International Water Security Network

Water Security on the Kafue Flats of Zambia

Funded by

Lloyd's Register Foundation

Led by

UWE Bristol University of the West of England

In partnership with

MONASH SOUTH AFRICA

The University of Arizona. Udall Center for Studies in Public Policy

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IWSN SOUTH AFRICA Report No. TP/MC/7/16

This document should be cited as:

Chomba, M.J. and Nkhata B.A. (2016) Water Security on the Kafue Flats of Zambia. Technical Report of the International Water Security Network, Water Research Node, Monash South Africa, Johannesburg.

Acknowledgements

We wish to acknowledge the funding contribution of the International Water Security Network which is funded by Lloyd's Register Foundation, a charitable foundation helping to protect life and property by supporting engineering-related education, public engagement and the application of research.

We further wish to acknowledge the leadership and intellectual contribution of Chad Staddon who supported us throughout the preparation of this technical report. Charles Breen is also thanked for his profound insights during the drafting of the report.

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Executive Summary

This technical report highlights key water security issues in Zambia with special reference to the Kafue Flats. It draws particular attention to issues of water availability and demand, competing water users, and institutional arrangements for securing water and associated resources. The report comes at a time when several countries in southern Africa including Zambia are negotiating trade-offs associated with developing water resources whilst trying to ensure ecosystem integrity. Such trade-offs are occurring amidst several other pressures including population growth, urbanisation, climate variability, and changing patterns of economic production and consumption.

Compared to other countries in the region, Zambia is relatively endowed with more water resources. For instance, the country’s per capita water availability is around 8,700 m^3 per year, which is almost 24% more than the average for southern Africa and 6% more than the global average. Yet, utilisation of this valuable resource is greatly constrained by uneven distribution of rainfall in both Zambia and the region.

It is in this context that most national development plans in the region are developed. For example, the Revised Sixth National Development Plan (2012–2016) for Zambia identifies agriculture, energy, livestock, fisheries, and infrastructure development as the main growth areas that are strongly dependent on water resources. Almost 60% of the population of Zambia falls under the geographical boundaries of the Kafue River Basin that supports the major mining, industrial and commercial activities of the country. In addition, a significant amount of hydropower is generated within the Kafue River Basin for residential and industrial use.

The basin further provides water for domestic water supply to three municipalities including Lusaka, the nation’s capital. This is not withstanding several subsistence activities that support local livelihoods. Given this context, water security issues, such as protection of vital aquatic ecosystems, availability of water resources for competing uses, and reduction of water related risks, are bound to take centre stage in the basin.

The term water security generally denotes the availability of adequate quantities and qualities of water for resilient societies and ecosystems in the face of risks and uncertainty. In this report, water security is framed as an emerging paradigm that evinces how social actors such as water managers, users, policy makers, and scientists grapple with water insecurity in arenas dominated by multiple priorities, values, expectations, and knowledge systems. Water security as a paradigm highlights fundamental governance issues such as equity, efficiency, and sustainability that dominate contemporary public debates in transitional societies.

Hydro-Ecological Description of the Kafue Flats

The Kafue River Basin extends over a total area of 155,948 km² representing approximately 20% of the total land area of Zambia covering three provinces. The basin is categorised into three main sections – upper, middle and lower- of which the Kafue Flats borders between the middle and the lower Kafue River Basin.

The Kafue Flats are an extensive area of wetlands and floodplains along the Kafue River between Itezhi-tezhi in the West and Kasaka in the East, covering around 6,500 km2. The land, as the name implies, is extremely flat, with a slope of less than 5 cm/km. It takes up to two months for water to pass through the Kafue Flats. In 1991, the Kafue Flats were designated a wetland of international importance under the Ramsar Convention.

The Kafue Flats is located in Agro-ecological region IIa of Zambia characterised by average rainfall of 800 mm to 1,300mm and temperatures of 15 - 16º C. Vegetation distribution and composition in the basin is a function of the distribution of soil type, rainfall, flooding, and human settlements. The vegetation types include forests in the upper sub-basin, woodlands, shrubs, and grass land in the middle and lower basins.

Land use on the Kafue Flats

The Kafue Flats are one of the most important ecological and economic systems in Zambia. Ecologically, the Flats provide vital habitat for several important wildlife species such as the Kafue lechwe, Blue wildebeest and Greater kudu. Key bird species include the famous Wattled crane. Most wildlife is concentrated in the Lochinvar and Blue Lagoon National Parks and the adjacent areas of the Kafue Flats Game Management Area.

Economically, the Kafue Flats are of great importance due to the several major commercial activities that depend on water resources such hydropower generation, commercial farming and fishing. The generation of hydropower at the Itezhi-Tezhi and Kafue Gorge Dams accounts for more than 50% of the total national electricity production. The Flats further host large commercial farms including the largest sugar cane plantation – Nakambala – in Zambia which together with other out-grower schemes account for 89% of the country's total sugar production. In addition, the Kafue Flats have the largest population of livestock in the country, with particularly high concentrations in the Namwala, Itezhi-Tezhi, and Mumbwa districts, which are often referred to as the "livestock districts", accounting for 20% of the national herd. Lastly, the Kafue Flats fishery system has between 61 and 77 species of fish, of which about 21 species are commercially important, making the Flats one of the most important and productive fisheries in Zambia.

Institutional and legislative Arrangements for Water Resource Management

Most natural resources on the Kafue Flats are governed under varying pieces of legislation. Of particular relevance to this report, water resources are governed under the Water Resources Management Act of 2011. This piece of legislation provided for the establishment of the Water Resources Management Authority (WARMA), replacing the Water Board and the Department of Water Resources. The Act devolves authority to Catchment Management Councils (CMCs), Sub-Catchment Councils (SCCs), and Water User Associations (WUAs). The process of establishing these local institutions has begun in the Kafue Flats sub-catchment. Emerging issues from this process include:

- The delay in the establishment of institutional structures under the new Act. This has resulted in the expiry of the old water rights systems that were based on the Water Act of 1948. Some stakeholders raised concerns about the slowness of the bureaucracy in facilitating a transition.
- High operational costs of WARMA: WARMA is envisaged to be financed through water fees, permits, government grants, subventions, and donations. The estimated costs of running WARMA at full capacity is estimated to be between K21 million and K45 million subject to variations in staffing levels. Estimates from 2010 figures place annual revenue collection at K6 million (US$1.1 million using 2010 rates of exchange). Revising the pricing strategy and ensuring stringent verification of water use could potentially raise this to K15 million per annum. Revising the pricing strategy for water permits is seen as strategy to raise revenue to support the operations of WARMA. A number of stakeholders expressed the need for the process of revising the pricing strategy to take into the economics of water use, conservation imperatives and the cost-benefit implications faced by commercial water users.
- Clarity of institutional roles and responsibility: WUAs are platforms for water users to collectively manage water resources at a sub-catchment level. Other local platforms, such as Area Development Committees established under the national devolution policy, also provide for local decision making. As such, the establishment of WUAs should not be viewed to conflict with other specialised local institutions.

Water Availability on the Kafue Flats

Determination of water availability on the Kafue Flats requires consideration of the following parametres: hydro-meteorological networks supporting the water system; inflow of water into the systems; evaporation rates and return flows into the system.

- Meteorological stations are a mandate of the Department of Meteorology in the Ministry of Transport and Communications. Out of a total of 100 stations in the Kafue River Basin, 33 are operational with 6 located on the Kafue Flats, namely Kafue Hook, Nyimba, Namwala Pontoon, Kasaka, Chiawa, and Nanzila.

- Runoff data is collected and processed through the hydrometric network operated by WARMA under the Ministry of Energy and Water Development. The Zambia Electricity Supply Corporation (ZESCO) operates a number of stations on the Flats as well. With the exception of Magoye, no gauging stations are currently installed on the following tributaries of the Kafue River within the Kafue Flats: Nanzhila, Mwembeshi, and Nangoma. As such, it is very difficult to ascertain actual contributions of these tributaries to the flow in main river channel. It is also important to note that the Zambezi River Authority maintains the network downstream of the Zambezi River system.
- Inflows at ITT and outflows at KGD are assessed through the hydrometric network at the two dams. The gauging station at Kafue Hook Bridge is the most important in terms of measuring inflows at ITT, with average flows for the past 20 year estimated at 224m³/s. It is difficult to determine return flows on the Flats due to the limited monitoring capacity of the Department of Water Resource Development. Return flows for the middle basin are estimated at about 27 million cubic metres per year from urban, industrial, mining and, agriculture water use.
- Evaporation greatly influences water availability on the Kafue Flats. Studies estimated water loses from evaporation on the Flats at between 1,605 mm and 2,166 mm compared to the national average which stands at 2,061 mm. Evapotranspiration rates tend to be higher in areas with high occurrence of invasive species.
- Inflows are measured at several points including Namwala Pontoon Nyimba, Iolanda Lusaka Water Sewerage Company Pumping station, and Kafue Gorge Dam (KGD). Outflows into KGD were estimated at 289 m³/s for the year 2015.

Water Use on the Kafue Flats

According to the water licencing system operated by WARMA, major water uses on the Kafue Flats include: hydro-power, agricultural, domestic, industrial, and recreational.

- A network of dams and hydro-power turbines generate electricity for ZESCO at Itezhi-Tezhi (ITT) and Kafue Gorge Dam (KGD) producing 120 MW and 990 MW respectively. Plans are in place for an additional turbine expected to be completed by 2018 downstream of the Kafue Gorge to take advantage of the water releases from the Kafue Gorge Upper. Historic water allocation to hydro-power generation stands at 215m³/s, with a condition of minimal release into the river channel of 40 m³/s for downstream users (15m³/s) and habitat maintenance (25m³/s). At the peak of the rain season in March, ZESCO is expected to increase the minimal release to 300 m³/s over four weeks to mimic natural flooding patterns.

