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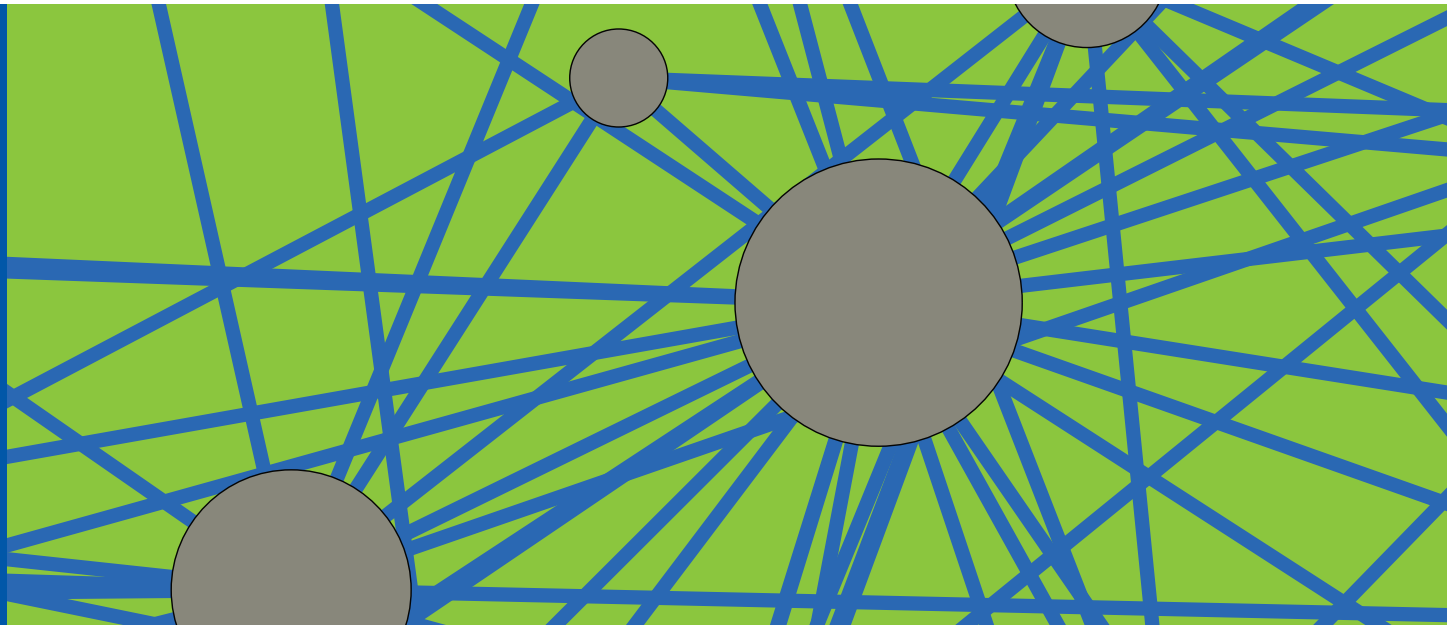

Advancing the Water-energy-food Nexus: Social Networks and Institutional Interplay in the Blue Nile

Christian Stein, Jennie Barron, Likimyelesh Nigussie, Birhanu Gedif, Tadesse Amsalu and Simon Langan

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Disclaimer

The opinions expressed in this paper and all errors are the responsibility of the first author. They do not reflect the position of the CGIAR Research Program on Water, Land and Ecosystems or of the institutions and individuals who were involved in the preparation of the report.

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Collaborators

This research study was a collaboration of the following organizations:

International Water Management Institute (IWMI)

Stockholm Environment Institute (SEI)

MetaMeta Research

CONTENTS

ACRONYMS

ABA	Abay Basin Authority
ARARI	Amhara Regional Agricultural Research Institute
AWWCE	Amhara Water Works Construction Enterprise
AWWDSE	Amhara Water Works Design and Supervision Enterprise
BDU	Bahir Dar University
BoARD	Bureau of Agriculture and Rural Development
BoFED	Bureau of Finance and Economic Development
BoWRD	Bureau of Water Resources Development
CRGE	Climate Resilient Green Economy
CPA	Cooperatives Promotion Agency
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
EPLAUA	Environmental Protection, Land Administration and Use Authority
EEPCO	Ethiopian Electric Power Cooperation
GTP	Growth and Transformation Plan
MEA	Mines and Energy Agency
MoARD	Ministry of Agriculture and Rural Development
MoWIE	Ministry of Water Irrigation and Energy
ORDA	Organization for Rehabilitation and Development in Amhara
TBGC	Tana and Beles Growth Corridor
WUA	Water User Association

SUMMARY

Ethiopia is currently undergoing rapid development, heavily reliant on its natural resources such as water and land. The government's Growth and Transformation Plan (GTP) and its Climate Resilient Green Economy (CRGE) strategy set ambitious targets in a variety of sectors including water, food and energy. In order to avoid trade-offs and create synergies between different development agendas, integrated planning and cross-sectorial coordination is crucial. The so-called 'nexus approach' is a recent way to frame the interconnected challenges in water, food and energy with the ambition to align policies for sustainable development.

This study fills a gap in the nexus debate by focusing on concrete actors and the nexus challenges they struggle with, instead of on abstract systems and the resource flows between sectors. Based on participatory, visual network mapping and focus group discussions, the paper illustrates three interdependent challenges of the water-energy-food nexus in the Upper Blue Nile in Ethiopia. First, it points to the central role of biomass-based energy resources and the need to balance national ambitions for hydropower and immediate energy needs for rural communities. Second, it identifies agricultural water management as a critical issue where linkages across sectors and scales need to be improved. Third, it highlights the need to strengthen actors working on environmental sustainability issues, and generating political support for their objectives, by making available evidence on the value of nature for development.

The findings of this scoping study show that participatory network research can facilitate dialogue and colearning among researchers and a range of actors on the interconnected challenges of the water-energy-food nexus. Such collaborative learning processes can play an important role in moving toward better coordination between key actors and improved development planning within the Upper Blue Nile.

1. INTRODUCTION

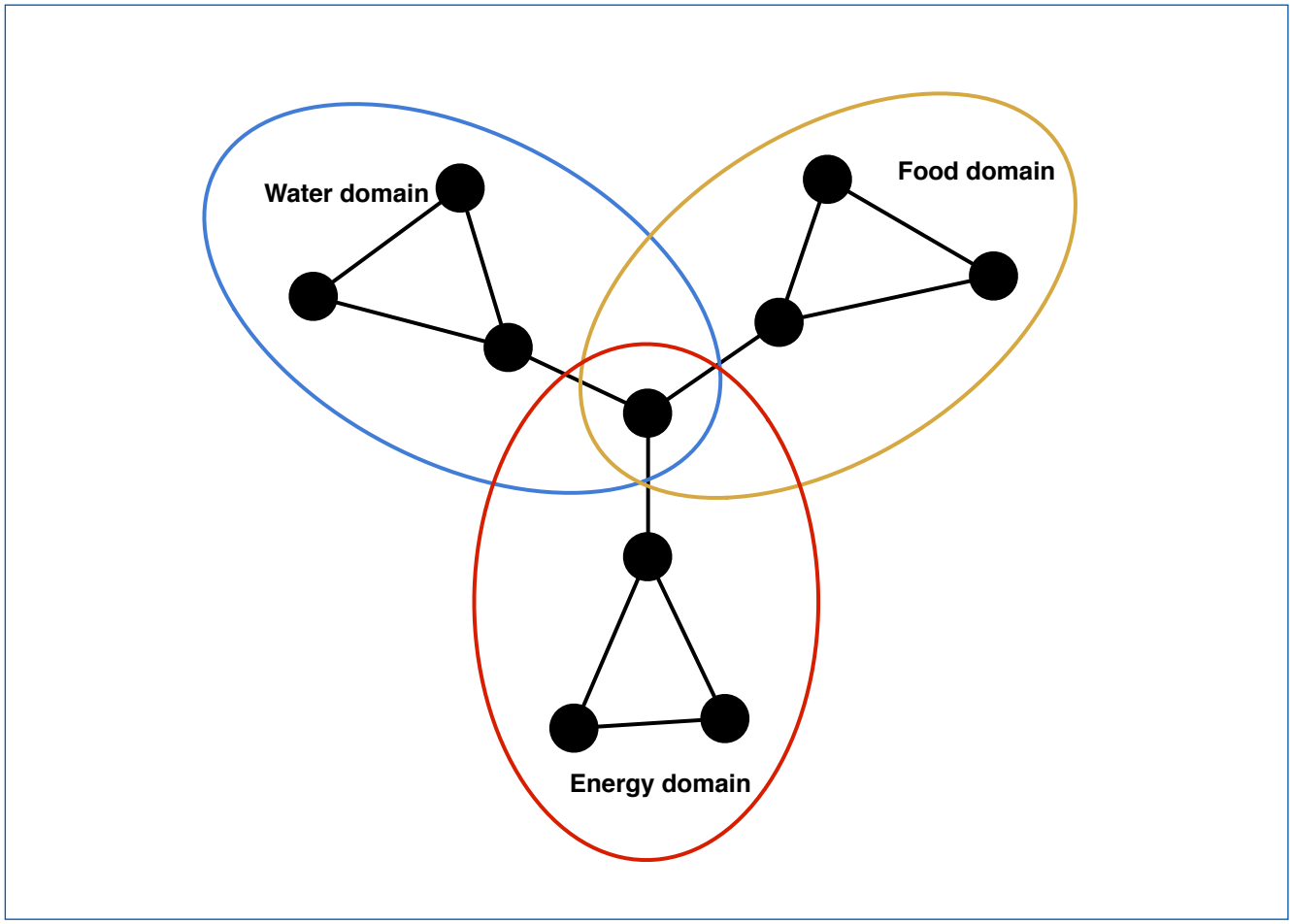
1.1 The water-energy-food nexus

How to manage the complex links between water, food, energy and the associated social, economic and environmental implications is a major policy concern. Within Ethiopia, as in many other countries, water, food and energy are predominantly managed as independent sectors, with little consideration of their interdependence or their cumulative impact on ecosystems. Increasingly, it is recognized that unless their interdependences are taken into account these different sectors cannot be developed and managed in a sustainable and effective way. The water-energy-food nexus perspective highlights the interdependence of water, food and energy systems and the natural resources that underpin those systems. The approach aims at reducing trade-offs and generating cobenefits for sustainable development (Hoff 2011). While previous research has identified critical linkages between the different sectors (Bazilian et al. 2011; Hoff 2011; Lawford et al. 2013), relatively little attention has been paid to the relevant actors shaping the water-energy-food nexus and the sociopolitical context in which further integration should be achieved.

