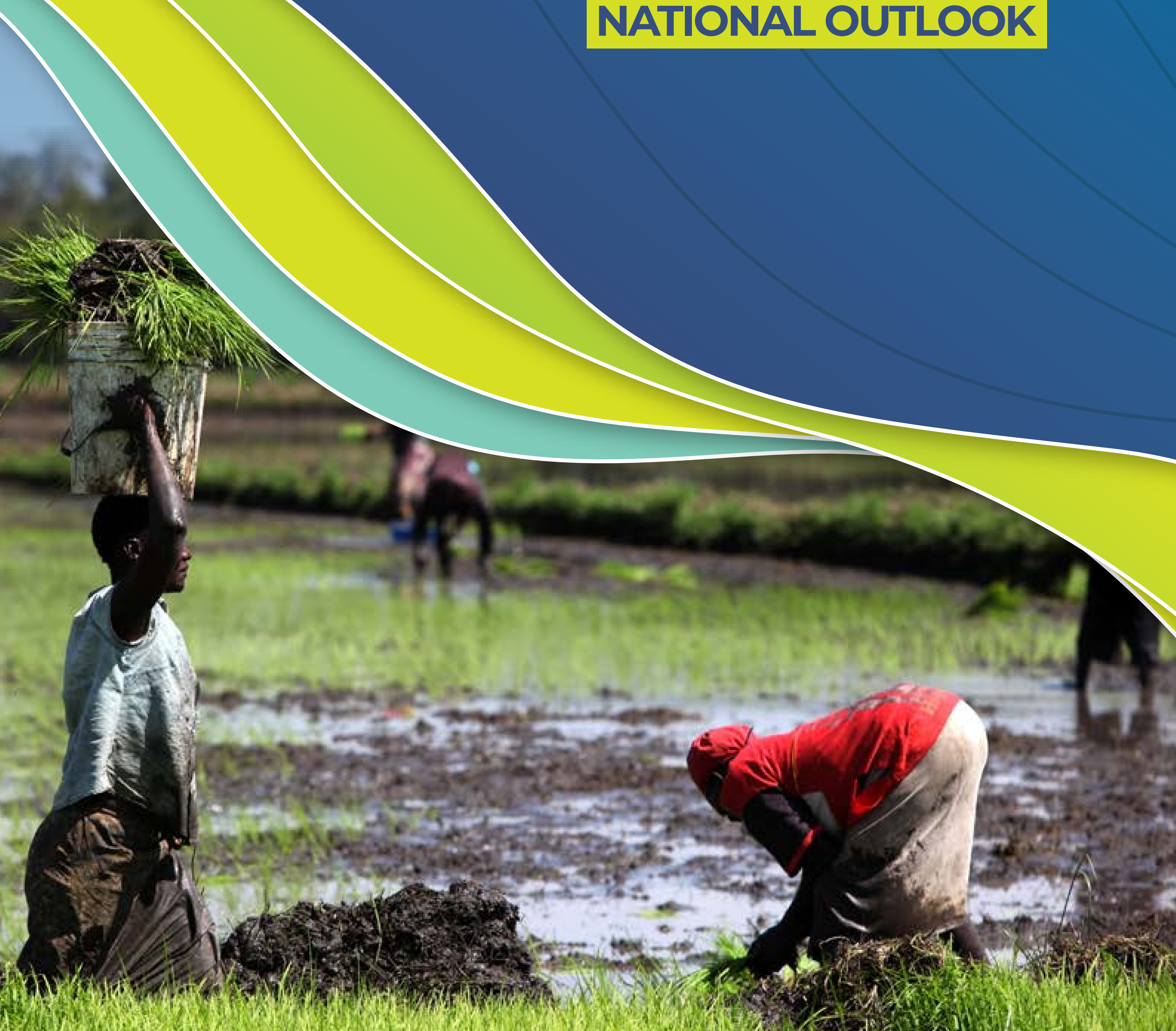
Food and Agriculture Organization of the United Nations

Efficient agricultural water use and management in paddy fields in Zambia

NATIONAL OUTLOOK



Efficient agricultural water use and management in paddy fields in **Zambia**

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2022

Required citation:
Salman, M., Hanae Suzuki, H., Ahmad, W., Giusti, S., Ali, A., Mwale, S., Chikuta, S., Nawa, M., Daka, A., Sitali, M., Mukanga, M., Chitambi, M., Chilala Mucheelo, M. and Lwatula, C. 2022. *Efficient agricultural water use and management in paddy fields in Zambia – National outlook.* Rome, FAO. https://doi.org/10.4060/cc2141en

ISBN 978-92-5-136911-1

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Foreword

Agriculture is an important sector of the Zambian economy, serving as an anchor for achieving sustainable economic growth, job creation, poverty reduction, and the provision of diverse nutritious food crops to meet national food needs. Agricultural growth rate has been highly volatile over the past 20 years due to land use change and rainfall variability. Despite Zambia's abundance of water resources, agriculture is largely rainfed, and rainfall variability has had a significant impact on agricultural production. Rainfed agriculture is frequently susceptible to drought and floods and is highly unreliable.

Over the past two decades, demand for rice as an important staple food has increased in Zambia, in addition to maize. However, demand for rice has outstripped production, and the shortfall is increasingly being met by imports. The government has recognized rice as one of the priority crops in the crop diversification policy, with the aim of contributing to increased production of diverse agricultural products that support household income and food and nutrition security in a changing climate. However, reduced yield due to low productivity has hampered self-sufficiency in rice. Paddy field systems are especially water demanding. In view of the projected growing water demand, enhanced water use efficiency in irrigated paddies is crucial to sustainably increase productivity.

The project “Efficient Agricultural Water Use and Management Enhancement in Paddy Fields”, funded by the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF), is designed to increase the understanding of the current status of water use efficiency and water productivity in Zambia, identifying both limits and potentials at national level.

The National Outlook on efficient agricultural water use and management in paddy fields provides the status of water use efficiency in paddy fields and agricultural water productivity in Zambia.

The report identifies the irrigation potentials, gaps and needs that exist at national level for paddy rice production. The analysis carried out in the outlook will form a basis for enhancing water resources management in paddy fields. The report addresses all stakeholders involved in the sector, including technicians, researchers, and extension agents, who will be directly and indirectly benefit from its recommendations.

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Abbreviations and acronyms

AER	Agro-Ecological Regions
7th NDP	Seventh National Development Plan
CWP	Crop Water Productivity
FAO	Food and Agriculture Organization of the United Nations
FISP	Farmer Input Support Programme
IDE	International Development Enterprises
IWRM	integrated water resources management
JICA	Japan International Cooperation agency
MCDSS	Ministry of Community Development and Social Services
MLNR	Ministry of Lands and Natural Resources
MNDP	Ministry of National Development Planning
MoA	Ministry of Agriculture
NAIP	National Agricultural Investment Plan
NAP	National Agricultural Policy
NRDS	National Rice Development Strategy
NWP	National Water Policy
PAWD	Partnership for Africa's Water Development
SDG	Sustainable Development Goals
SNAP	Second National Agricultural Policy
SNRDS	Second National Rice Development Strategy
WARMA	Water Resource Management Authority
WUE	Water Use Efficiency

Acknowledgements

This report was prepared by a joint team of FAO and Zambia national researchers led by Maher Salman, Senior Land and Water Officer and Team Leader of Irrigation and Water Resources Management Group, Land and Water Division (NSL) at FAO. The team included: Hanae Suzuki, Associate Professional Officer (NSL); Waqas Ahmad, Irrigation Specialist (NSL); Stefania Giusti, Programme Officer (NSL); Akhtar Ali, Monitoring and Evaluation Specialist (NSL); Shadreck Mwale, Ministry of Agriculture (Zambia); Sally Chikuta, Ministry of Agriculture, (Zambia); Mweshi Mukanga, Zambia Agriculture Research Institute (ZARI), Celestina Lwatula, FAO Country Officer, Zambia; Malumo Nawa, Department of Agriculture, (Zambia); Alick Daka, Ministry of Agriculture, (Zambia); Musika Chitambi, Zambia Agriculture Research Institute (ZARI); Mulako Sitali, Technical Services Branch, Ministry of Agriculture, (Zambia); and Mary Mucheelo, Ministry of Community Development and Social Services, (Zambia).

The team gratefully acknowledges the support received from Lifeng Li, Land and Water Division Director; and Sasha Koo-Oshima, Land and Water Division Deputy Director.

Executive summary

An increasing number of regions in the world are frequently facing water shortage, and water demand is likely to grow in the next 20-30 years due to intensified agriculture, population growth, urbanization and climate change. Future demand of water by all sectors will, thus, require as much as 25 to 40 percent of water to be re-allocated from lower to higher productivity and employment-oriented activities, particularly in water stressed regions. As such, these reallocations are likely to come from agriculture due to its high share of water use.

In view of the projected rise in water demand in both agriculture and non-agricultural sectors, appropriate actions that increase water use efficiency especially in irrigation are crucial to sustainably enhance agricultural production and productivity.

In Zambia, rice is one of the most important cereal food and is at the centre of major socio-economic activity for a large share of rural population. Paddy field system are especially water demanding as it needs continues inundation of the field during most of the growing season. In Zambia, there is no controlled infrastructure for paddy irrigation and nearly all of the rice is grown under paddy field system in the country rainfed lowlands.

The Food and Agriculture Organization of the United Nations (FAO) has been active to increase the understanding of the status of water use efficiency and water productivity in Zambia through the project "Efficient Agricultural Water Use and Management Enhancement in Paddy Fields", funded by the Japan Ministry of Agriculture, Forestry and Fisheries (MAFF). The project objective is to identify limits and potentials of paddy rice production at national level.

This report presents a comprehensive Outlook of paddy rice cultivation in Zambia which will form a basis for assisting the country to identify potential areas of improvement to achieve sustainable water resources management and food security.

The Outlook is organized in six sections:

Section 1 introduces the country profile focusing on the climate and agriculture, water resources, the multipurpose role of water, and the history of irrigation development in Zambia.

Section 2 describes the domestic production of paddy rice in Zambia and the challenges faced in achieving high yields. It also highlights the typology of landholding by paddy farmers, contribution of rice to the national food security, competitiveness of domestic rice and the past estimates of demand for rice import.

Section 3 describes the main ecologies in Zambia where paddy rice is produced, and the types of irrigation systems in place to support paddy farming. It also analyzes irrigation as a means for improved water productivity. The legislation and customary laws regulating water rights and charges for commercial use is also explained. Finally, it presents the arrangements made by the Agriculture Department for training and capacity building of water users.

Section 4 focuses on the cross-cutting issues of climate change, gender, disability, youth and integrated water resources management that are pertinent to paddy rice production in Zambia.

Section 5 describes the national policies and plans related to water resources management in Zambia.

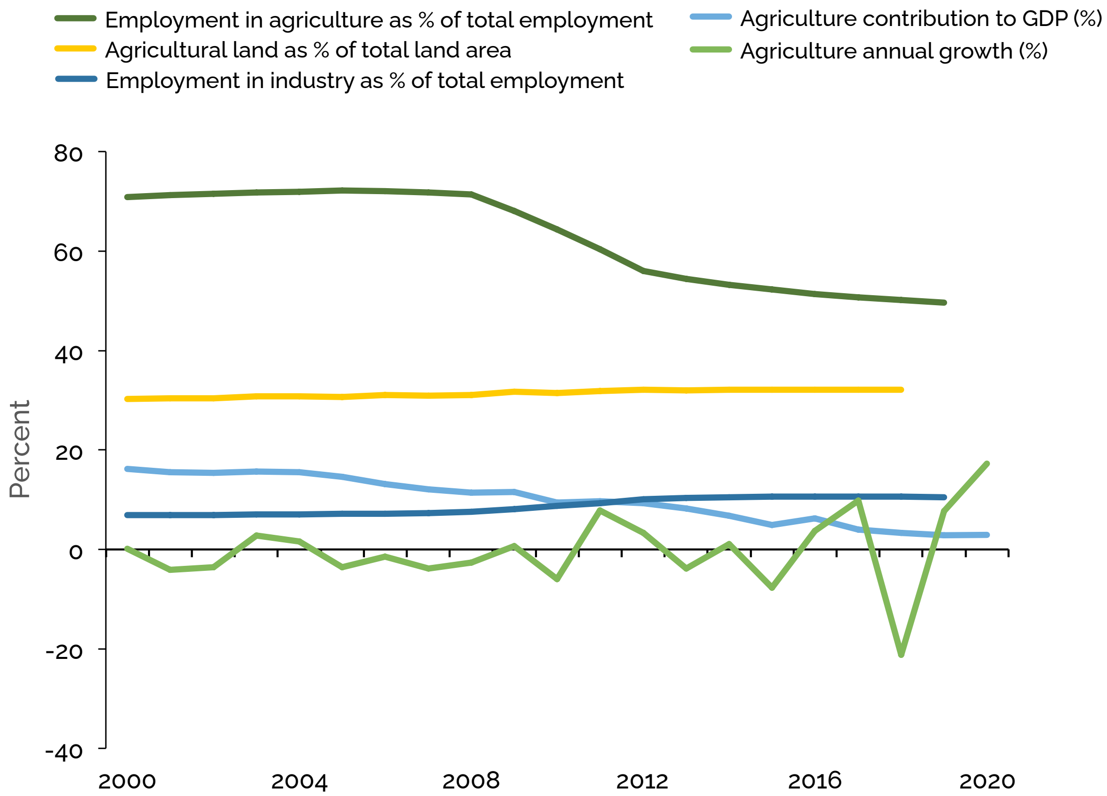
Section 6 summarizes the institutional arrangement for water use and enlists the government and external institutions and their role in water resources development and management in Zambia.

