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Transboundary Water Resources for People and Nature: Challenges and Opportunities in the Olifants River Basin

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Transboundary Water Resources for People and Nature

Challenges and Opportunities in the Olifants River Basin

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Abstract

This paper proposes that transboundary water governance needs to become an essential input to sustainable governance of protected natural reserves. The paper reviews the challenges and opportunities for such governance mechanisms, and identifies the factors behind successful practices. Successful transboundary governance of water and nature requires the reduction of associated transaction costs. Firstly, water diplomacy through joint research, data collection and monitoring, capacity building, dialogues for consensus building, promoting responsible leadership and providing advisory support can help in overcoming mistrust between stakeholders and create opportunities for cooperation. Secondly, power asymmetries may hinder transboundary water governance, therefore, there is a need to involve multi-scale links across stakeholders to counter-balance local power asymmetries and engage all stakeholders in consultations and negotiations. Thirdly, transboundary water governance is critically dependent on accurate and transparent data and analysis tools for informing policy decisions. Science-policy interactions for facilitating transboundary water governance were found to be most effective when the knowledge on joint water and nature governance is co-produced in a trans-disciplinary manner, in collaboration with wide-ranging informal networks of scientists, policy makers, and civil society. Finally, transboundary water governance organizations can serve as platforms for facilitating water diplomacy, building trust and cooperation, especially when they are granted the ability to enter into binding cooperative agreements regardless of external political pressures.

Keywords: Transboundary water and nature governance, game theory, transaction cost, stakeholder analysis, Olifants river basin

JEL codes: O13, Q01, Q25, Q26, Q51, Q52, Q57

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List of Abbreviations

DWA	Department of Water Affairs
ET	Euphrates Tigris
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GLTP	Great Limpopo Trans-frontier Park
IBWC	International Boundary and Water Commission
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
LICOM	Limpopo Watercourse Commission
LRB	Limpopo River Basin
MPRDA	Minerals and Petroleum Resources Development Act
MRB	Mackenzie River Basin
MW	Mega Watt
NGOs	Non-Governmental Organizations
NPB	National Park Board
NWA	National Water Act
PAs	Protected Areas
PES	Payment for Ecosystem Services
PPF	Peace Park Foundation
RBO	River Basin Organization
SADC	Southern Africa Development Community
SANParks	South African National Parks
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
TFCA	Transfrontier Conservation Area
TWG	Transboundary Water Governance
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
USD	United States Dollar

1 Introduction

Efficient and equitable management of transboundary water resources is essential for the achievement of practically all Sustainable Development Goals (UN, 2015). There are 276 transboundary surface water basins and 592 transboundary groundwater aquifers in the world (IGRAC, 2015; Wolf et al., 1999). These transboundary water basins cover nearly half of the world's terrestrial area (Figure 1) and provide 60% of its freshwater (Paisley & Henshaw, 2013). Over half of the global river flows cross national borders and about 40% of the world's population lives within these transboundary water basins (Bonvoisin, 2013; Shrestha & Ghate, 2016).

Figure 1. Transboundary water basin

Source: Wolf et al. (1999)

In Sub-Saharan Africa (SSA), there are 80 water basins covering 60% of the continent´s total land area (United Nations Economic Commission for Africa, 2000). Most of these water basins are transboundary (Figure 2). Specifically, in the Southern Africa Development Community (SADC), 70% of the land falls within transboundary water basins (Swatuk & Fatch, 2013). Similarly, transboundary water basins cover significant shares of the land areas in Asia, Europe, North and South America (Figure 1).

Figure 2. Transboundary water basins in Africa

Source: Wolf et al. (1999)

The mandate of the United Nations (UN) in managing transboundary water resources remains limited, therefore, water laws are more regional than global, which indicates there is a vacuum of water governance at the global level (Gupta et al., 2013; Shrestha & Ghate, 2016). International water basins have been historically governed by about 3,600 regional and bilateral agreements (Marton-Lefèvre et al., 2013), 200 of such agreements were signed in the past 50 years. The 1992 Helsinki Convention by the United Nations Economic Commission for Europe (UNECE) introduced the first international water law on transboundary water resources. The Helsinki Convention provides for monitoring, research, development, consultations, warning and alarm systems, mutual assistance and access as well as exchange of information on transboundary water resources (UNESCO, 2013; Shrestha & Ghate, 2016). Although initially the Helsinki Convention was open only to countries in the pan-European region, since 2016, it has become open to all countries globally. In 1997, the United Nations General Assembly adopted the *Convention on the Law of the Non-Navigational Uses of International Watercourses*. This Convention calls for equitable and reasonable utilization of transboundary water resources and participation in their governance. It obliges parties not to cause significant harm to international water resources, it mandates cooperation and peaceful settlement to disputes. The Convention went into force after ratification by 35 countries in 2014 (Zhong et al., 2016). However, it remains applicable only to those countries which ratified it (Albrecht et al., 2017).

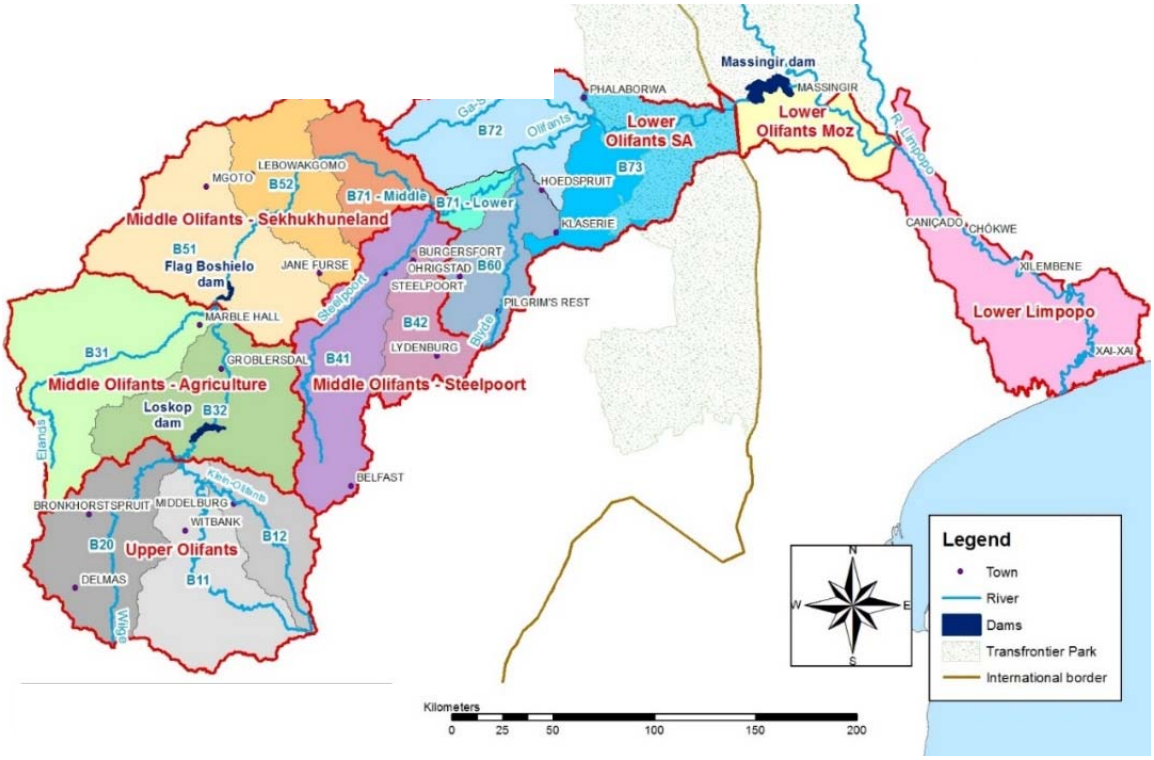
Box 1. Definitions of transboundary water governance (TWG)