- Commercial sugar cane production is the second largest consumptive water use on the Flats. Although the Zambia Sugar company has its own plantations, it also outsources sugar cane farming through outgrower schemes consisting of groups of farmers that grow sugar cane according to the company's standards in return for a guaranteed price. The main outgrower scheme, the Kaleya Smallholder Company, has its own water rights of up to 1,600 m^3 per day, a target which is rarely exploited due to high infrastructure costs. Kaleya thus ends up relying on water from Zambia Sugar, which supplies 13,000 m^3 during peak period.
- Lusaka Water Sewerage Company (LWSC) is the major abstractor of water for domestic use. Its abstraction from the Kafue River accounts for 40–50% of the total water supplied to the city of Lusaka. Abstraction levels are expected to increase from approximately 660,000m^3/day to 920,000m^3/day due to the increasing population of Lusaka and its surrounding areas.

Projected Water Use and Demand on the Kafue Flats

Projected water use and demand are based on sector development plans, institutional expansion programs, and growth projections in the energy, water and agriculture sectors, with specific focus on the Kafue Flats.

- Projections show that domestic water abstraction will increase by more than seven times. Due to reducing quantities of ground water in Lusaka, efforts are been made to increase abstraction from the Kafue River.
- Increase in demand for water is expected to be higher in the agricultural sector than in other sectors such as mining, urban use, manufacturing, and finally rural water use.
- Demand for hydro-power generation in Zambia is expected to increase due to rapid urbanisation and expanding industries. At a regional level, a number of hydropower projects are proposed by individual states.
- Climate change and variability is expected to affect water availability in several ways: reduced dam inflows as a result of decreased rainfall; increased occurrence of flooding, resulting in the risk of infrastructure failure; and increased surface water evaporation due to extreme temperatures.

Conclusion

In conclusion, the key water security issues on the Kafue Flats include:

- Capacity of newly established institutional structures for water resources management: The water sector in Zambia has undergone a series of reforms aimed at enhancing water resource protection and management, leading to the enactment of the Water Resource Act of 2011. One of the major implementation challenges has been the high costs of establishing water management structures.

- Quantity, Quality, and Timing Matters: Whereas the quantity and quality of water resources matters for hydro-power generation, irrigation for agricultural use, and domestic water abstraction, the timing of availability is mostly significant in the context of water for the environment. The dynamic relationship between quantity/quality and timing of water resources has been a contentious issue among water users on the Flats.
- Human versus environment: Water resource planning tends to prioritise domestic water use over water for the environment. With projected increases in the frequency and intensity of extreme weather events associated with climate change and variability in Southern Africa, the balance between conservation and development could become an increasingly contentious issue.

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1. Introduction

It is becoming increasingly recognised that development and management of water resources is vital for social economic development and the eradication of poverty. Achievement of these intertwined societal goals depends largely on the extent to which a country can harness and develop its water resources and attain a desired state of being water secure (Grey and Sadoff, 2007). Several countries in Southern Africa are grappling with the task of balancing development of water resources and maintaining ecological integrity; this challenge is largely influenced by the hydrological environment of the country, socio-economic status, distribution of water resources, and development stage of a country (Lautze and Manthrithilake, 2012; WWF and AfDB, 2015). The majority of countries in Southern Africa are still at a stage where socio-economic priorities include institutional and infrastructural development (WWF and AfDB, 2015). The implication of this in regards to water resource management is that negotiations regarding trade-offs and costs that accrue from the economic utilisation of the resource are highly contentious. Zambia, like several other countries in the region, is navigating these trade-offs amidst several other pressures, including population growth, climate variability, and changing patterns of production and consumption, while also committing to the preservation of the environment (ECZ, 2008).

Compared to other countries in southern Africa, Zambia is endowed with more water resources. The nation's per capita water availability is 8,700 m^3 per year, which is almost 24% more than the average for southern Africa and 6% more than the global average (World Bank, 2009). The total surface water for Zambia is estimated at 105 km^3 per year, of which 25 km^3 is produced externally as transboundary water inflows into the country. Notably, the Zambezi River receives significant amounts of water resources from outside the geographical boundaries of the country (Nyambe and Feilberg, 2010). Although this is the case, the per capita water withdrawal is three times lower than the average water withdrawal in other developing countries (World Bank, 2009). Of the total water withdrawals for the country, three quarters are accounted for by the agricultural sector and the remainder is taken up by domestic and industrial uses, including mining and manufacturing (Nyambe and Feilberg, 2010). Utilisation of water resources in Zambia is greatly constrained by the uneven distribution of surface water and rainfall, which vary graphically and temporally, especially between the northern and southern regions of Zambia (JICA, 1995).

It is within this hydro-social context that the economy of Zambia functions and is envisaged to expand. The Revised Sixth National Development Plan (2012–2016) identified agriculture, energy, livestock, fisheries, and infrastructure development as the main growth areas for the country. Half of the ten priority areas identified fall under the hydrological boundaries of the Kafue River Basin. As such, water security issues, such as protection of vital aquatic ecosystems, availability of water resources for competing uses, and reduction of water related risks, are bound to take centre stage in the basin. This report highlights key water security issues on the Kafue Flats. The report is largely based on a desktop study that specifically draws attention to issues of availability and demand of water resources in the basin, competing users, institutional arrangements for water and associated resources in the basin, and proposed water use projects in the basin.

2. Dimensions of Water Security

For the purpose of this report, water security is defined as the sustainable availability of adequate quantities and qualities of water for resilient societies and ecosystems in the face of risks and uncertainty (Scott et al., 2013, Grey and Sadoff, 2007). Although water security is often conceived by some authors as an over-arching societal goal and management framework (Cook and Bakker, 2012, Lautze and Manthrithilake, 2012, Tarlock and Wouters, 2009), in this report it is conceptualised more or less as a paradigm. A paradigm refers to the mutually agreed 'lens' through which social actors including managers, practitioners, regulators, scientists, and water users determine how water resource issues are addressed, thereby reflecting their beliefs, values, and preferences (Pahl-Worstl et al., 2011). As such, a paradigm includes scientific discourse, social mental models, and governance discourse, as well as the inherent planning and management processes. Conceiving water security as a paradigm provides a deeper frame that enables the interrogation of vital aspects of water security assumed in the definition above. The Society-Science-Practice Trialogue presented below (Figure 1) is used to highlight some of these aspects.

Water security requires societal recognition of various water uses in order to promote equity, efficiency, and sustainability (Bakker and Morinville, 2013). This principally advocates for a balance between water for nature and water for people by recognizing the trade-offs between these uses (Grey and Sadoff, 2007). The principle therein is that water for ecosystem use is prioritised in water allocation planning. Often, the process of balancing water for the ecosystem and for people is perceived in terms of competing uses. As argued by Everard (2014), water security for the environment should be a rational action by society for the sake of the environment, which underwrites options and future opportunities for humanity to sustain its well-being. However, the reality is that governance discourses at a societal level often do not reflect this line of argument, thereby denoting the importance of dominant values and preferences that determine societal goals.

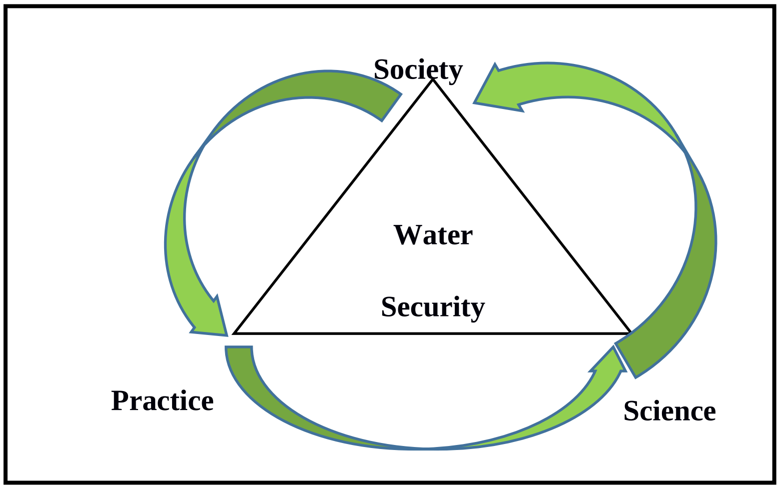

Figure 1: Society-Practice-Science Trialogue. Adapted from Scott et al. (2013) and Meisner and Jacobs (2016)

Although adaptive management and water security are often conceptualised as different management frameworks (Medema et al., 2008), Scott et al. (2013) integrate the two frameworks to emphasise the interaction between science, policy, and practice (Figure 1). In essence, adaptive management allows for interactive planning and knowledge-sharing between society and science in a responsive approach while taking into account societal and ecological resilience. Further adaptive management requires shared learning and response from all stakeholders, emphasising the polycentric governance approach (Bakker and Morinville, 2013). Using adaptive management as a lens to view water security highlights the need to consider the ontological and epistemological assumptions of science regarding the nature of a water resource problem (Pahl-Wostl et al., 2011). Epistemological and ontological assumptions determine the manner in which scientific discourse frames the problems associated with water resource management and the strategies aimed at addressing these problems (Pahl-Worstl et al., 2011). It is crucial that the nature of these problems and the underlying assumptions required to approach them is clear (Patterson, 1998). Ignoring these considerations can result in a disconnect between science and practice (Halbe, 2013).

The determination of acceptable quantity and quality of water resources required for water security is essentially a process in which stakeholders engage and negotiate on what is acceptable and what is not (Bakker and Morinville, 2013). The iterative process of continuously expressing, articulating, negotiating, and agreeing on quantity and quality demonstrates the contested nature of water resources and competing interests among users (Nkhata, 2010). Often, the interests of some negotiators are more dominant than others, requiring that those involved must interact to determine mutually acceptable standards and goals (Bakker and Morinville, 2013) .

