Bridging the Information Gap between Scientists and Decision Makers in the Eastern Nile

M. H. Barendrecht

TU Delft

NUS National University of Singapore

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By

M. H. Barendrecht

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Supervisor:	Prof. dr. ir. W. G. M. Bastiaanssen	
Thesis committee:	Dr. E. Mostert,	TU Delft
	Ir. H. Smit,	Unesco-IHE
	A. Onencan,	TU Delft
	Dr. Ir. B. Enserink	TU Delft
	Dr. Ir. Pat Yeh	NUS
	Prof. Dr. Liong	NUS

PREFACE

This thesis is about bridging the information gap between decision makers and scientists in the Eastern Nile. It shows that there is more to doing research for decision making than the research itself and scientists should realize this if they want to bridge the information gap. What makes the outcome of this research especially valuable, is that it is based on the opinion of decision makers themselves.

Without the help of Prof. Dr. Ir. Wim Bastiaanssen, who enthusiastically provided me with his contacts and ideas this thesis research would not have happened in the first place. Thanks go to my committee for their help and feedback. My thanks also go to Prof. Dr. Safwat Abdel Dayem, Prof. Dr. Yasir Abbas Mohamed, Mr. Abdo Elgadir, Mr. Yasir Hageltom and the ENTRO staff, for providing me with the necessary respondents and helping me contact them and for their generous help during my stay in their respective countries: without them this research would not have been possible.

CONTENTS

LIST OF ACRONYMS

Acronym	Definition
CFA	Cooperative Framework Agreement
COM	Council of Ministers
DSS	Decision Support System
ENCOM	Eastern Nile Council of Ministers
ENPM	Eastern Nile Planning Model
ENSAP	Eastern Nile Subsidiary Action Program
ENSAPT	Eastern Nile Subsidiary Action Program Team
ENTRO	Eastern Nile Technical Regional Office
GERD	Grand Ethiopian Renaissance Dam
JMP	Joint Multipurpose Project
NBDSS	Nile Basin Decision Support System
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
SAP	Subsidiary Action Program
SVP	Shared Vision Program
TAC	Technical Advisory Committee
WA+	Water Accounting Plus

ABSTRACT

Scientific research is scarcely used for policy making (Hickey, Forest, Sandall, Lalor, & Keenan, 2013). The problem is as much a lack of communication of research results as a mismatch between the information produced by scientists and the information needed by the decision maker (Hickey et al., 2013; Timmerman, 2004). This information gap is a problem all over the world, but it is perhaps an even more important issue in the Nile River Basin. The Nile river flows through eleven countries and these countries have to share its relatively small flow of 84 BCM (as measured at Dongola, Sudan). There have been several Nile treaties that allocate shares of the Nile waters to the various countries and try to ascertain that there will always flow sufficient water to the downstream countries (Salman, 2013). The latest treaty, which is still operative, is the 1959 Nile Waters Agreement (Nile Treaty, 1959). This agreement, between Egypt and Sudan, divides the complete flow of the Nile between these two countries. The other countries do not accept this treaty and claim that they also have the right to use (part of) the Nile waters. That this gives rise to conflicts is no surprise, especially in the Eastern Nile Basin, which includes both the biggest consumer of (Egypt) and the biggest contributor to (Ethiopia) the Nile flows. While scientists of the different countries are able to work together, they are not able to communicate their research findings to the decision makers and therefore, the conflict at the decision making level remains. Bridging the information gap is an important step in bringing the countries towards further cooperation. The water accounts of the Nile Basin (Karimi, Bastiaanssen, & Molden, 2013) might provide a useful tool in bridging this gap. Because of their tangibility, transparency and integrated approach, they might be a more comprehensible and trusted resource for the policy makers in the Eastern Nile countries. The aim of this research was therefore to identify and describe the information gap and determine whether Water Accounting + can indeed help in bridging it.

There are two sides to the information gap: (1) the decision makers' information needs and (2) the information provision by the scientists. This includes not only the information itself, but also the presentation and the way it is communicated. The decision makers' information needs were assessed using open, in-depth interviews. Five elements of useful research were derived from the information needs: multidisciplinarity, relevance, usefulness, presentation and trust. Additionally, a framework for the evaluation of water resources and hydrological models was developed based on a literature review. The framework was adapted according to the interviews results. Both the elements of useful research and the framework were used to evaluate the research that is done by the scientific community of the Eastern Nile. The models used and developed by the Eastern Nile Technical Regional Office, as well as the research presented at the New Nile Opportunities Conference and the publications on water resources management in the Nile of the year 2014 were evaluated to determine their usefulness for decision making.

Comparing the two sides enabled the identification of the information gap. On one side of the gap are the decision makers. They need multidisciplinary research that is tuned to their personal needs and the needs of society. It should be relevant (i.e. address an issue that the decision maker wants to solve) and

provide plans and options, with pros and cons. It should be presented in a short message, avoiding jargon and provided by someone they trust. The analysis of the research that is done by the scientific community shows that the scientists are producing research on the technical aspects only, not taking into account the socioeconomics or other aspects. Also, their research is not focused on the needs of the countries and generally does not provide any plans. ENTRO is highly restricted by its mandate and can only disseminate its research outcomes if the countries all agree on the outcomes.

With the information gap identified the usefulness of Water Accounting + in bridging this gap was assessed. The water accounts were evaluated using the framework and on their compliance with the elements of useful research. Additionally, the interview respondents were asked for their opinion on Water Accounting +. Both decision makers and scientists think that Water Accounting + is a useful concept and that it can give the decision makers a basic understanding of the water resources in a river basin. It can provide a more multidisciplinary approach to water resources management, provided that the socioeconomic aspects are included. However, Water Accounting + should, just like other research, try to address issues relevant to the countries and provide clear messages and options for the decision makers. Trust is a very important issue. The decision makers in the countries are not likely to trust any other data than their own, nor will they trust a scientist they do not know. This problem can be partly dealt with by validating the accounts together with national experts and international peers. Also, it is probably better to target the decision makers' advisors instead of the decision makers themselves when presenting the accounts. It is recommended to construct water accounts on national level and address the current needs of the individual countries. Once the water accounts are accepted at a national level, they might be trusted to give basin wide solutions, as well.

1 INTRODUCTION

1.1 The Eastern Nile

1.1.1 Hydrology of the Eastern Nile Basin

The Nile River is almost 6700 km long and flows through eleven countries, including: Burundi, the Democratic Republic of Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, the Sudan, Tanzania and Uganda. Although it is one of the world's longest rivers, it is not among the world's biggest rivers in terms of flow. The maximum annual flow of the Nile is believed to be 84 billion cubic meters at Dongola (Sudan) and has to be shared by these eleven countries. For the sake of reference, the total rainfall is 2008 km^3/yr (Hillhorst et al., 2011). Therefore good cooperation among these countries is essential to maximize the benefits and avoid conflicts.

The Nile river has 15 sub-basins (Figure 1), which are divided into two regions. One is the Equatorial Lakes region consisting of the Kagera, Lake Victoria, Semliki-Lake Albert, Victoria Nile, Albert Nile-Bahr al Jabal and Bahr el Gazal sub-basins, together contributing 15 % to the annual maximum Nile flow. The second is the Eastern Nile region consisting of the Sudd, Baro-Akobo-Sobat, Lower White Nile, Blue Nile and the Main Nile sub-basins and contributing 85% to the maximum annual Nile flow.

Figure 2 and Figure 3 present the spatial distribution of precipitation and evapotranspiration in the Nile Basin, respectively. While the southern half of the basin is very wet, the northern half (Egypt and Sudan) is very dry. Precipitation is minimal in Egypt but the country's evapotranspiration is high in case there is water available to evaporate. This water mainly originates from the "Water tower" in the Eastern Nile. Since all of the Eastern Nile water stems from the Ethiopian Highlands, Ethiopia is the main contributor to the Nile flow. By being the biggest consumer of as well as the biggest contributor to the Nile waters, the Eastern Nile is the most important and the most conflict prone (with regard to water resources) region within the Nile Basin. Therefore this research focuses on the Eastern Nile region only (Figure 4).

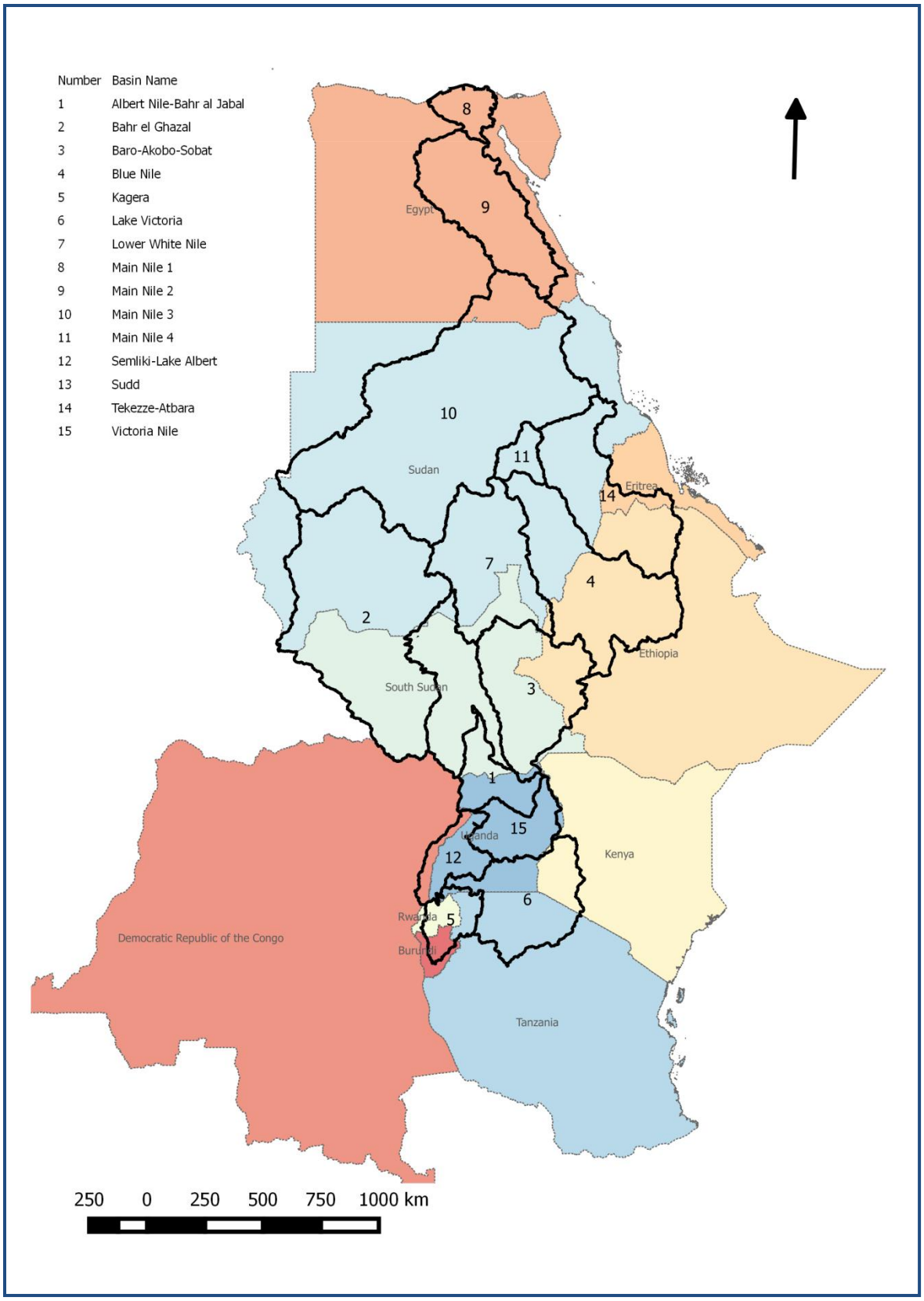

Figure 1 The Nile Basin and its sub-basins, according to the official boundaries assigned by the Nile Basin Initiative (NBI).

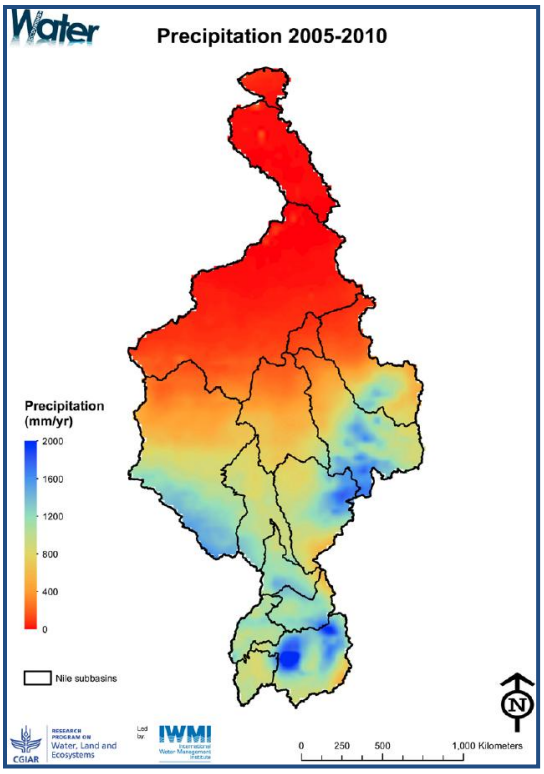

Figure 2 Average annual (2005-2010) precipitation in the Nile Basin - (www.wateraccounting.org)

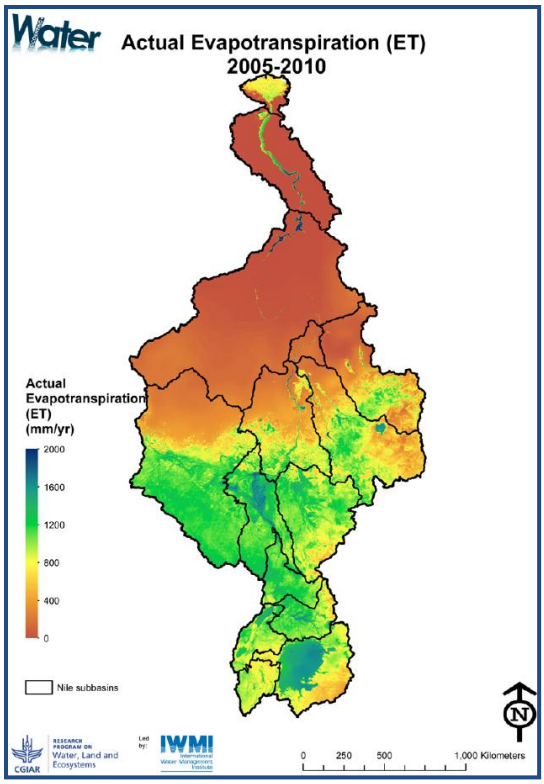

Figure 3 Average annual (2005-2010) evapotranspiration in the Nile Basin - (www.wateraccounting.org)

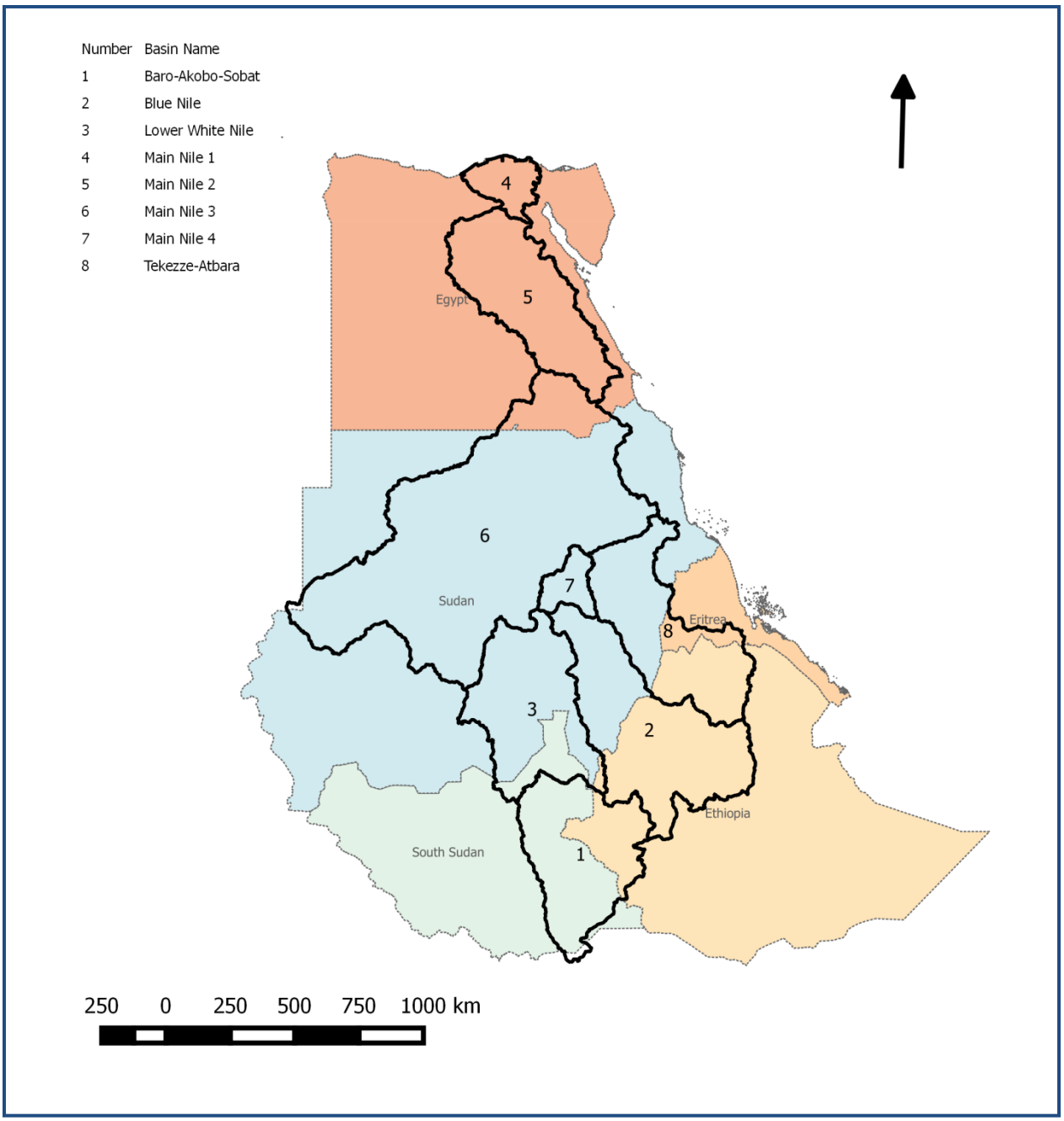

Figure 4 Eastern Nile Definition of Sub-Basins, according to the official boundaries assigned by the Nile Basin Initiative (NBI).

1.1.2 Politics of the Eastern Nile Basin

There have been several Nile treaties, first under colonial rule and later between the sovereign countries. These treaties allocate shares of the Nile waters to the various countries and try to ascertain that there will always flow sufficient water to the downstream countries, regardless of the structures that are built in the upstream countries (Salman, 2013). The latest treaty, which is still operative, is the

1959 Nile Waters Agreement (Nile Treaty, 1959). This agreement, between Egypt and Sudan, divides the complete flow of the Nile between these two countries. The other countries do not accept this treaty. They claim they also have the right to use (part of) the Nile waters. Despite their disagreement the countries made several attempts to work together, finally resulting in the creation of the Nile Basin Initiative (NBI), in 1999. The NBI being only a transitional institution, the countries agreed to continue negotiation to come up with the Cooperative Framework Agreement (CFA). However, the negotiations on the CFA have refuelled the conflict on the 1959 Nile Waters Agreement. Sudan and Egypt stick to their historical rights, which gives them the right to use all of the Nile waters, whereas Ethiopia and the other countries claim that they were not part of the agreement and want to renegotiate the agreement. At the moment six of the eleven countries have signed the CFA and Ethiopia has already ratified it, which means that it is now possible that the CFA enters into force. Upon the signing of the CFA in 2010, Egypt and Sudan pulled back out of the NBI. In 2013 Sudan has returned, but Egypt was still not willing to rejoin at the start of this research. Recently, however, Egypt attended an NBI meeting for the first time in five years (Nader, 2015).

One cause of this renewed participation could be the Grand Ethiopian Renaissance Dam (GERD), which is under construction in Ethiopia. Egypt and Sudan may fear that this project will diminish flows to their countries. However, Sudan was convinced by Ethiopia to see the benefits of this project in terms of flood reduction and more regular flows throughout the year. The three countries created an international panel with experts from the three countries as well as international experts to investigate the effects of the dam (Salman, 2013). Just after Egypt's return to the NBI, the three countries signed an agreement of principles with regard to the dam in March 2015 (Anonymous, 2015).

The Nile Basin Initiative

"The Nile Basin Initiative (NBI) is a regional intergovernmental partnership that seeks to develop the River Nile in a cooperative manner, share substantial socio-economic benefits and promote regional peace and security." (www.nilebasin.org)

Figure 5 shows the organizational structure of the NBI. In the Nile Council of Ministers (Nile - COM) all member countries are represented by their ministers of water resources (or similar). The Nile - COM is in charge of approving plans and projects and the drafting of policies. The Nile Technical Advisory Committee (Nile - TAC) provides guidance to the Nile - COM and supervises the NBI projects. Each of the member countries has two representatives in the Nile - TAC. Daily management of the NBI projects and plans is the task of the Nile - Secretariat, based in Entebbe, Uganda.

The Nile-COM initiated the Shared Vision Program (SVP) and the Subsidiary Action Program (SAP). The SVP was started "to achieve sustainable socio-economic development through equitable utilization of and benefit from, the common Nile Basin water resources" (ENTRO, 2015). The SAP is to promote cooperation through joint projects (Worldbank, 2013). This Subsidiary Action Program has two components: the Equatorial Lakes (NELSAP) and the Eastern Nile component (ENSAP).

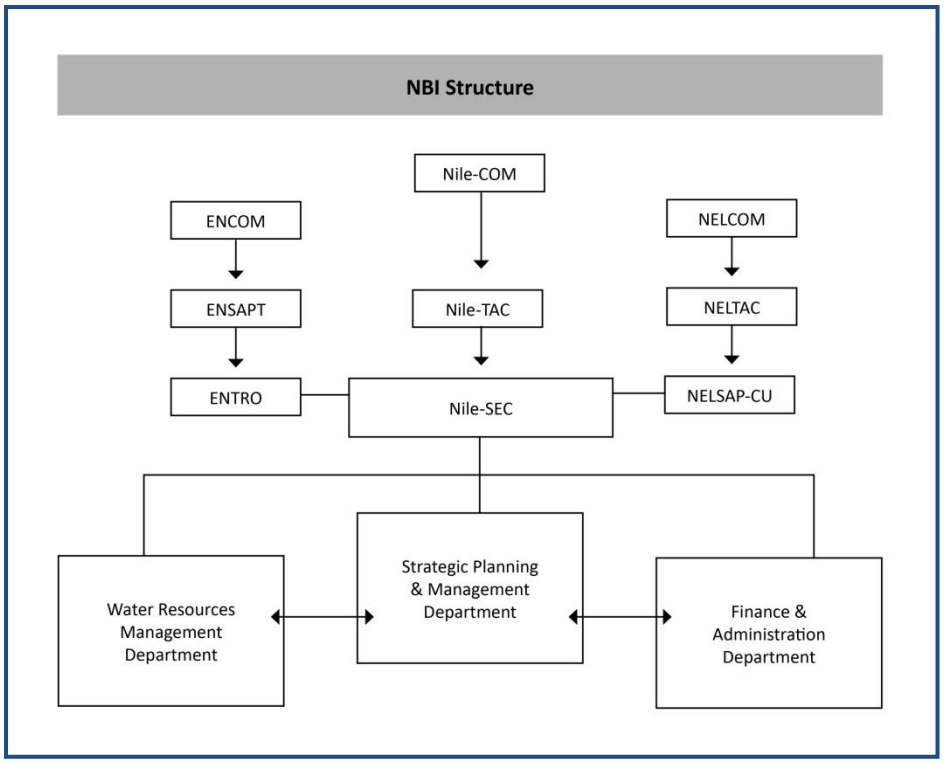

Figure 5 NBI Structure - (www.nilebasin.org)

The Eastern Nile Subsidiary Action Program

The Eastern Nile Subsidiary Action Program (ENSAP) involves Egypt (that is until 2010, when it was still participating in the NBI), Ethiopia, Sudan and South-Sudan (www.nilebasin.org). ENSAP implements regional projects aiming to show the benefits of cooperation and developing the river basin (Worldbank, 2013). The program is supervised by the Eastern Nile Subsidiary Action Program Team (ENSAPT) and projects have to be agreed upon by the Eastern Nile Council of Ministers (ENCOM). Both the ENCOM and ENSAPT are supported by the Eastern Nile Technical Regional Office (ENTRO), which is based in Addis Ababa, Ethiopia. ENTRO provides technical support and is in charge of the preparation of ENSAP projects. ENTRO staff consists of an executive director, project coordinators and interns, selected from the member countries (ENTRO, 2015).

ENTRO and NBI Projects

As part of the SVP a Nile Basin Decision Support System (NBDSS) was developed to have a shared platform that is accepted by all countries and that provides the means to share water resources related data and information among the countries (NBI, 2012). More on the NBDSS can be found in chapter 3.3.1.

ENTRO has various projects, the most important one is the Eastern Nile Planning Model (ENPM) project funded by the Worldbank. “The objective of the project is that the countries in the Eastern Nile operationalize an improved decision support modeling framework to identify water-related investments

and evaluate them in a regional context." (Worldbank, 2013) The project has three components. The first one is the development of knowledge about the Eastern Nile basin and the countries and the presentation of this information. Secondly the project aims to develop tools to evaluate and add to the knowledge of the first component, thereby using the Nile Basin DSS as a starting point. To support implementation of the first two components, capacity building is also included in the project. Models that were developed within the scope of this project are among others a SWAT, RiverWare, RIBASIM and HEC-ResSim model. These hydrological and river basin models will be discussed in chapter 3.3.1.

The Joint Multipurpose Project (JMP) is another ENTRO project that allows the countries to jointly identify and execute projects within the Eastern Nile basin. ENTRO is in charge of developing and implementing these projects.

Other projects and tools that have been developed by ENTRO as part of the ENPM or JMP or outside it are a "Flood Preparedness and Early Warning System" , "Irrigation and Drainage" (irrigation toolkit), "Regional Power Trade" (power toolkit), "Ethiopia-Sudan Transmission", "Watershed Management" and the "Baro-Akobo-Sobat Multipurpose Water Resources Study" (ENTRO, 2015).

Users can access the toolkits or reports per request. A website is available, but not up to date. Reconstruction of the website, however, is in process and when finished all relevant toolkits and reports should be available to the user. All countries have an ENSAPT member. Important research is communicated to them and this ENSAPT member is responsible for the communication to the respective governments.

1.2 The Information Gap

Scientific research is scarcely used for policy making (Hickey et al., 2013). The problem is as much a lack of communication of research results as a mismatch between the information produced by scientists and the information needed by the decision maker (Hickey et al., 2013; Timmerman, 2004). Scientists are often focused on producing more, rather than useful science (McNie, 2007).

Like the rest of the world the Nile River Basin faces an information gap between decision makers and scientists: one of the issues discussed at the *Water Security and Peace Conference* 2013 was the (lack of) interaction between policy makers and scientists in the Nile basin. In this region closing this gap might be even more crucial than in other parts of the world, because bridging the gap between scientists and decision makers may also help the countries understand each other better and bring them closer to cooperation. There are examples of situations where scientists from various countries in the Eastern Nile are able to work together and agree with each other, for instance the international panel of experts, investigating the Grand Ethiopian Renaissance Dam (Salman, 2013). If, however, the scientists cannot convey their research to their respective decision makers – even at a national level, the conflict on the decision making level will remain.

ENTRO is another example of scientists from four different countries working together, but it suffered greatly from the political consequences of the CFA negotiations: having developed numerous water

resources models, they are not able to have them implemented. The policy makers do not seem to be using the information that is generated with the models for their decision making. One of the issues in the Eastern Nile that the conflict over the Nile waters has given rise to and that ENTRO is struggling with, is the matter of information sharing. Each country has its own data and does not want to share these with the other countries. And even if data are shared, the other countries do not trust it.

This lack of (trusted) data and the lack of research addressing decision makers needs, makes it hard for scientists to convince decision makers.

1.3 Water Accounting +

Following the inaugural lecture of W.G.M. Bastiaanssen (2009) at the Delft University of Technology, Karimi et al. (2013) have developed a method to assess the natural and man-made flows, fluxes and stocks of water in a river basin system, using remote sensing data: Water Accounting Plus (WA+). The water accounts are based on the water balance by land-use, which makes it easier to assess the benefits and services produced by the consumptive use of water resources. It also allows the computation of net water producers (precipitation higher than evapotranspiration) and net water consumers (evapotranspiration higher than precipitation). van Eekelen et al. (2014) and Wim G.M. Bastiaanssen et al. (2014) showed how satellite measurements can be used to infer net withdrawals (i.e. gross withdrawals minus return flow). They provide insight into processes in a river basin and present them in a way that is straightforward and easy to understand. The accounts are made with publicly accessible data and are therefore not dependent on data of riparian countries. Since they are not owned by a particular organization, WA+ accounts can be exchanged freely with everybody interested.

Because of its tangibility, transparency and integrated approach, the water accounts of the Nile River Basin might provide a useful tool in bridging the gap between scientists and policy makers. They might be a more comprehensible and trusted resource for the policy makers in the Eastern Nile countries. It is a new and independent source of information that can be used as a second opinion in the decision making process.

1.4 Research Goals

In order to bring the countries towards a better joint management of the Nile River Basin, the information gap between scientists and decision makers in the Eastern Nile needs to be bridged. In order to do this, the gap first needs to be identified and described. That is what this research aims to do. There are two sides to this gap: (1) the decision makers' information needs and (2) the information provision by the scientists. This includes not only the information itself, but also the presentation and the way it is communicated.

To identify the information gap between decision makers and scientists in the Eastern Nile countries, the following questions will have to be answered:

1) What are the information needs of decision makers in the Eastern Nile countries?
2) What information are the scientists providing?
3) What is the information gap?

Water Accounting + is a tangible and comprehensive tool to assess the water resources in a river basin. More importantly, it is based on open access data, which makes it independent of the countries' data. Once the information gap is identified, the usefulness of Water Accounting + as a tool to bridge this gap can be determined. The fourth question this research aims to answer is thus:

4) Can Water Accounting + help bridge the information gap between decision makers and scientists in the Eastern Nile countries?

1.4.1 Definitions

Information Needs

Information needs are the information needs as perceived by the decision makers. They include the information types (e.g. hydrological, social, etc.), as well as the presentation and manner of communication. Specific projects that the decision makers want addressed (e.g. a certain irrigation scheme that needs improving or new dam that needs to be designed), were not part of this study. Rather the study focuses on the information that is needed for decision making on water resources management, projects and plans in general.

Decision Makers

There are various types and levels of decision makers. In this context the term decision maker signifies either a decision maker at the highest level (for example a minister) or one level below the highest level (such as a department head or undersecretary) that is supposed to facilitate higher level decisions, or make decisions by him- or herself. This thesis focuses on the official decision process and therefore on official decision makers, only. Other actors influencing decisions (e.g. NGOs, companies, etc.) are outside the scope of this study.

Information Provided

The information this master thesis aims to evaluate is mainly the information produced by ENTRO. This automatically includes the information that has been produced by international organizations and consulting firms. Additionally, the research that is done by the research community will be evaluated. This research is assumed to be well represented by the research presented at the New Nile Opportunities Conference held in Addis Ababa in December 2014 and the publications on water resources management in the Nile of the year 2014.

Eastern Nile Countries

The Eastern Nile basin lies within Egypt, Eritrea, Ethiopia, South Sudan and Sudan. Eritrea is only an observer to the NBI and its contribution to the Nile flow is minimal. South Sudan is an important country. However, the country is at war and has not formed a stable government since its separation from the Sudan administration in Khartoum, in 2011. Therefore, both Eritrea and South Sudan are not included in this research.

2 METHODS

2.1 Research Set-Up

2.1.1 Part 1 Information Needs

The information needs of the decision makers in the Eastern Nile countries were assessed using a combination of literature, government documents and interview response (chapter 2.2). Using three different sources of information makes it possible to support the outcomes of one with the outcomes of the others. This triangulation gives the research outcome more value and credibility. To assess the information needs of decision makers the following topics were considered:

- the decision process (part 1.1)
- the information needs (part 1.2):
    - the type of information needed
    - the presentation of this information
    - the information source.

2.1.2 Part 2 Information Provision

The models and information provided by ENTRO were evaluated using a framework for model evaluation (chapter 2.3) that was self developed through a literature review and then adapted according to the outcome of the first part of the research. The opinion of the Eastern Nile decision makers and the scientists at ENTRO on the models and information of ENTRO were determined through interviews.

The research presented at the New Nile Opportunities Conference held in Addis Ababa in December 2014, as well as the publications of the year 2014 as found by Web of Science and Scopus with the search term “Nile AND water resources management” were evaluated on their compliance with the information needs determined in the first part of this research. The resources term was added to filter out the research on Nile Tilapia populations and other non-relevant topics. It was assumed that one year’s research on the Nile is representative for all years. Research that is not on the Eastern Nile or that is fundamental (e.g. aiming to improve the understanding of the scientific community) was excluded from the analysis. This resulted in twenty-one (of forty-one) publications of the conference and 12 (of 29 not overlapping publications found with Web of Science and Scopus) of the other publications being analyzed.

2.1.3 Part 3 The Information Gap

To determine the information gap the findings of part 1 and part 2 were compared to each other. This enabled an identification of the missing items and the changes that are needed to close the information gap between scientists and decision makers in the Eastern Nile countries.

2.1.4 Part 4 Water Accounting +

The usefulness of Water Accounting + for bridging the information gap of the Eastern Nile was assessed in three steps. First, the water accounts were evaluated with the same framework that was used to evaluate ENTRO's models and its compliance with the information needs determined in the first part of this research was assessed. The performance of Water Accounting + was compared to the performance of the other models and other research. Secondly, the opinion of both the decision makers in the Eastern Nile countries and the scientists at ENTRO was determined through open in-depth interviews (chapter 2.2). The topics covered with regard to Water Accounting + are: the information itself, the presentation, the way of dissemination and its usefulness for decision making. Finally, the qualities and weaknesses of Water Accounting + were compared to the elements of the information gap to determine its worth in bridging this gap.

2.2 Interviews

To unravel information flows regarding a certain pre-defined topic, one can perform a literature review, which is possible if enough literature is available. There was, however, not enough literature on information needs and communication in the Nile basin available and therefore additional data was needed. These data can be obtained by conducting interviews. This can be done either individually or with a focus group (Bernard & Ryan, 2010). Using a focus group can show interactions and generate discussion among the respondents, making it possible to also generate data about these interactions and reactions (Mason, 2002). Using individual interviews offers the possibility to compare answers of different respondents and is therefore a more explorative method. This interview method was deemed more suitable for this research because of this more explorative nature. Individual interviews can be conducted in two different ways. The first possibility is to organize closed interviews or questionnaires, which enable quantitative analysis of the data (Bernard & Ryan, 2010). To conduct closed interviews, however, a lot of prior knowledge on the topic and people's views is needed, otherwise it will be hard to set up the questions in the first place in order to cover a topic adequately. Moreover, additional views and perceptions, that one has never heard of or has not considered will not be brought to light. The second option is to organize open or semi-structured interviews (Bernard & Ryan, 2010). This type of interview makes it possible to get an overview of all the views that are possible and to uncover information that is otherwise latently available. For this research, the choice was made to conduct open in-depth interviews to get as broad a view as possible regarding the information needs of decision makers in the Eastern Nile countries and their views on the research of the scientists at ENTRO, as well as Water Accounting +.

2.2.1 Interview

The available international literature on the information needs for decision making in environmental sciences was used to formulate the topics to be explored during the interview. The literature review on decision makers information needs and the interview structure are presented in Appendix A.

Prior to the interview itself the respondents were given an explanation about the goal of the research. Before Water Accounting + was discussed, an explanation of Water Accounting + was provided. The interviews were conducted in a conversational manner whereby the questions were not predefined.

To answer the first research question it was ensured that the following topics were covered (not necessarily in this order): the decision process on water related projects; and the information needs for decisions on water related projects (what sort of information and the presentation of the information). A project can be a water resources development related activity, re-allocation of water, concessions, etc.. Additionally, the water accounts of the Nile basin were discussed.

