



REPORT
SUMMARY

ZAMBIA
2018

THIS REPORT
WAS CREATED IN
COLLABORATION
WITH:



Water Situational Analysis of the Lower Kafue Basin

**SOCIO-ECONOMIC DEVELOPMENT
AND CLIMATE CHANGE:
RISKS AND OPPORTUNITIES**

WATER SITUATIONAL ANALYSIS OF THE LOWER KAFUE BASIN

**Socio-Economic Development and Climate Change:
Risks and Opportunities**

June 2018



CONTENTS

FOREWORD WWF	1
FOREWORD ZAMBIAN BREWERIES	3
EXECUTIVE SUMMARY	7
<i>UNDERSTANDING THE WATER RESOURCES OF THE LOWER KAFUE</i>	<i>7</i>
<i>UNDERSTANDING THE CONSUMPTION OF THE LOWER KAFUE</i>	<i>9</i>
<i>UNDERSTANDING THE CLIMATE AND CLIMATE CHANGE</i>	<i>9</i>
<i>UNDERSTANDING THE WATER BALANCE</i>	<i>11</i>
<i>HYDROPOWER FLOW REQUIREMENTS</i>	<i>12</i>
<i>UNDERSTANDING THE IMPLICATIONS OF CLIMATE CHANGE ON THE WATER BALANCE</i>	<i>17</i>
<i>SCENARIOS FOR SOCIO-ECONOMIC DEVELOPMENT</i>	<i>18</i>
<i>RESULTS OF WATER BALANCE MODELLING AND CLIMATE IMPLICATIONS</i>	<i>21</i>
<i>RISK PRIORITIZATION AND SYNTHESIS</i>	<i>30</i>
<i>THE VALUE OF WATER</i>	<i>32</i>
<i>ECONOMIC IMPLICATIONS OF RISKS</i>	<i>33</i>
<i>COST OF WATER AND ELECTRICITY, AND THE ASSURANCE OF SUPPLY</i>	<i>37</i>
<i>OPPORTUNITIES</i>	<i>38</i>

FOREWORD

WWF



Nachilala Nkombo
WWF Zambia
Country Director

Zambia has demonstrated renewed ambition towards achieving sustainable social and economic growth as enshrined in the Vision 2030.

As our population rapidly grows to 25 million by 2030, the pressure on our finite natural resources will be greatly exacerbated. This reality demands for our government, private sector and community institutions

to deliberately account for and sustainably use our precious, yet diminishing natural assets.

At WWF, our conservation work over the years has tirelessly complimented Government and community efforts to prudently use and manage our country's priceless resources. One such crucial and underlying resource is water. There is a growing global body of evidence demonstrating the threat of water risks for companies and economies. This can be seen from the World Economic Forum Global Risk Report (2017) which identifies water crises as one of the top five risks in terms of impact.

This document is a summary of the ***“Water Situational Analysis Study of the Lower Kafue Sub-Basin”***, focusing on the expanse from Itezhi-tezhi Dam to the confluence of the Zambezi River. Up to 50 per cent of the Zambian population is reliant on the Kafue ecosystem, which directly supports livelihoods with goods and services that include agriculture, hunting and fishing. The Kafue is also the backbone of the Zambian economy. Appreciating the pressures on this system will better equip us with the necessary understanding to adequately plan for its preservation and sustainable use.

This report confirms numerous previous studies that suggested that Zambia's current development trend is exploiting our water resources unsustainably, leading to possible depletion in the future. It also augments evidence that shows that the Kafue has reached its maximum allocation amounts. Furthermore, this has major economic implications for the country as the annual GDP for the Lower Kafue is estimated at K48 billion (USD 5.1 billion).

We realize that different companies bear risks due to the water challenges of the Lower Kafue, from the risk of decreasing production or increasing costs, to losing commercial opportunities, or reputational risks. We believe that for risk management efforts to be successful, there is a need for stronger collaboration with the private

sector. In the recent past, investors have been increasingly engaging in initiatives to improve water management. It is for this reason that we welcome the leadership of and value the partnership with **Zambian Breweries/ABInBev** in promoting efficient and effective use of the Kafue basin water resources.

In this regard, we appeal to the private sector in and around the Kafue Flats to also play your part and engage in water stewardship programs and other initiatives in accordance with the UN Global Compact's CEO Water Mandate. This can be achieved while working with stakeholders inside and outside of your company's operations to better understand, mitigate and manage direct and indirect risks to your operations.

On a broader level, WWF Zambia has been engaging the private sector through a water stewardship platform known as the Kafue Flats Joint Action Group (KF-JAG). The aim of the KF-JAG is to address shared challenges and implement joint action to reduce business-related water risks. This report is a direct result of that engagement.



We pledge to work with Civil Society to advocate for the sustainable use of water resources in the Kafue basin. We pledge to support vulnerable stakeholders with overcoming significant water-related challenges by creating platforms for them to voice water-related concerns, in a proactive and preventive manner, to the appropriate authorities and stakeholders.

Finally, we hope this report also begins a broader national discussion on the role of our precious water resources in driving our 2030 sustainable development agenda.

Nachilala Nkombo
WWF Zambia
Country Director

**WE HOPE THIS
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A BROADER
NATIONAL
DISCUSSION ON
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PRECIOUS WATER
RESOURCES IN
DRIVING OUR 2030
SUSTAINABLE
DEVELOPMENT
GOALS**

FOREWORD

ZAMBIAN BREWERIES

At **Zambian Breweries**, we place a high value on the importance of water both for our operations and the prosperity of Zambia as a whole. Water is more than a key ingredient in our products — it is a vital resource for the continued growth and wellbeing of Zambia.

Clean and reliable water supplies are essential for everything from increasing agricultural production to successfully expanding Zambia's economy. It is therefore paramount that we protect our water resources.



Jose Daniel Moran
Zambian Breweries
Country Director

As **Zambian Breweries**, we know the importance of being responsible water stewards in the areas where we operate. Thus, we make efforts to work with the government, suppliers, consumers and the communities to promote water stewardship.

ABInBev, our parent company, is passionate about water stewardship and works closely with WWF at a global level to ensure that water resources are preserved and used properly. We are delighted to continue to sustain a relationship with WWF, and we have thus partnered with them to produce the ***“Water Situational Analysis Study of the Lower Kafue Sub-Basin”***.

This report outlines ways to preserve and mitigate water risk in one of Zambia's most essential water sources. According to the report, about 50 per cent of Zambia's population depends on the Kafue River Basin for its livelihood. It supports both urban and rural communities.

Currently, the basin is at risk due to environmental issues such as climate change and increased pressure on it as the country's population continues to grow and businesses flourish. Although, as **Zambian Breweries** we are committed to helping preserve our water sources, we cannot do it on our own.

This report highlights the need for collaboration from the government, private sector and all stakeholders involved. By embracing opportunities such as the adoption of water stewardship programs, working with other stakeholders and supporting research efforts, we can save the Kafue River basin.



**WE CAN
SAVE THE
KAFUE
RIVER
BASIN**

This report is an important eye-opener for all the stakeholders involved. More importantly however, it outlines important opportunities to preserve the basin. We must not waste them.

Water is life; it supports so many aspects of our personal and economic lives. Let us treat it like the precious commodity that it is.

A handwritten signature in blue ink, enclosed within a blue oval. The signature appears to be 'JD Moran'.

Jose Daniel Moran
Zambian Breweries
Country Director

Upgrade of the water intake point to Lusaka,
Iolanda Pump Station, Kafue.

A rapidly growing population and increased
industrial activity have led to increased demand
for water supply in Lusaka.





EXECUTIVE SUMMARY

This summary is based on the “[Water Situational Analysis Study of the Lower Kafue Sub-Basin](#)” report, focusing on the stretch from Itezhi-tezhi Dam to the confluence of the Zambezi River. It includes an investigation of the water resources of the Lower Kafue, the ecological requirements for a functioning river, and the social and economic water demands and trade-offs. Added to this, the summary includes an analysis of the risks and opportunities faced by water users in the Kafue, particularly in the face of climate impacts and increasing development.

According to the Central Statistics Office (2010), the total population of the combined districts within the Kafue catchment is estimated at 7,719,024 inhabitants, which equates to 50 per cent of the total Zambian population. This population is dependent on the natural resources of the basin as a source of livelihood, through rain-fed and irrigated agriculture, as well as livestock, fishing and hunting. The Kafue River also provides water to various sectors of the economy. The main users of water in Zambia are the hydropower, agriculture, industrial and tourism sectors, as well as domestic supply and the environment. Meeting the water requirements of these sectors is critical to sustainable economic growth and poverty eradication in Zambia. However, the current uses of water, including environmental requirements, are reaching the limit of what can be reliably provided for with existing storage. Beyond this limit, users will experience economic losses in dry years.

50%

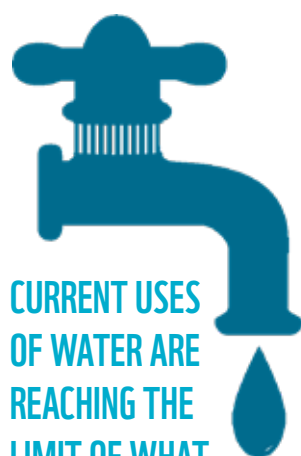
OF ZAMBIA'S
POPULATION
LIES WITHIN
THE KAFUE
RIVER BASIN

Water is therefore becoming a contentious issue in the basin; the government will increasingly face trade-offs when it comes to planning and allocating water. Man-made and climate-related shocks and stresses will continue creating risks for natural ecosystems, the people, the economic sectors and other stakeholders. As the region continues to develop, the demands for natural resources, such as water, will increase. Therefore, in order to ensure sustainable economic growth, it is important to secure a sustainable water supply, to equitably manage the existing and future allocations, and to ensure that the Kafue River's environmental flows and ecosystems are protected.

UNDERSTANDING THE WATER RESOURCES OF THE LOWER KAFUE

The Kafue River is the longest tributary of the Zambezi, and its catchment is entirely located within Zambia. The topography of the headwater area of the Kafue River is gently undulating, with many dambos. The water bodies found in the basin include the Kafue River, its tributaries, dams and the Kafue Flats wetland. The natural flow





CURRENT USES
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WITH EXISTING
STORAGE

regime of the Kafue River, especially the Kafue Flats area, is regulated by the two major dams that have been built for hydropower generation. Estimates from the wet season suggest that 75 per cent of the water flowing in the river's main channel (as it exits the Flats) stagnates within the highly productive floodplain. This exchange between the floodplain and river appears to play an important role in nutrient and carbon export to the river's main channel and out of the wetland.