3. Hydro-Ecological Description of the Kafue Flats

The Kafue River Basin extends over a total area of 155,948 km², covering almost 20% of the total land area of Zambia (AfDB, 2007). The river itself stretches a total distance of 1,200 km, starting in Zambia's North Western Province and draining southwards through the Copperbelt, Central, and Southern Provinces, before eventually reaching the Zambezi River (Gossert and Haugstetter, 2005) (Figure 2). The basin forms part of a larger basin that is drained by two of Africa's most important river basins: the Zambezi and the Congo. Although the Kafue River lies entirely within the geographical boundaries of Zambia, it is considered a vital sub-catchment of the Zambezi River Basin shared by eight other countries in the region (DHV, 1980).

Figure 2: Location of the Kafue River Basin. IWSN 2016

For ease of characterisation, the Kafue River Basin is categorised into three main regions: upper, middle, and lower (MEWD 2014). The Kafue Flats is a stretch of floodplain covering an area of approximately 6,500 km² and lies between the middle and lower Kafue basin, forming a broad alluvial stretch of meandering river, lagoons, marshes, levees, and oxbow lakes (Chabwela, 1986). The natural flooding of the Kafue Flats begins in December with the onset of the rainy season and is influenced by local inflows from tributaries, which account for approximately 30–60% of water resources on the flats. The main flooding occurs later in February and March as water flows from the upper and middle basins, starting from the western end and flowing towards the eastern part of the Flats.

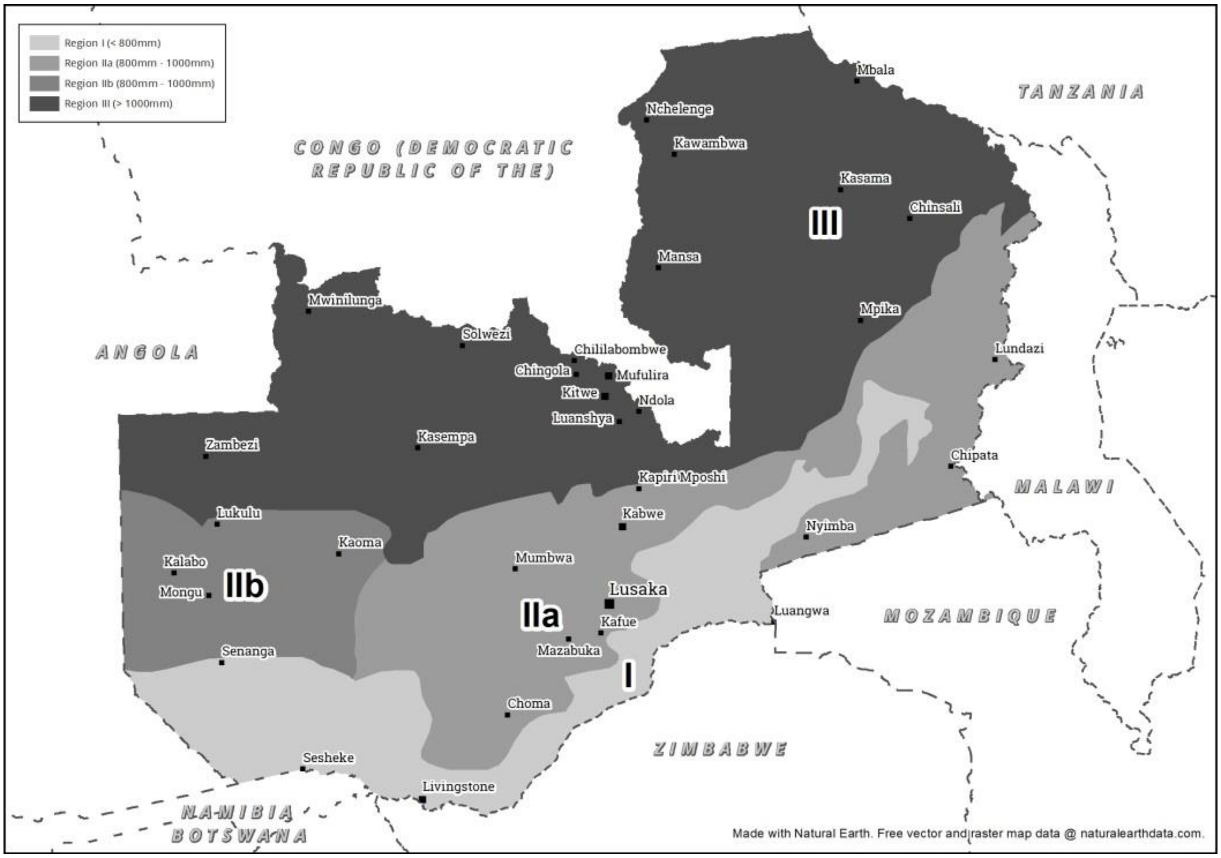

Figure 3: Agro-ecological regions of Zambia. IWSN, 2016.

There are three distinct seasons in Zambia: a rainy season in summer between November to April; a cool dry winter season from May to August; and a hot dry season from September to October (Thurlow et al., 2009). The country is divided into three agro-ecological regions that are defined by their dominant climatic patterns (Seigei, 2008). The Kafue Flats are located in Agro-ecological region IIa of Zambia (See Figure 3). Annual rainfall ranges between 1,300 mm in the north and 700 mm in the south, with a mean annual rainfall of 1,060 mm. The average temperature is 15–16 ºC in June/July and 24–25 ºC in October (MEWD, 2007).

The climatic patterns of the entire basin are influenced by the Inter-Tropical Convergence Zone (ITCZ) as well as the El Niño/La Niña Southern Oscillation phenomenon (GRZ, 2010, Chundama and Maseka, 2015). During summer months, the ITCZ is located north of the country and gradually moves south in the rainy season bringing with it large amounts of rain (FEWS, 2014). The El Niño Southern Oscillation results in drier than normal conditions in the rainy season in the southern part of the country whereas La

Niña causes the reverse: wetter conditions in southern region of the country (GRZ, 2010).

Vegetation in the basin consist of forests in the upper sub-basin, and woodlands, shrub, and grassland in the middle and lower basins as illustrated in Figure 4. The distribution of vegetation in the basin is a function of the distribution of soil type, rainfall, flooding, and human settlements along the basin. For instance, industrial plantations of eucalyptus in most parts of the Copperbelt and Central Provinces have replaced the natural woodlands. Towards the middle basin, the vegetation transitions into a combination of *Miombo* and mixed woodlands, thickets, and swamps (MEWD, 2007). In the lower basin, the river is bordered by levees, lagoons, and smaller channels that support aquatic plant species, such as water lilies and reeds. Other vegetation species include the invasive water hyacinth and *Mimosa pigra*. The floodplain grasslands and *Miombo* woodlands are mixed in some places with termitaria, *Acacia* species, and *Munga* woodlands (ECZ, 2008).

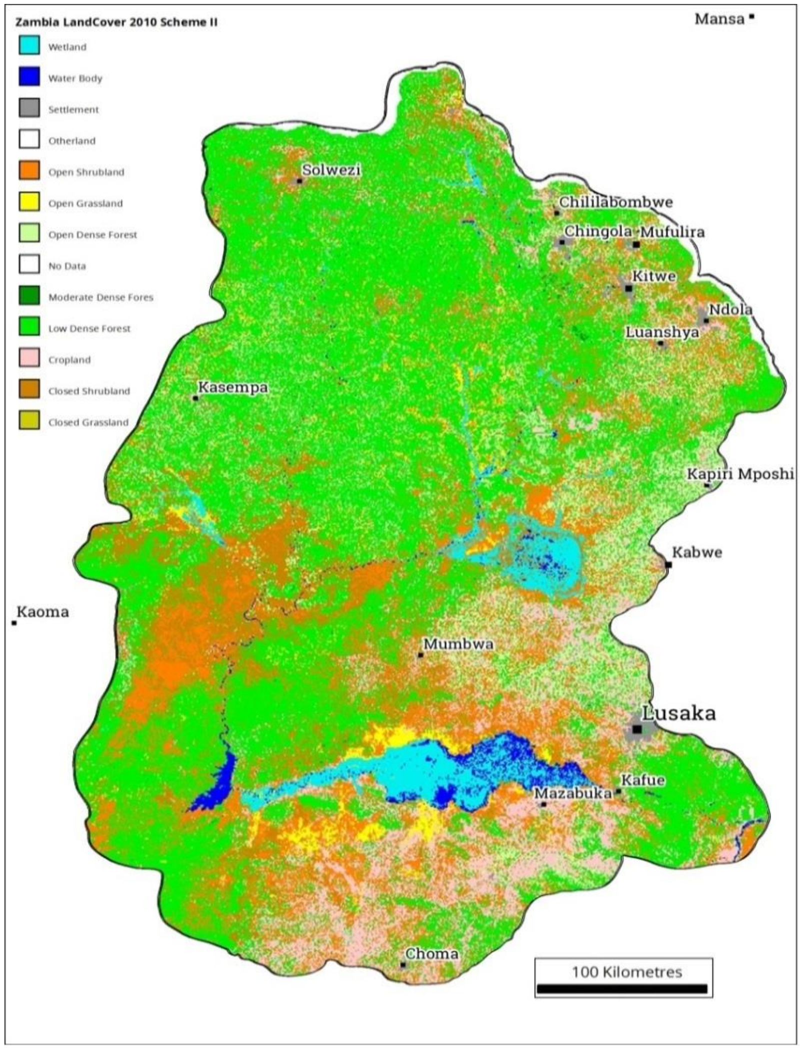

Figure 4: vegetation cover and distribution in the Kafue River Basin. IWSN, 2016.

