This project is funded by the Commission of the European Union

NEPAD Networks of Centre of Excellence in Water Sciences PHASE II

A C E W A T E R 2 P r o j e c t 2 0 1 6 - 2 0 1 9

CHARACTERISATION OF CURRENT AGRICULTURE ACTIVITIES IN ZAMBEZI RIVER BASIN (ZRB)

Project location Zambezi River Basin (ZRB)
Project start date: 29/09/2017
Project end date:

Title of the Deliverable	Database of Agriculture activities in the ZRB
Institution	Natural Resource and Environment Centre (NAREC), University of Malawi
Contact person	Cosmo Ngongondo
Postal address	P.O. Box 280, Zomba
Telephone	+2651524222
Fax:	+2651524046
E-mail	cngongondo@cc.ac.mw

2 April 2019

EXECUTIVE SUMMARY

The Zambezi River Basin (ZRB), in Southern Africa, is a key transboundary water resource that sustains the socio-economic livelihoods of a total population of between 30 and 40 million. This report presents a characterization of current agricultural activities in the ZRB and potential future developments in irrigation. These activities also include those based on local knowledge on crops, spatial distribution, productivity, irrigation in addition to rainfed production, livestock and fisheries. Various documents were reviewed and databases analyzed to inform the study. The study has found that food crop production is the most important agricultural sub-sector in the ZRB, accounting for approximately 80% of the cultivated area. Maize and cassava are the major staples and other food crops include rice, groundnuts, beans, sweet potatoes, sorghum, millet, and a wide variety of vegetables. Various studies conducted in the ZRB show that food and cash crop diversification has been promoted over the past 30 years. Under crop diversification, ZRB countries mostly practice sequential cropping and intercropping systems. However, most countries in the ZRB depend primarily on rainfed agriculture for their grain food and other agricultural production. Despite considerable strides being made in improving productivity and environmental conditions in the basin, a great number of poor families still face poverty, hunger, food insecurity and malnutrition largely due to their overdependence on rainfed agriculture. Livestock and fishing are the integral part of farming systems in the basin. A large number of animals, mainly cattle and goats are reared in the basin that represent important alternative livelihood strategies in addition with aquaculture, given the high risk of crop production due to the relatively low and unreliable rains and high evapotranspiration rates.

Keywords: Climate change; Economic livelihoods; Irrigation agriculture; Water resources; Zambezi River Basin.

Disclaimer

The views expressed in this report are those of the researchers at the University of Malawi's Natural Resources and Environment Centre.

Contents

Acknowledgements
This study was undertaken as part of the African Centres of Excellence Water 2 Project (ACE Water 2) with financial support from the European Commission (EC).

Abbreviations and Acronyms

ACE Water 2:	African Centres of Excellence Water 2 Project
ANG:	Angola
BOT:	Botswana
CA:	Conservation Agriculture
CAH:	Cereal Area Harvested
CT:	Chinyanja Triangle
EC:	European Commission
EU:	European Union
FAO:	Food and Agriculture Organisation
GDP:	Gross Domestic Product
IWMI:	International Water Management Institute
MAL:	Malawi
MOZ:`	Mozambique
NAM:	Namibia
NAREC:	Natural Resources and Environment Centre
NEPAD:	New African Partnership for Development
RUE:	Radiation Use Efficiency
SADC:	Southern African Development Community
SANWATCE:	Soother Africa Network of Water Centres of Excellence
TAN:	Tanzania
UNIMA:	University of Malawi
WUA:	Water Use Efficiency
WB:	World Bank
ZACPRO:	Zambezi Action Plan Project
ZAM:	Zambia
ZAMCOM:	Zambezi Basin Commission
ZAMWIS;	Zambezi Water Resources Information System
ZIM:	Zimbabwe.
ZRB:	Zambezi River Basin

List of Figures

List of Tables

This project is funded by the Commission of the European Union

1.0. Introduction

The Zambezi River Basin (ZRB) is an important transboundary basin (Figure 1) that is shared by eight riparian countries: Zambia (41.9% of total area), Angola (18.2%), Namibia (1.1%), Botswana (1.5%), Zimbabwe (15.9%), Tanzania (2.2%), Malawi (7.5%), and Mozambique (11.6%) (Beck & Bernauer, 2010; Shela, 2000). At 2,574 km long and a total catchment area of 1.39 million km^2, the basin is Africa's fourth largest and the largest river system in the Southern African Development Community (SADC). Annual rainfall decreases southwards from the high rainfall areas in the north. It varies between a minimum of 530 mm to a maximum of 2220 mm, giving a basin wide mean of approximately 930 mm. The basin is home to a total population of between 32 and 40 million, with 80% of these living in Malawi, Zambia and Zimbabwe.

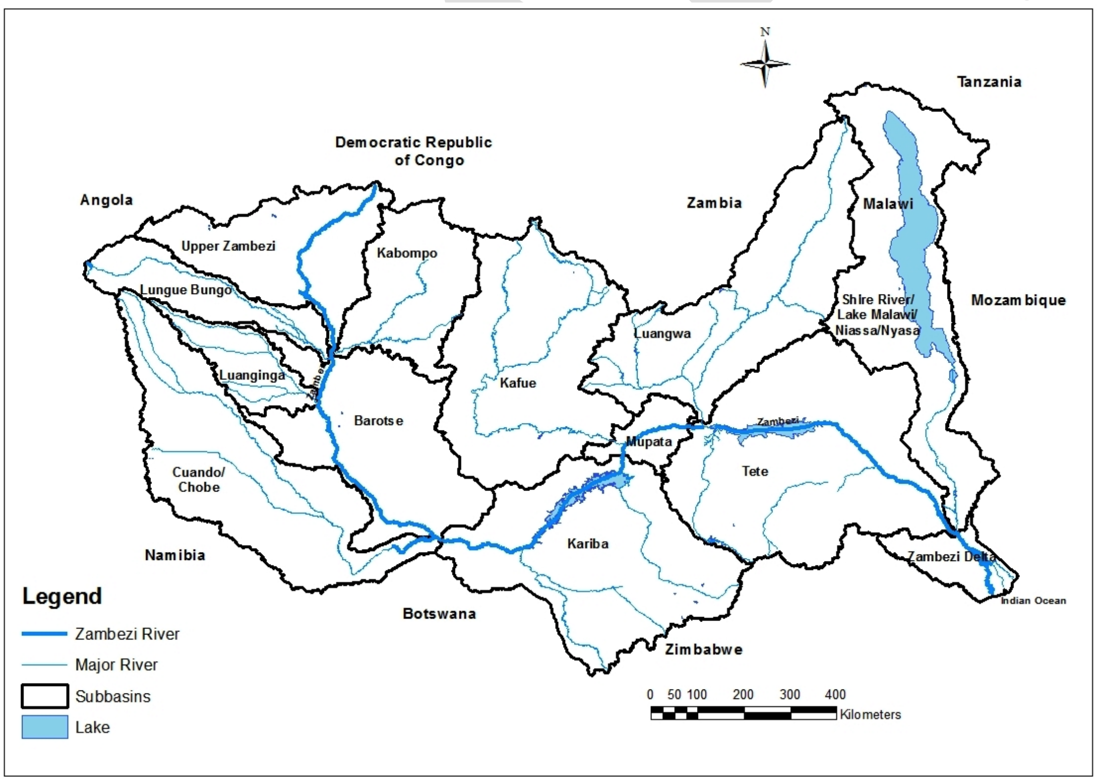


Figure 1. Map of the Zambezi basin and the 13 sub-basins (Source: ZAMCOM, 2016)

Agricultural production sustains the socio-economic livelihoods of about 80% of the total population and this goes up to 90% in some of the riparian states like Malawi (World Bank (WB), 2008; IRC, 2008; AGRA, 2014). The sector also contributes to 24% of the riparian countries GDP (WB, 2010). Most of the agriculture productivity is achieved through subsistence rainfed systems with irrigation accounting for about 5% of the total. The utilization of agricultural land and water resources among basin's traditional stallholder farmers, who constitute 80% of the farming communities, is however characterized by very low productivity. The river's upper flood plains are known to provide the better agricultural land (Gomo et al., 2018). Most of the farmers are also known to be resource poor and without access to reliable irrigation technologies, sufficient labour and agricultural inputs (AGRA, 2014). This situation is however a also prevalent in many parts of the Sub-Saharan Africa (SSA).

Climate change and variability is a key challenge to the already inefficient agriculture production systems, in addition to other pressures. The Zambezi is classified as a climate change hotspot (Midgely et al., 2011) and is among 11 major African river basins showing extreme responses to the effects of climate change and variability. A need for up scaling irrigation as means of coping with the various stresses such as population growth and climate change is therefore a priority in each of the riparian countries in order to stimulate agriculture sector growth, in particular in the rural areas, alleviate rural poverty, and improve household and national food security (World Bank, 2008). In order to inform decision making processes towards the up scaling of irrigation, there is a need for an understanding of the present state of agriculture activities in the basin.

1.1 Study Aims and Deliverable

This study presents findings on the characterization of current agriculture activities in the ZRB (crops, spatial distribution, productivity, irrigation vs. rainfed, including livestock and fisheries). The study is based on analysis of various kinds of data related to agriculture production, literature as well as local knowledge in the ZRB.

The study had two main aims:

- To understand baseline conditions in agriculture (including livestock and fisheries) by gathering and processing data and by-products (land use and coverage, local practices, seasonal patterns).
- To assess crops water demand, productivity and potential impact of irrigation expansion and scenario-based management practices.