Transboundary water governance is the mechanism in which cross-border water resources are governed by different stakeholders who have complex interests regarding the use and utilization of the limited water resources that flow across borders. Dore et al. (2012) defined transboundary water governance as a social process of dialogue, negotiations and decision-making to achieve a pre-determined objective regarding the transboundary water allocations and quality of water. Transboundary water resources governance involves different institutional arrangements between co-riparian countries such as treaties, agreements, conventions, charters, declarations and protocols (Boadu, 2016).

Various actors such as governmental institutions, non-governmental institutions (NGOs), mining companies, administrations of protected areas and households can be involved in the management and utilization of transboundary water resources. This leads to the competition for water among various uses (e.g. agriculture, cities, energy, tourism, wildlife and ecosystems). Successful water management requires a management system that allows institutions to flexibly adapt to times of abundance or scarcity; however, this may contradict the legal and regulatory frameworks that require enforceable and certain rules (Fischhendler & Katz, 2013).

The Olifants river basin is among such transboundary water basins, extending to the area of 54,570 km^2 and crossing South Africa and Mozambique (Figure 3). The current cooperation between riparian countries in the Olifants river basin, which is part of the bigger Limpopo river basin, is managed by the Southern African Development Community (SADC). SADC countries signed the Protocol on Shared Watercourse Systems in 2000, which stressed the importance of taking a basin-wide approach to promote sustainable management, protection and utilization of transboundary watercourses (Söderbaum, 2015). The protocol established the Limpopo Watercourse Commission (LICOM) in 2003, which provides recommendations for managing the transboundary waters in the Limpopo river basin (Petrie et al., 2015), including the Olifants river sub-basin. In addition, South Africa ratified the Convention on the Law of the Non-Navigational Uses of International Watercourses. However, Mozambique has not yet ratified this Convention.

Figure 3. The Olifants river basin



Source: USAID Southern Africa, based on the Atlas for Disaster Preparedness and Response in the Limpopo basin (2003), http://edmc1.dwaf.gov.za/library/limpopo

The Olifants river is heavily polluted by industrial, mining and residential waste, with high levels of eutrophication (Linz & Tsegai, 2009; Rudolph, 2016). The water pollution in the Olifants river has large scale negative impacts on the ecosystems of the Great Limpopo Transfrontier Park that it crosses. The Great Limpopo Transfrontier Park groups the Kruger National Park in South Africa and the Limpopo National Park in Mozambique. As a result of water pollution, numerous incidences of wildlife die-off were recorded in the past, especially among the populations of fish, crocodiles (Ferreira & Pienaar, 2011; Woodborne et al., 2012), and water-birds such as white-breasted cormorants, African fish eagle, white-crowned lapwings, and Goliath heron (Oberholster, 2009), dealing a heavy blow to the regional efforts for biodiversity conservation. Addo-Bediako et al. (2014) found that fish (*Oreochromis mossambicus*) caught at Flag Boshielo Dam contained higher than acceptable levels of lead, antimony and chromium, whereas the same fish species caught at the Phalaborwa Barrage contained higher than acceptable levels of lead, posing health risk to human consumers. Similarly, Jooste et al. (2015) showed that muscle tissues of fish species *Clarias gariepinus* contained risky levels of cobalt, lead, antimony and chromium in the Olifants river impoundments. The negative impacts of lower water availability and pollution can be also high among the animal species living closer to water sources due to their more frequent water drinking requirements, such as waterbucks and buffalos (Redfern et al., 2003). Water pollution in the Olifants basin has considerable costs not only in terms of these losses of biodiversity and indirect ecosystem services, but also in terms of their negative impacts on ecotourism and human health in the region.

The utilization of transboundary waters is a potential source of conflict among riparian states and competing water users within the countries (Conca et al., 2006; Lebed et al., 2005; Paisley & Henshaw, 2013). Specifically, this concerns the management of the environmental externalities, like those recurrent incidences of wildlife die-off and ecological damage in the Olifants river basin. Such water pollution impacts on the wildlife in protected areas and related transboundary water governance challenges are not unique to the Olifants river basin. All of the largest 15 transboundary protected areas identified in a 2007 UNEP report exist within multiple water basins or within a transboundary water basin, totalling 197,275 km^2 (Table 1).

To illustrate, such negative impacts of water pollution on biological reserves were observed in the Colorado river basin (USA-Mexico), the Indus river (Pakistan-India), the Danube river basin (Central Europe), the Mekong river basin (Pringle, 2001). In most cases, there is a lack of information on economic costs of these environmental externalities caused by water pollution in the natural protected reserves.

A number of protected areas crossed by transboundary waters are transboundary themselves. Such transfrontier parks are organized on the basis of transboundary natural resource management (TBNRM) initiatives or transfrontier conservation areas. The Great Limpopo Transfrontier Park between South Africa and Mozambique is one of such transfrontier parks.

Box 2. Definitions of transboundary nature governance mechanisms

Transboundary natural resource management (TBNRM) is a process of cooperation across boundaries that facilitates or improves the management of natural resources (Griffin, 2003), including by state and non-state actors. The main beneficiaries are people.

Transfrontier conservation areas are combinations of protected areas in neighbouring countries for improved biodiversity conservation organized by specialized state agencies (Jones & Chonguica, 2001). The main beneficiary is biodiversity conservation.

The ecosystem services provided by transboundary water basins, thus, have existential importance not only for people but also for biodiversity conservation. This needs to be taken into account in any transboundary water governance mechanisms. Conceptually, this link between water governance and nature governance is well understood, for example, through the principles of integrated water resource management (IWRM). However, from the legal and implementation perspectives, there are still significant gaps in integrated governance of Transboundary Rivers and protected natural reserves.