To be able to assess the information provision the respondents were also asked for their information sources. Scientists of the Eastern Nile Technical Regional Office were asked for their views on the advantages and disadvantages of the models they are working with and their ways of disseminating information to the decision makers of the different countries.

Individual interviews lasted in between 20 to 70 minutes and were conducted by the author of this thesis, inexperienced in conducting interviews, but with extensive knowledge on the topic. Test interviews were conducted to practice and prepare for the real interviews.

2.2.2 Respondents

The respondents (Figure 6) are from Egypt (n = 10), Sudan (n = 13) and Ethiopia (n = 9). The selection of these respondents was based on the network of an acquaintance in each of the countries. Among the respondents were high level decision makers (ministers or former ministers), lower level decision makers (the heads of a ministerial department), advisors (scientists directly advising decision makers) and scientists (working at the ministry or another organization). All were working in the field of water management or related fields. Respondents are further divided into those currently working for a national organization (e.g. a national ministry) and those working for an international organization (e.g. the Arab Water Council), since their opinion on international cooperation may influence their views on the information gap. Additionally three researchers working at the Eastern Nile Technical Regional Office were interviewed to acquire their views on the various models developed by and for them, as well as their views on the dissemination of their research to the decision makers of the three countries. No staff from the NBI has been interviewed.

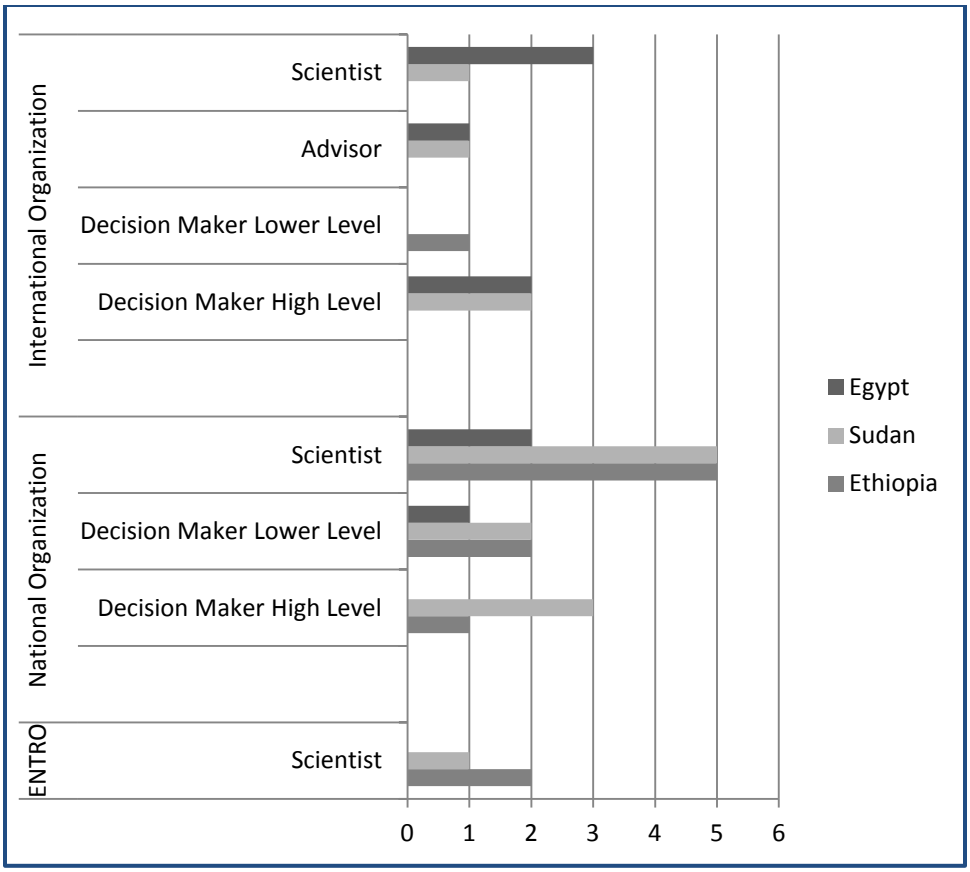

Figure 6 Respondents of the locally conducted interview

2.2.3 Analysis

Twenty-six of the interviews were recorded. Nine of the interviews were not recorded (26%), because the respondents did not give their consent. The transcripts of these interviews were written directly after the interview to preserve as much information as possible. All interviews were transcribed word for word and sent to the respondents for confirmation. Only a small fraction of the respondents (17%) provided some feedback. Transcripts are not publicly available, because the respondents were promised anonymity, which may not be guaranteed if transcripts are made available.

The transcripts were coded and codes were checked independently for objectivity and completeness by six other students from Delft University of Technology. Differences were discussed and adaptations were made accordingly. The final codebook comprises the themes presented in Figure 7, Figure 8, Figure 9 and Figure 10 (for the full codebook, including codes, see Appendix A.3). Themes 1 and 2 correspond to the different aspects of the information needs of decision makers. Theme 3 corresponds to the information source and the respondents views on ENTRO's research. The interview response was analyzed together with existing literature, governmental documents and interview responses. This triangulation enables the confirmation of one source with the other and makes the results more reliable.

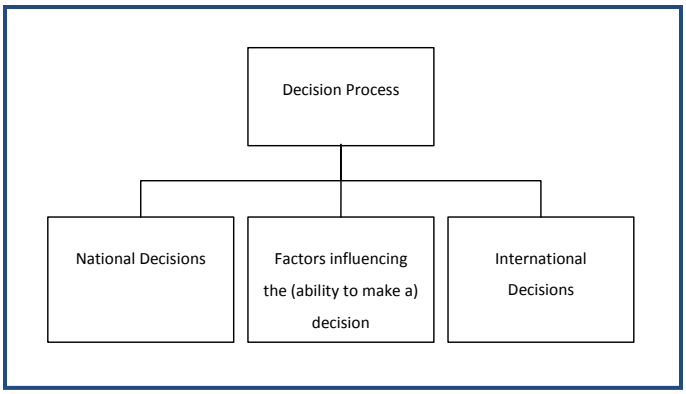

Figure 7 Theme 1 - Decision Process

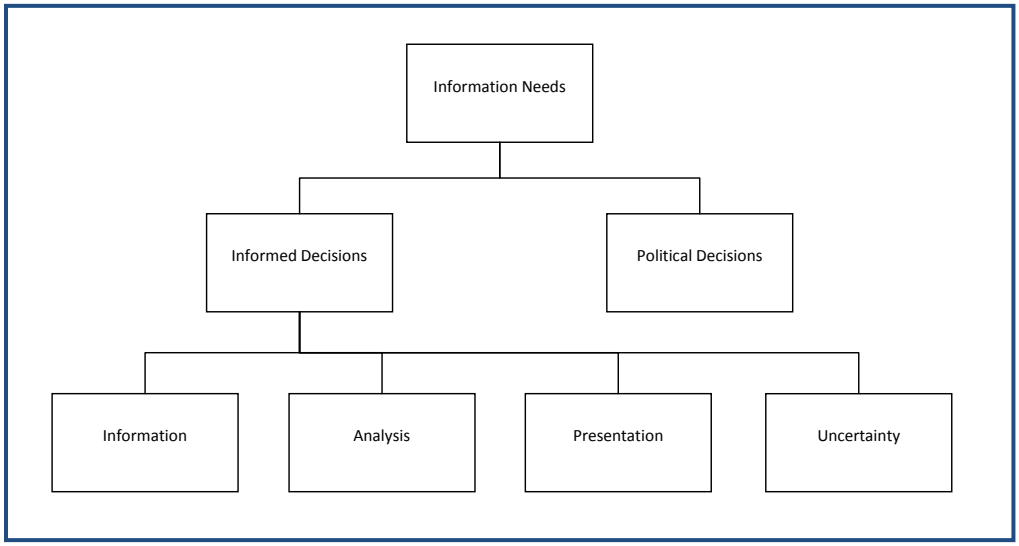

Figure 8 Theme 2 - Information Needs

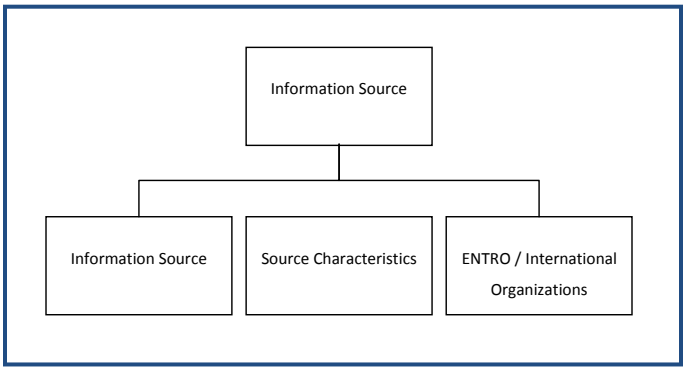

Figure 9 Theme 3 - Information Source

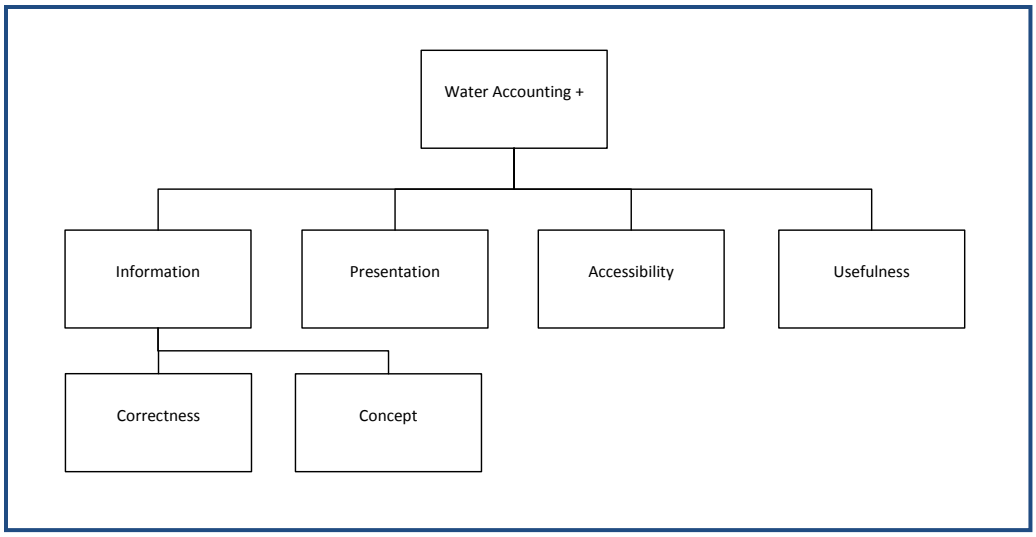

Figure 10 Theme 4 - Water Accounting +

2.3 Model Evaluation

To assess the value of the research done at ENTRO, a framework was developed to better define the differences between various models and appraise the type of information that can be inferred from these models. The model evaluation framework was derived for this thesis based on available literature. The framework's relevancy and completeness was reassessed based on the results of the first part of the research on the information needs of decision makers and adjusted accordingly (chapter 3.2.4). The framework could have been entirely based on interview response. However, the processes were not discussed in as much detail as they are covered in the framework and therefore the framework would have been less detailed, too. Also, the choice was made to not show the framework in its entirety to the respondents to avoid getting socially desirable responses. Rather, the groups and processes were kept on a side list for the interviewer, to ensure the topic was adequately covered.

The models were evaluated by giving them a score for each process. The following scores were used:

+ + If a certain physical process is included in a thorough manner.
+ If a certain process is included, but not very thoroughly.
+/- If elements of a physical process are described, but an incomplete total picture is provided.
- If a certain physical process is excluded, but can be included if desirable.
- - If a certain physical process is neither recognized nor included.

Table 1 Framework for the evaluation of hydrological and water resources models

Group	Process
Hydrology	Precipitation
	Infiltration
	Evaporation and Transpiration
	Surface runoff
	Stream flow
	Groundwater (recharge, storage, flow)
Flows, Uses and Withdrawals	
Natural	Lakes
	Wetlands and Swamps
	Rivers and Streams
	Other Ecosystems - Groundwater Dependent
	Other Ecosystems - Surface Water Dependent
Manmade	Domestic
	Industrial
	Agricultural
	Aquaculture
	Livestock
	Municipal
	Reservoirs
	Hydroelectric Power Production

	Recreation
Changes and Degradation	Climate Change
	Natural Disasters
	Erosion and Sedimentation
	Soil Salinization
	Water Quality
	Land Use Change
Economics	
Water Rights	

3 RESULTS AND DISCUSSION

3.1 The Formal Decision Process

In the following sections the decision process (on water related issues) of the three countries is discussed, as well as international water decisions. The type of decisions referred to can be decisions on new plans or changes related to hydropower, irrigation, land use change (urbanization or to cropland), drainage of wetlands, aquaculture or water quality. As was already explained the focus of this thesis is on formal decisions and thus on the formal decision process. There may be other actors that influence or even make decisions and while they are taken into account as an information source (section 3.2.1), their roles in decision making itself lies outside the scope of this research.

An effort was made to describe the decision process with the aid of existing literature, governmental documents and interview responses. The depth of the description varies per country, mostly due to a difference in the availability of documents and coherent interview response. However, the variation in depth of the description may also be attributed to the difference in level of development of the three countries: while the decision process in Ethiopia and Sudan is under continuous development and changing, Egypt has a more clear and well defined process. While respondents were asked for decisions on water related issues in their country in general and thus the decision process described may also be applicable to decisions outside the Eastern Nile Basin, this thesis focused on water related decisions in the Eastern Nile Basin.

3.1.1 Egypt

In Egypt, all decisions on policies are made at high level only, i.e. the Minister of Water Resources and Irrigation, the Cabinet or the President. The level of involvement depends on the strategic importance of the decision and whether it has far reaching impacts on other sectors (Luzi, 2010). According to the respondents, there are usually drivers to start thinking about a new project, like the availability of more water or new technologies. The decision process that follows is shown in Figure 11. Depending on the level of importance the decision to start a new project is made either by the cabinet or by the minister. After this decision is made, the Ministry of Water Resources and Irrigation will often start a consultation study. The development of such a study is the direct responsibility of the relevant sector (see Figure 12). An in-depth study can be done by the ministry's own specialists or a consultant is hired. Information that is needed for a certain in-depth study is often requested from other sectors and field offices. All communication occurs through the sector heads. When a certain study is finished and has been circulated and agreed upon by all sectors, there are two processes possible: in case of a less important decision,(i) the study findings and recommendations are communicated to the Minister and the Minister makes a decision himself or (ii) the Minister delegates the decision to a committee consisting of the sector heads and Under-Secretaries and headed by the minister himself , see (MWRI, 2005). In the

case of a more important decision, there will first be consultation at Under-Secretary level and Ministers of other Departments and the Ministry of Water Resources and Irrigation, before a decision is made by the Cabinet. Other Egyptian Ministries involved in water related projects are: the Ministry of Agriculture and Land Reclamation, Ministry of Housing, Ministry of Environment, Ministry of Finance, Ministry of Planning and the Ministry of Electricity and Energy.

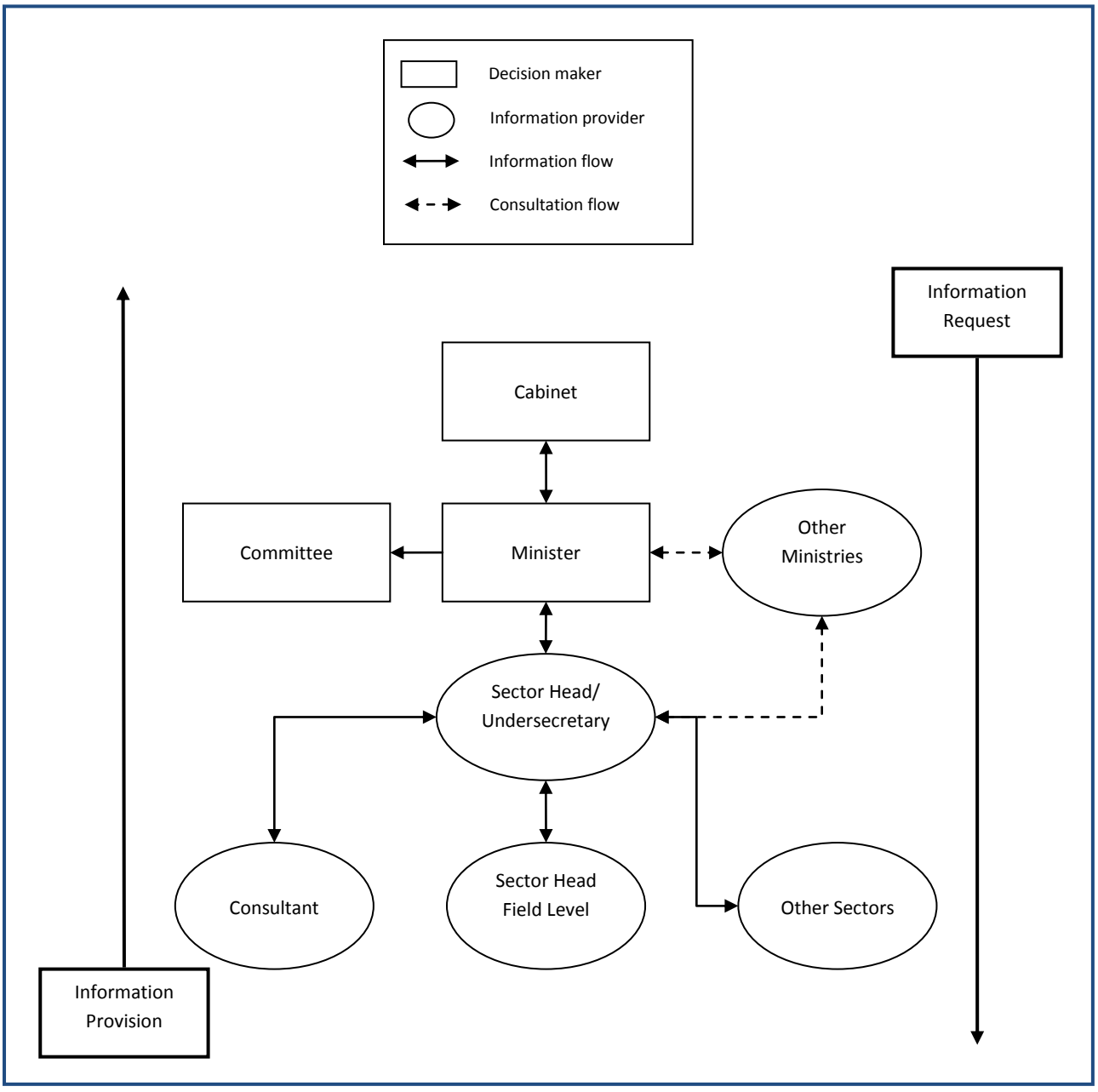

Figure 11 Decision process Egypt

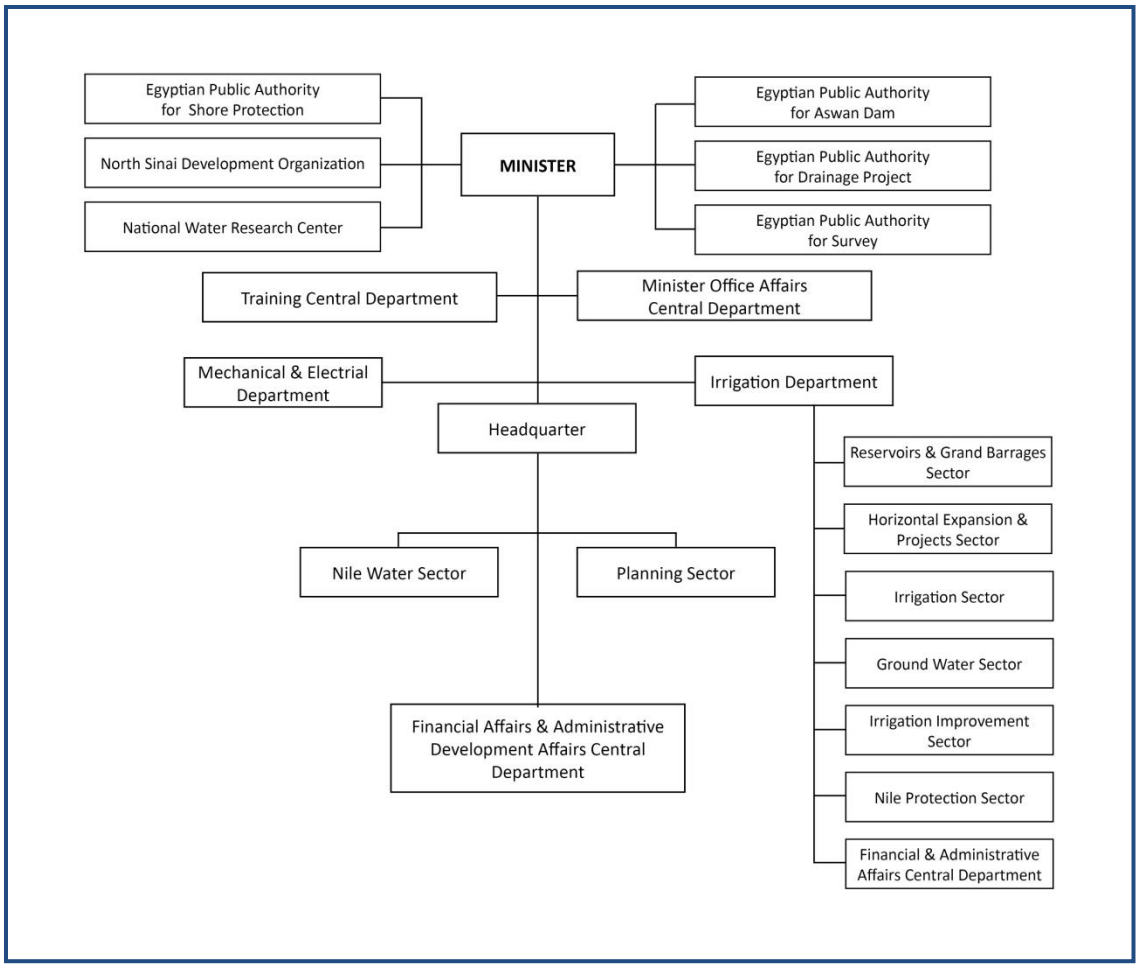

Figure 12 Organizational structure Ministry of Water Resources and Irrigation, Egypt - (MWRI, 2005)

3.1.2 Sudan

In Sudan all new plans used to go through the decision process as shown in Figure 13. New projects had to be reviewed by a council consisting of experts on all aspects related to water resources. A new initiative would be developed under supervision of the relevant directorate, who would usually hire a consultant to carry out the required background research. The consultant would make a technical proposal on for instance suggested infrastructure, economic assessment and an environmental and social impact assessment. These assessments are reviewed by the council of experts and either accepted or sent back with comments. Only after approval by the council of experts, a new initiative could go to the council of ministers for final approval. Hence, apparently, the high level decision makers remain more distant in these preparatory processes.

In December 2011 the Ministry of Water Resources and Irrigation was dissolved. The topic of water resources became part of the Ministry of Water Resources and Electricity and irrigation was integrated with agriculture into the new Ministry of Agriculture and Irrigation. According to one of the respondents, both water resources and irrigation are deemed to be of lesser importance than electricity and agriculture, respectively. Since the abolition of the Ministry of Water Resources and Irrigation,

decisions are no longer made following the process in Figure 13. Most decisions are made within the Ministry of Water Resources and Electricity without a proper involvement of other disciplines. New project initiatives in the field of water resources are based on old plans that were previously discarded and have not been reevaluated by a multidisciplinary team, but are just taken as is.

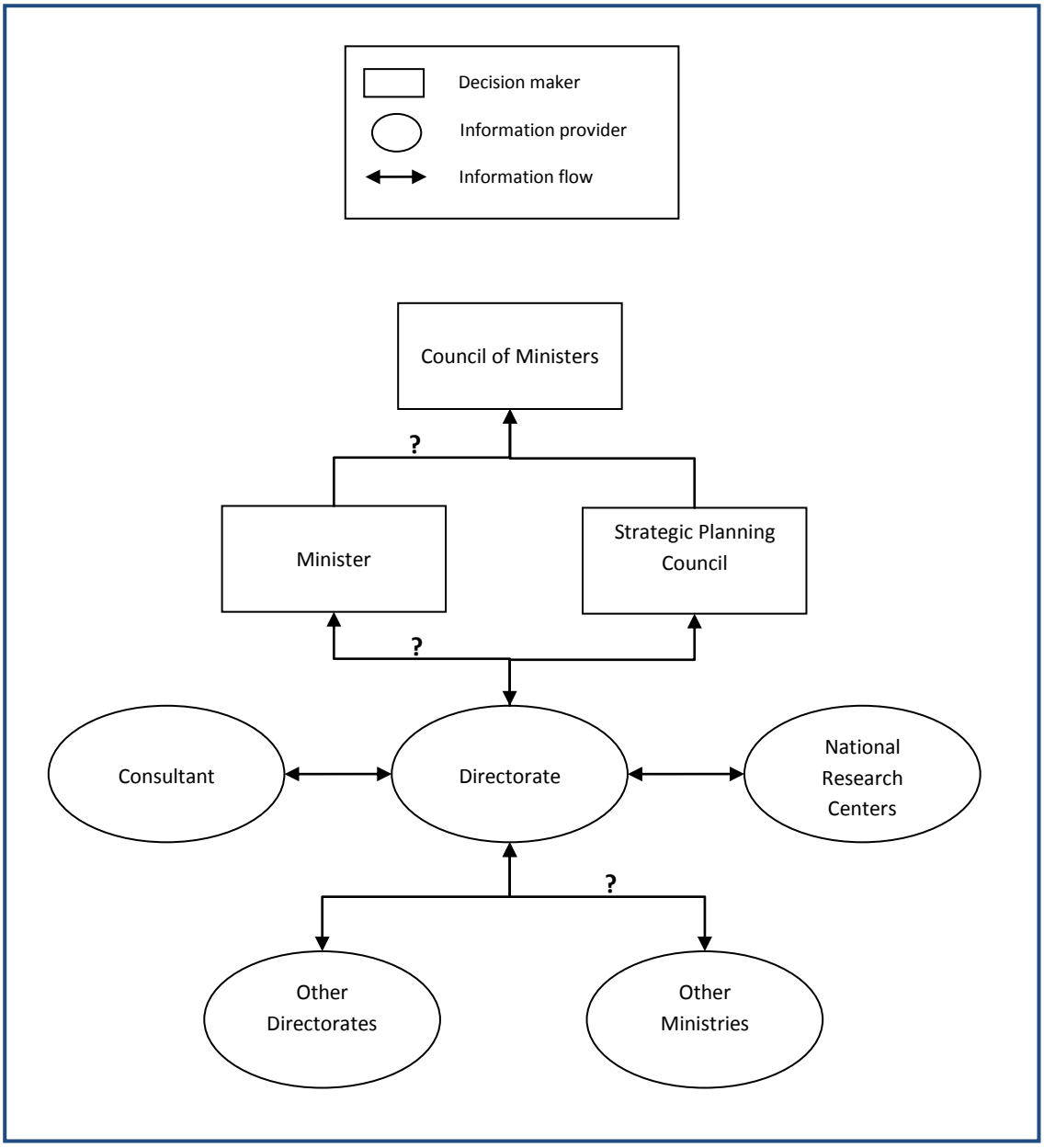

Figure 13 Decision process Sudan

3.1.3 Ethiopia

The Government in Ethiopia is highly decentralized. The country is divided into nine regions and two city states, that each have their own government. However, transboundary rivers and foreign affairs are among others addressed by the federal government (UNESCO, 2004).

The structure of the Ministry of Water Resources is shown in Figure 14. According to the respondents, the Minister will instruct the relevant directorate within the Ministry of Water Resources to start a study for a new project. Usually the responsible directorate will hire a consultant to execute the study. Other directorates that are relevant to a certain decision process, are involved in the study as well. Information is gathered from the relevant directorates and ministries and provided to the consultant to complete the study.

In 2007 the Government of Ethiopia made a proclamation on the establishment of “River Basin High Councils” and “River Basin Authorities” ("River Basin Councils and Authorities Proclamation," 2007). The proclamation states that the High Council is in charge of formulating all plans and policies regarding the management of water resources in a national river basin. The river Basin Authority “shall serve as the secretariat of the respective Basin High Council”("River Basin Councils and Authorities Proclamation," 2007). It supports the High Council in the preparation of plans and policies and is in charge of the implementation of said plans and policies. The River Basin Authorities do not only have a responsibility to assist the River Basin High Council, they are also accountable to the Ministry of Water Resources (2007; "River Basin Councils and Authorities Proclamation," 2007; Water Governance Centre, 2013a, 2013b). On what level exactly they are accountable is not clear, the structure of the Ministry of Water Resources (Figure 14) seems to indicate that they are accountable directly to the Minister.

According to the proclamation ("River Basin Councils and Authorities Proclamation," 2007) the plans and policies have to be approved by the government after they are approved by the River Basin High Council. However, according to the respondents, the River Basin High Council is chaired by the Ethiopian Prime Minister and includes all relevant (national) ministers and the prime ministers of the regional states inside the river basin. This implies that the approval of the High Council is enough, since the High Council consists of all relevant members of government. This suggests that the actual situation is different from the situation outlined in the proclamation. Since the implementation of this system of councils and authorities has only recently started, as was indicated by the respondents and is backed up by Water Governance Centre (2013a, 2013b), the final set up of the system may not be decided upon yet.

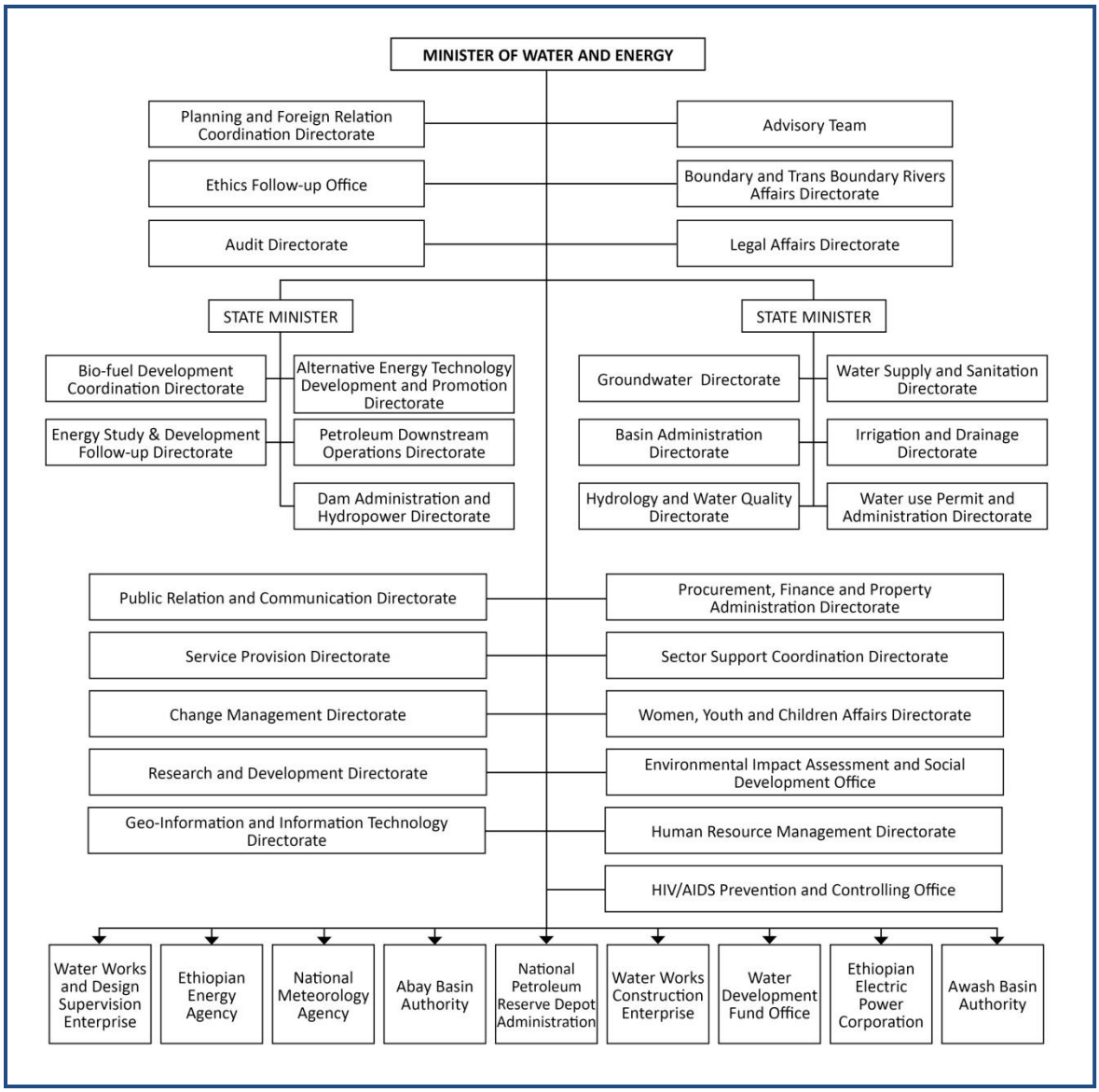

Figure 14 Structure ministry of Water Resources, Ethiopia - (MOWR)

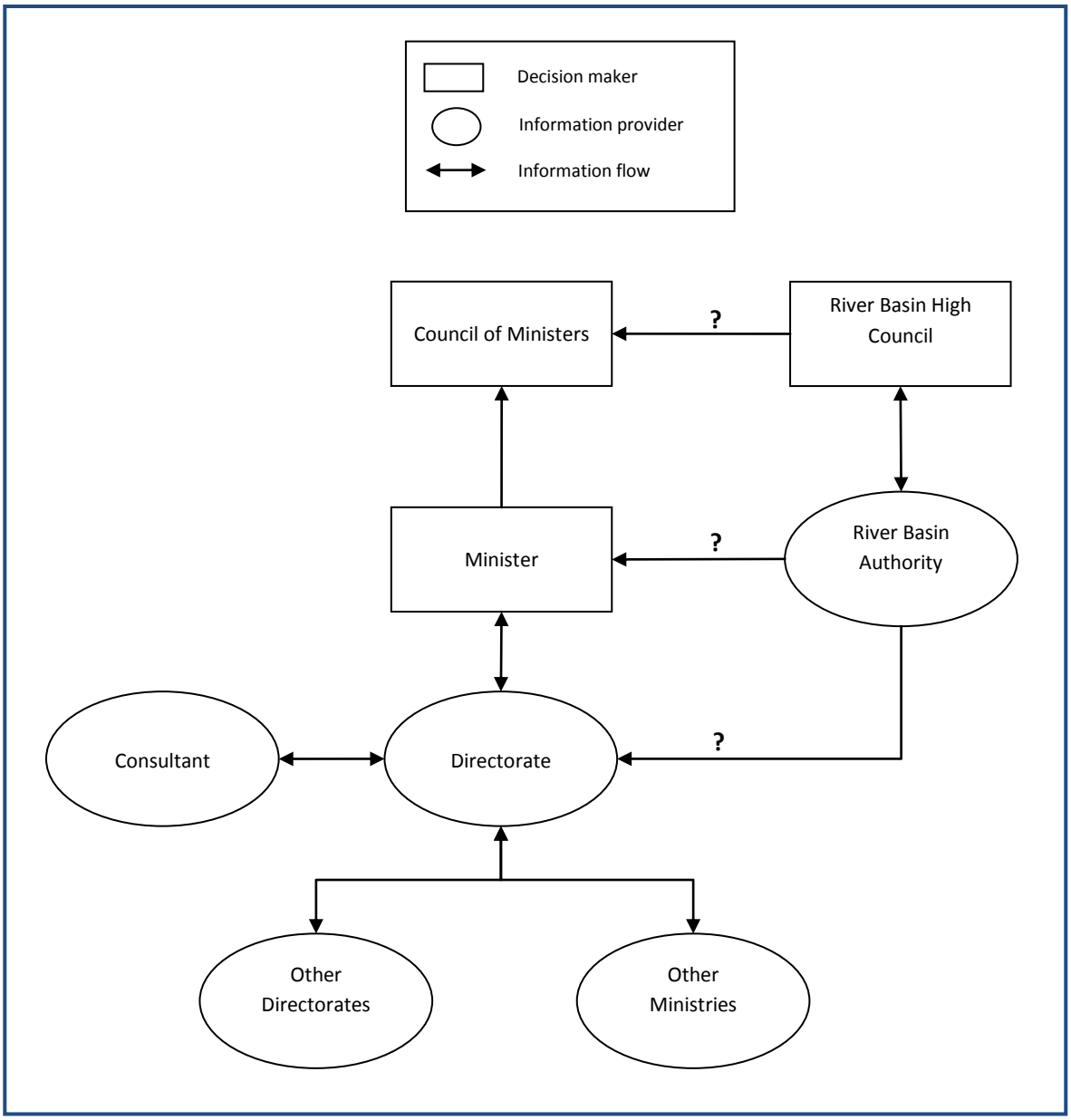

Figure 15 Decision process Ethiopia

3.1.4 International Decisions

The overview of the structure of the Ministry of Water Resources in Ethiopia shows that they have a Boundary and Transboundary rivers Affairs directorate. This directorate deals with the transboundary effects of national structures and interventions on transboundary rivers. International decisions (decisions that are made jointly by the countries) are made either by the ENCOM as described in chapter 1.1.2 and further elaborated in section 3.3.1, or through a joint committee like on the GERD.