The Kafue Flats as an important ecosystem provide a vital habitat for wildlife, including endemic species that utilise grassland on the plains, such as Kafue lechwe (*Kobus leche Kafuensis*), plains Zebra (*Equus quagga crawshayi*), Blue wildebeest (*Connochaetus taurinus*), and Oribi (*Ourebia ourebia*) (Shanungu et al., 2015). Towards the termitaria region, African buffalo (*Syncerus caffer*), Bushbuck *(Tragelaphus scriptus*), Impala (*Aepyceros melampus*), and Greater kudu (*Tragelapus strepsiceros*) can be found (Blaser, 2013). Bird species found on the Flats include the Wattled crane (*Grus caranculatus*) and the Grey crowned crane (*Balearica regulorum*). From an ecological perspective, the Kafue lechwe and crane species are highly sensitive to ecosystem disturbances and hence they are very vulnerable to changes in flood patterns on the Flats (Chabwela, 1986, Shanungu et al., 2015). The distribution of these endemic fauna is concentrated in the Lochinvar and Blue Lagoon National Parks and adjacent areas of the Kafue Flats Game Management Area (Figure 5).

According to the most recent National Census in 2010, the total population of Zambia was 13,092,666, with 60.5% living in rural areas and 39.5% in urban areas (CSO, 2012). The total population within the Kafue River Basin is estimated at 6,610,594, and represents more than 50% of the Zambian population (CSO, 2012; GIZ, 2013). The Kafue Flats is home to about 700,000 people engaging in various livelihood activities, such as cattle rearing, fishing, and exploitation of natural resources (GIZ, 2013). The main ethnic groups include Tonga, Illa, and Batwa under different traditional authorities including: Mwanachingwala, Choongo, Nalubamba, Musungwa, Mukobela, Shimbizi, Chiliabufu, Skakumbila, Mungaila, Hamosonde, and Muwezwa (GIZ, 2013). The population density is relatively high within the basin with a minimum of 5.8 persons per square Kilometre and a maximum of 100.1 persons per square kilometre (CSO, 2012). Although growth rates among the districts vary, the majority of the 27 districts within the basin show growth rates that are higher than the national growth rate of 2%. The high growth rates can be attributed to the major towns in the Copperbelt and Lusaka Provinces (GIZ, 2013). Growth rates that are below the national average in districts in the southern part of the basin are attributed to outward migration towards the North-Western Province, where the majority of the immigrants go to seek employment in the booming mining sector of the region (CSO, 2012).

4. Land Use on the Kafue Flats

4.1 Agriculture and Livestock

Agriculture is one of the most important livelihood strategies in the Kafue Basin, consisting of both commercial and small scale farming. Small scale farmers have estates of between 0.1 and 4.99 hectares, whereas medium scale farmers hold land between 5 and 20 hectares (GIZ, 2013). The predominant farming systems operated by small scale farmers include low input shifting and semi-permanent cultivation methods, which involve variations of ‘Chitemene’ and ‘Fundikila’ systems of agriculture that integrate crop and livestock farming extensively (MEWD 2012). Commercial farming on the flats occurs in the areas around Mazabuka and Kafue towns through mechanised farming methods. It includes a combination of sugar cane, maize, soybeans, wheat, cotton, tobacco, coffee, and other cash crops. Although pests, diseases, and seasonally varying rainfall are major constraints in commercial agriculture, the sector remains the dominant form of agriculture in the basin, accounting for 50,000 hectares of crop land (Uhlendahl, Salian et al. 2011).

The Kafue Flats have the largest population of livestock in the country, with particularly high concentrations in the Namwala, Itezhi-Tezhi, and Mumbwa districts, which are often referred to as the "livestock districts" of Zambia (Pegagys, 2016). Namwala district has the highest cattle population among the three districts accounting for 24.2% of the country's total livestock population, with almost 90% of locals engaging in cattle rearing (Musiwa, 2006). The traditional 'kuwila' method of livestock production is practiced on customary land as the floods recede from July to November (Gossert and Gaugstetter, 2005). Generally, flooding patterns affect the distribution of cattle rearing, with the majority of traditional cattle rearing taking place on the eastern part of the Kafue Flats as a result of the permanent inundation of the western part (Musiwa, 2006). According to Shanungu et al. (2015), the increasing interaction and competition between wildlife (such as *Kobus leche Kafuensis*) with cattle population have resulted in reduced capacity for grazing, increasing the risk of disease transfer. In addition, the expansion of irrigated agriculture for sugar cane and wheat production, as well as the presence of National Parks and Game Management Areas have greatly constrained and reduced the movement of traditional cattle (Gossert and Haugsetter, 2005). Traditional livestock production is increasingly vulnerable to climate change and ongoing ecological effects of the Itezhi-Tezhi (ITT) and Kafue Gorge (KGD) dams (Pegasys, 2016).

4.2 Fishing on the Kafue Flats

Fishing is undertaken for both subsistence and commercial purposes. Major towns, such as Lusaka, Mazabuka, and Kitwe provide a healthy market for fish stocks harvested from the Kafue River (Cowx et al., 2011). The Kafue Flats fishery system has between 61 and 77 species of fish, of which about 21 species are commercially important, making it one of the most important and productive fisheries in Zambia (Cowx et al., 2011). Fish yields on the Flats has fluctuated in recent years, with an average yield of 6,000 tonnes per year (Chabwela, 1986). Compared to other fishery systems, such as the Lukanga in Central Province, Bangweulu in Northern Province, and Mweru in Luapula Province, the yield of the Kafue Flats fishery system is dropping significantly (Cowx et al., 2011). Chabwela and Haller (2010) attribute this to over-fishing exacerbated by governance failure, the inability of local institutions to enforce regulations, and increased pressure from immigrant fisher-folk.

The majority of fishing on the Kafue Flats is undertaken by immigrant fishing communities from the Northern and Western Provinces (Chabwela and Haller, 2010). The majority of ethnic tribes on the Flats, including the Illa and Tonga, rank fishing activities second as a livelihood option (Ndalama, 2004). There are at least 11 major permanent fishing camps on the floodplain, each supporting 500 or more fishers (Chabwela and Haller, 2010). During the dry season, large temporary fishing camps are established that are occupied by more than 900 households (Haller and Merten, 2008). Bene et al. (2010) suggest that people living adjacent to the floodplain are better off compared to those in surrounding areas, this is most likely because their lifestyle combines cropping, livestock, and fishing, and benefit from flooding. It is estimated that, for these people, fishing contributes as much as 50% to their total household income per month; for many it is their main source of household income. These observations highlight the importance of environmental flow releases in both aquatic and agricultural production systems (King and Brown, 2010; Ratner et al., 2012; GIZ, 2013).

4.3 Institutional Arrangements for the Kafue Flats

The Kafue River Basin has a large network of protected areas (See Figure 5), including national parks, forest reserves, wildlife sanctuaries, and game management areas (World Bank, 2009). National parks occupy state land that is completely under the authority of the Department of Wildlife and National Parks, whereas Game Management Areas (GMA) is customary land. The wildlife in Game Management Areas is co-managed with local communities from surrounding areas. There are two main national parks on the flats: the Blue Lagoon National Park and the Lochinvar National Park. Although the Kafue National Park (the second largest national park in Africa, located on the western part of the Kafue Flats) does not form an essential part of the Kafue Flats, it is of great ecological importance to the entire basin as well as the Flats (Chundama and Maseka, 2015). The Lochinvar National Park is a relatively small park (approximately 400 km^2) situated on the southern bank of the Kafue River; it is one of the closest parks to the Zambia's capital, Lusaka (ZAWA, 2005). The core purpose of the park is the conservation and protection of the endemic Kafue lechwe and the diverse species of bird that inhabit the wetland ecosystem. Although these species provide the park with great potential for tourism, operational and administration challenges limit it to focusing on its core function of biodiversity conservation (ZAWA, 2005). It has been suggested that current efforts to refurbish the only lodge in the park and to control invasive species (*Mimosa pigra* and *Dichrostachys cinerea)* in the park will have a positive impact in improving the image of the park as a tourist attraction. Other management issues facing the park include encroachment by local communities and increased human activity near the park, changes in vegetation as a result of altered flooding patterns, unstainable fishing practices by temporal fishing camps (for instance those near Chunga lagoon to the north of the park), and limited and inadequate human resource (Chabwela, 1986, ZAWA, 2005).

The Blue Lagoon National Park (estimated at 450 km²) is located on the northern banks of the Kafue River and is slightly larger than Lochinvar (WWF, 2000). The more important fauna in the park include the Kafue lechwe, the Wattled crane, and the Zambian barbet (formerly known as the charplin barbet) (*Lybius chaplini*) (Shanungu et al., 2015). Both national parks are recognised as wetlands of international importance and were designated as Ramsar sites in 1991 under the Convention on Wetlands (Mumba, 2000). Major management problems in the park include unclear park boundaries, limited and inadequate human resources, illegal poaching, limited accessibility, and limited co-management of wildlife with local communities (ZAWA, 2004). These issues are exacerbated by the absence of a management plan for the Kafue Flats Game Management Area adjacent to the two national parks. In their recommendations, Shanungu et al. (2015) suggest merging the two national parks to create what could be referred to as the "Lechwe National Park".

Figure 5: Protected Area Network on the Kafue Flats. IWSN, 2016

The different protected area categories on the Kafue Flats mean that different sector legislations govern particular resources. This is often cited as one of the major institutional challenges for natural resource management on the Kafue Flats, as the overlap in institutional jurisdictional creates lack of clarity in institutional roles and mandates. Table 1 outlines the legal and institutional framework for natural resources on the Kafue Flats.

