore, the GERD has at the time of writing not started operating yet, causing a lack of data to research the actual effects of the GERD on water supply in Egypt. Further research is therefore recommended once Ethiopia publishes the filling policy and operation policy of the GERD.

2. Hegemony and Counter-Hegemony in the Nile Basin

International Relations - Marlies Groeneveld

Introduction

Looking at the building of the Grand Ethiopian Renaissance Dam from an International Relations perspective is very interesting. International Relations is the study and theorizing of international relations and politics. The political situation in the Nile Basin is both a cause and a reaction of the disruption (i.e. building of the GERD) challenging the status quo. It is therefore important to understand the asymmetrical power relationship between Egypt and Ethiopia and the underlying processes of compliance and consent to analyse the past, present and future situation of the hydro-hegemonic structure of the transboundary water interactions. Mark Zeitoun and Ana Cascão, leading researchers in the field of politics and transboundary water interactions, define hydro-hegemony as "hegemony [that is] active at the basin scale, and occurs where control over transboundary flows is consolidated by the more powerful actor" (2010, p. 27). The focus of this chapter will thus be on how disruptions, e.g. the Grand Ethiopian Renaissance Dam, influence the hydro-hegemonic structure and counter-hegemonic processes in the Nile Basin between Egypt and Ethiopia.

The goal of this chapter is to give a review of existing literature regarding transboundary water politics and the influence of power, hegemony, power asymmetry and counter-hegemony. It proposes a combination of the Framework of Hydro-Hegemony (FHH) (Zeitoun & Warner, 2006) and the Dynamic Transboundary Water Interaction Framework (DTWIF) (Zeitoun et al., 2017). The Framework of Hydro-Hegemony inspired many scholars to research the role of power and discourse in hydro-political situations (see for example Nasr & Neef, 2016; Daoudy, 2009; Hussein & Grandi, 2017) and it has introduced critical IR theory to water politics (Menga, 2016). This chapter will, as it gives an overview of literature regarding hydro-politics, tend to be a critical IR perspective.

The FHH is a useful tool to analyse more nuanced discourses and power relations, instead of mere "'water wars' or 'water peace' discourses" (Warner & Zeitoun, 2008, p. 809). While the FHH has proved to be helpful in analysing forces that play a role in hydro-politics, a more in-depth analysis of hegemonic processes should also include counter-hegemonic mechanisms of contest, as they often coexist with hegemonic mechanisms of compliance (Cascão, 2008). It is therefore that the DTWIF is introduced to give more insight in the process of counter-hegemony. This chapter will redesign the DTWIF to include the concepts of power asymmetry, form of interactions

and the intensity of conflict from the FHH. The dynamics of conflict and strategies of the hegemonic and counter-hegemonic countries in the Nile Basin are analysed with this framework . This chapter will be divided into five sections. Underlying the FHH and the DTWIF are mechanisms of power and the idea of hegemony and how they overlap. To be able to understand the frameworks, a comprehensive review of these concepts is necessary. The first section reviews the existing literature on the concept of power by analysing different dimensions and the concept of hegemony by elaborating on conventional and critical neo-Gramscian notions of hegemony. These concepts are linked with hydro-politics to introduce the different processes of the FHH and the DTWIF. These will then be combined into one coherent framework in the second section. This framework will be used to analyse the situation in the Nile Basin between Egypt and Ethiopia in the third section.

2.1 Hydro-Politics: Power, Hegemony and Water

Hydro-politics is a subdivision of IR that focuses on the politics of water. It combines power and hegemony to analyse situations in which water plays an important role. In the next section, the concepts of power and hegemony will be elaborated upon, so the overlap and interconnectedness will become clear before explaining the workings of the Framework of Hydro-Hegemony and Dynamic Transboundary Water Interaction Framework.

2.1.1 Power

An analysis of hydro-politics cannot proceed without a more in-depth understanding of the concepts of hegemony and power and how these are connected. Although power is an essentially contested concept and thus does not have one clear definition or meaning, this section will provide an overview of the definitions and ideas from leading scholars of International Relations.

One of the first contemporary analyses of power comes from Machiavelli, who argued that power is an end in itself and not a means to an end (Menga, 2016). This implies a behavioural aspect of power; that power is inherent of human nature. Drawing on behavioural sciences, Robert Dahl (1957) identified power as the ability to make someone do something or act a certain way

that this person would otherwise not do. He thus implied power includes a relationship between two or more actors. This is directly visible power and often referred to as 'hard' power.

On the other hand, 'soft' power includes more concealed forms of power. Joseph Nye defines soft power as "the power of attractive ideas or the ability to set the political agenda and determine the framework of debate in a way that shapes others" (1990, p. 166). Bacharach and Baratz (1962) extended this concept by introducing the processes of non-decision-making. This is the power to not make things happen, e.g. imposing barriers for setting conflict on the political agenda. Using both the ideas from Dahl and from Bachrach and Baratz, Steven Lukes (2004) developed three dimensions of power. The first dimension is coercion: the directly visible power, e.g. material power and economic strength. The second dimension is bargaining: the ability to set the agenda and control the rules of the game. The third dimension is ideological: the ability to change people's interests and thoughts in favour of the powerful, even if they do not agree.

As explained, defining power and understanding the different aspects is quite challenging. It is a concept with multiple interpretations at various levels. For the purpose of this chapter, power needs to be explained and defined to understand the dynamics of hegemony and compliance and contest. Power can thus be described as the capability of one actor to get the outcome it prefers through coercion, bargaining and ideological means. These three dimensions are interrelated and the notion of hegemony is based on power, as will be shown in the next section.

2.1.2 Hegemony

The concept of hegemony is also widely used in IR. Like power, hegemony can have different meanings. In conventional IR studies, e.g. realism, hegemony is seen as "a single dimension of dominance based on the economic and military capabilities of states" (Bieler & Morton, 2004, p. 87). This can be linked to the idea of hard power, as this type of hegemony is dominance through coercive mechanisms.

Many researchers of hydro-politics expanded this view by incorporating the ideas of Antonio Gramsci (see for example Cascão, 2008; Menga, 2016; Nasr & Neef, 2016; Zeitoun et al., 2017). Gramsci defined hegemony as a relational power, not just enforced but also involving ideological power flowing from moral leadership (Bieler & Morton, 2004). It is thus an asymmetrical power relation between two or more actors. Without an imbalance of power in the

world, a hegemonic situation could never occur. And it is only with power that the hegemon can maintain the hegemonic situation. Robert Cox, a neo-Gramscian theorist, highlights the difference between hegemony and dominance. Dominance uses coercion, while hegemony is based on legitimacy and some kind of consent (Cox, 1983). This does not mean that a hegemonic power does not use force, but as Cascão explains: "Hegemony is an articulation of ideas with material forces, although it involves achieving consent via the force of ideas rather than military or coercive force" (2008, p. 15). A hegemonic power usually uses a combination of coercion and consent (i.e. 'sticks and carrots').

Lustick (2002) has identified four mechanisms of compliance: (1) coercive: using or threatening to use force, (2) utilitarian: incentives (e.g. bribes and services) to accept status quo, (3) normative: the conscious decision of the non-hegemon to comply because it beliefs the best situation is hegemony and (4) ideological: obtaining a state of mind where hegemony is unquestioned. This last mechanism, inspired by Gramsci, is the most efficient mechanism to ensure that no conflict will occur, as long as the non-hegemonic states comply with the preferences of the hegemon (Zeitoun & Warner, 2006). The mechanisms of compliance by Lustick (2002) and the power dimensions by Lukes (2004) are interrelated in the analysis of transboundary water interactions. They both focus on the 'hard power'-dimension with coercion and force, but also on the less visible 'soft power'-dimensions with normative and ideological mechanisms of compliance.

There appears to be a connection between power and hegemony. Power is used for compliance to a hegemonic situation. Thinking of hegemony only as domination based on coercion seems a bit rudimentary and limited. Many scholars have come to the conclusion that hard power is not sufficient to maintain a hegemonic position (Menga, 2016). A combination of hard and softer forms of power are often more useful to make other actors comply.

2.1.3 The FHH and DTWIF

The relationship between power, hegemony and water was first put in a framework by Frederick Frey (1993). He presented a power-analytic framework and analysed the relation between downstream and upstream countries and the influence of power asymmetry (Frey, 1993; Menga, 2016). Zeitoun and Warner (2006) continued with his ideas and came with the Framework of

Hydro-Hegemony. They applied the Gramscian notion of hegemony and the three dimensions of power by Lukes and focused on how hegemons maintain their power and how conflicts vary in intensity (Zeitoun & Warner, 2006). The FHH is a framework that highlights the process of compliance and intensity of conflicts that might emerge.

Although the FHH the hegemonic process of conflict and compliance explains, it does not focus much on the counter-hegemonic processes of contest. Counter-hegemony is the contesting of the hegemonic structure, thereby potentially changing the international order and power relations. As explained earlier, power is relational, so all actors involved determine the outcome. That means that the non-hegemonic actors also have considerable influence (Cascão, 2008). The Dynamic Transboundary Water Interactions Framework by Zeitoun et al. (2017) shows that the processes of hegemony and counter-hegemony occur simultaneously.

Resistance of a hegemonic order can occur through several mechanisms, similar to the mechanisms of consent. Zeitoun et al. (2017) identify three mechanisms of contest: (1) coercion: forcing others by using or threatening to use force (e.g. violence or sabotage), (2) leverage: increasing influence, works within the existing order existing rules (e.g. forming alliances and initiating hydro-diplomatic relations) and (3) transformation: undermining existing foundations that support hegemonic situation (e.g. ideational discursive reframing of issue). These three mechanisms also correspond to the different forms of hard and soft power.

By contesting the hegemonic structure of the international order, conflict might start. Apart from the overt type of military conflict, various intensities of the conflict have been identified. The North Atlantic Treaty Organization (NATO) has identified five stages of conflict: durable peace, stable peace, unstable peace, crisis and war (NATO, 1999 in Zeitoun & Warner, 2006, p. 440). These variations have different implications for further actions and international relations. The relation might be warm at durable and stable peace, move towards cold relations (e.g. diplomatic and economic actions) and cold war at unstable peace and military occupation and war at the stages of crisis and war (Zeitoun & Warner, 2006). Transboundary water interactions often occur on the scale somewhere between cooperation and competition. All these different aspects of hydro-politics discussed above are combined into one framework in the next section.

2.2 Framework

This section connects the concepts and frameworks discussed in the previous sections into a single, more comprehensive framework.