This paper advances transboundary water governance as an essential element of sustainable environmental governance in the protected natural reserves. It reviews the challenges and "best practices" for such governance mechanisms and their impacts. To our knowledge, there has been limited research into the interactions of transboundary water governance and nature protection in the past (Biggs etal., 2017; Pollard et al., 2011). The present paper and the subsequent field work that this paper will guide in the Olifants river basin seek to contribute to filling this important gap.

Tab 1. The largest 15 transboundary protected areas and their water basins

Protected Areas	Bordering Countries	Transboundary Water Basins	Area (km^2)
North-East Greenland	Greenland/Canada	Arctic Ocean Islands/NW Territories	1,008,470.17
Yapacana	Venezuela/Brazil	Amazon/Orinoco/South Atlantic Coast	443,976.25
Rio Negro	Paraguay/Bolivia/Brazil	La Plata	305,747.04
Zambezi	Zimbabwe/Zambia/Angola/Botswana/Namibia	Zambezi/South Interior, Africa	244,567.43
Wrangell-St. Elias	United States/Canada	Pacific and Arctic Coast	190,238.41
Yukon Flats	United States/Canada	Pacific and Arctic Coast	146,824.27
Urochische Peschanka	Russian Federation/Mongolia	Lena/Yenisey	112,366.59
Yaigoje-Rio Apaporis	Colombia/Brazil	Amazon/Orinoco	80,389.12
Richtersveld	South Africa/Namibia	Coast, Namibia/Orange	78,512.19
Torres del Paine	Chile/Argentina	Pacific Coast, Chile/South Atlantic Coast, Argentina	67,854.97
Sengwe	Zimbabwe/Mozambique/South Africa	Limpopo/South Coast, South Africa	65,092.40
Manu	Peru/Brazil	Amazon	56,858.71
Titicaca	Peru/Bolivia	Amazon/La Puna	53,712.89
Parc national de la Keran	Togo/Benin/Burkina Faso/Niger	Niger/Volta	52,619.01
Sagarmatha National Park	Nepal/China/India	Ganges Brahmaputra	51,903.25
			197,275.51

Source: compiled from UNEP database

2 Conceptual Framework

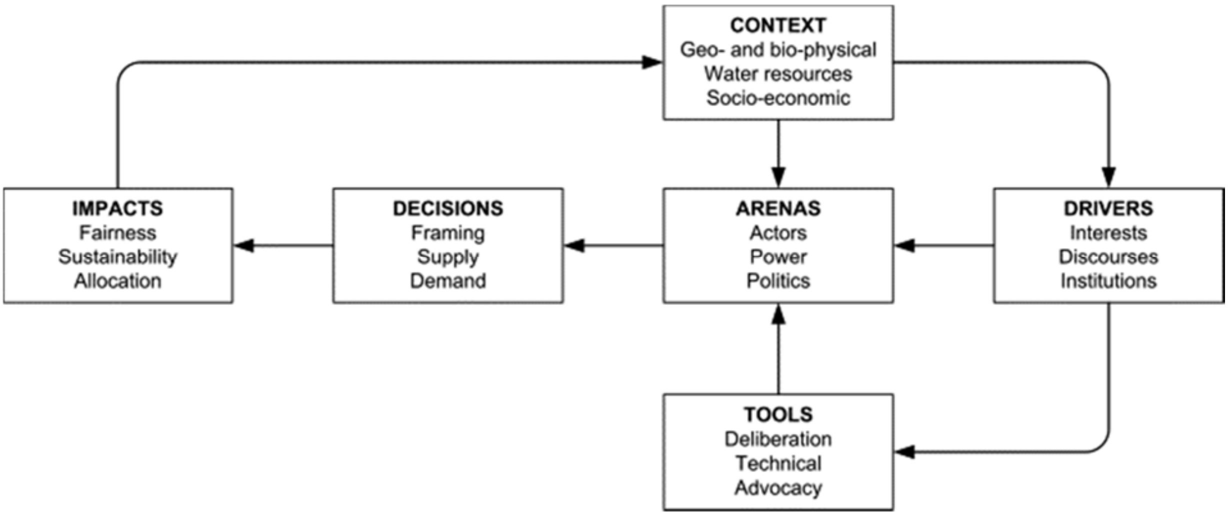
Efficient and equitable allocation of water resources as well as prevention of water pollution problems can become difficult to achieve in transboundary water basins using only formally stipulated agreements and regulations when the transaction costs for monitoring and enforcement of these regulations are high. In this context, the application of game-theoretic concepts can help inform the improved implementation of transboundary and national water governance mechanisms (Dema, 2014).

Game theory is a science of decision making that helps to understand how actors would interact strategically to maximize their benefits (Bhagabati & Kawasaki, 2014). In other terms, a game is a set of strategic interactions when the outcome of one actor's actions depends on actions taken by other actors (Bhagabati & Kawasaki, 2014; Myerson, 1997). It studies actors' choice of optimal behaviour in the face of uncertain costs and benefits (Nolan & Adam, 2008; Osborne, 2004). Game theory involves players, information, strategies, rules of the game and outcomes and payoffs. *The players* (e.g., individuals, organizations, companies, co-riparian states, local administrations, non-state entities) are the rational decision makers whose action is to maximize their utilities. *Information*, is the data used by the players on which decisions are made. Information can be private (known to some players only) or public (known to all players). *Strategies* are the alternative actions from which the players' choices come from. *Rules of the game* are the ones who shape and govern information. They include, laws, regulations, treaties, etc. *Social outcomes* are the end results of a given strategy after playing out, whereas *payoffs* are the individual players' valuations of a given outcome (Meinzen-Dick et al., 2018; Oftadeh et al., 2017; Zanjanian et al., 2018).

The governance of resources that require collective action and institutions do not come for free (Marshall, 2013; Ostrom, 2010). While optimizing their behaviour under uncertain costs and benefits, the actors consider various transaction costs that each alternative scenario of behaviour would involve. Transaction costs are the costs associated with exchange of goods or services and incurred in overcoming market imperfections. McCann et al. (2005) defined transaction cost as 'the resources used to define, establish, maintain, and transfer property rights'. Transaction costs include 1) search and information costs, 2) bargaining and negotiation costs, and 3) monitoring and enforcement costs.

The conceptual framework applied in this paper follows Dore et al. (2012) and was used previously to study the transboundary water governance in the Mekong river basin (Figure 4). We expand this framework to include nature governance organizations and related civil society organizations. The framework shows how transboundary water governance is shaped by the interlinkages between context, arenas, drivers, tools, which inform the transboundary water governance decisions and their impacts, including on biodiversity conservation.

Figure 4. Transboundary water and nature governance framework



Source: Dore et al. (2012)

The context includes the geo- and bio-physical, hydrological and socio-economic factors which shape the interests, discourses and institutions (drivers) determining actors' behaviour, and the relationship between actors in terms of power asymmetries and politics. Actors' behaviour is also influenced by the tools available to them such as access and participation in decision-making on transboundary water and nature governance, technical capacities and skills. The interactions between actors, then, lead to specific decisions related to transboundary water governance and subsequent impacts of these decisions in terms of water allocation, water pollution and environmental sustainability.