Considering both the diversity of actors influencing the nexus and the complex relationships between these actors, there is a need for analytical tools that allow for mapping of these actor networks and the facilitating processes of stakeholder coordination. As acknowledged by Ringler and colleagues (2013), *"following the nexus approach, comprehensive assessments of existing institutional arrangements are needed to identify common factors that enable integrated management approaches."*

Addressing challenges in one nexus domain without considering the connections to other actors or nexus dimensions can have the result that problems are not solved but shifted to other actors, sectors, geographic locations or scales. For example, expanding irrigation systems upstream may reduce downstream water availability for hydropower and ecosystems. Since no single actor has the knowledge or the resources to address interconnected nexus challenges unitarily, a plurality of actors need to coordinate their activities in order to find comprehensive solutions to their interconnected problems. Pathways toward more sustainable management of water, land, energy and ecosystems will need to work with and through these actors and their relationships. Figure 1 illustrates, in a stylized form, how the different water-energy-food nexus domains and associated actor networks are interconnected.

FIGURE 1. INTERACTIONS OF DIFFERENT NEXUS DOMAINS AND ACTORS WITHIN THEM.



Source: Author's creation

Despite their strategic importance, most social networks remain hidden from the view of decision makers and the organizations that shape them (Cross et al. 2002). More recently, social network analysis has been applied to study natural resource management and governance arrangements (Bodin and Crona 2009; Bodin and Prell 2011; Schneider et al. 2003; Stein et al. 2011), providing new and important insights into how social networks affect rural economic development (Murdoch 2000; Newman and Dale 2005) and sustainable agricultural production (Lockie 2006; Lubell and Fulton 2007). Social network analysis provides analytical tools to make patterns of interaction visible and to assess certain aspects of social complexity. This scoping study explored actor networks relevant for the water-energy-food nexus in the Upper Blue Nile using a range of social network methods.

1.2 Research objectives and questions

The main objective of this study was to map existing actor networks and discuss their interplay with other, relevant stakeholders who are influencing the water-energy-food nexus.

With reference to the Blue Nile river system, Ethiopia, the research was guided by the following research questions:

1. How do actors from different sectors and scales relate to each other and coordinate their activities?

2. What systemic interventions could facilitate transformations toward more sustainable land, water and ecosystem governance based on existing actor networks?

The project built on an existing, unique, quantitative social network data set of 85 organizations, including government, private sector and civil society actors, that are relevant for the water-energy-food nexus in the Upper Blue Nile (Stein and Barron 2012; Stein 2013). In order to better understand the interplay between actors and network dynamics at specific junctures (e.g., critical cross-sectorial interactions), qualitative data on the meaning of network relations, which reflects the perceptions of key actors embedded in the networks, were collected. Visual network maps were used as narrative-generating tools and as boundary objects helping to facilitate the conversations in focus group discussions. By using visual, participatory network-mapping methods, we could explore cross-sectorial coordination among the organizations relevant for the nexus.

The paper is structured in the following way: A description of key development policies in Ethiopia is followed by an account of how these policies shape the water-energy-food nexus in the Upper Blue Nile. Experiences from the Tana Beles Growth Corridor (TBGC) serves to illustrate how national policies have been implemented at basin and landscape scale. This is followed by a description of the concepts and methods used in this study. The results and discussion are organized around three key nexus challenges: sustainable energy management and use; agricultural water management linkages; and ecosystems as an integral element of the wider water-energy-food nexus. We conclude with some general remarks on the governance dimension of the water-energy-food nexus and reflections on how a network approach can contribute to assessing the social dimension of the complex actor constellations that characterize this nexus.

2. DESCRIPTION OF THE STUDY AREA AND POLICY SETTING

2.1 Ethiopia: General context and key policies

Ethiopia is one of the fastest growing economies in Africa, yet despite considerable progress, it is still one of poorest and most vulnerable countries in the region. With more than 80 million inhabitants, Ethiopia is the second most populous country in Africa, and the country is projected to have more than 120 million people by 2030. Population growth increases the pressure on the land and natural resources that are the bases of Ethiopia's economy. Agricultural production, which is dominated by smallholder farming systems and rain-fed agriculture, employs about 80% of the population and account for more than 40% of the gross domestic product (World Bank 2006). As a consequence, Ethiopia's economy and people's livelihoods are still intricately linked to agriculture and natural resources. The government of Ethiopia aims to reduce poverty, accelerate economic development and achieve middle-income status by 2025. To this end, the government has developed two policy instruments: the Growth and Transformation Plan (GTP) and the Climate Resilient Green Economy (CRGE) strategy.

The Growth and Transformation Plan (GTP) is a five-year strategy that lays out development and industrialization targets from 2010 through 2015. The plan was developed to achieve accelerated economic growth and to meet the Millennium Development Goals in 2015. According to the GTP, agricultural development will remain the basis for economic growth. This growth is expected to increase income for farmers, to ensure food security for the growing population and to boost the export of agricultural products. In order to increase the productivity of available resources, such as land and water, due attention is given to the use of improved technology and the expansion of irrigation schemes. Based on the federal GTP, all administrative levels in Ethiopia develop their own GTP, taking into account the specific local contexts.

The second policy instrument, the Climate Resilient Green Economy (CRGE), is a strategic framework developed to protect the country from adverse effects of climate change and to support the development of a green economy. To

this end, the government of Ethiopia seeks to use emerging climate finance schemes to exchange greenhouse gas (GHG) emission reductions for funds that can be invested into building a green economy and achieving the GTP. The CRGE initiative is based on four pillars: (i) improving crop and livestock production practices, (ii) protecting forests and reforestation, (iii) expanding electricity generation from renewable sources and (iv) leapfrogging to modern and energy-efficient technologies. In addition to the reduction of GHG emissions (i.e., mitigation), the CRGE aims to increase the resilience of the most vulnerable sectors of the economy (including agriculture, water and energy) to climate change (i.e., adaptation).

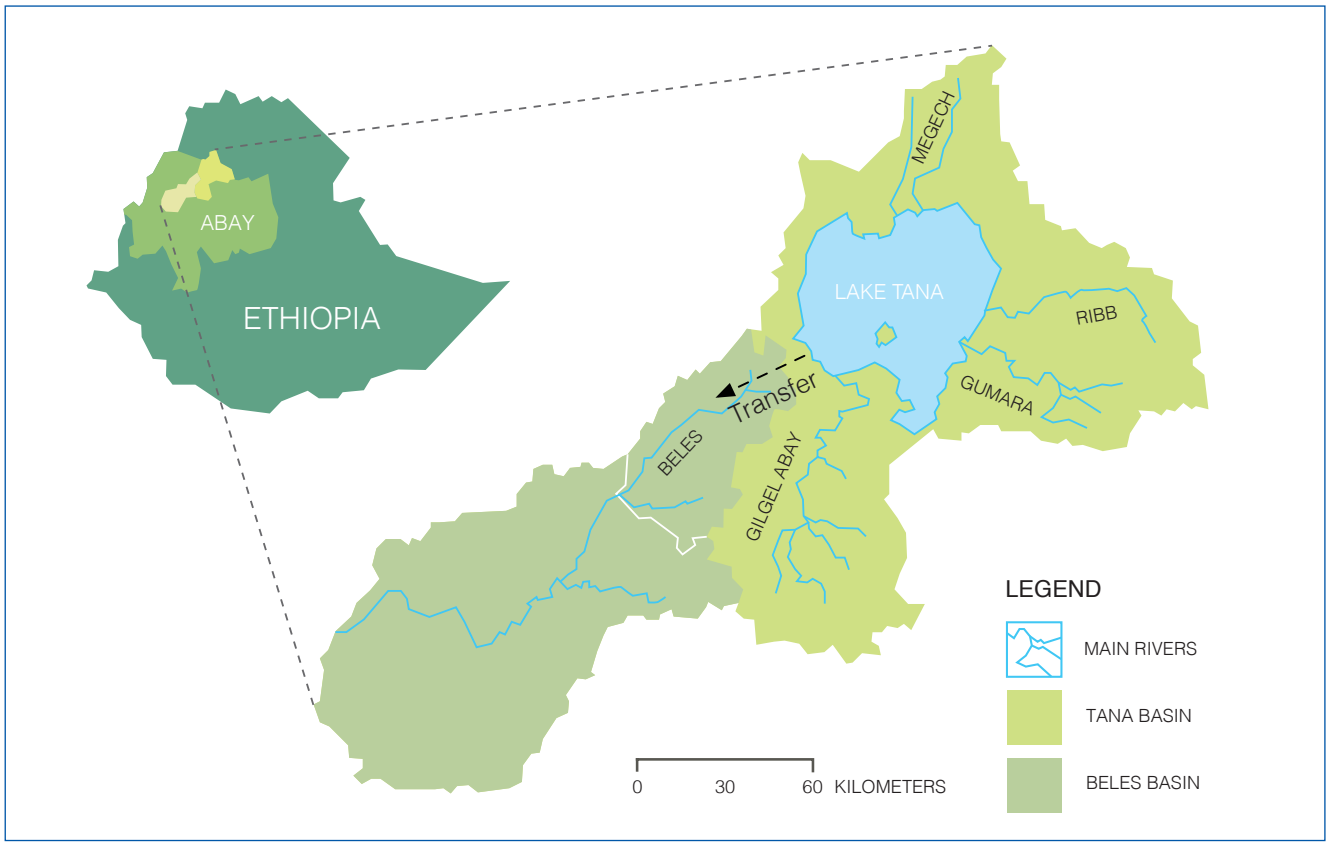
2.2 The Blue Nile (Abay) and the Tana and Beles subbasins