Table 1: Legal and institutional outline for selected natural resources

Legislation	Mandate	Institution
Environmental Management Act of 2011	Protect natural environmental through regulation and control of pollution for welfare of human, flora and fauna.	The Zambia Environmental Management Agency (ZEMA)
The Forest Act of 2015	Provides for the conservation, use and development of forests and trees for sustainable forest management.	The Forest Department working through decentralised offices and local communities living near forests.
The Water Resource Management Act of 2011	The Act establishes the Water Resources Management Authority (WARMA) for the conservation, management and development of water resources in Zambia	WARMA and its decentralised catchment and water user associations in the defined hydrological catchment.
The Zambia Wildlife Act, 2015	To conserve and management wildlife in national parks, game management areas and bird sanctuaries for purposes of enhancing and conserving wildlife. Under the new act, fisheries in National Parks is under the jurisdiction of NPWD	Devolved Zambia Wildlife Authority (ZAWA) established under the old Act of 1998 and established the National Parks and Wildlife Department.
Fisheries Act of 2011	Provides for the control, conservation and development of fisheries resources in Zambia.	The Fisheries Department. A subsequent policy provides for the establishment of fisheries management committees with local communities. The challenge has been in establishing and implementing local communities committees.
National Heritage Conservation Act of 1989	Protection of heritage, archaeological sites	The National Heritage Conservation Commission.

The Water Resources Management Act enacted in 2011 is of particular relevance to this report. This legislation established the Water Resources Management Authority (WARMA), which incorporates the functions previously performed by the Water Board and the Department of Water Resources (now referred to as the Department of Water Resources Development). For various reasons, the Act is hailed as an innovative piece of legislation, taking into account current discourse on adaptive management of water resources and participatory water governance. For instance, the new permit system for water abstraction which replaced the old system of water rights, allows water users to adjust their permits according to volumetric water use, availability and demand of water resources. In addition, the act enables the establishment of Catchment Management Councils (CMCs), Sub-Catchment Councils (SCCs), and Water User Associations (WUAs). According to the Act, WUAs are responsible for developing management plans and water allocation budgets and provide a platform for decision making at user level, among other functions. Water permits are approved at the national level upon recommendation by WUAs and CMCs (GRZ, 2014).

The national process of establishing CMCs and WUAs has started in three basins including on the Kafue (Jani, 2016). For the Kafue Basin, three establishment meetings were held in three towns: Kitwe in the upper catchment, and Choma and Kalomo in the lower catchment. Meetings are also planned in Mazabuka in the middle catchment (Jani, 2016). Some of the issues emerging from these meetings include:

- The time lag between the enactment of the Water Resources Act of 2011 and the establishment of WARMA resulting in the expiry of the old water rights systems that were based on the Water Act of 1948.
- Operational costs of WARMA: Stakeholders raised concerns regarding the risk of "taxing" a water user who constructs a dam that benefits other water users such as communities downstream, as the farmer up-stream is the only one who bears the costs through paying for water use to WARMA. This could reduce the incentive for commercial farmers to invest in water resources management as the cost of conducting business becomes exponentially high. It is thus important that the pricing strategy takes into account the nuances underlying the economics of water use, conservation imperatives and the cost-benefit implications faced by the water user. WARMA is envisaged to be financed through fees, water permits, government grants, subventions, and donations. The estimated costs of running WARMA at full capacity is estimated to be between K21 million and K45 million subject to staffing levels (RSU, 2012). Estimates from 2010 figures place annual collection at K6 million (US$1.1 million using 2010 rates of) (GIZ, 2013). Revision of fees, registration, and verification of water use could potentially raise

this to K15 million per annum (Reini, 2013).

- Clarity of institutional roles and responsibility: WUAs are platforms for water users to collectively manage water resources at a sub-catchment level. While other local platforms such as Area Development Committees and similar local institutions in other sectors provide local decision making, WUAs are specialised local platforms for water resource management issues and are designed to address water use related issues on a frequent basis. As such, members from other local user platforms could still be members of WUAs.

5. Water Availability on the Kafue Flats

Determination of availability of water resources on the Kafue Flats requires a consideration of the following: inflow of water into the system at Itezhi-Tezhi (ITT); inflows from tributaries within the area; evaporation from the two reservoirs (ITT and KGD); from open waters, rainfall contributions; return flows into the system, and the hydro-meteorological network supporting the system. These factors, as well as their implications for water availability on the Kafue Flats starting with the hydro meteorological network, are highlighted below.

Meteorological stations are operated by the Department of Meteorology in the Ministry of Transport and Communications. Although there are close to 200 stations in the country, only 50 are operational (DHV, 2004). As a result of their proximity to the floodplain, the most important stations include Mumbwa, Kafue Polder, and Magoye (Chibuye, 2008). Out of a total of 100 stations in the Kafue River Basin, 33 are operational with 6 occurring on the Kafue Flats, namely Kafue Hook, Nyimba, Namwala Pontoon, Kasaka, Chiawa, and Nanzila (Chibuye, 2008, Jani, 2016). Runoff data is collected and processed through the hydrometric network operated by WARMA under the Ministry of Energy and Water Development. The Zambia Electricity Supply Corporation (ZESCO) operates a number of stations on the Flats as well. Once information is collected, it is sent to Lusaka and entered into the HYDATA database (DHV, 2004). With the exception of Magoye, no gauging stations are currently installed on the following tributaries of the Kafue River within the Kafue Flats: Nanzhila, Mwembeshi, and Nangoma. This makes it very difficult to assert actual contributions of these tributaries into the main river channel (Chibuye, 2008). It is also important to note that the Zambezi River Authority maintains the network on the Zambezi River system upstream of the Kariba dam (Chibuye, 2008).

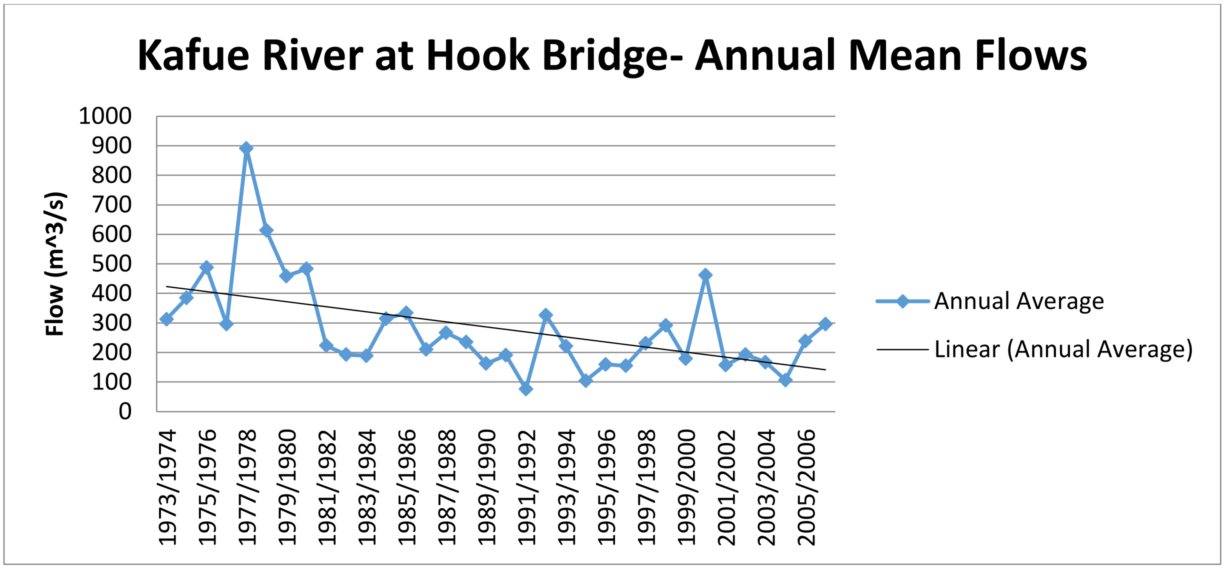

Figure 6: Mean flows at Kafue Hook Bridge for a 30 year period (1973–2006). Source: Department of Water Affairs

Inflows at ITT and outflows at KGD are assessed through the hydrometric network. Although variation occurs, the difference in rainfall can be attributed to the topography of the area (IH, 1994). The gauging station at Kafue Hook bridge is the most important in terms of measuring inflows at ITT, with average flows for the past 20 year estimated at 224 m^3/s (Chibuye, 2008, ZESCO, 2016). Flows start to increase in December and reach peak levels in March followed by a steady decrease from May to November. Return flows on the flats are not well documented as a result of the limited monitoring capacity of the Department of Water Resource Development. However, previous assessments by the then Water Board estimated return flows from the Zambia Sugar Company's Nakambala Estate at 2.1% of the total allocated water (Chibuye, 2008). Personal communication with a representative of Zambia Sugar pegged return flow at 1% of the total allocated quantity. Return flows for the middle basin are estimated at about 27 million cubic metres per year from urban, industrial, mining and, agriculture (GIZ, 2013).

Evaporation plays a significant factor in determining water availability on the Kafue Flats. High evaporation rates are attributed to the flat topography of the area (IH, 1994). Several studies have been undertaken on evaporation rates on the Flats: DHV (1980) and SHLP (1990) estimated it at 1,745 mm and 1,605 mm respectively, whereas JICA (1995) estimated evaporation rates in open water to range between 1,902 mm and 2,166 mm with the national average standing at 2,061 mm. Evapotranspiration rates (the combined effect of evaporation and plant transpiration) tend to be higher on average, leading to significant implications in water losses due to the increase in invasive species such as Water hyacinth *(Eichhornia crassipes)* on the Flats (Chibuye, 2008).