2.2.1 The Framework Explained

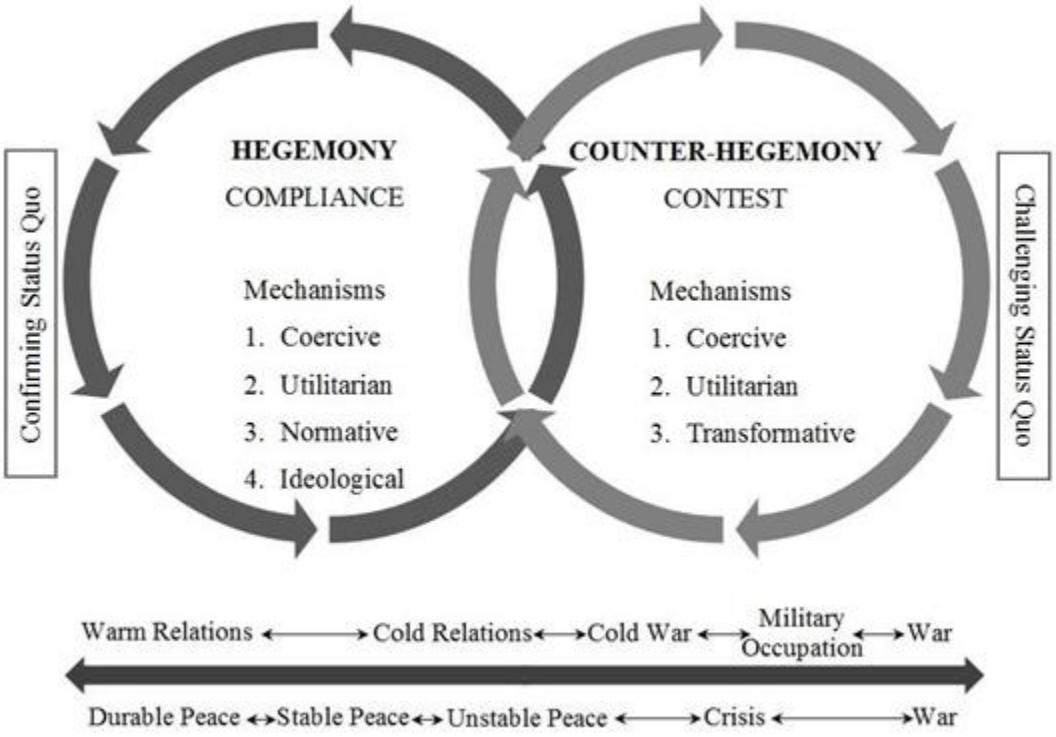

Figure 3: An abstract framework of compliance and contest in a hegemonic order. The framework combines the processes that might either reinforce or challenge the hegemony and the consequences that it might have regarding peace of conflict. Based on Cascão and Zeitoun (2010, fig. 2) and Zeitoun and Warner (2006, fig. 2).

The first process in Figure 3 is incorporating the concepts of compliance and hegemonic power. It is shown in the left circle and confirm the status quo. It mentions Lustick's (2002) four mechanisms that reinforce compliance. At first, it might be depending on military force, economic strength or geographical position. But if time progresses, more subtle expressions of power might become

more useful up to the point that the non-hegemonic state believes that compliance is the best. Hegemony constructs common sense and legitimacy through instilling discourses, ideas, beliefs and knowledge (Cascão, 2008). This does not mean that non-hegemonic states are completely powerless; they have the ability to negotiate and resist (to some extent) the situation. As Cascão explains: "Hegemony and counter-hegemony shape and define each other" (2008, p. 16). The process of counter-hegemony starts with undermining the hegemonic construction of common sense and legitimacy and with building an alternative status quo.

The second process shown is the intertwined region of the compliance and contesting processes. It is hypothesised that most transboundary water interactions are shaped by a coexistence of contest and compliance (Zeitoun et al., 2017). Counter-hegemonic resistance usually start within the existing status quo while maintaining an appearance of consent. According to Cascão (2008), this might be considered "an expression of 'apparent consent but actual veiled contest" (p. 17). The coexisting of consent and contest might develop into overt contest of the hydro-hegemonic order.

It is the third process of contesting that is important for the analysis of the situation in the Nile Basin. In Figure 3, this phase is shown in the circle on the right. In this situation, the counter-hegemonic strategies are no longer veiled by consent. The strategies required to undermine the hegemon are categorized in three mechanisms.

This framework further shows the conflict intensity scale and the corresponding relational status. It moves from durable peace and warm relations by compliance of the hegemonic situation to ultimately war by contest the hegemonic situation. With regards to water, it is likely that the transboundary interactions vary from cooperation to competition. In areas where there is an abundance of water, it is expected that countries will cooperate to adequately manage it, while in areas with scarcity countries are more likely to compete over it (Zeitoun & Warner, 2006). A stable and peaceful situation can occur if the hegemon negotiates an agreement that is perceived as beneficial for all parties. A crisis can occur if the hydro-hegemon is perceived as too dominant or if the power of the non-hegemon grows.

2.2.2 Transforming the Hegemonic Structure

As explained in the previous section, the counter-hegemonic movement is not only about contesting the status quo, but also transforming it. This new situation might be a more balanced distribution of power and share of water resources. It might however also be a kind of new world order that does not exist yet, and thus also cannot be imagined yet. Warner (2007) has identified three possible responses to hegemony.

The first type coincides with the neo-realistic notion that countries strive for power and cooperation is not possible. This type is called hegemonic challenge and exists within the current status quo (Warner, 2007). Changes occur within the same hegemonic system; it does not transform. The non-hegemon only competes with others for more/the most power.

The second type identified by Warner (2007) is counter-hegemony. In this situation, the non-hegemonic power contests the status quo and the dominance of the hegemon. It focuses more on the normative aspects of the situation by promoting a different set of rules within the international system. Hypothetically, a perfect balance of power might exist with no dominant force. Neo-liberalist Robert Keohane (1984) explains that it is possible to cooperate, especially when every state is equal, if one looks at absolute gains instead of relative gains.

Another option, perhaps the most difficult to grasp, is a complete transformation of the international system. It completely moves away from hegemony and counter-hegemony and their enabling system. This new order might take different forms, this is entirely unknown in the current world, as people might not be able to even imagine what such a new order would look like. This new system is therefore introduced by Warner (2007) as an a-hegemonic system.

What kind of distribution of power will emerge, within or outside the present system, also depends heavily on the reaction of the hegemon to the challenger of the status quo. If it fully retaliates, a war might begin. If the hegemon makes enough compromises, the new order might be consolidated relatively peaceful and give the old hegemonic power a chance to retain some power and influence. Whether this new transboundary situation might be more positive (i.e. reduces inequality and tensions) cannot be predicted.

2.3 Hydro-politics in the Nile Basin

The Nile Basin is a good example of how hegemony and power asymmetry influence the present situation. The Nile flows through eleven countries and is the major resource for water (Hussein & Grandi, 2017). Egypt, the farthest downstream country, is relying heavily on the Nile for its agriculture, economy and freshwater for people (Paisley & Henshaw, 2013). More than 85% of the water of the Nile originates in Ethiopia and flows through Sudan before it arrives in Egypt (Hussein & Grandi, 2017). A combination of drought, climate change and historical troubles makes the situation difficult to manage and any move might become a threat to the peace in the Nile Basin and change the conflict intensity. The aim of this section is to understand how Egypt's hydro-hegemony is challenged by Ethiopia. This will be done with the help of the insights of the previous sections about power, hegemonic and counter-hegemonic strategies. At first, a short introduction about the two main actors – Egypt and Ethiopia – will be given. After this, the underlying motives and mechanisms of Ethiopia building the GERD will be reviewed.

Egypt is the hegemon in the Nile Basin. This position is mostly based on history. It used this historical reason to influence the other countries on a deeper level: that it is Egypt's right and purpose to lead the region. The 1959 Agreement between Egypt and Sudan, which established the allocations of water for the two countries, is used by Egypt to claim 'historical rights' and prevent other riparian states from building water infrastructure (Nasr & Neef, 2016). According to Cascão (2008), Egypt has used several methods to validate and reinforce its hegemonic position: coercive mechanisms to control resources and to control challenges to its power, bar, utilitarian mechanisms such as expertise-based services and discursive methods to reinforce the idea that Egypt is the legitimate leader.

Ethiopia on the other hand is a non-hegemonic country and until recently consented to the situation. However, it has contested the status quo by counter-hegemonic actions. Ten countries in the Nile Basin have signed the Nile Basin Initiative (NBI) (including Egypt) and try to achieve development (Tawfik, 2015). One initiative by Ethiopia is the Cooperative Framework Agreement (CFA) with the intention to intensify cooperation (Paisley & Henshaw, 2013). Another form of resistance is the building of the GERD. Egypt has strongly opposed any form of hydro-infrastructure that could interfere with the water flow.

These moves indicate a counter-hegemonic strategy on several levels. The initiative of the CFA indicates a form of contest in the leverage mechanism as defined by Zeitoun et al. (2017). Ethiopia uses the existing rules and procedures of the NBI to push the CFA. By building the GERD, Ethiopia also shows its expertise and the benefits of contesting the status quo for its own profit (Tawfik, 2015). Ethiopia shifts the image of Egypt as most beneficial power and biggest economic force to itself as being the best 'benefit provider' for the region (Hussein & Grandi, 2017). Zeitoun et al. (2017) explain that it also changes the ideological element of power and can lead to a new discourse.

Of course, the case of hydro-politics in the Nile Basin sketched above only provides a small insight in the complex situation. It is for example argued by Hussein and Grandi (2017) that other processes, e.g. shifting international alliances, also have impacted the events and decisions made in the Nile Basin. Nasr and Neef (2016) also point to the internal struggles in Egypt with economic crises and political turmoil. This section merely shows that a disruption, e.g. the building of the GERD, can have several intentions that go beyond the economic or environmental consequences that are explained in chapter 1 and 3. It challenges the hegemonic structure that Egypt has upheld at different levels of power.

Conclusion

The focus of this chapter was on the political aspect of the transboundary water interactions in the Nile Basin. The dynamics of the hegemonic situation were analysed from the discipline of International Relations. A review of literature on hegemony and counter-hegemony was done to analyse concepts of power, hegemony and counter-hegemony. These concepts were transformed into a comprehensive framework that combined the FHH and the DTWIF that is used to analyse the situation in the Nile Basin.

The combined framework has proven useful to illustrate the processes of hegemony and counter-hegemony. Egypt uses a smart combination of hard and soft power to reinforce the current situation. The building of the GERD can be seen as a move of contest by Ethiopia and marks the beginning of a counter-hegemonic process.