This conceptual framework aligns well with the game-theoretic understanding of actors' interactions driving transboundary water governance decisions and impacts. Moreover, this conceptual framework provides a well-defined guidance for the methodological design and data collection for the analysis of transboundary water and nature governance issues in the Olifants river basin.

There are numerous actors with stake in transboundary water governance in the Olifants river basin: such as mining enterprises, agriculturalists, industry, national parks and households. These actors are driven by their organizational and individual interests as well as shared contexts such as discourses, institutions and transaction costs (Njiraini, 2016). The actors with their varying power and political access negotiate the allocation of water into farming, mining, residential use, industry, and ecological reserve. The allocation of the transboundary water resources into the decision categories and subsequent behaviour of actors affect the fairness and distribution of water, pollution, future sustainability of the water resources, with critical impacts on wildlife and ecosystems in the Great Limpopo Transfrontier Park. The current transboundary water governance affects the present and future context of the coupled socio-ecological systems, which in turn reflect back on the interest of actors.

3 Transboundary Water and Nature Governance: International Experiences

3.1 Transboundary Water Governance

International experiences of transboundary water governance are rich both in successes and failures. Our assessment of the literature shows that the major reason behind successful cases of transboundary water management were mutual trust and cooperation between the riparian countries. On the other hand, mistrust, strong power asymmetries and competition were often shown to lead to conflicts and inefficient transboundary water governance mechanisms (Abdolvand et al., 2015; Cascão & Nicol, 2016; Hanasz, 2017; Jensen, Lange, & Refsgaard, 2018; Petersen-Perlman & Wolf, 2015)

Biswas (2011) highlighted how **cooperation and conflict** affect the economic, social and environmental aspects in transboundary rivers in the Himalayan region. The cooperation between India and Bhutan has yielded positive impacts on both countries. In the 1970s, Bhutan introduced a plan to build a hydropower at Chukha in cooperation with India. The agreement between the two countries was that the power will be used as per Bhutan's capacity and the excess supply will be sold to India. Before the agreement and construction of the dam, Bhutan's per capita energy consumption was only 17 kWh. It was more than 10 times less as compared to the 173kWh of India. The per capita electricity consumption of Bhutan increased gradually since the Chukha project. By 2008, Bhutan's per capita energy consumption increased to 4,303 kWh, as compared to 4,470 of India, 4,303 kWh of Pakistan, 1,453 kWh of Bangladesh and 547 kWh of Nepal. On the other hand, Biswas (2011) also notes that the successful case in transboundary water management between Bhutan and India could not be replicated between Nepal, India and Bangladesh due to **mistrust and institutional failure**.

The Euphrates-Tigris (ET) river basin in the Middle East is considered as a prime example for transboundary water-related conflicts (Warner, 2012; Starr and Stoll, 1998; Bulloch and Darwish, 1993). The tension over the access to transboundary water resources further exacerbated after Turkey started the construction of the Ilisu Dam (Kibaroglu, 2017; Warner, 2012). The stakeholders (states in the riparian region and other actors, such as, international NGOs) used **securitisation, de-securitisation and counter-securitisation tactics** to influence the water politics in the region. Securitisation refers to the situation where some stakeholders in the basin present the transboundary water issues as a life-and-death concern using constructed problems which are not true in the actual world (Austin, 1962; Warner, 2012). An international NGO was able to deter international funding for the Ilisu dam in 2001/2002 using the same tactics. As a result, the inter-states relationship among the riparian countries deteriorated (Warner, 2012). De-securitization of issues related with transboundary water management and willingness to compromise in transboundary water governance in order to gain mutual trust and collaboration for a wider-range of economic activities allowed to reduce conflict potential and is promoting economic integration in the Amudarya and Syrdarya river basins in Central Asia. On the other hand, strong entrenchment of positions and politization of the transboundary water management issues are limiting cooperation in the Eastern Nile river basin (Egypt, Ethiopia, Sudan)(Berga et al., 2017).

In this context, **water diplomacy** through research and testing of ways of how to implement transboundary cooperation in water management, organizing trainings for learning and dialogues for consensus building, promoting responsible leadership and providing advisory support were shown to help in overcoming such mistrust and creating opportunities for cooperation in Coatan (Guatemala-Mexico), Goascorán (Honduras-El Salvador), Sixaola (Costa Rica-Panama), Zarumilla (Peru-Ecuador), Catamayo-Chira (Peru-Ecuador) and Titicaca (Peru-Bolivia) basins (Marton-Lefèvre et al., 2013).

The experiences from the Mekong river basin also showed that water diplomacy critically depended on accurate and transparent data and analysis tools for informing policy decisions (Dore & Lebel, 2013). Water security implies that stakeholders, both humans and ecosystems, have sufficient access to water in the appropriate quality at the right spatial-temporal scale. Therefore, **assessments and monitoring**

of water quantity and quality must be conducted regularly encompassing all related aspects, such as impacts on biodiversity and human livelihoods (Veilleux & Anderson, 2016). **Science-policy interactions** for facilitating transboundary water governance were found to be most effective when all stakeholders recognize science as a crucial input to policy-making process, the knowledge on water governance is co-produced in an trans-disciplinary manner, and informal networks of scientists, policy makers, and civil society are facilitated (Armitage et al., 2015).

Transboundary water governance is influenced by numerous power dynamics between actors. The analysis of historical water conflicts in transboundary basins suggests that social and economic development increases the likelihood of hydro-political tensions if institutions are not present to negotiate changing jurisdiction over resources (De Stefano, Petersen-Perlman, Sproles, Eynard, & Wolf, 2017). Therefore, the socio-political arena, political institutions and hegemonic arrangements need to be identified to predict how actors will consent or contest over water governance arrangements (Zeitoun et al., 2017).

Transboundary water governance organizations serve as platforms for facilitating water diplomacy, building trust and cooperation. All major global international river basins have such transboundary river basin organizations; a few examples are the Mekong river basin commission, the Nile basin initiative, Inter-state Commission for Water Coordination in the Aral Sea Basin, the International Commission for the Hydrology of the Rhine Basin, the Niger Basin Authority, Limpopo Watercourse Commission. Despite various shortcomings that they may have, such transboundary water basin organizations play a key role in promoting trust and cooperation among riparian countries (Griffiths & Lambert, 2013). To illustrate, the Colorado River flows from the United States into Mexico and creates the border between the two countries. Rapid industrialization and population growth led to pollution and water management problems in the Colorado river basin, resulting in the formation of several transboundary water governance organizations (Frisvold & Caswell, 2000). One of these institutions, the International Boundary and Water Commission (IBWC), focuses on water management issues impacting both countries, only implements projects with bi-national support, and supersedes decisions of domestic agencies. Although the IBWC has been equally praised and criticized, the existence of such an institution has promoted cooperative solutions (Frisvold & Caswell, 2000). Recently, the IBWC adopted Minute 323, an addendum to the 1944 Water Treaty between United States and Mexico, that allows Mexico to store water, commits the United States to funding water efficiency projects in Mexico, obliges both parties to fund environmental restoration and monitoring, and outlines water cutback strategies in times of water shortages (Nature Conservancy, 2017).