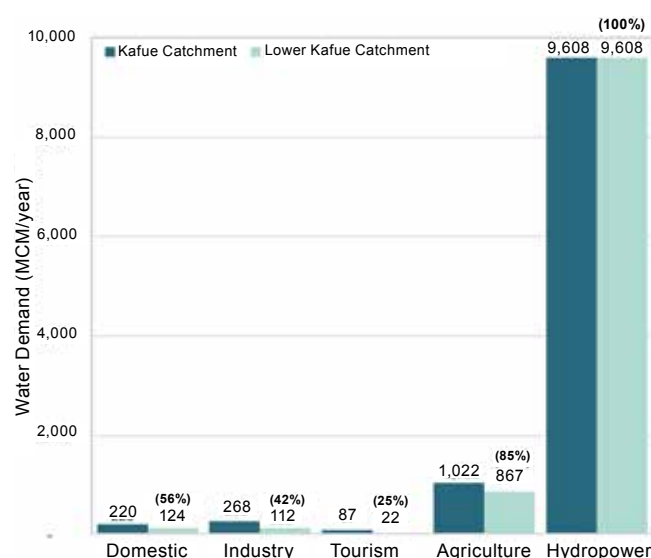
The Kafue River is in good condition as it flows through the Kafue National Park, before declining after Itezhi-tezhi Dam. This decline is initially due to the flow manipulations at the dam, which reduce flooding of the Kafue Flats and create abnormally high flows in the dry season, and later due to agricultural and mining activities in the east and artificial inundation of the Flats by the Kafue Gorge reservoir.

Runoff from the Kafue basin is highly modified by the operation of Itezhi-tezhi and Kafue Gorge Upper dams for hydropower production (which are typically about 168 m³/s). The current operating conditions for the Itezhi-tezhi Dam provide for a minimum flow release of 25 m³/s, and an "ecological freshet" of 300 m³/s for a four-week period (typically March). This release has occurred fairly consistently over the past decade, except during low rainfall conditions. In terms of flood dynamics, the new rules were found to be an improvement, as a larger area is flooded in the wet season while on the other hand, a larger area falls dry in the dry season. However, the regime was still far from mimicking natural flows.

Groundwater is a major source of water in many parts of the country. It sustains river flows, especially during the dry season, for perennial rivers and streams, and can contribute to between 30 per cent and 90 per cent of the total flows. JICA-MEWD (1995) estimated Zambia's average renewable groundwater potential to be 49.6 km³. This is based on an average of 8 per cent of the rainfall, which is the main source of renewable water in Zambia at an average annual total rainfall of 1000 mm. It is usually assumed that the variation from year to year is very small. For the Lusaka region, recharge rates vary between wet and dry periods. Estimates of average recharge rates are in the order of 20 per cent to 25 per cent of annual rainfall, which is about 180 mm. Annual groundwater recharge rates vary from 100 mm to 380 mm. Clearly, rainfall, groundwater-level fluctuations and groundwater abstractions need to be monitored closely, as these provide the basis for decision-making with regards to sustainable abstraction and water supply scenarios. The dolomite plateau around Lusaka stands out as the most important recharge area.

UNDERSTANDING THE CONSUMPTION OF THE LOWER KAFUE

Figure 1
Comparison Of Current
Water Demand: Kafue
Catchment vs Lower
Kafue Catchment



The estimated water demand in the Kafue catchment is 11,284 MCM/year; water use includes hydropower, municipal, industrial, commercial, agricultural (irrigation and aquaculture), environmental and recreational. Hydropower generation (non-consumptive) requires about

8,195 MCM/year and is by far the largest user. Figure 1 illustrates the water demand for the Kafue and the Lower Kafue catchments. For each sector, the figure also illustrates the percentage of the Kafue's total water demand that is utilized in the Lower Kafue catchment. Other contributors of sustainable livelihoods, such as small-scale agriculture and fisheries, rely on natural resources/sustainable ecosystems, such as rainfall, vegetation, soil, and ecological flows.

UNDERSTANDING THE CLIMATE AND CLIMATE CHANGE



There are two main seasons: the rainy season (November to April) corresponding to summer, and the dry season (May to October/November) corresponding to winter. The dry season is subdivided into the cool dry season (May to August), and the hot dry season (September to October/November). The modifying influence of altitude gives the country subtropical weather for most of the year. The mean annual precipitation in the Kafue River basin varies from 1,400 mm in the north to 700 mm in the south.

Considerable variability in rainfall occurs across the Zambezi basin, from arid/semi-arid regions in the south and southwest to high rainfall regions in the north.

**CONSIDERABLE
VARIABILITY IN
RAINFALL OCCURS
ACROSS THE
ZAMBEZI BASIN**

Increasing temperatures throughout the Kafue catchment will lead to greater evapotranspiration, creating less flow through the river. As the headwaters of the Kafue begin in the Northern Zambezi in the Miombo woodlands, deforestation and seasonal burning will significantly impact the amount of water that is available in the Kafue. Both these drivers affect the Kafue sub-basin, as the wetlands and floodplains require a certain amount of wetting, both from flooding and rainfall, to continue functioning appropriately.

KAFUE IS PLAGUED BY INVASIVE SPECIES

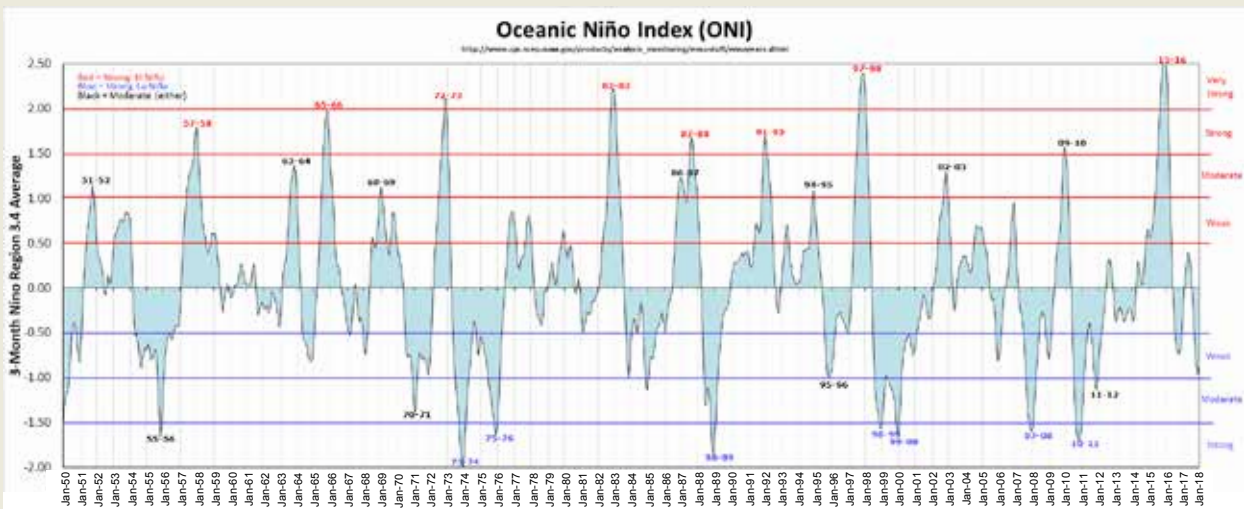


The Kafue is also plagued by invasive species, such as the water hyacinth, which consume additional water from the system. Furthermore, the Kafue Flats are downstream of significant mining developments in the Copperbelt. These developments adversely impact water quality, which becomes significant when the ecosystem no longer functions appropriately. This, together with the projected changes in the climate, will impact the sectors of the Kafue sub-basin, such as hydropower, irrigated agriculture, and fisheries.

Zambia experienced a drought caused by El Niño. Zambia experienced below-normal rainfall from 2015 to 2016 due to the El Niño, and the Lusaka, Southern, Central, Eastern and Western provinces were severely affected. The lack of rainfall has negatively impacted the recharge systems in the water bodies, and also affected the water and energy sectors. The El Niño weather phenomenon (2015-2016), one of the worst in 50 years, caused intense drought in Southern Africa that has had a "devastating" impact on the region's economy and food security.

According to Zambia's Meteorological Department, El Niño takes place every two to seven years, and is known to peak between October and January after which it starts to decline. Previously, the more notable El Niño's took place between 1972 and 1973, 1982 and 1983, as well as between 1997 and 1998. (These El Niño events correspond to drought conditions in Zambia). Figure 2 provides the Oceanic Niño Index, which has become the de-facto standard that the National Oceanic and Atmospheric Administration uses for identifying El Niño (warm) and La Niña (cool) events in the Pacific Ocean. The image illustrates that a weak La Niña trend will be experienced in 2018, likely bringing some rainfall relief although dry spells may still be experienced.

Figure 2
Oceanic Niño Index
(ONI) For Identifying El
Niño (Warm) and La Niña
(Cool) Events



UNDERSTANDING THE WATER BALANCE

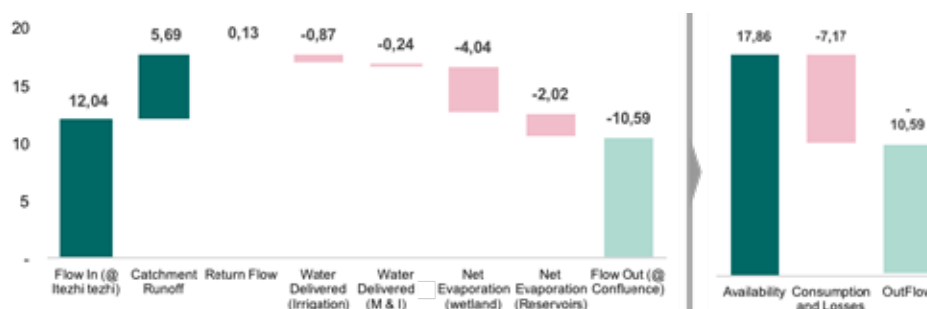
Table 1 shows the simulated water balance for the Lower Kafue catchment based on the Zambezi basin water systems model. Positive contribution of water in the catchment comes from the flow in, the catchment runoff, and the return flow.

Table 1
Water Balance
of the Lower Kafue
Catchment

Water Balance (BCM/year)			
Flow In (@ Itezhi-tezhi)	+12.04	Water Delivered (M&I)*	-0.24
Catchment Runoff	+5.69	Net Evaporation (Wetland)	-4.04
Return Flow	+0.13	Net Evaporation (Reservoirs)	-2.02
Water Delivered (Irrigation)	-0.87	Flow Out (@ Zambezi Confluence)	-10.59

* Includes tourism figures

Figure 3
Water Balance of the
Lower Kafue Catchment
(BCM/year)



MAINTAINING A SUSTAINABLE BALANCE IS VITAL



Flow of about 12 BCM/year enters the catchment at Itezhi-tezhi. The runoff from the catchment itself, meaning the contribution to stream flow that enters both the river and the wetland, is about 5.7 BCM/year. Return flow, which is primarily from water delivered for irrigation, is about 0.13 BCM/year. The negative values in the water balance come from abstractions, net evaporation, and flow out. Water delivered for irrigation is about 0.87 BCM/year with the majority of that occurring in the dry season. Water delivered to the municipal and industrial sectors (M&I), including tourism, is about 0.24 BCM/year. Net evaporation from the Kafue Flats removes about 4 BCM/year from the system, while evaporation from both Itezhi-tezhi and Kafue Gorge Upper is roughly 2 BCM/year. And finally, the remainder of the water exits the catchment into the Zambezi at an average rate of about 11 BCM/year, slightly less than the flow into the catchment.