Respondents from Egypt and Sudan indicated that there is not enough information about the impacts of the GERD. Egypt and Sudan are afraid that they will be negatively affected by the GERD. Interestingly, the same Egyptian that indicated that there is not enough information also stated that models show that there will be negative impacts, which seems contradictory. As was briefly mentioned in section 1.1, the three countries set up a Tripartite Technical Committee. The committee is tasked with the preparation of the terms of references for a consultancy study and selecting an international consultant. This consultant will study the GERD and its effects and report to the committee. The committee will then discuss the outcomes and try to resolve their differing opinions. If that is not possible, the decision is referred to the three countries' Ministers of Water. If they cannot solve the difference either, it is referred to the cabinet and if that still does not work, the countries will hire international advisors (not consultants, but renowned experts in transboundary water issues) to solve the issue. Deciding on which data is needed by the consultant to conduct the study is also a task of the committee. Together they decide on which information will be shared.

Two scientists from Egypt and Sudan, mentioned that the negotiations should be more multidisciplinary, including all aspects. They think that negotiations should take place at the highest level and not only include the water ministers. In this way, it would be easier to focus on sharing of benefits instead of water sharing.

Respondents from both Egypt and Ethiopia mentioned the importance of equitable utilization of the Nile waters. Apparently, they do both think this is important. The CFA negotiations show, however, that both countries have different views on this equitable use.

3.2 Information Needs

In theory, there are two types of decisions: informed decisions and political decisions. Informed decisions are decisions that are based on facts, research and information. Political decisions are decisions that are based on societal, legal and regulating matters, that can be contradictory to scientific facts. In practice, almost all decisions are based on a combination of scientific facts and political aspects.

Respondents of all countries and all positions agree that informed decisions are hard to achieve because of turnover and time constraints of decision makers. Decision makers change seats relatively fast and there is hardly time available to get adjusted and familiarize with the system. Egypt, for instance, has had 5 Ministers of Water Resources since January 2011 (www.mwri.gov.eg). Unfortunately, top level decision makers do not have sufficient time to spend on one decision or issue, which makes it hard to give them all information. Additionally, one of the respondents from Egypt pointed out that some issues that are already hard to understand for scientists are almost impossible to grasp for decision makers. One of them is the accumulative effect of various projects or measures, which is not always a simple addition of effects. Two projects cannot be seen independently from each other, since the effects may be far worse if both projects are executed or on the contrary, the two projects may mitigate each other's negative effects. A very simple example would be a new irrigation scheme that is constructed at the same time that the irrigation efficiency in a scheme next to it is improved. The first project increases the overall water use, but this is mitigated by the savings in the second project. Another difficult issue is indirect consequences, which is an important aspect to consider, especially in water resources management, but is hard to grasp, especially beforehand. An example that is easy to understand is the consequences of a new dam. The first consequence is the fact that less sediment will flow to the area downstream of the dam. The consequence of this is that farmers will have to use non-natural fertilizers to farm their land and that in turn, will decrease water quality downstream of these farmers.

Two respondents (from Ethiopia and Sudan) also mentioned that decision makers often do not trust the scientists and therefore will not use the scientists' information for their decision making. According to respondents of all three countries, more often than not, decision makers make a decision that is not based on facts. Either because the facts are not there (or they do not trust the source or level of confidence) or because there are other societal and political interests at play, which influence the decision. A very important factor influencing decisions is the fact that decision makers are trying to make a good impression in order to be re-elected. The decision that goes with making a good impression is not always a decision based on facts. The information needs that come with these two types of decisions are discussed in the following chapter.

3.2.1 Informed Decisions

The information needs of decision makers for making informed decisions are described in the following sections. Not only the type of information itself and the way it is analyzed are discussed, but also the way it is presented and the source that provides the information. An overview of the results can be found in Appendix C.

Information

In Figure 16 the different information types that were recognized by the respondents as being relevant are given. Both technical and socio-economic information are mentioned as important information by the majority of the respondents from all three countries. Information on the economic and environmental aspects is mentioned less often but is still deemed important by a large part of the respondents. The legal and political aspects were also brought up as important for decision making (legal in all three countries, political only by one Sudanese and three Ethiopians), as well as whether the project applies to international standards (twice, in Egypt and Sudan). One respondent from Egypt mentioned that the institutional set up of a new project also needs to be considered. Technical, socio-economic and economic information is considered important in all three countries. Information on the environmental aspects was not mentioned at all by the respondents from Egypt, except that it was remarked that the environmental aspects of a project are donor-driven. Scientists and decision makers from both national and international organizations do not differ in opinion regarding the importance of the different information types, except for the environmental aspects (Appendix C). The environmental aspects were only mentioned by respondents currently working for a national organization. These coincide, however, with the Egyptian respondents. Therefore, this difference is probably due to the difference between countries rather than whether or not the respondent is favored towards international cooperation. Also interesting to note is that Ethiopians believe that political aspects (both national and international) are essential for the decision making process, while Egyptians did not raise this. This might be explained by the fact that the politically more powerful countries often downplay the role of politics because they want to focus more on the other aspects that underline their needs. In this case Egypt probably wants to focus more on their water scarcity problem. One Ethiopian respondent mentioned the importance of equitable allocation of water between different water use sectors (within the country). Apparently, thoughts and perceptions on water management sometimes hardly go beyond the own backyard.

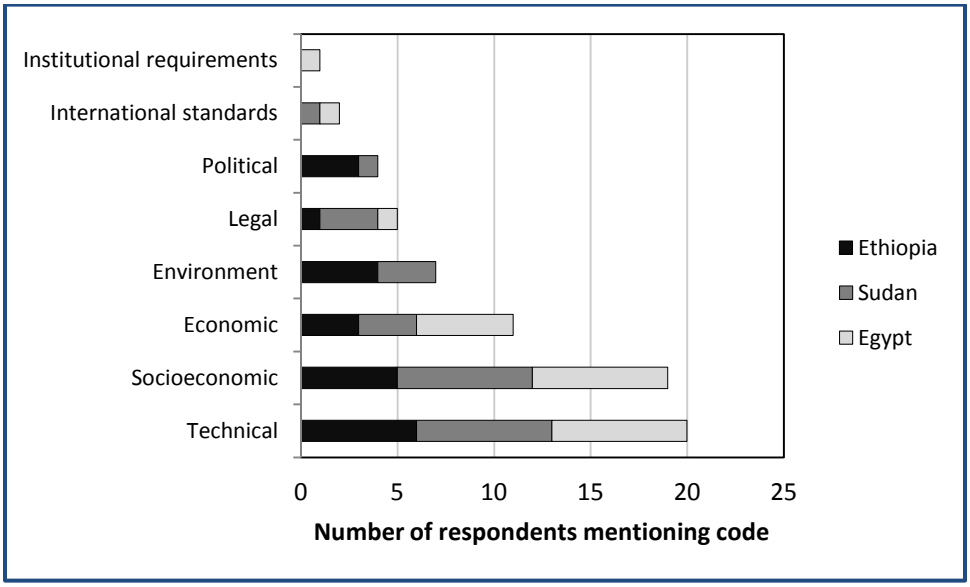

Figure 16 Information types that are needed for decision making

The technical aspects of a project that were mentioned by the respondents are provided in Figure 17 and Figure 18. Hydrological information is by far the most important factor of technical information. Water availability is, in turn, the most important hydrological aspect of a project. Interesting is the fact that water requirements are mentioned more often in Egypt than in the other countries, probably because Egypt is the most water stressed country of the three.

It can be concluded that it is important to provide multidisciplinary information for decision making, since the non-technical aspects are just as important as the technical.

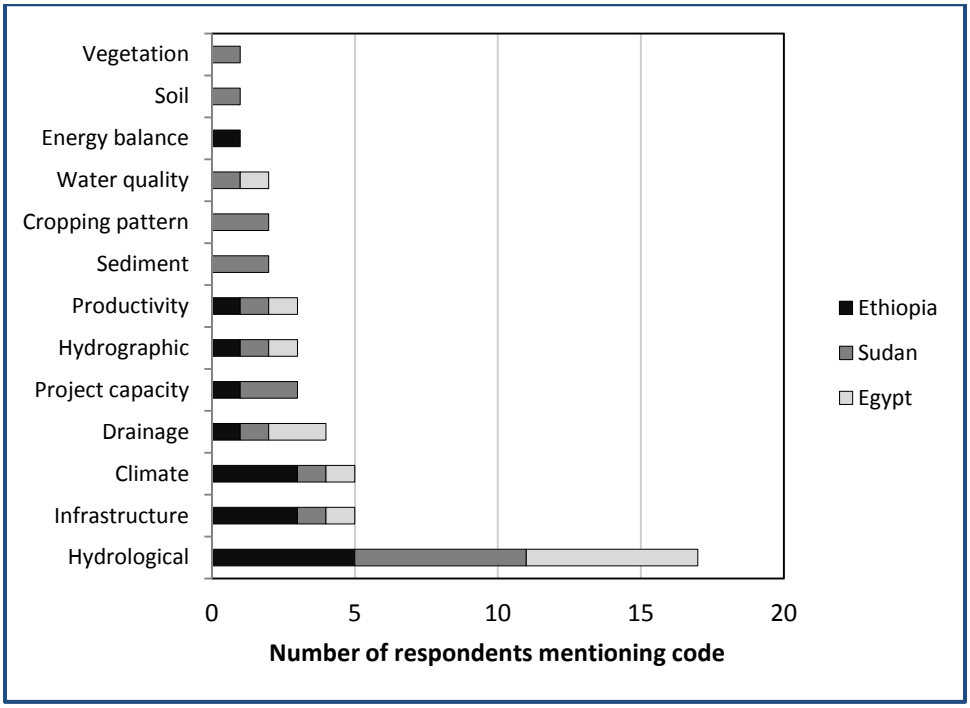

Figure 17 Technical Information that is needed for decision making

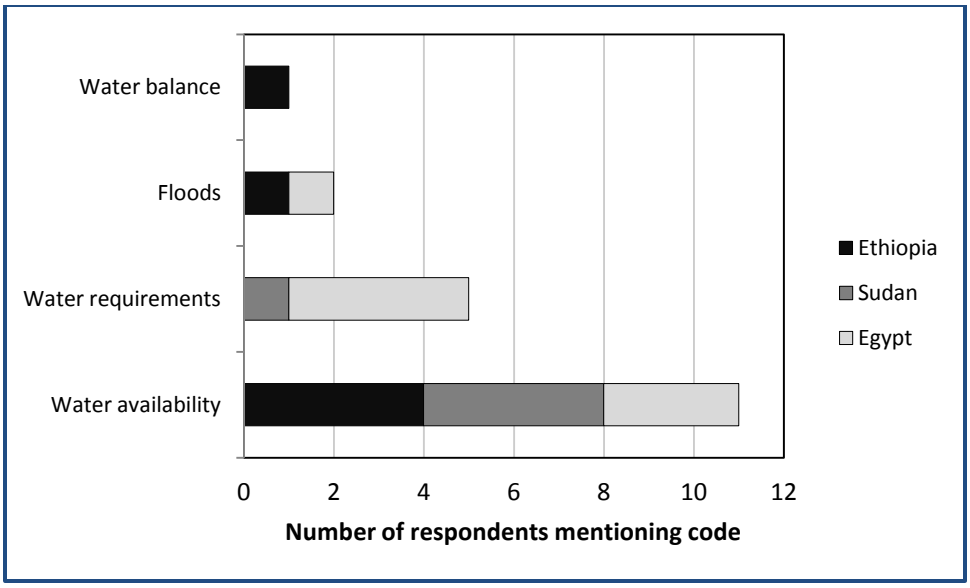

Figure 18 Hydrological Information that is needed for decision making

Information Analysis

For making informed decisions, decision makers require a thorough analysis with regard to the information types that were discussed. A table with the codes of the important aspects of information analysis can be found in Appendix C2. To start with, decision makers want to know the current land-water-ecosystem situation as well as forecasts of natural changes (e.g. climate change). The historic situation can also be relevant (perhaps for lessons learned), although that was only referred to twice. Decision makers want to understand the plans along with their impact, and wish to choose from various alternatives, with pros and cons. Finally it is considered important that the scientists provide a clear recommendation with arguments. Other aspects of the information format that were mentioned are: operation schedule (of a new scheme or dam) and adverse impacts (i.e. land degradation, displaced people, reduction of ecosystem services). One respondent from Ethiopia mentioned that the process of how the information was collected and processed is also an important aspect for decision makers, but this was not confirmed by others. But, indeed, according to scientific standards, a thorough analysis should always report its sources, assumptions and uncertainties.

If uncertainty in the data or information is reported it has to be by giving an upper and a lower bound. One Ethiopian high level decision maker indicated that the uncertainty should be brought back to acceptable gaps, like plus minus 5%. Other than that respondents did not specify the required uncertainties for making decisions. However, some respondents mention that they just report on how the data is collected or compare the data to historical data to get a sense of how accurate the data is.

Information Presentation

As was pointed out earlier, decision makers always have a lack of time. Therefore, most of the respondents (from all three countries) agree that decision makers want the information in a short message. This can be in the form of a summary (with or without the bigger report) or another kind of written note. However, when the decision maker is a technician, he may be interested to read the whole report himself. Respondents from all three countries also indicated that, most of the time, the written message will be accompanied by an oral explanation, which may or may not be in the form of a presentation. Workshops or seminars to inform the stakeholders concerned with the project were also mentioned as a form of communication, however, the respondents also pointed out that it is unusual for a decision maker to attend such a workshop or conference. Thus workshops are a good vehicle to get certain messages across, but they are not necessarily, directly affecting the decision making process.

As for the content of the message, it should be written in a language that is understandable for decision makers. The use of jargon should be avoided, or if unavoidable, terms that are used should be explained in a clear way. Five of the respondents suggested that graphs and pictures (if clear and easy) are a good way to present the information in a comprehensible manner. Another point that was stressed is that it is important to end with a clear and sticking message. One good bullet point can be sufficient.

Of course the way the information should be presented depends on the person that is targeted (Mostert & Raadgever, 2008). As will be further elaborated in the next section a relationship with the decision makers is important and therefore a scientist may choose to approach an advisor instead of the decision maker himself. In that case the need for briefness and easy language is less critical.

Information Source

The process of decision making was explained earlier in chapter 3.1. In all countries, the relevant department within the Ministry investigates a new project or plan. Another common denominator for all three countries, is that the study itself is executed by a consultant. The information that is needed for the study is gathered from field offices, the hydro-informatics department of the ministry or national research centers (Figure 19). According to one of the respondents from Egypt, sometimes these different sources are gathered together in a task group, because Egypt has separated scientific centers with special dedicated tasks. By absence of independent research institutes, research from universities are more commonly used as a source of independent information in Ethiopia. In Egypt and Sudan respondents are divided on whether research from universities is used or not. Research done by the Nile Basin Initiative and other international organizations may be used, but both were only mentioned once, the NBI in Ethiopia and international organizations in Egypt. The respondents do not use ENTRO commonly as a source of information, however, as is explained more elaborately in chapter 3.3.1, ENTRO is highly restricted by its mandate in the information it can disseminate to the countries.

Media as a source of information was also mentioned. One Sudanese respondent explained that the media are not an effective way to inform decision makers, because they do not have time to watch or read the media. Two others (one Sudanese and one Ethiopian) pointed out that decision makers use the

media to get an idea of the issues that are relevant to society and that need to be dealt with. In this case, however the media is not actually used as a source of information but rather to get a sense of society's needs and problems.

As was mentioned before, one of the things affecting decision making is the fact that decision makers do not trust scientists and therefore do not use the information that is provided by scientists. Two respondents, one from Egypt and one Sudan are of the opinion that decision makers have or should have one or a few trusted advisors, who can tell them whether information is correct or not. Apparently, trust in selected individual experts is more valuable to the decision makers, than advice from scientists who's character and perceptions are vague.

According to several Sudanese respondents, a scientist is only trusted if he/she appears to be confident about his own research. Also having regular contact with the decision maker and building up a social relationship is considered a prerequisite for getting trust. To reach decision makers, scientists should at least make sure that their research is multidisciplinary, they should be proactive and have clear communication skills: the very moment that an issue is raised, they should respond straightaway in an elaborated manner that demonstrates seniority and expertise. If the scientist does not have a relation with the decision maker, he can try to let others bring his concerns forward. He can try to approach and convince the personal advisor to a decision maker or he can let people from society bring issues to the attention of the decision makers through the media.

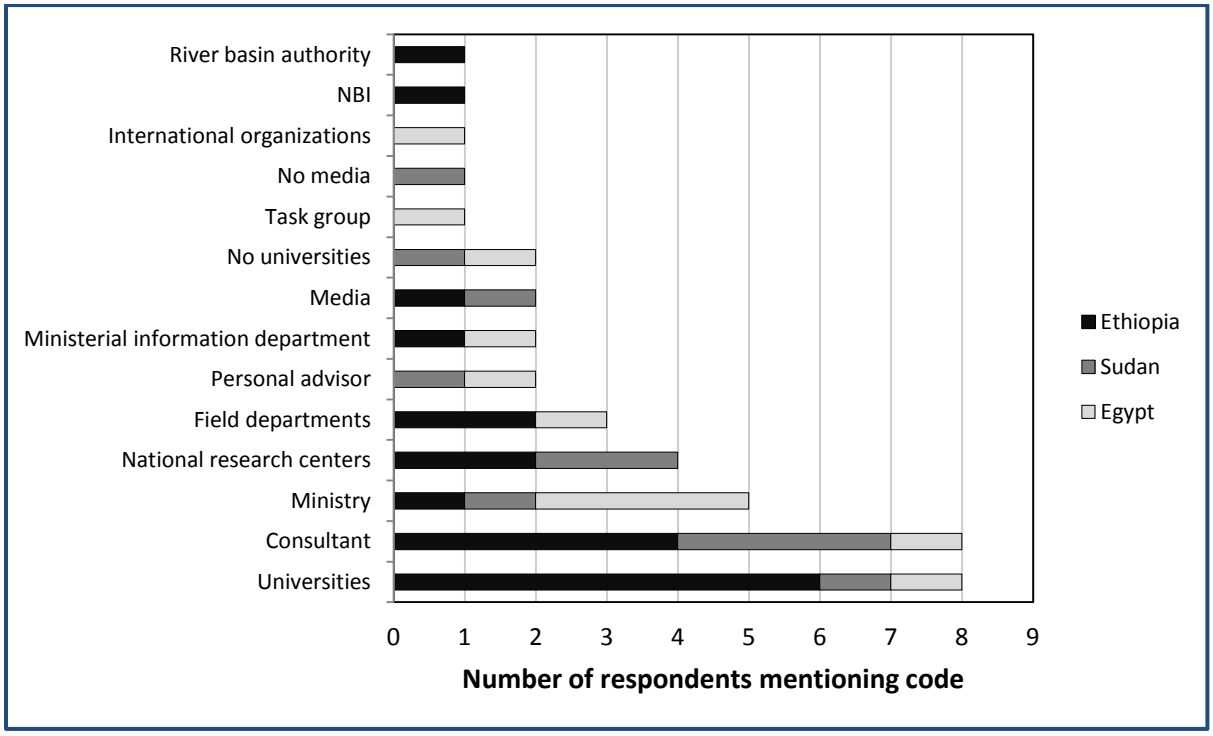

Figure 19 Information sources that provide information for decision making

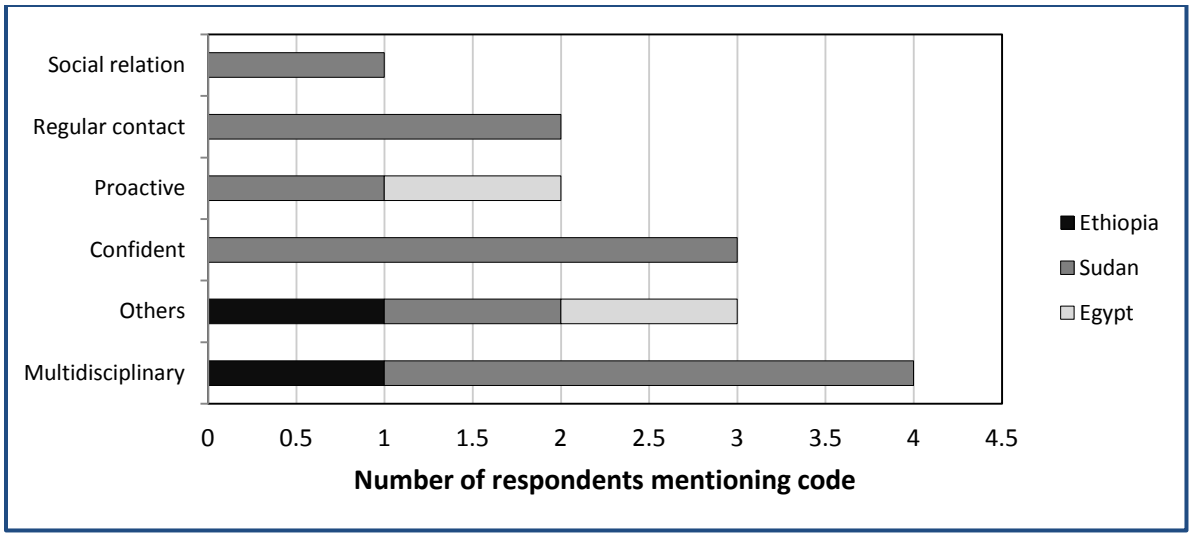

Figure 20 Characteristics of information sources that provide information for decision making

3.2.2 Political Decisions

Most decisions have a political dimension, and even though a scientist tries to fulfill the information needs of the decision maker as best as he can, the decision maker may still base his decision partly or entirely on other factors.

An important point that was mentioned by respondents from all countries is the fact that the research agenda is often not in accordance with the nation's plans and needs. Research can be solid and include all relevant aspects, but if it does not address directly the societal concerns of the decision makers, the research will be disregarded. Sometimes an issue will not be considered as critical by the decision maker, even though it is. What exactly the issues are that the decision makers of the various countries think is important, was not addressed. The decision makers overlook the longer term impact of measures. One example given by an Egyptian respondent is using groundwater. This will draw down the water table, making it harder to extract water every year, until, eventually, the groundwater is depleted. It might be that, if water is needed now, this is still a feasible option for the decision maker with short term goals. The respondents mentioned that researchers should focus more on the societal needs. An example of this could be that, in the groundwater example researchers may look for (other) solutions to the water scarcity problem, instead of doing research to prove that extracting groundwater has negative long term effects. Also, researchers should be more active in strategic communications regarding certain problems in water management.

Decision makers want to make a good impression on the people and often their decisions are based on personal aspirations. According to some respondents, scientists can bring decision makers to a decision, by addressing these aspirations. In this regard, decision makers will probably be more interested in research that focuses on the needs of their own society, rather than on another country's society, even though their decisions may affect this other country's society.

Information sharing

Another political difficulty in the Eastern Nile countries is the issue of data and information sharing. The countries consider data and information on water resources a national secret and therefore do not want to share it with each other. On the other hand, when the countries do share data, the other countries do not trust it. An example is the flow going into Lake Nasser. Officially it is 84 billion cubic meters, but the number is disputed and believed to be higher than that by scientists from both inside and outside the Eastern Nile. The countries do occasionally share their information with ENTRO, when they have jointly decided on a project that ENTRO will prepare and execute. ENTRO can only use this information for those projects and has to find other data sources for the rest of its research. They are trying to use publicly available data (mainly satellite data), to avoid the issue of data sharing. However, the difficulty with this is that it needs to be validated and that is next to impossible if there is no consistent, agreed upon data set. The respondents call this issue of trust in others' information a big problem in the Eastern Nile.

3.2.3 Information Needs for Decision Making in the Eastern Nile

Decision makers need multidisciplinary research to base their decisions on. The socioeconomic aspects are thereby just as important as the technical. While in Egypt and Ethiopia the decision process also reflects this need, since all relevant ministries are included in the process and the final decision, in Sudan the ministries other than the ministry of water resources and electricity seem not to be involved anymore. This could be due to the fact that in Sudan decisions are almost all political decisions. The political aspects of the decision making process were also mentioned by Egyptians and Ethiopian respondents, hence politics are strongly intertwined in water management of the Nile basin. The situation in Sudan differs due to the priorities going to electricity, rather than good water resources management.

The environmental aspects are deemed less important in Egypt, than observed for Ethiopia and Sudan. In Egypt it was only mentioned as something that the international community and thus the donor community finds important. Perhaps this is precisely the reason that the other countries are interested in environmental information- such as the effects on biodiversity, etc. - , since they are quite dependant on the donor community for their water projects. Ethiopians are also interested in the political aspects and the equitable distribution of water among users within the country. This is probably related to the fact that the government is highly decentralized, which means that within Ethiopia, federal governments are also "fighting" over the Nile resources. In Egypt people are more interested in the water requirements than in other countries, probably because they are using (and reusing) all of their water and therefore have to plan their distribution carefully.

Perhaps even more important than doing multidisciplinary research is the relevancy of the research and the way it is presented to the decision maker. Most decisions are political and, it is more important to do research that is relevant to society and the decision maker than to undertake research that addresses issues scientists think is important. In this regard, research should culminate into clear plans with pros and cons, so that the decision maker gets a good oversight in a short time span. It should be presented

in a short message, without using scientific jargon, giving one or two bullet points. To be able to influence both political and informed decisions, a relationship with the decision maker is essential. The decision maker has to build up trust with the scientist, and this is often difficult due to practical limitations. If the scientist does not have a direct line to the decision maker, he should communicate with the scientific advisor of the Minister, if there is one.

If research thus aims to influence informed, but also political decisions and change plans it should be multidisciplinary, address issues that are relevant to the targeted decision maker (i.e. the decision maker deciding on the issue that is raised by the research) and provide a plan and options to choose from. Also, the scientist needs to find an efficient way to bring this information to the decision maker.

What the issues are that are relevant to the decision makers remains unknown. Scientists should try to get an overview of the research questions that their research should answer to be relevant for decision makers. In the Eastern Nile these questions should probably be focused on addressing the basic needs of society (e.g. food security, electricity) in a sustainable manner, while taking into account future changes to the basin (e.g. climate change, population growth). The selection of issued to be addressed is probably an iterative process between scientists and decision makers. Raising important issues to the attention of decision makers can be made easier if scientists take into account the mentioned aspects. The communication of important issues from decision makers to scientists is an aspect of the information gap that should be addressed in further research.

One of the remaining issues is the decisions that are made by for example an Ethiopian decision maker that affect another country's society, for example Egypt's. The consequences for Egyptian society are not likely to change the Ethiopian decision maker's decision. To influence these decisions the scientists should find a way to make the effects on Egypt's society the concern of the Ethiopian decision maker or to find the decision's negative consequences for Ethiopian society. This is incredibly hard and remains a problem. An example of how this might work is the problem of sedimentation in Sudan. This is caused by erosion in Ethiopia as a consequence of land degradation. This land degradation is an issue of concern for Ethiopians. Research on the issue of land degradation and possible measures can be brought to the decision makers of Ethiopia and, as a side effect, the sedimentation problem in Sudan may be (partly) solved.

3.2.4 Significance for Hydrological and Water Resources Management Research

The findings on the information needs of decision makers in the Eastern Nile countries were used to evaluate the information provision by the scientific community. To be able to do this the framework for the evaluation of hydrological and water resources models was adapted according to the interview response. Also, the elements of useful research that research should comply to if it is to be used by decision makers were determined. Both are described in the following sections.

Adaptation Framework for Model Evaluation

The framework on water flows derived from the earlier literature review was compared to the hydrological information indicated as needed for decision making, during the interviews with decision makers. The information framework has been completed and adapted accordingly. It describes the bridge between classical hydrology and civil engineering on the one hand and its relevance as perceived by practical persons involved in decision making.

Technical information (Figure 17) is well represented in the framework. Water availability and water requirements are embodied by the groups “Hydrology” and “Flows, uses and withdrawals”, respectively. Floods, climate, sediment and water quality are included in the group “Changes and degradation”. Cropping pattern, vegetation and soil are more or less represented in the group “Agriculture". Productivity, infrastructure and project capacity can be placed under “Economics”. Hydrographic information is not included, but since it is not really a process, it was left out of the final framework.

Economics and the environment are included in the framework, but socioeconomics are clearly missing. Also, the legal and political aspects are poorly represented, with only water rights included in the framework. Therefore, the group “Socioeconomics” was included and the group “Water rights” replaced with the groups “Legal” and “Political”. The final framework is given in Table 2.

Table 2 Final framework for the evaluation of hydrological and water resources models

Group	Process
Hydrology	Precipitation
	Infiltration
	Evaporation and Transpiration
	Runoff
	Stream flow
	Ground Water (recharge, storage, flow)
Flows, Uses and Withdrawals	
Natural	Lakes
	Wetlands and Swamps
	Rivers and Streams
	Other Ecosystems - Groundwater Dependent

	Other Ecosystems - Surface Water Dependent
Manmade	Domestic
	Industrial
	Agricultural
	Aquaculture
	Livestock
	Municipal
	Reservoirs
	Hydroelectric Power Production
	Recreation
Changes and Degradation	Climate Change
	Natural Disasters
	Erosion and Sedimentation
	Soil Salinization
	Water Quality
	Land Use Change
Socioeconomic	
Economic	
Legal	
Political	

The Elements of Useful Research

There are five essential elements that research, its presentation and dissemination should comply with. These can be separated into aspects that need to be addressed by the research, the presentation of the research and the source of the research. The first three elements concentrate on the aspects that need to be addressed:

1) The multidisciplinarity of the research: does it include technical, socioeconomic, economic and (in the case of Sudan and Ethiopia) environmental information?
2) The relevance of the research: is the issue it addresses relevant to the people making the decision (e.g. are the people affected by the outcomes of the research from the same country as the decision makers the research is trying to influence)?
3) The usefulness of the research: does it provide plans the decision maker can actually implement?

However, complying with these three elements is not enough. The presentation and trust are important, too, leading to the following two elements:

4) Presentation: the research has to be presented in a short and concise way and without using jargon.
5) Trust: the decision makers need to trust not only the information and data, but also the scientist that provides them with the information.

The value of the available research and publications for decision making can therefore be evaluated using these five points. Trust is perhaps the most important, but also the most difficult element to achieve for scientists. Presentation becomes relevant once the scientist has found a way to get his research to the decision makers, which is difficult. The compliance of available research with these two elements is also the most difficult to assess. It is easier to evaluate the compliance with the first three elements. Although the relevance of the research is also not that easily evaluated, since this thesis did not focus on the actual problems the decision makers want to address. As was mentioned, however, the research should in the first place address the societal needs of the decision maker's own country or the political needs of the decision maker (which are often related to the societal needs, as was explained in section 3.2.2). Issues relevant to the society of the countries in the Eastern Nile Basin were identified by the NBI (Nile Basin Initiative, 2012):

"restoration of degraded water catchments that are critical for sustaining the flow of the major Nile tributaries, restoring badly degraded lands that export large quantities of sediments and cause serious siltation in the Nile tributaries and establishing a regional hydrometric and environmental monitoring system." Both to address water and environmental resources degradation in the basin. Additionally "interventions to increase agricultural productivity should include programmes to increase rainwater harvesting, expand irrigated areas, improve the water-retention properties of soil in the upstream countries and improve productivity and water-use efficiency in the downstream countries." To address the possible effects of climate change "the basin countries would do well to implement a number of 'no-

regret' measures aimed at building resilience to current climate variability while enhancing adaptive capacity for future threats."

To address these issues research could focus on questions such as:

- Can we save water in agriculture by using modern irrigation technologies?
- Is it feasible to expand irrigated land in a sustainable manner?
- What is a safe abstraction rate for groundwater?
- Do we need more storage for meeting water requirements during dry season?
- Could wetlands survive with lower consumptive use rates?
- Does it make sense to raise the embankments?
- Is it possible to reduce erosion and prevent expensive investments to remove sediments in reservoirs?
- Can we sustain rainfall in the Nile basin by promoting more evaporation?
  Do water level management in Lake Victoria, Lake Tana and Lake Nasser improve water availability?
- Are waste water treatment plants meaningful for the local water availability?

These questions should lead to plans and policies that could be implemented in the basin's countries.

3.3 Information Provision

With the information needs of decision makers in the Eastern Nile known, the information that is provided by the scientific community can be evaluated. ENTRO's models as well as other research on water resources management in the Eastern Nile are evaluated using the framework and the elements of useful research in section 3.2.4.

3.3.1 ENTRO/NBI

This section first evaluates ENTRO's models using the framework described in section 3.2.4 and then explains the way ENTRO disseminates its models and reports. Also, it provides the decision makers' views on ENTRO's models as obtained from the interviews.

Review of Models

Table 3 gives an overview of the performance of the various model used an developed by and with ENTRO as assessed with the framework. A brief explanation of each model, its uses and the results it yields as well as the reasoning behind the scores is given in the following sections.

HEC-ResSim

HEC-ResSim was used by (Lako, 2012) to construct a model of the Baro-Akobo-Sobat sub-basin. The model describes the processes in the Baro-Akobo-Sobat sub-basin (Figure 4). Hec- ResSim in general and thus also the Nile model focuses on the simulation of reservoirs. Other processes are not included in very much detail and are, if included at all, only included to complete the water balance. Only the main tributaries have been added to the Nile model, the smaller ones were left out. In the baseline model, the following "dams" are modelled: Abobo Dam, Jebel Aulia Dam and the Machar Marshes. Four diversions are included: Adura Bifurcation, Diversion Losses, Diversion 2 (a diversion included just before the Jebel Aulia Dam) and Mechar Spills. In scenario 1 the following dams are modelled in addition to the dams included in the baseline scenario: the Baro 1 Dam, the Baro 2 Dam and the Geba R. Dam. In scenario 2 the additional dams are: the Gambella Dam, the Gilo 2 Dam and the Kashu Dam.

Hydrology – hydrological processes are not included in the model. The model is fed with flow data and does not simulate rainfall-runoff processes. Evaporation from reservoirs is included. Stream flow is simulated but no routing or losses are applied, although this would have been possible with Hec-ResSim. Groundwater is not included at all and this is also not possible.

Flows, Uses and Withdrawals – some abstractions have been defined. These are, however, not based on real abstractions, but are defined to account for losses and thus complete the water balance. The Machar Marshes are modelled as a reservoir, since this is the only way to model them. Reservoirs and hydropower production are included in the model. Hec-ResSim makes it possible to include them with very much detail. Although the Nile model does not use all the possibilities, reservoirs are represented in a thorough manner.

Changes, Degradation and Pollution – the only changes that are modelled are the planned reservoirs and their operations. In that sense a land use change is modelled, but the only effects taken into account are the direct effects on the amount of available water.

Socioeconomics – not included.

Economics – the energy that is generated with the power plant is included in the model, as well as the efficiency and the flow. Therefore the economics of the power plant are included in the model.

Legal – not included.

Political – not included.