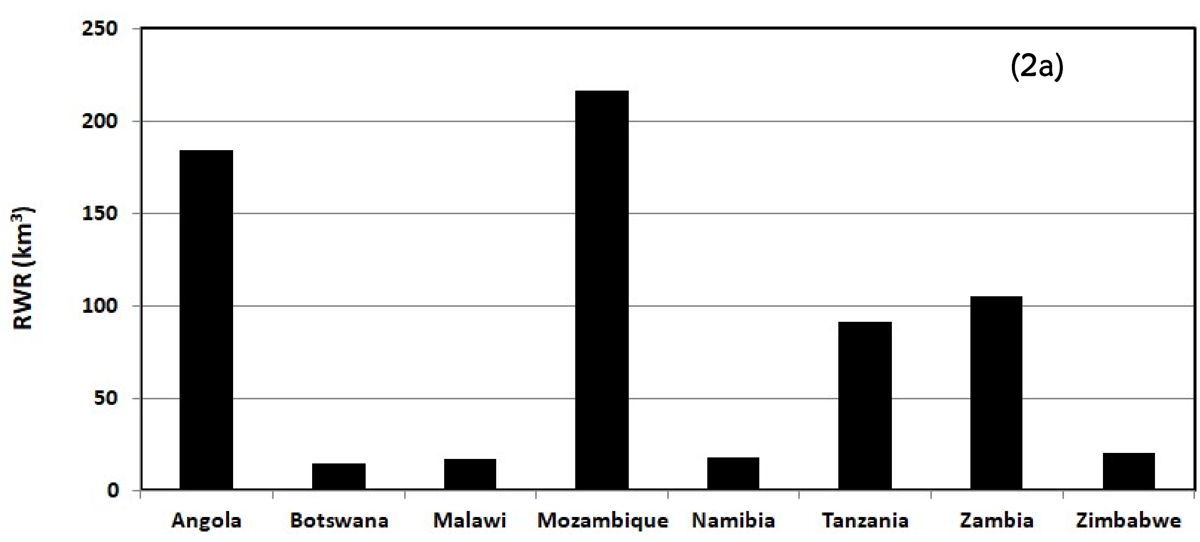
The main deliverable from the study is a characterization of current agriculture activities, future potential irrigation developments and food security face to climate variability in ZRB.

2.0 Current Agricultural Activities in ZRB

This section presents information on the state of agriculture activities in the ZRB. The section starts with an overview of water resources availability at both riparian country and the ZRB levels, against present demands, land use classification, cultivated area, major crops, cropping systems and types of irrigation.

2.1. Water Resources Availability and Demands

The annual renewable water resources (ARWR) in a country represent the theoretically available amount of water based on the long-term average flow of rivers and groundwater (FAO/BRGM, 1996). The total ARWR in each of the ZRB riparian countries and the total withdrawals from the RWR are shown in Figures 2a and 2b. Mozambique has the largest ARWR at 216.1 km^3 /year and is followed by Angola (184 km^3) and Zambia (105 km^3). On the other hand, Botswana has the lowest production of ARWR at 14.4 km^3. It can also be noted in Figure 2b that the country specific water withdrawals from annual ARWR can be considered to be on the on the lower side as compared to the available ARWR.



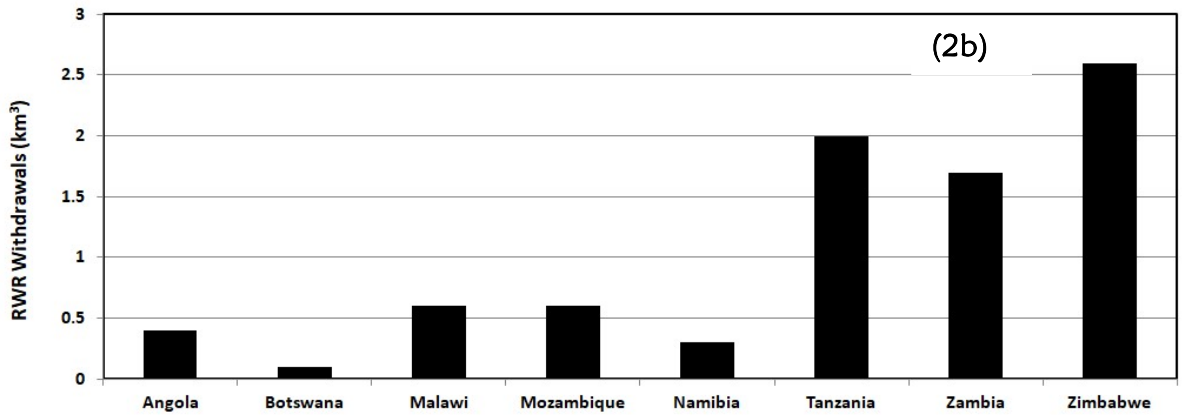


Figure 2. (a) Annual Renewable water resources (RWR) in the ZRB countries. (b) Annual water withdrawals in the ZRB riparian countries (Source: Adapted from FAO Aquastat)

At the basin level, the ZRB has a total available runoff of about 10,320 km^3 per year (Table 1). In addition, the various sector-based water demands against the total runoff in the ZRB are shown in Table 1 (Euroconsult Mott Macdonald, 2008; WB, 2010). Total water demands in the ZRB are equivalent to about 21.2% of the total runoff. Evaporative losses from lakes and hydropower reservoirs account for the largest water demands equivalent to about 16.5% of the total runoff, and this is followed by agriculture (3.13%) and environmental releases (1.16%). Water for domestic water supply for both rural and urban areas, industry, mining and livestock have relatively minimal demands of less than 1% each. It can also be added that these demands are much less than the available water available in the entire ZRB. This therefore gives the basin a huge potential for the intensification of irrigation agriculture (IWMI, 2012).

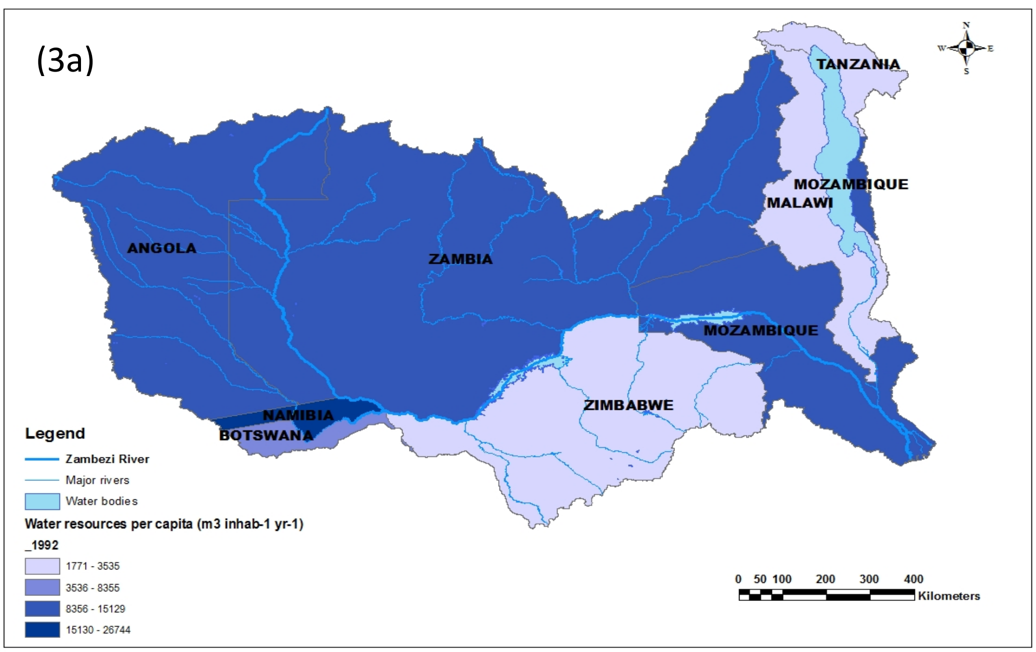
Table 1. Available runoff against present demands in the ZRB

Available Runoff/Demands	km^3	%
Available Runoff	10,320	100
Hydropower (Evaporation)	1,700	16.46
Agriculture	320	3.13
Urban(Domestic)	0.18	0.17
Rural (Domestic)	0.024	0.02
Industrial	0.025	0.02
Mining	0.12	0.12
Environmental Releases	120	1.16

Livestock	0.11	0.11
Total Water Demand	**2190**	**21.19**

Sources: Euroconsult Mott Macdonald (2008) & WB (2010)

The spatial distribution of water in the ZRB suggests that large parts of the basin have abundant water resources in terms of the annual per capita per availability (Figures 3a and b). As of 1992 (Figure 3a), the annual per capita water availability was the least in Malawi, Tanzania and Zimbabwe, approaching the water scarcity threshold of 1000 m^3 per person per year. This can be attributed to their relatively larger populations living in the ZRB as compared to the other riparian countries. As of 2013, the annual per capita water availability situation in the basin (Figure 3b) suggest considerable changes from the 1992 situation already, mostly in Mozambique, Zambia and Angola which experienced decreases.