1. Country profile

1.1 BACKGROUND

Zambia is a low-to-middle income country in south-central Africa with a population of 17.9 million. In the past, agriculture was an important sector of the economy, employing more than 70 percent of the active labour force. However, over the last two decades, the performance of this sector has declined sharply, resulting in more than 50 percent of the population falling below the national poverty line. Despite suitable arable land, a favourable climate and the third largest annual renewable water resource of 105 billion m^3 in the region, Zambia's agricultural potential has not yet been fully tapped, with only 32 percent of its land under cultivation. Agricultural production is dominated by smallholder rainfed agriculture, which is practiced by 70 percent (1.6 million) of farmers. Figure 1 shows the contribution of the agricultural sector to the national GDP and annual growth from 2000 to 2020. This trend is not promising as crop production fluctuates due to rainfall variability and agricultural land development is almost stagnant. Despite the declining contribution of the sector to GDP, it is considered the basis for integrated rural development as it still employs 50 percent of the national labour force, serves as a source of income and employment for the rural population, and provides livelihoods in the other economic sub-sectors, especially industry and services.

Figure 1. Performance of agriculture sector in Zambia



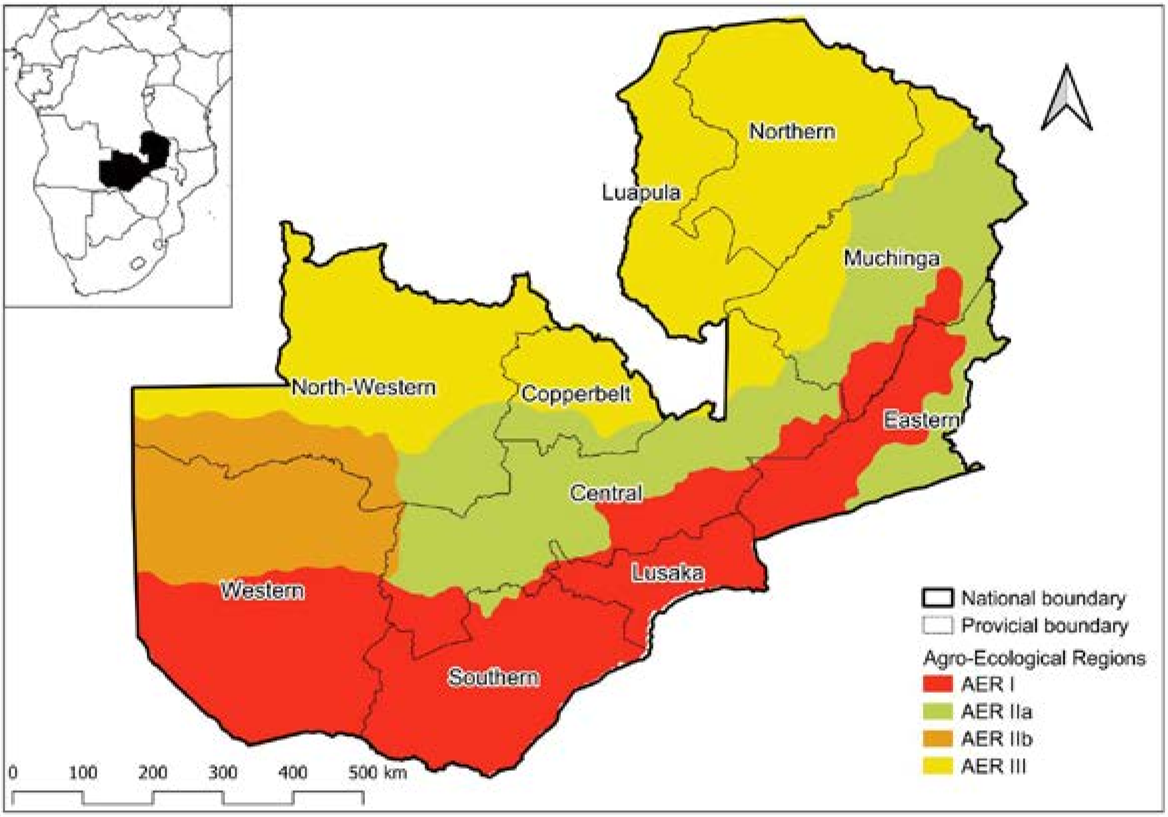
Source: World Bank. 2022. *World Bank National Accounts Data, and OECD National Accounts Data Files. In: World Bank Open Data.* https://data.worldbank.org

1.2 CLIMATE AND AGRICULTURE

The climate in Zambia is subtropical, with an average annual rainfall of 1 050 mm. Rainfall is influenced by the Intertropical Convergence Zones (ITCZ), where the northeast trade winds and southeast monsoon meet, as well as the subtropical high-pressure area in the southern Indian Ocean. In addition to the ITCZ, Zambia receives the northwest monsoon in conjunction with tropical Atlantic air via the Congo Basin. The highest annual rainfall of 1 400 mm is observed in the north, particularly in the northwest and northeast, decreasing to 700 mm towards the south. The driest areas are in the extreme southwest, namely the Luangwa River and Middle Zambezi River valleys, which are considered semi-arid. Seasonal average temperatures vary between 9 and 24 degrees Celsius, with the winter season lasting from May to August.

Zambia covers an area of 752 616 km² (75 million ha), of which 47 percent (35 million ha) has medium to high potential for arable activities. Only 15 percent of the potentially arable land is currently used for agriculture and 24 percent is used for livestock, leaving more than half of the arable land unused. The topography of the country can be divided into four agro-ecological regions (AER) based on soil characteristics and rainfall patterns, namely Region I, IIa, IIb and III (Figure 2).

Figure 2. Agro-ecological regions of Zambia



Source: United Nations, 2020 "modified [GRZ. 2016. Second national rice development strategy 2016-2020. Lusaka, Ministry of agriculture. https://riceforafrica.net/wp-content/uploads/2021/09/zambia_nrds1-2.pdf]"

Agro-ecological Region I accounts for 12 percent of Zambia's total land area and covers the south, southwest and east of the country. It includes river valleys and therefore has steep plains with a hot and humid climate. This region consists of loamy to clayey soils in the valleys, and coarse to fine loamy soils on the escarpment, while the soils on the western side are shallow. Rainfall in this region is unreliable at less than 800 mm/year, resulting in occasional droughts and significant lowering of groundwater table, which affects the availability of water for irrigation.

The agro-ecological Region II is a plateau that covers 42 percent of the country's area and is subdivided into Regions IIa and IIb. Region IIa covers the central, southern and eastern parts of Zambia. In this region, the rainy season lasts an average of 160 to 180 days, rainfall is more reliable (800 to 1 000 mm) and the groundwater table is higher than in Region I. The soils are fertile, sandy and loamy and suitable for agriculture. This region has good potential for irrigation, especially in the Lower Kafue Basin and in several dambos[1] in Central Province. Region IIb consists mainly of the western plateau, which includes the Kalahari sand plateau and the Zambezi floodplains. It also receives annual rainfall of 800 to 1 000 mm and has coarse, infertile sands.

[1] A *dambo* is a class of complex shallow wetlands in Central, Southern and Eastern Africa.

The agro-ecological Region III covers the northern and northwestern plateau area. The rainy season lasts an average of 180 to 190 days and annual rainfall ranges from 1 000 mm to 1 500 mm. It accounts for 46 percent of the country's land area and has well-drained, acidic soils. Rainfall in this region is reliable and shows little variation. The dry season in this region is relatively short which provides favourable conditions for agriculture.

The distribution of rainfall in the AER shows that the opportunities and constraints for agricultural production vary depending on the location. While agro-ecological Region I has 17.3 million ha of land with 20 percent agricultural potential, Region II has 27.4 million ha with 87 percent agriculture potential and Region III has 30.6 million ha with 70 percent agriculture potential. In addition to variable rainfall, agricultural production in Zambia is also affected by low soil fertility and the incidence of pests and diseases. The diversity in farmers' characterization and differences in AER justify the need to set priorities disaggregated by farmers' types and AER.

Figure 2 shows the AER of Zambia's while Table 1 shows the suitability of different crops to the agro-ecological regions.

Table 1. Crop suitability to agro-ecological regions in Zambia

Regions	AER (I)	AER (II) (a & b)	AER (III)
Rainfall (mm/year)	Less than 800	800 – 1 000	More than 1 000
Growing period (days)	80 - 120	100 – 140	160+
Crop suitability	Millet, sorghum, lentils, bananas, paprika, maize, dairy, aquaculture	Maize, sorghums, cassava, millet, rice, groundnuts, cowpeas, tobacco, sunflowers, coffee, soybeans, groundnuts, sweet potatoes, horticulture, irrigated wheat	Cassava, sweet potatoes, maize, beans, groundnuts, pineapples, bananas, tea, coffee, cattle, dairy, poultry, small ruminants, aquaculture
Irrigated crop	Sorghum, bananas	Maize, tobacco, wheat, soybeans, horticulture, coffee	Fruit crops, coffee, tea

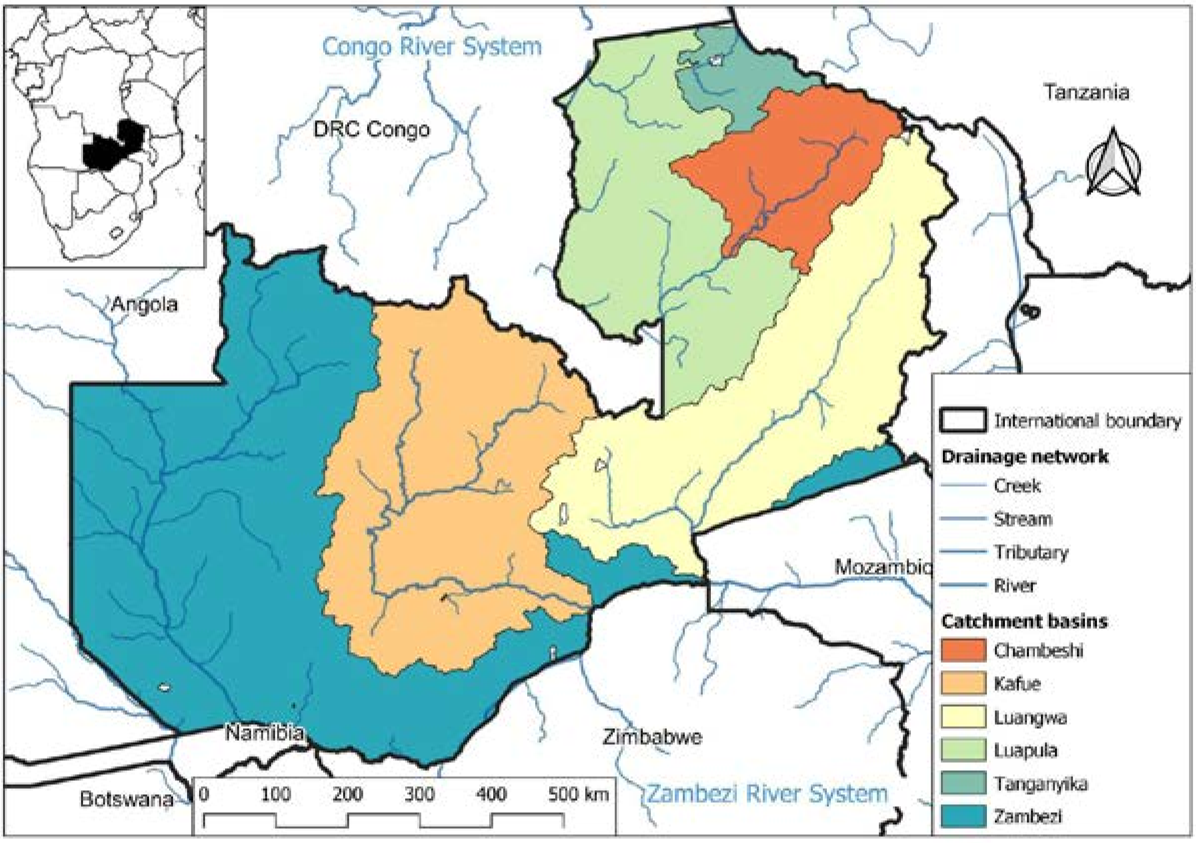
Source: Reproduced by authors from GRZ. 2016. Second national agricultural policy. Lusaka, Ministries of agriculture, and fisheries and livestock. http://cbz.org.zm/public/downloads/SECOND-NATIONAL-AGRICULTURAL-POLICY-2016.pdf

1.3 WATER RESOURCES OF ZAMBIA

Compared to other countries in the region, Zambia has abundant surface and groundwater resources. The country is strategically located in the headwaters of major international rivers such as the Congo and Zambezi (Figure 3). There are three major river systems in the Zambezi catchment and two in the Congo catchment. The upper Zambezi main river system is complemented by the Luangwa and Kafue tributaries in Zambia. The upper Zambezi rises in Angola and flows into Mozambique after forming the border with Zimbabwe. The Kafue River system covers an area of 152 000 km². The river has two major dams, the Itezhi-Tezhi Dam and the Kafue Gorge Dam, the latter of which is used for hydropower generation. The Luangwa

River has a catchment area of 165 000 km². It drains most of the central and eastern part of the country and flows into the Zambezi. The Chambeshi and Luapula rivers are connected to Lakes Mweru and Mweru-Wa-Ntipa and discharge their waters into the Congo River system. The small Tanganyika drainage system is also part of the large Congo River system.