RiverWare

A RiverWare model for the Eastern Nile was created by Water Balance Consulting (Wheeler & Setzer, 2012) as part of the ENPM Project. Riverware is a tool for modelling river basins and is especially focused on reservoir operation. The RiverWare model describes the main Eastern Nile sub-basins, with their main tributaries and dams: The Blue Nile, Baro-Akobo-Sobat, Tekeze-Setit-Atbara, (part of the) White Nile and Main Nile. The model consists of three parts: a calibration model, the baseline model and the scenarios. Historical data (1956-1990) were used to build the calibration model . The calibration model is calibrated to simulate the situation in the period 1956-1990. From the simulation model, the baseline model could be constructed, this model runs from 2018 to 2052 and includes all of the reservoirs that have been constructed or are planned to be finished at that time. The scenarios make it possible to add (combinations of) future dams to the simulation and see the effects. The calibration model and the baseline model use the same input data for the hydrologic inflows as well as for the demands. The only difference between the two models is the simulation method. The calibration model uses a normal simulation based on historical (elevation) data for the operation of the dams and the baseline model uses a rule-based simulation with operating rules. The baseline model describes the situation without any future changes for the period 2018 to 2052. The scenarios focus on the effects of various (combinations of) new reservoirs on the water quantity in the basin. It does not include any changes in demand or in climate. The effects of the reservoirs are evaluated using the following parameters:

- Pool elevations
  The effect of a (combination of) new reservoir(s) on the pool elevations of the existing reservoirs is modelled and provided as an output.
- Hydropower generation
  The change in hydropower generation of the existing reservoirs as well as the total power generation of the different countries and the basin as a whole as a result of a new reservoir is provided.
- Reservoir spills

The change in total spills and the percentage of the outflow spilled as a result of the new reservoir is calculated.

- Reservoir evaporation
  The evaporation per reservoir, as well as per country and for the basin as a whole as a result of the construction of a new reservoir is provided.
- Ability to meet demands
  Given the historical monthly depletions, the ability of the basin to meet these demands is evaluated as well as the changes in the ability to meet demands due to the construction of a new reservoir.

Hydrology – RiverWare and thus also the RiverWare Nile model only models the processes within the river and does not include precipitation, infiltration, evaporation, transpiration and runoff. It uses measured or modelled inflow as input. Evaporation from reservoirs is included, but evaporation or seepage from the river is modelled as losses. The model does include stream flow, but no routing is applied.

Flows, Uses and Withdrawals – the major lakes are included in the model. Marshes are included as a diversion and (partial) return flow, however, processes within the marshes are not included. Most of the dams have operating rules based on environmental requirements, so in that way a minimal flow for ecological purposes is set. Withdrawals are grouped and not split into different uses. However the abstractions are mainly located near irrigation projects and are therefore qualified as agricultural abstractions. Reservoirs that were present at the time the model was made as well as some planned reservoirs are included in the model. Hydroelectric power is included in the model. Not only power generation from dams, but also inline power generation. Recreational flows and uses are not included in the model.

Changes, Pollution and Degradation - there are no changes or pollution modelled with the model, although it is possible to model water quality with RiverWare. The only changes that are included in the model are the new dams that are considered. These can be interpreted as land use change and therefore land use change is considered partly included in the model. No new irrigation projects are considered, nor is climate change, although it could easily have been added using the scenarios.

Socioeconomics – not included.

Economics – no economic values for the uses of the water are modelled. It would have been possible but has not been done.

Legal – no water rights system is included in the model. It would have been possible to include water rights, but that has not been done.

Political – not included.

RIBASIM

Deltares has developed a model for the Eastern Nile River Basin using RIBASIM7 (Krogt & Ogink, 2012). It includes the Baro-Akobo-Sobat, Abay-Blue Nile, Tekeze-Setit-Atbara and the Main Nile sub-basins. RIBASIM is a tool to model river basins. The Eastern Nile Model includes hydrological processes, as well as water uses and their characteristics. RIBASIM makes it possible to analyze different scenarios for the management of structures and user demand. The base model for the Eastern Nile is the situation in 2012, with all the existing infrastructure and using hydrological time series for the period January 1900 to December 2002.

The user has the possibility to simulate changes and measures with the following scenarios:

1. Socio-economic scenarios: predicting changes in population, irrigation and industry.
2. Agriculture sector scenarios: with crop plans.
3. Climate change scenarios: predicting changes in hydrological processes.
4. Measure and strategy data: containing a list of measures.

A couple of cases with different measures have been modeled to demonstrate the use of the model.

Hydrology – precipitation and evaporation data are included as well as runoff data. However, the rainfall-runoff process itself is not modelled. Stream flow is modelled using the 2-layered Muskingum routing method. Evaporation losses for river reaches are modelled as well. Ground water flow is not included in the model, but the groundwater balance and the groundwater use is modelled.

Flows, Uses and Withdrawals – lakes and wetlands are included as model nodes. Minimum low flows are included at several points in the basin. Irrigation demand is modelled based on the annual crop plans for the different irrigation systems. Domestic, municipal and industrial water demand are included as well. Reservoir and hydropower production are included. Evaporation, rainfall and seepage in and from the reservoir are modelled and the operation of the reservoir depends on the function of the reservoir. Recreational use of water is not included.

Changes, Pollution and Degradation – climate change and in a way land use change are modelled using various (combinations of) scenarios. Land use change is included through the change in size of irrigation area and the change in crop plan. The basic water quality is included in the model as well.

Socioeconomics – the socioeconomics are included in the scenarios. Population growth and other changes can be taken into account. However, the effects of measures on the socioeconomics are not included.

Economics – economics are not included in the model, although it would have been possible to include agricultural yield and production costs.

Legal – water rights are included in the form of allocation priorities.

Political – not included.

SWAT

Hassan (2012) has developed a water balance model for the Eastern Nile using SWAT. SWAT is an hydrological model that can model the hydrological processes in a river basin with very much detail. The Eastern Nile model is build up as follows:

- The watershed is delineated, to determining the sub-catchments, streams and flow directions.
- Land use, soil types and slopes are determined and added, assigning a combination of these three to each watershed.
- Rainfall, temperature, solar radiation, wind speed and relative humidity data are used as weather input.
- Five reservoirs are included in the model (Roseires, Sennar, Jebel Aulia, Girba, Aswan), the reservoirs collect water from the upstream watersheds and the outflow is modelled as a predefined monthly outflow.
- Irrigation is included using quite some detail. The model automatically applies irrigation if there is a water shortage in the soil. The amount of water that is irrigated can be controlled using various restrictions (e.g. the maximum amount of irrigation per day) and the source of the irrigation water can be specified, as well.
- The main model input is rainfall data, but since the model is for the Eastern Nile only, the water flowing into the Eastern Nile basin through the White Nile has to be included as input, as well.

Different exogenous and endogenous scenarios are defined. The exogenous scenarios include one drought scenario and two climate change scenarios. The endogenous scenarios include dam scenarios, irrigation scenarios, land use scenarios and sediment management scenarios. All of the endogenous and exogenous scenarios can be combined, as well.

Hydrology – The rainfall runoff process is modelled quite extensively. This is to be expected, since it is exactly what SWAT is meant for. Rainfall is used as an input and the evaporation is modelled, as well as the runoff processes.

Flows, Uses and Withdrawals – Reservoirs and irrigation are included with quite some detail. Since land use was determined, different ecosystems are also indirectly included. Manmade abstractions are not included other than abstractions for irrigation.

Changes, Pollution and Degradation – Land use change, climate change and sedimentation are included in the various scenarios. Other changes or degradations are not included.

Socioeconomics – not included.

Economics – not included.

Legal – not included.

Political – not included.

NBDSS

The Nile Basin Decision Support System (NB-DSS) is not just one model. It is an environment where all information related to the water resources management of the Nile River Basin can be stored, analysed and modelled. The possibilities are endless and include not only hydraulic and hydrological processes but also social, economic and environmental processes and impacts. There are ten different user interfaces, so called "managers" (NBI):

1) Time series manager
   Here the user can get access to the time series. It is possible to create, import and export time series data. Outputs from model runs are also stored here.
2) GIS manager
   This environment gives the user the possibility to view spatial data. Within the environment there are tools that make it possible to process the spatial data.
3) Scenario manager
   This interface manages the different models, scenarios and simulations. It manages all external models that can be connected to the NB-DSS. It can link models together (irrespective of their purpose) depending on what processes the user wants to model together. The scenario manager includes the possibility to do a simulation based optimization. The user can define objectives, decision variables and constraints and determine the optimization method to evaluate different options.
4) Indicator manager
   In the indicator manager the user can define his own output. Indicators can be created that fit the needs of the user and make it easier to evaluate the results of different models and scenarios.
5) Script manager
   In this environment the user can write his own script if the available models are not sufficient.
6) Analysis manager
   In the analysis manager it is possible to do a Multi Criteria Analysis or a Cost Benefit Analysis. The user can define his own criteria to evaluate different projects and interventions.
7) Spreadsheet manager
   In the spreadsheet manager the user has the possibility to evaluate and process all data in an Excel like environment.
8) Tools explorer
   The tools explorer shows the tools that can be used on a specific object, when that object is selected. There are also tools that are not specific to an object and a list of these tools van be viewed, as well.
9) Properties window
   In the properties the information and metadata about tools and objects is stored and can be viewed.
10) Database
    The database includes all the data that is used and produced with the DSS is stored in the database.

It is possible to connect all sorts of models to the NB-DSS, but at the moment only the following models are connected:

- MIKE 11
  This is software for river modelling. It includes hydrodynamics and distributed hydrology (including: overland flow, unsaturated infiltration, evapotranspiration and groundwater). Also there are add-ons for the simulation of: rainfall-runoff, structure operation, dam breaks, automatic calibration, stratified-multilayered river flow, flood forecasting, noncohesive sediment, advection-dispersion, cohesive sediment and ecological models. (DHI)
- MIKE BASIN
  This software can be used for river basin planning. It includes: water allocation and sharing, reservoir operation, hydropower simulation, river routing, irrigation water demand and crop yield estimation, catchment hydrological modelling, catchment and river delineation tools, reservoir sedimentation and water quality. (DHI)
- MIKE SHE
  This is software for integrated catchment modelling. It includes the following processes: overland flow, river flow, unsaturated zone, evapotranspiration, snow, groundwater, water quality and water balance. (DHI)

Given all the features of the NB-DSS and the three models together, this is a tool that could give a very complete picture of the Nile River Basin.

For the Eastern Nile Joint Multipurpose Programme a model was made of the Blue Nile, including the last part of the Main Nile. For this model a combination of MikeBasin and Mike11 was used within the Nile Basin DSS. A baseline scenario and four additional scenarios were evaluated. The baseline scenario was (2012) the current situation including the heightening of the Roseires Dam. The other scenarios are as follows:

1) Including the Border Dam and maximizing its hydropower generation.
2) Including both the Border Dam and the Mandaya Dam and maximizing hydropower generation of both.
3) Including both the Border Dam and the Mandaya Dam and maximizing hydropower generation of both while maintaining the irrigation supply.
    a. Same as scenario 3, but including climate change.
4) Including the Border Dam with flood damages.
    a. Same as scenario 4, but including operation of dam for flood mitigation.

The results of the scenarios are evaluated in terms of social, environmental and economic impacts. Within the Nile DSS indicators were defined to quantify the effects of the different interventions. The social indicators can be grouped as follows: water availability, community health and safety, food security and livelihoods and displacement. The environmental indicators are separated into the following groups: footprint areas, downstream areas and water quality. The economic indicators include

impact on navigation, energy production, evaporation loss, flood damage, food production and a detailed cost-benefit analyses. (Aurecon, 2012)

Hydrology – precipitation, evaporation and runoff are all includes in the model. Also stream flow is modelled. Infiltration and groundwater seem not to be included. This would have been possible with MIKE SHE.

Flows, Uses and Withdrawals – wetlands, environmentally sensitive areas, ecological stress, biological production are all included in the form of environmental indicators. Thus they are not explicitly modelled, but the way they are affected by certain measures is included in the outcomes. Reservoirs, irrigation and hydroelectric power generation are included in the scenarios. Domestic, industrial, municipal and recreational water use seem not to be included. Aquaculture and livestock are not modelled but the way they are affected is included in the outcomes.

Changes, Pollution and Degradation – climate change is included as a scenario, as well as flooding (a natural disaster). Sedimentation and soil salinization are not included. Water quality is not modelled, but is included as an indicator. Land use change is only included in the form of the building of a dam, which creates a water body where first there was land.

Socioeconomics – the socioeconomic effects of the different measures are assessed with the help of parameters.

Economics – the economic effects of the different measures are assessed with the help of parameters.

Legal – water rights are included indirectly. In one of the scenarios, the hydropower generation is optimized while maintaining the irrigation supply.

Political – not included, but it would be possible to include it in the indicators.

Table 3 Evaluation of ENTRO Models Performance

Process	HEC-ResSim	Riverware	RIBASIM	SWAT	NBDSS
Hydrology					
Precipitation	- -	- -	+ +	+ +	+ +
Infiltration	- -	- -	- -	+ +	-
Evaporation and Transpiration	+/-	+/-	+ +	+ +	+ +
Runoff	- -	- -	+ +	+ +	+ +
Stream flow	+	+	+ +	+ +	+ +
Ground Water (recharge, storage, flow)	- -	- -	+	+ +	-
Flows, Uses and Withdrawals					
Natural					
Lakes	- -	+ +	+	+/-	-
Wetlands and Swamps	+	+	+	+/-	+
Rivers and Streams	-	+	+	+/-	+
Other Ecosystems - Groundwater Dependent	- -	- -	- -	+/-	+
Other Ecosystems - Surface Water Dependent	- -	- -	- -	+/-	+
Manmade					
Domestic	- -	- -	+ +	- -	-
Industrial	- -	- -	+ +	- -	-
Agricultural	- -	+	+ +	+ +	+

Aquaculture	- -	- -	-	- -	+
Livestock	- -	- -	-	- -	+
Municipal	- -	- -	+ +	- -	- -
Reservoirs	+ +	+ +	+ +	+ +	+ +
Hydroelectric Power Production	+ +	+ +	+ +		+ +
Recreation	- -	- -	- -	- -	-
Changes and Degradation					
Climate Change	-	-	+ +	+ +	+ +
Natural Disasters	-	-	-	+	+ +
Erosion and Sedimentation	- -	-	- -	+	-
Soil Salinization	- -	- -	- -	-	-
Water Quality	- -	-	+	- -	+/-
Land Use Change	+/-	+/-	+/-	+ +	+/-
Socioeconomic	- -	- -	+	- -	++
Economic	+/-	-	-	- -	++
Legal	-	-	+	- -	+/-
Political	- -	- -	- -	- -	-

Summary of ENTRO Models Performance

HEC-ResSim and Riverware do not score that well on the hydrological processes, which is not strange, since both of these models are river basin models focusing on the uses of water. However, both models have included reservoirs, their operation and hydropower production extensively, while only marginally including other uses. Reservoir simulation is what the models are made for, but it limits their use for broader application. No other changes than the construction of new reservoirs are included in the scenarios. Also, no consequences other than the direct consequences (e.g. evaporation, losses, water availability) can be assessed. The socioeconomic, economic, legal and political aspects are not included at all, although with both models it would be possible to include water rights in the form of allocation priorities.

RIBASIM is more complete, it includes hydrological processes as well as uses and withdrawals. Still the changes and degradation could be better represented. Socioeconomics are included as input, but the socioeconomic nor the economic consequences are included.

The SWAT model is somewhat different from the other models, it focuses more on the hydrological processes and therefore scores better on these aspects than the other models. While the SWAT model focuses on hydrological processes it still includes reservoirs and irrigation with quite some detail. Also changes and degradation are included by using scenarios. The performance on socioeconomic, economic, legal and political aspects is less good, though.

The NBDSS model is the most inclusive model. It includes all of the groups of processes and those things that are not included are available in the software and therefore could be included. Especially on the socioeconomic and economic aspects, the NBDSS scores remarkably better than the other models. Because of the possibilities of the NBDSS to formulate indicators and to link these to the model results, these aspects can be included easily.

Even though RIBASIM, SWAT and the NBDSS include a lot of the necessary processes and could therefore be quite helpful, there are still problems with the implementation and dissemination of the research. This probably has other causes than the model capabilities itself.

Dissemination

When the three (or two) countries agree on a project, ENTRO will hire a consultant to do the research. The countries will provide ENTRO with the necessary data. When the consultant finishes the report, ENTRO will organize a workshop, where representatives of the three countries come together to discuss the contents. If the three countries agree with the contents, the report may be disseminated to the countries and the public and the project will be executed. According to the scientists at ENTRO, this is the only way that ENTRO can disseminate information. This dissemination then goes through the Eastern Nile Subsidiary Action Plan Team, who have representatives in each country who are responsible for the dissemination of ENTRO's research in their country.

If ENTRO is involved in other research than a joint project, the achievements cannot be disseminated through ENTRO, but have to find alternative ways provided that public domain data has been used. If the countries' data was used for the research it cannot be disseminated at all, because the countries first need to give their consent and if it is not a project they agreed upon, they will not provide the required permissions for dissemination.

According to one of the respondents, ENTRO's significance in this regard is more on the cooperation process than the amount of projects they concluded or the research they do. ENTRO is there to do projects that the countries agreed upon and thereby promote regional cooperation and it is not mandated to start doing its own research.

Respondent's Opinion of ENTRO Models

Egypt has stepped out of the NBI and is therefore also not recognizing ENTRO, or its research. The other countries do implement the joint projects that are developed by ENTRO as was explained in the previous section. ENTRO also tries to make its models available and the NBDSS was of course developed to create an information platform for the countries.

A scientist from ENTRO pointed out that the DSS was developed by all countries together after extensive consultation, which makes that the countries will feel ownership of the tool and are more likely to use it. However, several Sudanese respondents remarked that the DSS has not yet yielded any results, while it has been there for some time now. Egypt has stepped out of the NBI and thus is not using the DSS, which is why they did not have any remarks on it. The Ethiopians did mention that they are starting to use the DSS. The DSS is seen as a black box that is time consuming to work with and too big to be useful. It is not strange that the DSS being a black box is an issue, since it is normal not to trust something when one does not understand it and trust was already determined to be an important issue. The main problem with the DSS, however, is that it still runs on old data and thus it all comes back to the issue of data sharing again.

Almost all of ENTRO's models and also the DSS were developed by foreign consultants. The models often have a black box character. It is hard for the people in the countries, even the scientists, to understand how processes are calculated in these models. Therefore, the respondents pointed out that capacity building is very important. Deltares has organized three trainings for ENTRO staff (Krogt & Ogink, 2012), but no capacity building has been conducted in the countries. The NBI is giving training sessions and trying to improve capacity building of the NBDSS, but apparently this has not yet yielded the desired results. According to the respondents, another problem with international consultants is that their goal is to make profits. The countries need to buy licenses, which are very expensive, especially for a developing country. What they need from organizations like this, is capacity building, so that they can build and work with the model themselves. Apparently, the Terms of References for the foreign consultants are not perfect, and perhaps non-profit international organizations and NGOs should get a stronger role in the tool development.

According to ENTRO's respondents the main problem with the DSS, except for the difficulties with the licenses and capacity building, is the fact that it does not have enough adapters. An adapter is a built in function that allows the user to integrate other models into the NBDSS, than Mike-Basin. The NBDSS is based on Mike type of models only, and the scientists at ENTRO are of the opinion that the various models they have and are familiar with are helpful for different purposes. The DSS should have adapters for all of them, to make the tool versatile and more flexible for the operators.

3.3.2 Other Research

The analysis of the information needs of decision makers in the Eastern Nile countries shows that there are five important aspects of research for it to be used by decision makers:

1) The multidisciplinarity of the research: does it include technical, socioeconomic, economic and (in the case of Sudan and Ethiopia) environmental information?
2) The relevance of the research: is the issue it addresses relevant to the people making the decision (e.g. are the people affected by the outcomes of the research from the same country as the decision makers the research is trying to influence)?
3) The usefulness of the research: does it provide plans the decision maker can actually implement?
4) Presentation: the research has to be presented in short way and without using jargon.
5) Trust: the decision makers need to trust not only the information and data, but also the scientist that provides them with the information.

There are many international symposia and conferences related to the water resources of the Nile or one of its sub-basins. This is a good vehicle to present new findings and encourage free exchanges between scientists and between scientists, advisors and consultants. Below is a report of only one of these conferences, just for the sake of demonstrating the type of information exchanged during such international event.

The research that was presented at the New Nile Opportunities Conference organized in Addis Ababa, December 2014 and the publications on water resources management in the Nile in the year 2014 were evaluated on their compliance with the first three elements of useful research. The other two, trust and presentation, are impossible to assess, because it is not known whether the scientist that did the research is trusted by the decision makers his research targets, nor is it known how the scientists presented their research to the decision makers (or if they did at all).

New Nile Opportunities Conference 2014

The topics of the research presented at the conference vary from erosion and sedimentation to assessments of various aspects of the GERD. The assessment of each of the publications can be found in Appendix D1. Only 33% of this research can be considered multidisciplinary. In general the research scores slightly better on the other two points, with 62% being useful and 71% being relevant. Figure 21 presents the percentages of the research that comply to all three, two, one and none of the requirements. Only 24% of the research complies to all three of the points and 14% does not fulfill any of the three requirements.

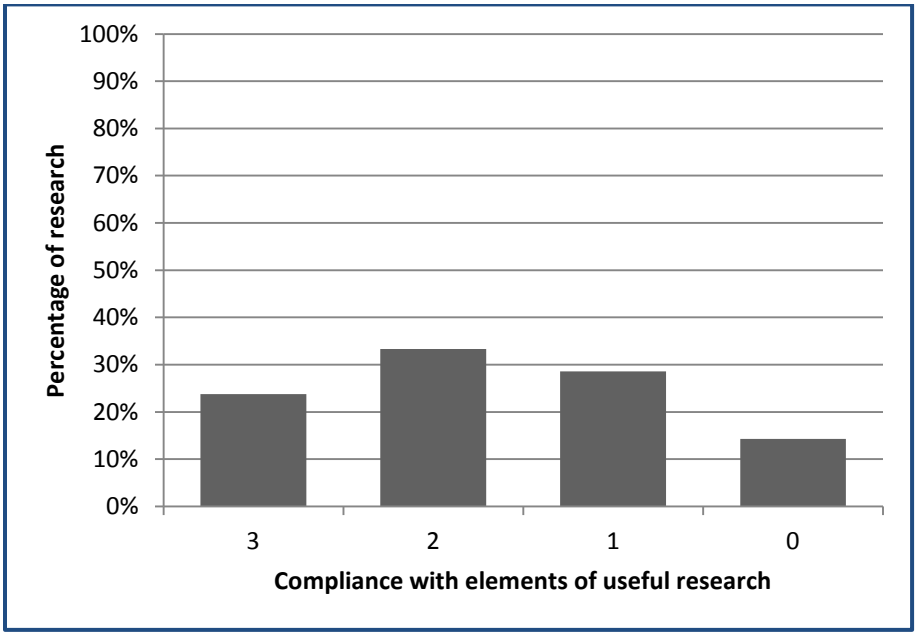

Figure 21 Compliance of the research presented at the New Nile Opportunities Conference to the elements of useful research

Publications on Water Resources Management of the year 2014

Eleven of the publications on water resources management in the Nile were evaluated on their compliance with the three elements of useful research (see appendix D2). 33% of this research is multidisciplinary. The publications score relatively good on relevancy, with 92% of the research being relevant to society. The score on usefulness is 58%. Figure 22 shows the percentages of the publications that comply to all three, only two and only one of the criteria. There are no publications that do not comply to any of the elements. Only 25% percent of the research complies to all three of the elements of useful research.

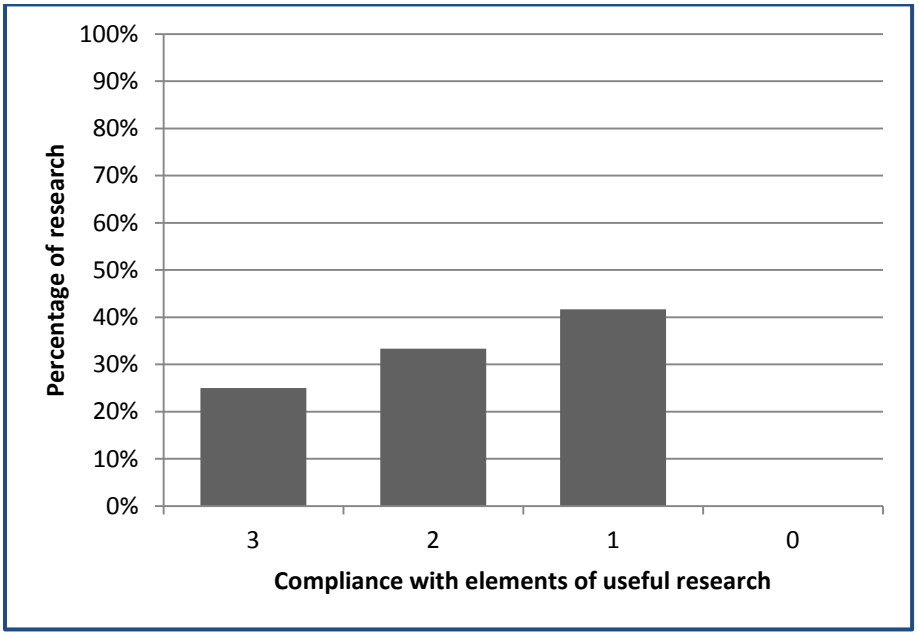

Figure 22 Compliance of the publications on water resources management in the Eastern Nile of 2014 with the elements of useful research

3.4 The Information Gap

Part 1 of the research showed that decision makers need multidisciplinary research that gives them plans with pros and cons in a short clear message. Also, the research should address issues that are relevant to the country's needs.

The multidisciplinarity of ENTRO's models is sometimes unsatisfactory. Some of ENTRO's models should include more processes to really address all aspects of water resources management. Especially the socioeconomic and economic consequences are overlooked. But even the implementation of models that do include the larger part of the processes is difficult. The main difficulties, aside from the issue of data sharing (which is restricting the availability of input data), are capacity building and the fact that the consultants developing the models need to make profits. Additionally, ENTRO is restricted by its mandate in the possibilities it has to share information and data. Thus for research other than the projects that the countries agreed upon, even ENTRO has to use open access data. The focus of ENTRO is (or should be) more on cooperation, rather than producing scientific knowledge. Perhaps the construction of models should be left to non-profit organizations. Also, it might be wise to do it independently from ENTRO, to avoid the restrictions induced by ENTRO's mandate.

Of both the research presented at the New Nile Opportunities Conference and the publications on water resources management in the Eastern Nile of the year 2014, only 25% (or 12.5% if one considers that only the half that was not fundamental was included in the analysis) is multidisciplinary and relevant and provides plans and options. Clearly, the scientists need to start providing more useful research if they want their research to be used for decision making. This does not mean that a scientist has to be an engineer, economist, sociologist and environmentalist at the same time, rather scientists from different disciplines need to work together. Nor does it mean that scientists should completely direct their research towards the decision makers' agendas. If their aim is to change decisions, however, it would not hurt to take into account the relevancy of the research. The decision makers also indicated that the scientist should find a way to bring his research to the attention of the decision makers. How this is or is not done by the scientists whose research was evaluated in this thesis was not addressed and the lack of good communication of the research may be another reason it is not used for decision making.

It can be concluded that the information gap is partly caused by the lack of multidisciplinary, relevant and useful research on the part of the scientists. This is one of the things that should be addressed to bridge the gap. Capacity building is another part of the gap, which could be made easier if models and research are created by non-profit organizations. The issue of data sharing and trust (in other people's data and information, but also in the scientists) remains difficult to solve.

4 WATER ACCOUNTING +

The information gap has been identified in chapter 3 and in this chapter the usefulness of Water Accounting + in bridging this gap will be evaluated. First, a description of the water accounts is provided, followed by an evaluation on the basis of the framework for the evaluation of hydrological and water resources models. The water accounts are evaluated on their compliance with the elements of useful research that were determined in chapter 3.2.4 and the views of the interview respondents from the Eastern Nile countries on Water Accounting + will be discussed.

4.1 The Water Accounts

Accounting is clear language that most policy makers understand. Water Accounting (WA+) reports on the water resources in a river basin in a clear manner. The outcomes are to the point and presented in various sheets that make it possible to quickly understand the state of the basin. The idea behind WA+ is to create a standard reporting system on water resources conditions of river basins. Unlike the conventional tools it includes multiple water users and reports for each user how much water is used, where it comes from and what happens with the water after it is used. This is done both for natural ecosystems as well as for withdrawals from rivers, lakes, reservoirs and aquifers. The main data source is open access data. This makes it a transparent and tangible tool for policy makers to use in their decision making. The water accounts can provide an independent assessment of water flows in the Nile Basin and supply much needed data, under all circumstances, also if local agencies do not share data.

The most important sheets of the Water Accounts for the entire Nile Basin averaged over the years 2005 to 2010 are shown in

Figure 23, Figure 24 and Figure 25. Other sheets can be found in Appendix E.The Resource Base sheet in Figure 23 shows the overall conditions of the river basin. The left hand side of the diagram shows the amount of water entering the basin and in what form. The central part of the diagram displays the partitioning into landscape evapotranspiration and exploitable water. Landscape evapotranspiration is the water consumed by protected forests, wetlands, glacier, etc. The utilized land use describes pastures used for grazing, natural water bodies, etc.). Modified land use classes deals with rain fed agriculture, settlements, leisure parks etc. that affect for instance surface runoff, soil moisture dynamics and evapotranspiration. The exploitable water or managed water use reflects water being withdrawn for intended processes such as irrigation, hydropower, etc. The right hand side of the diagram describes water flowing out of the basin. The Utilized Flow sheet in

Figure 24 provides more detail on the flows of managed water use. It describes water withdrawals, consumptive use and the return flows. This water is used for the various sectors listed in the middle of

the sheet. The water use per sector is split into consumed and non-consumed water. The focus of the Evapotranspiration sheet in

Figure 25 is on water consumption by land use class. It describes the physical process of water consumption in terms of evaporation, transpiration and interception. Also it indicates how much of this water use is beneficial. It shows whether the benefits are agricultural, economical, environmental or provide energy or leisure in return for water consumption.

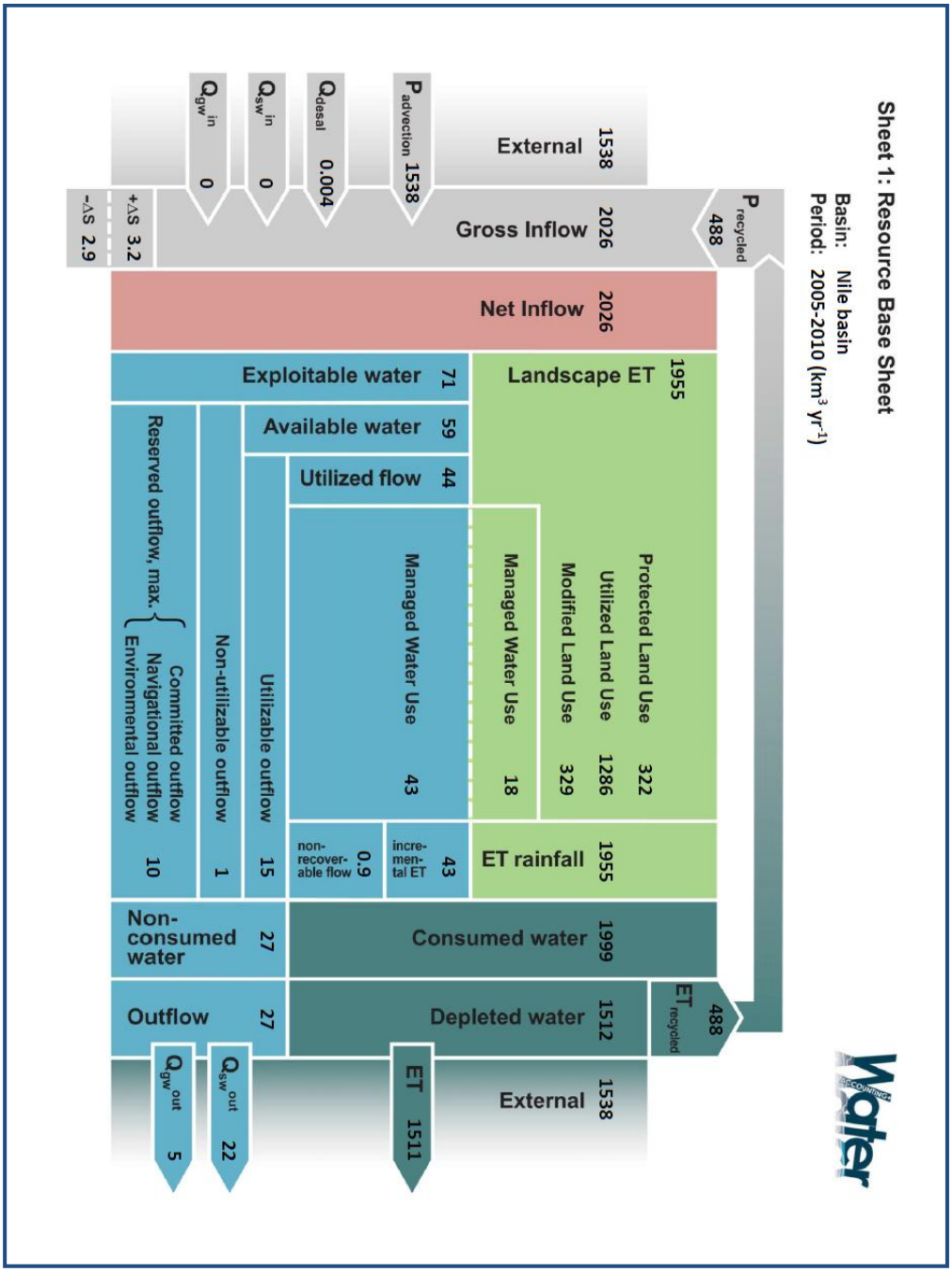

Figure 23 Nile Basin Resource Base Sheet - (www.wateraccounting.org)

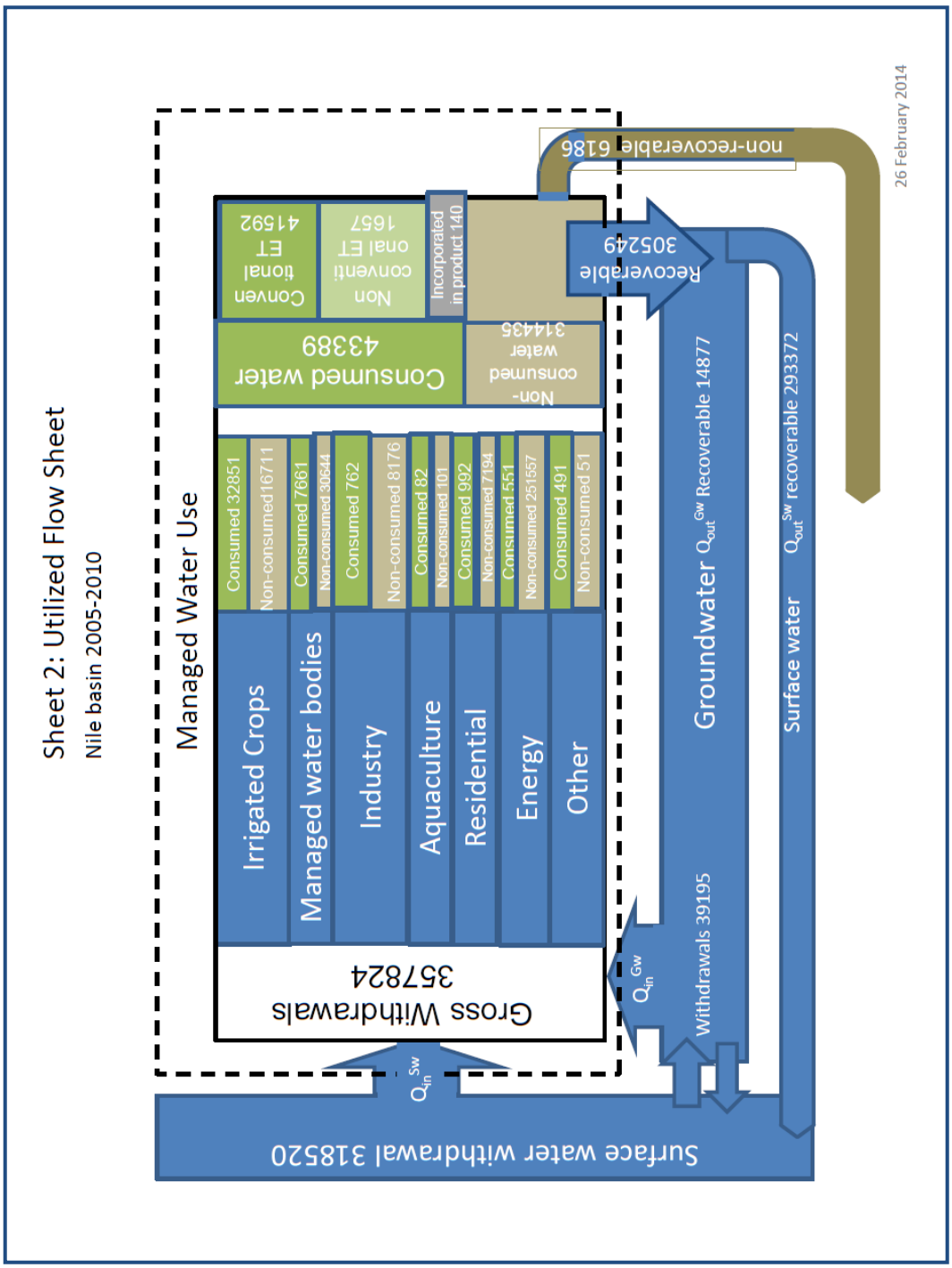

Figure 24 Nile Basin Utilized Flow Sheet - (www.wateraccounting.org)

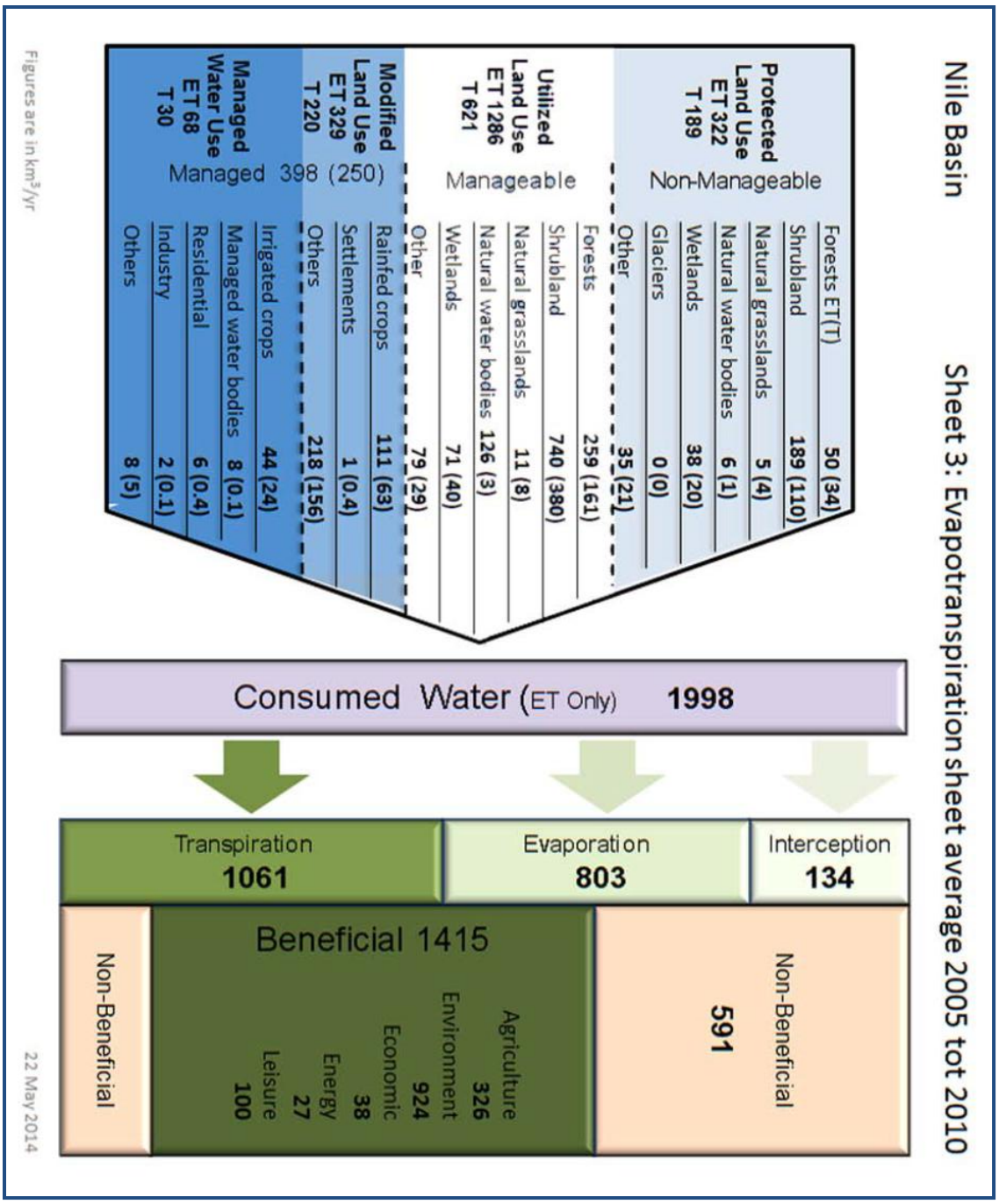

Figure 25 Nile Basin Evapotranspiration Sheet - (www.wateraccounting.org)

4.2 Evaluation

4.2.1 WA+ Model Evaluation

Table 4 gives an overview of the performance of Water Accounting + as assessed with the framework. The reasoning behind the scores is explained below. Overall the score of the water accounts is very good. They include almost all of the hydrological processes and report very thoroughly on the flows, uses and withdrawals. A lot of the other aspects can be easily included and assessed using scenarios.