One element of the national development strategy is the creation of growth corridors with a high potential to contribute to the GTP. Within the Blue Nile basin, the Tana and Beles Growth Corridor (TBGC) has been identified as an area with a substantial potential for irrigation and hydropower development. Figure 2 shows the Tana and Beles subbasins, situated in the upper Blue Nile.

The government of Ethiopia has started an ambitious program to develop large-scale irrigation schemes. In the Tana basin, dams are being planned or constructed on all four major rivers—the Megech, Ribb, Gumara and the Gilgel Abbay—which together contribute around 93% of the inflow to Lake Tana (Kebede et al. 2006). The main purpose of the dams is irrigation, but most of them serve multiple purposes, including flood mitigation, water supply and the regulation of water levels for hydropower production.

Rapid population growth has led to severe land shortage, and the removal of forests for fuel and construction purposes has resulted in natural resource degradation, especially in the highlands of the Tana basin. Since harvested trees are not replaced and, thus, expose the soil, fertile topsoils are washed away into rivers and lakes. Lake Tana itself is the largest lake in Ethiopia and an important ecosystem that provides habitat and breeding grounds for birds and fish. The lake and the surrounding wetlands are important for fisheries, tourism and navigation, and they provide a wide range of ecosystem functions and services. The Blue Nile (Abay) river is the natural outflow of Lake Tana, but since 2010 the Tana-Beles transfer is diverting water from Lake Tana to the Beles basin for hydropower production and irrigation. Lake Tana now acts as a natural reservoir for the 460-megawatt Tana Beles hydropower scheme. After passing through a cascade of turbines for electricity production, the water is planned to irrigate up to 140,000 hectares of sugar cane in the upper and lower Beles basin. The Tana and Beles basins are highly regulated, and additional infrastructure for managing water and land resources for multiple uses is under development to meet demands for water, food and energy.

FIGURE 2. MAP OF THE TANA AND BELES SUBBASINS.



Source: Author's creation

Previous work on polices and institutions in the Upper Blue Nile has identified a lack of linkages and strategic alliances between key actors as one of the major challenges for improved land and water management (Hagos et al. 2011; Haileslassie 2008). Hagos and colleagues (2011) found that institutional objectives and arrangements are fairly well defined in Ethiopia, but that inter-sectorial coordination among actors in the Tana and Beles basins was poor. Merry and Gebreselassie (2011) stressed the need for strengthening partnerships that build on existing institutional arrangements. While previous research has considered institutional networks in a metaphorical sense, it has not used network analysis to explicitly map the relationships between actors, neither has it taken a nexus perspective to consider institutional linkages pertaining to energy issues. In this scoping study, we used participatory network mapping in collaboration with stakeholders to visualize and explore actor linkages from a nexus perspective.

3. CONCEPTS AND METHODS

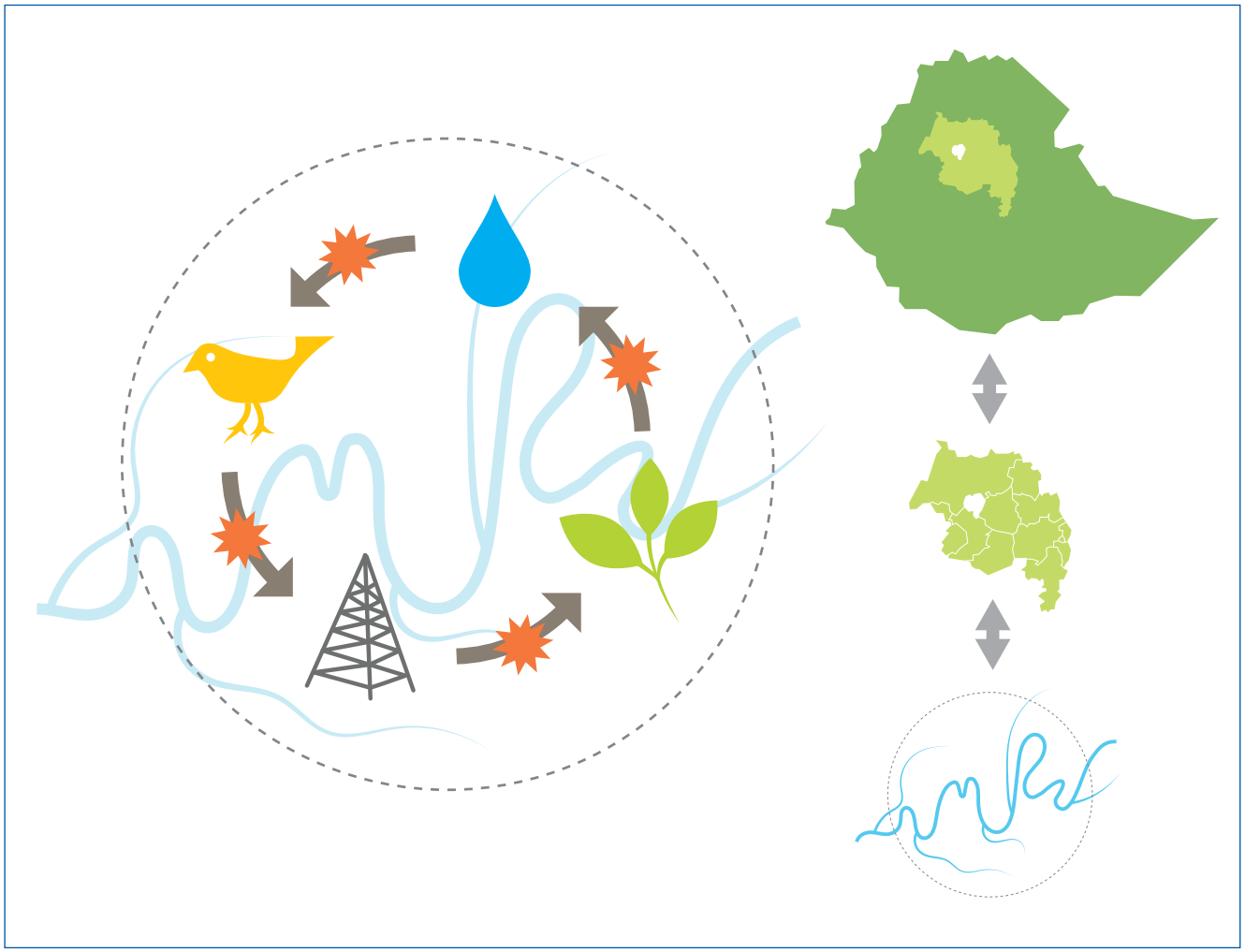
3.1 Institutional interplay

Managing natural resources involves a range of actors, who are pursuing sometimes independent, but often interdependent, goals. Through their activities, farmers, government agencies, basin organizations, non-government organizations and donors influence not only the biophysical landscape but, importantly, also each other. In this report, we use the concept of institutional interplay as a way to conceptualize how different institutions and associated actors interact across sectors and scales. Basically, *"interplay occurs when the operation of one set of institutional arrangements affects the results of another or others"* (Young et al. 2008). Understanding the organizational arrangements in which interplay occurs and the linkages between actors is an important prerequisite to improving the coordination among diverse actors relevant for the water-energy-food nexus. Based on an understanding of existing arrangements, actors can forge strategic links between institutions to pursue individual or collective goals (Young 2002). An analytical distinction can be made between horizontal (i.e., at the same scale or level) and vertical (i.e., across scales) interplay (see Figure 3).

3.2 A network perspective

A social network perspective is based on the assumption that the relationships among interacting units are important. The core analytical unit is neither the whole 'system', nor

FIGURE 3. HORIZONTAL INTERPLAY (LEFT) AND VERTICAL INTERPLAY (RIGHT).



Source: Adapted from Moss 2003

individual 'parts', but rather the 'relation between parts'. Considering that nexus challenges involve a range of actors that are socially and/or biophysically interdependent, a network perspective provides a set of promising conceptual and methodological approaches to explore nexus issues. For example, the key premise of policy network theory, the need for coordination among a plurality of interdependent actors, is highly relevant for addressing nexus challenges, considering that coordination is at the heart of nexus applications.