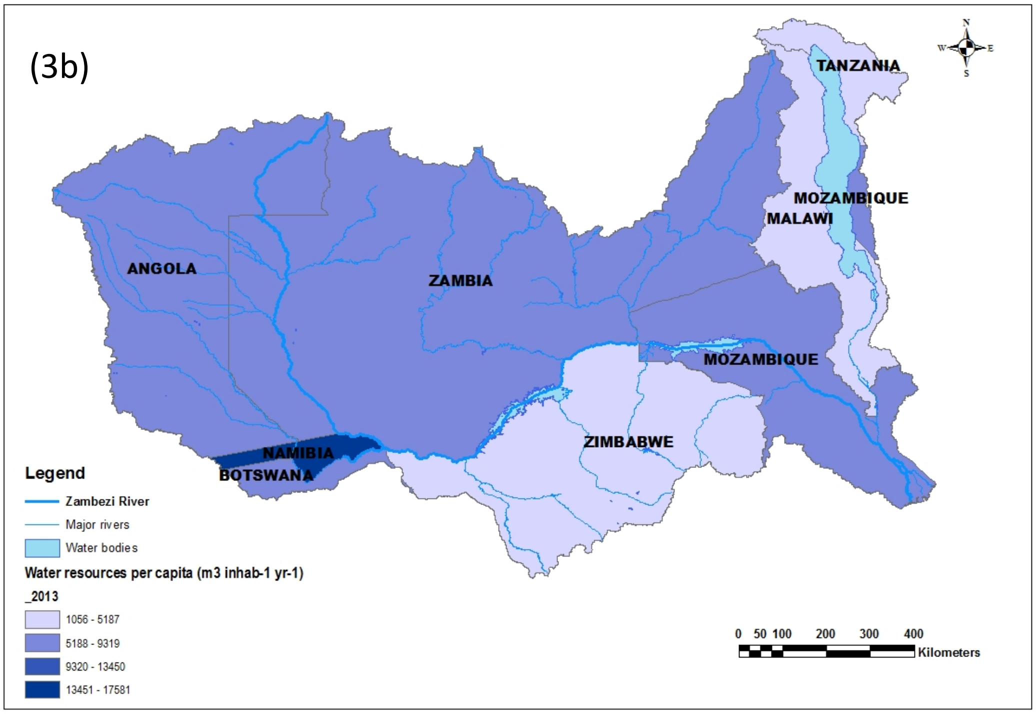


Figure 3. Water resources in the ZRB per capita in m³ inhabitant per year: (a) in 1992; and (b) in 2013 (Source: ZAMCOM ,2016).

In terms of consumptive use in each of the ZRB riparian countries, irrigation agriculture presently accounts for most of the withdrawals, ranging between 70 to 90% of the total water withdrawals. The only exception is in Botswana, where agriculture utilizes 44% of the total water withdrawals (World Bank, 2010).

Across the various sectors, utilization of ARWR is also low (Table 2 and Figure 4) according to the World Bank (2008) and ZAMCOM (2016). Water for agriculture use accounts for the highest proportions in all the riparian countries, apart from hydropower reservoir evaporative losses. The largest agricultural use can be found in the Zimbabwe part of the ZRB with 16% of water utilization. This is followed by the agriculture sectors in Malawi and Namibia which utilizes 5% each of their RWR. The domestic and industrial sectors in each of all the 8 riparian countries presently utilize less than 1% of the RWR. As the population and the levels of development in the basin increase, it can be expected that water utilization across the various sectors should considerably change.

Table 2. Sectoral Utilization of ARWR (%) in the ZRB Riparian countries

Sector	Ang	Bots	Mal	Moz	Tanz	Nam	Zam	Zim
Domestic	0.05	0.2	0.3	0.02	0.4	0.5	0.3	2.9
Industry	0.01	0.7	0.9	0.03	0.1	0.1	0.15	1.5
Agriculture	0.14	0.7	5	0.25	1.2	5	1.25	16.6

Source: World Bank (2010)

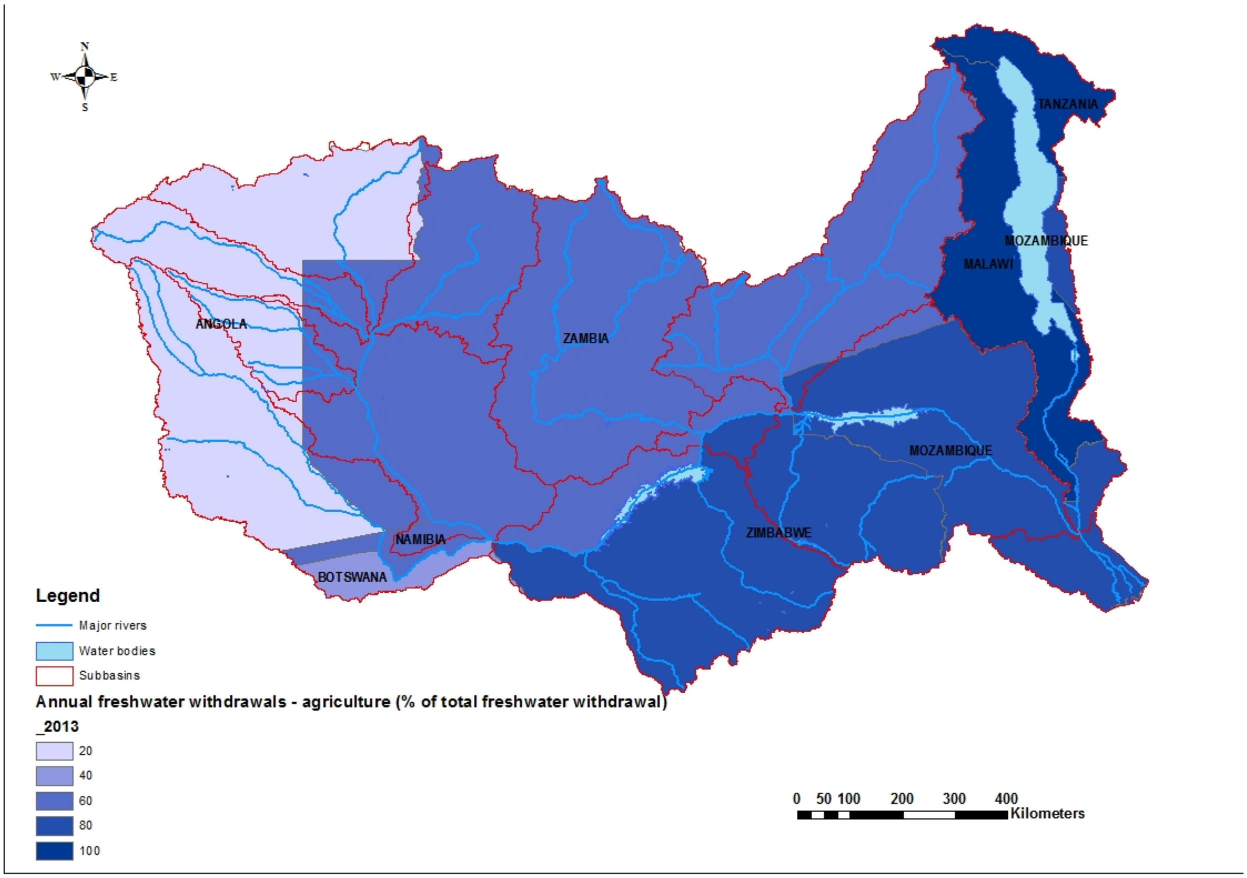


Figure 4. Annual Agricultural water withdrawals as % of total freshwater withdrawals in ZRB (Source: ZAMCOM ,2016).

The GDP in most of the ZRB riparian countries are significantly dependent upon crop production agriculture (Table 3). Malawi has the highest GDP component of crop agriculture at 50% and this ranges between 23 and 45 % in the other countries, with the exception of Botswana and Namibia whose GDP primarily depends on livestock. Currently, apart from Angola, Botswana (principally livestock) and Namibia, where agriculture is less than 10 percent of GDP, the agriculture component of GDP in the other Zambezi countries ranges from 23 percent to 45 percent (**Table 3**).

Table 3. GDP and Agriculture Value Added (2003 values)

Sector	ANG	BOT	MAL	MOZ	NAM	TAN	ZAM	ZIM
Other sectors (%)	91	98	62	74	89	55	77	83
Agric. contribution to GDP (%)	8.8	2.4	38.4	26.1	10.8	45.0	22.8	17.4
Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.								

Source: World Bank (2008) Irrigation Study

2.1. Land Use Classification

Large parts of the ZRB are relatively underdeveloped. Figure 5 shows the present land use classification in the basin based on the World Bank (2010). Forest and bush dominate, occupying about 75% of the total basin area. This is followed by cropped land, which is predominantly rainfed (13%) and grassland (8%). Infrastructural developments are the least, occupying 4% of the total basin area.