Hydrology

Most hydrological processes are covered in the water accounts. Precipitation, evaporation and transpiration are at the basis of the whole concept and therefore included quite extensively (evapotranspiration even has its own sheet). Infiltration is not explicitly defined. Surface runoff and stream flow are covered in the surface water sheet (under development). Groundwater recharge, baseflow and groundwater abstractions are encompassed in the groundwater sheet (under development).

Flows Uses and Withdrawals

Both natural and human flows, uses and abstractions are included in detail. The evapotranspiration and the utilized flow sheet give an extensive overview of all the water uses and the corresponding demands.

Changes and degradation

Changes and degradation are not included. Only water quality is included in the sense that there is a non-recoverable flow in the utilized flow sheet. It would be possible to include changes and degradation by developing sheets for different scenarios, this has not (yet) been done. Erosion and sedimentation and soil salinization are not included in the model at all.

Socioeconomic

The socioeconomic aspects are not included. It would be interesting to see how many people are benefiting from a certain abstraction and to have other information like that.

Economic

Economic information is only partly included. There are sheets that present the benefits of water use, like for example the agricultural yield. But the financial aspects are missing.

Legal

In the surface water sheet the reserved flow is presented. One could say that with this the legal aspects are somewhat included in the water accounts. However, the legal aspects of water resources are not really represented in the water accounts.

Political

The surface water sheet has a flow that is called the unofficially committed flow. This can be seen as a political aspect. Other than that political aspects are not included in the water accounts. However, this is a very subjective and therefore dangerous aspect. The amount of unofficially committed flow may be perceived differently by different countries or even persons, it is not an objective figure. Including these kind of subjective political aspects may be unwise, unless one leaves the actual determination of the figure to the users of the information.

Table 4 Water Accounting + Performance

Process	Water Accounting +
Hydrology	
Precipitation	+ +
Infiltration	-
Evaporation and Transpiration	+ +
Runoff	-
Stream flow	+ +
Ground Water (recharge, storage, flow)	+ +
Flows, Uses and Withdrawals	
Natural	
Lakes	+ +
Wetlands and Swamps	+ +
Rivers and Streams	+/-
Other Ecosystems - Groundwater Dependent	+ +
Other Ecosystems - Surface Water Dependent	+ +
Manmade	
Domestic	+ +
Industrial	+ +
Agricultural	+ +
Aquaculture	+ +
Livestock	+ +
Municipal	+ +
Reservoirs	+ +
Hydroelectric Power Production	+ +
Recreation	+ +
Changes and Degradation	
Climate Change	-

Natural Disasters	-
Erosion and Sedimentation	- -
Soil Salinization	- -
Water Quality	+/-
Land Use Change	-
Socioeconomic	- -
Economic	+/-
Legal	-
Political	-

4.2.2 Comparison to ENTRO Models

Overall the performance of Water Accounting + as assessed with the framework is very good. Water Accounting + scores, in general better than Hec-ResSim, Riverware, RIBASIM and SWAT. Water Accounting + includes both the hydrological processes and the flows, uses and abstractions in much detail, while the other models mostly score well on only part of these processes. The NBDSS scores just as well though, but on other aspects than WA+. Processes where the NBDSS scores badly are more thoroughly included in WA+ and the other way around. However, the processes under changes and degradation (one of the aspects where the NBDSS scores better) can easily be included by including different scenarios. Socioeconomic and economic aspects are harder to include, but should be included if Water Accounting + wants to compete with the NBDSS.

Even if the water accounts would be updated to include the missing processes, this is not a warranty that they will be used. This thesis has shown that there are other aspects to be considered, if aiming to close the information gap.

4.3 WA+ Compliance with Elements of Useful Research

Multidisciplinarity

The water accounts do include the various aspects of water resources management. There are some aspects, however, that are not included in much detail or included at all as was also concluded in

chapter 4.2. Especially socio-economic impacts are not given enough attention, but also the legal and political aspects could be included more explicitly.

Relevance

The water accounts address the availability, withdrawals and uses of water in the basin. Which is quite relevant to society in the basin and thus also to its decision makers. The management of water resources is a hot topic in the Eastern Nile basin and the water accounts provide information to assess the water resources and their uses.

Usefulness

The water accounts themselves do not provide clear plans and options, with pros and cons that can be used by the decision makers. They present the current status of water providers and water users in the basin. There are important conclusions that can be drawn from the water accounts, like the fact that water resources and land management plans should focus on the utilized land use, because this land use type is the biggest consumer of water and provides room for improvement. If these conclusions are included and presented more clearly, the water accounts would be useful. Still, a clear plan would be missing. It is possible, though, to use the accounts to explore scenarios and provide the pros and cons of various management scenarios. Also one can include new projects and plans in the scenarios to evaluate their effects.

Presentation

The water accounts give an overview of the water resources in a river basin. They provide the various aspects in concise sheets, which make it possible to get a quick understanding of the state of the water in the basin. The sheets, however, are not that easily interpreted. They use difficult terms that might not be easily understood by decision makers. When presenting the water accounts to decision makers one should explain all terms that are used and, more importantly, come up with one or two important messages that can be derived from the water accounts.

Trust

Whether the water accounts will be trusted remains to be seen. They use open access data, which makes them an objective information source. It is important, however, to address the issue of how to include the political aspects, because including these in the wrong way, might mean that the water accounts lose their objectivity and are not trusted anymore.

Whether the water accounts are trusted does not only depend on whether the accounts themselves are trusted, but also on whether the person presenting the accounts is trusted. Investment in a good relationship with decision makers or their advisors and a strategy to determine who to target is vital, if that has not been done yet.

4.4 Respondent's Opinion of WA+

4.4.1 Information

One of the issues mentioned is the limited validation of WA+. Respondents from all countries indicated that the data must be validated with country data for it to be trusted by the countries. Using country data is impossible, however, because the countries do not share their (correct) data. A possibility could be to use a specialist from each of the countries to validate the accounts. Still, this does not really solve the problem of the countries not wanting to share their data. Some respondents pointed out that some values were wrong and need to be changed. Rainfall was the most disputed value, with one of the respondents from Egypt saying that the value for the rainfall in Egypt is too high and the value for the basin wide rainfall too low. Another aspect mentioned is that according to the water accounts there is some outflow into the Mediterranean sea, while in fact there is not.

Other comments about the information provided in the sheets were that the basin level is very nice, but also that country level sheets would be interesting and, according to some respondents, essential. One Egyptian respondent mentioned that seasonal instead of annual accounts would be useful. Additionally, it was indicated that it would be interesting to include alternative scenarios and the countries plans, to see their effects. A Sudanese respondent missed socioeconomic consequences (as was also concluded by the analysis in chapters 4.2 and 4.3) and two other respondents (from Sudan and Ethiopia) were interested in seeing the principles of equitable use and sharing of benefits included in the accounts.

Two other outstanding issues (aside from the validation) that the respondents remarked are the absence of an explanation of what the terms that are used in the accounts exactly mean and an explanation of how the data is obtained and what calculations are made, including an indication of how accurate the data is. Also, a map showing the delineation of the sub-basins would be helpful.

4.4.2 Presentation

Overall the respondents thought that the concept and the way it is presented are comprehensible and a good way to present it to decision makers. However, it was also pointed out that the sheets are more useful for scientists and that it is important to have some clear short messages to give to the decision makers. Some of the respondents asked about the unit of the data, which indicates that it is not clearly shown on each of the sheets. Two of the respondents were interested in seeing the data in the form of an interactive map, so that decision makers can click on the part of a basin or country that they are interested in and see the information for that part.

4.4.3 Dissemination

Presenting the sheets on the website is considered a good way of disseminating the water accounts. However, it was suggested to send an invitation to the website to the relevant people. One of the respondents indicated that decision makers would not have time to go to a website and that it is better to bring the water accounts to the attention of the decision makers' advisor. Three respondents from

Egypt and ENTRO pointed out that capacity building, possibly by means of a web tutorial is an important aspect and can help in further disseminating the water accounts. One Egyptian respondent suggested to set up centers in the three countries and to give them the responsibility of doing and disseminating the water accounts.

4.4.4 Usefulness

Respondents from all countries believe that the water accounts can provide decision makers with a basic understanding of the water resources in the Nile basin and in their country. They can show where the opportunities for development are and how to improve water resources management. One respondent from Egypt even believes that “this can resolve all the conflict”. However, respondents also indicated that this will be useful for informed decisions, but not for political decisions. One of the Ethiopian respondents thinks that the water accounts can provide a point of reference for testing the countries’ data and thus determine their accuracy. It is like "nice to have a second and independent opinion" free of charge.

4.5 Bridging the Gap

This thesis showed that the information gap might be (partly) bridged by providing multidisciplinary research that is relevant to society and the decision maker and that provides useful options. The issues of trust, data sharing and the dissemination of research to the decision makers remain difficult to address, though.

Water Accounting + was generally seen as useful by the respondents of the Eastern Nile countries. However, just like all other research, the water accounts can and should be improved for them to possibly become a bridge to the information gap. On the bright side, the basic principles of Water Accounting + provide a very good starting point.

Multidisciplinarity

Even though Water Accounting + includes a lot of the aspects of water resources management, it lacks an assessment of the socioeconomic and economic aspects. To be really useful for decision makers, these should be added. This can be done for example, by including a population map and combining this with the water uses, to get insight in the amount of people benefiting from a certain withdrawal. The socioeconomic aspects can also be included more easily by analyzing how they are affected by certain changes and measures.

Relevancy

The water accounts give an overview of the basins water resources and its uses, which is quite relevant. If however, the countries' plans and problems are evaluated and assessed using the accounts, they might become more relevant to the decision makers. Examples of plans and problems where the water accounts might be useful are the development of river basin plans in Ethiopia and the issue of non-integrated water resources management in Sudan.

Usefulness

Their ability to give an overview of the water resources in a river basin in a thorough but concise way, makes them very useful. To get through to decision makers, however, clear messages drawn from the accounts, should be provided. Also, the accounts would be more useful if they were provided at national level, rather than basin level.

Trust

Other data sources than their own are hardly trusted by the countries. Water Accounting + is no exception. To create trust, the water accounts should be validated by people from the countries and/or renowned and trusted advisors. Additionally a clear description of the water accounts themselves, but also of the way the data has been collected and processed should be included. A water accounting manual is currently under development that describes the terminology, data sources and computational

steps. Although the need for and way of reporting uncertainty did not become very clear in this research, it would be wise to report on the uncertainty. This should be done by giving a range, rather than giving confidence levels.

Not only the water accounts and their transparency themselves are important to get the trust of the decision makers, it is also important that the decision makers trust the person presenting the accounts. Therefore, personal contact with (someone close to) the decision makers is important if the water accounts are to be used for decision making.

Dissemination

Water Accounting + faces the same problems the other models face in the dissemination of the model and its results. One clear advantage that Water Accounting + has over the other models, is that the developer is a non-profit organization. This gets the issue of licenses out of the way. Capacity building remains important, though. This should be done by training and involving not only ENTRO, but also the countries' universities and research communities. To bring the water accounts and the results to the decision makers one would be wise to target the decision makers' advisors.

5 RESEARCH LIMITATIONS

Interview respondents

As explained in chapter 2.2.2 the respondents were selected because they had a personal connection to the acquaintances in each country. The acquaintances were Dr. Safwat Abdel Dayem in Egypt, Dr. Yasir Abbas Mohamed in Sudan and the ENTRO staff in Ethiopia. The result of this selection method was that a lot of the respondents had a technical background, even the high level decision makers. However, since quite a few high level decision makers were interviewed and they all had a technical background it can be concluded that it is, apparently, customary for those countries to have technicians installed at positions of high level decision making. Therefore, it is assumed that the respondents were representative for the formal decision makers in those countries. This thesis is about linking modern technologies to decision making processes, hence it is a pre-requisite that the correspondents have a technical background.

The respondents from the different countries were comparable in terms of education , but diverge when it comes to experiences and implementation of their technical knowledge. Figure 6 already showed that most of the Egyptian respondents are now working for an international organization and most of the Ethiopian respondents are working for a national public organization. This may have affected their answers, especially on Water Accounting +. The respondents from Ethiopia were in general a bit more careful and less willing to discuss Water Accounting +, for whatever reason. The impression is, that they understood the framework though.

The limited international experience and interviewing skills of the author of this thesis may also have influenced the process of interviewing. Even though the interview was practiced in the Netherlands, the interview situation in the Eastern Nile was different. The fact that the respondents were very important people meant that the interviewer had less control over the situation and sometimes even over the interview itself, than desired. On the other hand, the important respondents (decision makers) often seemed less reluctant to answer all questions than the scientists, but this could also be because they are practiced in giving evading answers. The responses do not seem to be evading, though and give adequate information to draw conclusions. Additionally, the fact that the interviews were recorded may have resulted in respondents not disclosing everything. Again, it does not seem like respondents left things out of their answer and, supposedly, more information would have been lost if interviews were not recorded.

These factors were taken into account when analyzing the data and when drawing a set of final conclusions. Care was taken not to generalize information given by the respondents too easily, but also not to draw conclusions on the basis of one of the respondents not mentioning something.

The scientists at the NBI were not interviewed, leaving a part of the scientists side unrepresented. The scientists at ENTRO are believed to be partly representative for the scientists at the NBI, but especially with regard to the NBDSS the scientists at the NBI may have differing views, since they developed the DSS.

Also, since this thesis focused on the official decision process, only official decision makers and their advisors were interviewed. Other people may have a strong influence on the decision process, too. However, to identify those the unofficial decision process and its actors would have to be identified first. This could be an interesting topic for further research.

Data sources

The research that was analyzed comprises the research at ENTRO, the research at the New Nile Opportunities Conference and the publications on water resources management in the Nile of the year 2014 as found with Scopus and Web of Science. The author of this thesis is aware that this does not provide an exhaustive analysis of all research available. It is believed however that the considered research is representative for the research done by the scientific community. The research that is done by the ministries itself or by order of the ministries is probably not included by using this approach. Research that is done by order of the ministries is expected to be more conform the requirements than other research.

Important Issues for Decision Makers

One side of the gap that was not included in this research is the actual problems that are relevant for the decision makers in the Eastern Nile. These are the things that scientists need to address if they want their research to be used for decision making. However, the defining of these problems is probably an interactive process between scientists and decision makers, whereby the findings of this research may provide the scientists with a way to communicate their ideas to the decision makers. This aspect of the information gap would be an interesting topic for further research.

6 CONCLUSION

The Information Gap

The aim of this research was to determine the reasons for the information gap in the Eastern Nile. The research tried to determine what the information needs of decision makers are and how well they are met by the scientists.

Decision makers need multidisciplinary research that is tuned to their personal needs and the needs of society. It should be presented in a short message, avoiding jargon and provided by someone they trust. Scientists are producing research on the technical aspects only, not taking into account the socioeconomics or other aspects. Also, their research is not focused on the needs of the countries.

ENTRO is highly restricted by its mandate and can only disseminate its research outcomes if the countries all agree on the outcomes. If ENTRO does or facilitates research other than on projects the countries have agreed on, it needs to use public domain data because of the data sharing issues in the Eastern Nile. However, ENTRO was created to promote cooperation through joint projects and although there are difficulties, some joint projects have been successfully executed. It can be concluded that within their mandate ENTRO is doing a good job, but scientists outside of ENTRO need to start producing multidisciplinary research that is relevant to society if they want their research to be used for decision making.

It is clear that something has to change in order to bridge the gap between scientists and decision makers, which may help improve water resources management both at country level and at basin level. Advances in technology are not explored to their full extent, in particular due to limited data sharing, researchers having their own agenda, lack of communication and the political agenda overruling fact-based decision making processes. Even though Egypt has rejoined the NBI and the three countries have signed an agreement of principles, bridging the gap between scientists and decision makers remains vital to bringing the countries towards further cooperation.

Water Accounting +

Having discovered the information gap, the second goal was to determine if Water Accounting + can help in bridging the gap. Both decision makers and scientists think that Water Accounting + is a useful concept and that it can give the decision makers a basic understanding of the water resources in a river basin. Also, it might help in the development of the new river basin plans in Ethiopia and help bring the decision process in Sudan back to how it used to be.

Still, trust is a very important issue. The decision makers in the countries are not likely to trust any other data than their own, although their own data bases can be very limited. This problem can be partly dealt with by validating the accounts together with national experts and international peers. A full explanation of the concepts and calculation procedures need to be provided. Also trust in the scientist

that is making the accounts is important. In that regard, it might be feasible to visit the countries and talk to the decision makers instead of only providing the accounts on a website. Additionally, the decision makers are probably not the one to target. It is better to disseminate the research to trusted advisors and scientists. ENTRO is probably not a proper vehicle to disseminate WA+, since it is too much restricted by its mandate. Working together with ENTRO and universities for capacity building is still recommended, because it will create wider support for Water Accounting +.

Concluding, Water Accounting + might be able to help in bridging the information gap in the Eastern Nile countries. However, just like all other research, Water Accounting + should address the issues that are of importance to the countries, for it to be used and accepted. Therefore, it is recommended to construct water accounts on national level and use those to provide information for the Ethiopians to help in setting up their basin plans and for the Sudanese to show the importance of integrated water resources management and to find a need in Egypt for which the water accounts can provide a solution. Local universities and agricultural/water research centers should be educated on the possibilities and constraints of WA+. Once the water accounts are accepted at a national level, they might be trusted to give basin wide solutions, as well.

Further Research

As was discussed in chapter 5 this thesis has its limitations. The decision process that was studied, was limited to the official decision process. The unofficial and less defined actors and factors influencing the decision process were not identified. Actors that could influence the decision process are NGOs, companies, etc.. Also factors like financial interests could influence decisions. The unofficial decision process and the role of scientists in it, would be an interesting topic for further research.

This research was on the information gap between scientists and decision makers. While the communication from scientists to decision makers was extensively covered, the other side of this gap, the communication from decision makers to scientists was not addressed. Decision makers may have specific issues and projects they want to have researched and the communication of these needs to scientists is an aspect of the information gap that should be addressed in further research.

In this thesis it was indirectly assumed that scientists want to (unless they are doing very fundamental research) and also should influence decision making with their research. In her inaugural speech Zwarteveen argues that the role of water scientists is no longer that of all knowing heroes and that we should rethink the role that scientists play in the decision making process (Zwarteveen, 2015). This thesis shows that there are a lot of aspects that come into the decision process, which influence the possible role of scientists and the worth of their research. Perhaps we cannot and should not expect scientists to be experts in all disciplines related to water resources management and it may not even be desirable to have one person being the all knowing, powerful expert (Zwarteveen, 2015). But this thesis most certainly showed that there is more to doing research on water resources management for decision making than only the research on water flows itself.

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APPENDIX

A Interviews

A.1 Literature Review

Several researchers have tried to find the answers to these questions by asking the decision makers themselves what it is they need. In the field of forestry Guldin, Koch, Parrotta, Gamborg, and Thorsen (2004) have done studies in Europe, Africa and the Middle East (Guldin et al., 2004) and in the Americas (Guldin, 2003). Janse (2006) has studied the information search behaviour of forest policy makers in Europe. Decision making in environmental sciences in general has been studied in the United Kingdom (Holmes & Clark, 2008), Europe (Hanger, Pfenninger, Dreyfus, & Patt, 2013; Holmes & Savgård, 2009), Canada and Australia (Hickey, Forest, Sandall, Lalor, & Keenan, 2013; Lalor & Hickey, 2013), New Zealand and Ireland (Lalor & Hickey, 2014) and the United States (Eden, 2011). Feldman and Ingram (2009) have studied how to make science useful in the areas of climate forecasts and water management.

What?

The problem is not that there is not enough information for policy making (Hanger et al., 2013), but that most research does not include the information that is most important for policy makers. Guldin (2003); (Guldin et al., 2004) shows that research and information for policy makers has to include the cultural and human dimensions. This is confirmed by Hanger et al. (2013); (Lalor & Hickey, 2013, 2014), who have found that the political, social and economic consequences of policy decisions are important and should be included in research on environmental issues.

Uncertainty is a big issue (Hanger et al., 2013; Lalor & Hickey, 2013). Feldman and Ingram (2009) state that “decision makers often want probabilistic information but scientists often assume they want deterministic information.“ Policy makers often need more certainty than scientists can provide. How uncertainty is treated by the scientists and understood by the policy makers is a very important aspect of the science-policy boundary (Holmes & Savgård, 2009).

It is often hard for policy makers to value research. Ministers have the feeling that they have to decide which research is more reliable and more valuable (Lalor & Hickey, 2014). If research is valued (not only peer-reviewed) it might result in research being more often used for policy making (Hickey et al., 2013).

Studies suggest that users (policy makers) should be involved in formulating the hypotheses to be researched (Eden, 2011; Holmes & Savgård, 2009). In that way, research may be better adapted to the needs of the policy makers. However, it is important that scientists retain their independence, or they will lose credibility (Guldin, 2003; Guldin et al., 2004).

How?

Policy makers rarely read peer-reviewed scientific papers (Holmes & Clark, 2008). Peer-reviewed articles are important, to ensure the quality of the research, but for the policy makers the information should be

summarized and presented in a language that they can understand (Guldin et al., 2004; Hickey et al., 2013; Holmes & Savgård, 2009; Lalor & Hickey, 2013).

Research also shows that a good relationship between the researchers and policy makers is important for the communication of research (Guldin, 2003; Holmes & Savgård, 2009). Furthermore, personal contact is more important than written information and workshops and congresses are a good way to ensure personal contact and communicate research (Holmes & Savgård, 2009; Janse, 2006).

So called “boundary objects” are an important factor in the connection between researchers and policy makers. They can be permanent or a one-time thing and in the form of a person, organization or event (Feldman & Ingram, 2009).

Where?

Janse (2006) concludes that internal colleagues are the most important source of information, followed by professionals, experts and scientists. Lalor and Hickey (2014) have found that the primary source of information are environment agencies, but external sources (like scientists) are important as well. Holmes and Clark (2008) also show, that external experts are indeed an important source of information. Hanger et al. (2013) conclude that in countries that are ahead with the development of the interface between science and policy making, the research agenda is set by the government and only if there are very specific research needs, the assignment is referred to scientists and consultants.

According to Guldin et al. (2004) "scientific organizations with a long-term vision that are also able to continuously deliver short-term relevant results are most influential."

A.2 Interview structure

Introduction

I did my bachelor at the Technical University of Delft and am now studying Water Resources Management. My MSc thesis is on the information gap between policy and decision makers and scientists in the Eastern Nile. For that I want to know what the information needs of the policy/decision makers of the countries of the Eastern Nile are.

Everything you tell me will be confidential and information will be used anonymously.

Is it okay if I record the interview?

Do you have any questions?

1. General Information

As I said I am interested in the information needs of policy and decision makers in the field of water management.

1.1. Can you tell me something about your involvement in decision making on water resources management related topics?
Role, Position

1.2. How does the decision process work?
Structure of the organization

1.3. What is the role of information and data?

2. What

Can you tell me something about the information and data that is needed for decision making?

Topics/Processes: *Technical, hydrological, economic, social, political*

3. How

How would you like the information to be presented to you?

3.1. Formulation
Peer-reviewed scientific paper, Summary of scientific paper, Summary of effects of measures, Pros and cons and recommended decision

3.2. Way of communication
Personal contact, Written information, Workshops/conferences, Per request/on demand

3.3. Which medium
Mail, Letter, Report, Oral

3.4. Uncertainty
Probabilistic or deterministic information

4. Where

Where do you currently get the information that you use?

4.1. Which organization
Organization within the ministry, Organization connected to the ministry, ENTRO, NBI

4.2. ENTRO
What about organizations like ENTRO?
NB-DSS (DHI), Riverware (Water Balance Consulting, Center for Advanced Decision Support for Water and Environmental Systems University of Colorado), Ribassim (Deltares), HEC-Ressim, Nile DST(GeorgiaTech)

5. Water Accounting +

There is a new way of studying the water resources in a river basin.

I will use this to discuss information needs some more and with the aid of an example. I will show you Water Accounting now and would like to have you opinion on it.

The idea is to look at the water use in relation to land use and focus more on the various users of water. It is mainly based on open access data from satellite measurements.

Resource Base Sheet

This sheet shows the overall state of the water resources in the basin. On the left is shown how much water enters the basin and in what form. The middle part shows how the water is used. On the right is shown what happens with the water after it is used. There are a few interesting things: A quarter of the water that is evaporated returns as rainfall within the basin, this recycled rainfall is in turn a quarter of the water coming into the basin. The water use that is not managed is far bigger than the managed water use. Meaning that there is a lot to improve by managing this land use instead of the so called blue water.

Utilized flow sheet

This sheet gives more detail on the utilized flow, so on the managed water use that we just saw in the other sheet. On the left we see how much water is abstracted. This water is used for various purposes, those are shown in the middle. On the right is given how much of the water that is used is consumed and how much flows back to surface water and groundwater and is available for further use. This shows that some water uses, like energy production, use a lot of water, but do not actually consume it, which means the water can be used again.

Evapotranspiration sheet

This sheet shows for the four land uses and their subcategories how much water is consumed by evapotranspiration. On the right it shows how much of this evapotranspiration is beneficial.

Agricultural services sheet

This sheet gives the amount of water that is used per crop. These are separated in rain fed and irrigated crops. The second sheet gives the land productivity, so how much is produced per hectare and the water productivity, how much is produced per cubic meter of water for each crop. These sheets make it possible to see which crops need a lot of land and which crops need a lot of water.

Surface water sheet

This sheet gives an overview of the surface water in the Nile Basin. At the top it gives per sub-basin how much water is coming in, how much water is abstracted how much water returns and how much is stored. With that the actual flow is calculated. At the bottom is shown how much of this flow is usable and how much is committed.

5.1. What do you think of the concept and the information itself?

5.2. Is there information that you miss and would like to have?

5.3. What do you think of the presentation?

5.4. Are there other forms that you think better suitable to present this information?

5.5. Any other remarks?

5.6. The information is accessible through a website, do you like that, or would you want to access it in another way?

End of the interview

- Do you have anything to add?
- Would you like to have the report of the research when it is finished?

A.3 Codebook

Theme 1 The Decision Process

Sub Theme 1.1 National decisions

Code	Explanation Code
Ministerial board of undersecretaries	The board of undersecretaries of a ministry, headed by the minister. Big decisions within the ministry are referred to the board of undersecretaries.
Minister	The minister makes decisions, or refers them to the board of undersecretaries.
Strategic Planning Council	The strategic planning council advises and makes decisions. It includes experts on: water, agriculture, energy, economics and environment.
Top management	There is a top management consisting of minister and state ministers, they make the important decisions.
Middle management	The middle management are the directors of the directorates, they make the technical decisions. Other decisions are discussed with the top management.
Ministries separated	The ministry of water resources and irrigation became energy and water resources and agriculture and irrigation.
Not multidisciplinary	The water resources plan now is only made by the minister of electricity without involving other ministries and experts. The planning used to be done by including experts on all aspects of water management.
Ministries involved	The ministries that are involved in decision making.
Drivers	New projects are started because there is a new development or more water becomes available, these are drivers to start a new project.
Top down	The decision to do a new project is taken by the council of ministers and then the ministries start developing it, after that it comes back to the council of ministers to discuss the proposal.
Pilot phase	For most big projects they start with a pilot phase first, in this phase a small pilot area is selected to be the first project area. The pilot phase of a project is the most important, if that goes well the rest is no problem.
Old plan	Old plans that have never been implemented are used for the planning of new projects. They are not revised or discussed with experts on the related aspects.

National decisions	Description of decision process and information flows.
River basin plan	A master plan was made for all of the basins, it is an old plan, now new plans are being made, which is still difficult.
Equitable use nat.	It is important to ensure that water is used in an equitable way, so that other regions are not harmed.
River basin organizations	There are river basin organizations that are involved in the water management of these basins.
Decentralized	The government of Ethiopia is decentralized.
River Basin High Council	There is a river basin high council that decides on all big inter-basin projects.
Prime Minister	The prime minister chairs the river basin high council.
Regional presidents	The regional presidents are part of the river basin high council.
EPA	The Environmental Protection Agency is involved in decision making on water projects.
No implementation	In theory problems are addressed but the policies are not implemented.

Sub Theme 1.2 Factors influencing the (ability to make a) decision

Code	**Explanation Code**
Political Impression	Politicians make decisions because they want to make a good impression so that they will be reelected.
Time constraints	Decision makers have little time.
Informed decision	A decision that is based on facts.
Political decision	A decision that is based on political motivations. Politicians have to want to make a decision based on facts.
Conflicting interests	Decision makers do not understand the concept of zero sum game. They need to find a balance between their own and the others wishes and needs.
Turnover	Turnover of politicians and scientists is a problem. Every time you have to start again with building up understanding and a relationship.
Accumulative effect	The combined effect of different projects is hard to understand.

Short term	Decision makers look only at the short term effects and do not take into account the long term effects.
Consequence of consequence	Decision makers do not understand the consequence of the consequence.
Mistrust researchers	Politicians do not trust the researchers.

Sub Theme 1.3 International decisions

Code	**Explanation Code**
Multidisciplinary negotiation	Try to negotiate on the top level, to avoid problems at the lower level and to include all disciplines.
Info GERD not enough	The info provided by the Ethiopians on the Grand Ethiopian Renaissance Dam is not enough to be able to tell anything about its effects
GERD is harmful	The models that were made show that the Grand Ethiopian Renaissance Dam is harmful to downstream countries.
Basin plan	The countries should make a basin plan together
Tripartite technical committee	The tripartite technical committee is in charge of studying the Grand Ethiopian Renaissance Dam and the effects of the dam and working out the technical issues.
Unsolved to ministers	If an issue cannot be solved by the tripartite committee it is forwarded to the ministers of water.
Unsolved to government level	If an issue cannot be solved by the ministers it is forwarded to the government level (including all ministers).
Equitable use int.	The water should be divided in an equitable way among countries, uses and users.
Advisors	When issues about the GERD cannot be resolved by the ministers they can hire advisors to help them resolve the issues.
Consultant GERD	An international consultant is hired to study the GERD.
International decisions	Description of international decision process and information flow.

Theme 2 Information Needs

Sub Theme 2.1 Informed Decisions

Sub Sub Theme 2.1.1 Information

Code	Explanation Code
Technical	Technical information about the project.
Legal	Legislation that puts constraints on the project.
International standards	The project has to apply to international standards before it is approved.
Institutional requirements	The institutional requirements for a project/plan.
Socioeconomic	The socioeconomic aspects of a project/plan.
Project capacity	The capacity of the project.
Environment	The environmental aspects of a project/plan.
Political	Political aspects of a project/plan.
Economic	Economic information.
Water availability	The amount of water available for new projects/plans.
Infrastructure	The infrastructure that is needed for the new project. Both “normal” (e.g. roads, telecommunication, etc.) and water infrastructure (irrigation, drainage).
Drainage	Information on drainage requirements and availability.
Hydrological	Water levels, discharge, etc.
Cropping pattern	The cropping cycles and amount and types of crop planted.
Hydrographic	Length, width, depth, etc. of channels, rivers, etc.
Soil	Information on the soil characteristics.
Vegetation	Information on the vegetation cover .
Climate	Information on the climate (change).
Sediment	Information on sedimentation and erosion.

Water requirements	The amount of water that will be needed for a project/plan.
Water quality	Information about water quality.
Water balance	Water balance.
Energy balance	Energy balance.
Productivity	The productivity per unit of water.
Floods	Information about floods: timing, spread, etc.
Costs	The costs of a project.
Revenues	The revenues of a project.
Benefit cost ratio	The benefit to cost ratio of a project.
Internal rate of return	The internal rate of return of a project.