3.3 Social network analysis

Social network analysis is a well-established methodology in the social sciences that provides a range of tools to analyze the relationships among social entities and the patterns and implications of these relationships (Wasserman and Faust 1994). A social network can be defined as a set of ties between a defined set of actors. Actors can be individual people, households, organizations, groups or other collectives. The relationship can be kinship, the flow of resources, communication or any other relation between two interacting actors.

A network perspective has been applied across a range of disciplines and in diverse ways. Formal approaches allow the systematic collection and quantitative analysis of large data sets using mathematics. Qualitative approaches focus less on structural information but are useful to answer questions about the meaning of networks and about how they change over time. They can also be used to validate or complement quantitative data.

In this scoping study, we used qualitative approaches to complement and address the limitations of an existing, formal network study. By combining qualitative and quantitative network approaches, complementary insights can be gained. Table 1 summarizes the three types of analytical network approaches relevant for this study. Below we will briefly outline the key features of the formal network study that informed this project and then describe the visual network mapping methods employed during this scoping study.

3.4 The preceding quantitative social network study

In a previous study, we interviewed representatives from 85 organizations about their relationships to other organizations pertaining to water, agriculture, energy and ecosystem management issues in the Tana and Beles subbasins. To generate the network data, we asked respondents about which organization they regularly collaborate or coordinate activities with. Interactions could be formal or informal but should be reoccurring institutionalized relations. The results were gathered into four social network data sets. The networks include governmental organizations, non-government organizations, universities, parastatal companies and bilateral development organizations from different sectors and levels of government (federal, regional and local). Figure 4 shows the four networks of collaborative relations concerning water, agriculture, energy and ecosystem management. Each actor is represented by circles, or 'nodes', and the size of the node indicates how many direct relations the actor has in the respective issue network. The quantitative analysis of the multiplex networks facilitated the identification of key actors (e.g., actors that are central in the sense that they have many connections to others) as well as critical junctures (e.g., points of interaction between actors from different nexus domains) to be further explored in this scoping study by using participatory network mapping methods.

3.5 Visual, participatory network mapping

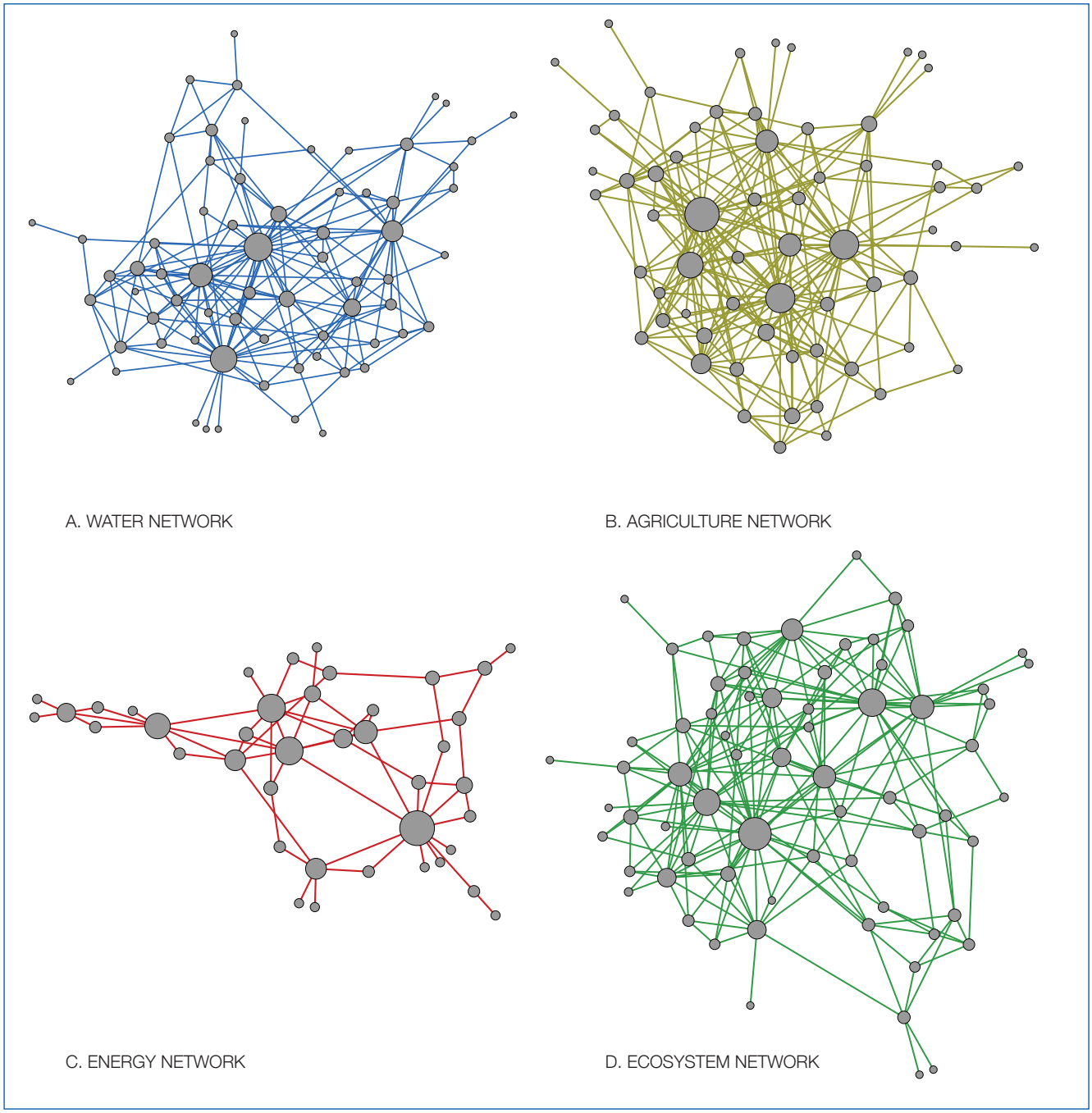
In this scoping study we used qualitative and visual network research approaches to map existing actor networks and to discuss how the interplay among key stakeholders influences the water-energy-food nexus in the Upper Blue Nile. This included exploring how nexus challenges are interconnected from the perspective of relevant stakeholders and how key actors are embedded in networks of social relations. Data collection, analysis and visualization involved participatory modeling tools that allowed instant visualization, discussion and documentation of social network data. Network maps drawn by research participants were used as a means to facilitate discussion and joint learning.

TABLE 1. DIFFERENT METHODS FOR SOCIAL NETWORK RESEARCH AND THEIR APPLICATION IN THE STUDY.

	QUANTITATIVE	QUALITATIVE, PARTICIPATORY NETWORK MAPPING	
	Formal network analysis	Ego networks	Net-Map
Main focus	Systematic measurement and quantitative analysis of relations among many actors using statistics	Understanding how a person or organization (i.e. ego) is embedded in its social environment	Exploration and description of network structure and explanation of system behavior
Purpose in study	Identification of key actors and community structures in the four issue networks (see Figure 3)	Understanding the support network of key actors and their relations across different nexus domains (see Figure 4)	Joint learning and identification of challenges and potential interventions (see Figure 5)

Source: Adapted from Fuhse and Mützel 2011

FIGURE 4. NETWORKS RELATING TO (A) WATER, (B) AGRICULTURE, (C) ENERGY AND (D) ECOSYSTEM ISSUES IN THE TANA AND BELES SUBBASINS.



Source: Author's creation

For the data collection, we used qualitative, egocentered network analysis in combination with the Net-Map[1] tool for network and influence mapping. Ego networks were used to gain a detailed understanding of the networks of implementation agencies from the water, energy, agriculture and environment domains. Net-Map was used in a stakeholder consultation workshop to map the multistakeholder networks relevant for specific development challenges identified during the scoping study. While relational (i.e., network) data were generated during the mapping exercises, the main objective was to generate narratives about the interplay among actors and discuss their implications with research participants.

3.6 Ego networks

When studying ego networks, the main interest is to understand how a person or organization (i.e., ego) is embedded in its social environment. An ego network consists of a focal node ("ego"), together with the nodes they are directly connected to (termed "alters") plus the ties, if any, among the alters. These networks are also know as personal networks or ego-centric networks (Borgatti and Halgin 2011). The method allows for mapping of the ego's personal network from a subjective point of view and for discussing opportunities and constraints associated with how and where the ego is embedded in a specific actor constellation.

[1] See also http://netmap.wordpress.com

In this study, the main purpose of the ego network maps was to understand with whom key actors (i.e., ego) interact, whom they perceive to be important for their work, in what nexus domains their interactions take place and which relationships facilitate or constrain coordination across the different nexus domains. To this end, we conducted focus group discussions with two to three representatives from organizations at regional and woreda[2] or district level.

Government agencies at regional and local level that are responsible for the implementation of key policies (e.g., GTP) and that come from different nexus domains (water, energy, agriculture or environment) were selected for a detailed ego network mapping. Most of them had also been identified as central actors in our previous quantitative network analysis (Stein and Barron 2012). Table 1 in the annex lists the organizations that participated in the ego network mapping. Figure 5 shows the template map that was used in the focus group discussion and illustrates how participants used it for drawing the ego network of their organization.