HYDROPOWER FLOW REQUIREMENTS

Table 2
Flow Requirements
for Hydropower
Generation

Hydropower Dam	Required Releases
Itezhi-tezhi	25 m ³ /sec
Upper Kafue Gorge	7.2 m ³ /sec
Lower Kafue Gorge	7.2 m ³ /sec

Table 2 illustrates that Itezhi-tezhi is required to release a minimum of 25 m³/s (approx. 788 MCM/year), while both the Upper and Lower Kafue Gorge are required to release

a minimum of 7.2 m³/sec (approx. 227 m³/year) downstream. In addition to the minimum flow requirements, the three hydropower stations require sufficient water to be able to generate electricity. According to GFA Consultants (2013), hydropower generation presently makes use of about 6,623 MCM/year, although this is non-consumptive (i.e. does not involve abstraction). However, net evaporative losses (1,413 MCM/year) due to storage takes out significant amounts of water from the river system. Data provided by ZESCO Limited shows that a total of 8,195 MCM/year (turbine discharge) was used in 2012 for electricity generation at Kafue Gorge Upper plant, which indicates that water use is actually higher than what is recorded.

Figure 4
Water Balance (BCM/
year) - Hydropower
Implications

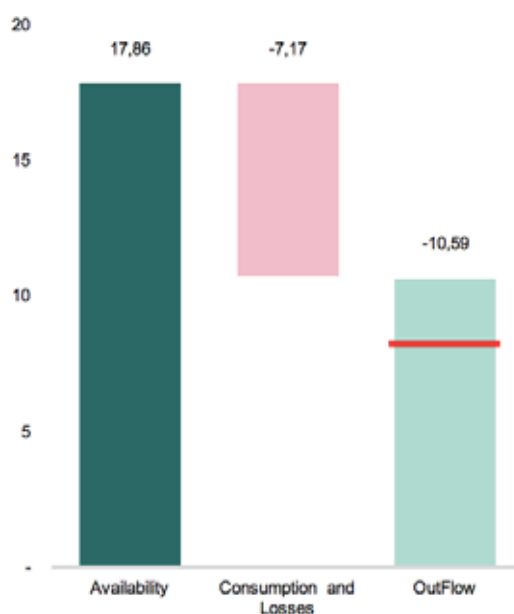


Figure 4 provides a comparison of the water balance and the non-consumptive water requirements for hydropower (i.e. 8.2 BCM/year). (Losses due to evaporation have been included under “consumption and losses”.) The figure illustrates that in an average year, the water balance meets the minimum required for downstream hydropower generation, with a balance of 2.5 BCM/year. However, considering that environmental flows have not been included in this assessment (minimum

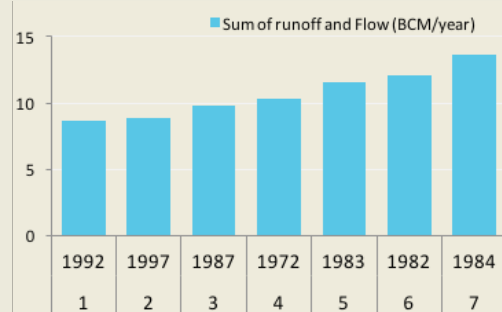
of 788 MCM/year), it seems that the basin has reached the maximum level for water allocation. Any increase in water withdrawal or decreases in water availability will impact downstream water availability and hydropower generation.

**THE BASIN HAS
REACHED THE
MAXIMUM
LEVEL FOR
WATER
ALLOCATION**

1992

WAS THE DRIEST YEAR

Figure 5
Ranking the
7 Driest Years



Zambia has recently experienced a drought that has been induced by an El Niño event.

This drought is said to be the worst drought in the last 50 years. Over a 30-year period (1971-2000), the water balance over the driest years (25th percentile) was assessed. According to

the water balance records, the seven driest years are 1992, 1997, 1987, 1972, 1983, 1982 and 1984. Six of these correspond to El Niño trends; the only “dry” year that does not correspond to the El Niño signal is 1984, although it followed two dry years.

Figure 6 compares the various components of the water balance over the seven dry years. These components are also compared to the mean of the seven dry years as well as the entire thirty-year record.

According to Figure 5 above, the driest year was 1992, and the least driest of the seven driest years was 1984. Interestingly, as indicated in Figure 6, while the inflow follows a similar trend, the catchment runoff does not; the catchment runoff is the lowest in 1997, and the highest in 1982 (the second driest and second “wettest” years in the seven-year period, respectively). The outflow to the Zambezi River also does not follow the trend shown in Figure 5; the flow is the lowest in 1997 and the highest in 1982. As expected, the inflow, runoff and outflow are significantly lower during the dry periods than over the 30-year record, while irrigation water demand and wetland evaporation are higher. Interestingly, the reservoir evaporation is lower during the dry periods than across the 30-year record. This indicates that, on average, the reservoirs are fuller across the 30-year period due to the expected reservoir drawdown during drought periods—the larger surface area enables more evaporation. Outflow from the Flats during the driest years is about half the average outflow and is well below the hydropower flow requirement. Thus, in the driest years, the system is considerably over-allocated, with adequate water only being available in average to wet years.

Due to the nature of the downstream hydropower stations, the amount of outflow to the Zambezi (and, therefore, through hydropower stations) should correspond to the amount of hydropower that would be generated (all things being equal). Figure 7 indicates that there is a strong correlation between the outflow and hydropower generation. There is also evidence of seasonal variation in the outflow and the hydropower generation.

Figure 6
Components Water
Balance (BCM/year) –
7 Driest Years

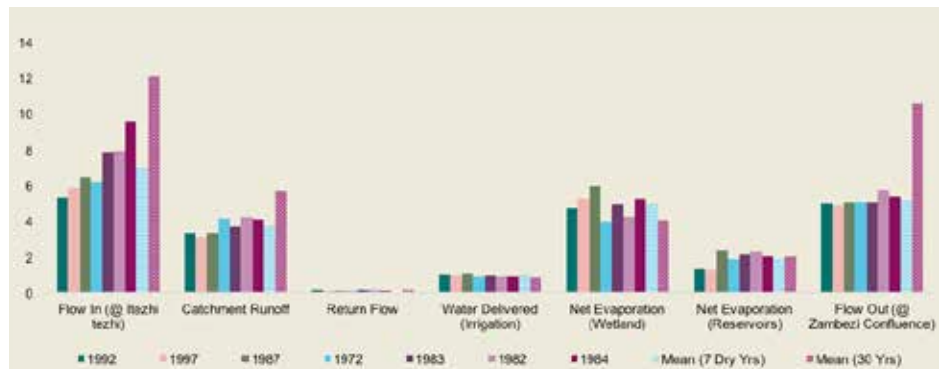
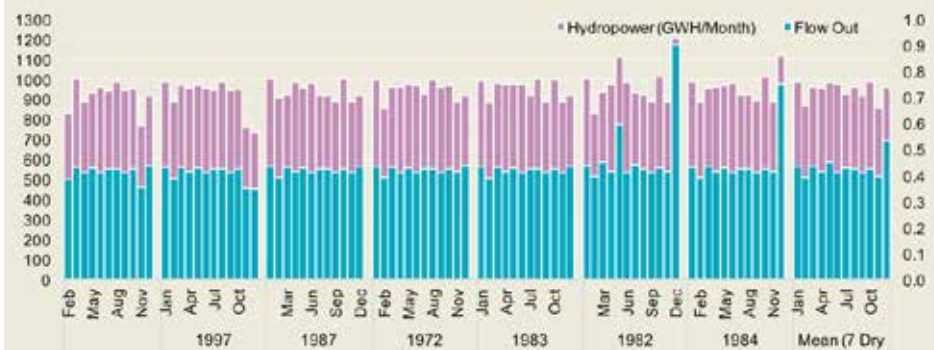


Figure 7
Outflow (BCM/month)
and Hydropower (GWh/
month) – 7 Driest Years



Mid-way through the rainy season (December and January) runoff and generation tend to increase, while decreases are evident during the dry season (particularly in July). February has also experienced decreases in flow and in hydropower generation, indicating that during the dry years the rainfall ceases. Although 1992 is the driest year on record, the runoff and hydropower generation were the lowest in December 1997.

Since Zambia's average hydropower generation is currently 1050 MW (which is less than the total capacity of 1770 MW), it is evident that during dry years, Zambia fails to meet its generation potential. Over the dry years that were analyzed, the average hydropower generation was seldom achieved. For a country that is almost wholly reliant on hydropower, dry periods have consistently presented challenges in hydropower generation. The 2015-2016 drought, for instance, resulted in water and electricity shortages for the population of the Kafue and Zambia as a whole, which caused detrimental effects to the general and mining economy. This is likely to be exacerbated in future, as climate projections indicate an increasing likelihood of dry periods.

**IN THE DRIEST
YEARS, THE
SYSTEM IS
CONSIDERABLY
OVER-ALLOCATED**

An upcoming lodge situated along the Kafue River.

3



4

UNDERSTANDING THE IMPLICATIONS OF CLIMATE CHANGE ON THE WATER BALANCE

The climate projections, through changes in rainfall patterns, temperature and precipitation, help predict the impact on streamflow, evaporation, and irrigation demand. For example, in a drier and hotter climate, stream flows will be reduced, evaporation will increase, and irrigation demand will increase. To quantify the climate projections for the catchment, climate scenarios were selected to span a range from wet and cool to hot and dry—namely; wettest, semi-wet, semi-dry, and driest. To provide a sense of the changes in climate, variations in certain elements of the water balance across four climate scenarios are shown in Table 3 and Figure 8. The figure also illustrates the level of uncertainty that exists due to climate projections, considering both a wet and dry climate future. Due to the projected seasonal and inter-annual climate variability, both a wet and dry future is possible.