International basin commissions are recognized as an important mechanism to manage water resources; however, their mere existence does not guarantee success (Green, Cosens, & Garmestani, 2013). For example, River Basin Organizations (RBO) may lack political relevance as they are designed to deal with specific basin issues, when other factors outside of their control impact their operations (Söderbaum, 2015). If RBOs institutions are granted the ability to enter into the binding cooperative agreements regardless of external political pressure; however, this overcomes political restraints, as was shown by the above example of the International Boundary and Water Commission (IBWC) in the Colorado river basin.

River basin commissions are not the only organizations that promote cooperation in transboundary water basins. Grassroots, **bottom-up mechanisms for transboundary cooperation** in water management were also show to yield positive results. For example, Jetoo (2017) analyzed the role of regional and city networks on the implementation of the 1974 Helsinki Convention between the Baltic States and the 1972 North American Great Lakes Water Quality Agreement between Canada and the United States. United States and Canadian cities developed a Cities Initiative to bridge gaps, merge collective voices and optimize resources by sharing information, skills and pooling financial resources to ensure ecological perseveration of the Great Lakes. Similar strategies were utilized by the Union of Baltic Cities, a coalition of international cities around the Baltic Sea. Both networks represented geographically diverse cities; however, they clustered around cities of influence. Although this enhances the networks influence both nationally and regionally, passive cities outside of the cluster should be identified and engaged to ensure they do not undermine the water management and conservation efforts (Jetoo, 2017).

Knieper & Pahl-Wostl (2016) showed **that decentralized governance and low corruption result in good water management practices**. However, good water management by itself may not be sufficient for achieving good water quality in the river basins when human pressure on water resources is high. In such a context, good water governance mechanisms are seen a part of broader societal transformation or more sustainable water use (Knieper & Pahl-Wostl, 2016).

Loë & Morris (2014) analyzed the cooperation in transboundary water governance in the Mackenzie River Basin (MRB) which is shared by three provinces, three territories, a federal government, and Aboriginal[1] government in Canada. A framework agreement was developed in 1997 which creates a river basin organization. However, bilateral agreements under the 1997 MRB Transboundary Waters Maser Agreement among the riparian stockholders entered into force only since 2010. The authors noted that the **lack of empowerment of the stakeholders** by the government prevented the stakeholders from engaging in transboundary water governance. The authors recommended future commitment and coordination of the bilateral agreements for a better governance outcome in the basin. Earle & Neal (2017) also found that inclusion of non-State stakeholders is a critical element for successful transboundary water management. Pollard et al. (2011) suggest that stakeholder-centered vision and learning-focus on adaptive management are the key factors behind improved access to rover water by the Kruger Park in South Africa.

Engaging all stakeholders in consultations and negotiations was found to be a key tool in improved management and allocation of water resources (Yang, Chan, & Scheffran, 2016). Yang, Chan, & Scheffran (2016) analyzed the management and allocation of water resources in the Dongjiang River basin in China. The authors applied a stakeholder analysis to identify the key players and determined that the influence wielded by a stakeholder, in most cases, was in proportion to impact that water management affected them.

Water treaties and allocation mechanisms need to be sufficiently flexible in the face of increasing variability of water due to changing climate. Green et al. (2013) showed that Angola, Botswana and Namibia applied resilience theory in the management of the Okavango River Basin in order to adapt to water variability. It was found that allocation by percentage flow (rigid entitlements) is not sufficient for ecological resilience, and a degraded environment has negative feedback loop on the water flow (especially with climate change stressors). Environmental impacts (upstream and downstream) must be the primary consideration, which requires **local participation and capacity building**.

3.2 Transboundary Water Governance in Protected Natural Areas

The location of a protected natural area within a watershed determines the level impact response of human activities disturbance in the watershed. Natural reserves in middle or lower watersheds suffer direct hydrologic alterations that result in modification of the habitat and exacerbate pollution. For example, dams prevent sediment deposition in the wetland delta reserves, causing coastal erosion, while reserves in the upper watershed may be intact, but result in species/genetic isolation and migratory species extinction (Pringle, 2001).

Feedback loops from development and pollution outside of the watershed may impact hydrological systems inside the natural reserves. Therefore, focus on protected areas only neglects surrounding areas that influence the resilience and health of the protected areas (Mawdsley, O'Malley, & Ojima, 2009). For example, strategies implemented in Kruger National Park in South Africa to manage water for biodiversity protection include reallocation of upstream waters, agreements with upstream communities regarding water extraction in wet/dry seasons, and dam management (analysis of current operations and potential new dams for water storage) (Pringle, 2001).

[1] This refers to an indigenous people according to the Canadian constitution.

River basins that encompass natural parks must develop water management plans that consider the impact of human activities on water availability and quality for animal populations. Tshipa et al. (2017) found that elephant migration patterns shift depending on resource availability, as evidenced by elephants changing behaviors to incorporate man-made watering holes in the Kavango-Zambezi Transfrontier Conservation Area (TFCA). The authors tracked elephant movements to determine their wet-dry season ranges, and found that surface water availability increased the likelihood of seasonal migration. Water-driven migration is not unique, as also evidenced by zebra and wildebeest populations in Tanzania; however, the impact of artificial watering holes on elephant migration patterns highlight the importance of human water management decisions on the natural habitat (Tshipa et al., 2017; Morrison *et al*., 2016). Therefore, a regional water governance system should be able to adapt to changes in water availability (i.e. increased incidences of severe droughts, etc.) to ensure biodiversity conservation.

The valuation of water resources could inform the development of inter-basin water fees to compensate upstream areas for protecting water quality by investing in afforestation and preventing pollution (Yang et al., 2016a). For example, a Payment for Ecosystem Services (PES) model in South Africa integrates biodiversity, water and socioeconomic development, while managing the scarce water supplies. Unemployed individuals tender for contracts to restore private or public lands by removing invasive alien plant infestations that impact the amount of water catchment runoff. Between 2001-2006, 66% payments were made for activities outside of conservation enclaves (Turpie, Marais, & Blignaut, 2008). However, game theory solutions to unidirectional externalities result in the "victim pays", which contradicts the polluter pays theory, and downstream countries may not be able to offer incentives to prevent upstream countries from polluting or diverting waters. Therefore, it is important to link games - make negotiations conditional, allowing for equilibrium in solutions and yielding higher outcomes for both sides.