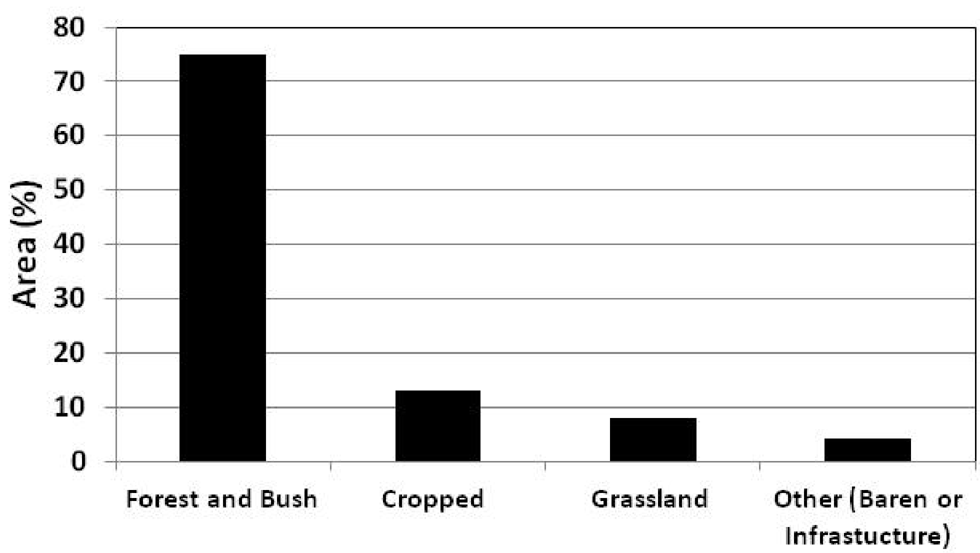
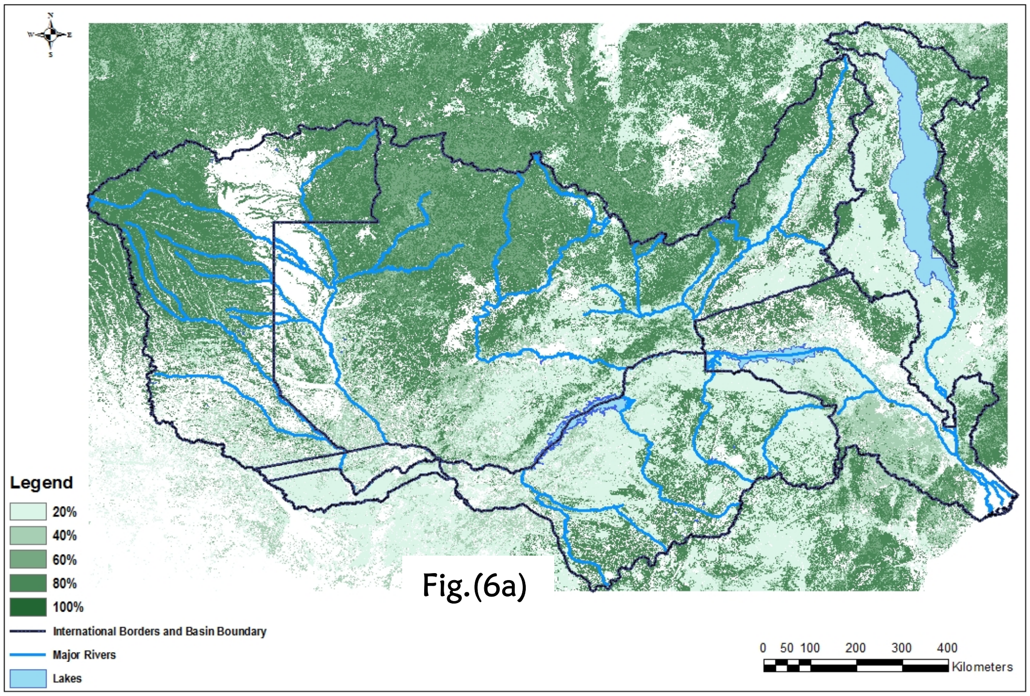


Figure 5. Land use classification in the ZRB (**Data Source: World Bank, 2010**)



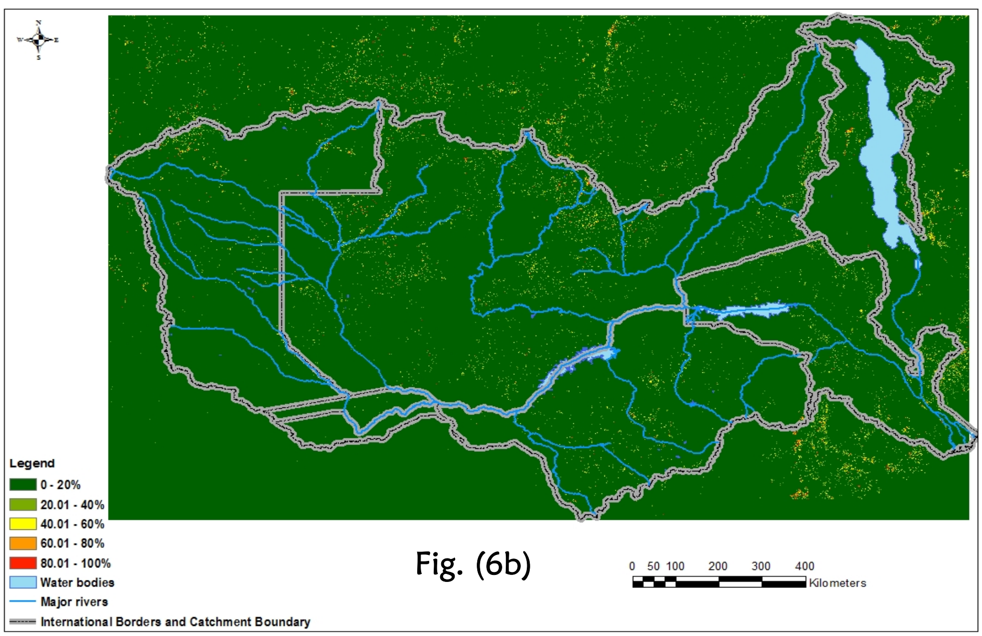


Figure 6. Forest Cover in 2000 (6a) and Forest Loss between 2000 and 2013 (6b) in the ZRB (Source: ZAMCOM, 2016)

The ZRB has experienced some land use and land cover changes (LULCC), largely involving conversion of the forest and bush area to cropped and urbanized areas. Figure 6 shows the forest cover in 2000 and the forest loss between 2000 and 2013. The situation from Figure (6b) suggests minimal forest loss spatially, although mostly around

40-60% for those parts that experienced forest loss. A large part of the basin had forest loss ranging between 0-20%. According to Gomo et al. (2018), cropped area increased to 15.98% between 1992 and 2015 (Table 4). Although the urbanized area increased considerably by 108%, the actual area occupied as a proportion of the ZRB total area is still quite low, at 0.12%. Forest cover on the other hand decreased by 4% between 1992 and 2015.

Table 4. Percentage changes in land cover from 1992 to 2015 in ZRB

Land Cover Type	% change 1992–2015	% of basin area in 2015
Cropland and herbaceous cover	15.98%	15.43%
Tree Cover	-4.57%	49.07%
Mosaic cropland and natural vegetation	1.10%	4.64%
Shrubland, grassland and sparse vegetation	-0.19%	25.38%
Bare areas	6.78%	0.07%
Urban areas	108.66%	0.12%
Wetlands and water Bodies	2.95%	5.29%

Source: Gomo et al. (2018)

2.2 Cultivated Area in the ZRB

The total cultivated area under crop production in the ZRB is about 52,050 km^2. Out of this total cultivated area (Figure 7), the largest area is in Malawi (36.56%) followed by Zimbabwe (26.28%) and Zambia (22.17%). The three countries account for 86% of the total cultivated area in the ZRB. Minimal cultivated areas are located in the Botswana (0.29%) and Namibia (0.19%) parts of the ZRB, partly due to their predominantly semi-arid conditions.

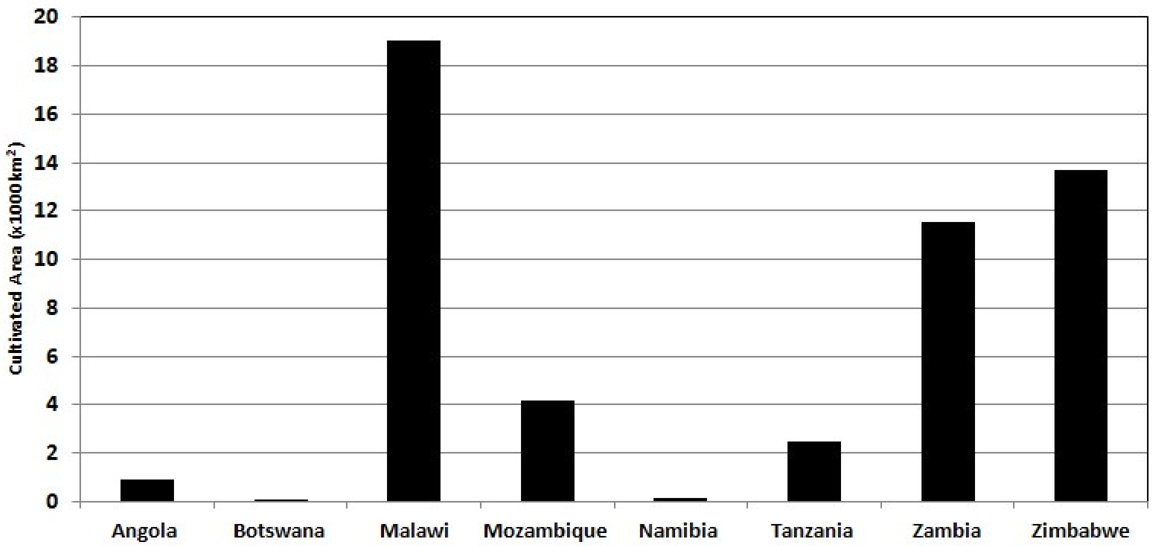


Figure 7. Cultivated area in the ZRB classified per riparian country

Crop production in the cultivated area of the ZRB is predominantly rain-fed. However, irrigation agriculture is practiced in some of the riparian countries and presently accounts for about 4% of the total cultivated area. Figure 8 and Table 5 show that the largest irrigated area within the ZRB is in Zimbabwe, representing 15.3% of the total cultivated area. Zambia has the second largest irrigated area and is followed by Tanzania, Malawi and Mozambique. Minimal irrigation is presently taking place in Namibia, while there is no area under irrigation in Botswana.