Sub Sub Theme 2.1.2 Analysis of Information

Code	**Explanation Code**
Options	The different design options for a new project and their advantages and disadvantages.
Results	The results of a project, both direct and indirect and both positive and negative.
Recommendations	The scientist or advisor should give his opinion and recommendations on what to do.
Current situation	What the current plans and projects are.
Past situation	Past projects and plans.
Plans	What the plans are for a new project/plan.
Pros and Cons	Give the pros and cons of a project/plan.
Forecasts	Forecasts of what the future status of the water resources will be.
Mitigation measures	Measures to mitigate the negative effects of a project/plan.
Degradation	The degradation of the land, water and environment.

Operation	The operation rules of a (hydropower) dam.
Process	The process of how the information was developed has to be explained.

Sub Sub Theme 2.1.3 Presentation of Information

Code	Explanation Code
Graphs	Graphs are a good way to show information (if they are easy to understand).
Technical note	Information is presented in a technical note.
Short message	Information may be presented in a short message.
Informative workshop or seminar	Workshops or seminars may be given, but these are to advise and discuss a project. Minister might attend, but most of the time he does not have time.
No Jargon	Do not use scientific jargon, use easy language and easy diagrams.
Pictures	Give the information in pictures.
Concluding message	Finish your message or presentation with a sticking conclusion.
No big report	Decision makers do not want a big report.
Summary	Give a report with a summary or a summary by itself.
Oral briefing	Give an oral briefing with the document to explain, may be in the form of a presentation.
Big report	Decision makers want to read the whole report.

Sub Sub Theme 2.1.4 Uncertainty

Code	Explanation Code
Uncertainty bounds	Show that the information lies between certain bounds, instead of giving percentages etc.
Check quality data	The quality of the data and the data provider is checked.
No uncertainty reported	Uncertainty is not reported when the data/information is delivered.
Compare to historical	Data is compared to historical data to try to see how certain the data is.

Report uncertainty	It is very important to report the uncertainty to the decision makers.
Collection method reported	The collection method is reported to the decision maker.
Reduce uncertainty	Uncertainty has to be reduced to acceptable bounds.

Sub Theme 2.2 Political Decisions

Code	**Explanation Code**
Issue of dm	The scientist should present the issue as if it is coming from the decision maker.
Aspirations dm	Link the issues and their solutions to the aspirations of the decision maker
Relevant	Research should be focused on the issues that are (currently) relevant.
Information sharing	Information sharing between countries is a difficult issue.

Theme 3 Information Source

Sub Theme 3.1 Information Source

Code	Explanation Code
Ministerial information department	Information is obtained from the information department of a ministry
Field departments	Information is obtained from the field departments of a ministry.
Ministry	Studies on a small new project are done within the ministry.
Consultant	Studies on a big new project are done by a national or international consultant.
National Research Centers	National research centers (that may be part of the ministry) are used as an information source.
No Universities	Universities are not used as an information source.
Media	Media is a source of information.
No media	Media is not used as a source of information.
Universities	Information is obtained from universities.
NBI	Information is obtained from the NBI.
Personal advisor	Each decision maker has a personal advisor that they trust.
River basin organizations info	The river basin organizations provide the information for the basin plans and projects.
Task group	They put up a task group, with experts on the relevant fields, to do the research for a certain project.
International organizations	Sometimes they use international organizations for their information.

Sub Theme 3.2 Source Characteristics

Code	Explanation Code
Multidisciplinary	The research should include experts from all disciplines related to the project.

Confident	Scientists/technicians should appear confident about what they are presenting.
Social relation	The scientists should also interact with the decision maker on a social level.
Others	The issue (should) come(s) from someone else other than the scientist. (Society for example)
Regular contact	The scientists should have regular contact with the decision maker.
Proactive	The scientist should be ready address the issues currently discussed in the cabinet and country.

Sub Theme 3.3 ENTRO/NBI/International Organizations

Code	**Explanation Code**
Profitability	The goal of most international organizations is making money.
Capacity building	There should be capacity building for a model/research done by international consultant for it to be accepted.
No black box	Models should not be a black box. It should be clear what is going on in the model and how things are calculated.
DSS black box	The Nile Basin Decision Support System is a black box model and it is hard to understand.
DSS no results	The Nile Basin Decision Support System has been there for a while and has still not yielded any results.
DSS easy	The Nile Basin Decision Support System is easy to work with.
DSS preparation hard	The preparation of data for the Nile Basin Decision Support System is hard
DST not finished	The Decision Support Tool was never finished.
DSS time consuming	The Nile Basin Decisiion Support System is a time consuming program to work with.
License	There is a dongle with license needed to work with the DSS.
No ENTRO	ENTRO is not used as an information source.
DSS too big	The DSS is too big to be useful.

DSS old data	The DSS only has old data and should have new data.
ENTRO Dissemination	Information on the way ENTRO disseminates its research.
Model development	Information on the process of model development by ENTRO
Info development	Information on the process of information development by ENTRO
Public domain data	ENTRO tries to use public domain data for some of its project so that the information can be disseminated.
More adapters	More adapters for the Nile Basin Decision Support System should be developed, so that other models can be used, as well.
Variety of models	Having a variety of models is good, because each model is good for another purpose.
DSS ownership	The process of development of the Decision Support System creates ownership for all the countries and thereby a higher chance of acceptance.

Theme 4 Water Accounting +

Sub Theme 4.1 Information

Code	Explanation Code
Rainfall too high	The rainfall in a certain country or over all is too high.
Rainfall too low	The rainfall in a certain country or over all is too low.
Validation	The data should be verified and validated.
Incremental water productivity	The incremental water productivity is not reasonable.
Outflow zero	The outflow into the mediterranean sea is zero.
Change values	Some of the values are not correct.
Desalination not in NB	Desalination only happens outside the Nile Basin, so it should not be included in the water balance.
Data acquisition	Explanation on how the data is obtained and calculated should be given.
Accuracy	Explanation on how accurate the data is should be included.
Basin level good	It is good to show the data on a basin level. Showing the advantages of and possibilities for each sub-basin
Include socioeconomic	The socioeconomic data and impact should be included.
Include changes	Include changes and the countries' plans in the accounts to see the effects.
Seasonal scale	The water accounts should be made on a seasonal scale.
Country level	The water accounts should also be made per country.
Explanation terms	The terms used in the diagrams should be explained.
Explanation sub-basins	The delineation of the sub-basins should be explained.
Smaller spatial scale	Data on a smaller spatial scale is needed.
Add principles	The principles of equitable use, insignificant harm, cooperation have to be added to the concept.

Sub Theme 4.2 Presentation

Code	Explanation Code
Interface	For scientists it would be good if there is an interface, so that they can easily work with the model.
Diagram good	The diagrams are a good way to present the data.
Add Graphs	Graphs to show the data would be nice
Sheets for scientists	The sheets are for researchers
Messages for dm	For decision makers there should be a clear message.
Clear Units	The units should be put more clearly on the sheets. Bcm instead of km3.
Comprehensive	The sheets are comprehensive.
Interactive map	The accounts should be presented in an interactive map of the basin.
Concept good	The concept of water accounting is good.

Sub Theme 4.3 Dissemination

Code	Explanation Code
Website good	The website is a good way to make the water accounts available.
No website	The website is not a good way to present data to decision makers, because they do not have time to visit a website.
Invitation	An invitation to the website should be sent to all critical people.
To advisors	The water accounts should be brought to the advisors. They can bring it to the decision makers.
Capacity building WA+	To make sure that the tool is used, you should do capacity building.
Web tutorial	There should be a kind of tutorial.
Centers	There should be regional centers for WA+.

Sub Theme 4.4 Usefulness

Code	Explanation Code
Political Decision No WA+	WA+ cannot be used for political decisions.
Informed decision WA+	WA+ can be used when there is logical negotiation based on facts.
Basin Plan WA+	WA+ can help in making a basin plan.
Basic understanding	WA+ provides understanding of the current situation and all aspects related to water resources management.
Needed for dm	WA+ gives the information that is needed in a way that is needed for decision makers in the Nile Basin.
Not useful	WA+ is not useful
WA+ good info	WA+ can provide information to check the other information sources.
Comparison SWAT	WA+ can be used to compare with the results of the SWAT model.

B Framework for the Assessment of Hydrological and Water Resources Models

To be able to assess the worth of ENTRO's models and Water Accounting +, a framework was developed to compare the various models and their outcomes. The first framework was developed based on a literature review, which is provided in this section

Computer simulation models are indispensable in water management decision making processes. A numerical model helps to quantify key hydrological processes, both natural and human induced. Different types of models have been developed over the years, and their goals can be rather diverging. Singh and Frevert (2005) wrote a book describing the different watershed models, but do not compare them. Wurbs and Yerramreddy (1994) have compared different modelling approaches and others have compared model performance on different subjects: water resources management (Koch & Grünewald, 2009), predictions of the impacts of climate change (Jiang et al., 2007), sediment yield on field level (Sommerlot, Nejadhashemi, Woznicki, Giri, & Prohaska, 2013), prediction of floods in a groundwater fed basin (Habets et al., 2010) and prediction of water, nitrogen and phosphorous discharges (Boomer et al., 2013). All of them provide a description of the model and its components and then proceed to compare the output of the models with observed data. None of them use criteria to compare the models with each other, and hence the selection of models remains a challenge by itself.

Assaf et al. (2008); Haberlandt (2010); Sulis and Sechi (2013) do use some criteria, like training required, costs, appropriate use, etc.. They also compare the modelled output with observed values. However, none of the comparisons is made using a predefined framework of some sort that justifies the criteria used for the comparison. Laniak et al. (1997) use a framework to compare risk assessment models based on a predefined list of features that are based on the various aspects of risk assessment. A framework like that makes it possible to compare different models in a structured and objective way.

There are three main categories of hydrological and water resources models:

1) Models for hydrological research.
   These models are made and used to get a better understanding of water flows. The model can be of a river basin as a whole, but can also include just a part of the basin or just one hydrological process. It includes models like SWAT that model the precipitation, evaporation, atmospheric, etc. processes; hydrodynamic models that model the flows and movements of water; runoff models like Riverware and Mike-Basin; groundwater models; etc..
2) Models for water resources assessment
   These are made and used to get an idea of how much renewable water is available for multiple purposes and how it is transported through a catchment. These models are often (combinations of) a form of the models used for hydrological research.
3) Models for water resources management
   With water resources management models changes in the catchment or allocation of water resources can be investigated. This category includes optimization models, decision support

systems, water allocation models, etc. They either include information that is generated with the models for hydrological research, or they are an adapted version of these models.

Then there are also different ways of modelling: a model can be based on physical laws (deterministic), on stochastics (like artificial neural networks) or it can be conceptual (based on physics and empirics). It can be lumped, which means that the whole catchment is given the same characteristics and input. It can be distributed, which means that each pixel has its own characteristics and input data. Or it is something in between: with some parts lumped together or with some processes lumped and other processes distributed.

This chapter describes a framework that makes it possible to compare all these types of river basin models. The framework should describe models of similar nature, as well as models with different purposes. The framework will compare the physical and managerial processes addressed.

Processes

To be able to compare different river basin models, an analytical framework has been set up to review all relevant hydrological and water resources processes. Also the possibility to study water and environmental decision making processes should be analysed. Water managers have to make decisions on (i) surface water allocation, (ii) groundwater concessions, (iii) dam construction, (iv) wetland drainage, (v) flood protection and (vi) land use changes, among others. To determine which processes are relevant for providing key data, handbooks on hydrology as well as water resources management text books were consulted.

Open any hydrology handbook and you will find chapters on the following hydrological processes: precipitation; evaporation and transpiration; infiltration; surface runoff; stream flow and groundwater (Brutsaert, 2005; Davie, 2002; Dingman, 2002; Jones, 1997; Maidment, 1992; Patra, 2001; Serrano, 2010; Shaw, Beven, Chappell, & Lamb, 2011; Thompson, 1999; Ward & Trimble, 2004) ("Hydrology handbook - second edition," 1996). That makes sense, since these are the basic components of the hydrologic cycle. It is important to include these in the framework. While not all models include the modelling of the hydrologic processes (some use the inflow derived from the processes) precipitation is the basic source of water in any river basin and the other processes describe where and how the water flows. Water quality is also an often mentioned concept (Aswathanarayana, 2011; Cech, 2010; Davie, 2002; DeBarry, 2004; "Hydrology handbook - second edition," 1996; Jones, 1997; Maidment, 1992; Pennington & Cech, 2010; Serrano, 2010; Shaw et al., 2011; Stephenson, 2003) and very important to include, because if the water is of very poor quality it cannot be used anymore. Therefore, water quality indirectly influences (usable) water quantity.

When the water has come into the basin, nature and humans will use it, therefore the processes of water management are also very important to include into the framework. Books on water resources management contain chapters covering various forms of water use, not only human, but also natural: domestic, municipal, hydroelectric power generation, irrigation or agriculture, lakes, reservoirs, wetlands, rivers, ecology (Aswathanarayana, 2011; Cech, 2010; DeBarry, 2004; Pennington & Cech,

2010; Stephenson, 2003). Any water withdrawal is based on a right to extract water, use water and the obligation or permission to return excess water. A solid water rights system covers all these aspects.

There are various other processes related to water that influence the catchment and change the availability of water. Floods and droughts are frequent topics in both hydrology and water resources management books (Dingman, 2002; "Hydrology handbook - second edition," 1996; Jones, 1997; Maidment, 1992; Serrano, 2010; Shaw et al., 2011; Stephenson, 2003; Thompson, 1999). Climate change (Aswathanarayana, 2011; Cech, 2010; Shaw et al., 2011; Stephenson, 2003) is discussed too, as well as other forms of change: vegetation change, desertification, urbanization, pollution, erosion and land use change (Jones, 1997; Maidment, 1992; Serrano, 2010; Stephenson, 2003).

Finally, the economics of water is also discussed quite often (Aswathanarayana, 2011; Cech, 2010; Patra, 2001; Stephenson, 2003) and is also important since one way of assessing the use of water is through its economic benefits.

These aspects and processes can be divided into three groups: hydrology; uses and abstractions (natural and human) and economic. Table 5 gives the processes included in the framework and their division into groups. This is consistent with (McKinney, Cai, Rosegrant, Ringler, & Scott, 1999) on modelling water resources management at the river basin level. According to the report a river basin consists of three components: source components, off-stream and in-stream demand components and intermediate components (like treatment plants and reuse). These are more or less the groups included in the framework, with the exception of the third group, which is formulated in a somewhat different way. According to the report a river basin model should have the following characteristics:

1. *" Integration of hydrologic, agronomic, and economic relationships in an endogenous system that will adapt to environmental, ecological and socioeconomic statuses related to the river basin domain*

2. *Specification of an integrated river basin network, on which mathematical models are built, that includes the water supply system (surface water and groundwater), the delivery system (canal network), the water users system (agricultural and non-agricultural), the drainage collection system (surface and subsurface drainage) and the wastewater disposal and treatment system, as well as the connections between these subsystems*

3. *Representation of the spatial and temporal distribution of water flow and pollutant transport and mass balance through the river basin*

4. *Representation of water demands from all water-using sector for analysis of intersectoral water allocation policies*

5. *Evaluation of the economic benefits of each of these demands, including crop acreage and crop production functions incorporating both water application and quality*

6. *Incorporation of economic incentives for salinity and pollution control, water conservation and irrigation system improvement as policy levers within the model"*

(McKinney et al., 1999, p. 56)

The first characteristic is fully included in the framework, it is represented in the processes groups. The second, third and fourth characteristic are included in the processes and the economics are also included as a group. Thus, it can be concluded that the framework contains all the components that can and should be included in a complete river basin model.

Table 5 Framework for the evaluation of hydrological and water resources models

Group	**Process**
Hydrology	Precipitation
	Infiltration
	Evaporation and Transpiration
	Surface runoff
	Stream flow
	Groundwater (recharge, storage, flow)
Flows, Uses and Withdrawals	
Natural	Lakes
	Wetlands and Swamps
	Rivers and Streams
	Other Ecosystems - Groundwater Dependent
	Other Ecosystems - Surface Water Dependent
Manmade	Domestic
	Industrial
	Agricultural

	Aquaculture
	Livestock
	Municipal
	Reservoirs
	Hydroelectric Power Production
	Recreation
Changes and Degradation	Climate Change
	Natural Disasters
	Erosion and Sedimentation
	Soil Salinization
	Water Quality
	Land Use Change
Economics	
Water Rights	

C Interview Results Information Needs

In the following sections the results on the information needs of decision makers are presented. The charts in section C.1 present the information types that decision makers need, both per country and per decision maker position. Section C.2 presents results on the analysis of this information and section C.3 on the way of presentation. Section C.4 gives the information sources that are used for decision making.

Positions of respondents are divided into national and international and can be a scientist, advisor, low level (LL) decision maker or high level (HL) decision maker.

C.1 Information

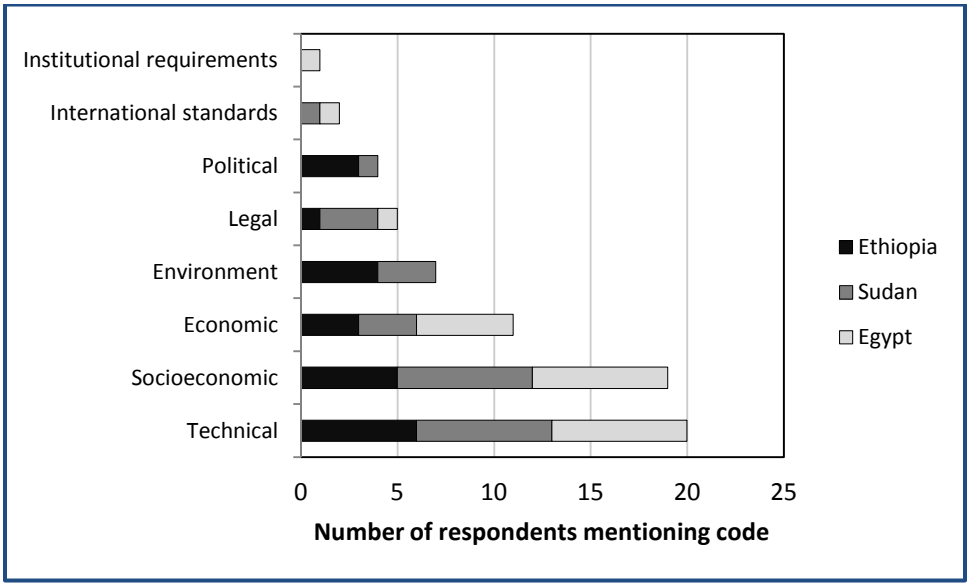


Figure 26 Information types needed for decision making according to respondents of the various countries.

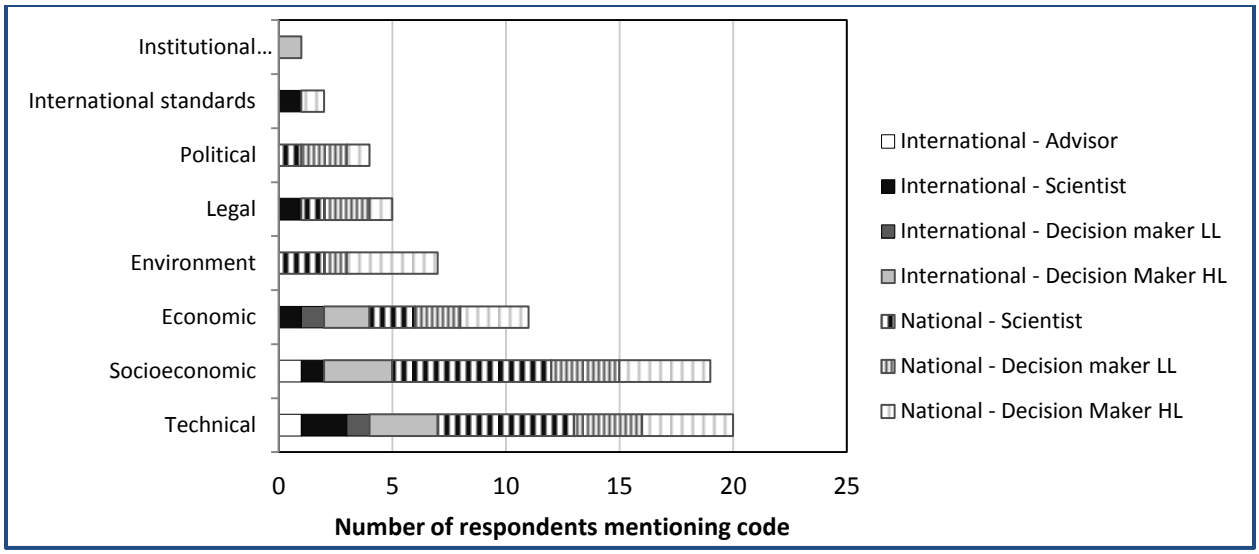


Figure 27 Information types needed for decision making according to respondents of various positions.

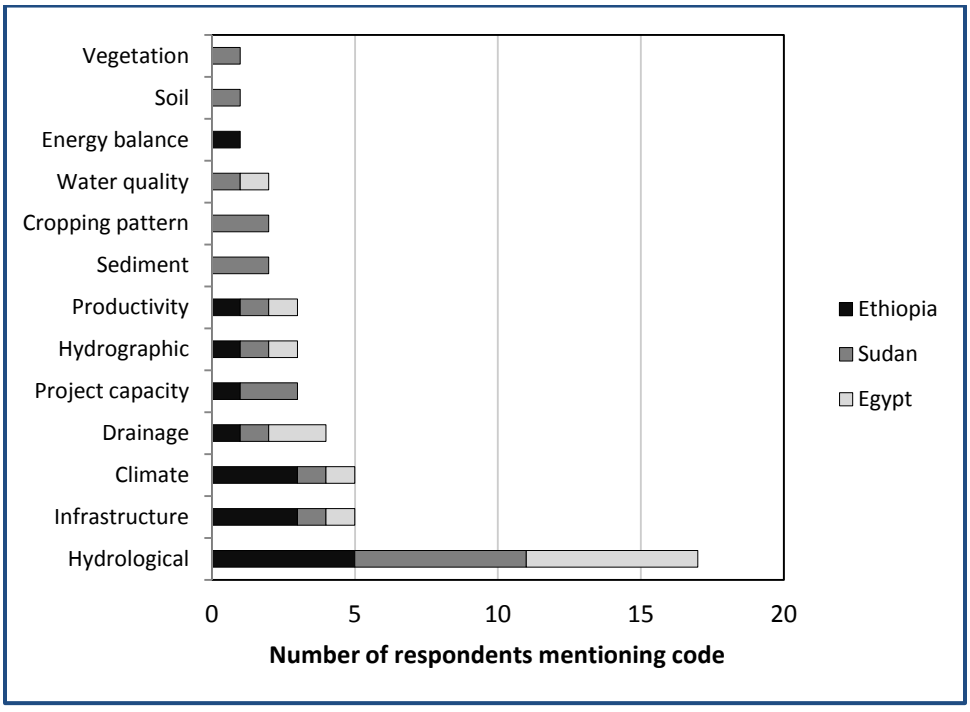


Figure 28 Technical information types needed for decision making according to respondents of the various countries.

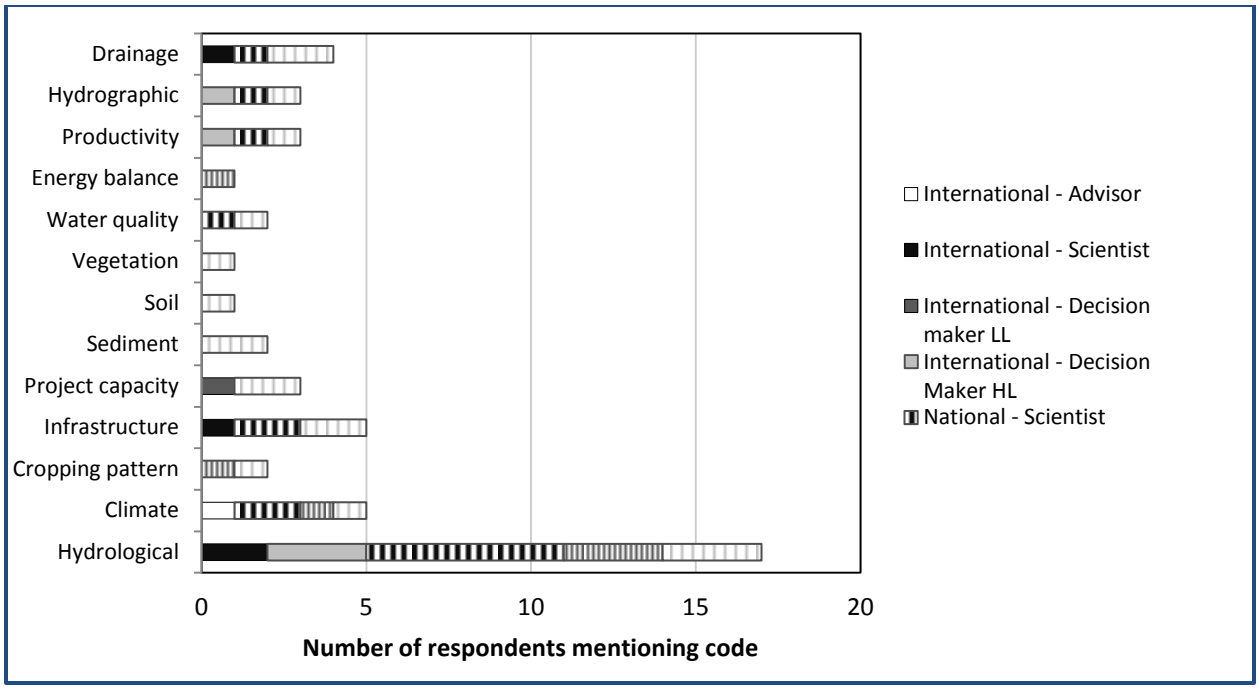


Figure 29 Technical information types needed for decision making according to respondents of various positions.

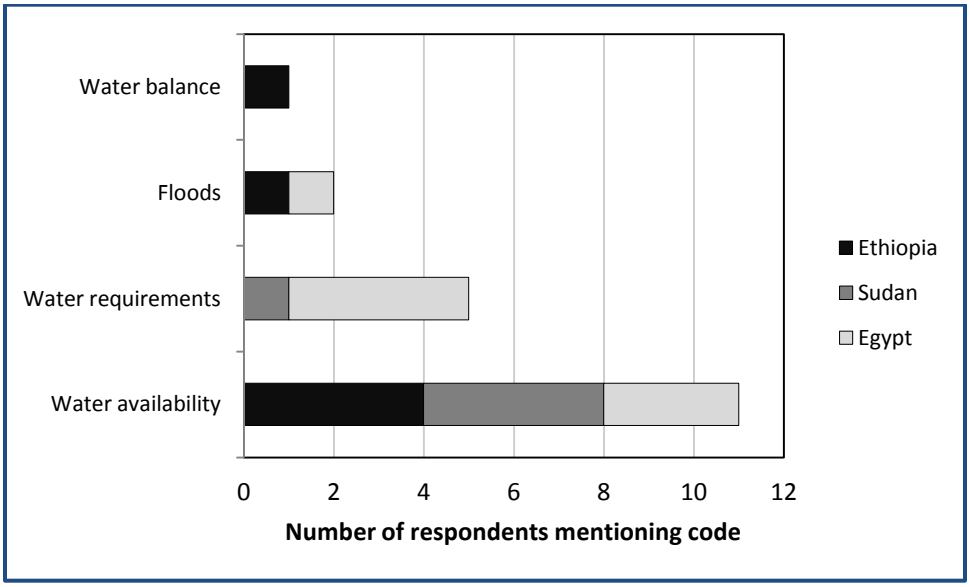


Figure 30 Hydrological information types needed for decision making according to respondents of the various countries.

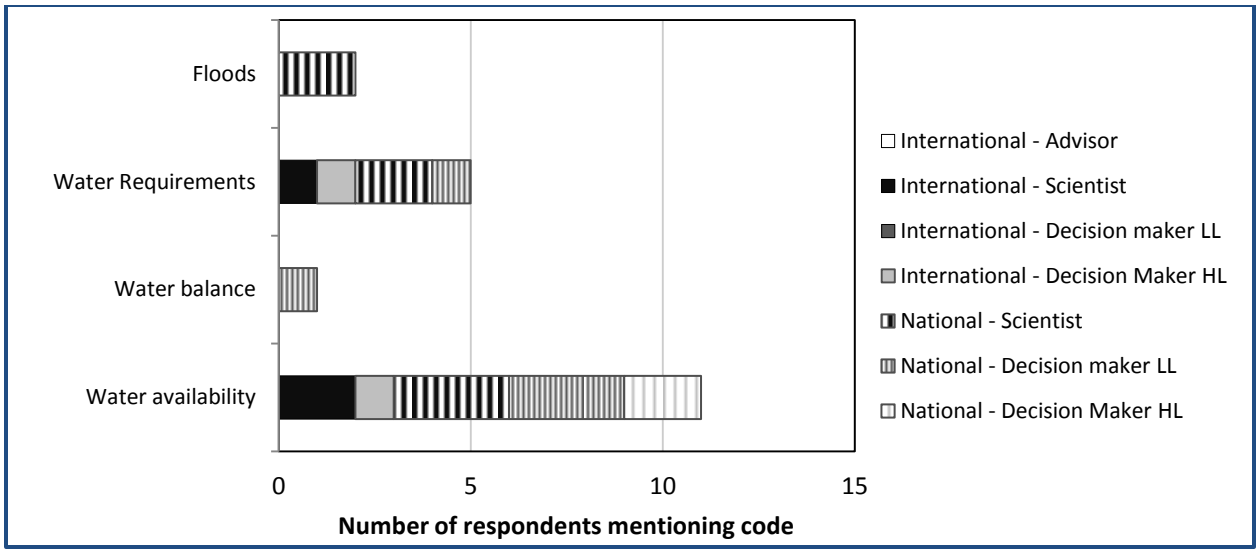


Figure 31 Hydrological information types needed for decision making according to respondents of various positions.

C.2 Information Analysis

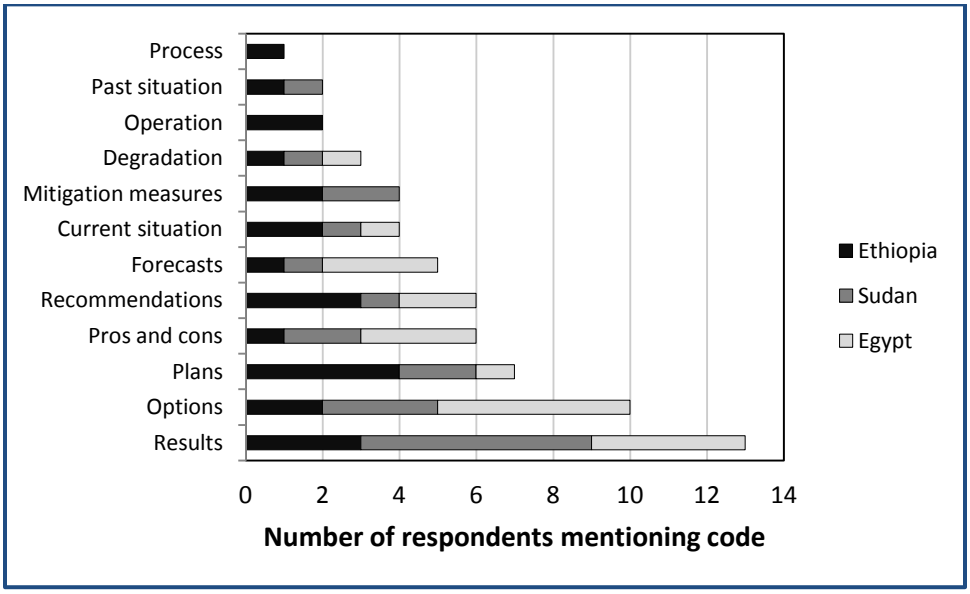


Figure 32 Information analysis needed for decision making according to respondents of the various countries.

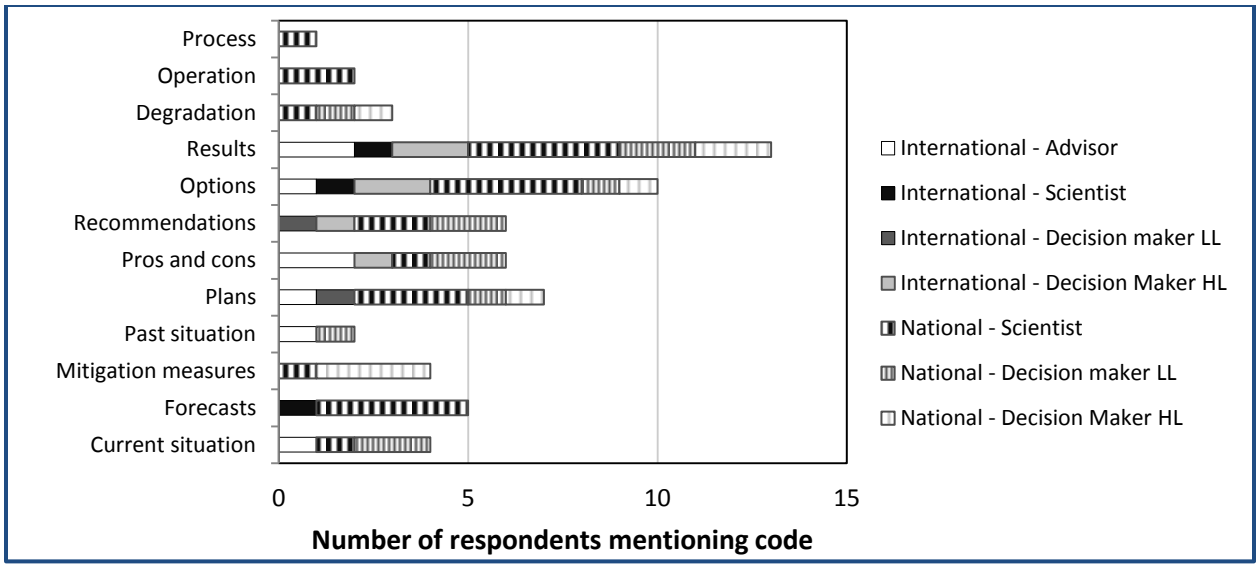


Figure 33 Information analysis needed for decision making according to respondents of various positions.

C.3 Information Presentation

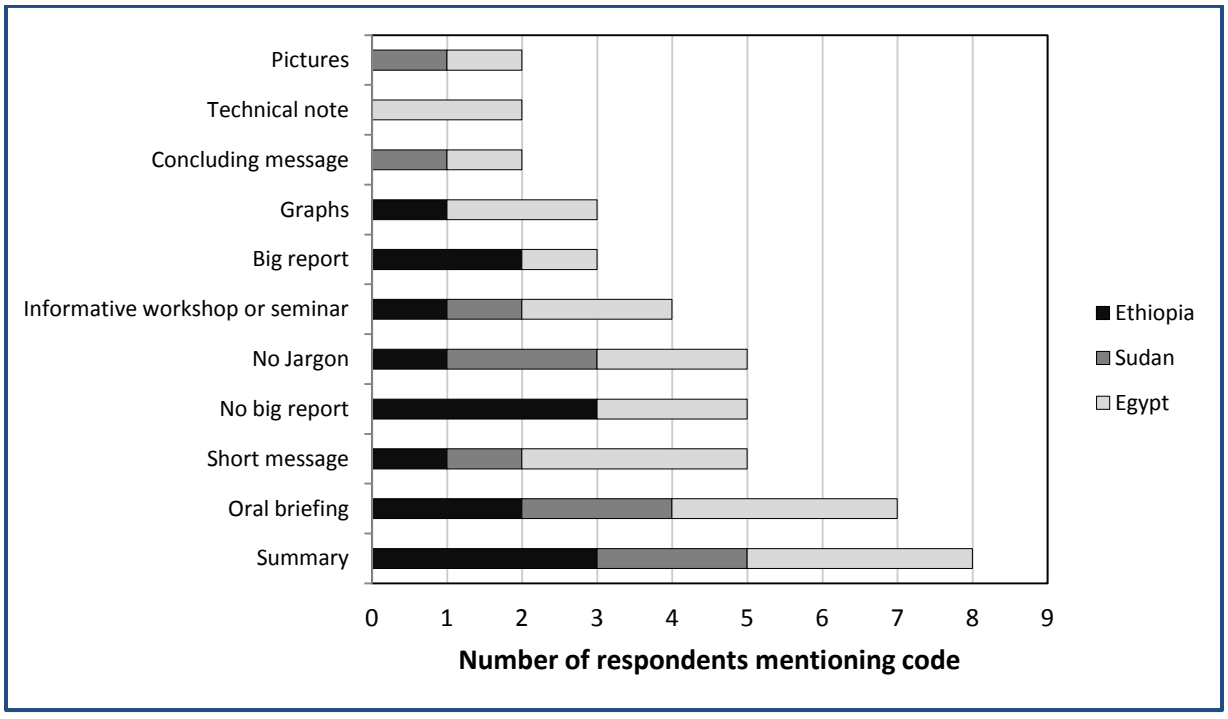


Figure 34 Information presentation needed for decision making according to respondents of the various countries.