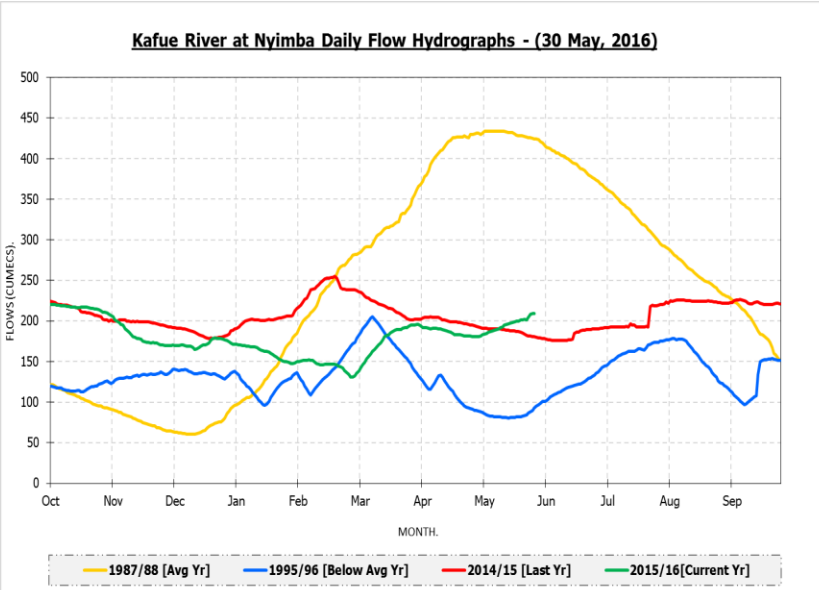

Figure 7: Daily Hydrographs at Nyimba gauging station. Source: ZESCO

Inflows at KGD are largely influenced by the evaporation rates, abstraction levels among users, and drainage patterns of the area (King and Brown, 2015). Flows into KGD are measured at several points of the hydrometric network, in particular at Namwala Pontoon Nyimba, Iolanda Lusaka Water Sewerage Company Pumping station, and KGD itself. Figure 7 illustrates the monthly mean flows for average years, below average years, and the last two years. Outflows into KGD include total flows of spillage at the dam. Turbine flows were estimated at 289 m^3/s for the year 2015 (ZESCO (2016).

6. Water Use and Demand on the Kafue Flats

Water demand refers to the total volume of water that is allocated and required to meet a specific requirement or use. According to the water right record managed by the Department of Water Affairs through the then Water Board, Kafue Flats has 64 valid water users of the following types: hydro-power, agricultural, domestic, industrial, and recreational (GIZ, 2013). Domestic water abstraction and water for agricultural irrigation are considered as consumptive use, whereas hydro-power generation and environmental protection are considered as non-consumptive (MEWD 2012).

6.1. Hydro-Power Generation

Hydro-power generation was one of the earliest major water uses in the Kafue River Basin. A network of dams and hydro-power turbines provide infrastructure for generation of electricity for ZESCO. Currently, the utility company operates water dams and turbines at ITT and KGD, with installed capacities of 120 MW and 990 MW respectively. A further turbine is planned downstream of the Kafue Gorge Lower to take advantage of the water releases from the Kafue Gorge Upper. This is expected to be completed by 2018. ZESCO project that there will be little impact on water availability as a result of the expansion projects on the Kafue River (Chizinga et. al. 2015).

The allocation for ZESCO stands at 215 m^3/s, with a minimal release into the system of 40 m^3/s for downstream users and habitat maintenance broken down as 15m³/s and 25m³/s respectively (King and Brown, 2015). The historical water rights ZESCO hold are based on a condition to release a further 300 m³/s for four weeks in March as a “freshet” to mimic natural flooding patterns (DHV, 2004). This condition was incorporated into dam operating rules referred to as Swedish Consultants (SWECO) rules at the time of completion of the dam in 1977 (King and Brown, 2015). In practice, dam releases tended to be higher than normal in the dry season, with lower and shorter releases in the wet season, resulting in decreased flooding at the western end of the flats (King and Brown, 2015, COWI, 2009). The freshet release was not adhered to in the 15 years of operation under the SWECO rules. King and Brown (2015), reported mean releases of 464 m³/s across this entire period. The SWECO dam operating rules were enforced from 1977 to 1994.

Over the years, the operating rules for the two dams have been through a number of changes. In 1994, new Southern African Development Community (SADC) rules were introduced that emphasised flow releases for hydro-power generation as a priority in response to the severe droughts of 1990/91. Essentially, the SADC operating rules had a lower rule curve for both reservoirs indicating minimum water levels throughout the year and emphasising power generation (King and Brown, 2015). No efforts were made to mimic natural flooding patterns on the wetland during the flood months under the SADC operating rules. This is evident from an examination of Figure 8 that shows a steady release between inflows under the curve line for 1995/6. Under this period, dry season flows had a maximum of 280 m³/s and wet season flows had a minimum of 96 m³/s. Operational strategies were recommended, with the aim of maximizing storage of water in the wet season and releases of water for hydropower generation in the dry season.

Against this background, between 2002 and 2003, the World Wide Fund for Nature (WWF) facilitated a tripartite agreement between ZESCO, Ministry of Energy and Water Development (MEWD) and WWF for improved operating rules. Improved dam operating rules were developed under simulation models to maximise hydro-power while ensuring “Freshet” releases in March. However, due to concerns over the accuracy of the models and simulation, the improved rules were not adopted (DHV, 2004). WWF Zambia is still working with ZESCO to address these concerns and improve the simulation models. Currently the dam operating rules are such that flows are maintained between 120–150 m³/s in the dry season in order to maintain the firm power generation.

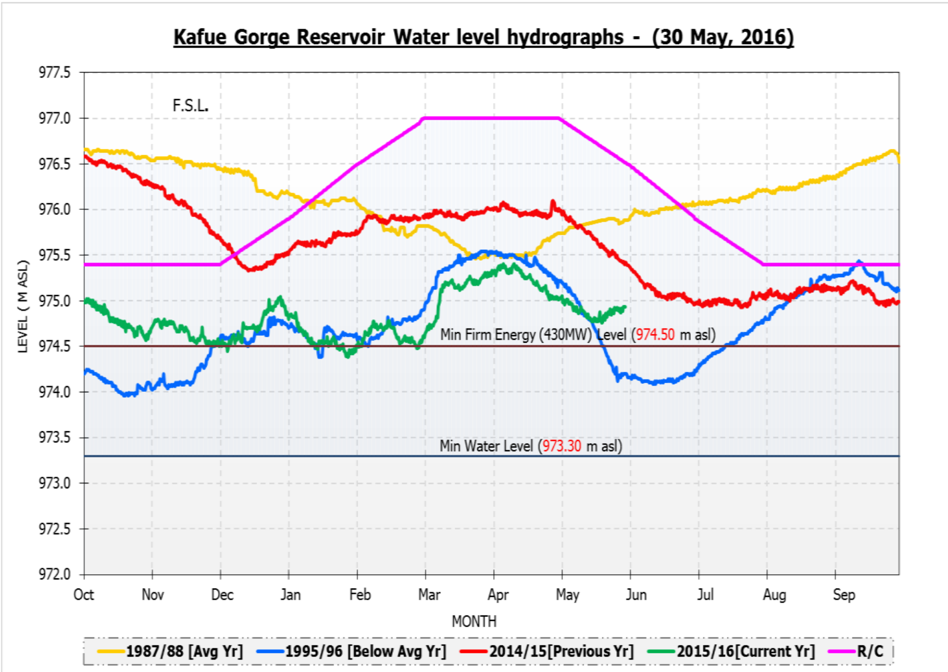

Figure 8: Kafue Gorge Dam Hydrographs. Source: ZESCO, Hydrology Department

In cases where water levels in the Kafue Gorge Reservoir drastically reduce, flows are released from ITT to meet hydro-power generation targets, with flows reaching 500 m^3/s. Since the installation of the Itezhi-Tezhi power turbine, dam releases are undertaken on a diurnal peaking demand regime with variable releases of water for 8 hours and 16 hours of base generation in a day (GIZ, 2013). Minimal impacts on downstream users and the ecosystem are expected under this regime (Chizinga et al., 2015). In their assessment, ZESCO (2004) noted an increase in water level of 1.4 m downstream of ITT and expected a reduction of 0.1 m at Namwala. The potential impacts of this include drowning cattle in Namwala, necessitating the need for robust communication mechanisms with local communities downstream.

The construction of the ITT and KFG resulted in the alteration of the flooding patterns on the Kafue Flats. The operation of the upstream reservoir reduced inflows to the flats during the wet season and increased outflows during the dry season. The Kafue Flats is one of the most researched ecosystems in Zambia, with studies going back as far 1977 under the University of Zambia's Kafue Basin Research Project. A number of studies have explored the hydrological changes as a result of the dams and their impact on wildlife habitat (Chabwela and Ellenbroek, 1990, Chabwela and Haller, 2010, Godet and Pfister, 2007, Gossert and Haugstetter, 2005, McCartney and Carr-Houghton, 1998, Mumba, 2000, Nalubamba, 1978, Sheppe and Allan, 1985, Turner, 1984). These studies indicate the following major effects of hydro-power generation on wildlife habitats:

- A permanently inundated region in the central eastern area that is caused by a back-water effect.

The back-water effect further resulted in a permanent lagoon in the north of the Lochinvar National Park (known as Chunga Lagoon) that occupies 40% of the park (DHV, 2004).

- Encroachment of *Mimosa pigra* distributed along Chunga Lagoon in the northern half of the park. This invasive species reduces access of the Kafue lechwe to shallow water on the flats, as well as reducing habitat for Wattled cranes (Shanungu et al., 2015). This has also resulted in the encroachment of the grassland region of the flats by *Dichrostachys cinerea* from the termitaria region (DHV, 2004).