Three relationships have been mapped: funding, information and collaboration. In addition, collaborative relationships that need to be strengthened to facilitate cross-sectorial integration have been identified. After being drawn on paper, the maps were digitalized with the VennMaker[3] software to store the network data as a basis for further processing and analysis.

3.7 Net-Map

Net-Map is an interview-based mapping tool that helps people understand, visualize, discuss and improve situations in which many different actors influence outcomes (Schiffer and Hauck 2010). Net-Map was used to complement the ego networks by bringing together a diverse range of stakeholders, including those that took part in the ego network data collection, to discuss specific issues that emerged as key nexus challenges during the study.

Net-Map was used in a stakeholder consultation workshop in Bahir Dar, which is the regional capital and base of most of the stakeholders consulted. Participants discussed and then voted for what they perceived as pressing nexus challenges for the Tana and Beles basins. Each of the two maps created with the Net-Map method was drawn by eight to ten workshop participants, with the help of two facilitators. Participants came mainly from the regional bureaus responsible for the implementation of sectorial policies, but also included local research organizations, the responsible river basin organizations and non-government organizations. The intention was to bring together a diverse group of actors to jointly map the current state of collaboration patterns regarding concrete nexus challenges. After identifying who is involved and who influences the issue, participants discussed bottlenecks in the existing networks as well as changes necessary to improve the situation. For a detailed description of the Net-Map method see Hauck and Schiffer, (2012); Schiffer and Hauck (2010); Schiffer and Waale (2008). Figure 6 shows participants working on and discussing during a Net-Map exercise. See Table 2 in the annex for a complete list of organizations that participated in the workshop.

4. RESULTS AND DISCUSSION

The following section presents the findings that emerged from network mappings and focus group discussions. We have organized the discussion around three crosscutting nexus challenges that are faced by actors in the Tala and

FIGURE 5. EGOCENTERED NETWORK MAP AND PARTICIPANTS DURING A FOCUS GROUP DISCUSSION.

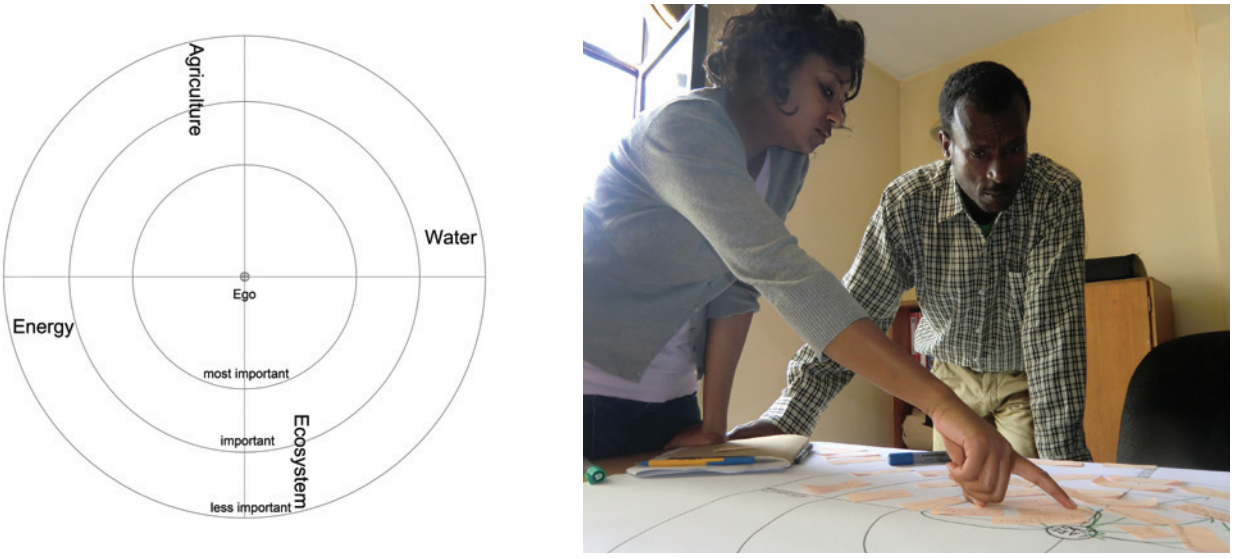


Photo: C. Stein

[2] Woredas or districts are the smallest government administrative unit for planning, budgeting and implementation. They are composed of a number of wards (kebele) or neighborhood associations.
[3] http://www.vennmaker.com/

FIGURE 6. PARTICIPANTS DRAWING AND DISCUSSING DURING A NET-MAP EXERCISE IN A CONSULTATION WORKSHOP.

Photo: C. Stein

Beles basins: First, we address energy management and use. Second, we focus on agricultural water management linkages. Third, we explore ecosystems as an integral part of the nexus. The three challenges take a specific nexus domain (i.e., water, food, energy or environment) as a starting point, but consider a range of interdependent issues that are relevant with regards to cross-sectorial interactions. The findings should not be considered conclusive, but they illustrate how participatory network mapping can reveal patterns of interaction among relevant actors as well as nexus challenges from the perspective of diverse stakeholders.

4.1 Sustainable energy management and use

The Ministry of Water, Irrigation and Energy (MoWIE) is the main actor responsible for the energy sector in Ethiopia. The MoWIE and the Ethiopian Electric Power Cooperation (EEPCO) manage hydropower at the federal level. There are various departments within the MoWIE and respective line agencies at lower levels that deal with different energy issues, including 'traditional' (e.g., wood fuel) and 'modern' energy sources (e.g., wind and solar) as well as energy efficiency (e.g., energy-efficient cook stoves). The line agencies under the MoWIE, the water resources development offices, deal with household energy at the local level. A notable exception is the Water Resources Development Bureau (BoWRD) at the regional level, which does not work on energy issues. At the regional level, the Mines and Energy Agency (MEA) is fulfilling this role. Aside from government offices, there are also a number of non-state actors, including international donors, non-government organizations and the private sector, that work on sustainable energy access for rural households.

Most actors dealing with household energy issues focus on technological solutions, such as the distribution of energy-efficient cook stoves and the promotion of alternative 'modern' energy sources, such as biogas and solar. Interviewees working on energy issues mentioned that the out scaling and wider adoption of new technologies and alternative energy sources remains a challenge as farmers are not aware of such alternative technologies, lack the financial resources needed to acquire them, or both. While household energy needs and hydropower production are intimately linked, they are addressed by different actors, in different sectors and at different scales. Furthermore, it seems that the development and management of hydropower schemes is relatively detached from local planning and management (i.e., few linkages to regional or local institutions exist).

Although more than 90% of the rural population depends on biomass for their energy needs (e.g., on wood fuel, charcoal, dung and crop residuals), management of the supply side of biomass appears institutionally weak. Considering that energy security is intricately linked to all other nexus dimensions, the institutional setup appears rather fragmented. There is no apparent strategy or actor that addresses biomass as an energy resource in a holistic way. Different actors deal with the sources of traditional biomass energy (i.e., agriculture and ecosystems), impacts from wood fuel demand (e.g., deforestation) and the promotion of alternative energy sources (e.g., biogas). The Bureau of Agriculture and Rural Development (BoARD) promotes the planting of trees and the protection of natural forests. But despite millions of trees being planted, interviewees at woreda or district level pointed out that the success of such efforts, in terms of the regeneration of natural forests, has been limited. Partly this has been attributed to reforestation sometimes being part of mass mobilizations led by the government and local communities not feeling ownership or the need to nurture seedlings (see also Ludi et al. 2013). Whilst it was pointed out that afforestation of natural forests has been limited, the planting of Eucalyptus trees by farmers for fuel wood and construction is expanding. This contributes to afforestation, but it comes at the cost of crop production if farmers plant Eucalyptus trees on their scarce fertile land. Individual households and the informal sector have not been

investigated explicitly but seem to play an important role for the production, harvesting and marketing of biomass energy resources (e.g., charcoal and fuel wood). It was also mentioned that the sources and flows of biomass as well as the associated value chains need to be better understood in order to manage traditional energy resources more effectively.

No particular Net-Map exercise was made on energy issues, but the one created on agricultural water management and ecosystem management (see details below) highlighted actors from the energy domain (e.g., EEPCO, MoWIE and the Mines and Energy Agency) as influential for agricultural water management and ecosystem management, indicating interdependencies between institutions from the energy domain and the other dimensions of the nexus.

Networks of key actors (ego networks) of the energy domain showed fewer relationships when compared to similar maps of organizations that work on water and environment issues. This result confirms finding from the previous study, which analyzed interactions quantitatively (Stein and Barron 2012) (see Figure 4). While the quantity of interactions in each nexus domain does not allow for drawing conclusions about the quality of the institutional interplay or the outcomes thereof, it suggests that more frequent and perhaps more institutionalized interactions are taking place in some domains compared to others, and it could indicate that less attention is given to energy issues. While highlighting a number of challenges in the energy domain, the ego networks also showed that existing institutional relationships span across sectors and scales. These relationships open up important opportunities for addressing the challenges associated with sustainable energy provision and use.

Key research findings

- Biomass energy resources, the main source of energy for rural communities, are intricately linked to the other nexus dimensions, especially agricultural production and environment. Existing institutional arrangements do not adequately reflect the central role of biomass-based energy resources for local communities. The development of the energy sector is focused on centrally planned hydropower projects and technological solutions (e.g., efficient cook stoves and biogas).
- Efforts to improve energy access and security would benefit from more diverse approaches that reflect the synergetic requirements for developing both traditional and modern energy sources while taking into account both the needs of rural communities and policy ambitions at the national level.