It has become clear that two processes can exist within the hegemonic situation: affirming the status quo or challenging it. In this case, Egypt and Ethiopia are seen as hegemonic and non-

hegemonic powers. This power relationship can be classified as being asymmetrical and being maintained in three dimensions: coercion, bargaining and ideological. Compliance with the hegemonic status quo can be reinforced through four mechanisms, often simultaneously used: coercive, utilitarian, normative and ideological mechanisms. The building of the GERD by Ethiopia can be seen as contesting the hegemonic situation. This counter-hegemonic move can be the beginning of a period of contest and resistance through coercion, manipulation and transformation. If Egypt does not comply with the new status quo, the result might be a conflict. This can have various intensities. In the far future, this might result in a new order with either Ethiopia as a new hegemon, a more equal balance of power or a transformed new international system that is a-hegemonic. It all depends on how the current situation evolves. The present situation is a combination of compliance-producing tactics used by Egypt to maintain the hegemonic structure, while Ethiopia contest the status quo by building the GERD.

Discussion

This chapter can be seen as a short introduction into the complicated transboundary water interactions from a critical IR perspective. Although it is simplified for the sake of argument and the length of the chapter, it provides valuable insights regarding hegemonic processes and the situation in the Nile Basin. IR studies situations from different perspectives, including insights from other disciplines, such as law, economics, environmental studies, history and cultural studies. This means that the changes described here occurred within broader contexts (e.g. historical relationships and changing environmental discourses). It would therefore be presumptuous to assume that the situation of the Nile Basin can be sufficiently analysed by only looking at the political aspect of power relations. On the other hand, the impact of the hegemonic processes should not be marginalised and do play an important role.

This analysis is mainly done by reviewing and incorporating existing literature by prominent scholars in the field of IR and specifically transboundary water interactions. To fully understand the motives of Egypt and Ethiopia in regard to the building of the GERD and the hegemonic situation, more primary sources, e.g. official documents and motives of the representatives of the states, should be evaluated.

3 Economic solutions for the water troubles

Economics - Elise van Rooden

Introduction

The GERD is the first big project that has ever been constructed by one of the upstream countries of the Nile Basin (Nigatu & Dinar, 2015). The countries that are included in the Nile Basin are Ethiopia, Egypt, Sudan, Uganda, Kenya, Eritrea, Tanzania, Burundi, Democratic Republic of Congo, Tanzania and Rwanda (Madani *et al*, 2011).

For this research, Egypt and Ethiopia will be the main focus. Egypt is a downstream country, which heavily depends on the Nile for its own economies. The countries that are developing dam projects for water resource management, in this case Ethiopia, have issues with poverty, pressure of population growth which demand more water resources, desire a reliable energy source for economic development and want to control the fluctuations of water due to climate change. The hydropower dams are seen as a solution for creating economic development. However, these dams possibly create conflict between countries. It may exclude downstream countries from the water resource (Veilleux, 2013).

3.1 The definition of water

Water can be seen as an economic good. Therefore, it has economic value. The definition of economic value of water is not only that people use water for being economically productive, but it is also tradable good. For example, a farmer can stop extracting water from its natural source in exchange for money. But when a user is willing to pay money for an amount of water one can speak about "user value". User value is when a good has economic value for a particular user in a specific point in time and location. It is how much a person is willing to pay for water. The value of water is based on transaction value[4] and the level of scarcity (Whittington *et al*, 2005).

When water is treated as an economic good, it is possible, just like other economic goods, to be allocated where there is the highest economic return. Therefore, the water will be treated with more care, so it keeps the same quality and its economic value (Nigatu & Dinar, 2015).

[4] Psychological satisfaction gained from a price which is in comparison higher/lower than the reference price (Xia & Monroe, 2010).

Furthermore, water can be used as a generator for Hydropower. It is then most beneficial to let as much water flow through the dam as possible. Therefore, the dam should be build upstream, otherwise there are opportunity costs. The consumption of water before letting it go through the dam will result in less hydropower generated by the dam and therefore lose the opportunity to generate profit from the dam (Whittington *et al*, 2005).
Eventually the building of the dam will lead to economic development and domestic supply of electricity, which can be sold internationally. However, environmental cost are possible in the long-term (Veilleux, 2013).

A problem might be the scarcity of the natural resource. A natural resource is in most cases a non-renewable good or it cannot keep up with the high demand for the natural resource (Hackett, 2006). Scarcity of a resource of product indicates that there is competition for it. Participants of this kind of competitive market need to make decisions based on the options they have and what serves in their best interest (Tietenberg & Lewis, 2012).

A market needs to meet four conditions to allocate the resources most efficiently: perfect competition, perfect information accessible for all participants in the market, mobility of the resource and the property rights are clear to all participants (Hussen, 2000). A competitive market is a market with many buyers and sellers, so no one has influence on the price for the product (Pindyck & Rubinfeld, 2015). An equilibrium reached in this market is when the price set causes the quantity supplied being equal to the quantity demanded (Pindyck & Rubinfeld, 2015). However, in a competitive market there is a pareto efficient allocation (Burkett, 2006). This is when no one can be better off without someone else being worse off (Pindyck & Rubinfeld, 2015). In this case, there is an economic efficient equilibrium, where the net benefit of participants in the market are maximized (Burkett, 2006).

However, in a market for natural resources, there is no clear understanding of property rights (Tayia, 2019). These natural resources lack property rights, because these resources are common-pool resources. Everybody has excess to these kind of resources without having to ask permission, which possibly causes the market equilibrium to fail to be efficient (Tayia, 2019).

3.2 What is Game Theory and why use it?

Game Theory is used for analysing conflicts by exploring the possible actions and strategies every participant of the conflict can perform and therewith look for possible outcomes and solutions for the conflict (Madani *et al*, 2011). Every game consists of players, actions (also known as strategies), payoffs of every action and information set, which is the amount of information known by a player (Rasmusen, 2007). Every player has preferences for particular actions which are not only based on economic, but also social and political values (Madani *et al*, 2011).

When all these requirements are known, Game Theory can predict possible outcomes for the situation of interest. These outcomes are the most efficient and beneficial for the players in the game (Madani *et al*, 2011). Taking into account how the players will play their actions, an equilibrium point can be found. An equilibrium point is when a view actions combined from each player results in the best strategy for the game (Rasmusen, 2007).

Game Theory is used for multiple situations, experiments or real, to explain the development and possible outcomes of these situations. It is also used for predicting possible outcomes for conflicts or events and therefore provide recommendations to solve these situations (Dixit *et al*, 1999).

A "situation" can thus be seen as a game. There are two types of game theories: Cooperative and non-cooperative. In a cooperative game the players can solve the conflict by making binding commitments. These games are based on fairness. The game is not focused on the strategies to achieve a specific outcome, but on the outcome itself. A non-cooperative game is the total opposite. The players of the game cannot make binding commitments, because of their clashing preferences for different actions. In this kind of game, the players strive to maximize their own utility, and thus not taking into account the feelings of the other players (Rasmusen, 2007).

In the next part of this chapter a non-cooperative and a cooperative game will be examined and compared for the current conflict in the Nile Basin. The main focus will be on Egypt and Ethiopia, however Sudan and other upstream countries will be mentioned.

3.3 Non-cooperative game

The first research is done by Kaveh Madani, Laila Elimam, David Emmanuel Rheinheimer and Christina Connell-Buck, and analysed by a non-cooperative perspective on the conflict. The hydro-political conflict in the Nile Basin has been there since the 11 century, mainly between Egypt and Ethiopia. In 1929 and 1959 the first treaties came which concerned the water allocation in the Nile Basin area. However, they were mainly focused on the downstream countries, Egypt and Sudan. In these treaty's the upstream countries are not recognized and left out. The treaty of 1959 builds on the older treaty of 1929 and forbids the upstream countries from using water of the Nile, for consumption or building obstructions. The upstream countries therefore do not recognize the 1959 treaty (Madani *et al*, 2011).

A new potential agreement has been constructed in 2002, which is The Nile Basin Initiative (NBI). However, it is not yet in force. This agreement is less focused on the allocation of the water, but more on how countries can go to a more cooperative posture towards each other (Madani *et al*, 2011).

In this research, the Nile Basin conflict is analysed and tried to be solved. The used system is the Graph Model for Conflict Resolution (GMCR II). This system is used for translating the conflict in a game and solving it to find its equilibrium point (Madani *et al*, 2011). Figure 4 shows the process of how the GMCR works and processes information.

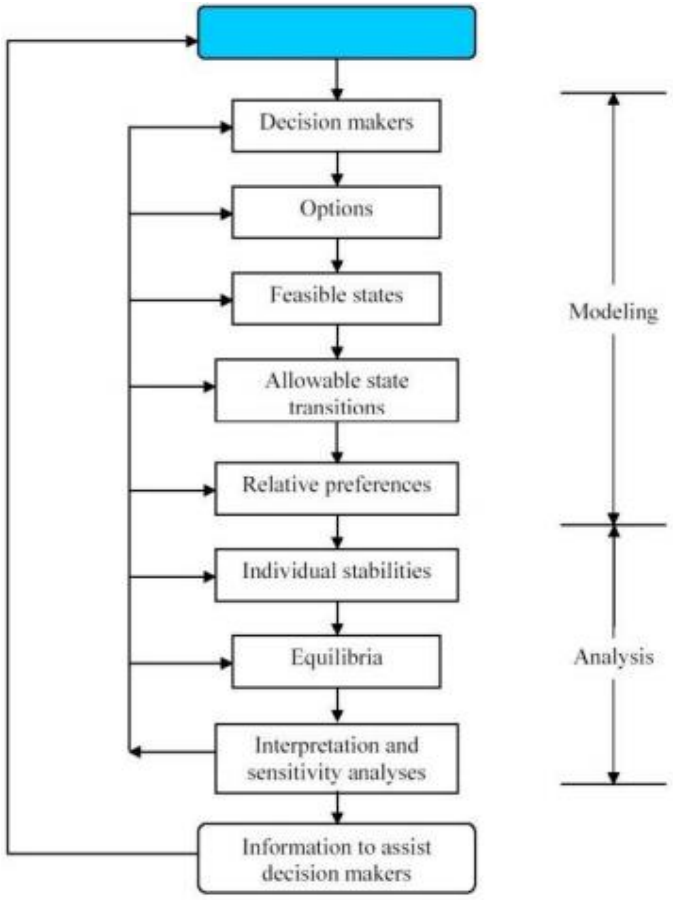

Figure 4: Process of applying the GMCR II (Hipel et al, 1993)

First, the decision makers have to be determined. These are the players participating in the game. Next, the possible options, in other words, actions and the feasible states. Then the allowable state transitions are determined. The last step for the modelling phase are determining the preferences of each player. Then the stable individual points can be found and the equilibria points can be constructed. The next step is applying the sensitivity analyses on the game. By changing some parameters in the game, other factors can be influenced, which then give possibly different equilibria points. These are the steps which will be taken to calculate the equilibrium points. These steps will be further explained (Hipel *et al,* 1993).