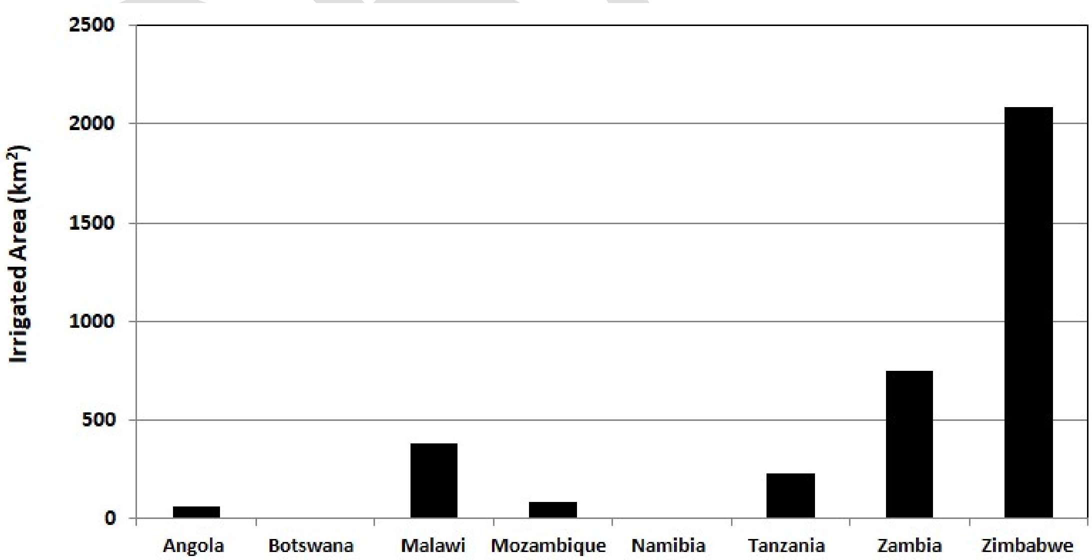


Figure 8. Area under irrigation in the ZRB classified per riparian country (Source: Adapted from World Bank, 2010)

Table 5. Area under irrigation in the ZRB riparian countries

Country	Irrigated Area (km^2)	% Total Cultivated Area
Angola	61	6.6
Botswana	0	0.0
Malawi	378	2.0
Mozambique	84	2.0
Namibia	1	0.7
Tanzania	231	9.2
Zambia	747	6.5
Zimbabwe	2087	15.3

Source: Adapted from World Bank (2010)

2.3. Major crops grown in Zambezi River Basin

Agricultural production in the ZRB is achieved through both rain-fed and irrigation although the former (rain-fed) dominates. Maize is the main major staple crop across the basin. However, in recent years, many studies have found that most communities in the ZRB have adopted more horticultural crops, departing from the traditional crops such as maize and tobacco due to frequent occurrence of drought which often results in crop destruction. Consequently, most smallholder farmers in the ZRB have adopted crops such as legumes (such as pulses), cereals (such as millet and sorghum) and root and tubers (such as sweet potatoes and cassava) owing to their drought tolerance (Waldman, 2017). Other widely grown crops across the region include vegetables (especially green vegetables like mustard and rape, onion, tomatoes, and chilies) and cotton which have better income prospects. In the estate subsector, cash crops include tobacco, cotton, rose flowers, cashew nuts, spices, macadamia, coffee, tea and sugar and these are considered to have better economic comparative advantage.

The food production index (FPI) is a statistical indicator used by the FAO to show the levels of food and livestock productivity against inputs and related costs in a reference period at country, regional or global scales (FAO, 1986). Just as the Consumer Price index (CPI), the FPI is calculated using the Laspeyres formula with 100 considered as the normal. Using data based on the FPI, food crop production in many parts of the ZRB for the base period 2004 and 2006 can been considered to have been satisfactory (Figure 9). Spatially in ZRB, it had actually improved between the year 2002 (Figure 9a) and 2013 (Figure 9b). As of the year 2013, the FPI ranged between 80 in the semi-arid parts of the basin in Zimbabwe and the Caprivi Strip in Namibia to 140 in Botswana, Mozambique and Tanzania, 200 in Zambia and 230 in Malawi and Angola. The Zimbabwe FPI suggests the only decrease in the basin as compared to the 2002 situation.

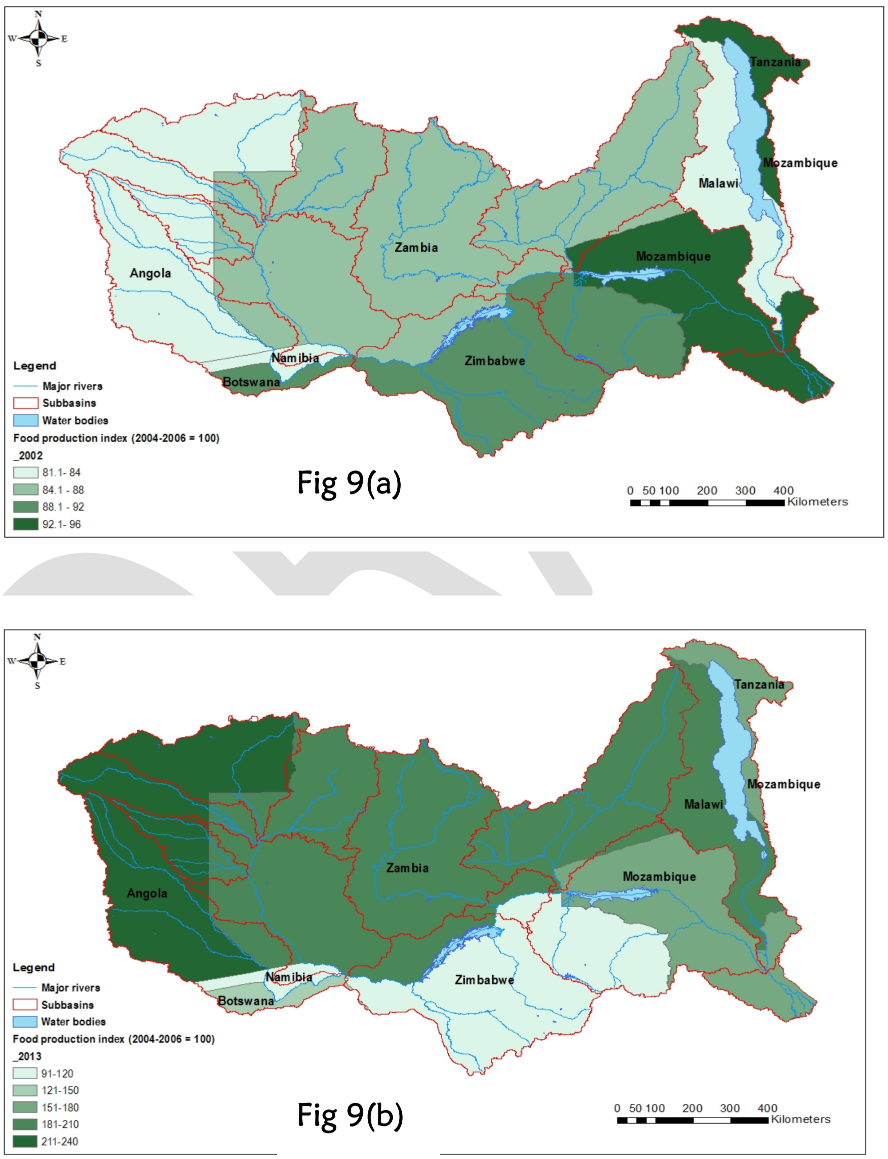


Figure 9. Food Production Index in the ZRB (2006 and 2010=100): (a) in 2002; and (b) in 2013 (Source: ZAMCOM (2016)

2.4 Cropping systems practiced in the basin

Various cropping systems are practiced in the ZRB as a result of the adoption of crop diversification. Two dominant cropping systems that are predominant in the ZRB according to O'Leary et al. (2011) are sequential cropping and intercropping systems.

2.4.1. Sequential Cropping

Sequential cropping is the practice of growing two crops in the same field, sequentially one after the other in the same year (Waldman et al., 2017). This is practiced in parts of the ZRB where the rainy season is long enough such that two main crops can be grown sequentially in one season. Growing two crops is also observed in the ZRB countries where enough moisture is left in the soil to grow a second crop. For example, in Malawi, some districts plant maize in the long rains, then beans, sweet potatoes or cassava during the short rains between March and April (Waldman et al., 2017).

2.4.2. Intercropping

Intercropping refers to the growing of two or more crops in the same field at the same time (Mloza-Banda, 2005). In ZRB countries, most people plant maize and beans in alternating rows or grow a cover crop in between the cereal rows. One advantage of intercropping is that there is increased water use efficiency (WUE) and radiation use efficiency (RUE) by crops such as maize and beans when compared to their sole cropping (O'Leary et al., 2011) leading to an increase in yield per area of land. Intercropping of legumes and maize is promoted and therefore common in the basin since it improves maize yields, from nitrogen fixation, and household nutrition. Legumes provide protein and micronutrients such as iron, zinc, or vitamin A, which are often lacking in the predominantly maize based diets (Waldman, 2017).

Special types of intercropping have been identified in the Chinyanja Triangle (CT), an area within the ZRB encompassing large parts of central and southern Malawi, Tete province of Mozambique and eastern Zambia (Figure 10). The area is inhabited by Chinyanja speaking people who share a similar language, heritage, history and culture. According to Amede et al. (2014), two overlapping intercropping systems were identified across rainfall gradients in the CT namely: maize-cassava-beans and sorghum-millet integrated with legumes, roots or fruits. The Maize-Cassava-Beans-based intercropping system is characterized by the production of maize and cassava as major crops and these are intercropped with beans, groundnuts, pigeon peas and other legumes. In the dry and semi-arid regions of the CT (Makanga and Moatize in Tete Province, Katete in the eastern province of Zambia and Mwanza and Ntcheu districts of Malawi), sorghum, millet, legumes, roots or fruits production is predominant with integrates of pigeon peas and potato. The area also has a strong potential for the production of fruits such as mango and citrus. Amede et al. (2014) also identified a predominantly livestock-based livelihood system in the driest parts of the CT where annual rainfall is below 300 mm. The agro-ecological conditions in this system favours the growing of sorghum and millet.