Emerging research priorities

- Identifying energy sources and technologies that complement existing farming systems and livelihood strategies, based on an understanding of local contexts and people's needs, to enable a wider diffusion of appropriate and desirable technological solutions.
- Achieving a better understanding of biophysical and institutional linkages relevant for the sustainable management of energy sources (e.g., biomass and hydropower) and identifying potential synergies between immediate energy needs for rural communities (e.g., biomass) and hydropower for national development ambitions.

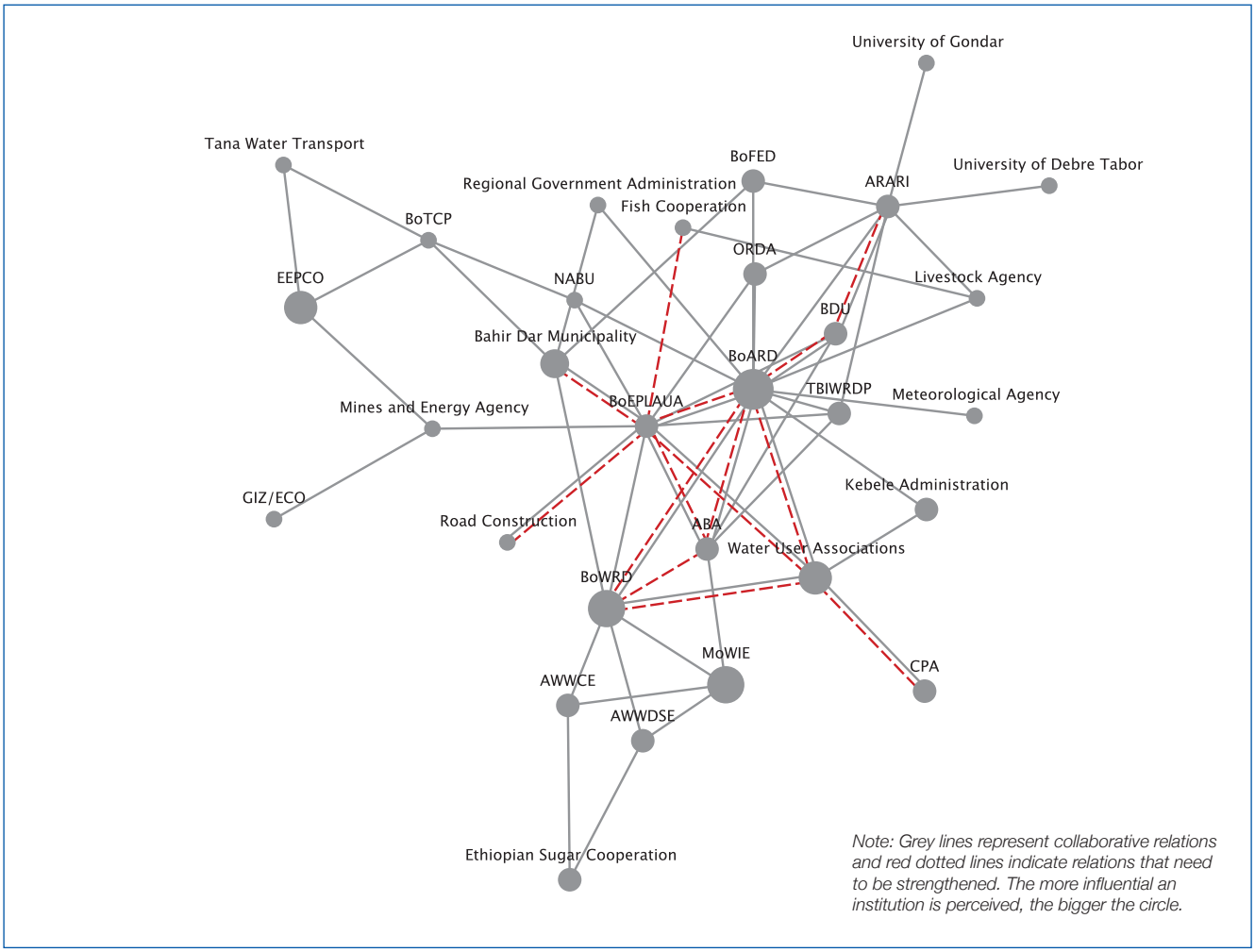
4.2 Agricultural water management linkages

The Net-Map exercise on agricultural water management highlighted key actors influencing agricultural water management and led to the identification of relationships and actors in need of further support and strengthening. Figure 7 shows the network of influential actors in agricultural water management in the Tana and Beles subbasins, as drawn by the participants of the workshop.

The linkages between the most influential actors can be summarized in the following way: While the Bureau of Water Resources Development (BoWRD) is responsible for small-scale irrigation (up to 200 ha), the MoWIE is responsible for large- and medium-scale irrigation. The Bureau of Agriculture and Rural Development (BoARD) takes over responsibility of an irrigation system after the secondary or tertiary canal and deals with the agronomic part. The Cooperatives Promotion Agency (CPA) organizes water user associations (WUAs), e.g., by facilitating the drafting of bylaws and collection of fees. In general, the MoWIE is responsible for large-scale irrigation and the Ministry of Agriculture and Rural Development (MoARD) for small-scale irrigation, but at regional level both the BoWRD and the BoARD can work on the same irrigation scheme, addressing different but interdependent aspects. For example, studies are being carried out by one actor, but implemented by another. At the local level, individual water offices focus on domestic water supply and agricultural offices deal with everything related to agricultural water management.

As can be seen in Figure 7, some of the most influential organizations identified through the Net-Map exercise are also the ones with relationships that participants considered to be in need of improvement. With regards to irrigation management, this applies to both vertical linkages (i.e., between local, subnational and national scales) and horizontal linkages (i.e., between sectors). Since the responsibility for planning, construction, operation and maintenance of irrigation schemes is distributed across different actors, sectors and scales, there is a risk that work is being duplicated, not done effectively, or both. As one interviewee pointed out, *"The problem is that sometimes taking over of the scheme is not done at the right time, and stakeholders are not sure who is in charge. […] This needs some mechanism to be solved."* Recently established river basin organizations create new opportunities—but also challenges—for the integrated management of water and related natural resources. During the ego network and Net-Map exercises it became evident that the interplay between the regional bureaus and the

FIGURE 7. NETWORK OF ACTORS INFLUENCING AGRICULTURAL WATER MANAGEMENT.



Source: Author's creation based on Net-Map exercise in Bahir Dar, December 2013

river basin organizations was not entirely clear. As the Abay Basin Authority (ABA) is going to take over some of the mandates from the regional bureaus (e.g., issuing of water permits), the roles and responsibilities of ABA in relation to the various bureaus requires further clarification. Coordination mechanisms should be strengthened. As the following quote from an expert at the Bureau of Water Resources Development illustrates, there is also a need to reconcile political and hydrological boundaries: *"Actually the structure for the river basin organization and the water bureau is the same […] they plan to the basin, this office plans to the region."*

In order to identify key actors for agricultural water management, we calculated the degree centrality (i.e., number of direct links to others) for all actors in the agricultural water management network and compared the results with the perceived influence of actors. The most striking discrepancy between the quantitative network measure and the participants' perception was with regards to the Environmental Protection, Land Administration and Use Authority (EPLAUA) and the Ethiopian Electric Power Cooperation (EEPCO). While EPLAUA is the second most central actor according to the number of relations (i.e., degree centrality) after the Bureau of Agriculture, it is not perceived as particularly influential in the Net-Map. In the discussion on how to improve the existing system, EPLAUA and the ABA have been identified as critical actors that need to be strengthened in order to improve agricultural water management in the Tana and Beles basins in the future.

With regard to vertical interactions across scales, it was pointed out in one of the ego network discussions that the relationships between the Bureau of Agriculture, research institutions (e.g., Amhara Agricultural Research Institute and Bahir Dar University), extension services and farmers are critical and should be strengthened further. As one interviewee put it, *"There are no strong links between extension, research and farmers [and as a consequence] the amount of research that goes into the ground is very low."* This was also evident in the Net-Map exercise, which highlighted the need to improve the relations between WUAs and key actors at the regional level, such as BoARD, BoWRD, CPA and EPLAUA. It is important to note that institutional issues concerning rain-fed agriculture and livestock systems did not receive the same amount of attention in the mapping processes as irrigation, despite their importance in local farming systems. What kinds of institutional arrangements are relevant for rain-fed agriculture at local and landscape level did not become evident from the discussions and should be explored further.

Key research findings

- The responsibility for agricultural water management moves between sectors and scales. As a result the institutional arrangements have both gaps and overlaps (i.e., institutional fragmentation and redundancies). To improve agricultural water management, coordination mechanisms should be strengthened (e.g., through multistakeholder platforms), and the roles and responsibilities of the different actors should be clarified.