As seen above, before defining the equilibrium point, it is important to evaluate all players' preferences. The players that are acknowledged in this research are the Upstream countries, Ethiopia, Sudan and Egypt (Madani *et al,* 2011). For describing the research, all the players will be examined. However, evaluating the equilibrium point found, the focus will be on Egypt and Ethiopia.

The actions each player has are shown in Table 1.

Player	**Options**
Egypt	-Acknowledgement of 1959 treaty -Cooperation between all countries (NBI) -Military or economic action
Ethiopia	-Acknowledgement of 1959 treaty -Cooperation (NBI) -Independent water development
Upstream countries	-Acknowledgement of 1959 treaty -Cooperation (NBI) -Independent water development
Sudan	-Acknowledgement of 1959 treaty -Cooperation (NBI) -Independent water development

Table 1: The possible actions of every player (Madani et al, 2011)

The preferences of the players are shown in Table 2. When cooperation is mentioned, it is through the NBI. Doing nothing means securing their own country from retaliation by Egypt (Madani *et al*, 2011).

Preferences	*Egypt*	*Ethiopia*	*Upstream countries*	*Sudan*
1	1959 treaty	Doing nothing	Doing nothing	Doing nothing
2	Retaliate against Sudan (if necessary)	No 1959 treaty	If no retaliation by Egypt, build their own water development projects	1959 treaty
3	Retaliate against Ethiopia (if necessary)	Build water development projects	Cooperate NBI	If Egypt cooperate (NBI), Sudan does the same
4	Coop when pressured by Sudan and Ethiopia	Cooperation with NBI	No 1959 treaty	If Ethiopia cooperate (NBI), Sudan does the same

5		Want Sudan to enter NBI too		If Ethiopia and Upstream countries build their own water development projects, side with Egypt
6				If Ethiopia and Upstream countries build their own water development projects, side with them

Table 2: The preferences for every player ranked from 1 to 6 (Madani et al, 2011)

By entering the following options and preferences in the GMCR II, the equilibriums found are shown in Table 3.

Equilibrium	
1	Upstream countries, Ethiopia and Sudan build own water development projects. Egypt retaliates.
2	Upstream countries and Ethiopia build own water development projects. Egypt retaliates as response and stays in the 1959 treaty. Sudan also stays in 1959 treaty.
3	Ethiopia builds own water development project. Egypt retaliate as response and maintains 1959 treaty. Upstream countries and Sudan maintain the 1959 treaty.
4	Upstream countries develop own water development project. Egypt retaliates as response and maintains 1959 treaty. Ethiopia and Sudan maintain 1959 treaty.
5	Upstream countries develop own water development project. Ethiopia, Egypt and Sudan cooperate through NBI.
6	Upstream countries develop own water development project. Egypt retaliates as response. Egypt, Ethiopia and Sudan cooperate through NBI.

Table 3: Equilibrium points found (Madani et al, 2011)

The most remarkable aspect about the results are that Egypt retaliates in five of the six equilibrium points. This shows how strong Egypt as a nation is, economically and military. The only equilibrium point where no retaliation by Egypt is when the upstream nations develop their own water development projects and the rest cooperate through the NBI. Also remarkable is that none of these equilibria represent the current state of the conflict. Furthermore, the strategy profile where all the nations work together is not an equilibrium (Madani *et al*, 2011).

The research also makes use of sensitivity analyses. These analyses mean changing one or a few parameters to influence the outcome of the game and analyzing the difference. The most important change is the attitude of Egypt. Taking into consideration a more peaceful Egypt, the following equilibria can be constructed by the GMCR II (Madani *et al*, 2011):

1. Egypt, Sudan and Ethiopia cooperate under the NBI and the upstream countries develop their own water development projects.
2. If all nations construct their own water development projects, Egypt will retaliate.

Another change, which is more important for the conclusion, is the removal of the upstream countries. The countries left in the game are Ethiopia, Egypt and Sudan. With the old preferences the following equilibria are constructed (Madani *et al*, 2011):

1. All countries cooperate and thus accept the NBI
2. All countries accept the 1959 treaty
3. Ethiopia and Sudan develop their own water development projects and Egypt retaliates

The conclusion for this article is that in five of the six equilibria Egypt will retaliate. Therefore, Egypt has the most impact with their preferences on the outcome. Other nations are scared for the possibility that Egypt will retaliate against them. This shows in the preferences of each players in Table 2**.** Ethiopia, Sudan and the upstream countries all favour to do nothing to keep Egypt from retaliating against them. From Game Theory perspective, it does not look like it will be easily resolved. However, the Nile Basin countries are working with an international community which can help resolve the conflict (Madani *et al*, 2011).

3.4 Cooperative game

The next research is done by Xun Wu and Dale Whittington. The authors make use of the cooperative game theory to solve the Nile Basin conflict. Cooperative game theory gives insights in how countries can get the most economic benefit as a group. In this research the options are a basin-wide cooperation, partial coalition cooperation or individually constructing water development projects (Wu & Whittington, 2006).

The theories that are part of the cooperative game theory and used in this research are the Core, the Nucleolus theory and the Shapley theory. A cooperative game has three requirements: 1. players, 2. actions for each player and 3. a characteristic function for every player (Wu & Whittington, 2006).

The players participating in this game are Ethiopia, Egypt, Sudan and equatorial states (other upstream countries, assumed working as one entity). Every player has the following actions: Act alone and construct own water development projects, join the Grand coalition (every player in the game working together) or form a partial coalition with another player. The potential partial coalitions are shown in Table 4 (Wu & Whittington, 2006).

Type of coaltion	**Coalitions**
One country	-Egypt -Sudan -Ethiopia -Equatorial states
Two countries	-Egypt & Sudan -Egypt & Ethiopia -Egypt & Equatorial states -Sudan & Ethiopia -Sudan & Equatorial states -Ethiopia & Equatorial states
Three countries	-Egypt, Sudan & Ethiopia -Egypt, Sudan & Equatorial states -Egypt, Ethiopia & Equatorial states -Sudan, Ethiopia & Equatorial states
Four countries (Grand coalition)	Egypt, Ethiopia, Sudan & Equatorial states

Table 4: Possible coalitions between the countries (Wu & Whittington, 2006)

Important for the formation of a coalition is to know the Economic incentive of each country. Thereby, it can be determined how much value a country can contribute to the coalition. The economic incentive of each country is based on three things (Wu & Whittington, 2006). First, the

hydrological position of the country. If the position is better, the country will have less interest in participating in a coalition. This country will not need a coalition to gain more benefits. Second, if a country can develop their own water development projects. This is based on their financial conditions. If they cannot build their own projects, it is necessary for this country to participate in a coalition. Third, the ability of a country to make strong alliances.

The characteristic function calculates how much minimum extra benefit the country will get by working individually, joining a partial coalition or participating in the Grand coalition. If a country gets near the same amount of minimum extra benefit when it is on its own as in a coalition, the country will therefore not participate in a coalition. The value of a coalition calculated by the Characteristic function is shown in Table 5 (Wu & Whittington, 2006).

Coalition	**Benefits of the Coalition, x10^6 US$**	**Characteristic Function Value, x10^6 US$**
Egypt	1804	V(Egypt) = 1804 (1804 – 0)
Sudan	1029	V(Sudan) = 1029 (1029 – 0)
Ethiopia	600	V(Ethiopia) = 600 (600 – 0)
Equatorial states	1233	V(Equatorial states) = 1233 (1233 – 0)
Egypt & Sudan	3107	V(Egypte & Sudan) = 274 (3107 – 1804 – 1029)
Ethiopia & Sudan	3131	V(Ethiopia & Sudan) =1502 (3131 – 600 – 1029)
Ethiopia & Egypt	3759	V(Ethiopia & Egypt) = 1355 (3759 – 1804 – 600)
Egypt & Equatorial states	3731	V(Egypt & Equatorial states) = 694 (3731 – 1804 – 1233)
Sudan & Equatorial states	2900	V(Sudan & Equatorial states) = 728 (2990 – 1029 – 1233)
Ethiopia & Equatorial states	1833	V(Ethiopia & Equatorial states) = 0 (1833 – 600 – 1233)
Egypt, Sudan & Ethiopia	6746	V(Egypt, Sudan & Ethiopia) = 3313 (6746 – 1804 – 1029 – 600)
Egypt, Sudan & Equatorial states	5509	V(Egypt, Sudan & Equatorial states) = 1443 (5509 – 1804 -1029 – 1233)

Egypt, Ethiopia & Equatorial states	5684	V(Egypt, Ethiopia & Equatorial states) = 2047 (5684 – 1804 – 1233 – 600)
Ethiopia, Sudan & Equatorial states	4642	V(Ethiopia, Sudan & Equatorial states) = 1780 (4642 – 600 – 1029 – 1233)
Egypt, Sudan, Ethiopia & Equatorial states	9112	V(Grand coalition) = 4446 (9112 – 600 – 1804 – 1029 – 1233)

Table 5: Values of the coalitions calculated by the Characteristics function (Wu & Whittington, 2006)

Concluding from Table 5, the most beneficial coalition, calculated by the Characteristic function, is the Grand coalition. The second highest possible coalition is the combination of Egypt, Ethiopia and the Equatorial states. Furthermore, it is interesting to see that a coalition consisting of Ethiopia and the Equatorial states has a value of 0 US Dollar (Wu & Whittington, 2006). A possible reason for this is that a coalition between two upstream players does not benefit to solving the conflict. Another possible reason is that the two players are both upstream countries, and therefore have both less interest in trading with each other. A coalition with a downstream country will benefit more, because then there are reasons for trading water and electricity generated by the dam.

After determining the important aspects of a cooperative game, the theories can be applied which can solve the conflict in the Nile Basin. The first is the Core. This theory can calculate equilibria which are immune to deviating from a coalition. Thus, an equilibrium point which satisfies both the individual and group demands (Serrano, 2007). It shows the Economic incentives which are needed to get countries cooperate. Table 6 shows these incentives (Wu & Whittington, 2006).

Country	**Lower Bound, x10^6 US$**	**Upper Bound, x10^6 US$**	**No cooperation, x10^6 US$**
Egypt	1804	4107	1804
Sudan	1339	3109	1029
Ethiopia	600	3603	600
Equatorial states	1233	2366	1233

Table 6: The boundaries for every country in which they can come to an agreement (Wu & Whittington, 2006)

For getting the results in Table 6, it is necessary to include two assumptions. The first one is:

$$\Sigma u_i \leq v(I)$$

The meaning of this condition is that the benefits for the countries on their own is less or equal to the benefits allocated in a Grand coalition (Wu & Whittington, 2006).