Figure 10.Location of the Chinyanja Triangle (CT) in the ZRB (Source: Amede et al.,2014)

2.5 Current Irrigation Activities

Irrigation agriculture is just a small component of crop production area in the ZRB as most of the basin farmers rely on rained production. However, irrigation water requirements are the second largest water using activity, after evaporative losses from hydropower reservoirs. Table 6 shows the major irrigated crops in the ZRB countries.

Table 6. Crops grown in each country under irrigation and their areas in the ZRB

Country	Rice	Wheat	Sugarcane	Vegetables	Cotton	Maize	Fruits	Barley	Soybean
Angola	16,000		9,000	15,000					
Botswana					1,000	1,000			
Malawi	13,000					2,000			
Mozambique			18,000	3,000					
Namibia		1,000			1,000	2,000	1,000		
Tanzania	34,000		13,000	38,000		16,000	7,000		
Zambia	9,000	10,000	11,000	15,000	4,000		5,000		
Zimbabwe		56,000	40,000	1,000		9,000	5,000	5,000	20,000
Total (ha)	**73,000**	**68,000**	**95,000**	**66,000**	**6,000**	**30,000**	**18,000**	**5,000**	**20,000**
%	**19.1**	**17.8**	**24.9**	**17.3**	**1.6**	**7.9**	**4.7**	**1.3**	**5.2**

Source: WWF (2003)

Among the ZRB major crops in Table 6, sugarcane covers the largest area of 95,000 ha representing 24.9% of the irrigated area. This is followed by rice (73,000 ha), wheat (68,000 ha) and vegetables (66,000 ha). The staple maize is not appearing as it is generally grown under rainfed condition. Sugarcane probably dominates due to its importance as a foreign currency earner (Djenvironmental, 2003). According to WWF (2003), sugarcane, rice, wheat and vegetables account for the largest water demands among the irrigated crops.

Figure 11 shows the area equipped for irrigation in the ZRB. The best equipped areas are in Zambia, Tanzania and Zimbabwe parts of the catchment with over 200 ha per 1000 ha of equipped area. Large parts of Angola, Botswana and Namibia are still unequipped while many parts of the ZRB in Malawi and Mozambique have less than 100ha per 1000ha that are equipped, which translates to less than 10% of their equipped area.

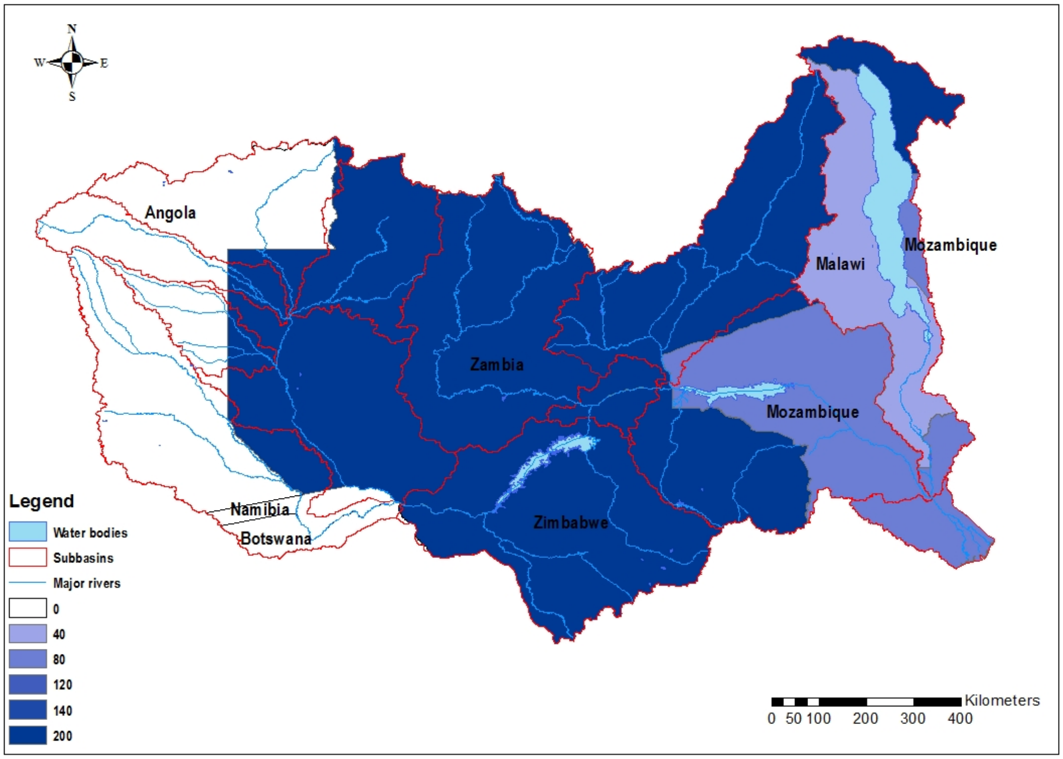


Figure 11. Area equipped for irrigation in the ZRB as total per 1000 ha (Source: ZAMCOM, 2016)

2.5.1 Sources of Water for Irrigation

Both groundwater and surface water resources are used for irrigation in the ZRB (Table 7). According to Hoekstra et al. (2001), most of the withdrawals for irrigation as of 1990 were from surface water resources. Irrigation withdrawals from groundwater resources are mostly found in the Zambian part of the ZRB with 15% of the total withdrawals in Zambia. Minimal withdrawals are in Botswana, Namibia and Malawi each having 0.3%, 1% and 0.1% of their total withdrawals, respectively. However, groundwater resources have predominantly been exploited for domestic water supply throughout much of the region and this aspect has received considerable attention in terms of investigation and data collection. In addition, there are substantial reserves of renewable groundwater in Zimbabwe and Zambia while the resource is very limited in Mozambique and unlikely to be an option for irrigation development except in isolated localities. Nevertheless, groundwater contributes to irrigation indirectly through the sustenance of a large component of total river flows through base flows. Most of the irrigation is in the dry season and this makes groundwater resources a very important resource in the basin.

Table 7. Withdrawal for the irrigation sector in 1990 (in 10^6 m^3/yr)

	Ang	Nam	Bots	Zam	Zim	Tanz	Mal	Moz	Total
From surface water	60	0.6	0.4	233	251	0	200	233	978
From ground water	0	1	0.3	15	0	0	0.1	0	16
total	60	1.6	0.7	248	251	0	200	233	994

Source: Hoekstra et al. (2001)

In the 13 sub-basins of the ZRB, the amounts of irrigation abstractions are shown in Table 8. Most of the irrigation withdrawals are taking place in the ZRB sub basins of Kafue, Kariba, Mupata, Shire/Lake Malawi and Tete. These are however not heavily committed abstractions as compared to the amount of water available, giving considerable potential for expansion.

Table 8. Irrigated areas in the sub-basins of the Zambezi River Basin

Sub-Basins	Sub-Basin Number	Abstractions	Percent
Kabompo	13	4,817	0%
Upper Zambezi	12	37,623	1%
Lungue Bungo	11	15,674	0%
Luanginga	10	14,203	0%
Barotse	9	3,491	0%
Cuando/Chobe	8	10,139	0%
Kafue	7	626,021	19%
Kariba	6	649,154	20%
Luangwa	5	120,498	4%
Mupata	4	308,562	10%
Shire River-LakeMalawi/Niassa/Nyasa	3	648,649	20%
Tete	2	669,032	21%
Zambezi Delta	1	126,973	4%
Total		3,234,836	100%

2.5.2 Potential Future Development in Irrigation

The water resources of the ZRB are presently not heavily committed as the demands are less than 22% of the total annual runoff generated. However, increasing demands should be expected as the area develops and the population increases. In addition, frequent occurrence of droughts, as the climate changes, mean that irrigation expansion will become a priority to meet increasing food needs. The International Water Management Institute (IWMI) estimated that the ZRB irrigated area would need to increase by 29 per cent from 1995 in order to meet food and other nutritional requirements by 2025 (Djenvironmental, 2003). Currently, most of the irrigation schemes are also known to be inefficient with some 20-50 percent of the diverted waters actually reaching the targeted crop area. Measures to support such irrigation initiative include the construction of additional storage and diversion facilities and ensuring more efficient use of the water already allocated to agriculture. A key challenge however is to balance the irrigation water requirements without undermining the sustainability of freshwater ecosystems (Djenvironmental, 2003).

Table 9 shows the total irrigation potential and the current irrigated areas in the riparian countries of the ZRB based on FAO (1997). As of 2000, the irrigated areas had increased in most of the countries except Angola (Table 10). However, it can also be noted from Tables 9 and 10 that there was considerable population growth in the riparian countries.