Figure 3. River catchment basins of Zambia



Source: United Nations, 2020 "modified [World Wildlife Fund-Zambia. 2022. HydroATLAS-Zambia V10, Hydro-environmental characteristics of all sub-basins and river reaches of Zambia. In: WWF-Zambia. https://hydroatlas-zambia.weebly.com]"

Renewable water resources per capita are estimated at about 8 700 m³/year, above the average for sub-Saharan Africa, which is 7 000 m³/year per capita per year, and the global average of 8 210 m³/capita per year. The main source of renewable water resources in Zambia is rainfall. The country's water resources are subject to seasonal and spatial variability, often resulting in floods and droughts. It is estimated that this hydrological variability cost USD 13.8 billion over the period of 1997 to 2007, with a 0.4 percent annual loss of economic growth, and a 1 percent loss of annual agricultural growth. Adding to hydrological variability, Zambia's water resources are under increasing pressure from mining and pollution, particularly in the Kafue Basin. Despite increasing pressure in some basins, the country's water resources remain largely unused. Zambia's inability to adequately utilize its vast water resources is a compelling constraint to growth in various sectors such as agriculture, manufacturing, energy, transport, mining and tourism.

The average rainfall in Zambia is 1 020 mm/year (768 billion m³). It is lowest in the south at 750 mm, while the central parts of the country receive between 900 and 1 200 mm/year and the northern regions receive over 1 200 mm/year. Rainfall totals and distribution within seasons vary greatly from year to year, especially in the south. This makes rainfed agriculture, which is easily affected by droughts, very unreliable. Zambia's total renewable water resources are about 104.8 billion m³/year (Table 2), of which about 80 billion m³/year is produced internally. An extensive area of 25 000 km² is covered by limestone aquifers that extend from Lusaka to the northwest, this aquifer stores 47 billion m³/year.

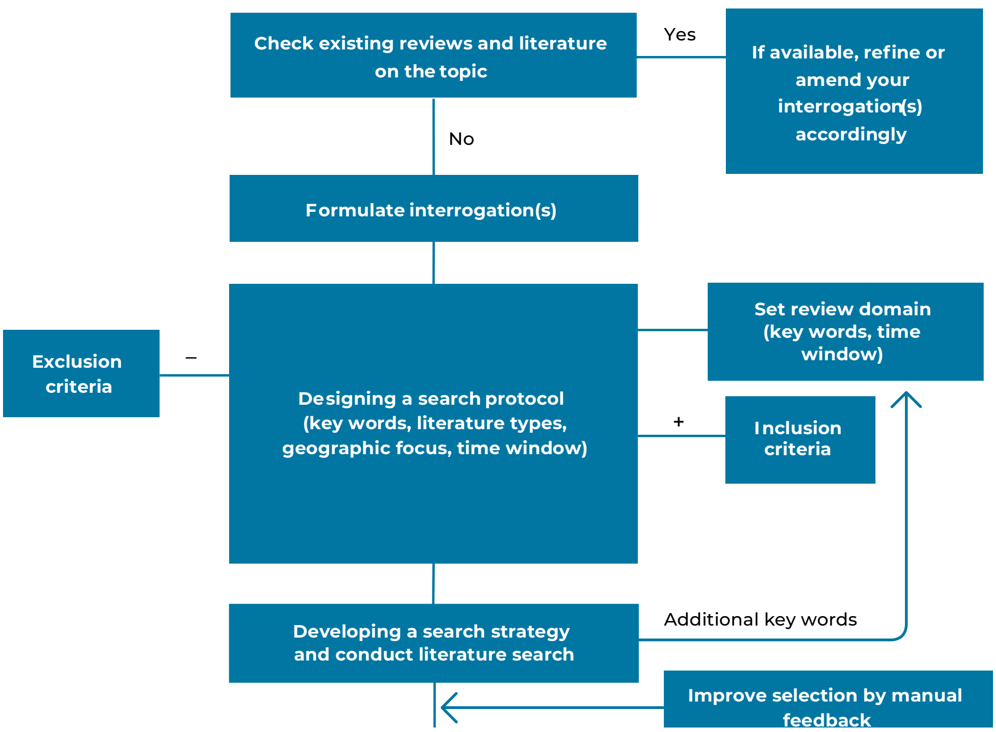
Table 2. Water resources of Zambia

Water resources	Amount	Unit
Average annual precipitation in depth	1 020	mm/year
Average annual precipitation in volume	768	Billion m³/year
Total internal renewable water resources	80	Billion m³/year
Total external renewable	25	Billion m³/year
Total renewable surface water	105	Billion m³/year
Total renewable groundwater	47	Billion m³/year

Source: FAO. 2022. AQUASTAT – FAO's Global Information System on Water and Agriculture. In: FAO. Rome. www.fao.org/aquastat/en

The available water resources in Zambia are the second highest in Southern African region among nine countries, only Mozambique has the highest level in the region (Figure 4).

Figure 4. Renewable water resources of Zambia and the regional countries



Source: FAO. 2022. AQUASTAT – FAO's Global Information System on Water and Agriculture. In: FAO. Rome. Cited 1 September 2022. www.fao.org/aquastat/en

In contrast, the country's gross water storage capacity is much lower compared to other countries in the region. There are currently six medium to large dams with a total storage capacity of about 101.13 billion m^3, most of which is used for power generation. In some areas, low-cost earth dams have been constructed for informal irrigation. This type of small-scale water use does not require the use of pumping machinery for irrigation or drainage. In drought-prone areas in the east, Lusaka, central and southern provinces of the country, about 2 000 small dams have been built with an estimated storage capacity of 1 500 million m^3. Besides growing crops, the small dams also provide drinking water for livestock in the surrounding areas. However, most of the small earth dams are in poor condition because they are either broken, not maintained or poorly constructed.

Another important source of water in Zambia are wetlands such as the dambos (Figure 5), which cover about 3.6 million ha or 4.8 percent of the total land area. Dambos are important for dry season crop production especially vegetables. They are also used as grazing areas for livestock during the dry season, when vegetation in the highlands is dry and has little nutritional value. They are also used for fishing, watering livestock, hunting areas for small wild animals - and collecting thatching grass. Near the dambos, seepage zones and shallow wells are also used to collect water.

Figure 5. Dense aquatic vegetation in a dambo in Zambia

The upper Zambezi, Sioma and Mongu.

1.4 MULTI – FUNCTIONAL ROLE OF WATER

According to the National Water Policy, the Zambian Government recognizes the importance of water for socio-economic development and its fundamental role in the environment for the sustenance of all forms of life. Zambia's water resources are yet to be fully utilized for the benefit of the people to increase productivity and improve livelihoods. The productive activities of the Zambian economy are all dependent on water, e.g. water use in agriculture (73 percent), municipal water use (18.4), and mining and industry (8.2 percent). In agriculture, water is needed for growing crops, raising livestock and maintaining fisheries, while in the municipal sector it is used for cleaning, bathing, washing, cooking and irrigation of civil landscape. In industry, water is used for electricity generation, steam generation for industrial processes, cooling, production of reagents and detergents, and dilution processes. It is also used for navigation and recreational purposes that promote tourism. Each of the above water use sub-sectors has different water quality requirements, which also makes recycled water a potential resource.

1.5 IRRIGATION DEVELOPMENT IN ZAMBIA

FAO estimates that Zambia has an irrigation potential of 2.75 million ha, of which 523 000 ha can be economically developed. By 2012, the total irrigated area was 256 000 ha, of which an estimated 155 912 ha were under controlled irrigation, while another 100 100 ha were under uncontrolled irrigation, such as flood recession (Table 3). Most irrigation developments during the period 2000-2020 were driven by increased food demand and increased drought frequency. This period also saw more allocation of public funding for smallholder irrigation development (Figure 6). Large portions of irrigated land are located near rivers, streams, dams, and lakes, as well as in dambos for smallholders and emerging farmers. The main irrigated crops are sugarcane, wheat, tea, coffee, floriculture, soybean, banana, and rice. Eighty-five percent of irrigation for these crops is by gravity-fed surface irrigation and is known for its low water use efficiency. Zambia's existing surface and groundwater resources are abundant at 105 and 47 billion m^3, respectively. Water abstraction for all sectors in 2018 was 1.572 billion m^3 and 73 percent of the water abstracted is for all forms of irrigation. This indicates that the irrigation potential in Zambia is highly untapped, and more than 50 percent of the potential areas can be readily developed for various types of irrigation schemes, offering a real prospect for the expansion of irrigation in Zambia.

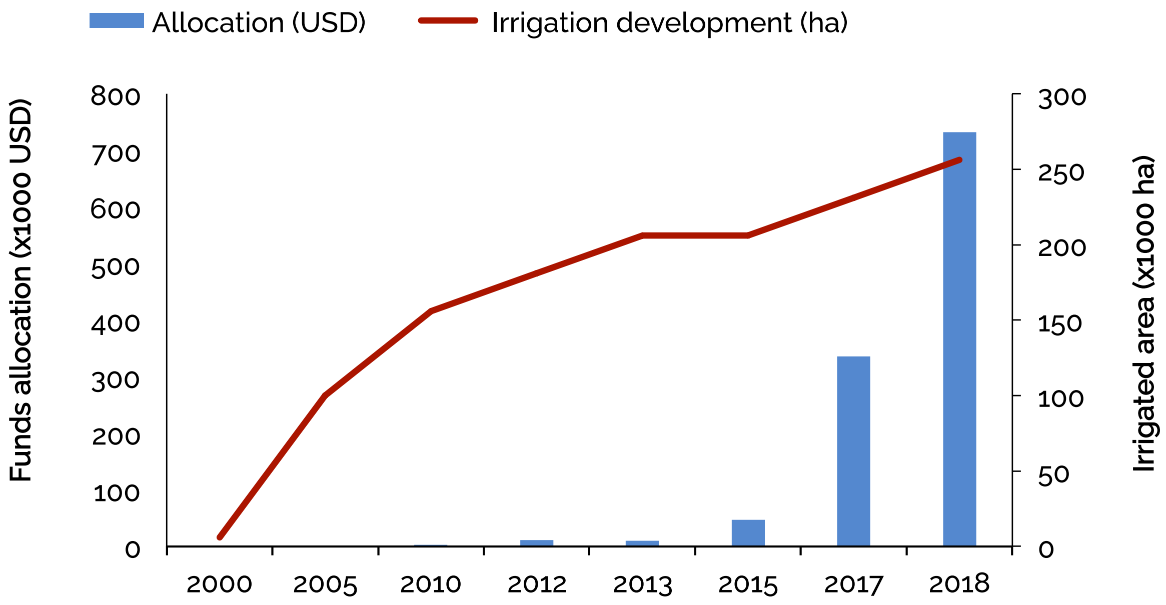
Table 3. Estimates of irrigated land in Zambia

Land use type	Area (ha)
Irrigation potential	2 750 000
Total area under irrigation	**155 912**
Surface irrigation	32 189
Sprinkler irrigation	17 570
Localized irrigation	5 628
Developed lowlands (equipped wetlands)	100 525

Total area under water managed agriculture (Includes irrigated area)	**256 012**
Flood-recession cropping area	100
Cultivated lowland	100 000

Source: FAO. 2022. *AQUASTAT – FAO's Global Information System on Water and Agriculture. In: FAO. Rome. Cited 1 September* 2022. www.fao.org/aquastat/en *and* Evans, A. E. V., Giordano, M. & T. Clayton. (Eds.). *2012. Investing in agricultural water management to benefit smallholder farmers in Zambia. AgWater solutions project country synthesis report. Colombo, International Water Management Institute (IWMI). doi: 10.5337/2012.212.*

Figure 6. Allocation of public funds (USD)2 for smallholder irrigation development



Source: Government of the Republic of Zambia. Various Years. *Annual Budget Yellow Books.* Lusaka, Ministry of Finance and National Planning; and *FAO.* 2022. AQUASTAT – FAO's Global Information System on Water and Agriculture. In: *FAO.* Rome. Cited 1 September 2022. www.fao.org/aquastat/en

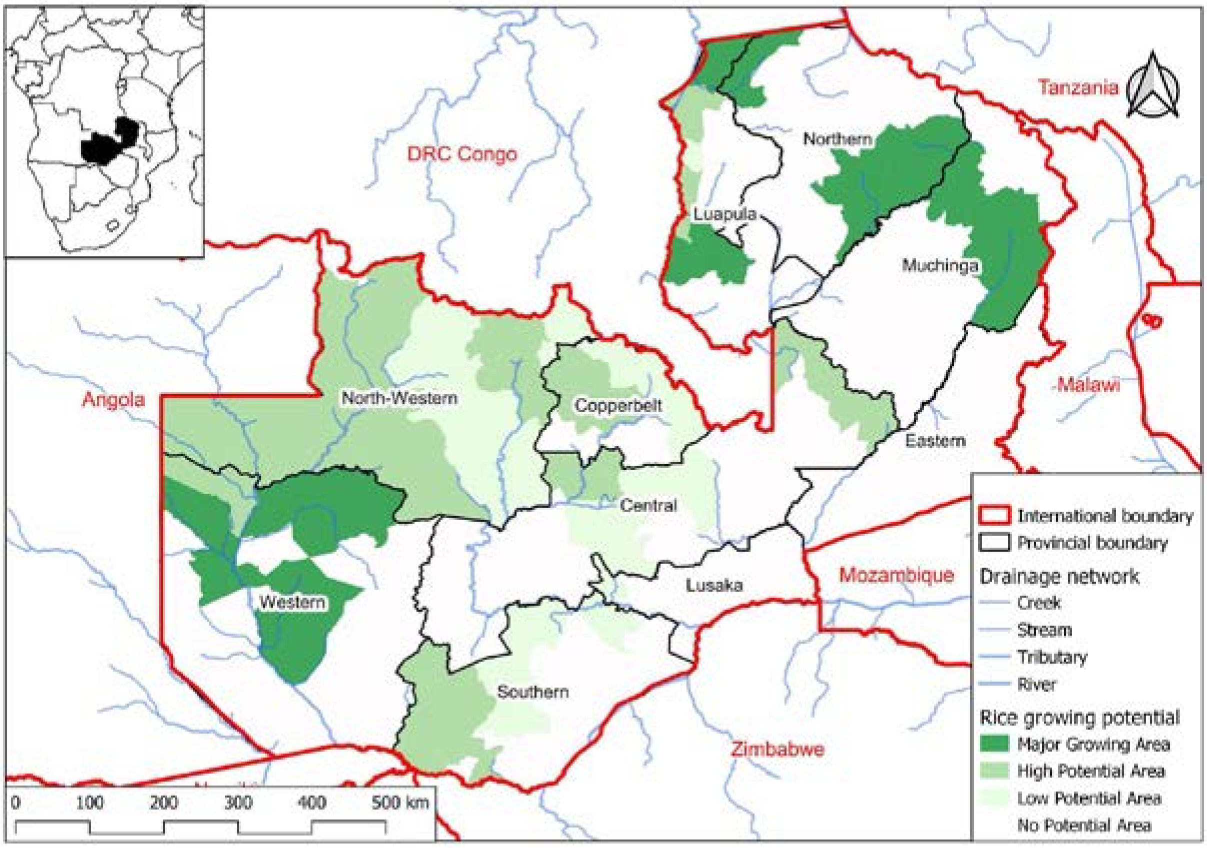
[2] Amount of allocated funds is converted from Zambian Kwacha to USD at the June 2022 conversion rate of 1 USD = 16.9 ZMK.