The non-market values of biodiversity in conservation areas should also be calculated to protect biodiversity, as competition for water resources increases. For example, the Colorado River is important for recreational purposes. Surveys of users found that individuals supported restoration of the aquatic ecosystem to ensure continued access. Results found that, depending on the mean income, the median willingness to pay ranged from $7-13 USD per car entering the protected area (Kerna, Colby, & Zamora, 2017). Similarly in South Korea, Lee & Han (2002) found that the economic values people attach to ecosystem services provided by the protected natural reserves are 3.7 times bigger than the admission price to the protected area and the per person maintenance cost. Calculating a non-market aspect of the basin will help protect basin ecosystems from intense competition for resources. However, the willingness to pay presented by the respondents may not be enough to keep the water safe it might not represent the actual value of the resource. It may be also difficult to collect the stated willingness to pay from the users due to the non-exclusive nature of the water resources.

4 Transboundary Water and Nature Governance in the Olifants River Basin

4.1 Water Governance in the Olifants River Basin

The Olifants river forms a sub-basin of the larger Limpopo river basin (LRB), which extends to 415,000 km^2, spanning four countries: Botswana, Mozambique, South Africa and Zimbabwe (Petrie et al. 2015; Zhu & Ringler, 2012) (Figure 5). The river originates in the South Africa, Botswana and Zimbabwe highlands, before entering Mozambique and draining into the Indian Ocean (Midgley et al. (2013). The majority of the basin resides in South Africa (45%), followed by Mozambique (21%), Botswana (19%) and Zimbabwe (15%) (FAO, 2004). As of 2010, South Africa accounted for 60% of the total water usage; however, this water use distribution will be harder to maintain as the other riparian countries experience rapid urban growth and development (Midgley et al., 2013).

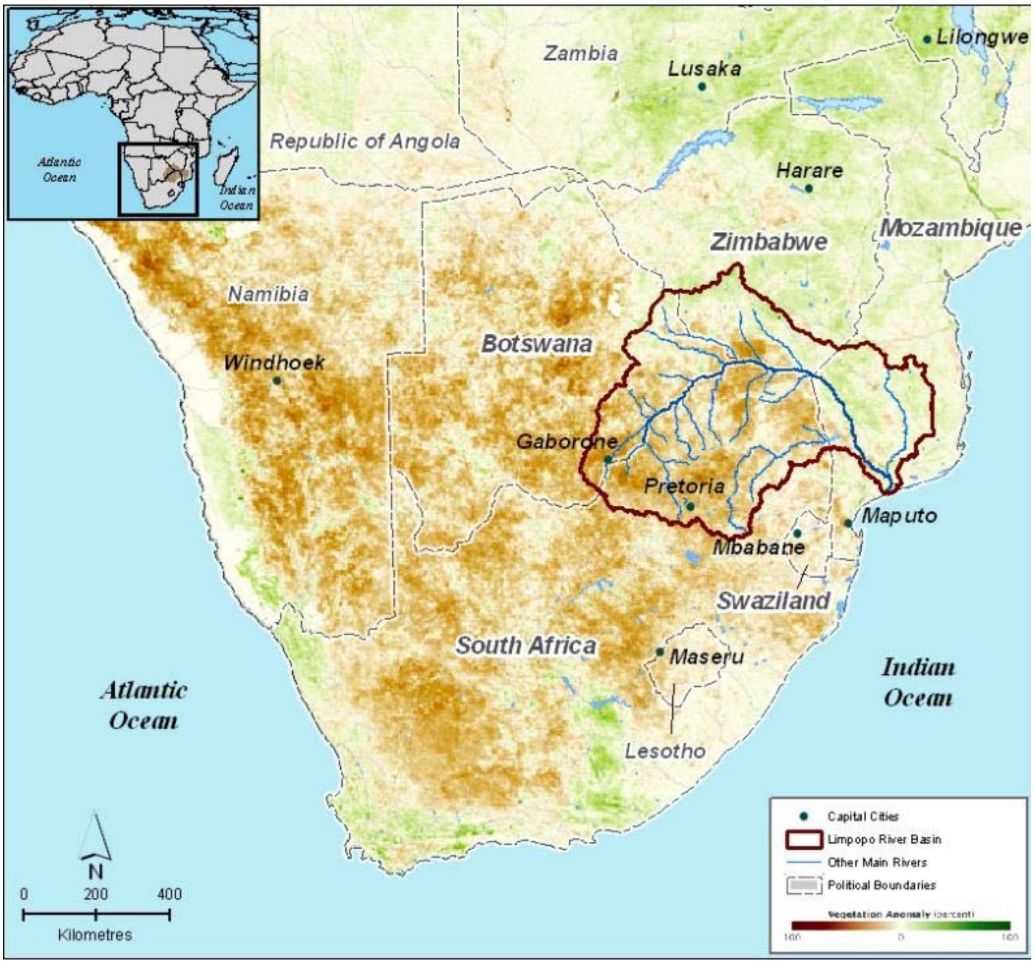
The Olifants river basin, crossing South Africa and Mozambique, is one of the tributaries of the Limpopo River. The Olifants river catchment area covers 54,570 km^2 and passes through three provinces of South Africa, namely, Gauteng, Mpumalanga and Limpopo Province, flows through the Kruger National Park, and into Mozambique, where it joins the Limpopo river (Hobbs, Oelofse, & Rascher, 2008; Magagula, van Koppen, & Sally, 2006). The topography of the Olifants river basin diverges widely in terms of altitude. The upper part of the catchment has the highest point with 2,300 m above sea level, while near the Mozambique border, it has the lowest altitude of 300 m (Magagula et al., 2006). The Olifants river catchment in South Africa has an estimated population of approximately 3.2 million. Approximately two-thirds of the population lives in rural areas (Magagula et al., 2006). The estimates show that about 500,000 people live on the Mozambican side of the Olifants basin.

Available water in the Olifants river basin is highly variable and under great demand (Petrie et al., 2015). Water is required for agriculture, forestry, urban and rural communities, mining, power generation, ecosystem flows, and tourism; however, demand by sector differs among the countries. Climate change is projected to result in rising temperatures, in addition to increased variability and intensity of rainfall in the basin by 2050 (Chapman, 2011). All IPCC scenarios unanimously point to temperatures increase in the Olifants river basin (Nkhonjera, 2017). On the other hand, precipitation is projected to increase in winter months, but decrease in summer by 2050 (Cullis et al., 2011; Nkhonjera, 2017; Singh, van Werkhoven, & Wagener, 2014).

South Africa is the biggest consumer of water in the basin. In spite of this, it is facing huge water resource constraints (Herrfahrdt-Pähle, 2010). The main source of water in South Africa is from surface water abstraction (Herrfahrdt-Pähle, 2010). The Department of Water Affairs and Forestry (DWAF) of South Africa[2] estimated that by 2025 South Africa will be classified as chronically water scarce. Even now, if the water requirement for the ecological reserve is taken into account, all the renewable water resources in the Olifants river basin are fully allocated to various uses (Kahinda et al., 2016).