Table 3

Water Balance
of the Kafue
Catchment under
Four Climate Scenarios

Water Balance (BCM/year)	Historical	Climate Scenarios			
		Wettest	Semi-Wet	Semi-Dry	Driest
Flow In (@ Itezhi-tezhi)	+12.04	33%	8%	-24%	-43%
Catchment Runoff	+5.69	27%	6%	-20%	-30%
Return Flow	+0.13	-4%	-1%	5%	6%
Water Delivered (Irrigation)	-0.87	-4%	-1%	5%	6%
Water Delivered (M&I)*	-0.24	0%	0%	0%	0%
Net Evaporation (Wetland)	-4.04	-24%	-7%	18%	13%
Net Evaporation (Reservoirs)	-2.02	-4%	3%	5%	-15%
Flow Out (@ Zambezi Confluence)	-10.59	35%	8%	-35%	-55%

* Includes tourism figures

CLIMATE
CHANGE IS
REAL

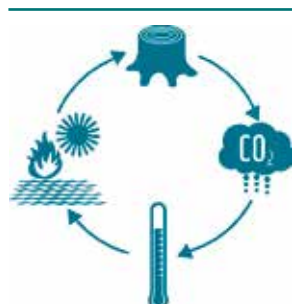
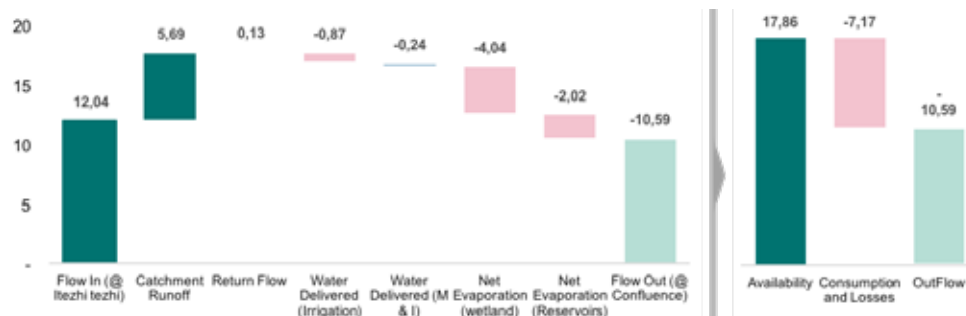


Figure 8
Climate Scenarios and
the Water Balance
(BCM/yr) Under Four
Climate Scenarios



50%
OF POTENTIAL
CLIMATE
FUTURES
SHOW THAT
CURRENT
DEMAND
PATTERNS
RESULT IN
INADEQUATE
WATER FOR
HYDROPOWER

As shown, flow in at Itezhi-tezhi ranges from +33 per cent of historical conditions to -43 per cent. The semi-wet scenario shows a slight increase in flow of 8 per cent and the semi-dry shows a decrease of 24 per cent, indicating that the flow in is more likely to decrease in the future than to increase. Catchment runoff follows a similar pattern, with a greater likelihood of decreasing than increasing. The volume of irrigation water delivered increases under drier climates due to the increased demands caused by both less precipitation and higher temperatures, which increase crop transpiration and soil evaporation. Net evaporation decreases under the wettest and semi-wet scenario due to increases in precipitation. The wetland evaporation is higher in the semi-dry scenario than the driest. This is caused by large decreases in wetland area during the wet season, which reduces evaporation. Similarly, the driest scenario decreases reservoir evaporation significantly because in this situation, the reservoir volumes are so low that the area decreases significantly. Flow out ranges from +35 per cent to -55 per cent, with a higher likelihood of decreasing than increasing.

These reductions in flow may have implications for downstream development since a significant portion of flows in this part of the Zambezi are delivered through the Kafue River. In at least half the potential climate futures, current demand patterns result in inadequate water for hydropower generation, even under average conditions, indicating significant future stress on the catchment.

SCENARIOS FOR SOCIO-ECONOMIC DEVELOPMENT

Socio-economic development along the Lower Kafue is difficult to predict as it could follow various pathways. Thus, this report proposes four scenarios for future development in the region, based on the development trajectories outlined in Vision 2030 and the Seventh National Development Plan. The four scenarios are:



THIS REPORT PROPOSES FOUR SCENARIOS FOR FUTURE DEVELOPMENT IN THE REGION

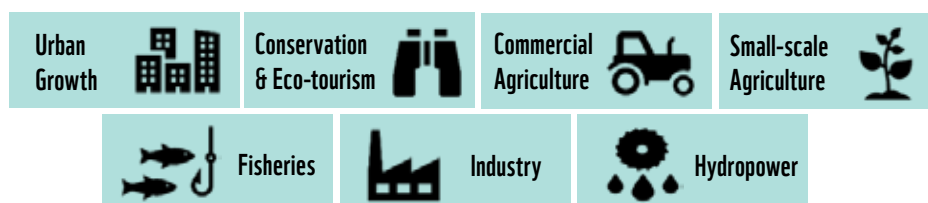
Business-As-Usual Scenario: A scenario where socio-economic development and water management continue following current patterns.

Urban- and Energy-Driven Growth Scenario: A scenario where the growth of the urban population, industrial economy and Zambia's energy demands surpasses current trends.

Agriculture-Driven Growth Scenario: A scenario where growth is driven by commercial agriculture, which includes the participation of small-holder farming in formal markets.

Green Growth Scenario: A scenario where livelihoods and ecosystem conservation are prioritized – by promoting sustainable small-scale agriculture and fisheries, eco-tourism, and green energy.

Each scenario comprises varying growth patterns across key economic sectors (as shown on page 21); this includes the expansion of certain economic sectors, while other sectors either continue to grow based on current trends, or contract and cease to grow. In each scenario, these growth patterns are shown visually as either ➡ for continued growth at current trends, ↑ for growth at an increasing rate, or ↓ for growth at a decreasing rate. These scenarios were then coupled with climate scenarios, so as to assess the relationship between development and water resources.



Each scenario would manifest due to a combination of endogenous factors, such as population growth, private sector investments, as well as Zambia's governance regime (such policies and measures include industry-specific support measures, private sector investments, and measures facilitating or impairing the investment climate). These factors will be influenced by exogenous factors, such as regional demand for goods and services, commodity prices on global markets, and the impact of climate change on water and crops.



Business-As Usual	Green Growth	Agriculture-driven Growth	Urban- & Energy-driven Growth
A scenario where socio-economic development and water management continue following current patterns	A scenario where livelihoods and ecosystem conservation are prioritized – by promoting sustainable small-scale agriculture and fisheries, eco-tourism, and green energy	A scenario where growth is driven by commercial agriculture, which includes the participation of small-holder farming and informal markets	A scenario where the growth of the urban population, industrial economy and energy demands surpasses current trends

Growth Implications for Each Scenario: Each scenario focuses on the expansion of certain economic sectors, while other sectors either continue to grow based on current trends, or contract and cease to grow.

Urban Growth:	→	→	→	↑
Conservation & Eco-Tourism:	→	↑	↓	→
Commercial Agriculture:	→	↓	↑	→
Small-scale Agriculture:	→	↑	→	↓
Fisheries:	→	↑	↓	↓
Industry:	→	→	↑	↑
Hydropower:	→	→	↓	↑
Risk and Vulnerability:	Risk, Vulnerability and Trade-offs: Due to the changes in water balance under each scenario, each sector will be exposed to different risks and vulnerabilities. Added to this, under each scenario, trade-offs will be realized.			



**UNDERSTANDING
THE IMPACT OF
DEVELOPMENT
CHOICES IS
CRUCIAL**

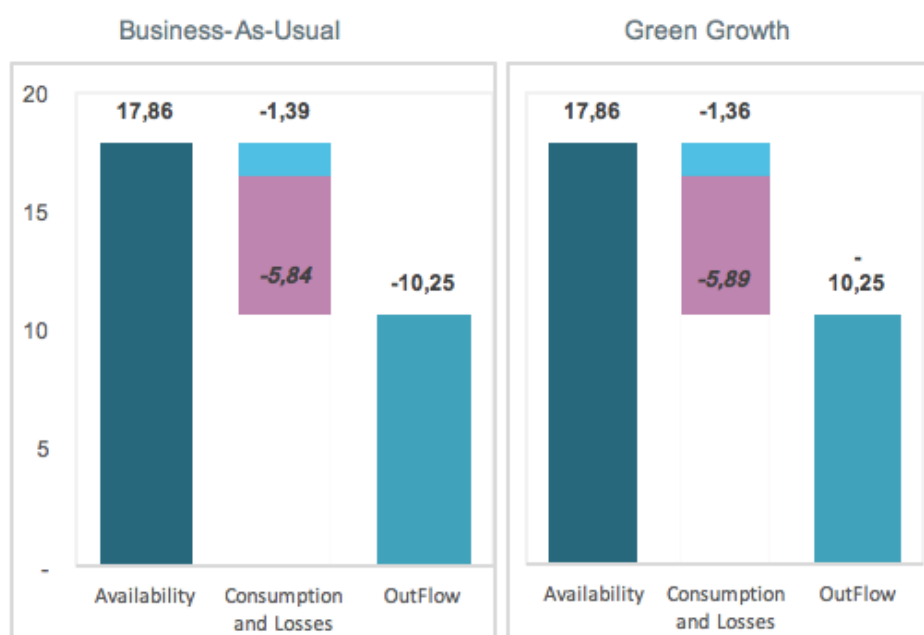
RESULTS OF WATER BALANCE MODELLING AND CLIMATE IMPLICATIONS

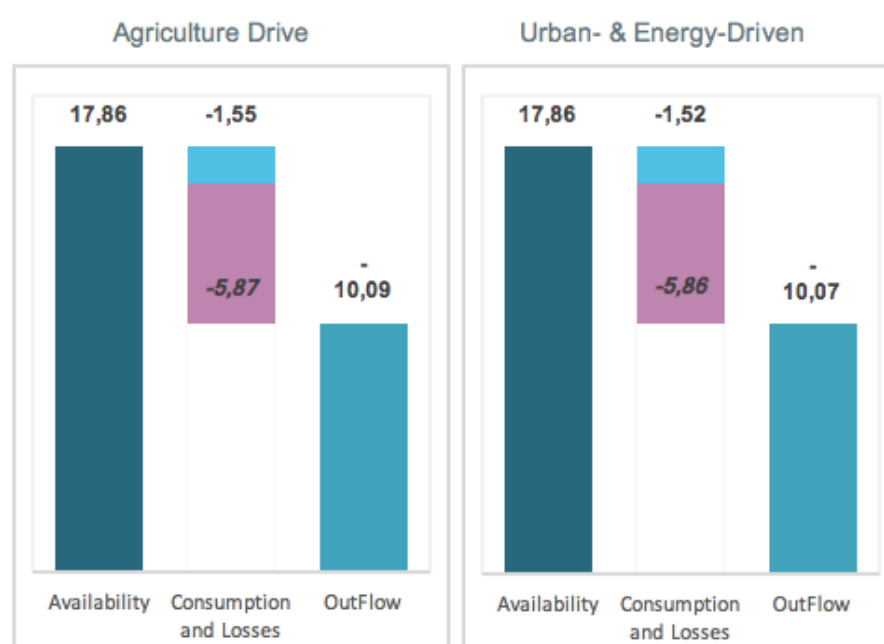
Through changes in temperature and precipitation, the climate projections impact streamflow, evaporation, and water demand (particularly irrigation). Table 4 and Figure 9 show the water balance for the four development scenarios. Flow into the system at Itezhi-tezhi remains the same because development upstream (Upper Kafue) is assumed to follow a business-as-usual development path.