2. Rice cultivation in Zambia

2.1 DOMESTIC PRODUCTION OF PADDY RICE

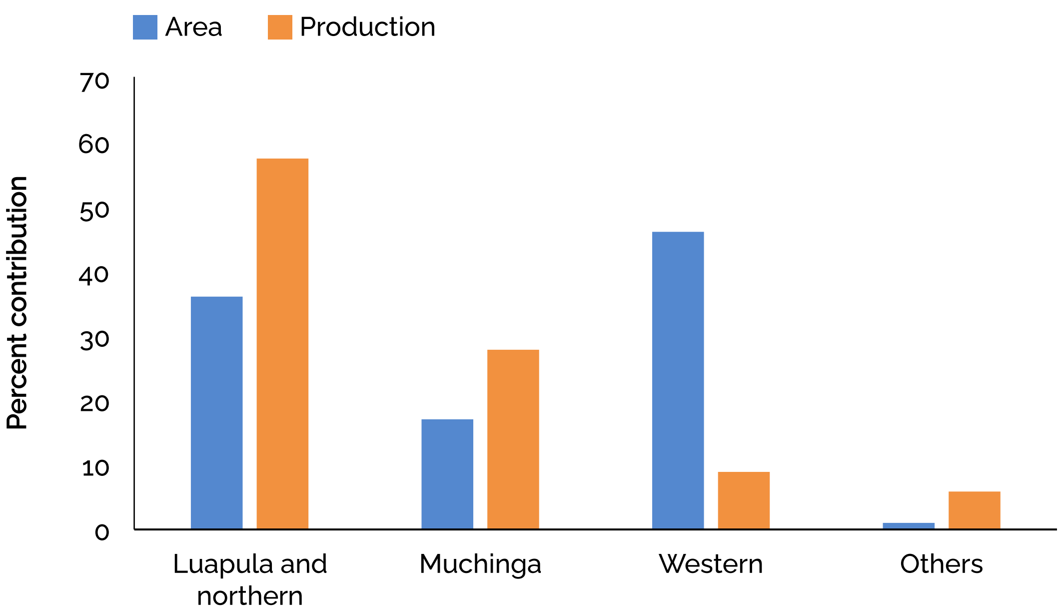
The Government of Zambia recognizes rice as one of priority crops on the crop diversification agenda. Rice is considered to contribute to increased production of diverse agricultural commodities that can support households' income and food security in a changing climate. It is anticipated that rice production will offer an alternative to famers who rely on a single maize crop. Rice became the third most important cereal crop after maize and wheat, it is also an important cash crop in Zambia economy and has recently been included in the national food balance sheet. At producer level, rice is a major source of income in three regions: (i) Chambeshi floodplain in Luapula and northern province, (ii) Upper Luangwa valley and Chama district, in the Muchinga province, and (iii) Zambezi floodplain and Mongu in the western province, where it is grown under rainfed condition. Figure 7 shows a district level map of major rice growing and potential districts in the three regions of Zambia. There are small pockets of areas with high potential of rice production in southern, northwest, copper belt, central and in Luapula provinces but farmers in these areas generally grow small amount of traditional, aromatic, and low yielding rice varieties for own consumption. During the 2013-14 growing season, rice was grown on a total of 54 075 ha of land that produced 53 921 tonnes of rice. Such production accounted for a total of 94 percent of the national rice production. Figure 8 shows the breakdown of percent area under rice cultivation in the three regions and its production share. This data shows that the areas in the northeast and northwest have high yields as compared to the southwest, due to the high rainfall distribution in the north.

Figure 7. Major rice growing and potential districts in Zambia



Source: United Nations, 2020 "modified [GRZ. 2016. Second national rice development strategy 2016-2020. Lusaka, Ministry of agriculture. https://riceforafrica.net/wp-content/uploads/2021/09/zambia_nrds1-2.pdf]"

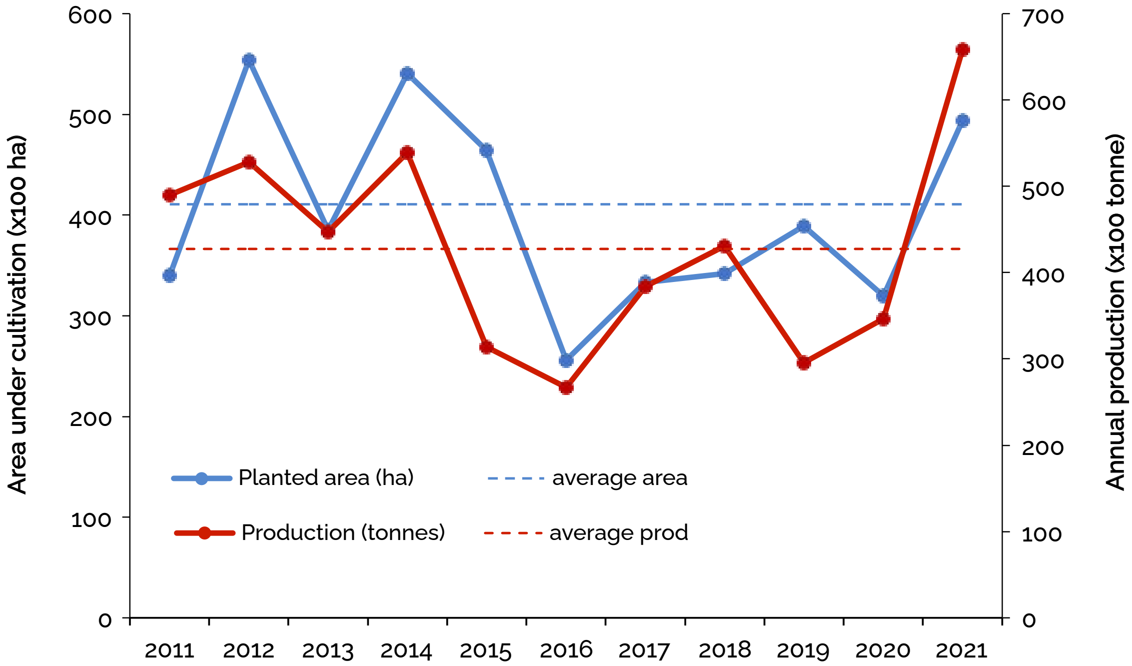
Figure 8. Rice production in the three main regions of Zambia, 2013-14



Source: GRZ. 2016. *Second national rice development strategy 2016-2020*. Lusaka, Ministry of agriculture. https://riceforafrica.net/wp-content/uploads/2021/09/zambia_nrds1-2.pdf and CSO. 2015. Agriculture statistics of Zambia. In: *Central Statistics Office data portal*. Lusaka. https://zambia.opendataforafrica.org/ionawve/agriculture-statistics-2014

On average, between the 2011 and 2021 growing seasons, Zambia has been producing 42 734 tonnes of paddy rice per year from 40 166 ha land (Figure 9), with an average yield of 1.06 tonne/ha. Such figures are relatively low compared to other eastern and southern African countries, whose average yield is between 1.5 to 2.5 tonnes/ha. The comparison of ten years data shows that large variation in rice cultivation and its production is highly dependent on inter-annual rainfall. Farmers generally keep 30 to 35 percent of the rice they produce for household consumption, and the extra production is traded through different channels at farm and market level.

Figure 9. Area under rice cultivation and its production in Zambia during 2011-2021



Source: GRZ. 2016. *Second national rice development strategy 2016-2020*. Lusaka, Ministry of agriculture. https://riceforafrica.net/wp-content/uploads/2021/09/zambia_nrds1-2.pdf and CSO. 2022. Agriculture statistics of Zambia, In: *Central Statistics Office data portal*. Lusaka. Cited 1 September 2022. https://zambia.opendataforafrica.org

2.2 CHALLENGES IN ACHIEVING HIGH YIELD

Large number of smallholder farmers have adopted rice cultivation for 20 years because it required fewer inputs and resulted in higher net income. The country's current rice production of 42 734 tonnes is far below its national demand of 84 271 tonnes. Rice growers continuously face low rice yields, despite the availability of 24 high yielding varieties developed and released for various ecological regions (Table 4). Low yield has hindered Zambia's effort to achieve self-sufficiency in rice. The reasons for low yield and production include lack of mechanized farm operation, broadcasting of seed, the use of low yielding tradition varieties, the use of recycled seeds, limited fertilizer application, limited weeding of paddy fields, poor on-farm water management, limited access to credits and extension services, access to market, poor farm-roads infrastructure, and small field size. The prolonged use of recycled seeds has also led to contamination of rice product, i.e., rice that is a mixture of two or more varieties. To deal with this, the country has been cleaning, purifying, and multiplying the cleaned rice varieties since 2016.

To improve yield to the global levels, researchers have recommended improved farm practices, including land preparation, transplanting, appropriate fertilizer application, weed control, improved water management, and crop protection measures. Improved farm practices not only increase yield but also prevent wastage and unnecessary cost of crop inputs; for instance, the recommended seeding rate for transplanting is 28 kg/ha, compared to 60 kg/ha when using drill planting and 80 kg/ha when using broadcasting.

Table 4. High yielding rice varieties released in Zambia

Variety	Year of release	Title holder/agent	Potential yield (tonne/ha)
A. Paddy rice			
Var. 1329	1969	Zambia seed company Ltd	3-6
Var. 1345	1969	Zambia seed company Ltd	
Var. 1632	1969	Zambia seed company Ltd	
Var. 7601	1970s	Zambia seed company Ltd	
Angola Crystal	-	Zambia seed company Ltd	
Malawi Faya	1960s	Zambia seed company Ltd	
Burma	1947	Zambia seed company Ltd	
Kalembwe	1975	Zambia seed company Ltd	
Sindano	1972	Zambia seed company Ltd	
IR 36	-	Zambia seed company Ltd	
Mulonga	1995	Zambia seed company Ltd	
ITA 230	2009	ZARI	
Kilombero	2009	ZARI	
PAC 801R	2012	Advanta	
PAC 807R	2012	Advanta	
Supa-Mg	2015	ZARI	
Misamfu–2	2018	ZARI	
Misamfu–3	2018	ZARI	
B. Upland rice			
Nerica 1	2009	ZARI	2-3.5
Nerica 4	2009	ZARI	
Longe 1	2014	ZARI	
Longe 2	2014	ZARI	
Longe 3	2014	ZARI	
Mansa–2	2019	ZARI	

Source: SCCI. 2022. *Variety release register. Lusaka, Ministry of agriculture.*

2.3 LANDHOLDING OF PADDY FARMERS

In Zambia, rice is mainly grown by small-scale farmers under rainfed conditions in Northern, Muchinga, Western, Eastern and Luapula provinces. In these areas, the abundance of water creates favourable conditions for rice cultivation, especially in the dambos and wetlands. Between 2010 and 2015, there were about 68 000 small-scale rice farmers in the country, cultivating an average of 0.47 ha. Female headed households grew about 33 percent of all the rice grown by small-scale farmers. During the 2020-21 growing season, the number of small-scale rice farmers increased to 80 011, cultivating an average of 0.62 ha, according to the Ministry of Agriculture and Agriculture Statistics of Zambia.

2.4 CONTRIBUTION OF RICE TO NATIONAL FOOD SECURITY

The recognition of rice as both food and cash crop by the Zambian government has improved the contribution of rice to the national food security. Between 2011 and 2021, it was estimated that the crop has seen a steady increase in demand and its growing importance is evidenced by its status as a strategic food crop. Between 2011 and 2021, the country produced on average about 42 734 tonnes of paddy rice annually, while the demand averaged 84 271 tonnes.

Per capita consumption of rice is estimated to increase from 1.49 kg/year to 4.11 kg/year. Due to the increasing population and per capita consumption, it is expected that rice consumption will continue to increase in the coming years. However, compared to other cereals such as maize, per capita consumption of rice is still low. The average maize consumption per capita is about 105 kg/year. Nevertheless, the double role of rice as a food and cash crop for smallholder farmers as well as numerous market processing and trading possibilities makes it ideally suited to contribute to improved food security, poverty reduction and wealth creation.