[2] Department of Water Affairs and Forestry was divided in 2009, with the forestry responsibility being transferred to the Department of Agriculture, Forestry and Fisheries. The remaining Department of Water Affairs was renamed as Department of Water and Sanitation in 2014.

Figure 5. The Limpopo River Basin



Source: NASA GIMMS Group at Goddard Space Flight Center 2007

The South African National Water Act (NWA) adopted in 1998 has been hailed as a model legislation that operationalizes all the elements of Integrated Water Resources Management (IWRM). The major element of the NWA is that it abolished the previous system of riparian private water rights and established water under State's stewardship (Pollard et al., 2011). According to the NWA, "basic human needs and ecological reserve" must be determined at the catchment level for each water body (RSA Act No. 36, 1998). Despite the comprehensive and integrated approach outlined in the NWA, South Africa experienced difficulties implementing critical components due to challenges related with leadership, technical skills, accountability, implementation timeframes, and lack of implementation capacities (Mehta et al., 2014). Thus, water use equity, water license issuance, and protection of aquatic ecosystems are ongoing challenges for South Africa (Schreiner, 2013). South Africa amended the 1998 NWA in 2014 to address these issues, and the impact of the revisions is yet to be seen (Schreiner, 2013).

In Mozambique, two different ministries oversee two aspects of water management: the National Directorate of Water Affairs (DNA) of the Ministry of Public Works and Housing oversees the overall water management and is the body charged with developing water policies. The National Directorate for Agricultural Hydraulics (DNHA) within the Ministry of Agricultural and Rural Development manages the water use in agriculture (Midgley et al., 2013). The Mozambique Water Act, enacted in 1991, provides the formal framework to determine water rights according to licenses and payments, differentiating between *usos comuns* (i.e. households and small scale agriculture) and *usos privativos* (i.e. industry, agriculture and energy) (Alba, Bolding, & Ducrot, 2016). These water payments finance the Regional Water Administrations, which is meant to ensure that water agencies are focused on water users' needs. Later, water reforms were introduced, but never fully integrated, the concepts of IWRM (Mehta et al., 2014).

The transboundary cooperation in the Olifants river basin between South Africa and Mozambique is based on the cooperative arrangements for the entire Limpopo river basin. Historically, these include:

1) Tripartite Permanent Technical Committee (TPTC) of 1986 between Mozambique, South Africa and Swaziland,

2) Limpopo Basin Permanent Technical Committee (LBPTC) between Botswana, Mozambique, South Africa and Zimbabwe established in 1986.

3) Agreement on the Establishment of the Limpopo Watercourse Commission signed in 2003 by Botswana, South Africa, Zimbabwe and Mozambique. The objectives of the Commission are to advise the riparian countries and provide recommendations on the protection, preservation and management of the Limpopo river basin.

Despite these joint initiatives, the transboundary collaboration in water management between South Africa and Mozambique has been negatively affected by limited operational capacities, the language barrier, and lack of inclusion of Mozambique in regional data and information collection initiatives (Midgley et al., 2013)

4.2 Nature Governance in the Olifants River Basin

Kruger National Park (South Africa)

About 6% of the total land surface of South Africa and 20% of the marine environment is incorporated under protected areas, including over 400 terrestrial and 23 marine sites (Paterson, 2009). Fifty-six percent of this total area is made up by the 21 national parks. These range in size from almost 2 million hectares (Kruger National Park) to 2,662 ha (Wilderness National Park), with the total area (excluding marine areas) of about 3,8 million hectares.

During the Apartheid regime, before 1994, protected areas in South Africa were established based on the top-down approach, as in other parts of the developing world (Anthony, 2007; Campbel & Shackleton, 2006; Lahiff, 1997; Volkman, 1986). Households and communities were often deprived from accessing and using the protected areas, which resulted in hostile attitudes towards these initiatives, despite successes in conserving biodiversity (Anthony, 2007; Khan, 1994). However, after 1994, the National Park Board (NPB) (its name was changed into South African National Parkes (SANParks) in 1997) was established, and in 2003 new Protected Areas Act was adopted, which changed the philosophy and organizational structure of protected areas in South Africa. In addition to the core objective of protecting wildlife and natural resources, socio-economic aspects of the neighbouring communities are given due attention. Therefore, the attitudes of local communities towards protected areas have been gradually changing.

Limpopo national Park (Mozambique)

The Mozambique side of the Limpopo National Park was established in 1998 with the collaboration of Mozambique, South Africa and Zimbabwe after the end of the civil war in Mozambique. An NGO called Peace Park Foundation (PPF) supported the creation of the National Park (Ducrot, 2011). Around 27, 000 people were evicted from the area of Limpopo and Shingwedzi rivers in the process of forming the national park (Ducrot, 2011). The implementation and planning of the park followed a top-down approach. Local livelihood strategies include crop cultivation, livestock husbandry, handicrafts, environmental products harvesting and remittances. Land and environmental products are the main stay of the livelihood strategies. Additionally, the local communities are used to traditional land system where the local chiefs control access to land and natural resources. Therefore, the establishment of other institutions to manage the national park overlaps with the traditional institution which results in power conflicts and in some cases disruption of local institutions for the governance of the natural resources (Nhancale, 2007).

The Great Limpopo Transfrontier Park

The Great Limpopo Transfrontier Park (GLTP) was established in 2001, linking the Kruger and Limpopo National Parks (Spierenburg et al., 2008). The GLTP is one of the world's largest conservation areas extending to 35,000 km^2, and the area is growing with Mozambique signing a Memorandum of Understanding to incorporate the Greater Limpopo Conservancy, privately owned land along the border with South Africa (Peace Parks, 2017; Lunstrum, 2016). About one third of the transfrontier park are located in South Africa and two thirds in Mozambique.

The regional cooperation in biodiversity conservation and protected natural reserves is guided by the SADC Wildlife Policy signed in 1997 which promotes interstate co-operation in the management and sustainable use of ecosystems, as well as the SADC Protocol on Wildlife and Conservation and Law Enforcement signed in 1999.

5 Water Pollution in the Olifants river basin

The Olifants river basin is considered to be one of the most polluted water basins in the Southern Africa region. The major water quality problems in the basin are related with eutrophication, fecal pollution, salinization and acid mine drainage (DWA, 2012). The problem is exacerbated by asymmetric power relations where environmental advocacy organizations, natural parks and local populations have relatively limited political and economic influence compared to the mining industry (Midgley et al., 2013). Thanks to the efforts by the South African Department of Water and Sanitation to limit pollution from mining activities, the situation with chemical pollution has considerably improved in the Olifants river quality in the Kruger Park. However, water pollution through siltation due to soil erosion, agricultural residues and spilling of untreated sewage waters to the Olifants river remains an important problem[3].