Table 4
Water Balance of the
Lower Kafue under
the Four Development
Scenarios

Water Balance (BCM/ year)	Business -As- Usual	Green Growth	Agri- culture- Driven	Urban- & Energy- Driven
Flow In (@ Itezhi-tezhi)	+12.04	+12.04	+12.04	+12.04
Catchment Runoff	+5.69	+5.69	+5.69	+5.69
Return Flow	+0.13	+0.13	+0.13	+0.13
Water Delivered (Irrigation)	-1.03	-0.98	-1.10	-1.03
Water Delivered (M&I)*	-0.36	-0.38	-0.45	-0.49
Net Evaporation (Wetland)	-3.86	-3.88	-3.89	-3.89
Net Evaporation (Reservoirs)	-1.98	-2.01	-1.97	-1.98
Flow Out (@ Zambezi Confluence)	-10.25	-10.25	-10.07	-10.09

Figure 9
Water Balance (BCM/yr)
of the Lower Kafue under
the Four Development
Scenarios





**WATER
ABSTRACTIONS
ARE HIGHEST
UNDER
AGRICULTURE-
DRIVEN GROWTH
& URBAN- &
ENERGY-DRIVEN
SCENARIOS**

The business-as-usual scenario assumes continued unregulated water use, therefore resulting in the highest abstraction (1,390 MCM/year), although this is quite low relative to other scenarios. The green growth scenario provides a future with the lowest abstractions total (1,360 MCM/year) which allows the wetland and reservoirs to fill more often. This results in higher evaporation rates from the three reservoirs (5,890 MCM/year,) although the difference is small. Although it seems as though the business-as-usual scenario and the green growth scenario have similar impacts on the system, and release similar amounts to the Zambezi River (10,250 MCM/year), the green growth scenario enables the highest amount of hydropower generation, mainly due to the lower abstraction.

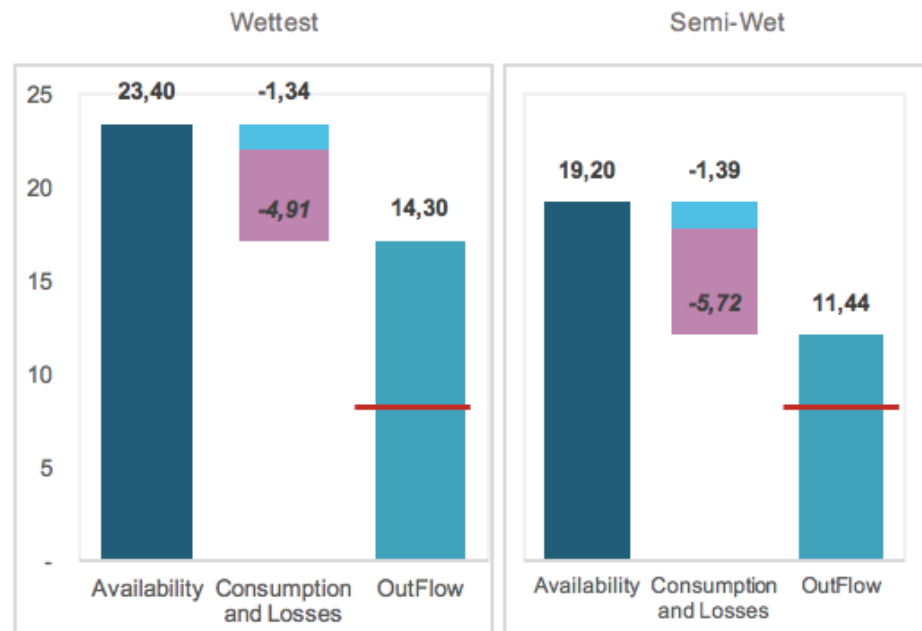
Water abstractions are highest under the agriculture-driven growth and the urban- and energy-driven scenarios (1,550 MCM/year and 1,520 MCM/year, respectively), where irrigation and industrial demands are relatively high. Under these scenarios, Itezhi-tezhi releases additional water to meet the larger demands for irrigation and Lusaka users. This is especially apparent in the dry season, and creates a system where the wetland inundated area is maintained even though abstractions are higher. The primary impacts of these higher demands are on the flow that enters the Zambezi and on the downstream hydropower generation, which are lower. Lower flows into the Zambezi may have impacts on downstream users including hydropower generation in Cahora Basa. While reducing flows into the Zambezi may not have major impacts on Zambia, they may have impacts on Mozambique's economy, potentially resulting in future water disputes.

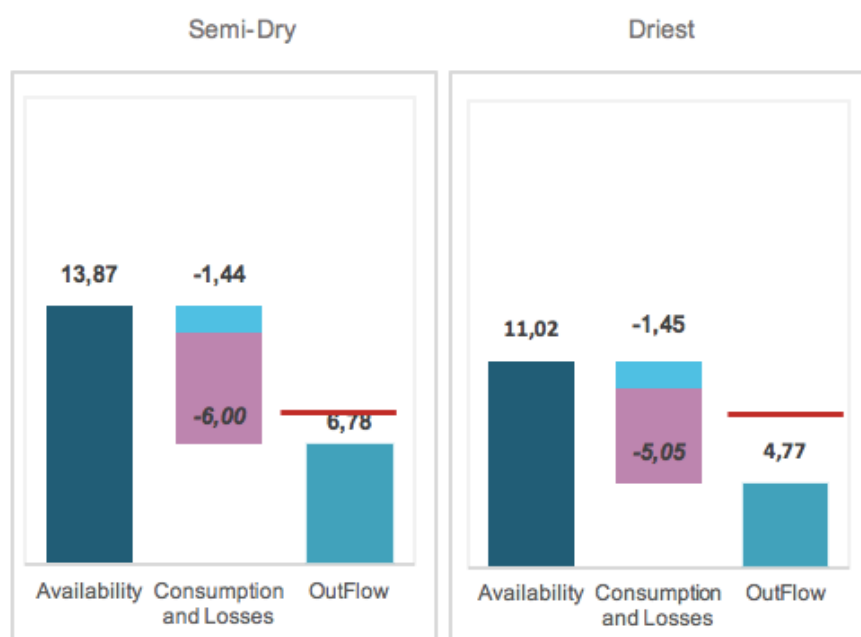
Due to the region's dependence on water resources, climate change will have major impacts on Kafue's development trajectory.

Climate impacts such as changes in rainfall, runoff variability, and temperature increases will influence the water balance of the Kafue through changes to water demand and water availability. In each scenario, these changes will manifest in different ways. Below is a detailed overview of how each development pathway will play out based on the different climate futures and the associated water and temperature implications.

Under the business-as-usual scenario, water use allocation and natural resource management continue based on current trends. If one considers possible climate futures, the total water consumption and losses—which includes water abstraction and evaporation—will be the highest in a semi-dry future (7,438 MCM/year), and the lowest in a wet climate future (6,252 MCM/year). Under this scenario, the total evaporation is the highest in a semi-dry future (5,999 MCM/year), and the lowest in a wet climate future (4,909 MCM/year). Water abstraction, on the other hand, will be the highest during a dry future (1,448 MCM/year), and the lowest during a wet climate future (1,343 MCM/year). As expected, the outflow is the highest in a wet future (14,297 MCM/year), and the lowest in a dry climate future (4,766 MCM/year). In terms of hydropower generation, in a semi-dry and dry future, downstream hydropower will be compromised.

Figure 10
Water Balance
(BCM/yr) of the
Lower Kafue under the
Business-As-Usual
Scenario



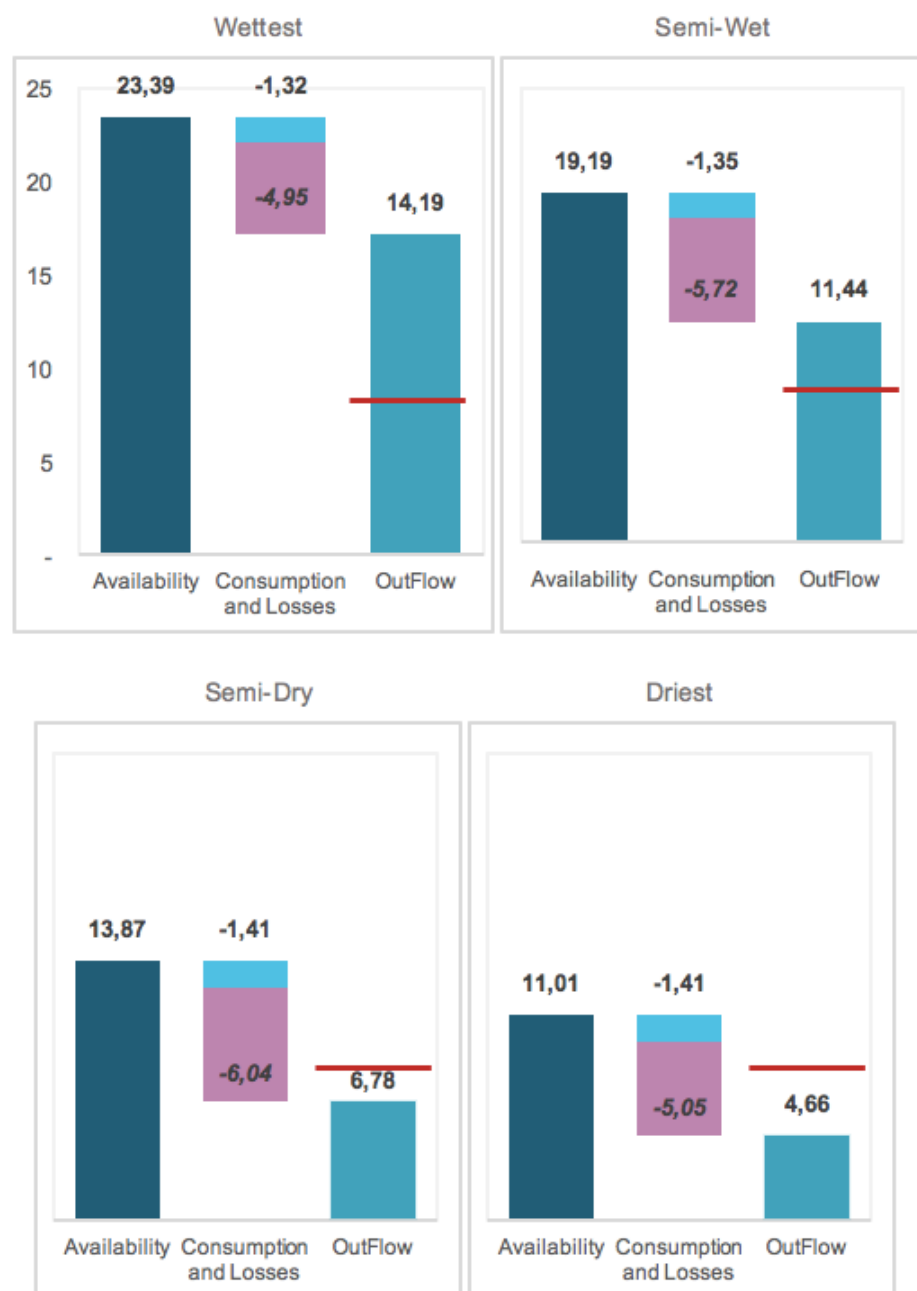


Under the green growth scenario, conservation, tourism, healthy ecosystems, alternative and decentralized green energy, and natural resource management are prioritized. When comparing the four probable climate futures, the total water consumption and losses will be the highest in a semi-dry future (7,446 MCM/year), and the lowest in a wet climate future (6,268 MCM/year). Under this scenario, the total evaporation follows similar trends; it is the highest in a semi-dry future (6,040 MCM/year), and the lowest in a wet climate future (4,949 MCM/year). Water abstraction, on the other hand, will be the highest during a dry future (1,415 MCM/year), and the lowest during a wet climate future (1,319 MCM/year). As expected, the outflow is the highest in a wet future (14,191 MCM/year), and the lowest in a dry climate future (4,660 MCM/year). In terms of hydropower generation, while this scenario presents the highest generation potential, in a semi-dry and dry future, downstream hydropower will be compromised.