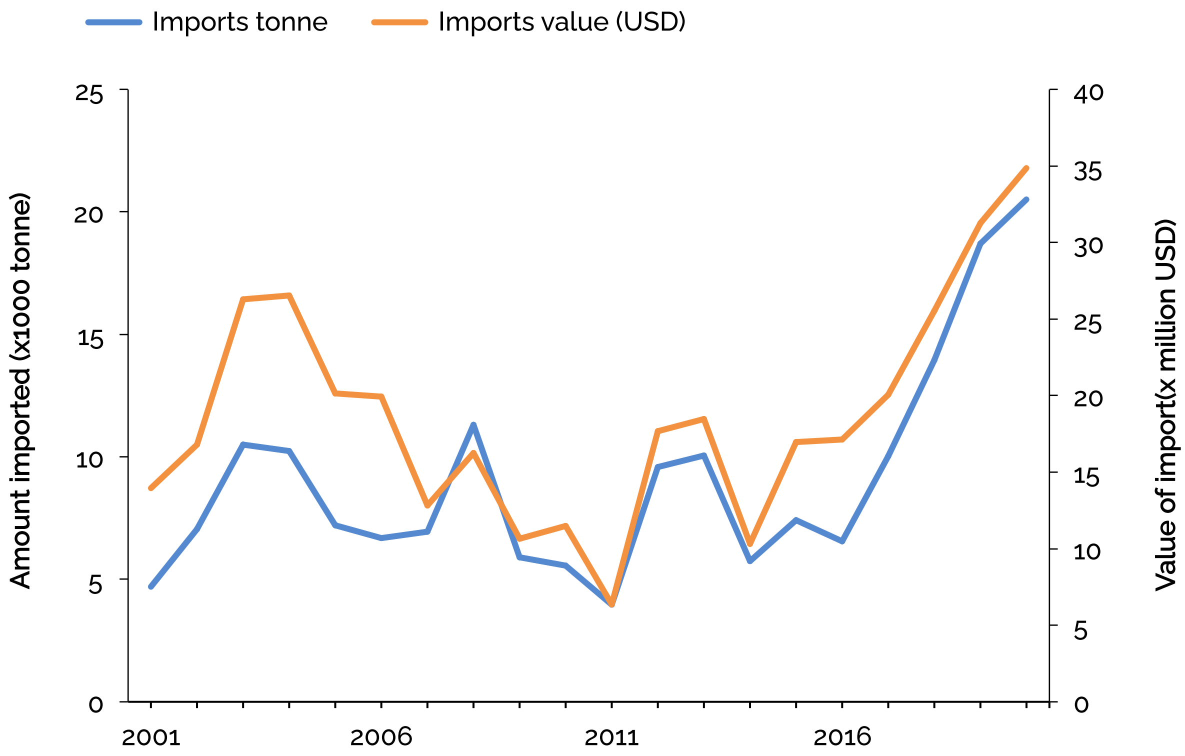
2.5 COMPETITIVENESS OF ZAMBIA RICE

Participatory rural appraisals and consumer surveys have revealed that Zambians generally have a preference for the aromatic rice like Supa-Mg, Kilombero, Kalembwe, Sindano, Malawi Faya varieties, locally branded as Mongu, Nakonde and Chama rice. In addition, Zambian consumers mostly buy rice on the basis of quality which is evident from the size, colour and aroma of the grains and is cleared from impurities. However, locally produced high quality rice is less competitive on the market largely due low production, which results into higher retail prices. Generally, the price of locally produced low quality rice is also non-competitive compared to the price of imported rice of better quality.

2.6 DEMAND OF RICE AND IMPORTS

Growing consumer demand has pushed the retail price of rice to higher limits, both in the country and in the African continent. In addition to maize and cassava, Zambia has seen a considerable rise in the demand of rice as an important staple food. In recent years, the demand exceeds domestic production, and the deficit is met through imports from Asian countries. During the 2017-2021 growing seasons, domestic production averaged at 42 315 tonnes/year, while average imports stood at 15 799 tonnes/year with an import bill of 27.93 million USD/year. Zambia exports relatively very little amount of rice as compared to import. During the 2011-21 period, it has exported only an average of 645 tonnes/year to Mozambique and other countries.

Figure 10. Amount of rice import and its monetary value



Source: International Trade Center. 2022. Trade statistics for international business development, Zambia rice import. In: *International Trade Center.* Geneva. Cited 1 September 2022. https://intracen.org/resources/trade-statistics#import-of-goods

3. Water use for paddy rice production

3.1 RICE PRODUCTION ECOLOGIES OF ZAMBIA

Zambia has a diversified environment for rice cultivation which includes dambos, floodplains, river valleys and upland. The major production ecologies are the: (i) Chambeshi flood plains in the Luapula and northern province, (ii) Upper Luangwa valley and Chama district in the Muchinga province, and (iii) Zambezi flood plain and Mongu in the western province. The location of these ecologies and their contribution to rice production are shown in Figure 7 and Figure 8. Excess water availability in these areas creates favourable conditions for rice cultivation, especially in the flood plains and dambos. Based on the topography of the land, the rice production zones are further categorized into three ecologies, namely rainfed lowland ecology; rainfed upland ecology, including seasonal dambos; and irrigated lowland ecology. Most of the rice in Zambia is grown in rainfed lowlands, with a small contribution from rainfed uplands and irrigated lowlands. The characteristics of each rice ecology and the opportunities and challenges for rice cultivation are summarized in Table 5.

Table 5. Characteristics of rice growing ecologies in Zambia

Rice ecology	Location	Opportunities	Ecological challenges
Rainfed lowland	Northern, Muchinga, Luapula, North-western, Eastern, Lusaka, Central and Western provinces	Availability of water in the rainy season, availability of suitable land, potential for integrating rice production system with aquaculture, long tradition of rice production by small-scale farmers	Unpredictable flooding patterns, difficulties in controlling water levels, difficult of accessibility, low soil fertility, high water infiltration
Rainfed and irrigated upland	Northern, Muchinga, Luapula, North-western, Lusaka, Central, Eastern and Copperbelt	Availability of large potential areas for expanding rice cultivation	Stress due to low moisture as a result of unreliable rainfall
Irrigated lowland	All the ten provinces	Availability of large potential areas for expanding rice cultivation, high potential for increasing productivity	Lack of irrigation infrastructure, lack of maintenance skills, high investment cost

Source: GRZ. 2016. Second national rice development strategy 2016-2020. Lusaka, Ministry of agriculture. https://riceforafrica.net/wp-content/uploads/2021/09/zambia_nrds1-2.pdf

3.1.1 Rainfed lowland ecology

The predominant rice producing areas in Zambia are found in the rainfed lowland ecology, characterized by annual flooding during the rainy season. The extent of flooding in these areas depends on the amount and distribution of rainfall pattern, and the characteristics of the lowland. This ecology offers readily available and least costly option for increasing rice production through soil moisture conservation during flooding, increased yields and expanding area under cultivation. However, the occurrence of unpredictable and uncontrolled floods poses serious challenges to crop damage and on-farm water management, which makes it difficult to reap all the benefits. The estimated area under rainfed lowland production is 37 997 ha (98.9 percent), while production is estimated at 43 888 tonnes.

3.1.2 Rainfed upland ecology

Rainfed upland, which includes seasonal dambos, solely depends on rainfall to sustain plant growth. Rice growing in this ecology is relatively new in Zambia and production is rather lower. Rice cultivation in this ecology has been boosted in recent years, mainly due to sufficient rainfall and the ability of soil to hold water. New varieties of upland rice such as NERICA 1, 4, Longe 1, 2, 3 and Mansa 2, have also been released during the last decade for this ecology. The introduction of these varieties has enabled the Zambian farmers to bring additional arable upland under rice cultivation. However, the variability in rainfall pattern and amount, and inherently low soil fertility, limits productivity. The estimated area under rainfed upland production is 462 ha (1.2 percent) while production was estimated at 534 tonnes.

3.1.3 Irrigated lowland ecology

Irrigated lowland ecology is ideal for rice production, but it needs a well-functioning and extensive irrigation infrastructure. Irrigated lowlands are still limited and underdeveloped in Zambia, except in the case of Sefula irrigation scheme in Mongu district and Chanyanya irrigation scheme in Kafue district, where the irrigation infrastructure for rice production was developed in 1970s. The irrigation method used at Sefula irrigation scheme is controlled flooding. Currently, 150 ha of land is under production having an average yield of 2 tonne/ha. The farmers are contracted by Japanese NGOs on an annual basis to grow Kashkari rice variety in Sefula. There is a high potential to develop new and rehabilitate existing small-scale irrigation schemes for rice production in certain districts, such as Kalabo, Kaoma, Mongu, Senanga, Sesheke, Mungwi, Kaputa, Isoka, Chinsali, Chama, Mwense, Mansa, Chiengi, Lundazi and Mambwe. These potential schemes are located in various valleys and flood plains. Irrigated lowland ecology could offer the best option for achieving high grain yield per hectare to both small and medium scale farmers. The recent trend of investment in the rehabilitation and development of smallholder's irrigation schemes (Figure 6) shows that the area of irrigated paddy rice is projected to increase by 6 000 ha (75 percent of the potential) by 2025, less than one percent of which is currently being developed.

3.2 TYPES OF IRRIGATION SYSTEMS IN ZAMBIA

There are three main types of irrigation systems in Zambia, which can be categorized according to the size of the irrigated area. These types are: small-scale and informal irrigation, medium-scale irrigation schemes, and large-scale commercial irrigation schemes.

3.2.1 Small-scale and informal irrigation

This type of irrigation is used by smallholder farmers who practice subsistence agriculture mainly in dambos and floodplains of rivers and streams. The irrigation practice is based on maintaining moisture in the root zone, either by retaining receding floodwaters with the help of bunds or by irrigating with water from small reservoirs or river diversions. Smallholder farmers across the country practice informal irrigation in their fields, using buckets, watering cans and hoses to grow vegetables, rice, bananas and some local varieties of sugarcane. This type of irrigation is usually not capital intensive, is self-operated and is often indigenous in origin, responding to the needs of individual farmers. Droughts, for example, are a direct cause for the development of such irrigation systems. The areas irrigated in this way are generally small (between 100 and 200 m^2). However, the introduction of treadle pumps has improved irrigation efficiency, and farmers can now irrigate an area of 1 000 to 2 500 m^2 with one treadle pump. In areas where it is too wet to grow crops, farmers wait until the water percolates below the root zone and then lift groundwater either manually or mechanically from shallow wells to irrigate their crops. The pumped water is distributed among different fields through open channels which are built by the farmers without any technical supervision. Most of these small irrigation systems are built using traditional methods and local material, and are operated by private individuals including women with little or no government support. In some cases, these systems are formally developed by the government with the support of cooperative partners and farmers. The individual area irrigated by this method may be small, but the total area irrigated by this traditional method is considerable.

3.2.2 Medium-scale irrigation schemes

Medium-scale irrigation schemes in Zambia, such as the Sefula and Kanakantapa irrigation schemes, are being developed by the government in collaboration with the Japan International Cooperation Agency (JICA) as a funding partner. Medium-size irrigation schemes cover an average area of 50 to 500 ha. The irrigation infrastructure usually consists of a main canal, secondary and tertiary canals, and drainage channels with water control structures. The water is diverted from the irrigation canals by gravity or lifted by pumps and applied to the crops using surface irrigation method. In this case farmers have partial control over the use of water. Several medium-scale irrigation schemes in Zambia have failed because operation and management were ineffective, operating cost recovery were poor, and the officials responsible for operation and maintenance did not have sufficient knowledge of agriculture, irrigation, and infrastructure maintenance.

3.2.3 Large-scale commercial irrigation schemes

Large irrigation schemes in Zambia are mostly developed and owned by the private sector for commercial purposes such as sugarcane and coffee cultivation. The Kaleya Irrigation Project, covering 2 200 ha, was the first successful irrigation project developed under the public-private partnership (PPP) model in 1980. In Zambia, there are no large-scale irrigation systems for paddy cultivation, which can offer extensive opportunities for development. In this context, a National Water Resources Master Plan was prepared with the support of JICA in 1995. The study identified more than 360 000 ha for potential surface irrigation projects, including the Nansanga and Luena areas, and another 60 000 ha for groundwater irrigation development. These projects are well suited to exploit the vast untapped surface and groundwater resources.

3.3 IRRIGATION FOR IMPROVED WATER PRODUCTIVITY

There is a great need to promote the cultivation of irrigated paddy rice as the population is growing at the rate of 3 percent and the production of rainfed crop is low due to regular droughts and high rainfall variability. Moreover, water is a scarce natural resource that needs to be managed and used efficiently, especially in paddy fields. Despite this, most smallholder irrigation systems in Zambia use uncontrolled flooding, a method that is not very efficient in water use. In the face of increasing water scarcity, smallholder irrigation systems in Zambia need to adopt more water-efficient and productive irrigation methods. The feasibility and cost implications of such changes need to be further investigated, as the water productivity of rice under controlled irrigation in Zambia has not yet been fully studied. However, in Sefula (200 ha), Siatwinda (60 ha) and Buleya Malima (40 ha), it has been observed that irrigated rice has the potential to be grown well under partially controlled flood irrigation, rather than under uncontrolled flooding as is the case with smallholder irrigation. Lessons on water productivity can also be drawn from the studies conducted elsewhere in the region and several water management strategies can be applied at the farm level to improve water productivity in rice irrigation schemes. Some of the water management strategies include optimization of water use in rice field operations, reduction of water losses during field activities, and synchronizing the periods of increased water demand with periods of increased rainfall and river flows. Such strategies, if implemented, can improve water productivity, and allow flows to meet environmental demands in the downstream of the rivers.

3.4 WATER PRODUCTIVITY OF PADDY RICE

Water productivity per crop is termed as Crop Water Productivity (CWP), and it is defined as the agricultural production per unit volume of water. CWP can be influenced by several external factors since agriculture production is the result of selected crop variety, cropping season and crop management practices.