6.2. Irrigation Sugar Cane Agriculture

Three companies dominate the sugar industry in Zambia: the Zambia Sugar Company (ZS), Consolidated Farming Limited (CF), and Kasama Sugar.These companies contribute 89.6%, 9.8%, and 0.4% respectively to national sugar production (Parlem et al. 2010). The water allocations for these and other sugar cane growers are illustrated in Table 2. Water abstraction for sugar cane irrigation is the second largest consumptive water use on the Kafue Flats. The sector contributes 3–4% to Zambia's Gross Domestic Product (GDP) and employs approximately 11,000 people within the sector value chain (COWI 2009). The Kafue Flats hosts one of the largest sugar cane commercial farming areas in Africa,the Nakambala Sugar Estates, located in Mazabuka and owned by Zambia Sugar Plc. The major sugar growing areas owned by ZS are located at the lower end of the Kafue Flats, while the other outgrowers are situated on the southern banks near Mazabuka. CF mainly operates on the northern banks (COWI, 2009).

Table 2: Water allocations for sugar cane growers. Source: Parlem et al. (2010)

Water user	Area (Ha) under sugar cane	Area under furrow irrigation	Area under center pivot	Water Rights Allocated	
				m^3/day	m^3/s
Zambia Sugar (ZS)	16, 500	10,916	5,584	1,246,428	14.4
Outgrowers under ZS	7, 724	3,126	4,598	575,540	6.7
Consolidated Farming (CF)	7, 430	0	2,898	515,000	6.0
Outgrowers under CF	0		0	-	-
Kalungwishi Estate	400	0	400	-	-

Although the Zambia Sugar company has its own plantations, it also outsources sugar cane farming through outgrower schemes consisting of groups of farmers that grow sugar cane according to the company's standards in return for a guaranteed price. Out-growers receive agribusiness support and logistical services (Bangwe and Van-Koppen 2012). The Kaleya Smallholder scheme is a major out-grower scheme that was initially established to expand production of sugar at the Nakambala Sugar Estate (Parlem et al. 2010; Bangwe and Van-Koppen 2012). This scheme supplies about 2,156 ha of sugar cane, of which half is grown by 161 smallholders while the remainder from an estate company called the Kaleya Smallholder Company (Bangwe and Van-Koppen 2012). Although the Kaleya Smallholder Company has its own water rights of up to 1,600 m^3 per day, it does not exploit this due to the high infrastructure costs and thus relies on water from Zambia Sugar, which supplies 13,000 m^3 during peak period (Bangwe and Van-Koppen 2012). With the proposed expansion of operations by Zambia Sugar, two other schemes are being set up, including the Magobbo Cane Growers Association (MCGA) and the Manyonyo Water Users Association (Parlem et al. 2010).

A number of studies have explored options for expansion of land under irrigation ((COWI (2009), Parlem et al. (2010)). The salient findings of these studies pertain to the potential for expansion under a moderate expansion of the hydro-power dam infrastructure. Under this scenario, cane irrigation could be expanded to 36,000 ha (COWI, 2009). Generally, these studies suggest expansion of irrigation farming under the premise of low power demand and moderate generation of hydro-power.

Due to the limited capacity of WARMA to monitor water abstractions, illegal abstractions and over-abstractions pose potential risks for hydropower generation whereby power simulations are done based on water releases at the Itezhi-Tezhi Dam (Chomba et al., 2015). According to the legislation, all water users are required to submit monthly abstractions to WARMA. Discussions with ZESCO revealed that Zambia Sugar submit monthly abstraction figures.

The most apparent externalities between hydropower generation and sugar irrigation farming includes: decreased supply of steady flow of water resources as a result of the damming and potential risk of over-abstraction. Dam release schedules correspond well with the water requirements of sugar cane especially during the dry season. Without the dam, seasonal variability would have been a constraint to sugar cane production (Parlem et al., 2010). In years of low water levels in the reservoirs, irrigation farmers have had to sink their pumps lower to maintain pump pressure and avoid damage to the pumps.

6.3. Domestic Water Abstraction

The Lusaka Water Sewerage Company (LWSC) is the major abstractor of water for domestic use in Lusaka and surrounding areas (Parlem et al, 2010). The commercial utility company supplies water to Lusaka and surrounding towns, such as Kafue, Chilanga, and Chirundu, through a mix of ground water and surface water abstractions from the Kafue and Zambezi rivers. Chirundu is supplied through water abstraction from the Zambezi River. Water abstraction from the Kafue River represents 40–50% of the water supply, while the rest of the supply is met through bore holes (PEGASYS and WWF, 2016).

Figure 9: Water abstraction point for Lusaka water and Sewerage Company from Kafue River. Photo credit: Machaya Chomba

The increasing population of Lusaka and its surrounding areas are expected to lead to a drastic increase in demand for domestic water. Coupled with variability in ground water resources, this has led the LWSC to expand its operations with the support of international partners such as the Chinese government through various funding mechanisms and United States Government through the Millennium Challenge Account. Two further water pumps are expected to be operational by 2018, alongside infrastructural upgrades at the existing station (Personal communication[1]). This means that water abstraction from the Kafue River will increase from approximately 660,000 m³/day to 920,000 m³/day (MCC, 2011). The company's major operational risks are effluent discharge from surrounding industries in Kafue and land use practices in some tributaries that increase the cost of processing raw water from the Kafue River. Thus, up-catchment land management poses both quantitative and qualitative challenges to water security of the Kafue River.

6.4. Waste Water and Effluent Discharge

The main sources of pollution in the Kafue River Basin include effluent discharge from mining activities in the Copperbelt Province, agricultural activities through nutrient loading from agricultural activities, sewerage discharge in the river, and effluent discharge from industrial processing activities (Alsterhag

[1] Personal communication with a representative of the Lusaka Water and Sewerage Company in Kafue.

and Petersson, 2004). A number of industrial and chemical processing companies release effluent into the Kafue River within the geographical boundary of the flats. These include: Nakambala Sugar Estate, Kafue Sewerage Treatment Plant, Nangongwe Maturation Ponds, Kafue Fisheries, and the Kafue Industrial Area (Alsterhag and Petersson, 2004). Chemicals and pesticides are the main sources of agro-based pollution and lead to increased amounts of nutrients and heavy metals in the system. Although the amounts of nutrients in the Kafue Flats is generally low, which is attributed to the filtering role of the wetland, studies such as that by Sichilongo and Torto (2006) have found significant concentrations of contamination in the fauna and flora of the Kafue Flats. Alsterhag and Petersson (2004), attributed the increased occurrence of water hyacinth downstream to the waste water discharge by Zambia Sugar. Zambia Sugar releases approximately 8,541,200 m^3/year of effluent into the natural environment (Illovo Sugar, 2004). Communications with Zambia Sugar indicate that a large amount of the waste water is treated and reused in the operations of the company.

6.5. Wildlife habitat and Local Livelihoods

The most significant human activities involving wildlife (particularly the Kafue lechwe) are fishing and cattle rearing (Figure 10). Interactions between wildlife and local communities mostly occur in the areas surrounding the Lochinvar and Blue lagoon National Park. During the dry season, when floods recede, the Kafue lechwe move near the main river channel, thereby exposing themselves to human conflicts associated with fishing and cattle grazing areas as shown in Figure 10. It should be noted that the area between the national parks is a Game Management Area in which fishing and cattle grazing are permitted. No General Management Plan exists for the area.

The main sources of conflicts between wildlife and humans are poaching and competition for grazing land between commercial farmers and local communities (Simasiku, 2002). This was part of the rationale behind the project led by the WWF in establishing a conservancy for wildlife protection and conservation involving local communities, commercial farmers, and tour operators (DHV, 2004). Concerns regarding poaching by local communities in commercial farms are still an issue, albeit not such contentious one.