**HEALTHY
ECOSYSTEMS
ARE A
PRIORITY**



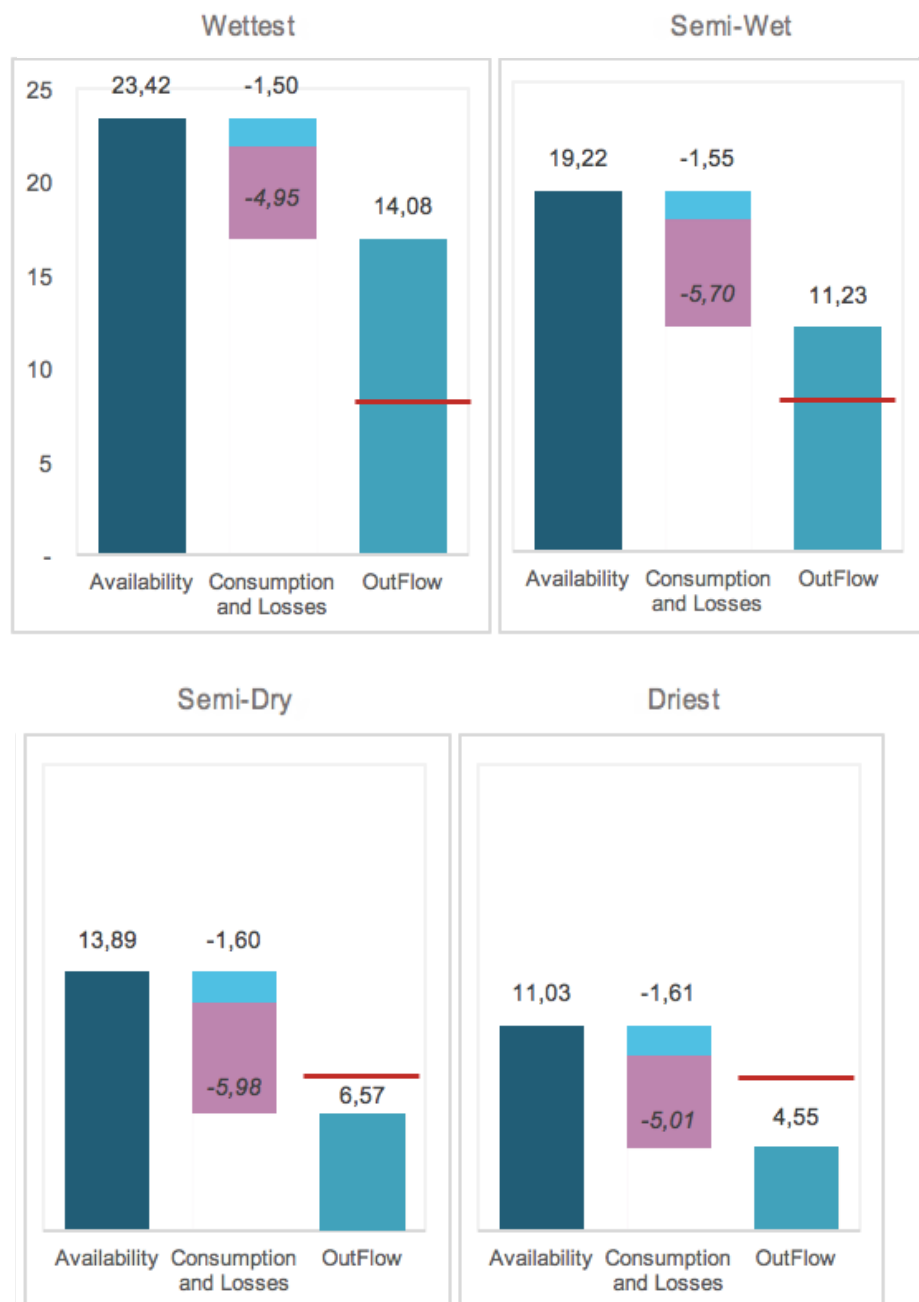
Figure 11
Water Balance
(BCM/yr) of the
Lower Kafue
under the
Green Growth
Scenario



Under the agriculture-driven growth scenario, commercial agriculture is prioritized, for both export purposes and for promoting food security. If one considers possible climate futures, the total water consumption and losses—which includes water abstraction and evaporation—will be the highest in a semi-dry future (7,579 MCM/year), and the lowest in a wet climate future (6,453 MCM/year). Under this scenario, the total evaporation is the highest in a semi-dry future (5,979 MCM/year), and the lowest in a wet climate future (4,949 MCM/year). Water abstraction, on the other hand, will be the

highest during a dry future (1,608 MCM/year), and the lowest during a wet climate future (1,504 MCM/year). As expected, the outflow is the highest in a wet future (14,085 MCM/year), and the lowest in a dry climate future (4,554 MCM/year). As with the other scenarios, in a semi-dry and dry future, downstream hydropower will be compromised.

Figure 12
Water Balance
(BCM/yr) of the
Lower Kafue
under the
Agriculture-Driven
Growth Scenario



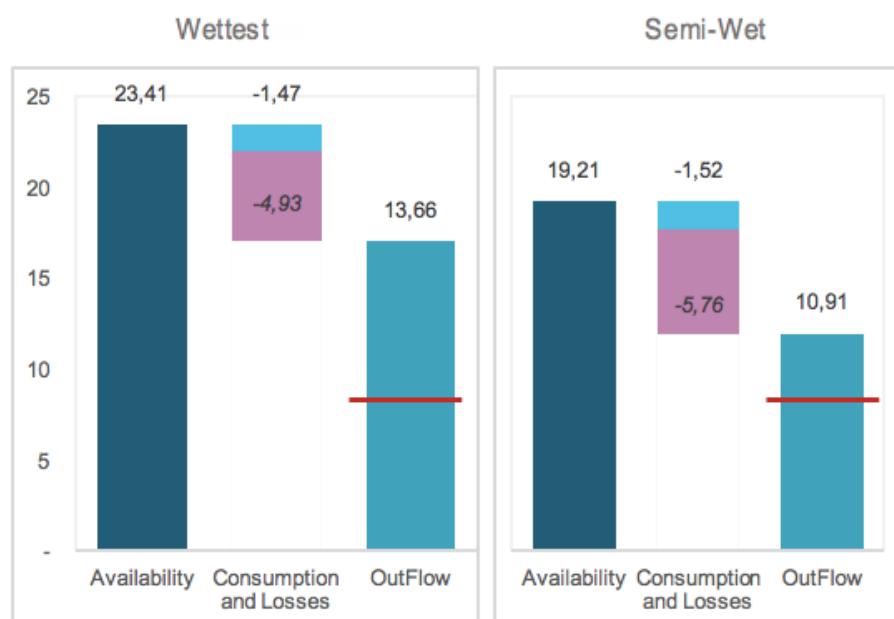


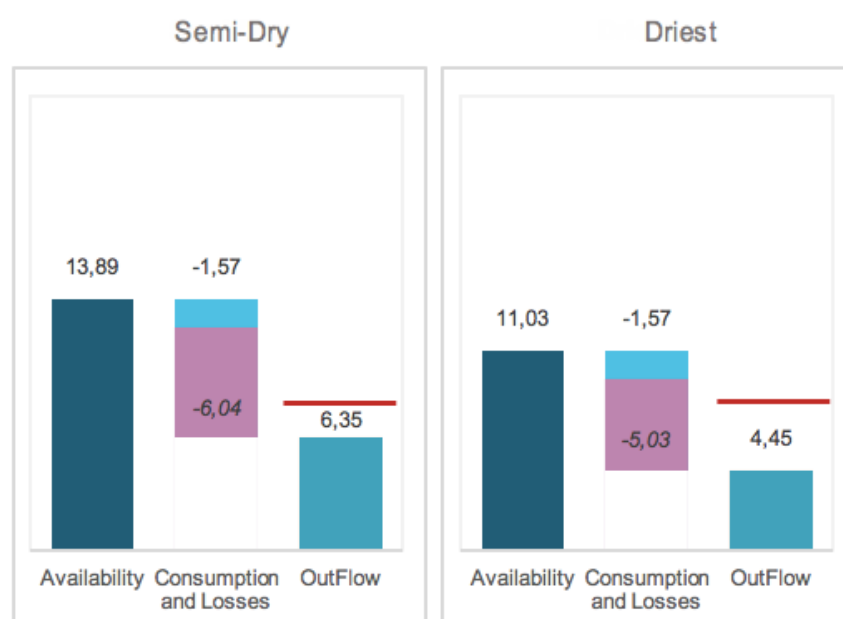


HYDROPOWER WILL ONLY REACH THE MAXIMUM ECONOMIC BENEFITS UNDER A WET CLIMATE FUTURE

Under the urban- and energy-driven growth scenario, urban development, industrial growth and hydropower energy production are prioritized. When comparing the four probable climate futures, the total water consumption and losses will be the highest in a semi-dry future (7,608 MCM/year), and the lowest in a wet climate future (6,402 MCM/year). Under this scenario, the total evaporation is the highest in a semi-dry future (6,040 MCM/year), and the lowest in a wet climate future (4,929 MCM/year). Water abstraction, on the other hand, will be the highest during a semi-dry and dry future (1,568 MCM/year), and the lowest during a wet climate future (1,473 MCM/year). As expected, the outflow is the highest in a wet future (13,661 MCM/year), and the lowest in a dry climate future (4,448 MCM/year). As with the other scenarios, in a semi-dry and dry future, downstream hydropower will be compromised. This means that although this scenario prioritizes hydropower energy, hydropower generation (and income) will only reach the maximum economic benefits under a wet climate future.