In Zambia, rice is mostly grown under uncontrolled lowland flooding and very little information is available on the impact of uncontrolled or continuous flooding on water use in paddies or on water productivity. It is observed that flooding is highly variable, especially in the Barotse rice farming systems of Western Province. Sometimes the rice crops are one or two meters under water. At other times, water may be absent and young seedlings may dry out. Under irrigated dambo condition, some farmers have opted to use treadle pumps to apply control irrigation with shallow groundwater. Transplanting under controlled flood conditions is not common. Especially in Western Province, continuous flooding is the main water management practiced by small rice farmers. Rice fields closer to the Zambezi River may be damaged at times by high floods, while fields closer to the uplands may suffer from drought at other times. In the absence of irrigation infrastructure, farmers cannot control or predict the levels and timing of floods. To reduce the risks, they plant both low-lying and upland fields at the same time. The fields with optimal water levels in a given year will produce the best yields.

Water use in paddies and water productivity of paddy rice have not been quantified in Zambia. However, studies conducted in Asia show that rice plants growing under a wide range of water applications require 3 000 – 5 000 liters of water to produce one kilogram of rice. Field water use for rice is typically between 1 000 mm and 2 000 mm, 2-3 times higher than other major cereals such as maize and sorghum. Traditionally, rice is grown in irrigated areas under constant flooding, resulting in high water consumption. For example, the water used for rice cultivation worldwide accounts for 12-13 percent of the water used to produce all food, grass, and fodder for livestock worldwide. The estimated water consumption through evapotranspiration of all rice fields in the world is 784 billion cubic meters per year.

On average, it takes about 2 500 litres of water supplied by rain and irrigation to a rice field to produce one kilogram of paddy rice. This amount includes all the outflows of evapotranspiration, seepage, and percolation. The variability of water use through evapotranspiration in rice crops is large, ranging from 800 to more than 5 000 litres. These variations are due to cultivation methods, such as the variety grown, fertilisation and pest and disease control, weather, and soil conditions. Rice requires more water at the field level than other grain crops. However, because these outflows, surface runoff can often be captured and reused downstream. That is why the water use efficiency of rice can be higher at the irrigation system level than at the field level. Since rice cultivation requires more water, it is essential to improve cultivation methods.

The soil texture of a rice field can affect the available water capacity (AWC) of the soil. As a result, the water productivity response of the same rice variety varies depending on the soil type. Clay soils can have a water productivity index up to 5 times higher than sandy loam soils. This is probably due to the fact that clay soils have a higher organic matter content and a higher water retention capacity than sandy loam soils.

Farmers believe that water should be stored in paddy fields to prevent weed growth. Studies to assess infiltration have shown that the infiltration rate increases as the standing depth of the paddy increases. Standing water of more than 10 cm leads to heavy leaching of soil nutrients and percolation losses in paddy fields. Losses due to deep percolation are comparatively higher in light-textured loamy sands than in heavy-textured clay soils. According to Mo'allim *et al*. (2018), a stagnation depth of 4-6 cm minimizes water losses from both deep percolation and surface runoff. A stagnation depth of six cm and intermittent irrigation at seven-day intervals support good crop performance and save 50 and 72 percent water, respectively, without affecting yields. Under high water demand conditions, weekly irrigation with water depth of 3 cm is recommended and adjusting crop water requirement to the onset of rainfall can be adopted and recommended as an appropriate practice for rice cultivation on saturated soils. Terminating irrigation 14-17 days before harvest ensures that grains mature evenly, and a considerable amount of water is saved without reducing yields. The use of well-defined crop rotations can also reduce water consumption and lead to higher yields. Better coordination between farmers, scientists and extension workers is needed to spread water-saving techniques.

3.5 WATER USE EFFICIENCY IN PADDY FIELDS

Water use efficiency is the ratio between the volume of water used to effectively irrigate crops and the volume of water diverted to the irrigation system. It indicates the amount of diverted water that does not reach the crop root zone, and is lost through evaporation, irrigation canal seepage, overflow, spillage, non-beneficial use by weeds and shrubs and deteriorated irrigation infrastructure. The volume of water used for crop irrigation includes green water (effective rainfall) and blue water (irrigation water from surface and groundwater sources). Water use efficiency in paddy cultivation is higher if the green water is used to the maximum and the blue water is conserve for other productive uses. Flood irrigation is widely used in Zambia, albeit inefficiently. However, switching from this method to controlled irrigation using treadle and motor pumps has the potential to significantly increase water use efficiency. Water use efficiency of improved irrigation techniques in developed countries is higher than with uncontrolled flooding in Zambia. In recent years, some parts of the country have started to suffer from water scarcity, especially in the dry season. Although other parts have sufficient water, seasonal fluctuations and the effects of climate change can have a devastating impact on the availability of water resources.

Improving water efficiency should increase the benefits from all water resources. In general, water demand management (WDM) practices are emerging in agriculture for both large- and small-scale farmers. The main reasons for demand management are the high cost of water and energy, water scarcity and competition for water in key catchments such as the Kafue plains and Lunsemfwa catchments. WDM considers water demand and use and has the potential to increase water availability through more efficient allocation and use. However, a barrier to effective WDM in Zambia could be the existing water policy and institutional legal framework, which are not fully compatible with WDM. The lack of a water fee collection culture is also a barrier to the adoption of WDM and most farmers take water for granted as a resource without paying attention to its efficient use.

3.6 IRRIGATION WATER RIGHTS AND CHARGES

The ownership, control, diversion, allocation, and use of surface water is described in the Water Resources Management Act 2011. Under this Act, the President, on behalf and for the benefit of the people of Zambia, is the owner of all water in its natural state in Zambia. The Zambian Government is the trustee of the country's water resources and ensures that water is equitably distributed, protected, used, developed, conserved, managed, and controlled in a sustainable and equitable manner and in the public interest, while promoting environmental and social values. The Act also establishes the Water Resources Management Authority (WARMA), which is mandated to promote and adopt a dynamic, gender-sensitive, integrated, interactive, participatory, and multi-sectoral approach to water resources management and development. The Act ensures gender equality in water issues and empowers women to fully participate in decision-making related to sustainable development and use of water resources. There is also a classification of primary, secondary and tertiary uses of water. Every person has the right to primary use of public water that is in its natural state. This could reasonably be interpreted as an implicit human right to water encoded in law. Primary use of water is defined as the use of water for domestic purposes and to sustain animal life. Secondary use refers to the use of water for irrigation and fish farming. Tertiary use is defined as the use of water for commercial and industrial purposes. In case of conflicts over water use and allocation, primary use takes precedence. Water permits are issued by WARMA, the public water regulatory authority established by the Act. WARMA sets a maximum volume of water that may be abstracted from a water resource or reservoir and the maximum monthly rate at which water may be abstracted from a borehole or reservoir in an area where the resource is scarce. Water permits are issued for volumes above 10 000 m^3/day. Lower quantities are considered domestic and do not fall under the water rights application. WARMA coordinates water rights at the national level, especially for large water users such as water suppliers, industrial users, and commercial farmers. For large users, state water rights and customary law is very important as Zambia has a dual legal system. Water rights follow the state law, which applies mainly in urban centers, while customary law applies in rural areas. Traditionally, inherited land with a water resource is not subject to state law, although it accounts for more than 70 percent of the country's area. Therefore, customary water laws and regulations have become more important than state water law in most of Zambia. The owner of traditionally managed or inherited land informs the local traditional leadership about the waters on his/her land and the intended use so that he/she does not hinder other communal users of the same resource.

Since 2018, WARMA has levied a fixed fee (around 10 USD) for agricultural and commercial use of up to 10 000 m^3 of water per day. The Zambian government does not pay any subsidies for water use, not even for the electricity used for irrigation. Depending on how a particular irrigation system was set up, its management is the responsibility of the community or a cooperative of farmers. The management of the system may charge fees for operation and maintenance and sometimes enter into a partnership with a commercial farmer in the region who pays for the overhead costs.

3.7 TRAINING AND CAPACITY BUILDING OF WATER USERS

The Technical Services Branch of the Agriculture Department, through its provincial, district and camp officials, provides training to communities on water use and management. International agencies and non-governmental organizations, such as JICA, International Development Enterprises (IDE), and Total Land Care also focus heavily on water management and capacity building for water use among smallholder farmers. The trainings provided to water users mainly deal with aspects of leadership and group organization, as well as technical aspects of managing and maintaining infrastructure such as canals, irrigation channels, small dams, and pumps. These trainings enabled irrigation communities to operate irrigation systems without external help from the government and to ensure that they are well maintained once handed over to farmers and water user associations.

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4. Cross-cutting issues in paddy rice production

4.1 CLIMATE CHANGE

Zambia suffers from high temperatures and more frequent and intense droughts, dry spells, floods, and flash floods, leading to high incidence of crops pests and diseases, increased water stress and lower crop yields. The cost of the two natural disasters that occurred between 1982 and 2016 was estimated at USD 610 million (with droughts amounting to USD 438 million and excessive rainfall and flooding amounting to USD 172 million). The frequency and intensity of climate events is expected to increase in the future, with negative socio-economic impacts on communities. It is estimated that climate change will cost the country about 0.4 percent of its annual economic growth, and without action, rainfall variability alone could lead to loss of 0.9 percent of GDP growth over the next decade. Climate-related losses in agriculture are estimated at between USD 2.2 billion and USD 3.1 billion over the next 10 to 20 years. Climate change is projected to reduce water availability by about 13 percent by 2100, affecting hydropower generation, agriculture and industrial production, and domestic use.

A number of adaptation measures have been taken to address the current and future impacts of climate change. Measures in agriculture include improving early warning systems, introducing weather index insurance, diversifying livelihoods and promoting climate smart agricultural technologies and practices such as improved irrigation, drought tolerant crop varieties, early maturing crop varieties, minimum tillage, residue retention, agroforestry and crop diversification. Interventions in the water sector include the use of water harvesting and wastewater recycling technologies, the introduction of energy-efficient and alternative renewable energy sources, the promotion of research and development for inter-basin water transfer, integrated watershed management, land use management, and the protection of aquifers. Global interventions also take into account climate proofing of infrastructure and renewable energy development.

Zambia has further ratified subsidiary instruments under the United Nations Framework Convention on Climate Change (UNFCCC), such as the Kyoto Protocol and the Paris Agreement. Frameworks and studies guiding climate change interventions include the following:

- National Adaptation Programme of Action (NAPA, 2007) to respond to immediate and urgent adaptation needs as a Least Developed Country (LDC).

- Zambia Climate Change Economic Impact Study (2011) to assess the economic impact of climate change on the national economy and the cost of addressing the challenge.

- Technology Needs Assessment (2014) to identify the country's technology needs and priorities for climate change adaptation and mitigation measures.

- Nationally Appropriate Mitigation Action (2015) to identify mitigation measures that are appropriate to the country's circumstances and result in a win-win situation.

- Nationally Determined Contribution (2015) to contribute to the achievement of the overall objectives of the Paris Agreement.

- National Policy on Climate Change (2016) to provide a policy framework for a coordinated response to climate change.

- National Strategy to Reduce Deforestation and Forest Degradation (REDD) (2015) to ensure sustainable management of natural resources, improve livelihoods and achieve a green economy.

- Forest Investment Plan (2018) to identify and prioritize how to reduce deforestation in Zambia.

Low uptake of climate-smart agriculture technologies and practices among smallholder farmers are some of the factors hindering efficient use of water resources in rice fields. Apart from the long-term impacts of climate change, the frequency and severity of extreme weather events have increased, creating both opportunities and challenges for irrigated rice production and productivity and efficient agricultural water use and management in paddy fields. Research has shown that global warming may have a negative impact on yields of paddy rice produced worldwide. Crop growth models show that as the growing season shortens and temperatures rise, yields are likely to decline. However, very few studies have been conducted all with different models, resulting in a very inconsistent estimate of the impact of climate change on rice in Africa.

Farmers can mitigate the effects of climate change by planting early and using varieties adapted to high temperatures, using improved irrigation methods such as alternate wetting and drying irrigation, and adopting nutrient or fertilizer management. If effective strategies to address yield loss are not implemented soon, global warming will lead to a shortage of paddy cultivation, resulting in increased food insecurity in the future. Farmers are aware of climate change as they have changed their farming practices, e.g., by growing high yielding varieties instead of traditional ones, by introducing new drought-tolerant crops and varieties that were not previously common in the region, and by switching to shorter cropping cycles that can take as little as three months from sowing to harvest.

4.2 ROLE OF GENDER

In Zambia, women make up 64 percent of the rural population and about 80 percent of food producers. Women rice farmers, like their counterparts in other agricultural sectors, face various constraints that are exacerbated by cultural norms that define "male" and "female" roles and responsibilities. Discrimination due to a rigid gender division of labour in agriculture, lack of education, ownership of transport, side-lined by extension workers, lack of access to credit, limited access to land and other cultural constraints are often present. The gender of the primary decision-maker affects the type of crops grown and ultimately the level of efficient water use in irrigated rice fields. In both male and female headed households, men control the production of cash crops such as rice, maize, sunflower, cotton, and soybean. Women mainly control the production of food crops grown primarily for subsistence, such as groundnuts, beans, Bambara nuts and vegetables. Women are the main determinants of the type of food consumed in the household. However, women have limited access to credit and land, as well as to the use of the latest technologies, which are essential for efficient agricultural water use and management of irrigated rice production and productivity. In the agriculture sector, although 60 percent of the labour force is female, only 9 percent of owners are women. This figure partly explains their limited access to agricultural resources.

The major gender-specific barriers to increasing rice production are limited access to technical knowledge and technologies, and limited access to credit, and land allocation. Men often have relatively better access to credit, can negotiate more easily with traditional leaders to get more land allocated, and are able to use mechanical equipment that are not readily available to women. The government has begun to acknowledge this gender imbalance and incorporate gender equality into its programming. These efforts are well articulated in both the national agricultural policy and the national development plan. In relation to SDG5 on gender equality, the government has highlighted gender equality in key legal provisions to close the gender gap.