The second assumption is:

$$\Sigma(I \subseteq S)u_i^K \geq v(S)$$

This condition states that it is more beneficial for the countries if the countries all work together in comparison to forming partial coalitions (Wu & Whittington, 2006).

The lower and upper bound in Table 6 are the bargaining power each country has. If this value is higher, this country will have more bargaining power. The lower bound represents the minimum amount of economic value a country wants. If the economic value is lower than the lower bound, it is not interesting for the country to cooperate. The upper bound gives the maximum economic value a country can request, while making sure the other countries will keep cooperating (Wu & Whittington, 2006).

This theory helps with determining if there is potential for an agreement and making a base for this agreement. Furthermore, the Core can determine potential allocations of the water of each country which will lead to an agreement. Without this data, there is no base for an agreement. Also, it measures if there is a chance that countries will deviate from the cooperation and predict potential actions taken by countries (Wu & Whittington, 2006).

So, the Core lays the boundaries for a potential agreement. The next theory, the Shapley value, is focused on distributing the surplus fairly among the countries, while taking into account every coalition their worth (Serrano, 2007). It provides an index which shows the strength of the coalition that a country is part of in comparison to the coalition the country is not part of. The Generalized Shapley value is the index that shows the influence of the coalition in the game (Flores *et al*, 2018). The results are shown in Table 7 (Wu & Whittington, 2006).

Egypt			Ethiopia		
Coalition	*Shapley*	*Generalized Shapley*	*Coalition*	*Shapley*	*Generalized Shapley*
Egypt	0.250	0.200	Ethiopia	0.250	0.300
Sudan – Egypt	0.083	0.100	Egypt – Ethiopia	0.083	0.000
Ethiopia – Egypt	0.083	0.000	Sudan – Ethiopia	0.083	0.100
Equatorial states – Egypt	0.083	0.000	Equatorial states – Ethiopia	0.083	0.000
Sudan – Ethiopia – Egypt	0.083	0.300	Egypt – Sudan – Ethiopia	0.083	0.100
Sudan – Equatorial states – Egypt	0.083	0.300	Sudan – Equatorial states – Ethiopia	0.083	0.100
Ethiopia – Equatorial states – Egypt	0.083	0.000	Egypt – Equatorial states – Ethiopia	0.083	0.000
Sudan – Ethiopia – Equatorial states – Egypt	0.250	0.100	Egypt – Sudan – Equatorial states – Ethiopia	0.250	0.400

Sudan			Equatorial states		
Coalition	*Shapley*	*Generalized Shapley*	*Coalition*	*Shapley*	*Generalized Shapley*
Sudan	0.250	0.200	Ethiopia	0.250	0.300
Sudan – Egypt	0.083	0.200	Egypt – Ethiopia	0.083	0.000
Ethiopia – Sudan	0.083	0.500	Sudan – Ethiopia	0.083	0.100
Equatorial states – Sudan	0.083	0.100	Equatorial states – Ethiopia	0.083	0.000
Sudan – Ethiopia – Egypt	0.083	0.000	Egypt – Sudan – Ethiopia	0.083	0.100
Sudan – Equatorial states – Ethiopia	0.083	0.000	Sudan – Equatorial states – Ethiopia	0.083	0.000
Sudan – Equatorial states – Egypt	0.083	0.000	Egypt – Equatorial states – Ethiopia	0.083	0.000
Sudan – Ethiopia – Equatorial states – Egypt	0.250	0.000	Egypt – Sudan – Equatorial states – Ethiopia	0.250	0.500

Table 7: Shapley and Generalized Shapley value (Wu & Whittington, 2006)

The Shapley value is calculated with the next formula (Wu & Whittington, 2006):

$$\phi_i = \sum_{S \subset N} \frac{(s-1)!(n-s)!}{n!}[v(S) - v(S-i)].$$

The marginal contribution of each country to a coalition is calculated by (Wu & Whittington, 2006):

$$[v(S) - v(S-i)]$$

The weight of the coalition stated by the countries with random order of entering of the countries in the coalition is calculated by (Wu & Whittington, 2006):

$$\frac{(s-1)!(n-s)}{n!}$$

The Generalized Shapley value is calculated by using the next formula (Wu & Whittington, 2006):

$$\phi_i = \sum_{S \subset N} r_i(S)[v(S) - v(S-i),$$

The difference with the normal Shapley value calculation is that the random order of entering of the countries is removed. This formula is more focused on the weight given by the countries to a coalition. Every country however can rate the weight of a coalition differently, because every country has different beliefs and knowledge about the possible coalitions (Wu & Whittington, 2006).

As seen in Table 7 some coalitions have a Generalized Shapley value of 0. This means that they are not feasible in real life, while in theory they might be. An example is the cooperation between Ethiopia and the Equatorial states, because not joining a coalition for both countries has more benefits. Also Egypt that cooperates with Ethiopia and the equatorial states is not likely. Sudan can interrupt by taking more water from the Nile. Furthermore, it is interesting to see that it is most beneficial for Sudan or Egypt to form a coalition with one of the upstream countries. The bargaining power of the upstream countries are increased. Furthermore, the Shapley value states that for every country working alone or working together in a Grand coalition will be most beneficial (Wu & Whittington, 2006).

The last theory of importance for cooperative Game Theory is the Nucleolus theory. This theory is based on Rawls's concept of "the veil of ignorance". If a country is unsure about what is going to happen, the best thing they can do is determining the maximum net benefits one can obtain if the worst possible outcome becomes reality. Rawl states that every individual would try to get

the least worst possible outcome, no matter what actions other players do. This theory is of high interest by countries which are at a disadvantage (Wu & Whittington, 2006).

However, the Nucleolus theory does not take into account the size of the coalition. Therefore, by changing the formula in the algorithm that is used to solve this, now the Per Capita Nucleolus Allocation can be calculated. The system used in this research is the General Algebraic Modelling System (GAMS). The results are shown in Table 8 (Wu & Whittington, 2006).

	Nucleolus Allocation, x10^6 US$	**Per Capita Nucleolus Allocation, x10^6 US$**
Egypt	3051	2996
Sudan	2309	2255
Ethiopia	1952	2344
Equatorial states	1800	1516

Table 8: The maximum benefit every country can obtain in case of the worst possible outcome (Wu & Whittington, 2006)

To calculate the Nucleolus allocation the following formula is used (Wu & Whittington, 2006):

$$\text{Min}\left\{\underset{S}{\text{Max}}\left[v(S)-\sum_{i\in S}u_i\right]\right\}.$$

The rejection the amount that is allocated between a coalition is (Wu & Whittington, 2006):

$$v(S)-\sum_{i\in S}u_i$$

This formula thus calculates what the best payoff is when the objection of the allocation in a coalition is minimized, thus the worst possible situation with the highest possible payoff (Wu & Whittington, 2006).

This theory is useful because, first, when someone is asked to help decide during the negotiations, but the countries in the negotiations are not sure what is preferred by the one helping. This can be used as a base to help. Second, because it is based on the theory Core, the values are calculated in a way that no one will deviate from the coalition and ensures that there are economic incentives. Third, it takes into account all countries and the disadvantages which some countries have. Therefore, it equalizes the proposals of benefits (Wu & Whittington, 2006).

This research focuses on solving the conflict with cooperative Game Theory. The Core theory helps by making a list of possible solutions. The Core sets boundaries between where the

possible allocations should be considered. The Shapley and the Nucleolus theory help by determining the more specific point, like the bargaining power based on economic incentives each country or coalition has. However, the Shapley theory is more focused on fairness while the Nucleolus theory takes into account the countries with the most disadvantages. Table 9 shows the outcomes of the Shapley and Nucleolus theory again as a summary next to one another (Wu & Whittington, 2006).

Solution	**Allocation**
Nucleolus	
Egypt	3051
Sudan	2309
Ethiopia	1952
Equatorial states	1800
Per capita Nucleolus	
Egypt	2996
Sudan	2255
Ethiopia	2344
Equatorial states	1516
Shapley value	
Egypt	2960
Sudan	2280
Ethiopia	2049
Equatorial states	1823
Generalized Shapley value	
Egypt	2835
Sudan	1900
Ethiopia	2386
Equatorial states	1987

Table 9: Summary of the Nucleolus and Shapley value theory (Wu & Whittington, 2006)

Concluding from this research is that with the possible boundaries set by the nucleolus theory, a beneficial allocation can be constructed. This acts as a base for negotiations between a coalition. The characteristic function states that the most beneficial solution is to form a Grand coalition which gives a value of 4446 US$ $x10^6$. The Shapley value shows that working alone as a country or working together in a Grand coalition is most beneficial for the countries. The Generalized Shapley value, however, shows that a coalition with the countries Egypt and Sudan can only be beneficial when there is an upstream country included (Wu & Whittington, 2006).

Conclusion

Water is an economic good. This is because water has the issue of scarcity. When there is scarcity, there is a competitive market for this particular good. Participants in this market then have to make decisions based on maximizing their own utility. A conflict can rise about the allocation of an economic good, if property rights are not clearly specified, such as in the international context of transboundary water management. An example is an upstream country building a dam on a river, hurting a downstream country. This can be analysed and solved by the use of Game Theory. There are two sub-theories which can be used to solve this transboundary water resource conflict. The first one is non-cooperative Game Theory. By applying this theory, the results state that Egypt will retaliate in five of the six equilibria. The only equilibrium point, in which Egypt will not retaliate, is when the Upstream countries develop their own water development projects. Furthermore, another solution is that Ethiopia, Egypt and Sudan work together under the conditions of the NBI. To control the aggression of Egypt, an international community can help to resolve the conflict without aggression. This will influence the interactions between Egypt and Ethiopia for the better. These possible solutions open the possibility that the GERD can be built without negative consequences.

Cooperative Game Theory is the second sub-theory used. The solution concepts, which are applied in this theory, are the Core, the Shapley Value and the Nucleolus theory. These theories calculate how beneficial cooperation is between countries and how these benefits can be allocated to maximize every countries utility. By cooperation is meant sharing resources and coming to an agreement how much water each country has the right to obtain. There can be concluded that working together in a Grand coalition is the most beneficial option for the Nile Basin countries. However, Egypt is seen as an country with an aggressive attitude and not willing to cooperate. But looking at the results of the research, it is more beneficial for Egypt to work together. By means of working together, Ethiopia can for example build the dam and share the benefits with Egypt. First they can come to an agreement about how much water will be hold in the reservoir in Ethiopia and still be enough for Egypt to facilitate their country. Second, the hydropower generated from the dam can also be traded between the countries.