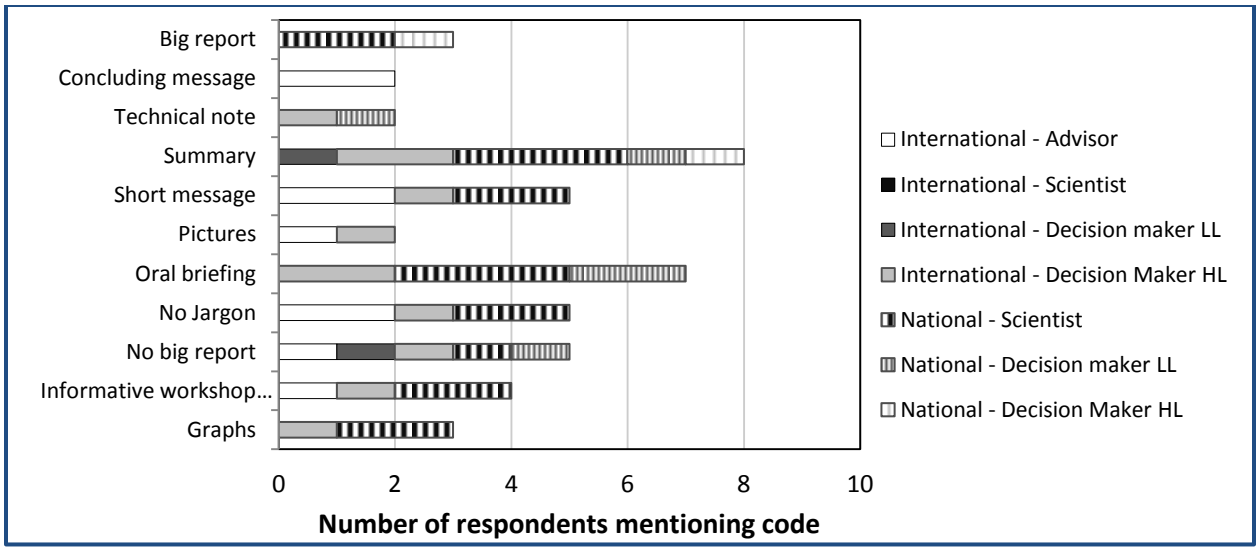


Figure 35 Information presentation needed for decision making according to respondents of various positions.

C.4 Information Source

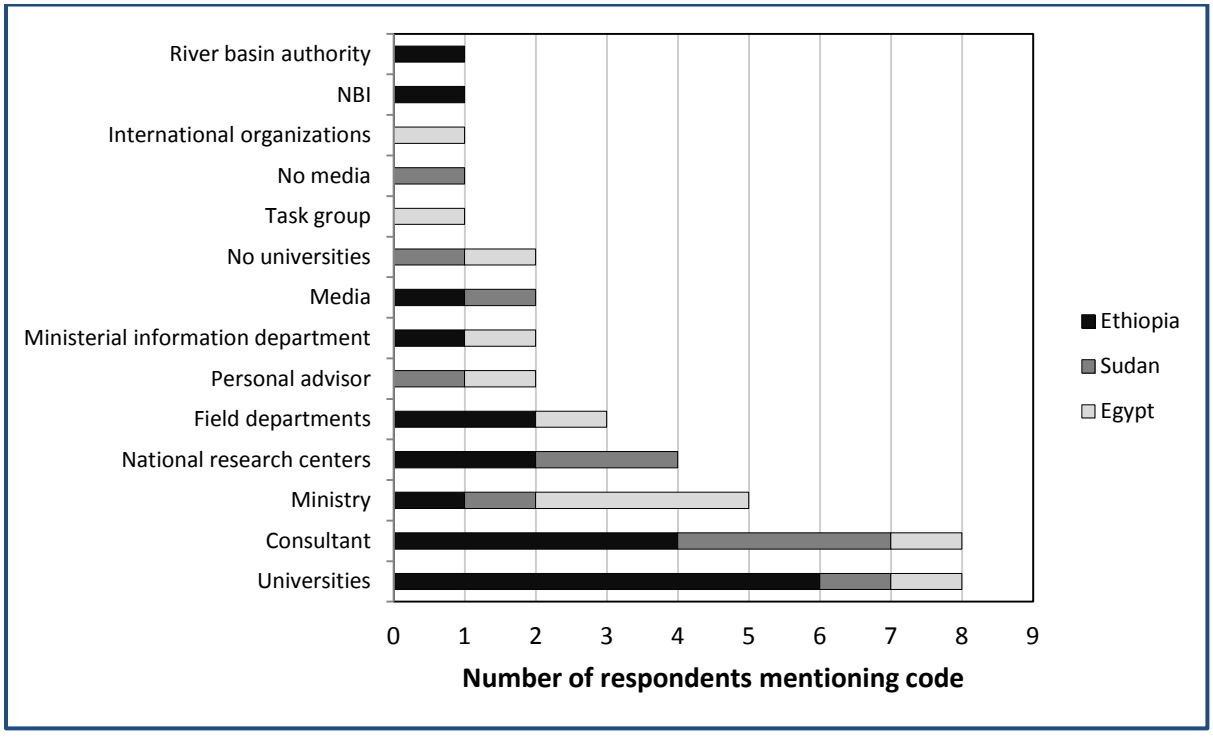


Figure 36 Information sources used for decision making according to respondents of the various countries.

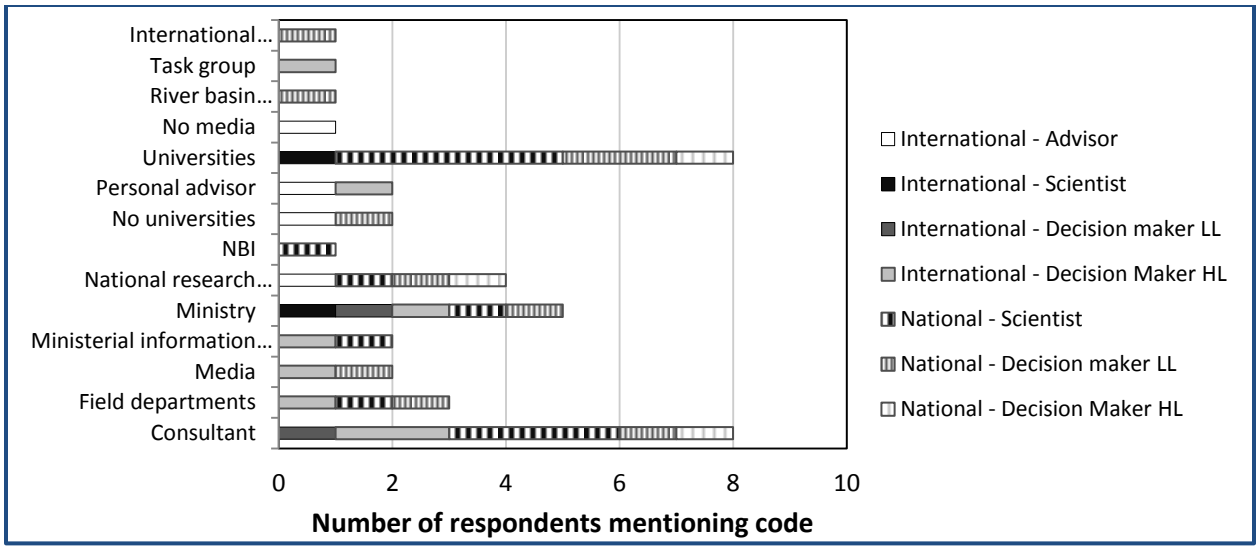


Figure 37 Information sources used for decision making according to respondents of various positions.

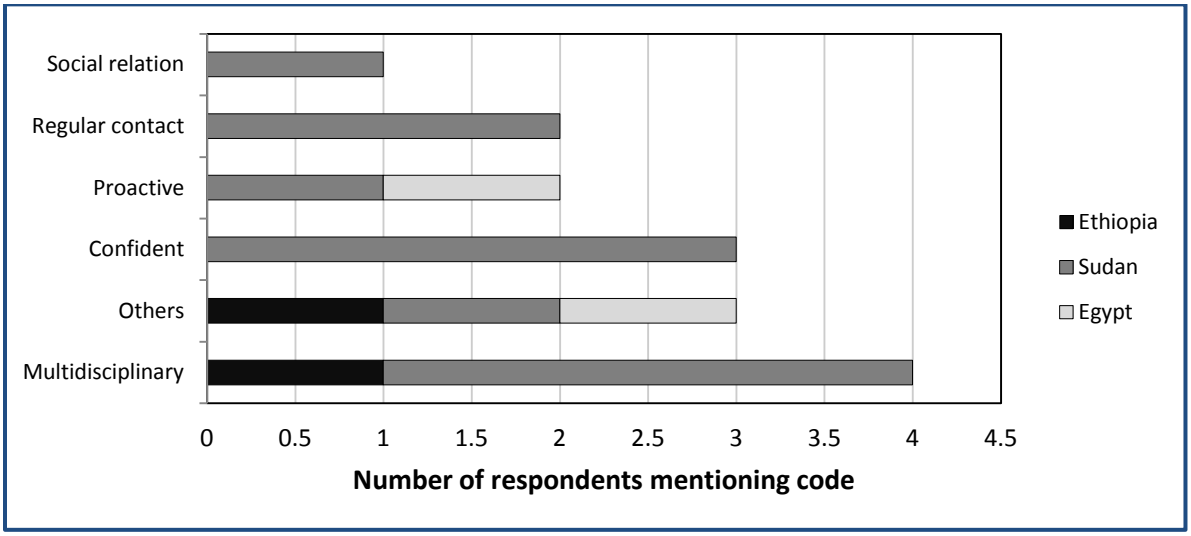


Figure 38 Information source characteristics used for decision making according to respondents of the various countries.

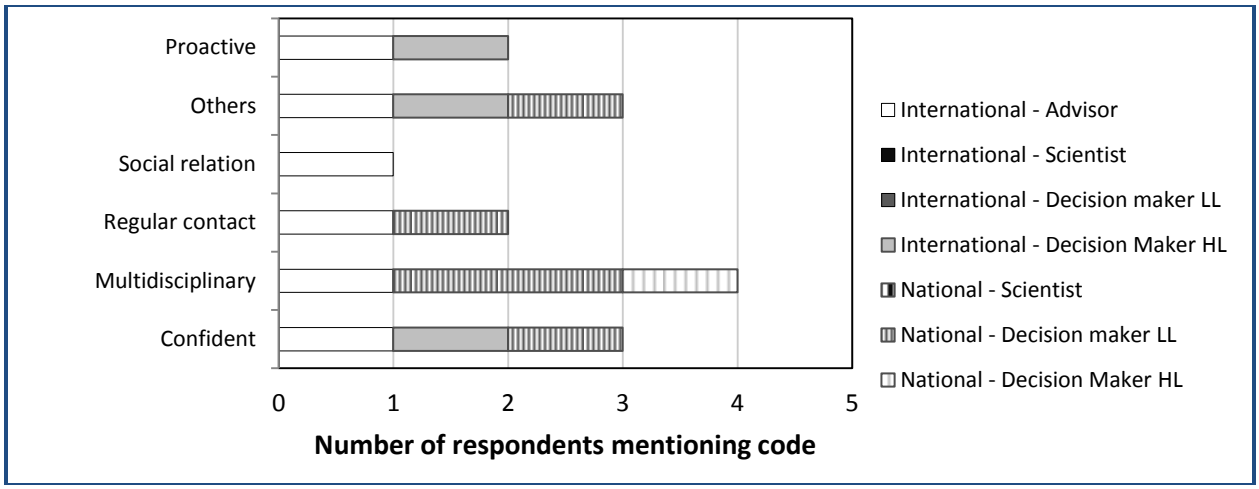


Figure 39 Information source characteristics used for decision making according to respondents of various positions.

D Research Assessment

D.1 New Nile Opportunities Conference

1) *Water monitoring in Nasser lake using satellite data (El-Shirbeny, Abu-Taleba, Alia, & Saleha, 2014)*

Goal: Fundamental
Score: N/A

2) *The impact of soil erosion in the upper blue Nile on downstream reservoir sedimentation (Ali, Crosato, & Mohamed, 2014)*

Goal: Identification of areas where erosion needs to be addressed in order to reduce downstream sediment input.
Score: Not multidisciplinary, Relevant, Useful

3) *On the wetlands of the Sudan (El Moghraby, 2014)*

Goal: Assessment of policies, strategies and legislation on the sustainable use of wetlands in Sudan.
Score: Multidisciplinary, Relevant, Not Useful

4) *Skill of developed hydrological models to forecast hydrological drought in Eastern Nile (Kotb & Amin, 2014)*

Goal: Explore the potential to improve and supplement hydrological drought early warning systems for the Eastern Nile.
Score: Not Multidisciplinary, Relevant, Useful

5) *Rainfall and runoff forecasting at Eddeim using time series analysis and hydrological model (El-Sayed & Attia, 2014)*

Goal: Fundamental
Score: N/A

6) *Climate change impact on variability of rainfall intensity in upper blue Nile basin (Lakemariam, 2014)*

Goal: Fundamental
Score: N/A

7) *Trend analysis of climate change using the long term water levels of lake Tana (B. Abate, 2014)*

Goal: Fundamental
Score: N/A

8) *Flood simulation using public domain data for a data scarce transboundary basin: the case of Gash river basin, Horn of Africa (Rokaya, Mohamed, Masih, & Zaag, 2014)*

Goal: Fundamental
Score: N/A

9) *The global dynamical features that influence hydrological fluxes in Ethiopia (Shiferaw, Demissie, & Dadi, 2014)*

Goal: Fundamental
Score: N/A

10) *Planform change analysis of Gumara river channel over 50 years, Upper Blue Nile Basin, Ethiopia (M. Abate et al., 2014)*

Goal: Fundamental
Score: N/A

11) *Dynamics in lake area at Er Roseires Dam as extracted from satellite images (Al Zayed, Elagib, & Ribbe, 2014)*

Goal: Fundamental
Score: N/A

12) *Water resources system monitoring framework for the Eastern Nile Basin (A. Hassan & Ahmed, 2014)*

Goal: Develop a framework with indicators to monitor and evaluate the hydrological functions of the water resources system in the Eastern Nile Basin.
Score: Not Multidisciplinary, Not Relevant, Not Useful

13) *Unlocking and using potentials of agroecosystems and vulnerability analysis for sustainable climate resilient development strategies in the Blue Nile highlands. (Simane & Zaitchik, 2014)*

Goal: Applying agroecosystem analysis and Livelihood Vulnerability Index for developing sustainable climate resilience strategies.
Score: Multidisciplinary, Relevant, Useful

14) *Eastern Nile developments: (re)shaping water and sediment flows in the Gezira irrigation scheme (Smit, 2014)*

Goal: Provide understanding of the morphology and meanings of Eastern Nile water infrastructure through an analysis of how they are shaped in relation with social relations of its users, in order to better target interventions for increasing water productivity.
Score: Multidisciplinary, Relevant, Useful

15) *Understanding the dynamics of socio-hydrological environment: upstream-downstream scenarios (Woyessa & Welderufael, 2014)*

Goal: Other area than Eastern Nile.
Score: N/A

16) *Modeling land use/cover dynamics in Fincha watershed, Blue Nile, using Mrkovian technique(Ayanaa, Edossab, & Kositsakulchaic, 2014)*

Goal: Fundamental
Score: N/A

17) *Impact of conservation practices on runoff and soil loss in the sub-humid Ethiopian Highlands: the Debre Mawi watershed (Dagnew, Tilahun, & Steenhuis, 2014)*

Goal: Analyze the impact of conservation measures to increase infiltration and reduce erosion in the Debre Mawi watershed.
Score: Not Multidisciplinary, Relevant, Not Useful

18) *The Impact of Settit and Grand Ethiopian Renaissance new dams on the Eastern Nile River Basin (Digna, Krogt, Mohamed, Zaag, & Uhlenbrook, 2014)*

Goal: The research provides an analysis of the impact of the GERD and Setit Dam on hydropower production and irrigation reliability.
Score: Not Multidisciplinary, Not Relevant, Not Useful

19) *Customized active hydro-meteorological GIS based map and data base for Blue Nile Basin (M. M. Hassan & Gaser, 2014)*

Goal: Show the possibilities of the NBDSS GIS component and provide the decision makers with an information system.
Score: Not Multidisciplinary, Not Relevant, Not Useful

20) *Flood plain mapping: comparison of different approaches to estimate design floods in the Blue Nile (Umer, 2014)*

Goal: Fundamental
Score:N/A

21) *Modeling potential operational policies of the Grand Ethiopian Renaissance Dam (Wheeler, Mersha, & Tesfaye, 2014)*

Goal: The aim of the research is to demonstrate the usefulness of the RiverWare model to support the negotiations on the operation of the Renaissance Dam.
Score: Not Multidisciplinary, Not Relevant, Useful

22) *Environmental and social impact of the GERD: seizing opportunities for broader collaboration in the Eastern Nile Basin (Simane & Tafesse, 2014)*

Goal: The research analyzes the social and environmental impacts of the GERD.
Score: Multidisciplinary, Relevant, Useful

23) *Filling options assessment for proposed reservoirs in Abbay (Upper Blue Nile) River Basin to minimize impacts on energy generation downstream reservoirs (Mulat & Moges, 2014)*

Goal: The research proposes different filling options for the cascade dams on the Abbay river.
Score: Not Multidisciplinary, Relevant, Not Useful

24) The biodiversity of the Abbay basin (Woldu, 2014)

Goal: The research analyzes the effects of the GERD on biodiversity in the region.
Score: Not Multidisciplinary, Relevant, Useful

25) Multipurpose water resource planning and management (Mekonen, 2014)

Goal: The research aims to evaluate scenarios for the development of the Lake Tana basin.
Score: Multidisciplinary, Relevant, Useful

26) Planning for sustainable use of floodplains along urban rivers in Khartoum, Sudan (Asnake, 2014)

Goal: The research deals with planning issues in floodplain development in Sudan as a result of the GERD.
Score: Multidisciplinary, Relevant, Useful

27) Deriving reservoir operation rules for new Atbara dam complex in Sudan (Heynert, Mohamed, & Mohamed, 2014)

Goal: The research derives operation rules for the operation of the new Atbara dam complex.
Score: Not Multidisciplinary, Relevant, Useful

28) Impact of changing policies on water management and agricultural productivity: a case of the Gezira scheme, Sudan (Abdelgalil, 2014)

Goal: Fundamental
Score: N/A

29) Development of agro-economic model for the assessment of agricultural policies in Sudan (Ibrahim, 2014)

Goal: The research develops a model to evaluate the effects of policies on the agricultural sector.
Score: Multidisciplinary, Relevant, Not Useful

30) Reservoir filling options assessment for the Grand Ethiopian Renaissance Dam using a probabilistic approach (Tesfaye, Wheeler, Mersha, & Ibrahim, 2014)

Goal: The aim of the research is to demonstrate the usefulness of the RiverWare model to support the negotiations on the operation of the Renaissance Dam.
Score: Not Multidisciplinary, Not Relevant, Useful

31) Humanizing regulation of the Nile: the human right to water in the Nile Basin(Bulto, 2014)

Goal: The research aims to show that the transboundary allocation of water should local rights holders at the basis.
Score: Not Multidisciplinary, Relevant, Not Useful

32) *Regionalization of conceptual rainfall-runoff model parameters for predicting stream flows of ungauged catchments in the Blue Nile basin (Akawka, Haile, & Rientjes, 2014)*

Goal: Fundamental
Score: N/A

33) *Impact of land cover dynamics in hydrological response in the Lake Tana basin, Ethiopia (Woldesenbeta, 2014)*

Goal: Fundamental
Score: N/A

34) *Upstream development in the Eastern Nile Basin and its impact on downstream w.r.t. Sudan (A. A. Ahmed & Siyam, 2014)*

Goal: The research studies the effects of the upstream developments in the Eastern Nile and the impacts on downstream uses.
Score: Not Multidisciplinary, Not Relevant, Useful

35) *Hybrid analytical approach for modeling the dynamics of interactions in a complex water networks (Ibrahim & Shafiqul, 2014)*

Goal: Fundamental
Score: N/A

36) *Contemporary water diplomacy in the (Eastern) Nile Basin: the Grand Ethiopian Renaissance Dam and the basin-sub-basin nexus (Yigzaw, 2014)*

Goal: Fundamental
Score: N/A

37) *Track two diplomacy in the Eastern Nile: emerging challenges and opportunities (Milicevic, 2014)*

Goal: Fundamental
Score: N/A

38) *Public participation in transboundary water governance: regional and national perspectives in the Nile (Abseno, 2014)*

Goal: Fundamental
Score: N/A

39) *A tale of two dams: a comparative hydro-political assessment of the Great Ataturk Dam of Turkey and the Grand Renaissance Dam of Ethiopia (S. Ahmed, 2014)*

Goal: Fundamental
Score: N/A

40) *Opportunities and challenges for transboundary cooperation in the Eastern Nile: legal and hydro-political perspectives (Cappuccini, 2014)*

Goal: Fundamental
Score: N/A

41) *Collaboration through libraries: the impact of digital libraries for the water resources development studies in the Nile Basin countries (Endeshaw & Webshet, 2014)*

Goal: The research suggests possibilities to expand digital libraries to promote knowledge sharing and the efficient utilization of the Nile.
Score: Not Multidisciplinary, Relevant, Useful

D.2 Publications on water resources management in the Nile of the year 2014

1) *Groundwater as a viable resource under climate change in the Nile Basin: A rapid hydrogeological assessment (Abiye & Mmayi, 2014)*

Goal: Fundamental
Score: N/A

2) *Water use at Luxor, Egypt: Consumption analysis and future demand forecasting (A. A. Ahmed, Fogg, & Gameh, 2014)*

Goal: The research analyses current and future water uses at Luxor and gives recommendations on how to cope with future demands.
Score: Multidisciplinary, Relevant, Useful

3) *Water resources assessment along the Blue Nile River, north Africa with a one-dimensional model (Ali, Crosato, Mohamed, Wright, & Roelvink, 2014)*

Goal: The aim of this research was to construct a model to analyze water availability in the Blue Nile River and show where extra water is lost.
Score: Not Multidisciplinary, Relevant, Useful

4) *Water storage changes and climate variability within the Nile Basin between 2002 and 2011 (Awange, Forootan, Kuhn, Kusche, & Heck, 2014)*

Goal: Fundamental
Score: N/A

5) *Characterization of Ethiopian mega hydrogeological regimes using GRACE, TRMM and GLDAS datasets (Awange, Gebremichael, et al., 2014)*

Goal: Fundamental
Score: N/A

6) *A shared vision (Basin, 2014)*

Goal: Fundamental
Score: N/A

7) *Earth observation based assessment of the water production and water consumption of the Nile Basin agrocecosystems (Bastiaanssen et al., 2014)*

Goal: The goal of this research was to assess water production and consumption in the Nile Basin.
Score: Not Multidisciplinary, Relevant, Not Useful

8) *Pathways for building capacity and ensuring effective transboundary water resources management in Africa: Revisiting the key issues, opportunities and challenges. (Chikozho, 2015)*

Goal: The research analyses capacity building in the Nile and Senegal River Basins.
Score: Not Multidisciplinary, Relevant, Not Useful

9) *Analyzing runoff processes through conceptual hydrological modeling in the upper Blue Nile Basin, Ethiopia (Dessie et al., 2014)*

Goal: Fundamental
Score: N/A

10) *Coupled humans and natural system dynamics as the key to the sustainability of Lake Victoria's ecosystem services (Downing et al., 2014)*

Goal: The aim was to develop a model to evaluate changes to the human and natural system of Lake Victoria.
Score: Multidisciplinary, Relevant, Useful

11) *An overview of integrated remote sensing and GIS for groundwater mapping in Egypt (Elbeih, 2014)*

Goal: Fundamental
Score: N/A

12) *Assessment of socioeconomic aspects in irrigation water use inefficiency in Sudan (Elgilany, Jamalludin, & Saidatulakmal, 2014)*

Goal: The goal of this research was to analyze the socioeconomic performance of the people in the Elzeidab irrigation scheme and provide options to improve irrigation practices.
Score: Multidisciplinary, Relevant, Useful

13) *Wavelet analysis of seasonal rainfall variability of the upper Blue Nile basin, its telecnnection to global sea surface temperature, and its forecasting by an artificial neural network. (Elsanabary & Gan, 2014)*

Goal: Fundamental
Score: N/A

14) *Optimization of integrated water quality management for agricultural efficiency and environmental conservation (Fleifle, Saavedra, Yoshimura, Elzeir, & Tawfik, 2014)*

Goal: The aim of the research was to apply a new model to the Nile Delta to optimize the water quality targets for water use in agriculture and the aquatic environment.
Score: Not Multidisciplinary, Relevant, Not Useful

15) *Emergency assessment of tilapia cage farming in a hydroelectric reservoir (Garcia, Kimpara, Valenti, & Ambrosio, 2014)*

Goal: Other area than Eastern Nile.
Score: N/A

16) *Forest cover change over four decades in the Blue Nile Basin, Ethiopia: comparison of three watersheds. (Gebrehiwot, Bewket, Gardenas, & Bishop, 2014)*

Goal: Assess forest cover changes in the Gilgel Abbay, Birr and Upper-Didesa basins.
Score: Not Multidisciplinary, Relevant, Not Useful

17) *Hydrological impacts of urbanization of two catchments in Harare, Zimbabwe (Gumindoga et al., 2014)*

Goal: Other area than Eastern Nile
Score: N/A

18) *Dynamics of land use and land cover and its effects on hydrologic responses: case study of the Gilgel Tekeze catchment in the highlands of Northern Ethiopia*

Goal: Asses the land cover changes and their hydrological affects in the Gilgel Tekeze Basin.
Score: Multidisciplinary, Not Relevant, Not Useful

19) *Hydrological modeling of large river basins: How much is enough? (Johnston & Smakhtin, 2014)*

Goal: Fundamental
Score: N/A

20) *Evaluating suitability of MODIS-Terra images for reproducing historic sediment concentrations in water bodies: Lake Tana, Ethiopia (Kaba, Philpot, & Steenhuis, 2014)*

Goal: Fundamental
Score:N/A

21) *Improving water quality in the Nile delta irrigation network by regulating reuse of agricultural drainage water. (Khater, Kitamura, Shimizu, Somura, & Abou El Hassan, 2014)*

Goal: Analyze the reuse of drainage water as a method to fulfill water needs in the Nile Delta.
Score: Not Multidisciplinary, Relevant, Useful

22) *Groundwater quality assessment of the shallow aquifers west of the Nile Delta (Egypt) using multivariate statistical and geostatistical techniques. (Masoud, 2014)*

Goal: Analysis of the water quality of aquifers for the identification of areas useful for groundwater development.
Score: Not Multidisciplinary, Relevant, Useful

23) *Impact of climate variability on the hydrology of the Sudd wetland: Signals derived from long term (1900-2000) water balance computations. (Mohamed & Savenije, 2014)*

Goal: Fundamental
Score: N/A

24) *Water resources and the potential of brackish groundwater extraction in Egypt: A review. (Nashed, Sproul, & Leslie, 2014)*

Goal: The research aims to identify areas that are suitable for the development of brackish groundwater extraction.
Score: Not Multidisciplinary, Relevant, Useful

25) *An important natural genetic resource of Oreochromis niloticus (Linnaeus, 1758) threatened by aquaculture activities in Loboi drainage, Kenya (Ndiwa, Nyingi, & Agnese, 2014)*

Goal: Other area than Eastern Nile
Score: N/A

26) *Accounting for environmental flow requirements in global water assessments. (Pastor, Ludwig, Biemans, Hoff, & Kabat, 2014)*

Goal: Fundamental
Score: N/A

27) *The Nile Delta: urbanizing on diminishing resources. (Redeker & Kantoush, 2014)*

Goal: Fundamental
Score: N/A

28) *Characterization of stable isotopes to identify residence times and runoff components in two meso-scale catchments in the Abay/Upper Blue Nile basin, Ethiopia (Tekleab, Wenninger, & Uhlenbrook, 2014)*

Goal: Fundamental

Score: N/A

29) *Analysis of suspended sediment transport data in the River Nile. (Zaid, Koll, Wiesemann, & Elzein, 2014)*

Goal: Fundamental
Score: N/A

E Water Accounting + Sheets

The water accounting sheets that are currently available for the Nile Basin are presented in Figure 40, Figure 41, Figure 42, Figure 43, Figure 44 and Figure 45. More sheets are under construction.

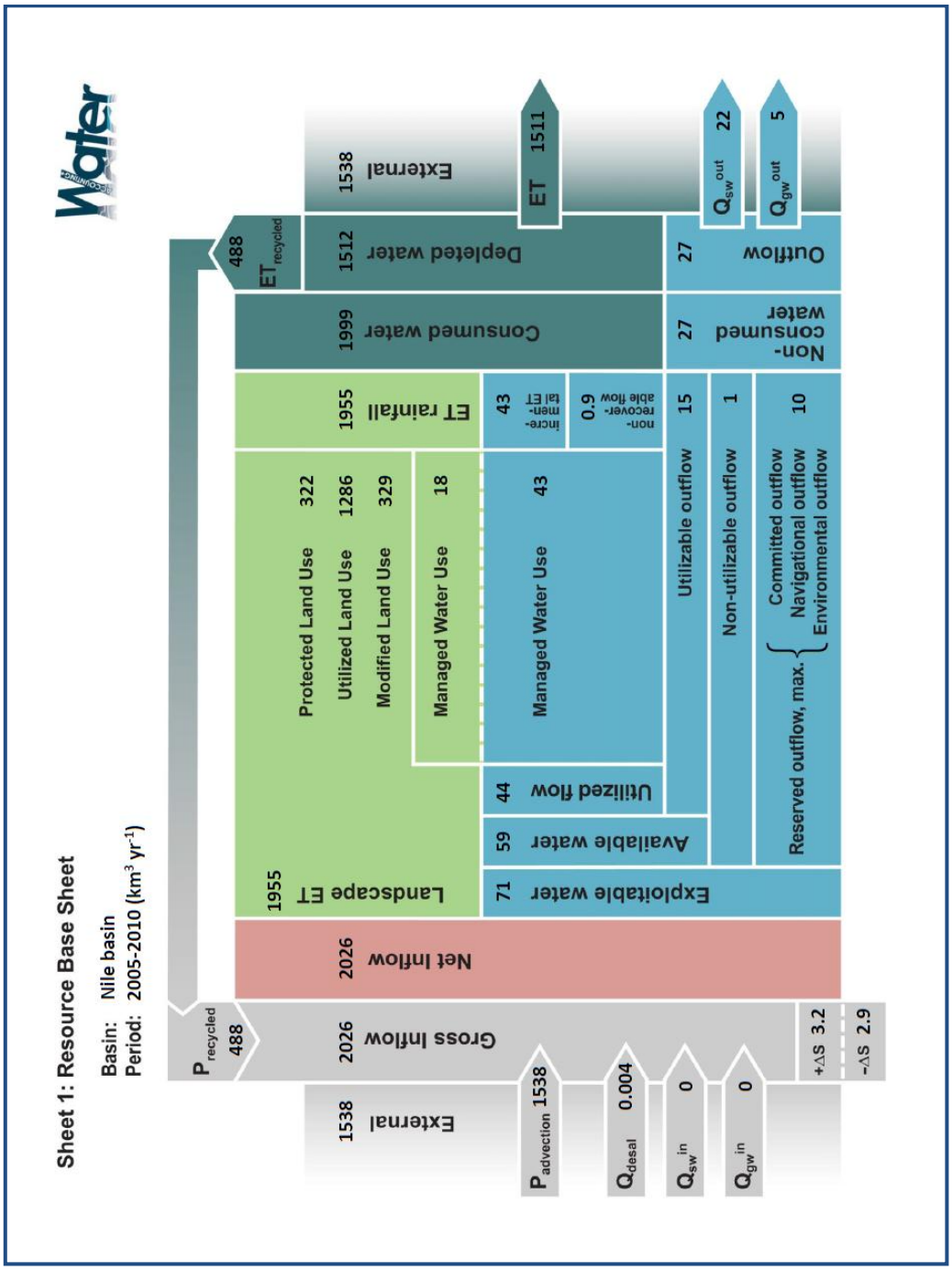


Figure 40 Nile Basin Resource Base Sheet - (www.wateraccounting.org)

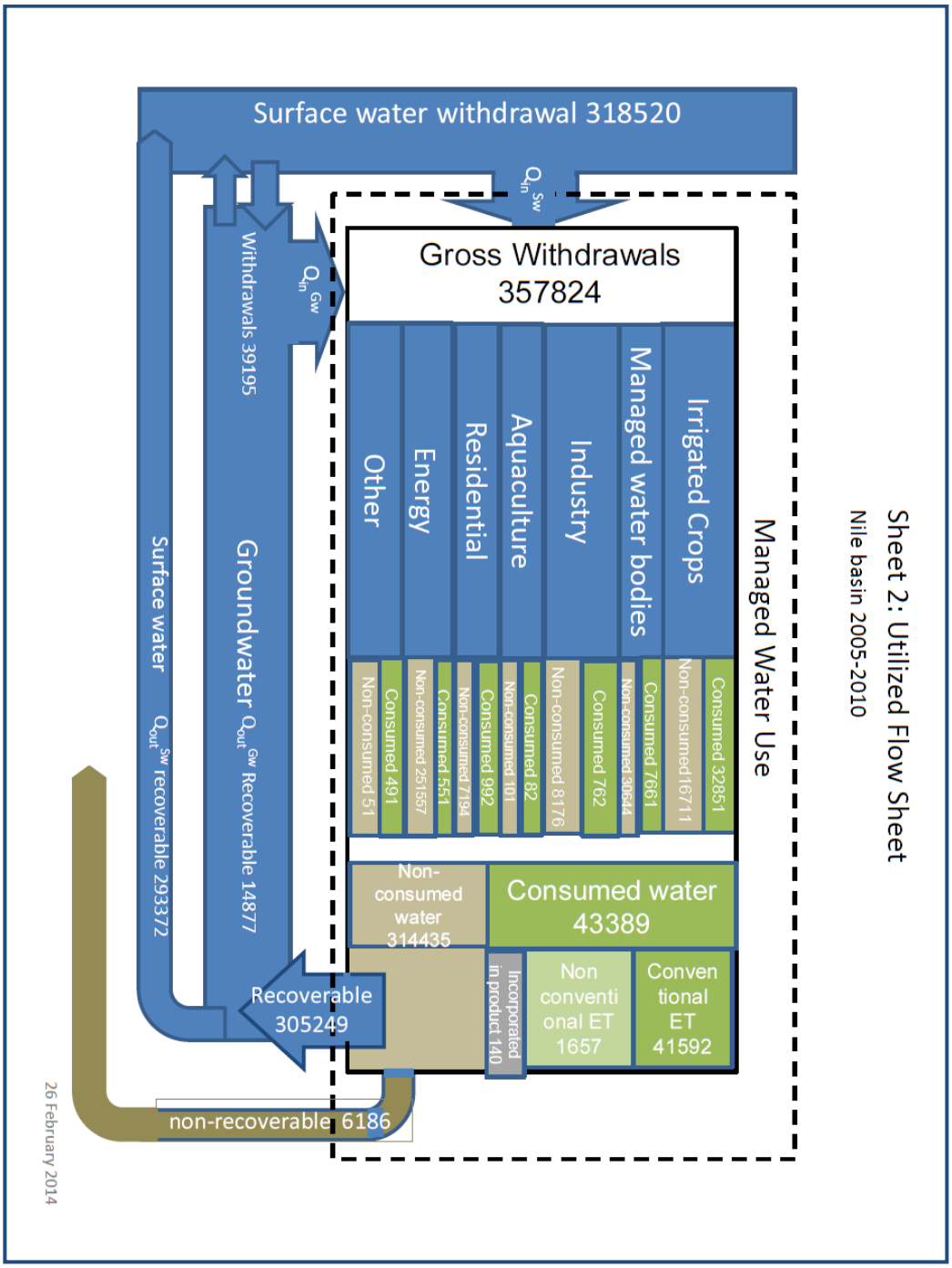


Figure 41 Nile Basin Utilized Flow Sheet - (www.wateraccounting.org)