Figure 13
Water Balance
(BCM/yr) of the
Lower Kafue
under the Urban-
and Energy-Driven
Scenario





In summary, both agriculture-driven and urban and energy-driven growth pathways reduce flow into the Zambezi more than the business-as-usual and green growth pathways. These differences generally increase under drier climates. Added to this, under the historical climate, hydropower generation does not vary considerably for each of the growth scenarios; although green growth provides the highest generation. For the climate scenarios, there is a clear decrease in generation under the two drier scenarios than the wetter scenarios; under the drier climates, the differences in growth scenarios becomes apparent.

RISK PRIORITIZATION AND SYNTHESIS

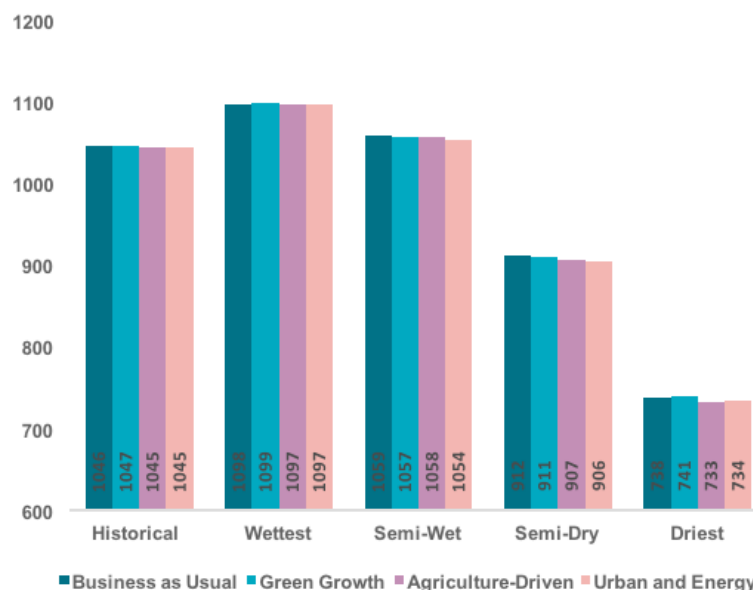
THE KAFUE HAS REACHED MAXIMUM ALLOCATION LEVELS

Several studies, including this report, indicate that the Kafue has reached maximum allocation levels and that Zambia's current development trend (business-as-usual) is not sustainable in terms of water use. Under the business-as-usual scenario, the winners will be the upstream users of the river, and the losers, the downstream users. Some sectors such as the urban sector might, however, be able to overturn this winner-loser situation by advocating to the government in order to protect their own water rights. However, it must be noted that, if water is over-abstracted, the system would collapse, and all stakeholders in the Lower Kafue basin would lose. In most cases, hydropower as the downstream user and the environment requiring variable flow regimes, will be the greatest losers.

To ensure a more sustainable future for the Kafue, three different plausible pathways were envisaged as alternatives to the business-as-usual scenario. Under the green growth scenario, preserving the health of ecosystems is a priority. The tourism sector, fishermen, cattle

farmers and rural communities will, therefore, be relatively better off than under a business-as-usual scenario; industrial activities might be restrained for their impact on the environment. Urban hubs will grow at a slower pace than under a business-as-usual or urban-driven growth scenario, which might allow for more sustainable growth.

Figure 14
Hydropower Generation
(GWh/year) for the
Development and
Climate Scenarios



Under the agriculture-driven growth scenario, agriculture is promoted by the government as central to the growth of the region, as well as central to guaranteeing food security in both the region and the country. Under this scenario, laws are in favour of irrigation practices, and the downstream dams might be getting less water for energy production. In that case, there must be a recognition that energy should be sourced from other regions in Zambia.

Under the urban-driven growth scenario, urban development, industrial growth and energy production are given the priority for water use and are therefore privileged. The losers are likely to be smallholder and commercial farmers whose water allocation quotas for irrigation might be restrained to guarantee a higher supply of water in the downstream part of the Kafue, where urban and industrial hubs are located.

**HYDROPOWER
GENERATION HAS
ALREADY BEEN
IMPACTED BY
CLIMATIC SHOCKS**



Below is a summary table of the winners and losers under each scenario.

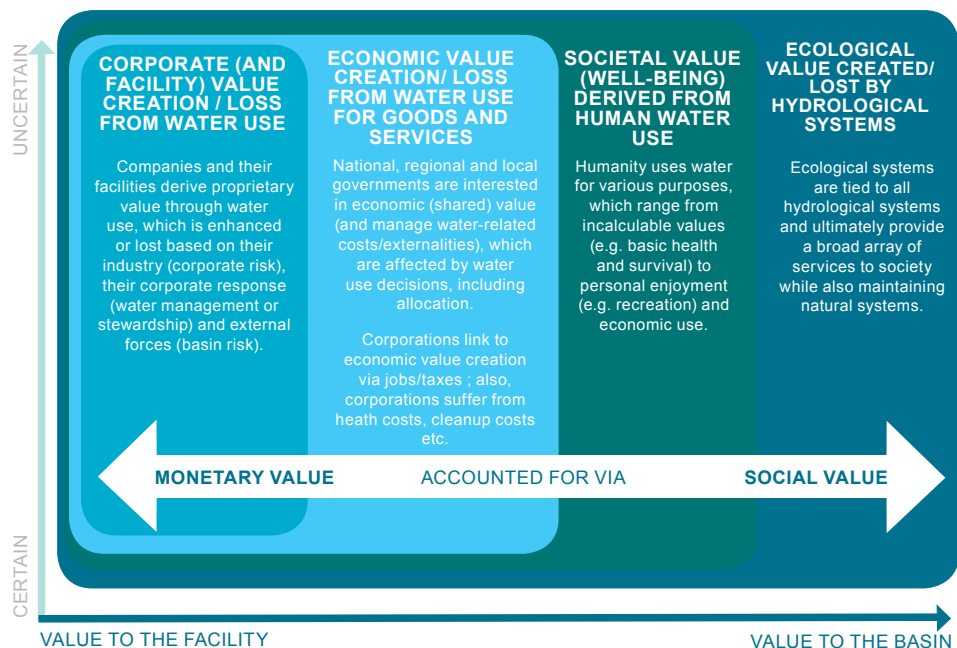
Table 5
Winners and Losers
under each Development
Scenario

BAU							

THE VALUE OF WATER

Water is arguably the most precious resource on Earth, and yet we often value and manage it extremely poorly. While the price of water traditionally reflects a limited set of costs to treat and transport water, the value of water is far greater. However, the value of water is difficult to quantify because various audiences conceptualize and describe its values differently (as shown in Figure 15). Added to this, all of the stakeholders have a legitimate claim on water and its use. The private sector tends to use the language of finance, while governments often employ concepts from economics and civil society, using a range of environmental, rights-based, or social-good language for valuing water.

Figure 15
The Value of Water
to a Company, the
Economy, Society
and Nature



WATER IS ARGUABLY THE MOST PRECIOUS RESOURCE ON EARTH

The importance of water and environmental resources is generally accepted; however, its value in economic terms is not. In Zambia, the economy is largely dependent on its stock of environmental and natural resources. Most sectors of the economy rely on environmental and natural resource goods and services to enhance their productivity, provide the necessary raw materials, and reduce the cost of public expenditure for providing the services in those sectors. A rapidly growing population poses an increasing challenge to environmental and natural resources management, calling for greater efforts to ensure that these resources are sustainably managed for present and future generations.

ECONOMIC IMPLICATIONS OF RISKS

The GDP for the Lower Kafue is estimated at K48 billion (as shown in Table 6). The biggest contributor to GDP in the Lower Kafue is the commercial sector in urban areas, with an estimated K36 billion (75 per cent of the total GDP). Of the total K48 billion, K2 billion represents small-scale agriculture; while small-scale agriculture does not directly contribute to GDP, it contributes to household income and reduces poverty levels and therefore has an economic value (through household income). It should also be noted that although the fisheries sector is estimated at less than 1 per cent of the GDP, some of the household income for small-scale farmers is from informal fishing activities.

Table 6
Changes in GDP
under Different
Development
Scenarios
(in K Million)

	Current
Urban Growth*	36 400
Conservation & Eco-Tourism#	1 200
Commercial Agriculture*	1 358
Small-scale Agriculture**	2 038
Fisheries##	42
Industry*	5 200
Hydropower*	2 200
TOTAL (K Million)	48 438

* Source: National Accounts, Gross Domestic Product - 2014 & 2015 (CSO, 2016), and then estimating the portion that is in the Lower Kafue.

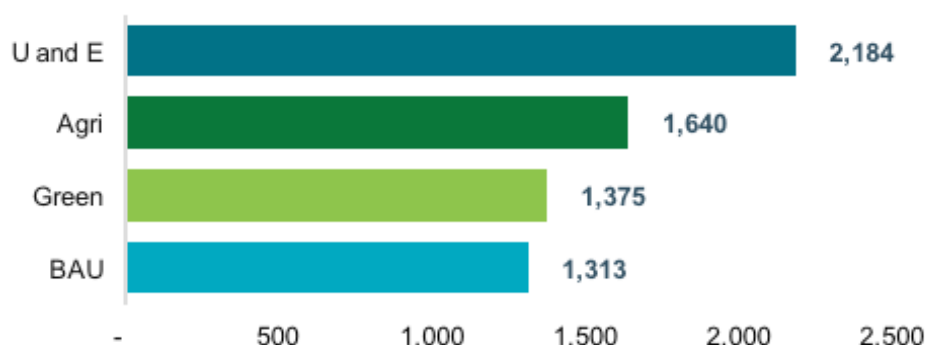
Source: Tourism Statistical Digest (2014), and then estimating the portion that is in the Lower Kafue.

** While small-scale agriculture does not directly contribute to GDP, it contributes to household income and reduces poverty levels. In the Lower Kafue, approximately 99% of households (245,000) practice small-scale agriculture. According to the Living Conditions Monitoring Survey Report (2015), the average income for small-scale farmers is K693.1 per month.

The fisheries subsector contributes around 1.24% of the gross GDP or 3% of agriculture GDP (Musumali et al, 2009).

The increase in annual GDP is greatest under the urban- and energy-driven scenario (at K2.2 billion), and the lowest under the business-as-usual scenario (at K1.3 billion). That means that for the urban- and energy-driven scenario, the GDP of the Lower Kafue will increase by close to K1 billion. While the green growth scenario does not have a substantial increase in GDP, it enables the largest increase in small-scale agriculture. This will have a direct impact on poverty reduction as household incomes could increase.

Figure 16
Increase in GDP
for the Four
Development
Scenarios



Based on the water used per sector (MCM/year), and the estimated GDP contribution, the value of water per sector was estimated (see Table 7). It is evident that hydropower uses the most amount of water to generate each Kwacha. However, since 95 per cent of Zambia's electricity is hydropower, it is important to recognize that hydropower not only generates direct GDP for the Lower Kafue, but also enables other sectors to operate and thus contribute to the economy. Mining and manufacturing sectors are reliant on hydropower; this reliance results in an economy that is completely dependent on its water resources and therefore sensitive to climate shocks and stresses associated with climate variability and change. Hydropower generation has already been impacted by climatic shocks such as drought, which have a double-edged effect, through the reduction of water supply itself and the reduction of water to generate hydropower, and the resultant electricity shortages. Going forward, the analysis needs to consider the imposed costs to the economy of dry periods (as outlined above), as well as the development potential of different growth trajectories.