Table 9. Irrigation potential and current area under irrigation in ZRB

Country	Irrigation potential (ha)	Gross potential irrigation water requirement		Area under irrigation (ha)
		per ha (m^3/ha/ year)	total (km^3/year)	
Angola	700000	13500	9.45	2000
Namibia	11000	5000-25000	0.255	6142
Botswana	1080	5500	0.006	0
Zimbabwe	165400	10500	1.737	49327
Zambia	422000	12000	5.064	41400
Tanzania	0	11000	0	0
Malawi	160900	13000	2.092	28000
Mozambique	1700000	11000	18.7	20000

Sum of countries	3160380	37.303	146869
Total for Zambezi	3160380	37.303	

Source: FAO (1997)

Table 10. 2020 Potential Irrigated Area in the Zambezi River Basin

Country	Population in the ZRB	Total irrigated area (ha)	Current irrigated area (ha)	Increase (Mm³)	Water required (ha)
Angola	815,000	16,109	1,989	14,120	161
Botswana	13,000	280	4	276	3
Malawi	14,351,000	169,520	43,987	125,533	1,695
Mozambique	4,609,000	91,966	11,211	80,755	920
Namibia	84,000	1,544	139	1,405	15
Tanzania	1,991,000	26,128	9,070	17,057	261
Zambia	9,518,000	227,458	34,016	193,443	2,275
Zimbabwe	9,346,000	141,226	70,850	70,376	1,412
Total	**40,728,000**	**674,230**	**171,266**	**502,964**	**6,742**

Sources: World Bank (2010) & FAO AQUASTAT (2005)

As of 2013, the whole basin still has a lot of potential for irrigation (Figure 12). Most of the irrigation commitments are presently in Malawi, Zambia and Zimbabwe.

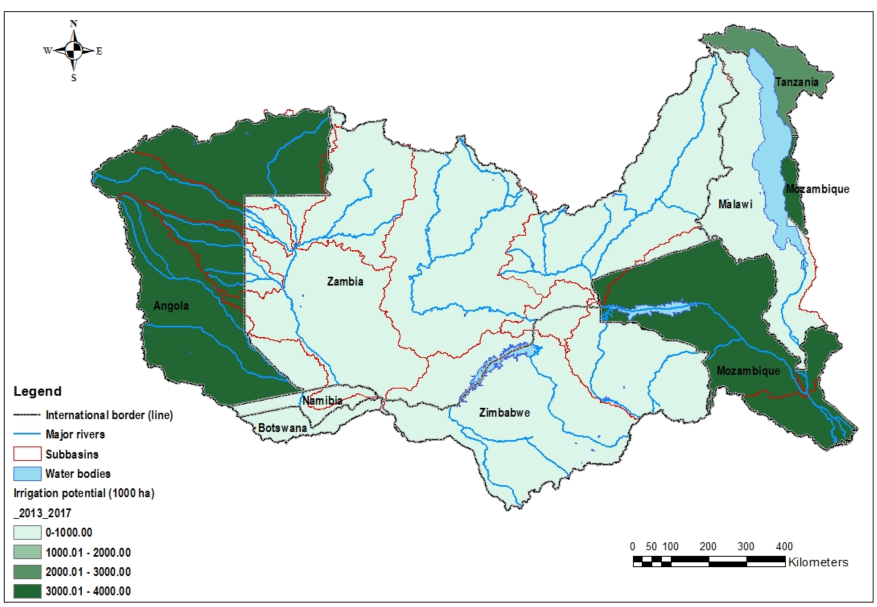


Figure 12. Irrigation potential in ZRB as of 2013-2017 (Source: ZAMCOM, 2016).

2.6 State of Livestock Water Demands in ZRB

Livestock is an integral part of farming systems. A large number of animals, mainly cattle and goats are reared in the basin that represent an important livelihood strategy given the high risk of crop production due to the relatively low and unreliable rains and high evapotranspiration rates (Amede et al., 2014). The rearing of cattle, pigs, goats, sheep and poultry has great potential as the existing supply does not meet domestic demand. Local production covers only a small fraction of the existing market demand (Vernooij et al., 2016). According to Euroconsult Mott MacDonald (2007), the middle and lower parts of the basin produces more livestock as compared to the upper basin (Table 11). Most of this production is also concentrated in Zimbabwe (41%), Zambia (31%) and Malawi (18%).

Table 11. State of livestock by country represented by cattle heads in ZRB

Country	Upper-basin*	Middle-basin	Lower-basin	Zambezi	% of Total
Sub-basins	8 to 13	4 to 7	1 to 4	1 to 13	
Angola	151,140			151,140	2%
Namibia	83,425			83,425	1%
Botswana	2,000			2,000	0.03%
Zambia	592,190	1,515,747	30,626	2,138,563	31%
Zimbabwe		1,557,593	1,245,153	2,802,746	41%
Malawi			1,252,566	1,252,566	18%
Tanzania			350,655	350,655	5%
Mozambique			115,170	115,170	2%
Total	828,755	3,073,340	2,994,170	6,896,265	
% of total	**12%**	**45%**	**43%**		**100%**

Source: Euroconsult Mott MacDonald (2008)

In terms of the actual livestock productivity, many parts of the ZRB located in Malawi and Zambia (Figure 13) have very high livestock production indices above 240. As of 2002, Angola and Mozambique accounted for the largest livestock productivity in the ZRB (Figure 13(a). The situation changed as of 2013, with Malawi accounting for the highest livestock productivity and followed by Zambia (Figure 13(b). The data suggest that livestock productivity in ZRB is actually among the highest figures globally. According to Euroconsult Mott MacDonald (2008), livestock water demands at present do not exceed 0.11% of the total consumptive water use in the ZRB. The future use is projected to reach 0.16% by 2025, representing a 45% increase from the 2007 situation, but only a 0.1% increase on the 2007 total consumptive uses.

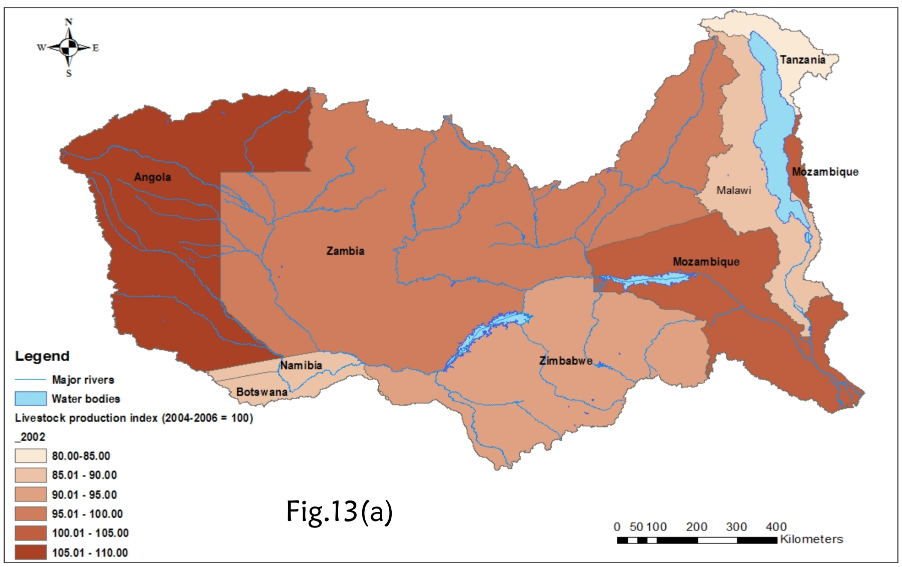


Fig.13(a)

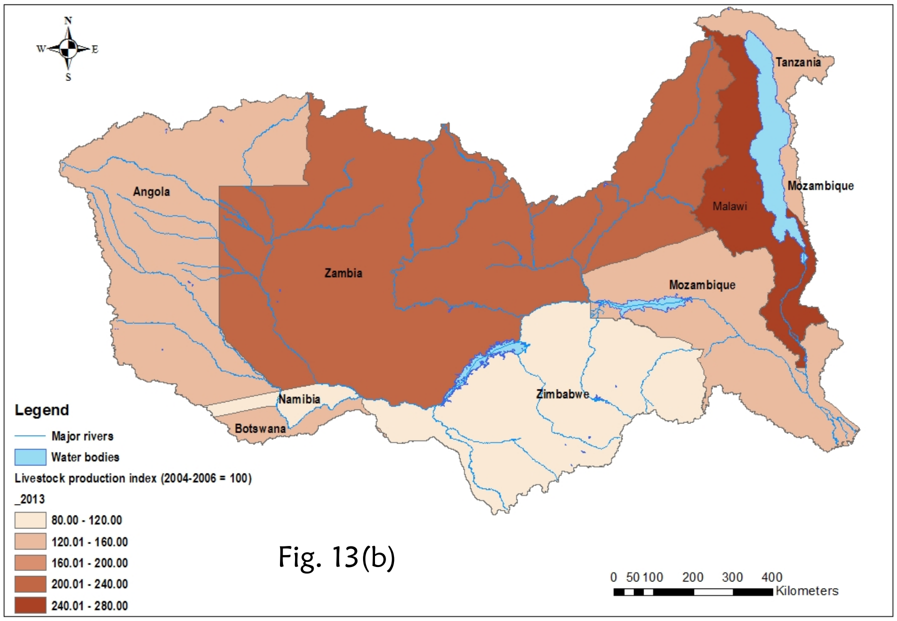


Fig. 13(b)

Figure 13. Livestock production Index in the ZRB (2004 and 2006=100): (a) in 2002; and (b) in 2013 (Source: ZAMCOM, 2016)

2.7 Aquaculture and Fisheries

The Zambezi basin has a wide diversity of fish species, with a significant number that are endemic. According to WB (2010), a total of 85 fish species can be found in the upper parts of the ZRB up to Victoria Falls and 80 species in the Kafue Rivers up to Kalomo Falls with 60 and 15 species in the middle and lower sections respectively. In addition, Lake Malawi has over 500 fish species but is considered having distinct fish ecology as rapids and waterfalls restrict migration of the fish species.