Emerging research priorities

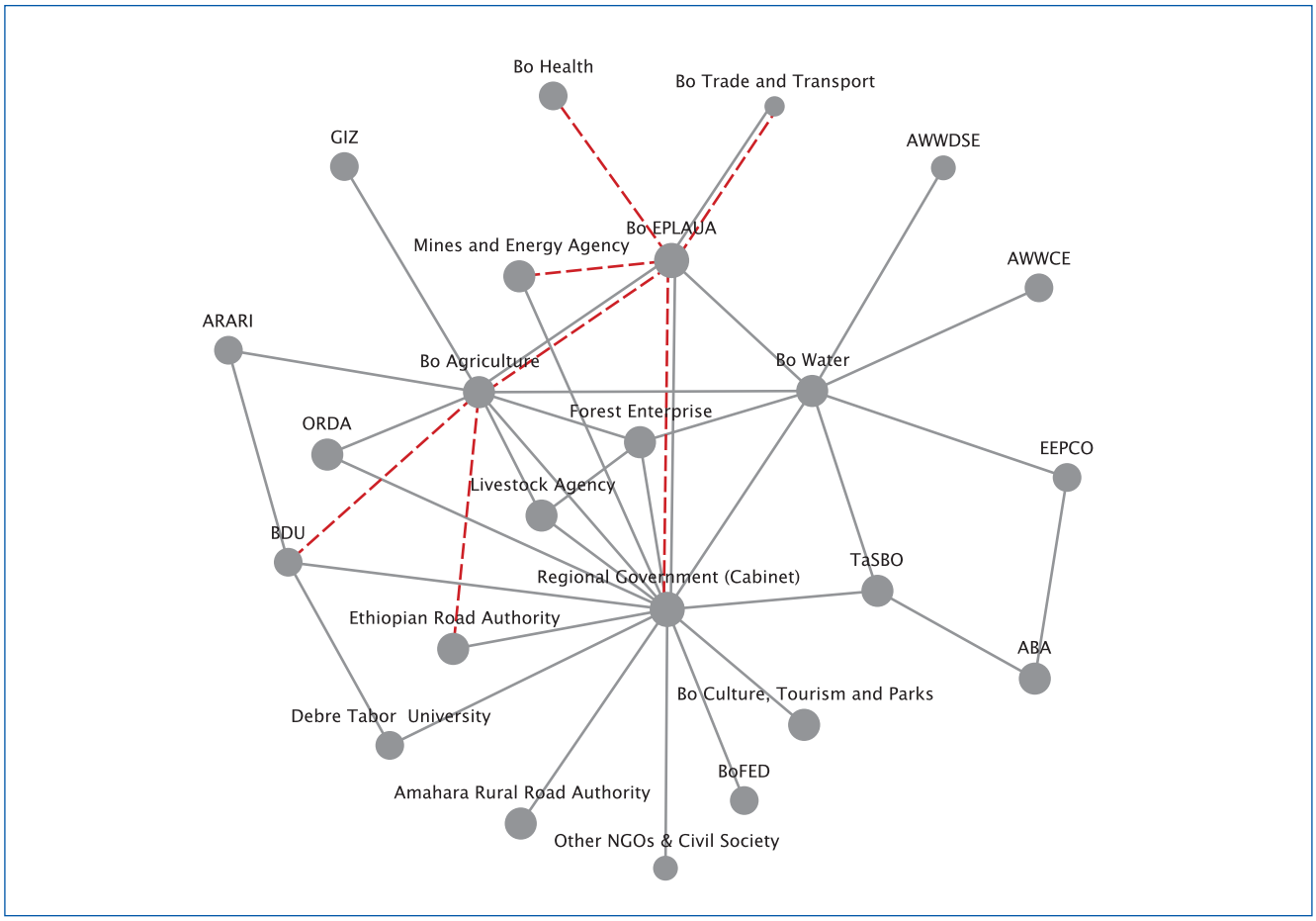
- Performing a detailed mapping of key processes in irrigation development and management to identify opportunities and constraints for the creation of sustainable irrigation links, both within and beyond the domain of agricultural water management.
- Carrying out an analysis of the existing institutional arrangements that are relevant for landscape-based approaches to rainwater management.

4.3 Ecosystems and the nexus

Interviewees from the environmental domain pointed out that environmental issues are perceived as being sidelined. The impression is that environmental issues do not carry the same weight as the other nexus dimensions when trade-offs (perceived or real) between ecosystem conservation and development arise. Against this background, participants of the consultation workshop in Bahir Dar raised questions about how to emphasize the importance of ecosystem management in development planning and how to strengthen the environmental domain in relation to the other nexus dimensions, such as water, agriculture and energy. Therefore, the second Net-Map exercise explored existing bottlenecks and opportunities for ecosystems to become an integral part of development planning (see Figure 8).

In the Net-Map exercise, linkages between actors from the environmental domain and actors from the other nexus domains (water, agriculture and energy) were mentioned frequently as in need of improvement. One reason that was given for the difficulties of mainstreaming (or integrating) the environment into wider decision making was the presence of the competing demands for land and natural resources. The EPLAUA works on both land and environmental conservation issues, and since land is a scarce resource in the basin, environmental concerns can be difficult to balance with other priorities. For example, land designated by EPLAUA for environmental conservation is being requested by other actors for the development of roads, mining projects and expansion of agricultural activities. EPLAUA is also responsible for environmental impact assessments (EIA), which have been seen as conflicting with the development objectives of other actors.

FIGURE 8. NETWORK OF ACTORS INFLUENCING ECOSYSTEM MANAGEMENT.



Source: Author's creation based on Net-Map exercise in Bahir Dar, December 2013

Even though regulatory mechanisms like environmental impact assessments (EIA) are in place, interviewees mentioned that environmental issues are given lesser weight when compared to priorities arising from the other dimensions of the nexus and other development agendas. Sometimes environmental regulations are not being enforced effectively due to a lack of influence, dependence on other actors to enforce them, or both.

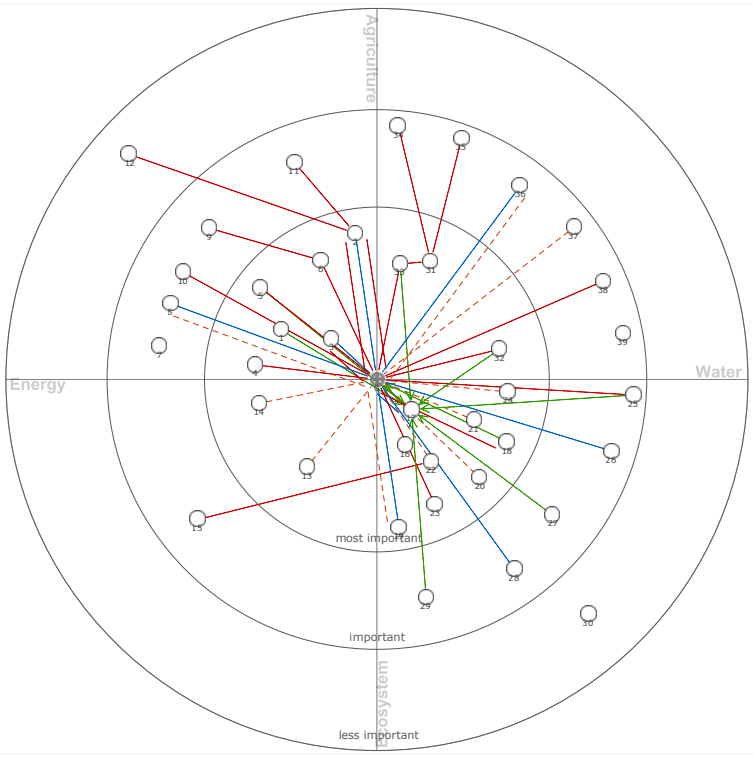
At a number of occasions interviewees expressed the need for research that provides clear evidence for the value of protecting ecosystems and the resulting, concrete benefits for development interventions in water, agriculture and energy. Respondents from the environmental domain pointed out that while evidence on the value of ecosystems for development is needed at all scales, it is important to address policy makers and politicians in a more direct manner in order to catalyze a shift in mindsets. Interviewees pointed out that environmental issues are presently being perceived as a barrier to development, while in fact ecosystems should be seen as providing the basis for such development. As one interviewee stated, *"Environmental protection is considered as a counteract to development by some."*

Both the ego networks and the Net-Map exercises highlighted EPLAUA as an organization with a diverse network that spans across sectorial boundaries. Figure 9 shows the ego network of EPLAUA, illustrating that the environmental bureau has many relations across all four nexus dimensions. However, the dotted lines also indicated that there are numerous linkages that interviewees would like to see improved.

Besides scientific evidence highlighting the benefits of ecosystems for development, political backing was repeatedly mentioned as an important prerequisite for strengthening the environmental dimension in the nexus. As one workshop participant commented, *"There is a hidden problem and that is politics. Political backing is very critical."* This was also evident in the Net-Map exercise on ecosystems where the regional government (cabinet) and the EPLAUA emerged as the most influential actors. When calculating degree centrality for the actors in the map on ecosystems, the central role of the regional government becomes even more evident, pointing to the importance of political support for the sustainable management of the water-energy-food nexus.

Some interviewees suggested that the establishment of a new Ministry of Environment and Forestry might help to strengthen the role of EPLAUA and other institutions working on environmental issues. The government's Climate Resilient Green Economy (CRGE) policy also provides a strategic framework for incorporating ecosystems management into

FIGURE 9. EGO NETWORK OF THE ENVIRONMENTAL PROTECTION, LAND ADMINISTRATION AND USE AUTHORITY.



Note: Green lines represent funding flows and blue lines information flows. Red lines are collaborative relations, and red dotted lines are relations that need to be strengthened.

Source: Author's creation based on egocentered network map of EPLAUA, November 2013

development planning, but in contrast to the Growth and Transformation Plan (GTP), the CRGE was not mentioned frequently during the focus group discussions, suggesting that its actual impact might yet be limited at local and regional levels so far.