Following the conclusions from both non-cooperative and cooperative Game Theory, the building of the GERD can influence the relation between Egypt and Ethiopia in a good way. By

joining the Grand coalition or coming to an agreement with the help of an international community, the benefits can be allocated in the best way possible. However, there are still possibilities that the bad relationship between Ethiopia and Egypt will not be resolved. Without any negotiations or help, the chance that Egypt might retaliate against Ethiopia, if Ethiopia builds the GERD, are high.

Discussion

This chapter is built on two researches to answer the research question of this chapter. However, there are points of discussion. The research based on non-cooperative Game Theory has points which has to be taken into account. The upstream countries in the Nile Basin, except for Sudan, are taken together as one unity. However, it is the possibility that these countries does not see eye to eye on different aspects in the conflict. Therefore, putting them under one name can cause a wrong input in calculating the equilibrium points for the conflict. Furthermore, the players in the game might have more than three preferences.

The research based on cooperative Game Theory has some discussion points too. All the mathematical models give results which would be most beneficial for the countries, however it is never sure whether the countries will do what is most beneficial according to the calculations. The countries might be stubborn or don't want to work together no matter what benefits. Furthermore, in this research the upstream countries are too put together as unity with the name Equatorial states.

There are discussion points too for the whole chapter. Next time it might be better to do a research with only the two players Egypt and Ethiopia. Now, other players are involved while in this thesis the focus is only on Egypt and Ethiopia. Furthermore, the cooperative Game Theory is more focused on possible coalitions and less focused on the influences of the GERD. So the only possibility is to speculate on how the countries will react on the building of the GERD by applying the results of the Core, Shapley value and Nucleolus theory.

4 Integration

Three different disciplinary perspectives on the transboundary water interactions in the Nile Basin were given in the previous chapters. These disciplinary insights are not contradictory as much as they highlight different aspects of the same problem. In this chapter, all those insights are reviewed, combined, transformed and integrated into a more comprehensive understanding to answer the question central to this thesis: How does the Grand Ethiopian Renaissance Dam influence the transboundary water interactions in the Nile Basin between Egypt and Ethiopia? First, the disciplinary insights will be reviewed and conflicts will be analysed. Second, to achieve effective integration of the disciplinary insights, it is necessary to first create common ground between these disciplines. Common ground will be established using multiple techniques. Building on this, a more comprehensive understanding can be constructed. This more comprehensive understanding will be formulated in section 3, building on the common ground and the integration of the three disciplinary insights in the next sections.

4.1 Disciplinary Insights

Repko and Szostak (2017) state the definition of a disciplinary insight as: “a scholarly contribution to the clear understanding of a problem based on research”. It is of most importance to discover conflicts between insights, because it can prevent creating common ground and, therefore, the process of integration. The conflict between insights can be caused by differences in concepts, theories or assumptions (Repko and Szostak, 2017).

First, the insights of the discipline Environmental Sciences will be summarised. In this chapter, the main conclusion that can be stated is that during the filling of the GERD reservoir, the water supply in Egypt will be negatively affected. Once the GERD is operational, this negative impact on Egyptian water supply will decrease. However, the extent of the impact of the GERD during the filling and post-filling periods strongly depends on the filling and operation policy of Ethiopia and to what extent Ethiopia takes Egypt’s needs in consideration. Furthermore, the reduced water flow downstream results in decreased water availability for irrigation, decreased electricity production and seawater intrusion in Egypt. To establish the optimal filling period of

the GERD, cooperation between Ethiopia and Egypt is required. The optimal operation policy at least requires the GERD to store extra water during wet seasons and release extra water during dry seasons. The Water-Energy-Food nexus could prove a valuable tool in allocating water resources between Egypt and Ethiopia to improve overall benefits for the Blue Nile Basin. Lastly, the AHD and GERD should be operated in accordance and groundwater pumping should be reduced 60% with a filling period of 3 years and 30% with a filling period of 6 years to prevent seawater intrusion.

In the second Chapter, the focus was on the political aspect of the transboundary water interactions in the Nile Basin. The dynamics of the hegemonic situation were analysed from the perspective of International Relations. Egypt and Ethiopia are seen as hegemonic and non-hegemonic powers, respectively. This power relationship can be classified as being asymmetrical and being maintained in the three dimensions identified by Lukes (2004). Hegemony is maintained through both force and 'voluntary' consent. Compliance with the hegemonic status quo can be reinforced through four mechanisms, often simultaneously used: coercive, utilitarian, normative and ideological mechanisms. The building of the GERD by Ethiopia can be seen as a disruption of the hegemonic situation. This counter-hegemonic move can be the beginning of a period of contest and resistance through coercion, manipulation and transformation. If Egypt does not comply with the new status quo, the result might be that a conflict emerges. This can have various intensities. In the far future, this might result in a new order with either Ethiopia as a new hegemon or a more equal balance of power.

Third, the GERD was analysed by the discipline of Economics. Water can be seen as an economic good, which can cause conflicts when there is scarcity. By applying the two sub-theories from Game Theory, a possible solution can be constructed for the Nile Basin conflict. The first theory is the non-cooperative Game Theory which gives multiple equilibria, however in five of the six equilibria Egypt retaliates against the other countries. The research concludes that with the help of an international community the aggression of Egypt can be controlled and therefore come to a solution which will not include retaliation. The second theory is the cooperative Game Theory. This shows, by the use of coalitions, that it is possible to resolve the conflict. Following the application of The Core, The Shapley value and Nucleolus theory, it can be concluded that it is most beneficial for the Nile Basin countries to participate in a Grand Coalition. Despite Egypt's mostly aggressive attitude, Egypt will benefit more from cooperation, than working alone.

4.2 Conflicts and Common Ground

According to Repko and Szostak (2017), conflicts between disciplinary insights are inevitable when analysing a problem from different disciplinary perspectives. These conflicts obstruct integration and therefore need to be overcome creating common ground before integration is possible. The conflict central to this research is the different epistemological approaches applied within the different disciplines and the resulting matching research method. The disciplinary insights within this research were drawn from disciplines embedded in the Natural Sciences and the Social Sciences. Natural Sciences apply empiricism, stressing that knowledge is created by the five senses and makes use of observation and experimentation. Environmental Sciences belongs to the Natural Sciences and combines elements of the following disciplines from the Natural Sciences: Biology, Ecology, Physics, Geosciences, Chemistry and Climatology. However, according to Repko and Szostak (2017), the epistemology of Natural Sciences is "inadequate for addressing value issues" (p. 46). In contrast, Social Sciences apply multiple epistemologies and are able to address these value issues Natural Sciences cannot address. Economics applies quantitative and qualitative research. By making use of statistical analyses, mathematical theories and mathematical modeling, economist analyse different kind of situations and conflicts. In International Relations, a variety of research methods and epistemologies are used, depending on the theoretical underpinning that is used. For this research, the focus was on a qualitative understanding of the case of the Nile Basin. Integrating disciplines within only Natural Sciences or Social Sciences involves minimal epistemological conflicts and is what Repko and Szotak (2017) call 'narrow interdisciplinarity'. Integrating disciplines from both the Natural Sciences and Social Sciences, as applied in this research, however involves conflicting epistemologies; a so called 'wide interdisciplinarity' (Repko and Szostak, 2017).

In this research, the distances between the theories, concepts and assumptions is the main conflict between the disciplines. Adding to these epistemological conflicts, there are three other conflicts based on concepts between the disciplines. These distances can be overcome by using the common ground techniques from Repko and Szotak (2017). The techniques that will be used are 'extension' and 'organization'. 'Organization' concerns mapping the relationships between the different disciplinary insights to create common ground. 'Extension' involves expanding the

broadest concept so that it encompasses the other concept. These techniques are applied on the conflicts about the concepts ‘water’, ‘power-asymmetry’ and ‘scale conflict-harmony’.

4.2.1 Epistemological Distance

The epistemological distance between the disciplines is a conflict that cannot be solved, since the epistemologies are embedded within and fundamental to the disciplines. Common ground can however be created by mapping how the disciplines relate to one another. Environmental Sciences makes use of quantitative research, while International Relations is based on qualitative research. Economics makes use of both quantitative and qualitative research. Figure 5 displays the relation between the disciplines. The arrows between Environmental Sciences and International Relations are small, meaning that there is almost no overlap between the disciplines regarding concepts, theories or insights. In general, the disciplines do influence each other: climate and nature are subject to governance and the effects of governance are felt in the climate and nature. In this particular thesis, no overt connections are made, but water and politics are connected. The disciplines Economics and Environmental Sciences both give a definition of water, this is however conflicting and will be drawn upon in the next paragraph. Furthermore, Economics influences the choices a country makes about natural resources and natural resources influence the economy of a country. They therefore influence each other and the arrows connecting these disciplines are thus relatively larger. Economics and International Relations have the biggest overlap. The concept of power asymmetry and the scale of conflict and harmony both are described in the disciplinary chapters. Furthermore, politics and economics are close areas. Politics makes important decision which influence economics, for example a treaty between the conflicting countries can help allocating their resources which will benefit their national economics the most. Therefore, the arrows are the biggest.

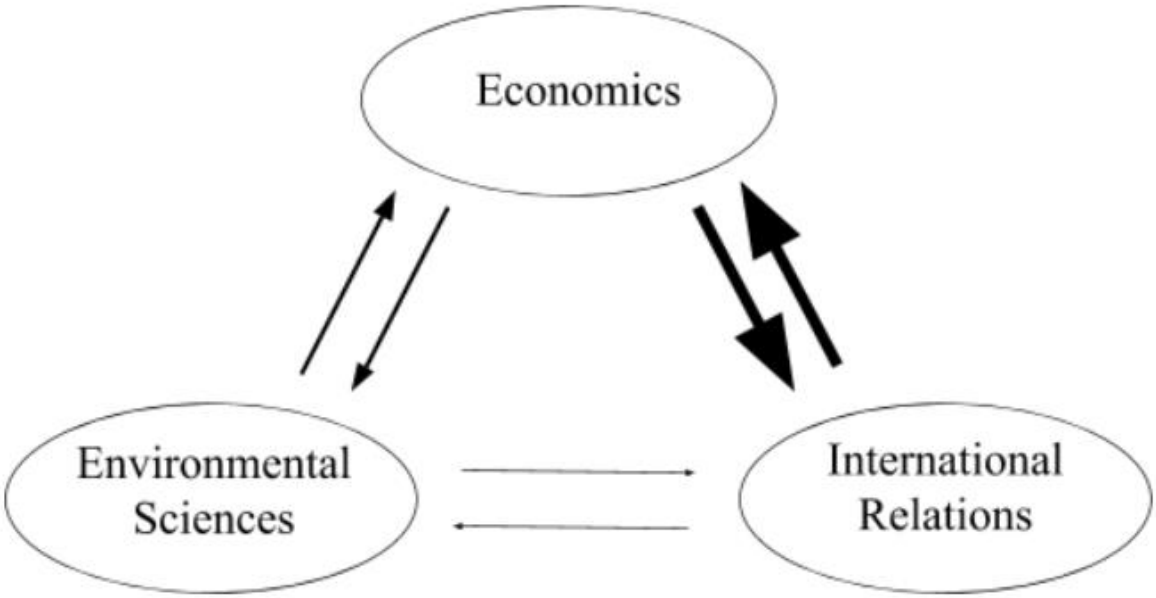

Figure 5: *The three disciplines displayed in an Organization chart that views the strength of the connection between the three disciplines.*

4.2.2 Water

The concept ‘water’ holds a conflict that is embedded within the disciplines Economics and Environmental Sciences. The disciplines Environmental Sciences and Economics both view ‘water’ differently. Environmental Sciences regards water mainly by the use of the concept ‘water security’, which is a general concept in this discipline. Water security is defined as a reliable access to an adequate quantity and quality of water to sustain a healthy lifestyle. However, Economics views water as an economic good, because there is a competitive market for it. The emerging problem for water is the combination of being a non-renewable good and water scarcity. The possibility of the demand being higher than the quantity supplied causes the natural resource to diminish.