Table 7
Value of Water
per Sector

	Water Use (MCM)	MCM per K Million	K Million per MCM
Urban Growth*	108	0,003	337,816
Conservation & Eco-Tourism#	22	0,018	55,172
Commercial Agriculture*	867	0,425	2,350
Small-scale Agriculture**	limited water demand, reliant on rainfall & sustainable ecological flows		
Fisheries##	limited water demand, reliant on healthy ecosystems & sustainable ecological flows		
Industry*	112	0,022	46,429
Hydropower*	9,608	4,367	0,229
TOTAL (K Million)	10,717	4,835	441,996





COST OF WATER AND ELECTRICITY, AND THE ASSURANCE OF SUPPLY

The price of water traditionally reflects a limited set of costs to treat and transport water. Low and subsidized water prices are important to ensure the human right to water is met, and yet water's low market-based cost has resulted in profligate use, freshwater contamination and, in general, inflicted costs upon society and nature. As Zambia is wholly dependent on hydropower, an increase in the cost of water and electricity (i.e. hydropower) will result in an increase in the cost of living and development. This will impact sectors both directly, through the increasing cost of water and electricity, and indirectly, through employees who demand higher wages due to an increasing cost of living.

**AN INCREASE
IN THE COST
OF WATER &
ELECTRICITY
WILL RESULT
IN AN
INCREASE IN
THE COST
OF LIVING &
DEVELOPMENT**



The infographic on the right illustrates the current and projected trends in the price of electricity (2010-2030). It is evident that the price of electricity will continue to increase, resulting in a rise in the



cost of production and operations, as well as the cost of living for the population of the Kafue. A similar trend is projected for the cost of water. As water demand is projected to increase across the various climate and development futures, the cost of production, operations and living will rise. This will result in a direct increase in expenditure for the sectors operating in the Kafue. Without increases in production output or income, a decrease in profit margins will be evident.

The percentage increase in the water demand is highest under the urban and energy-driven scenario (52 per cent), and the lowest under the green growth scenario (23 per cent). Across all climate futures, consistent trends are observed across all sectors (urban, industry and tourism), except for the commercial agriculture sector. For irrigated agriculture, water demand varies based on the climate future mainly due to changes in temperature and evaporation; the demand is the highest under the agriculture-driven growth scenario in a dry future (1.5 BCM/year), and the lowest under the green growth scenario in a wet future (1.1 BCM/year).

However, it is important to remember that water supply is not guaranteed. Water allocation in the Kafue will continue being a contentious issue as compromises will have to be made. This becomes even more important in the future, particularly since the catchment is projected to continue being exposed to seasonal and interannual climate variability. As previous droughts in the region have resulted in water and energy requirements for the sectors of the economy not being met, there is obviously a delicate relationship between the availability and competition for water resources, and the economy of the Lower Kafue. The climate future that does prevail, coupled with the development pathway that is selected, will have a large bearing on the socio-economic development of the Lower Kafue.

OPPORTUNITIES

The water resources of the Lower Kafue play a fundamental role in the socio-economic development of the region. However, water resources are limited and the quality is not sufficient to meet requirements and to satisfy the growth ambitions of all the sectors simultaneously. Added to this, seasonal and interannual variability will continue, placing increased pressure on the water users in the Lower Kafue. The stakeholders in the Lower Kafue, therefore, face current and future risks relating to water availability, particularly in dry seasons and years. The adoption of proactive adaptation measures to avoid and mitigate risks will help promote the sustainable growth of the Lower Kafue.

The water balance analysis in this study has been crucial in highlighting key factors that should be taken into account in any further work on the basin's water resources. This has provided justification for a planning process that takes into account both climate variability and change, particularly at a temporal and spatial scale. Importantly, this study shows significant water risks in the Lower Kafue, particularly in dry years, and therefore highlights the need for stakeholders of the Lower Kafue to work together and explore the benefits of an inclusive catchment planning process. The Water Resources Management Authority (WARMA) has initiated such planning work in the region.

Key actors in the management of water-related risks include the Government of Zambia, the private sector, and NGOs/civil society.

The Government: The government recognizes the fundamental role that water plays in the economy through its national development plans. Beyond this recognition, the government needs to adopt appropriate governance mechanisms. If not, it faces credibility, reputational and legitimacy risks, which could lead to a reduction of foreign direct investment and a decrease in Zambian exports, ultimately leading to poor GDP and employment performances.



**THE
GOVERNMENT
NEEDS TO
ADOPT
APPROPRIATE
GOVERNANCE
MECHANISMS**

The opportunities for the national and local authorities (including service providers such as ZESCO Limited, Lusaka Water and Sewerage Company and Southern Water and Sewerage Company) to mitigate and manage risks include:

- Developing a realistic risk management plan, that takes into account hydro-climatic variability. This should be coupled by putting in place adequate plans for the future, leveraging water-related opportunities and managing increasing demands.
- Putting in place and successfully implementing corporate strategies to minimise water use (by promoting efficiency) and improving the quality of water discharge.

- Participating in a multi-stakeholder catchment allocation planning process, and making sure implementation is successful.
- Working on interventions that minimise endogenous and exogenous water-pressuring factors, while also increasing the resilience of vulnerable communities or economic sectors.
- Collaborating with private sector expertise to gain knowledge, technical and software advances and management strategies.

For most of these activities, the government could explore funding and technical assistance from international development agencies and the private sector.

The Private Sector: Various companies bear risks due to the water challenges of the Lower Kafue, from the risk of decreasing production or increasing costs, to losing commercial opportunities, or reputational risks. Therefore, the sustainability and growth strategy of most of the companies will be impacted by water availability, water quality and hydropower, either directly or through the supply chain. Because of their dependence and impact on water and the economy, companies must take part in the efforts of mitigating water risks in the basin.

Private sector opportunities to mitigate water-risks and build resilience in the basin include:

- Adopting Water Stewardship programs and other initiatives in accordance with the UN Global Compact's CEO Water Mandate.
- Working with stakeholders outside of the company's operations to better understand, mitigate and manage direct and indirect risks to operations and employees.
- Transparently sharing information with governmental actors about current and anticipated future water demand. This will be key to discussing trade-offs and helping establish a fair water allocation plan.

Civil Society Organization (CSO): Ecosystem goods and services support a large number of livelihoods in the Kafue. However, despite its rich agricultural resources, the Kafue has continued to experience high poverty levels. CSOs play a key role in voicing the concerns of the most vulnerable stakeholders in the Kafue, as well as protecting the natural environment and ecosystems. Water resources are critical to achieving poverty reduction, inclusive growth, public health, food security and livelihoods, as well as promoting environmental sustainability.



**THE ADOPTION
OF PROACTIVE
ADAPTATION
MEASURES TO
AVOID & MITIGATE
RISKS WILL HELP
PROMOTE THE
SUSTAINABLE
GROWTH OF THE
LOWER KAFUE**

IT IS CRITICAL THAT STRONG RELATIONSHIPS ARE FORMED AMONGST A BROAD RANGE OF STAKEHOLDERS

CSOs can support vulnerable stakeholders with overcoming significant water-related challenges by:

- Voicing water-related concerns in a proactive and preventive manner.
- Lobbying and supporting the government in ensuring sustainable use of water resources in the Kafue.
- Supporting local stakeholders in their water resources governance.
- Supporting research activities that assess the impact of climate change and variability on the livelihoods of the population.
- Collaborating with stakeholders on solutions to water stress, to facilitate knowledge-sharing and financing.
- Working on building strong relationships of trust between key stakeholders in the basin to ensure cohesion in times of crisis.

It is evident that water plays a critical role underpinning sustainable development (i.e. economic, social and environmental). Water resources, and the essential services they provide, are critical to achieving poverty reduction, inclusive growth, public health, food security and livelihoods, as well as promoting environmental sustainability. The challenges associated with water resources management in the Lower Kafue cannot be underestimated. Therefore, it is critical that strong relationships are formed amongst a broad range of stakeholders before any crises associated with water resources manifest.

Future Studies

Reflections around the gaps of this report have enabled the identification of a series of key elements to be integrated into future studies. Importantly, this study has highlighted how water resource planning hinders an accurate understanding of the surface and groundwater resources. In instances of data limitations, analytical approaches such as hydrological modelling and water abstraction projections would prove crucial to understanding who has access to water and under what climate conditions.

Future studies on the Kafue basin should:

- Go beyond a 'multi-year average' basin-wide water balance analysis, and also include the temporal and spatial scale. This should focus on the impact of dry periods on water resources and assurance of supply, as well as an assessment of the tributaries of the Lower Kafue, as they are often vulnerable due to climate variability and climate change.
- Include e-flows considerations and evaluate the implications of reserves for water allocation plans, and reservoir operating rules.

**OTHER KEY
ELEMENTS
IDENTIFIED FOR
INTEGRATION
INTO FUTURE
STUDIES**



- Include a groundwater study to better understand groundwater consumption, and the interaction between surface and groundwater related to the conjunctive use of water, particularly in the tributaries.
- Develop a thorough understanding of water quality and its impacts on a reliable supply of water that is fit-for-use (as monitoring is currently inadequate).
- Map the geographic location of different socio-economic activities and note the source of their water intake, as this will assist the understanding of which stakeholders are impacted by stresses on the main river, and which are impacted by stresses on tributaries. This will enable an understanding of the spatial distribution of economic activities and infrastructure, the incremental supply to the catchment, as well as the sensitivities of different tributaries to climate change.
- In light of seasonal variability, distinguish different levels of assurance of supply required by different sectors. For example, due to the strong correlation between flows and energy production, the sustainability of hydropower activities requires high levels of assurance. On the other hands, the resilient nature of tourism means that the assurances of supply may be lower with greater restrictions in severe dry periods.
- Ensure that planning for drought operation is done as part of the allocation plan to ensure that all stakeholders understand the implications of assurance of supply and economic consequences under different development trajectories.
- Explore the role that additional tributary storage may play in improving resilience through localized improvement in the assurance of supply and system yield, noting the implication on downstream users and environmental flows.
- Investigate best practice interventions adopted in other water-stressed river basins, while recognizing the unique characteristics of the Kafue basin. This also includes exploring collaborative approaches such as community water quality monitoring programs or private sector-led water resource monitoring and recording partnerships.

KAFUE FLATS in numbers

\$5.1 MILLION

The GDP for the Lower Kafue Sub-Basin is estimated at \$5.1 million (K48 billion)

50%

50% of the total Zambian population lies within the Kafue Catchment

1 MILLION

Almost 1 million people depend directly on the Kafue Flats for their Livelihoods



Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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