In communities, especially rural ones, the empowerment of women does not mean that men are disempowered. Rather, both men and women have felt empowered. In the extension services, there has been better understanding of core gender concepts, such as access to and control over assets; gender division of labour; and decision-making. It was also found that the distance of cultivated land from home, the type of agricultural technologies used, and the number of adult male workers significantly influence women's participation in agricultural activities. The distribution of gender roles among rice producing households and traders largely depends on the extent to which an activity is considered laborious. For example, relatively easy tasks such as planting and weeding are considered women's work, while ploughing, threshing, and lifting, being more labour intensive, are largely considered men's work. In addition, other tasks such as harvesting, and marketing are done jointly by women and men.

Some NGOs and community-based organizations, such as the Catholic dioceses and the Sefula Rice Farmers Cooperative in Mongu, have implemented interventions that focus on building an asset base for women-headed rice farming households and also for poor women and men in general. Beneficiaries have had better access to service providers such as microcredit and insurance. Through the deposit-free initiative and the inclusion of rice in the Farmer Input Support Programme (FISP), women rice farmers have gained access to agrochemicals and improved rice seeds, among other facilities.

4.3 ROLE OF DISABLED

In 2015, results of the national disability survey undertaken by the Central Statistical Office (CSO), indicated a 7.2 percent prevalence rate, hence 1 080 000 people living with disabilities in Zambia. Prevalence of disability was estimated to be 10.9 percent among adults (18+ years), with higher rates in urban than in rural areas, and among females than males. Among children (2–17 years), the prevalence was estimated to be at 4.4 percent. Prevalence varied between the provinces, with the highest estimates in Luapula and Copperbelt provinces, among both adults and children.

Rice production is labour intensive and therefore affects the participation of people living with disabilities, who have limited access to land, finance and agricultural inputs essential for agricultural production. In paddy fields, people with disabilities also strive in the efficient agricultural water use and management of paddy field. Disabilities deprive individuals of the chance to participate in farming activities. Thus, it is important to develop strategies that promote the inclusion of people living with disabilities in agriculture. For many people living in poverty across the developing world, agriculture is a vital sector, yet one where disabled people face some of the greatest prejudice and exclusion.

Enabled people assume that disabled people are incapable of doing agricultural work. People with impairments are often assumed to be physically or mentally unable to undertake farming activities. Those with physical and visual impairments are perceived as being unable to move around farmland. Those with hearing and learning impairments are often believed to be incapable of learning agricultural techniques because of communication challenges.

The plight of women with disabilities in relation to employment is worsened by the fact that women tend to be less educated than men and therefore face double discrimination as women and as persons living with disability.

4.4 ROLE OF YOUTH

According to the 2020 United Nations Population Fund annual report, Zambia has a young population, with 19.1 million people (36. 7 percent) between 15 and 35 years, and 49.9 percent of this are females. Sixty-nine percent of Zambian youth are engaged in agriculture as their primary source of livelihood. However, their participation in agriculture is limited due to inadequate access to affordable agricultural finance and insurance, limited access to titled land, inadequate training in agri-business. The youth are characterized by innovative behaviour, low risk aversion, less conservativeness, greater physical strength, and greater knowledge acquisition tendency. As such, they have greater capacity to learn and apply modern agricultural technologies and practices required for efficient agricultural water use and management in paddy fields.

Although agriculture is the backbone of Zambian's economy, the sector is dominated by senior farmers. Several national and provincial programmes have been developed to attract young people into different agriculture sectors such as school production units. Moreover, jobs such as extension worker and agricultural technician have been promoted among new college graduates. However, young people still have a negative perception of agriculture, often seen as a last resort when jobs cannot be found in other sectors.

4.5 ROLE OF INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

During the year 2000, the government, through the Ministry of Mines, Energy and Water Development, promoted a more effective framework based on the principles of Integrated Water Resources Management (IWRM) to address water resources management challenges and unlock the development potential of the country's water resources. Two major initiatives have been developed to advance the IWRM agenda: A Water Resources Action Programme (WRAP) and a Partnership for Africa's Water Development (PAWD) project. The government worked with the WRAP and the support received under the PAWD to develop the IWRM plan for Zambia. As a result, an IWRM approach was adopted in the 2010 National Water Policy. In 2013, the World Bank funded a water resources development project, which was established as part of a programme to support the implementation of the IWRM plan.

4.6 MONITORING AND EVALUATION

At the national level, various programmes of the Ministry of Agriculture focus on monitoring and evaluation of paddy production and information on irrigated land. The Ministry of Agriculture collects various types of information on rice production, marketing and consumption (including taste) of paddy in both the uplands and lowlands. The Ministry also monitors rice grain stocks and seeds available in the country. Data collected includes the number of farming households, area planted and harvested, and yield. This information is collected through crop forecasts and post-harvest surveys. The Seed Certification and Control Institute (SCCI), under the Ministry, keeps statistics on the number and type of rice varieties available in the country and the amount of rice seed certified annually. The Zambia Agriculture Research Institute (ZARI), in turn, maintains data on the number of varieties developed. The Policy and Planning Department is responsible for maintaining a database of agricultural statistics, providing early information on food security, developing performance indicators and regularly assessing and reporting on the performance of the sector. Currently, there are no effective programmes to assess water use efficiency of different crops at different spatial level, due to the lack of flow monitoring systems at the irrigation scheme level. Hence, the monitoring and evaluation framework does not effectively track water use efficiency in crop production, including paddy rice.

5. National policies for water in Zambia

In Zambia, the management and use of water resources in agriculture is governed by several policies, laws, regulations, guidelines, and standards. These include Vision 2030, the Seventh National Development Plan (7^{th} NDP), the Second National Agricultural Policy (SNAP), the National Irrigation Policy and Strategy 2004-2015, the National Water Policy (NWP), the National Climate Change Policy 2016, the Water Resources Management Act of 2011, and the Environmental Management Act of 2011.

5.1 VISION 2030

The Vision 2030 sets out the goals and targets to be achieved in the various areas of socio-economic life to make Zambia "a prosperous middle-income nation by 2030". The Vision forms the basis for coordination among all sectors and provides direction for short and medium-term plans. The Vision is operationalized through the implementation of the Seventh National Development Plan (2017-2021). The Vision recognizes that the performance of the agriculture sector has been affected by poor irrigation infrastructure and variability in rainfall patterns. The poor performance of services sector has also severely affected the delivery of essential services, including technology, to farmers, which affects productivity. Therefore, to transform the overall agriculture sector, some of the performance targets set under the Vision are:

- Increase agricultural productivity and cultivated land to 900,000 ha by 2030.
- Increase exports of agricultural and processed agricultural products by 2030.
- Maintain the agricultural resource base by 2030.
- Increase irrigated cropped area to 400,000 ha by 2030.
- Increase the availability of agricultural machinery and the number of tractors per 100 ha by 2030.

5.2 SEVENTH NATIONAL DEVELOPMENT PLAN (7TH - NDP) 2017-2021

The Seventh National Development Plan (7th NDP) is a medium-term planning framework of the Government of Zambia. Its objective is to create a diversified and resilient economy for sustainable growth and socio-economic transformation, driven by agriculture among other sectors. The goal is to be achieved through five strategic development areas that are aligned with Vision 2030, the UN 2030 Agenda for Sustainable Development, the African Union Agenda 2063 and other development strategies. These development areas are summarized in Table 6.

Table 6. Strategic development areas of the seventh National Development Plan

No.	Area	Strategic focus
1	Economic diversification and job creation	• A diversified and export-oriented agriculture sector. • A diversified and export-oriented mining sector. • A diversified tourism sector. • Improved energy production and distribution for sustainable development. • Improved access to domestic, regional and international markets. • Improved water resources development and management. • Enhanced information and communication technology. • Enhanced decent job opportunities in the economy. • Enhanced research and development.
2	Poverty and vulnerability reduction	• Enhanced welfare and livelihoods of the poor and vulnerable.

3	Reducing development inequalities	• Reduced inequalities.
4	Enhancing human development	• Improved health and health related services. • Improved education and skills development. • Improved access to water supply and sanitation.
5	Creating a conducive governance environment for diversified and inclusive growth	• Improved policy environment. • Improved transparency and accountability. • An inclusive democratic system of governance. • Improved service delivery. • Improved rule of law, human rights and constitutionalism. • Enhanced national values, principles and ethics.

Source: GRZ. 2017. *National development plan 2017-2021*. Lusaka, Ministry national planning development. www.mndp.gov.zm/wp-content/uploads/2018/05/7NDP.pdf

A diversified and export-oriented agricultural sector is one of the critical development outcomes under the area of Economic Diversification and Job Creation. It addresses SDGs 2, 8, 9 and 10 through six strategies, namely (1) improving production and productivity, (2) improving access to finance for production and exports, (3) improving agricultural value chains, (4) promoting diversification within the agricultural sector, (5) improving investment in agricultural infrastructure, and (6) promoting smallholder agriculture. The expected results of the implementation of these strategies are shown in Table 7.

Table 7. Programmes and outputs under export-oriented agriculture sector

Strategy	Programmes	Outputs
Improving production and productivity	Productivity enhancing technology development	Climate Smart Agriculture technologies and practices developed and disseminated
	Farm block development	Standard farm blocks with climate proofed infrastructure developed and functional
	Irrigation development	Land under irrigation increased
	Agriculture input supply management	Input supply management system diversified and improved
	Research and development promotion (crops, livestock, forestry and fisheries)	Research products developed i.e., plant varieties, livestock breeds, and forestry varieties protected
	Early warning systems development	Coverage of early warning information systems increased, early warning systems and platforms integrated
	Farm power and mechanization enhancement	Farmers using mechanized farming systems increased
	Extension service delivery enhancement	Agriculture extension service coverage improved
Improving access to finance for production and exports	Agricultural finance product development	Access to agricultural finance services expanded
	Export financing and insurance promotion	Access to agricultural export finance and insurance increased, and access to agricultural insurance increased
	Product standardization and quality assurance	Compliance to sanitary and phytosanitary measures and technical regulations improved
	Business development services provision	Agribusinesses services provision strengthened
Improving agricultural value chains	Value chain linkages promotion	Smallholder farmers integrated into commercial value chains
Promoting diversification within the agricultural sector	Crop, forestry, fisheries and livestock product diversification	Commodity and product range of crops, livestock, fish and forestry increased
Improving investment in agricultural infrastructure	Storage facilities development	Capacity for storage at national, community and farm levels increased
	ICT development	Integrated agriculture management information system established and operational

Improving investment in agricultural infrastructure	Agricultural training institutions development	Capacity of agriculture training institutions
	Research and extension infrastructure development.	Standard infrastructure for targeted extension and agricultural research constructed and rehabilitated
Promoting smallholder agriculture	Farmers' organizations development	Entrepreneurial capacity of small-scale farmer organization developed

Source: GRZ. 2017. National development plan 2017-2021. Lusaka, Ministry national planning development. www.mndp.gov.zm/wp-content/uploads/2018/05/7NDP.pdf

Another key outcome under the Economic Diversification and Job Creation Pillar is improved water resources development and management, which is in line with SDGs 6, 8, 9 and 10. The outcome will be achieved through four strategies, namely: (1) improving rainwater harvesting and watershed protection; (2) promoting local and transboundary aquifer management; (3) promoting inter-basin water transfer programmes; and (4) promoting alternative financing options for water resources development. The objective is to increase the available storage capacity to 209.1 billion m^3 in 2021. The Plan departs from sectoral planning to promote an integrated (multi-sectoral) approach to development. The Plan recognizes the multi-faceted and interlinked nature of sustainable development and calls for actions to be addressed simultaneously through a coordinated approach to the implementation of development programmes.

5.3 SECOND NATIONAL AGRICULTURAL POLICY (SNAP)

The Second National Agricultural Policy 2016 (SNAP) is an overarching policy that guides the development of the agricultural sector. Its vision is "An efficient, competitive and sustainable agricultural sector that ensures food and nutrition security and generates more employment opportunities and income". SNAP provides a framework to promote sustainable agricultural diversification, agricultural commercialization, private sector participation and inclusive agricultural growth.

To increase agricultural production and productivity, the Policy includes measures related to water use. These are: (i) promoting investment in appropriate, affordable and cost-effective irrigation technologies and infrastructure suitable for different agro-ecological regions; (ii) promoting efficient use of available water resources for irrigation; (iii) promoting high value irrigable crops among small and medium-scale farmers; (iv) improving the management of smallholder irrigation systems; and (vi) promoting the establishment of irrigation facilities. These measures will contribute to the achievement of SDGs 1, 2, 8, 9 and 10. The Policy explicitly recognizes the importance of climate change adaptation by promoting climate-smart agricultural practices, such as conservation agriculture and agroforestry, and linkages with other sectors such as forestry, energy, land use, and infrastructure development. Mainstreaming the environment and climate change into the agriculture sector is also one of the policies supporting SDG 13.

5.4 NATIONAL AGRICULTURE INVESTMENT PLAN (NAIP) 2014-2018

Zambia launched the Comprehensive Africa Agriculture Development Programme (CAADP) process in 2006. Various technical and financial partners and key stakeholders supported Zambia's CAADP agenda and through a broad stakeholder consultation process that included dialogue and consensus on key issues. The National CAADP pact was signed on 18 January 2011. Subsequently, Zambia's first National Agricultural Investment Plan (NAIP) was launched in May 2013 for a four-year implementation period between 2014 and 2018. The NAIP was structured into four interlinked programmes: (i) Sustainable Natural Resource Management, including efficient water use and irrigation; (ii) Agricultural Production and Productivity Enhancement; (iii) Market Access and Services Development; and (iv) Food and Nutrition Security and Disaster Risk Management. NAIP objectives focus on increasing cereal production and agricultural exports, and reducing soil erosion, poverty and chronic child malnutrition. NAIP programmes and targets are in line with SDGs 1, 2, 8, 9, 10, 13 and 17. Between 2019 and 2021, the CAADP was implemented in Zambia under the Seventh National Development Plan. During this period, the NAIP was reviewed and a new NAIP was designed for the period 2022 to 2026 under the Malabo CAADP.