This conflict can be overcome by creating common ground between the two disciplines using the ‘organization’ technique. The redefined concept will be the opportunity to create common ground and overcome disciplinary disagreements. Water scarcity and security both focus on the value of water. Water scarcity concerns solely the extrinsic value of water and water security

highlights both the intrinsic and extrinsic values of water by focusing on both the quantity and quality of reliable water supply. A new definition of the concepts water scarcity and water security can therefore be a combination of the intrinsic and extrinsic values of water: access to an acceptable quantity and quality of water, is required to sustain a healthy life and because of its value, it becomes a scarce resource, susceptible to market influences.

4.2.3 Power Asymmetry

The conflict present in the term 'power asymmetry' between the disciplines International Relations and Economics is based on the use of the concept. International Relations defines and uses the concept, Economics only uses it but does not define it. In IR, power asymmetry is the key concept in analysing hegemony. Power asymmetry is the notion that one actor has more power than the other**.** This power is expressed through different levels: coercive, bargaining and ideological power (Lukes, 2004). The hegemonic situation can only be maintained through power, because it involves actors with unequal power. This inequality might result in resistance from the non-hegemonic power to change the international system and become more powerful. This might result in a new asymmetrical relation or a new order with an equal balance of power.

However, Economics uses power asymmetry only implicitly. Game theory does not only include economic factors, but also political and cultural factors. It is the basis for the theoretical and empirical research. The results, constructed by Game Theory, show that Egypt influences the decisions made by the other countries in the Nile Basin. They are scared Egypt will retaliate against them. This implies there is power asymmetry.

Therefore, using 'extension' for creating common ground is the most fitting. Using the implicit insight of Economics and expanding it with the theory of IR will give a more complete understanding of what power asymmetry is. The more powerful actor defines most outcomes in favour of themselves which is shown in the results, this implies power asymmetry. In those outcomes, the less powerful countries are negatively impacted by the more powerful actor. It might however also have positive results for the less powerful actor, as they will contest the power asymmetry and create a new balance of power.

4.2.4 Scale Conflict-Harmony

The disciplines Economics and International Relations have a conflict on the scale between conflict and harmony. International Relations states that there are five different outcomes between conflict and harmony. Harmony and conflict are two extremes on the scale. Economics however, states in the results that possible options are that retaliation, doing nothing or cooperation. For creating common ground, the technique of 'organization' is applied. First by displaying both the disciplines in Figure 6 and determining the overlapping portion of the concept.

Figure 6: 'Organization' technique to integrate both disciplinary definitions into an overlapping common definition

In Figure 6 is shown how Economics and International Relations have similar and overlapping ideas about the different levels of conflict. These differences can be solved by comparing the concepts of scale and introduce a new scale based on the Nile Basin that combines the two disciplines. War in Figure 6 is seen as an extreme consequence of retaliation.

4.3 More Comprehensive Understanding

Now that common ground has been created, a more comprehensive understanding can be formulated. The Transformative Disruption Model in Figure 7 shows an overview of how the more comprehensive understanding is constructed in this research. The model is based on the sequential integration technique, identified by Repko and Szostak (2017) as a "sequential causal order" (p. 328). The model shows a causal order on how the transboundary water interactions between Egypt and Ethiopia can evolve. First, the model combines different aspects of the situation before the construction of the GERD and the situation after the construction of the GERD. Second, the model shows that the tensions between Egypt and Ethiopia can evolve into harmony, conflict or any point on a scale between these two extremes. Last, the model shows resolution mechanisms for the scale of possible outcomes. The sequential steps of the model consist of different aspects that form the situation before or after the GERD. The conflict or harmony situation after the GERD and the scale between them also consists of multiple impacts. Therefore, the sequential integration technique has been combined with the multicausal integration technique. The multicausal technique can be defined as a technique where "several variables combine to produce an effect" (Repko & Szostak, 2017).

The transformative disruption model in figure 7 is the more comprehensive understanding organized in a model. The model follows in the paragraphs below, where each part of the model will be discussed starting with the situation before the GERD was built.

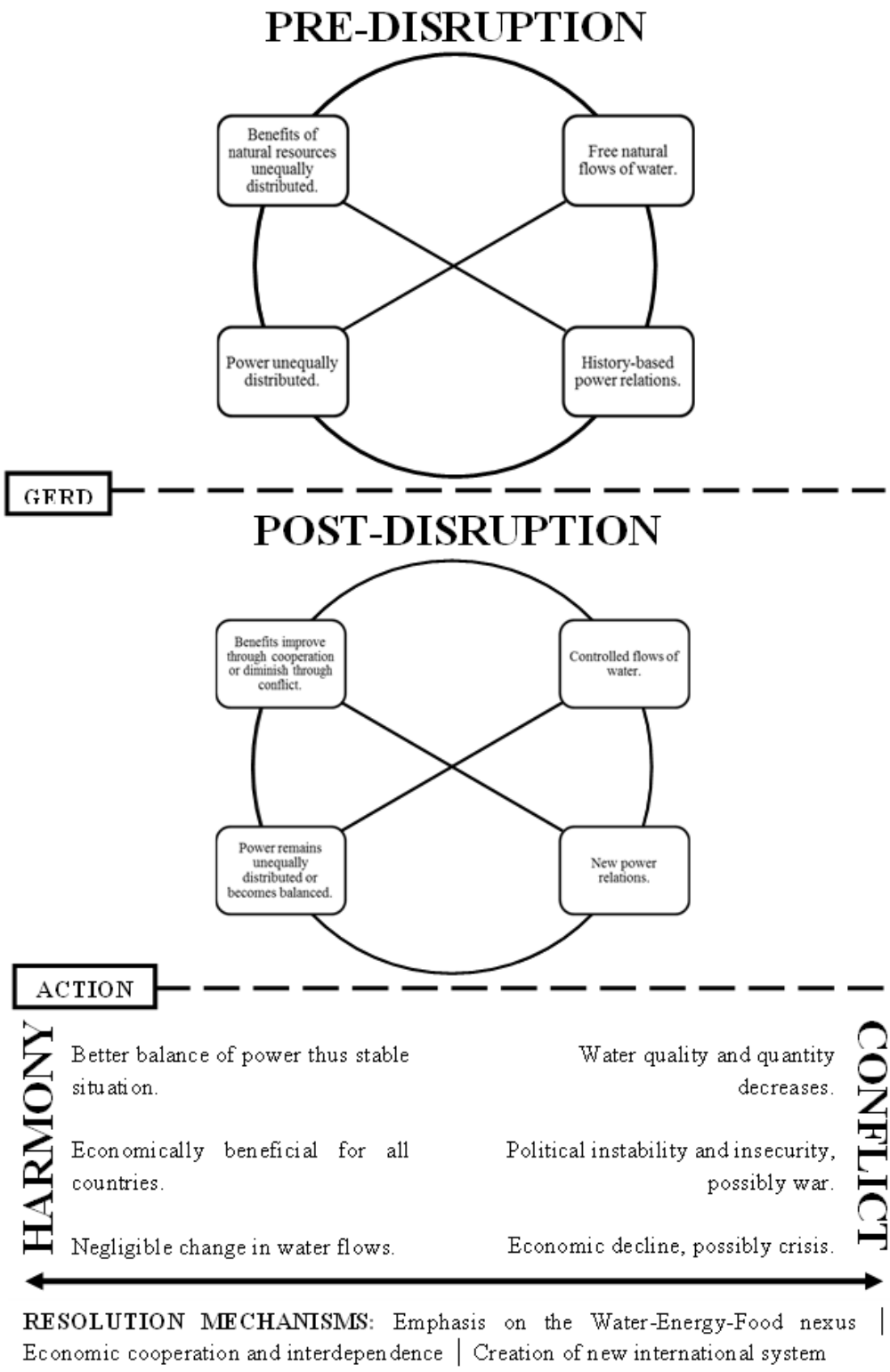

***Figure 7**: Transformative Disruption Model, which shows the situation before and after the building of the GERD. Egypt then can choose to accept the building of the GERD or start a conflict, which is followed by potential resolution mechanisms.*

4.3.1 Situation Before the GERD

Before the building of the dam, Egypt experiences interannual variability of water supply. With the annual flooding, grounds become fertile and can be used for agriculture. During this period of natural flooding, the 1959 treaty is the base point for Egypt and Sudan to regulate the water flows. The upstream countries are not satisfied with this treaty, because it excludes their rights of participating in the consumption of the Nile. Egypt has the most power in this period. It can enforce ideas with economic or military sanctions, it has the power to tell other countries what to do and manipulate countries to think they did agree on their own terms.

Ethiopia is struggling with the access to electricity, because the majority of the population has no access to it. The country itself does not have the most power in this conflict to make changes, but it is not powerless. Ethiopia strives to get out of the current 1959 treaty, to build their own water development projects and improve their own economic position.

4.3.2 Situation After the GERD

This section discusses the situation between Egypt and Ethiopia after the completion of the GERD expected in 2022. There will be a dramatic reduction of the Nile water flow during the filling period of the GERD reservoir. During the post-filling operation of the GERD this negative impact will decrease, however Egyptian water supply will still be lower compared to the situation before the completion of the GERD and Egypt will face seawater intrusion and decreased hydroelectricity generation. From a cooperative point of view, Egypt and Ethiopia will work together to gain maximum potential benefit from the situation. From a non-cooperative point of view, Egypt will retaliate and attack with economic or military forces. Moreover, Egypt loses face since Ethiopia has openly contested their position. Ethiopia will however gain more power and respect due to negotiations of the CFA in the NBI. Ethiopia may thus become a new hegemonic leader or establish a new kind of international system that is more equal.