Key research findings

- Actors working on environmental sustainability occupy central positions in many networks analyzed for this study, but they are often considered less influential compared to actors from the other sectors. When trade-offs between environmental conservation and other development objectives arise, environmental sustainability tends to lose out.

Emerging research priorities

- Making available evidence on the value of ecosystems for development so that decision makers and communities can consider the full range of development options.
- Developing frameworks and tools that allow for incorporating ecosystem functions and services in development planning and nexus analysis.
- Conducting research on innovative cost- and benefit-sharing mechanisms that reflect local contexts and peoples' needs to support decision makers in their assessments of different development options and their impacts.

5. REFLECTIONS AND CONCLUDING REMARKS

This scoping study explored interconnected water-energy-food nexus challenges in the Upper Blue Nile in Ethiopia from a network perspective. Participatory network mapping and focus group discussions were used in order to reveal which actors influence the water-energy-food nexus and to deliberate concrete nexus challenges.

The government of Ethiopia has adopted a range of ambitious development policies, but there are a number of challenges related to the effective coordination between actors and the implementation of these policies. We expected to find gaps (e.g., sectorial divisions) in the institutional setup, but many challenges in the Tana and Beles subbasins relate to institutional overlaps (e.g., in agricultural water management) and the lack of effective coordination mechanisms. There are also issues that should receive more attention, e.g., the role of traditional energy and ecosystems, in the context of the nexus. However, improving the institutional interplay among key actors in the nexus is not simply a technical matter. The key challenge for the nexus is governance, i.e., how to facilitate processes of institutional coordination and, importantly, who decides what issues are addressed when and, above all, how.

Addressing these issues requires significant changes in the governance of the nexus, starting with the ways in which processes of institutional coordination are facilitated so that the division of responsibilities and decision-making powers can become more clear. Establishing and maintaining multistakeholder coordination processes requires sufficient resources, skilled facilitators, time and political support for the implementation. Importantly, the necessary changes also require a shift in mindsets away from engineering approaches that favor optimization and control toward more diverse and flexible approaches that are grounded in local realties.

In this study, visual participatory network analysis has been an effective tool for making hidden relationships more visible and for allowing stakeholders from different nexus domains to engage in a structured discussion about interdependencies and common issues at stake. The innovative combination of participatory network tools allowed for rapid data collection and joint learning experiences among researchers and research participants. As much as the promise of research outcomes, it has been the research process itself that encouraged participants to reassess their activities and enabled them to better understand their activities in the contexts of the activities of others.

The scoping study reveals that addressing nexus challenges could benefit from

- Applying more diverse approaches to energy access and security that reflect both the important role of traditional biomass energy sources for rural communities along with national ambitions for hydropower development
- Strengthening the evidence base for the values, benefits and trade-offs of ecosystems for development and providing this knowledge to key end users
- Mapping key actors and processes in agricultural water management and supporting responsible actors to identify pathways for more sustainable irrigation and rain-fed livestock development

The research for this scoping study has been carried out in less than four months. Therefore, our contribution to a vast topic as the water-energy-food nexus has to be seen as a pioneering study that is up for scrutiny and requires further investigation. Our ambition was to facilitate and contribute to a structured dialogue with boundary partners around the challenges of the water-energy-food-environment nexus. In this regard the participatory network mapping tools have served the purpose of 'boundary objects' and 'narrative generators' in order to jointly identify relevant development and research challenges.

To reveal specific opportunities and barriers for improving the coordination among relevant actors further research should scrutinize the nexus through a political economy lens. Not all actors have the same resources and hence the capacity to shape interactions, and there are uneven gains from interactions (Adger et al. 2005). Therefore, an analysis of actors and social networks should be complemented by an analysis of the political economy (Allouche et al. 2014)

and institutional processes that underline these collaboration patterns to identify factors working against the changes required.

This study has shown that the institutional landscape of the water-energy-food nexus is just as complex as the biophysical processes it aims to govern. Understanding existing institutional arrangements and the linkages between them is a crucial prerequisite to move towards more sustainable management of natural resources for development in the Upper Blue Nile. Operationalizing the nexus approach requires analytical frameworks that capture the multidimensional linkages between actors engaged in or affected by the management of water and land resources for multiple uses to meet demands for food, energy and ecosystem services. A network approach provides some powerful conceptual and methodological ways to understand actor networks, but also to support the engagement of stakeholders in joint learning processes, improved planning and more effective implementation. In this regard, the field of social network analysis provides a range of tools and approaches that could be developed further in order to inform research for development in the Nile basin, and beyond.

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ANNEX

TABLE 1 ORGANIZATIONS PARTICIPATING IN THE EGO NETWORK FOCUS GROUP DISCUSSIONS

NO.	ORGANIZATION NAME	ADMINISTRATIVE LEVEL	LOCATION
1.	Agriculture and Rural Development Bureau	Regional	Bahir Dar
2.	Environmental Protection, Land Administration and Use Authority	Regional	Bahir Dar
3.	Mines and Energy Agency	Regional	Bahir Dar
4.	Water Resources Development Bureau	Regional	Bahir Dar
5.	Agricultural Development Office	Woreda/District	Libo Kemkem
6.	Water Resources Development Office	Woreda/District	Libo Kemkem
7.	Environmental Protection, Land Administration and Use Office	Woreda/District	Libo Kemkem

TABLE 2 ORGANIZATIONS PARTICIPATING IN THE STAKEHOLDER CONSULTATION WORKSHOP

NO.	ORGANIZATION	ABBREVIATION
1.	Abay Basin Authority	ABA
2.	Amhara Regional Agricultural Research Institute	ARARI
3.	Bahir Dar University	BDU
4.	Bureau of Agriculture and Rural Development	BoARD
5.	Bureau of Water Resources Development	BoWRD
6.	Environmental Protection, Land Administration and Use Authority	EPLAUA
7.	GIZ Energy Coordination Office	GIZ
8.	MetaMeta	MetMeta
9.	Mines and Energy Agency	MEA
10.	Nature and Biodiversity Conservation Union	Nabu
11.	Research-inspired Policy and Practice Learning in Ethiopia and the Nile region	RiPPLE
12.	Stockholm Environment Institute	SEI
13.	Tana Beles Integrated Water Resources Development Project	TBIWRDP
14.	Tana sub-Basin Organization	TsBO

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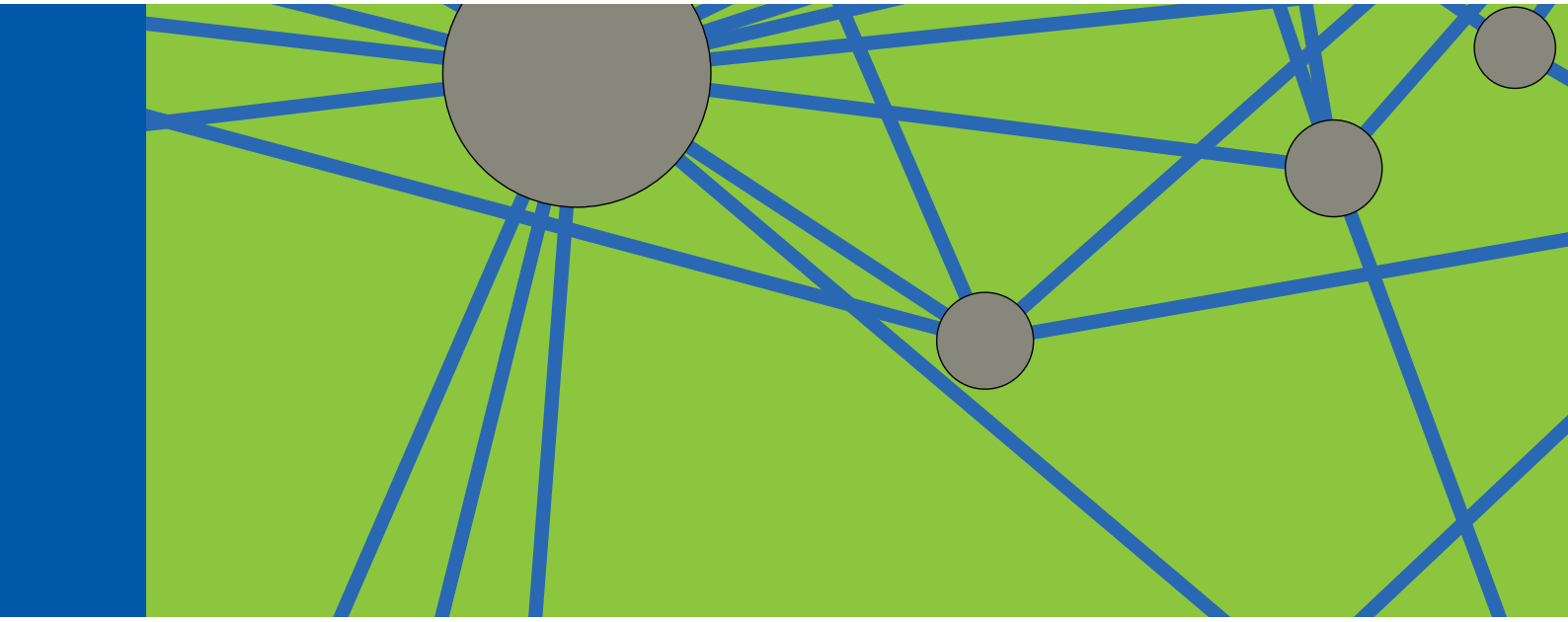

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