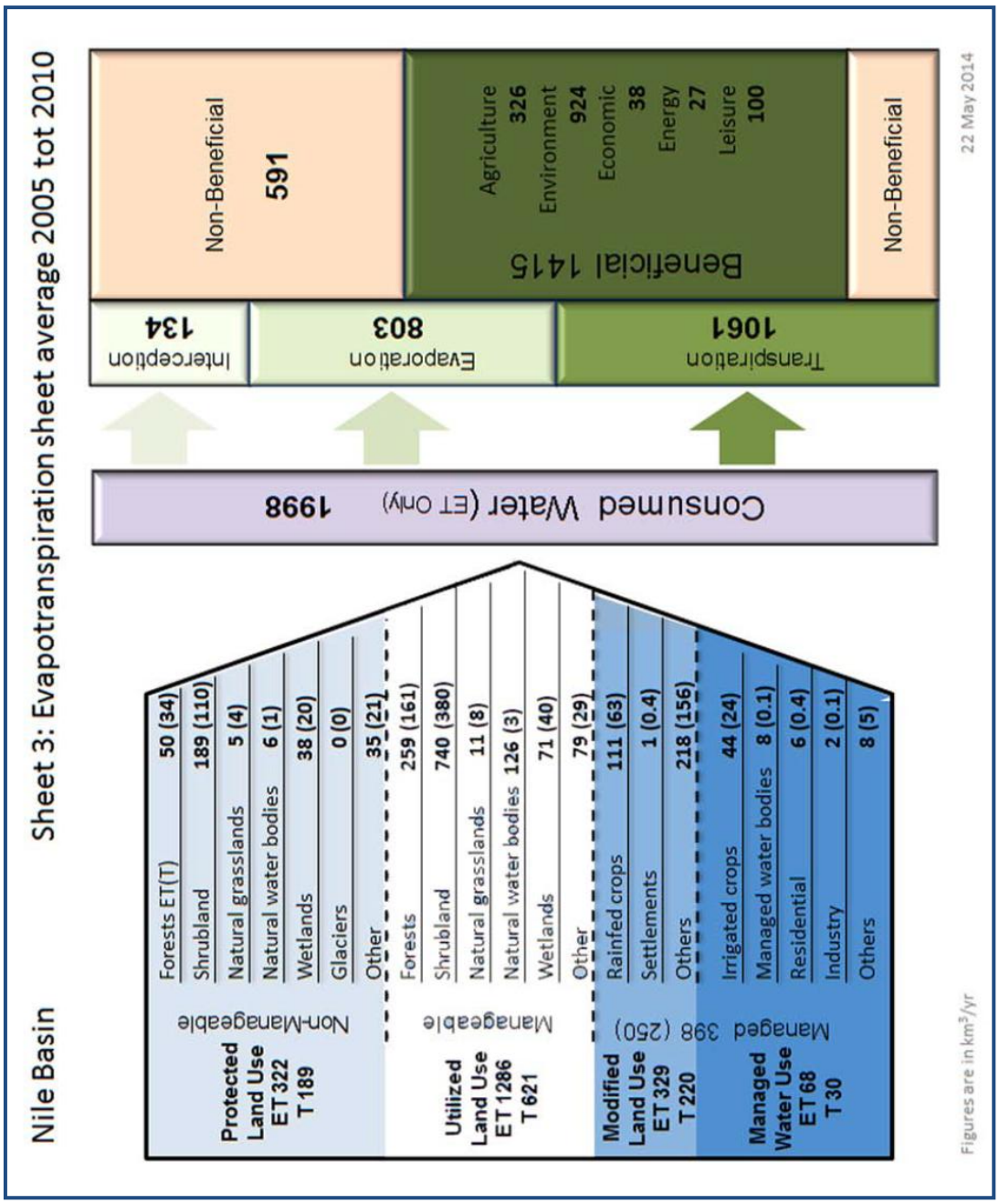


Figure 42 Nile Basin Evapotranspiration Sheet - (www.wateraccounting.org)

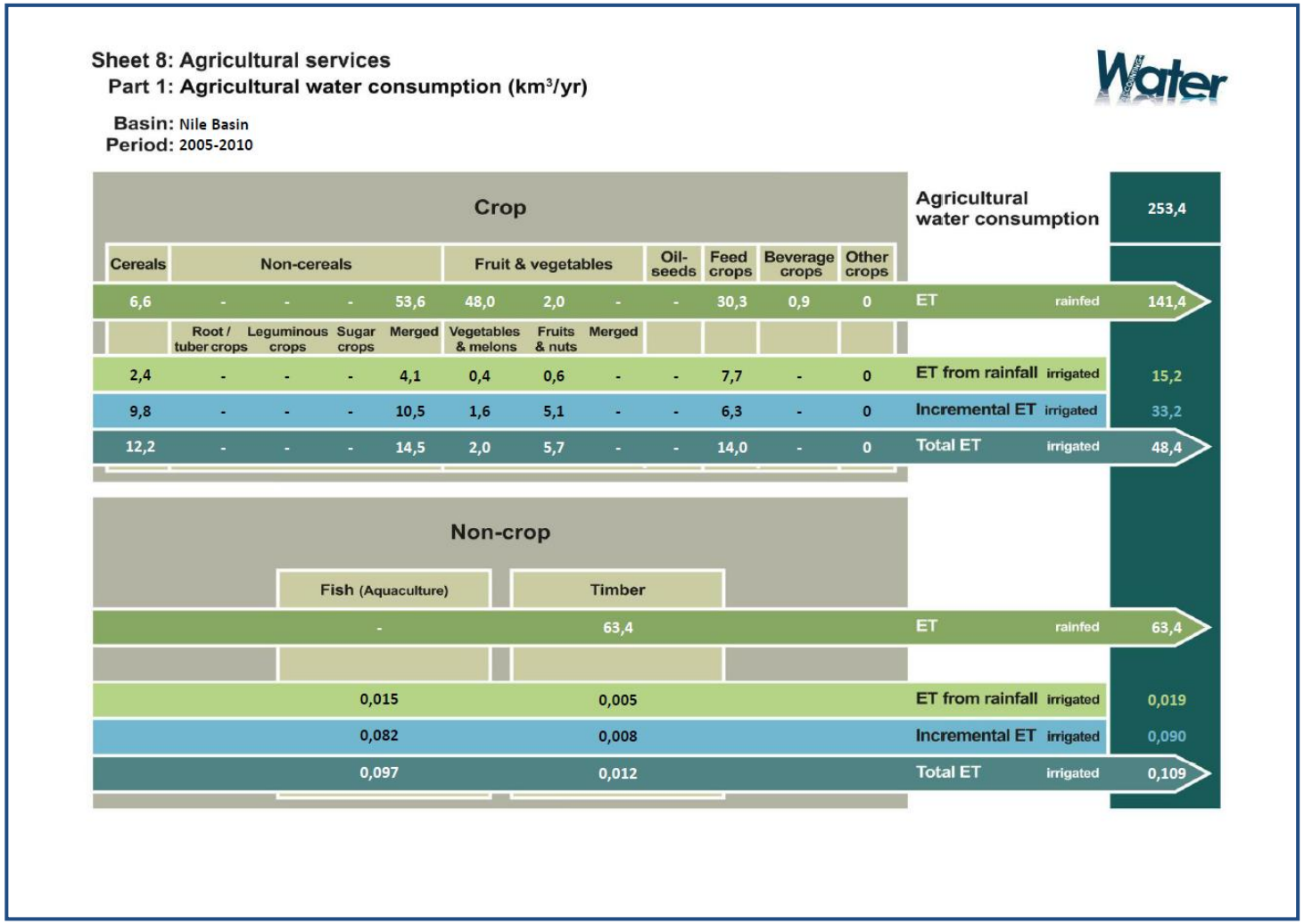
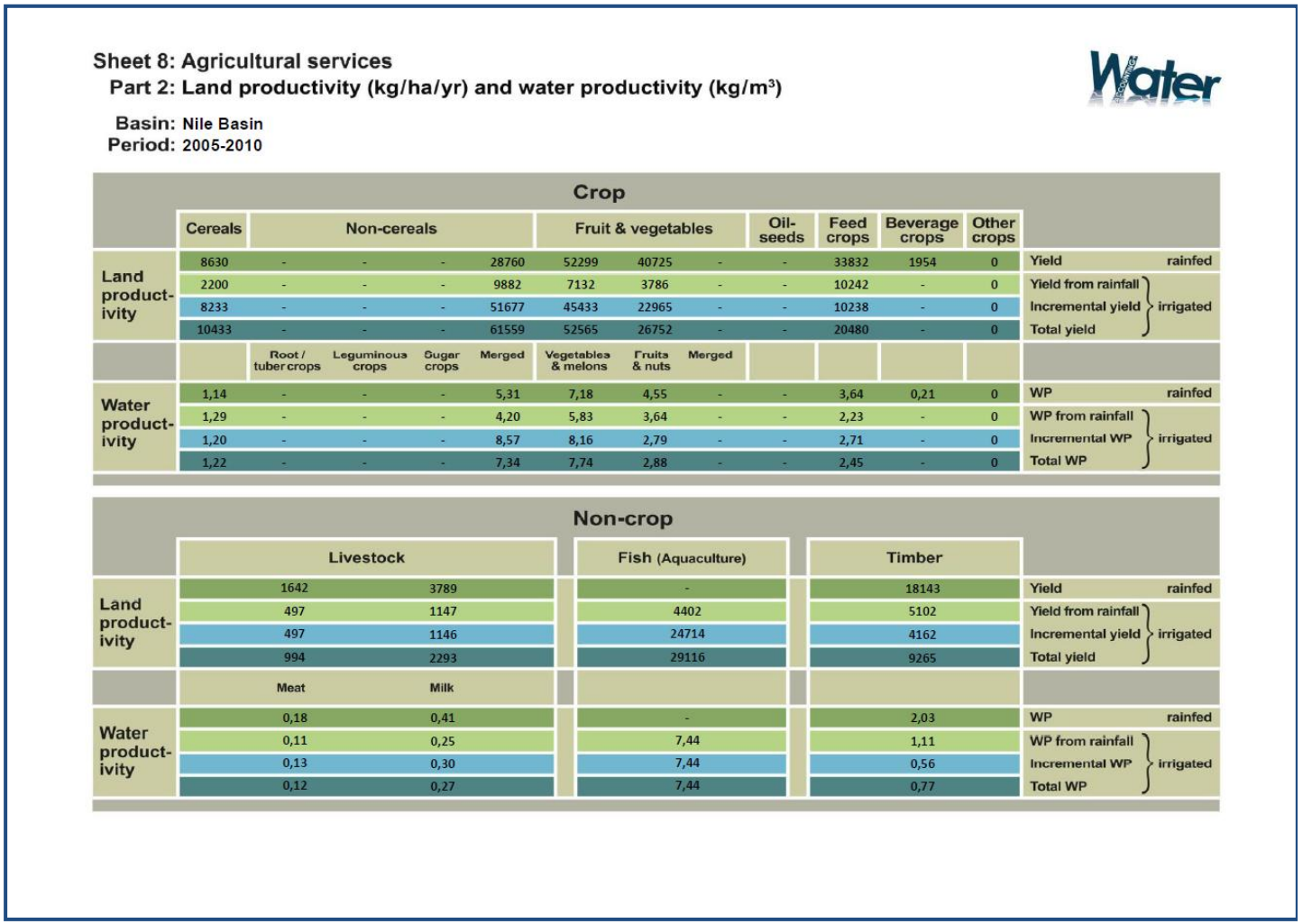


Figure 43 Nile Basin Agricultural Services Sheet 1



Sheet 8: Agricultural services

Part 2: Land productivity (kg/ha/yr) and water productivity (kg/m³)

Basin: Nile Basin
Period: 2005-2010

Crop

	Cereals	Non-cereals				Fruit & vegetables			Oil-seeds	Feed crops	Beverage crops	Other crops		
Land productivity	8630	-	-	-	28760	52299	40725	-	-	33832	1954	0	Yield	rainfed
	2200	-	-	-	9882	7132	3786	-	-	10242	-	0	Yield from rainfall	irrigated
	8233	-	-	-	51677	45433	22965	-	-	10238	-	0	Incremental yield	
	10433	-	-	-	61559	52565	26752	-	-	20480	-	0	Total yield	
		Root / tuber crops	Leguminous crops	Sugar crops	Merged	Vegetables & melons	Fruits & nuts	Merged						
Water productivity	1,14	-	-	-	5,31	7,18	4,55	-	-	3,64	0,21	0	WP	rainfed
	1,29	-	-	-	4,20	5,83	3,64	-	-	2,23	-	0	WP from rainfall	irrigated
	1,20	-	-	-	8,57	8,16	2,79	-	-	2,71	-	0	Incremental WP	
	1,22	-	-	-	7,34	7,74	2,88	-	-	2,45	-	0	Total WP	

Non-crop

	Livestock		Fish (Aquaculture)	Timber		
Land productivity	1642	3789	-	18143	Yield	rainfed
	497	1147	4402	5102	Yield from rainfall	irrigated
	497	1146	24714	4162	Incremental yield	
	994	2293	29116	9265	Total yield	
	Meat	Milk				
Water productivity	0,18	0,41	-	2,03	WP	rainfed
	0,11	0,25	7,44	1,11	WP from rainfall	irrigated
	0,13	0,30	7,44	0,56	Incremental WP	
	0,12	0,27	7,44	0,77	Total WP	

Figure 44 Nile Basin Agricultural Services Sheet 2

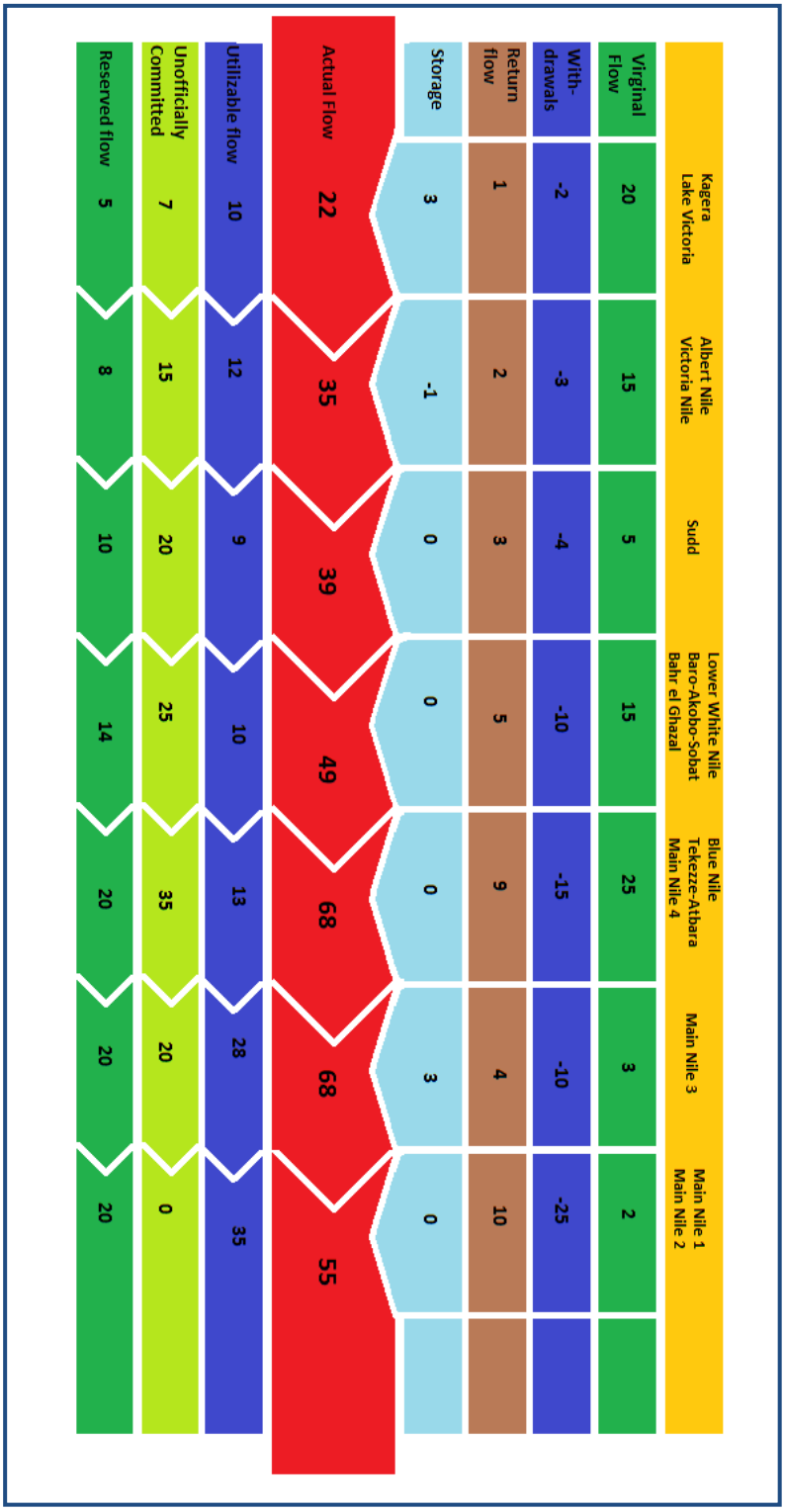


Figure 45 Nile Basin Surface Water Sheet

F Interview Results Water Accounting +

In the following sections the results on opinion on Water Accounting + of decision makers are presented. The charts in section F.1 present their views on the information itself, both per country and per decision maker position. Section F.2 presents results on the presentation of this information and section F.3 on the way of dissemination. Section F.4 gives their views on whether or not Water Accounting + would be useful.

Positions of respondents are divided into national and international and can be a scientist, advisor, low level (LL) decision maker or high level (HL) decision maker.

E.1 Information

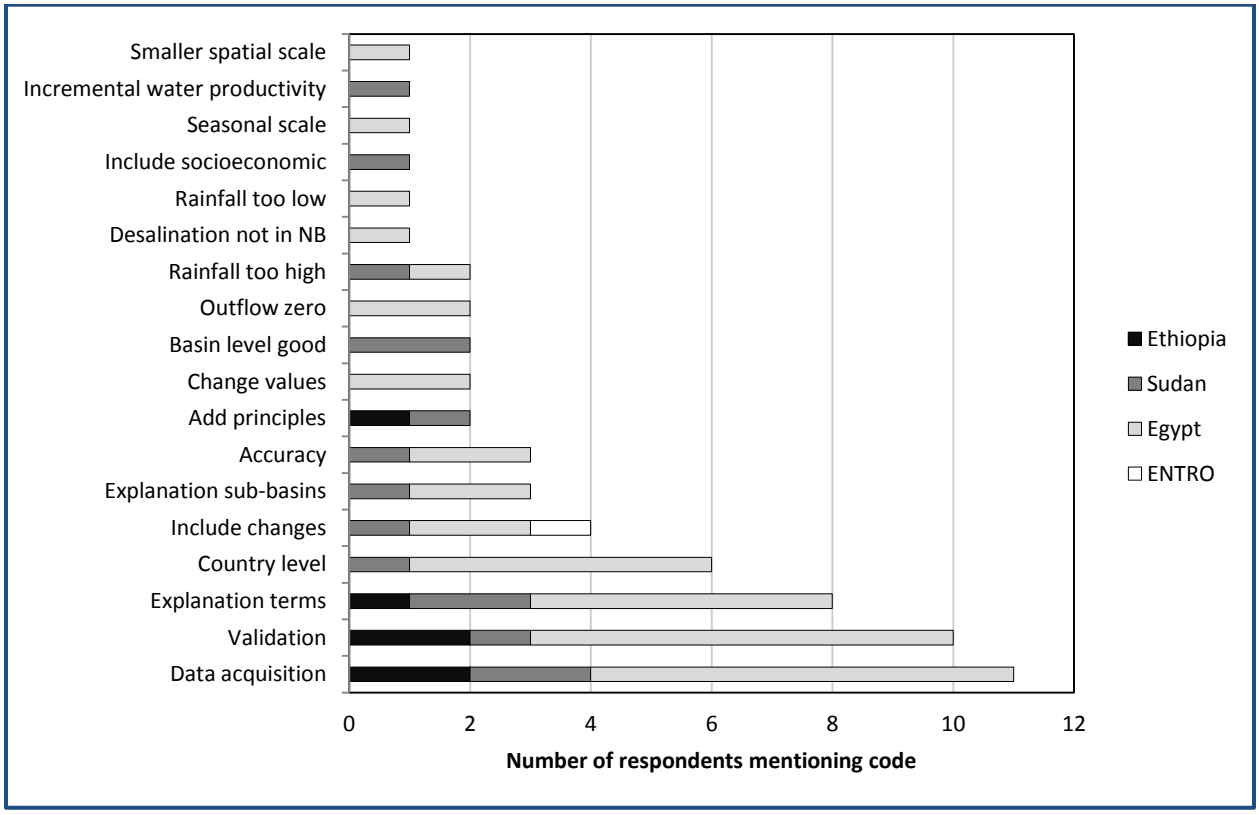


Figure 46 Opinion on the information presented in the water accounts of the respondents of the various countries.

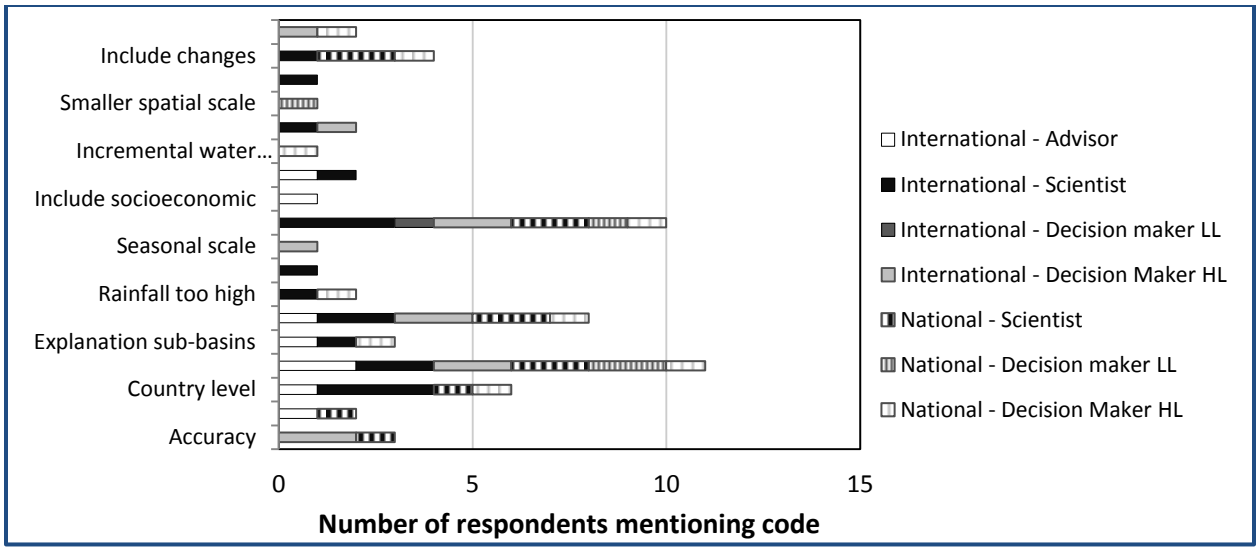


Figure 47 Opinion on the information presented in the water accounts of the respondents of various positions.

E.2 Presentation

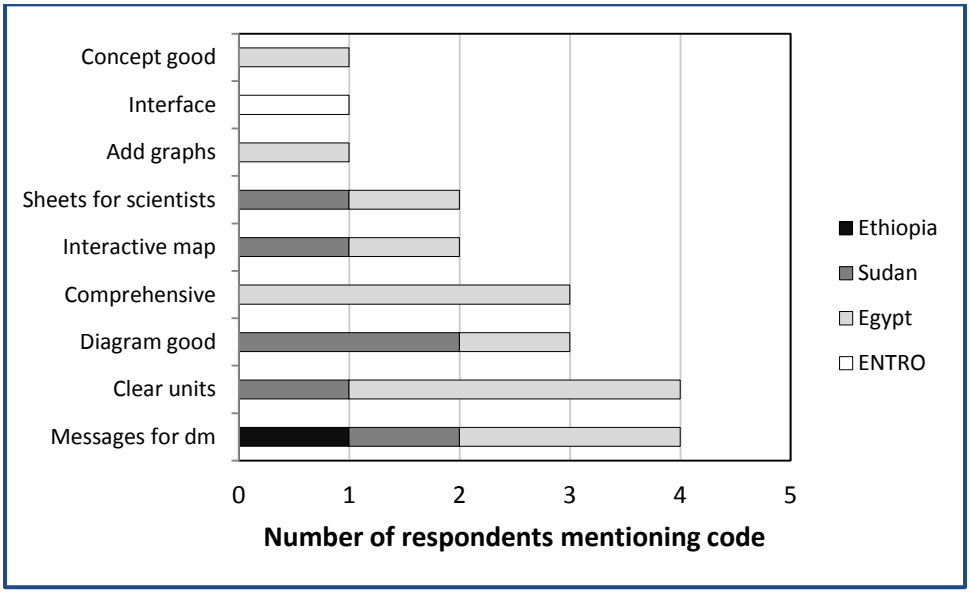


Figure 48 Opinion on the presentation of the water accounts of the respondents of the various countries.

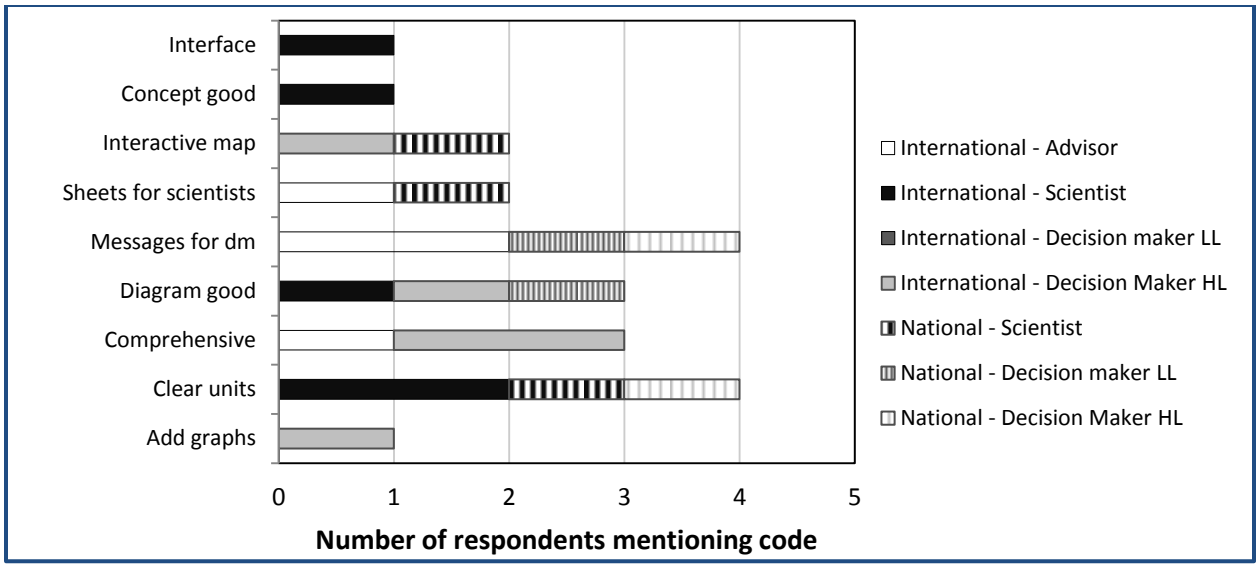


Figure 49 Opinion on the presentation of the water accounts of the respondents of various positions.

E.3 Dissemination

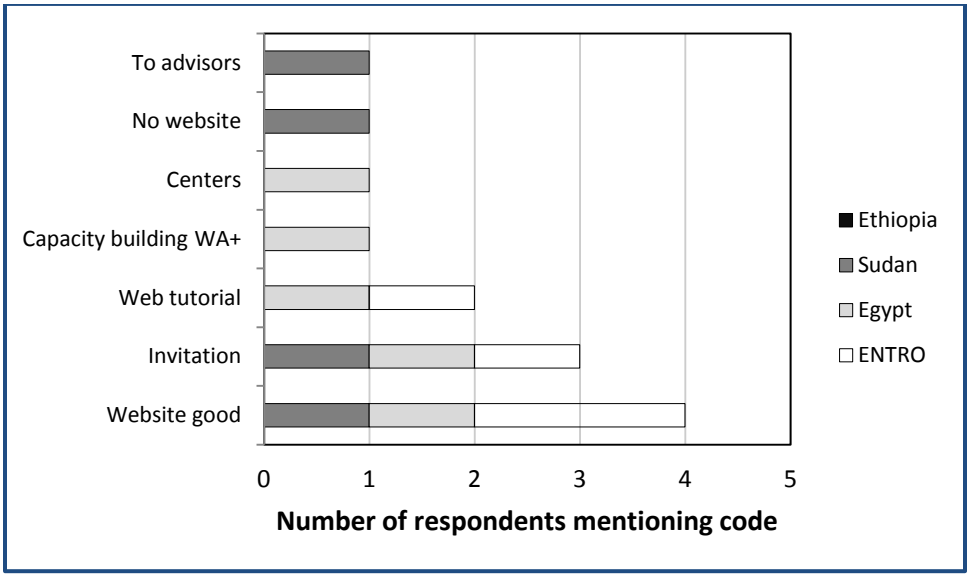


Figure 50 Opinion on the way of dissemination of the respondents of the various countries.

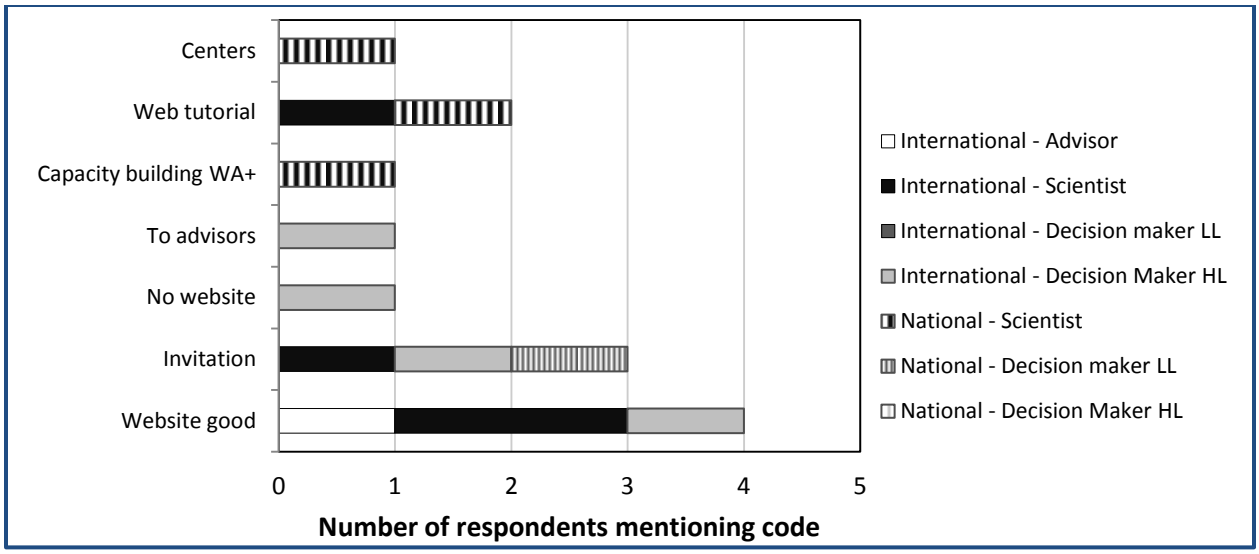


Figure 51 Opinion on the way of dissemination of the respondents of various positions.

E.4 Usefulness

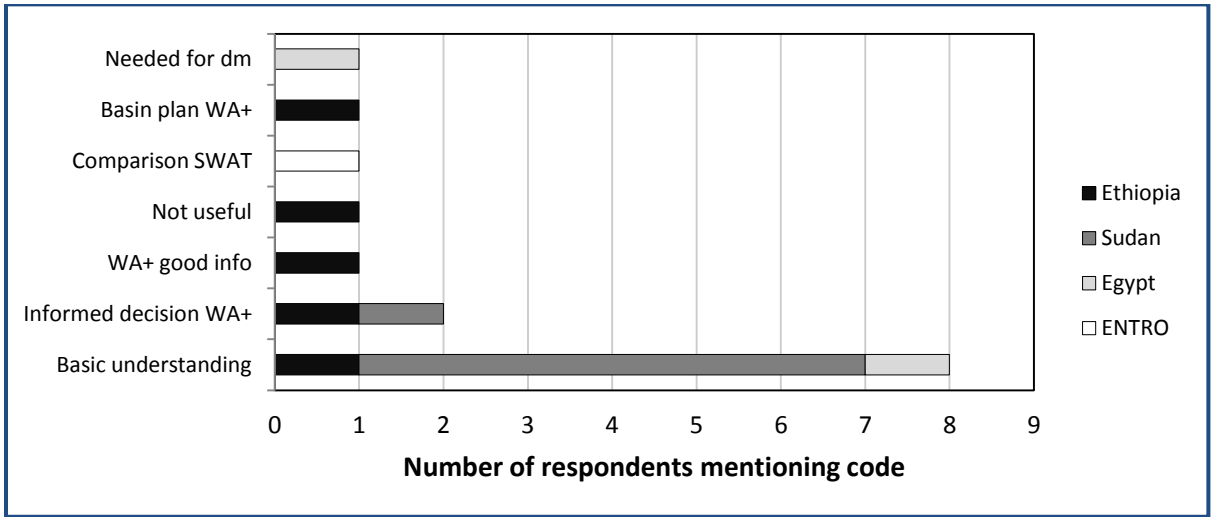


Figure 52 Opinion on the usefulness of Water Accounting + of the respondents of the various countries.

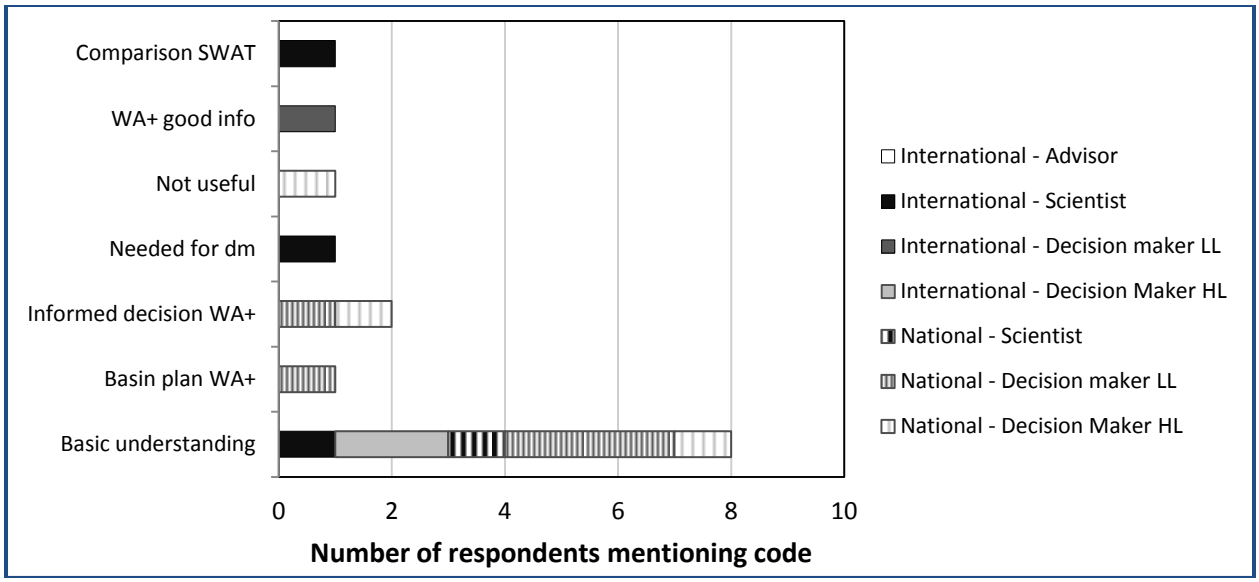


Figure 53 Opinion on the usefulness of Water Accounting + of the respondents of various positions.

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