Mean annual fish production from the most important fisheries in the ZRB as of 2008 is shown in Table 12. The table shows that production is highest in Lakes Malawi, Kariba, Cahora Bassa. As of 2013, Lake Malawi still accounted for the largest fisheries (Figure 14).

Table 12. Mean annual production of the most important fisheries in the ZRB in million tonnes per annum (m.t.p.a)

Fishery	Country	Mean Production (m.t.p.a.)
Lake Malawi	Malawi	50,000-64,000
Lake Kariba	Zambia/Zimbabwe	23,600-28,600
Lower Shire floodplains	Mozambique	4,000-17,000

Cahora Bassa	Mozambique	13,500
Lake Malombe	Malawi	10,000
Zambezi Delta	Mozambique	2250-10000
Barotse floodplains	Zambia	7,500
Kafue Flats	Zambia	7,000
Eastern Caprivi floodplains	Namibia	1,500
Lukanga swamp	Zambia	1,400
Lake Lusiwashi	Zambia	927
Lake Itezhi-tezhi	Zambia	640

Source: Euroconsult Mott MacDonald (2008)

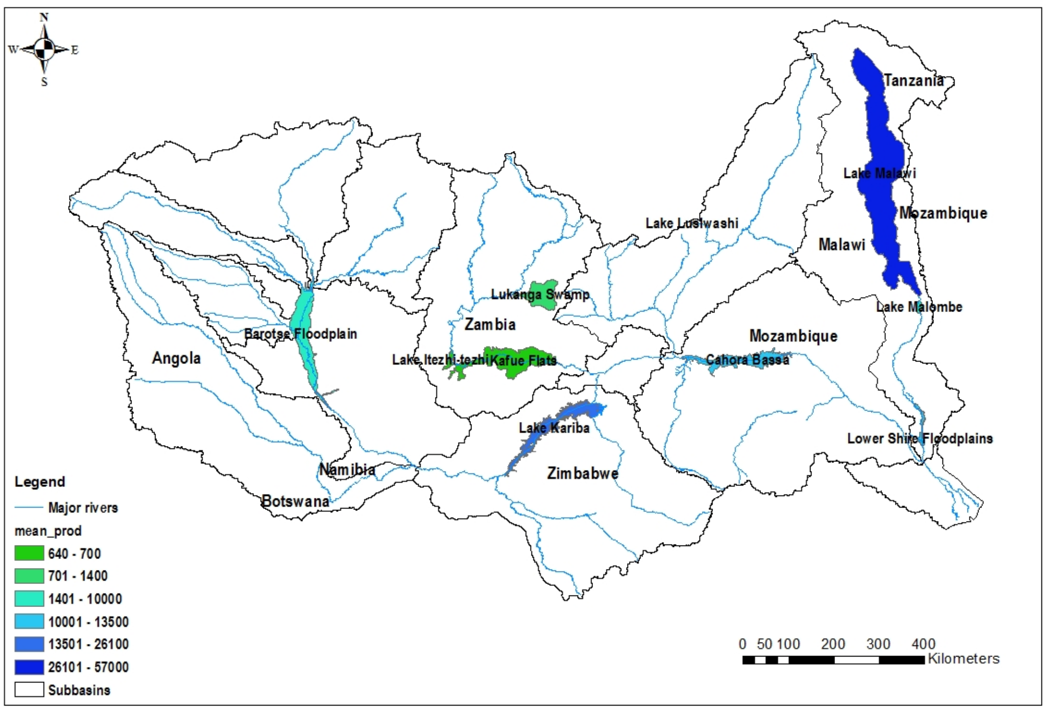


Figure 14. Major fisheries of the ZRB and mean annual production in m.t.p.a. (Source: ZAMCOM, 2016)

3.0 Conclusions

This study was aimed at providing baseline information on the state of agriculture in the ZRB in southern Africa. The study has found that agriculture is the main source of socio-economic livelihood of communities in the ZRB. Although irrigation potential is very high with abundant water resources, subsistence rain fed production is the dominant mode. Most communities in ZRB practice family agriculture where on-farm activities largely dependent mainly on family farm labour with very minimal mechanization if any. The study has also found that food crop production accounts for around 80% of the cultivated area and that maize and cassava are the major staples. Despite large strides being made in improving agricultural productivity and environmental conditions in the basin, a great number of poor families still face poverty, hunger, food insecurity and malnutrition as the rainfed agriculture is largely inefficient. In addition, food and cash crop diversification has been promoted over the past 30 years in the basin through sequential cropping and intercropping systems. Livestock and fishing also constitute an integral part of the agriculture systems in the basin. The relatively high risk of crop production due to the unreliable rainfall patterns coupled with high evapotranspiration rates has resulted in the adoption of livestock production (especially cattle and goats) and aquaculture as alternative livelihood strategies.

REFERENCES

Amede, T., Desta, L.T., Harris, D., Kizito, F. & Cai, X. (2014). The Chinyanja triangle in the Zambezi River Basin, southern Africa: status of, and prospects for, agriculture, natural resources management and rural development. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Beck, L. & Bernauer, T. (2010). Water Scenarios for the Zambezi River Basin, 2000 – 2050.

Djenvironmental, T.D. (2003). Agricultural Water Use and River Basin Conservation. Switzerland: World Wide Fund.

Euroconsult Mott Macdonald (2008). Integrated Water Resources Management Strategy and Implementation Plan for the Zambezi River Basin, SADC-WD/ Zambezi River Authority,SIDA/DANIDA, Norwegian Embassy Lusaka, Gaborone, Botswana.

FAO AQUASTAT (http://www.fao.org/docrep/W4347E/w4347e0o.htm).

FAO/BRGM (1996). Les ressources en eau. Rome.

FAO(1986). The FAO Agricultural Production Index. FAO Economic and Social Development Paper 63.

Gomo, F.F., Macleud, C.,Rowan, J., Yeleripati, J. & Topp, K. (2018). Supporting better decisions across the nexus of water, energy and food through earth observation data: case of the Zambezi basin. Edinburgh: Copernicus Publications on behalf of the International Association of Hydrological Sciences.

Gueneau, A. (2011). Irrigation in the Zambezi River Basin: Flexibility under Climate Uncertainty. ESD.71 Final Project

Hoekstra, A.Y., Savenije, H.H.G. & Chapagain, A.K. (2001). An integrated approach towards assessing the value of water: A case study on the Zambezi basin. Integrated Assessment 199:2008

Hussain, I., Turral, H., Molden, D. & Ahmad, M. (2007). Measuring and enhancing the value of agricultural water in irrigated river basins. Springer-Verlag. 25:263–282

Mloza-Banda, H.R. (2005). Integrating New Trends in Farming Systems Approaches in Malawi. Uganda: African Crop Science Society

Moyo, BHZ., & Moyo, DZ. (2013). The Use and Role of Traditional Ecological Knowledge in Small-scale Agricultural Systems in Africa. Thesis. https://www.researchgate.net

NEPAD (2013). African Agriculture, Transformation and Outlook. South Africa: International Business Gateway.

O'Leary, G.J., Walker, S., Joshi N.L., & White, J.W. (2011). Water Availability and Use in Rainfed Farming Systems: Their Relationship to System Structure, Operation and Management. Horsham, Australia/ Agricultural Research Council, South Africa.

Rankoana, S.A. (2017). The Use of Indigenous Knowledge in Subsistence Farming: Implications for Sustainable Agricultural Production in Dikgale Community in Limpopo Province, South Africa. MDPI, Basel, Switzerland.

SADC/SARDC et al. (2012). Zambezi River Basin Atlas of the Changing Environment. SADC, SARDC, ZAMCOM, GRID-Arendal, UNEP. Gaborone, Harare and Arendal

Shela, P.O.N. (2000). Management of shared river basins: the case of the Zambezi River. www.elsevier.com/locate/watpol
Songe, M.M. et al (2011). Field observations of fish species susceptible to epizootic ulcerative syndrome in the Zambezi River basin in Sesheke District of Zambia. Springer Science+Business Media B.V. 2011. Trop Anim Health Prod 44:179–183
The World Bank (2010). The Zambezi River Basin: A Multi-Sector Investment Opportunities Analysis, The World Bank Water Resources Management Africa Region. Washington, DC. Available at: http://documents.worldbank.org/curated/en/938311468202138918/State-of-theBasi
The World Bank (2008). Zambezi River Basin Sustainable Agriculture Water Development: Washington DC: The International Bank for Reconstruction and Development.
Tilmant, A., Kinzelbach, W., Beevers, L., & Juizo, D. (2010). OptimalWater Allocation in the Zambezi Basin. International Congress on Environmental Modelling and Software. https://scholarsarchive.byu.edu/iemssconference/2010/all/494
Timberlake, J. (2000). Biodiversity Of The Zambezi Basin, Occasional Publications In Biodiversity, No. 9. Bulawayo: Biodiversity Foundation For Africa.
Vernooij, A., dos Anjos, M., van Mierlo, J. (2016). Livestock Development in the Zambezi Valley, Mozambique: Poultry, Dairy and Beef Production. Wageningen UR (University and Research) Centre for Development Innovation. Report CDI-16-027.
Waldman, K.B, et al (2017). Preferences for Legume Attributes in Maize-Legume Cropping Systems. Springer Science+Business Media Dordrecht and International Society for Plant Pathology. DOI 10.1007/s12571-016-0616-4.
Zambia Development Agency (2011).Agriculture, Livestock and Fisheries. Zambia Agriculture Sector Profile.
ZAMCOM (2016). Zambezi Water Resources Information System (ZAMWIS). http://zamwis.wris.info/