5.5 NATIONAL IRRIGATION POLICY 2004-2015

The overall objective of the National Irrigation Policy, 2004 is to create a well-regulated and profitable irrigation sector that is attractive to both the private sector and other development partners. This is to be achieved by creating an enabling environment, promoting informal irrigation through water harvesting, the use of dambos, improving rainfed agriculture in the traditional sector, rehabilitating and upgrading irrigation infrastructure and constructing new irrigation infrastructure targeted at both traditional and commercial farmers. The National Irrigation Policy is currently being revised.

5.6 NATIONAL WATER POLICY (NWP)

Until 1994, Zambia did not have a coherent water policy for planning, management and development of water resources. The water supply sector operated on ministerial declarations that were based on various ad-hoc objectives of water users and only provided principles for the frequent management crises and uncoordinated development purposes. The NWP was developed towards the end of 1994. It aimed to promote sustainable development of water resources to provide adequate, equitable and good quality water supply to all users at acceptable costs and to ensure security of supply under different conditions.

The policy framework included the following key strategies:

- Recognition of the important role of the water sector in the overall socio-economic development of the country.

- Transfer of control of the country's water resources to the state.
- Promotion of water resource development through an integrated management approach.
- Provision of adequate, safe and cost-effective water supply and sanitation with due regard to environmental protection.
- Definition of clear institutional responsibilities of all stakeholders in the water sector for effective management and coordination; and
- Recognition of water as an economic asset.

In 2010, the NWP of 1994 was revised to provide a clear vision and holistic policy direction for the water sector, guided by the international frameworks, including a re-examination of the institutional and legal framework. The vision of the NWP 2010 is "the optimal use of water resources for efficient and sustainable use to increase economic productivity and reduce poverty", aligning it with SDGs 1, 2, 6, 8, 9 and 10. The policy statement of the NWP 2010 on water for food and agriculture is: "Manage and develop water resources to support the development of a sustainable and well-regulated agricultural sector that ensures food security and income generation at household and national levels and maximize the sector's contribution to GDP". The interventions proposed under the policy are:

- Develop and manage water resources to support the agricultural sector, especially irrigation;
- Support the development of the agricultural sector through the establishment of a fair, efficient and transparent water allocation system;
- Facilitate the protection of national water resources through dissemination and education on sustainable water and soil conservation measures. and
- Collect, process and disseminate information on water resources to facilitate agricultural development.

5.7 NATIONAL POLICY ON CLIMATE CHANGE, 2016

The National Climate Change Policy of 2016 provides a framework for coordinating climate change programmes to ensure climate resilient and low carbon development pathways for sustainable development towards the achievement of Zambia's Vision 2030, against the backdrop that climate change issues are being addressed in a fragmented manner through various sectoral policies, strategies and plans that have limited overall impact. The vision of the policy is "A prosperous and climate resilient economy by 2030". This vision is to be achieved through nine main objectives:

1. Promote and strengthen the implementation of adaptation and disaster risk reduction measures to reduce vulnerability to climate variability and change.

2. Promote and implement sustainable land use practices to help reduce greenhouse gas emissions from land use, land use change and deforestation.

3. Promote the integration of climate change into policies, plans and strategies at all levels to take into account the risks and opportunities of climate change in decision-making and implementation.

4. Strengthen institutional and human capacity to effectively and efficiently address all aspects of climate change at international, national, provincial, regional and local levels.

5. Promote communication and dissemination of information on climate change to improve awareness and understanding of its impacts.

6. Promote investment in climate-resilient and low-carbon development pathways to generate co-benefits and incentivize more effective management of climate change.

7. Promote research and development to improve understanding and decision-making in responding to climate change.

8. Promote climate change programmes and activities to improve gender equality and equity in the implementation of climate change programmes. and

9. Develop and promote appropriate technologies and build national capacity to benefit from technology transfer on climate change.

5.8 PADDY RICE STRATEGIES AND PROGRAMMES

Rice was recognized as one of the priority crops to be promoted under the crop diversification strategy to contribute to sustainable agricultural production, especially among smallholder farmers. It was considered that crop diversification through rice cultivation would contribute significantly to improving the living standards of farm households and provide farmers with various cropping alternatives instead of relying on a single maize crop. To achieve this, Zambia has adopted policies that provide public support and investment in agriculture to create an enabling environment that will attract private sector and smallholder interest in rice production, processing and trade. Under the Crop Diversification Programme of the Ministry of Agriculture, rice is recognized as one of the strategic commodities that contributes to food security and has the potential to significantly increase incomes and employment of rural producers. Therefore, the government has decided to include rice as one of the nine crops that will be supported through the Farmer Input Support Programme (FISP). Rice is also one of the crops listed as a designated crop in the Statutory Instrument of 2015. Of all the staple crops grown in Zambia, rice is currently the only one where there is a production deficit, which is increasing every year.

5.9 SECOND NATIONAL RICE DEVELOPMENT STRATEGY (SNRDS)

The Second National Rice Development Strategy (SNRDS), 2016-2020 provides the vision, goal and strategic objectives for the development of the rice sub-sector. The vision of the SNRDS is: "A competitive rice sub-sector based on best practices and sustainable use of natural resources that benefits all value chain actors". The goal is to contribute to improved food security and wealth and employment creation in Zambia, the goal of SNRDS is in line with SDGs 2 and 8. The overall objective of the SNRDS is to increase local rice production by at least 50 percent by 2020 and improve its competitiveness in the market. The strategic objectives are as follows:

1. Increase yields by at least 25 percent by 2020.
2. Expand the area under cultivation by at least 20 percent by 2020.
3. Improve the quality of local rice in terms of whole grains and aroma, etc.
4. Promote innovation capacity and knowledge management of stakeholders throughout the value chain.
5. Increasing the market share of locally produced rice; and
6. Develop and improve mechanisms for linking value chain actors and coordinating the rice sub-sector.

During the implementation of the SNRDS, the focus was on the lowland rainfed rice and upland rainfed rice ecologies. Interventions were carried out in the area of technology development, its dissemination and marketing, with the main support coming from cooperating partners. These included the World Bank-funded Agricultural Productivity Programme for Southern Africa (APPSA) and its sub-project "Strengthening rice seed delivery system for improved rice production among smallholder farmers", the FAO-funded "Strengthening rice seed production and enhancing extension services to increase rice production in Zambia", the IFAD-funded "Smallholder productivity promotion programme and enhanced smallholder agribusiness promotion programme", the JICA rice dissemination project and the AfDB-funded "Agricultural productivity and market enhancement project".

Various interventions during the implementation of the SNRDS contributed to: (i) 93 percent increase in rice area from 25 595 ha in 2016 to 49 398 ha in 2021, (ii) 147 percent increase in production from 49 398 tonnes in 2016 to 65 876 tonnes in 2021, and 35 percent increase in yields from 1.04 tonne/ha in 2016 to 1.33 tonne/ha in 2021. This data is based on the Ministry of Agriculture and ZamStats for the 2015/2016 to 2020/2021 growing season.

The support provided in the SNRDS for dedicated irrigation infrastructure for rice cultivation was limited to: i) rehabilitation and construction of irrigation facilities, ii) improvement of farmers' water management skills, iii) construction of rainwater harvesting and storage facilities, and iv) development and adaptation of appropriate water management technologies.

6. Legal and institutional arrangement for water use

6.1 LEGAL FRAMEWORK

The current legal framework on water use in Zambia is adequate and provides universal access to water. The primary law governing the development and management of water resources in Zambia is the Water Resources Management Act of 2011. The Act supports the management, development, conservation, protection and preservation of water resources and their ecosystems. It promotes the equitable, reasonable and sustainable use of water resources; ensures the right to withdraw water for domestic and non-commercial purposes and ensures that the poor and vulnerable members of society have an adequate and sustainable source of water free of charge. The Act creates an enabling environment for climate change adaptation; promotes the establishment, functions and composition of basin and sub-basin councils and water user associations. It encourages international and regional cooperation in the equitable and sustainable use of shared water resources; advocates the domestication and implementation of the fundamental principles and rules of international law relating to the environment and shared water resources as set out in the treaties, conventions and agreements to which Zambia is a party. In addition, the Act establishes WARMA as the authority for the conservation and protection of Zambia's surface and groundwater resources and regulates sustainable abstraction, allocation, use, development and management.

On the regional level, the Zambezi River Authority Act of 1986, is also an important legislation. It deals with the management of the water resources of the Zambezi River for the joint generation of electricity at Kariba between Zambia and Zimbabwe. At the Southern African Development Community (SADC) level, there is a revised Protocol on shared watercourses, which aims to promote harmonization and monitoring of legislation and policies for development planning, conservation, protection and allocation of shared watercourses.

Similarly, the Environmental Management Act of 2011 is the main environmental law in Zambia, providing support for the establishment of the Zambia Environmental Management Agency (ZEMA), which is mandated to support the integrated environmental management, environmental protection and conservation, and sustainable management and use of natural resources. It covers the development of sector-specific environmental management strategies and the use of strategic environmental assessment of laws, policies, plans and programmes that may have an impact on the environment in all sectors of national development.

6.2 INSTITUTIONAL FRAMEWORK

The institutional framework for efficient agricultural water use and improved paddy management involves many different institutions and agencies at different levels of policy formulation, administration, and regulation. The Ministry of Water Development, Sanitation and Environmental Protection (MWDSEP) has overall responsibility for the management and development of water resources projects in Zambia, together with other institutions that are directly or indirectly involved in water management. These include the Ministry of Agriculture (MoA), the Ministry of Lands and Natural Resources (MLNR), the Ministry of Local Government (MLG), the Water Resources Management Authority (WARMA) and the Zambia Environmental Management Agency (ZEMA). Private sector partners, non-governmental organizations and cooperatives are also involved. The water sector institutions and their main functions can broadly be divided into government and external institutions.

6.2.1 Government institutions

The MWDSEP monitors and controls water resource development and management activities to prevent indiscriminate consumption of water resources. The Ministry also provides the required data on the availability and demand of water resources in the country to enable effective planning. Other responsibilities of the Ministry include the use and management of water resources and the development and management of water conservation measures.

WARMA, under the supervision of MWDSEP, acts as a regulatory body for the management and development of water resources across the country and ensures equitable access to water for various stakeholders. Some specific functions of WARMA are:

- The identification and protection of potential sources of freshwater supply.
- Protecting, conserving and safeguarding the environment, especially wetlands, quarries, dams, and headwaters.

- Planning and ensuring sustainable and rational use, management and development of water resources based on the needs and priorities of the community and the public within the framework of national economic development policies.

- Ensure access to water resources of acceptable quantity and quality for various purposes.

The MoA is responsible for agricultural policy, agricultural credit, development, marketing policy, research, training, extension, field service, food security, irrigation development and seeds certification. In the context of efficient water use and management in agriculture, the MoA is responsible for the development and implementation of irrigation policy and for the development and promotion of irrigation technologies and management practices.

The Ministry of Land and Natural Resources (MLNR) is responsible for issuing title deeds and sustainable management of natural resources, including land and water resources.

Zambia Environmental Management Agency (ZEMA), under the MLNR, is responsible for the sustainable management of natural resources, protection of the environment and pollution control. The agency develops standards and guidelines for the protection of air, water, land and other natural resources.

While several other government agencies and some non-governmental organizations share responsibility for the irrigation sector, the Ministry of Water Development, Sanitation and Environmental Protection is the main agency. It houses the Department of Water Resource Development (DWRD) and the Water Resource Management Authority (WARMA), both of which are responsible for the development and management of water resources.

6.2.2 External organizations

The major external cooperation partners active in the agricultural sector include the African Development Bank (AfDB), European Union, FAO, IFAD, JICA, USAID, World Bank (WB), World Food Programme (WFP), Government of Finland, Government of Norway, and Government of Sweden, There is a comprehensive donor coordination framework at national and sectoral levels. The main activities of cooperating partners in the rice sub-sector between 2016 and 2021 include the following:

- AfDB-funded agricultural productivity and market enhancement project and feasibility studies for an upscaling project on smallholder irrigation, youth in agribusiness and agricultural commodity corridors.

- FAO-funded strengthening of rice seed production and improvement of extension services.

- IFAD-funded smallholder productivity programme and agribusiness smallholder programme.

- JICA-funded rice dissemination project. and

- The World Bank-funded Southern Africa Agricultural Productivity Programme.

In addition to the cooperative partners, there are also the private sector research institutions, non-governmental organizations, and community-based organizations active in the rice sub-sector.

The important cooperation partners in the water sector are: Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ), Norwegian Agency for Development Cooperation (NORAD), Irish Aid, Danish International Development Agency (DANIDA), European Union, World Bank, United Nations Development Programme (UNDP), Kreditanstnlt fuer Wieder (KfW), African Development Bank (AfDB) and Japan International Cooperation Agency (JICA). Several international non-governmental organizations are also involved in rural water supply, including Water Aid, Care International, Africare, World Vision international and Development Aid from People to People (DAPP).

The private sector and non-governmental organizations play an important role in mobilizing the community for irrigation when it comes to traditional farmers or emerging farmers opting for irrigation. Local non-governmental organizations such as International Development Enterprises (IDE) and start-ups have been instrumental in introducing low-cost irrigation technologies in the country. They provide technical assistance and facilitate access to equipment so that smallholder farmers increasingly adopt low-cost irrigation technologies such as treadle and motor pumps.

At the international and regional levels, organizations such as the African Union and SADC provide guidelines for agricultural development and the management of water resources for agriculture and other purposes.

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ISBN 978-92-5-136911-1

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CC2141EN/1/09.22