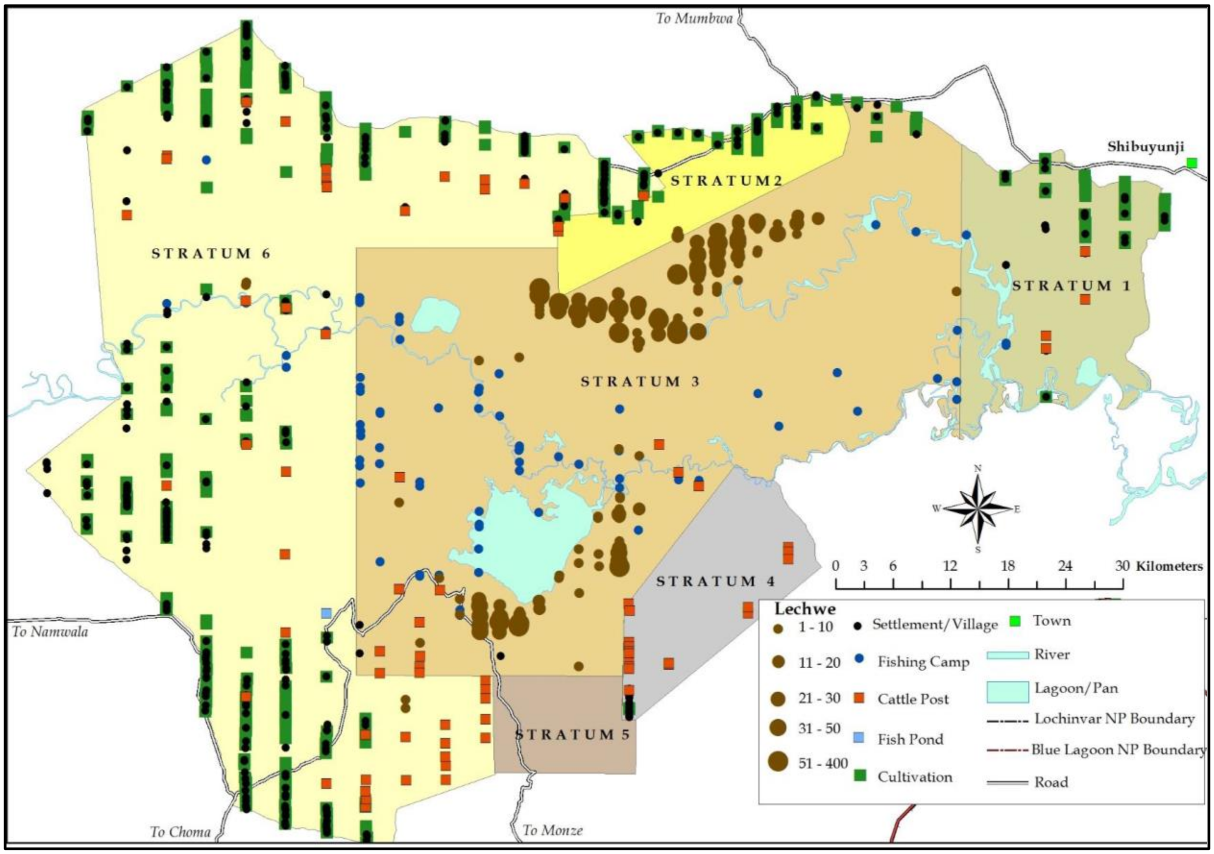

Figure 10: Distribution of Kafue Lechwe, Cattle posts, fishing posts, and settlements. Source: Shanungu et al. (2015).

7. Projected Water Use and Demand on the Kafue Flats

It is very difficult to determine projected water use and demand scenarios for the flats due to the limited platform for sharing information among water users regarding proposed projects and developments (Parlem et al., 2010). As such, estimates for projected water use and demand are based on sector development plans, institutional expansion programs, and growth projections in the energy, water and agriculture sectors, with specific focus on the Kafue Flats. Planned developments on the Kafue Flats are largely represented by hydro-power; irrigation, and domestic water. In 2011, the Ministry of Energy and Water Development indicated that projected water use would result in a balance of 4.63 Million Cubic Metres/day (MCM/day) against existing consumptive use, which totalled 4.22 MCM/day. Proposed developments could exceed available water resources. Expectations are that CMCs and WUAs will help in developing water budgets for sub-catchments. Although GIZ (2013) indicated the existence of a moratorium on issuance on water permits until a detailed water balance is done, water permits are still granted in some sub-catchments in the Lower Kafue.

Table 3: Planned projects in the Kafue River Basin. Source: Chundama and Maseka (2015)and GIZ (2013)

Name of Project	Purpose	Location Sub-basin	Abstraction/Use Volume (Mm^3/year)
Proposed Dam	Irrigation supply	Upper Kafue	4.0
Kafue Gorge Lower	Hydro power generation	Lower Kafue	2,786.5
Ithezhi-Tezhi Hydro Power Plant	Hydro-power generation	Middle Kafue	2,625.6 to 5,251.2
Upgrading Iolanda Water Works + new treatment plant by 2035	Domestic water supply	Middle Kafue	295.7
Chiyanshi Irrigation project, Chanyanya	Commercial/irrigation farming	Middle Kafue	13
NegaNega (small Scale Irrigation Project)	Irrigation of 595 ha	Middle Kafue	8
Mungu Farm Block agriculture (development 100,000 ha)	Sprinkler irrigation, furrow and treadle pumps	Middle Kafue	1,350
Machiya Farm Block (agriculture development 100,000) ha	Sprinkler irrigation, furrow and treadle pumps	Upper Kafue	1,368
Lunfwanyama Farm Block (agriculture development 100,000 ha)	Sprinkler irrigation, furrow and treadle pumps	Upper Kafue	1,368
Solwezi Farm Block (agriculture development 100,000 ha)	Sprinkler irrigation, furrow and treadle pumps	Upper Kafue	942

It is also important to consider the projected increase in water abstraction for domestic purposes that is summarised in Table 4. Projections show that domestic water abstraction will increase by more than seven times under the support of donor agencies at Iolonda water works by the Lusaka Water and Sewerage Company (GIZ, 2013). Notably, current water supply for domestic purposes is partly met through ground water abstraction. As a result of variations in water availability in the main aquifers in Lusaka, the largest utility company in Lusaka is migrating towards abstraction from the Kafue as a more reliable source of raw water. The increasing population and urbanisation in Lusaka and surrounding areas make it possible that demand will exceed the projected figures.

Table 4: Projected water demand for the Kafue River Basin. Source: GIZ (2013)

Sector	Water Demand (MCM/year)		
	2013	2015	2020
Urban	191	201	222
Rural	29	31	36
Mining	156	180	255
Manufacturing	112	136	218
Agriculture/irrigation	1,022	1,303	2,390
Total	1,510	1,851	3,121

Table 4 indicates that demand for water abstraction is expected to see the largest increase in the agricultural sector, followed by mining, urban use, manufacturing, and finally rural use. Regions with high projected demand for water include: agricultural and irrigation demand in the Mazabuka area extending towards Kafue, Choma, and Chirundu in Southern Province; domestic demand in the Lusaka, Chilanga, Chongwe, and Chirundu districts; and hydro-power demand along the dam infrastructure of the Kafue Flats. Industrial demand is limited in the northern part of the catchment extending towards the Coppebelt province (GIZ, 2013). With the decrease in copper prices, the future of demand for water in the mining sector is uncertain.

Future use scenarios and the possibility of collective action among water users will partly be influenced by the nature of use and interdependencies of those users. Hydro-power generation on the Kafue Flats is strongly connected with water abstraction for domestic and irrigation agriculture. The existence of the two dams creates a steady supply of water for abstraction that would otherwise have been seasonally unavailable. Currently, a situation exists whereby water users perceive little behavioural interdependence[2] and don't see water resource quantities as a limiting factor in expanding their use. Limited information regarding available water use and abstraction figures makes accurate projections for the basin very difficult. A scenario in which demand breaks even with water availability and behavioural interdependence becomes more apparent among users is plausible for the Kafue Flats.

Demand for hydro-power generation in Zambia is expected to increase, especially in the mining and

[2] Behavioural interdependence refers to the situation in which the actions of a party are dependent on the actions of another and *vice versa*. In other words, the actions of one party lead to consequences that affect their behaviour within the system (Coleman, 1994).

commercial sectors (BMI, 2015). This has huge implications on water allocation especially in the context of climate change and variability in the Kafue Basin and the Zambezi basin as a whole. The Zambezi Basin is listed as one of the worst impacted basins by climate change in Africa. The situation is exacerbated by the fact that almost 60% of countries in Southern Africa depend on hydropower for its power supply (Beilfuss, 2012). Climate change and variability could affect the region in several ways: reduced dam inflows as a result of decreased rainfall; increased extreme weather events, such as flooding, resulting in the risk of infrastructure failure; delayed surface area evaporation; and increased sediment load (Conway, et al., 2015). This is already manifesting in Zambia, as evidenced by recent low water levels in ITT and KGD on the Kafue River, which are attributed to the poor rainfall season of 2014/2015. The address to parliament by the Minister of Mines, Energy and Water Development revealed the penalties incurred by Zambia for going beyond the permissible national water allocation for Zambia as an attempt to curb energy deficits. This exemplifies the effects of climate change on regional water dynamics, particularly for shared river courses.

8. Conclusion

This technical report has highlighted some of the key water security issues facing the Kafue Flats with emphasis on water availability, existing demand, and projected demand. It has also brought to the fore the institutional frameworks that underpin water security and the management of associated resources in the basin. It is clear that the Kafue Flats delivers multiple ecosystem services that collectively underpin the efforts aimed at achieving water security, including provision of good quality water, flood regulation, water storage, fish resources, and agricultural production. The nature of the benefits that the country derives from the basin is determined by water availability, climate variability, and the ever-changing demands and levels of water use. Whereas many of the ecosystem benefits of the basin are readily apparent, the role of human institutions in ensuring water security goes largely unrecognised. Yet, the relationship between ecosystem and institutions is one of mutual benefit.

In that regard, the key issues that for water security in the Kafue Flats include:

- The limited capacities of the Water Resources Management Authority (WARMA) to effectively assess, regulate, and manage water resources in the river basin. The water sector in Zambia has undergone a series of reforms aimed at enhancing water resource protection and management, leading to the enactment of the Water Resource Act of 2011. One of the major implementation challenges has been the high establishment cost for water management structures. Alternative governance mechanisms such as partnerships between the private and public sectors will play an increasingly important role. The Kafue Flats exemplifies a situation in which partners in the private sector recognise the shared risks and benefits of collective action with state and non-state actors.

- Quantity, Quality, and Timing. Whereas the quantity and quality of water resources in hydro-power generation, irrigation for agricultural use, and abstraction for domestic water use form a major issue on the Flats, the timing of availability is equally as important. Hydro-power generation and commercial agriculture rely on an adequate quantity of water resources, while environmental flows needed for ecosystem functions depend on the timing of the quantity. This dynamic relationship between quantity and timing of water resources on the flats has been a contentious issue among water users on the Flats.
- Balance between conservation and economic development. The Water Resources Act of 2011 places domestic water use as first priority, followed by water for conservation and lastly for hydro-power generation. Due to the economic importance of hydro-power generation to mining activities upstream on the Copperbelt and commercial farming, hydropower has ascended as the *de facto* high priority use on the flats. With projected climate change and variability in Southern Africa, the balance between conservation and development could become an increasingly complicated issue.

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