The prevention and timely addressing of water pollution issues in the Kruger park depends on the collaboration between the Kruger park and the Department of Water and Sanitation. Biggs et al. (2017) showed that intensifying links across different scales of nature and water governance, trust building and shared vision were critical in responding to the drying-up of the Olifants river in 2005 and in the number of subsequent emergency cases affecting water quantity and quality in the Kruger park. Whenever water pollution levels exceed critical thresholds, the management of the Kruger Park contacts the Department of Water and Sanitation to investigate and address the reason for such pollution increases. At the same time, when sources of pollution are diffuse, for example, through soil erosion due to unsustainable agricultural practices, pollution of rivers by waste waters, the immediate options for addressing the sources of soil pollution are more difficult than when the pollution comes from concentrated mining activities. For agricultural activities, Njiraini, Thiam, & Muchapondwa (2016) found that compulsory licensing, membership in Water User associations (WUAs) and water pricing increased water use efficiency and decreased water pollution from agricultural activities. For limiting the negative impacts of water pollution through discharges from mining activities, Nieuwoudt & Lieb (2008) suggest establishing tradeable pollution permits allowing controlled discharges only when river flow is sufficiently high. Walter, Kloos, & Tsegai (2010) suggest that inter- and intra-basin re-allocations of water resources in the Olifants river could significantly help to offset water scarcity.

Although the impacts of water quality on biodiversity conservation were studied for the Kruger Park, the impacts on the wildlife and ecosystems of the downstream Limpopo Park in Mozambique received much less attention, although available studies point at significant pollution problems (Addo-Bediako et al., 2014; Chilundo et al., 2008). Most of the previous literature on water governance in the Olifants basin also focused on the South African side, whereas there has been relatively limited research conducted on transboundary joint coordination of water governance and biodiversity conservation in the Great Limpopo Transfrontier Park.

[3] http://www.krugerpark.co.za/krugerpark-times-3-14-kruger-rivers-23334.html

6 Research Design

The field research to be conducted under this project will collect data to answer the following three research questions:

1. **What are the impacts of current transboundary water governance on the provisioning and non-provisioning ecosystem services in the Kruger and Limpopo national parks?**

The above literature review will be used to identify the types of provisioning and non-provisioning ecosystem services in the Kruger and Limpopo National Parks affected by reduced water quantity and quality. The evaluation of the monetary value of these ecosystem services will be conducted through application of revealed and stated preference approaches during eight focus group discussions (FGD) in Kruger Park (4) and Limpopo park areas (4). In each case, one FGD will be conducted at the expert level with the participation of stakeholder institutions in the area, and three FGDs will be conducted with adjacent communities. The list of ecosystem services whose values are affected by changes in water quantity and quality could include animal and plant species biodiversity/numbers, agricultural production, tourism and recreation, fisheries, etc.

2. **Which alternative transboundary water governance approaches and what are their transaction costs and economic benefits?**

This study component will identify alternative transboundary water governance mechanisms and evaluate the transaction costs and benefits of implementing them. Alternative governance mechanisms are expected to result in higher total economic value of provided ecosystem services of water and nature, including positive externalities of clean water on livelihoods and ecological functions. Such improved governance mechanisms could include closer involvement of local communities and other local stakeholders in water governance by providing those incentives for more efficient and effective water management and allocation among various uses. The costs of the implementation of alternative governance mechanisms will also be evaluated through the two expert focus discussions indicated earlier.

3. **Are the evaluated alternative governance mechanisms locally applicable?**

This component will test the validity of proposed governance mechanisms and their local applicability through implementation research approaches. This will have the purpose of facilitating governance improvement (both in terms of effectiveness and efficiency) through implementation research with stakeholders (e.g. South Africa has good legal frameworks on water governance but poor implementation). Methodologically, this will be conducted through multi-stakeholder and multi-criteria analytical approaches and mapping of transboundary networks of water governance actors and stakeholders during the Focus Group Discussions. The analysis will also identify the tools for transparent internalization of external costs of water pollution and water scarcities across water stakeholders that derive indirect and direct environmental and nature conservation benefits.

7 Conclusions: Lessons learned for transboundary water and nature governance

Transboundary water resources are key, and often only, sources of water for the needs of ecosystems in numerous protected natural reserves around the world. Therefore, effective, efficient, and equitable transboundary water governance mechanisms are needed to meet both water demands for human use and the water requirements for ecosystems and biodiversity. The Olifants river basin and the Great Transfrontier Limpopo Natural Park represent a prime example of these interactions.

There has been relatively limited research on the impacts of transboundary water governance on the biodiversity conservation. However, existing literature on water governance and transboundary water governance *per se* allows to draw some lessons on the best practices for mitigating tradeoffs and facilitating synergies between transboundary water and nature governance.

Reduction of transaction costs of transboundary water governance is usually at the heart of successful cases. A major requirement for successful transboundary water governance is mutual trust and cooperation between various stakeholders. For building trust, it is important to de-politicize the water governance issues across the national boundaries. Water diplomacy through joint research, data collection and monitoring, capacity building, dialogues for consensus building, promoting responsible leadership and providing advisory support can help in overcoming mistrust between stakeholders and create opportunities for cooperation. Strong power asymmetries may hinder transboundary water governance, therefore, there is a need to involve multi-scale links across stakeholders to counter-balance local power asymmetries and engage all stakeholders in consultations and negotiations.

Grassroots, bottom-up mechanisms for transboundary cooperation in water management, decentralized governance and low corruption were shown to result in good water governance practices. However, good water management by itself may not be sufficient for achieving good water quality in the river basins when human pressure on water resources is high. In such a context, good water governance mechanisms are seen as a part of broader societal transformation towards more sustainable water use.

Achieving the sustainability of water use, especially for biodiversity conservation, requires overcoming market failures related with exclusion of the total economic values of ecosystem services and biodiversity in policy-making frameworks. For this reason, non-market values of biodiversity in conservation areas should also be calculated to protect biodiversity, as competition for water resources increases. Improved valuation of water resources themselves could inform the development of policy tools to internalize water pollution costs.

Transboundary water governance is critically dependent on accurate and transparent data and analysis tools for informing policy decisions. Science-policy interactions for facilitating transboundary water governance were found to be most effective when all stakeholders recognize science as a crucial input to policy-making process, and when the knowledge on joint water and nature governance is co-produced in a trans-disciplinary manner, in collaboration with wide-ranging informal networks of scientists, policy makers, and civil society.

Transboundary water governance organizations can serve as platforms for facilitating water diplomacy, building trust and cooperation, especially when they are granted the ability to enter into binding cooperative agreements regardless of external political pressures. Commissions for river basins that encompass natural parks need to develop water management plans that consider the impact of human activities on water availability and quality for animal populations.

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