4.3.3 Harmony/Stability

If Egypt accepts the existence of the GERD, it can be the beginning of a new Grand coalition, which will be economically beneficial for all the countries of the Nile Basin. The building of the

dam can be a turning point which will break the status quo in the relations between Egypt and Ethiopia. The balance of power can therefore be more equal and the situation more stable. And if Ethiopia takes Egypt's water needs into account, the reduction of the Nile flow during day-to-day activities is neglectable.

4.3.4 Conflict

The intensity of the conflict could vary from cold, unstable peace to violent war. The 1959 treaty only allocated the resources between Egypt and Sudan; no agreements between Egypt and Ethiopia were made. The other upstream countries were left out and therefore are forbidden to build their own water development projects. However, Ethiopia wants to improve their economic position by building the GERD. As a result, Egypt might experience a dramatic reduction of water supply, if Ethiopia does not take into account the needs of Egypt. Furthermore, Egypt might face seawater intrusions and a decrease in water quality, resulting in economic downfall. The conflict could worsen if Egypt contest the emerging power of Ethiopia. It might want to re-establish their hegemonic position and thereby trying to restore their economy. The conflict could easily escalate if the countries retaliate with economic or diplomatic sanctions or military interventions.

4.3.5 Resolution Mechanisms

There are multiple mechanisms to resolve the potential conflict. First, Ethiopia should collaborate with Egypt to find the optimal operation policy. Egypt and Ethiopia should collaborate to find the optimal allocation of water to hydroelectricity production and irrigation. The WEF nexus is a valuable tool in establishing this. Furthermore, the AHD and GERD could be operated in accordance, AHD reserves should be at least 10 BCM at all times, a part of the GERD reservoir should be reserved for downstream use, groundwater pumping should be reduced. Viewed from a non-cooperative Game Theory point of view, Egypt will retaliate in most situations except for one equilibrium point. This point is when the upstream countries develop their own water development project and Egypt, Ethiopia and Sudan collaborate through the NBI. From the International Relations perspective, Egypt would have to comply with the new status quo to have a chance of

holding some influence and power, thereby accepting the situation. Another option would be to create a completely new, unknown system outside the hegemonic system.

Conclusion

According to BBC (2018) “the world’s next war will be fought over water”. This shows the importance of water management in the future. It might be extremely complicated but also important to manage waters that exist on the boundaries of multiple countries. Transboundary water interactions in the Nile Basin are very complex, as the Nile counts eleven riparian states. BBC (2018) acknowledges that “there are few places as tense as the river Nile.”. The building of the GERD by Ethiopia is exactly the kind of provocation that could make the situation in the Nile Basin escalate into a conflict or even war. To avoid this, it is necessary to identify potential consequences of the GERD for the transboundary water interactions. Therefore, the following research question was investigated in this thesis: How does the Grand Ethiopian Renaissance Dam influence the transboundary water interactions in the Nile Basin between Egypt and Ethiopia? A sufficient answer to this question can only be given if multiple disciplines are involved.

The reason for this interdisciplinary approach were fourfold, as identified by Repko and Szostak (2017). First, the problem is complex. The meaning of complex is that it has to be studied from different disciplines. Especially for this transboundary water resource conflict, the disciplines Environmental Sciences, International Relations and Economics are necessary to analyse the conflict. Second, every discipline provides insights and theories for the problem. The disciplines used strengthen one another where needed. Furthermore, the disciplines combined can give a complete answer to the research question. Third, not one discipline can give a complete answer on the research question. Every discipline focuses on different aspects of the problem. Fourth, the problem is a societal issue which is far from being resolved, therefore it needs problem-based research. No agreement has been reached and there are concerns the conflict might escalate.

In chapter one, the discipline Environmental Sciences analysed the impact of the GERD on the water supply in Egypt. Furthermore, consequences of a changed water supply in Egypt were researched and responses to these problems were formulated.

In the second Chapter, the discipline of International Relations studies the relations between different actors (e.g. states, international institutions and regional organisations) with a main focus on politics, organizations, law and culture. It provided insights into how ideas such as power, hegemony and conflict are intertwined and combined into one framework to understand the situation in the Nile Basin from an IR perspective.

In Chapter three, the Economic discipline applied Game Theory to find potential solutions. Game Theory is not only focused on economic variables, but also other aspects of the issue, such as environmental and political preferences of the countries.

In the fourth Chapter, the disciplinary insights are combined and common ground is created. With this common ground, a more comprehensive understanding was constructed with the help of the transformative disruption model. This model shown in Figure 7 gives an overview of how the situation in the Nile Basin might evolve. The first stage is the situation before the dam was being built. Power is unequally distributed, the Nile flows naturally and resource allocation is not equally distributed. Then the dam is built, which causes the flow of the Nile to be controlled, the power is distributed more equally or stays unbalanced and benefits are shared more equally when there is no conflict. If the situation does not escalate after the building of the GERD, a coalition can be formed which would be economically more beneficial. The power between countries is more equally distributed. However, if this leads to a conflict, it might escalate to a war. If that would happen, the economic benefits are low. Also, the supply of water decreases dramatically for Egypt, as Ethiopia would have little incentive to keep the water flowing.

The three disciplinary Chapters and the integration together result in a final, more comprehensive answer to the research question. Due to historical political processes, economic forces and scarce natural resources, the transboundary water interactions between Egypt and Ethiopia are extremely complicated. In building the Grand Ethiopian Renaissance Dam, Ethiopia has begun to challenge the current, fragile situation. In the future, it will become clear what choices both countries have made regarding the situation. A positive outcome would be a change in the political system from a hegemonic one to a more equally balanced international order with an intense economic cooperation with benefit-sharing and win-win solutions to the problems that the building of dam might have for the water supply of Egypt. A negative outcome would entail that the water supply of Egypt will be completely regulated by Ethiopia, causing severe damage to Egypt's natural resources (e.g. salination of the water) and thereby its economy, that is depending on the natural resources derived from the river. Egypt might want to openly confront Ethiopia with these potential damages and intensify the political conflict into war. The two situations sketched above are not the only options; they are the extremes on a scale of possibilities, ranging from stable peace through unstable peace and cold conflict to complete war with all economic and natural measures and consequences involved. It is obvious that the most beneficial outcome would be to

form a Grand coalition, which includes all the countries in the Nile Basin. The allocation can therefore be done more peaceful and increase the equal distribution of resources through mutually interdependence by linking water, economy and politics together. This way, a water war will hopefully be avoided. Peace and stability then have the chance to blossom.

Discussion

According to Tayia (2019) transboundary water conflicts have a foundation consisting of three components: natural resources, sovereignty and survival. The other two types of conflict which are not of importance for this type of conflict are honour and ideology (Tayia, 2019). This implies that multiple disciplines can be excluded, like religion studies. However, as mentioned in the introduction, Tayia (2019) states that Environmental Sciences, International Relations and Economics are of extreme importance to solve transboundary water conflicts.

The disciplines contributing to this research have their own benefits and limitations. The Environmental Sciences makes a useful contribution to this research by mapping how the operation of the GERD affects the water supply in Egypt. It is purely based on models and these models are based on assumptions. Moreover, the situations can change and factors like climate change can cause the outcomes to vary. International Relations has focused only on states, not on other groups which might be of importance. It shows a simplified version of a very complex reality with many variables that might prove important in the future but seem insignificant in the present. Economics uses models where players are determined. One player in particular is called "the upstream countries/equatorial states". These are the less powerful and influential upstream countries, which are taken together and studied as one entity. These countries have their own agenda and interests in the situation and perhaps react differently than might be expected. It is however argued that Egypt and Ethiopia are the main players in this situation and will most likely have the biggest influence on how the future will be.

The epistemological distance between the disciplines can be seen as a complication, because finding overlap in concept, insight or theories is difficult. However, because of this wide interdisciplinarity, a broader area of the conflict can be studied. Broader than other possible disciplines together. Some combination of disciplines might have too much overlap, for example, International Relations, History and Religion Studies.

Reflecting on the interdisciplinary process, most of the steps that Repko and Szostak (2017) identify regarding the interdisciplinary research process are followed. However, STEP 3, defined as "Identify relevant disciplines' by Repko and Szostak (2017), has been moved to the beginning of the process within this research process. The disciplines were put together before choosing a subject, so step 3 was conversed: identify a relevant topic to the disciplines. Within the process of

"integrating disciplinary insights" (Repko & Szostak, 2017, p. 78), the common ground that was formed at first, later appeared to be the more comprehensive understanding and a new common ground had to be created. Therefore, the final common ground was formed after forming the more comprehensive understanding. Thus, STEP 8 "Create common ground between insights" was moved forward (Repko & Szostak, 2017). The disciplines that had to be involved within the research were thus determined at the start of the process and the insights used in the integration were based on the disciplines of the students involved. This process excluded other disciplines that may have been useful answering the research question, such as History.

It is furthermore important to reflect on the limited understanding of the authors. Competency of a student within a discipline does not guarantee that all theories, assumptions, concepts and methods of disciplinary papers can be understood completely because of the limited knowledge and this could have influenced the disciplinary insights. However, disciplinary insights were carefully considered while integrating and the impact on the more comprehensive understanding should therefore be negligible. This careful consideration however could also oppress disciplinary nuances. For example, Environmental Sciences concerns various nuances regarding the lower water supply in Egypt that cannot all be taken into account during integration. Despite neglecting extensive disciplinary nuances, it is argued that the more comprehensive understanding is still valid since the model formulated in the more comprehensive understanding provides an organized overview of situations before and after the GERD in the Nile Basin and gives an understanding of the tensions regarding the GERD. The understanding of the situation has thus advanced by this integration. It can also serve as a framework that can be extended, adjusted and used in other similar transboundary water interaction tensions. Moreover, the validity of the model is based on the disciplinary data. On the one hand, this enhances validity, considering the models that the disciplinary insights were based on, are both theoretical and simulated. On the other hand, validity could be affected by the notion that the more comprehensive understanding is based on models projecting the future based on assumptions and theories, and that the actual future events could differ from projections. Last, the research process has been positively experienced, the students worked well together and learned much from each other and their disciplines.

The model introduced in this thesis contributes to the existing literature by combining insights from three very different, but crucial disciplines into a comprehensive study. It has looked at the process of change, not just individual events which can make it a more dynamic and valuable

explanation. It will hopefully shine a light on aspects of the transboundary water interactions in the Nile Basin that might not have been previously known in the different disciplines. This model can serve as a starting point of further research into the topic of transboundary water interactions in the Nile Basin and different areas of the world, possibly incorporating more disciplines. For example, International Law could be useful by contributing an in-depth analysis of treaties and agreements between the riparian states of the Nile Basin or other areas.

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