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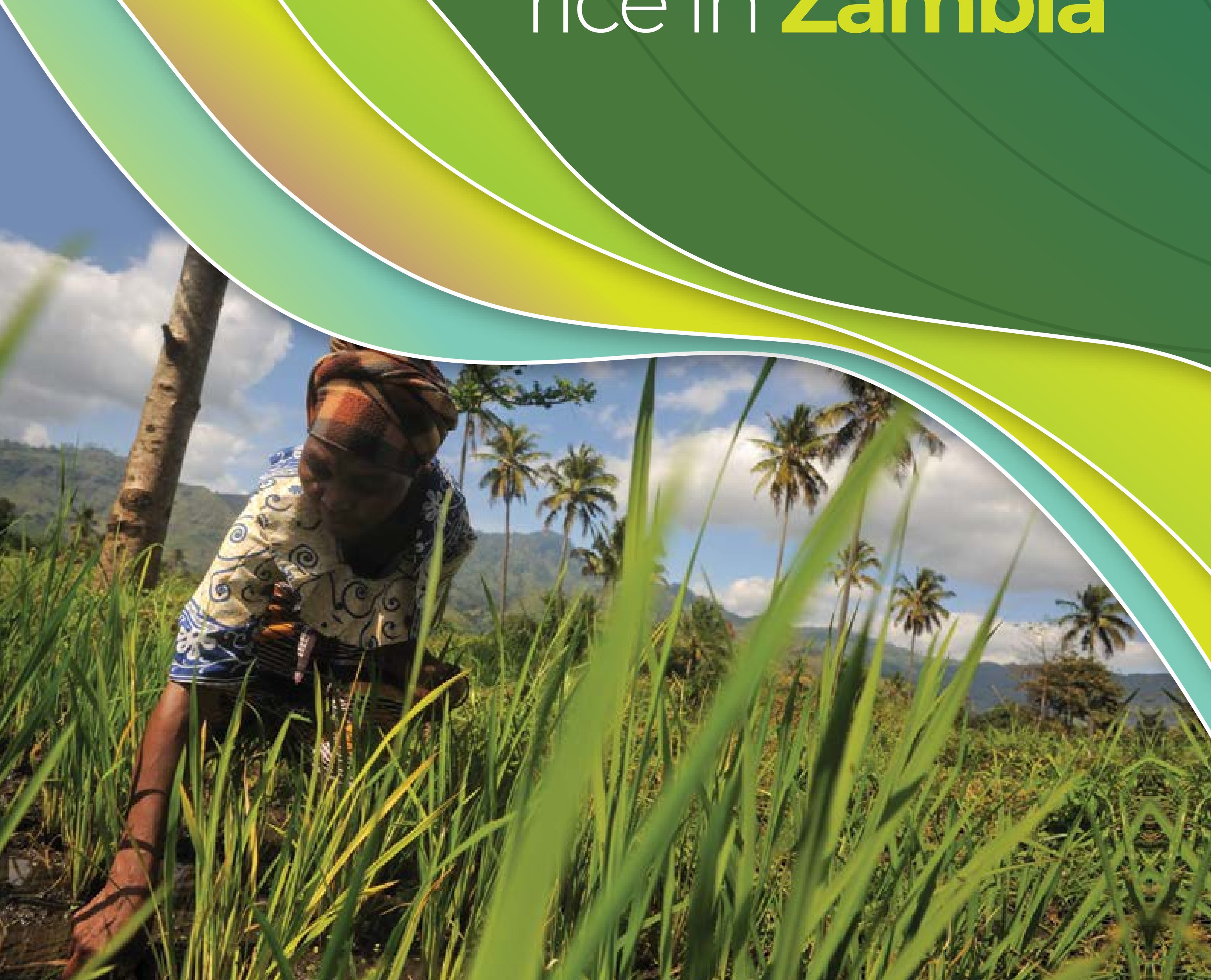
The status of water use efficiency and productivity with a focus on paddy rice in **Zambia**



The status of water use efficiency and productivity with a focus on paddy rice in **Zambia**

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Foreword

Agriculture is an increasingly important contributor to Zambia's national economy, as recognized in the key national policy "Vision 2030". The strategy sets out goals and targets to be achieved in various spheres of the socio-economic life to become a prosperous middle-income nation by 2030, including the increase of agricultural productivity and conservation of natural resources.

In the context of changing climate conditions, rice production requires a specific attention. While it is fundamental to increase households' income, food and nutrition security, it demands the employment of sector-specific approaches to mitigate related climate change challenges, such as crop and income diversification as well as the protection of resources.

Taking into account the projected increases in water demand, enhancing water use efficiency in irrigation is essential to sustainably increase productivity. However, the ability of the country to formulate and implement projects that target improving water use efficiency mostly depends on the responsiveness of the farmers and other value chain actors to seize the various opportunities available. These include an enabling policy environment, amongst others.

Significant progress in the enhancement of water use efficiency has been attained in the past few years through the development and implementation of relevant policies, such as the national Water Policy. Nevertheless, much more remains to be done to increase agricultural water use efficiency and manage resources in paddy fields.

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 and Sri Lanka, identifying both limits and potentials at national level.

This report focuses on the technical and policy measures to address existing challenges, and outline gaps in the implementation of policies to improve agricultural water use efficiency and enhance management in paddy fields in Zambia. It promotes the formulation and deployment of an effective system for the development of the untapped potential for agricultural water use efficiency and management in paddy fields. The report addresses all stakeholders, including policy makers, researchers, and extension agents, who will be directly and indirectly benefit from its recommendations.

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Acronyms

AfDB	African Development Bank
AGRA	Alliance for a Green Revolution in Africa
AgWA	Agricultural Water for Africa
AWD	alternate wetting and drying
CAADP	Comprehensive Africa Agriculture Development Programme
CARD	Coalition for African Rice Development
CWP	crop water productivity
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FG	Farmer Group
GDP	gross domestic product
IFAD	International Fund for Agricultural Development
ITCZ	intertropical convergence zone
JICA	Japan International Cooperation Agency
MFL	Ministry of Fisheries and Livestock
MGEE	Ministry of Green Economy and Environment
MLGRD	Ministry of Local Government and Rural Development
MLNR	Ministry of Lands and Natural Resources
MoA	Ministry of Agriculture
MWDS	Ministry of Water Development and Sanitation
NGO	Non-Government Organization

OECD	Organisation for Economic Co-operation and Development
SADC	Southern Africa Development Community
SLR	Systematic Literature Review
SNAP	Second National Agricultural Policy
SNRDS	Second National Rice Development Strategy
WARMA	Water Resources Management Authority
WUA	water user association
ZEMA	Zambia Environmental Management Agency

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Executive summary

In view of the projected world water demand, increased water use efficiency in irrigation is crucial to sustainably increase agricultural productivity. Paddy field systems are especially water demanding, though products such as rice is not only a staple food, but also constitutes a major social and economic activity providing public goods and is a key source of employment and income for the rural population in Zambia.

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 implementing 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. The project findings presented in this report is a basis for assisting the country with the evaluation of the status of water use efficiency and water productivity of paddy fields, providing technical and policy support to enhance water resources management in Zambia.

This report will help increasing the knowledge and building capacities of technical experts in relevant institutions, ministries and universities in Zambia. Its analysis of best practices will assist in determining the needs and existing gaps and what options are available to fill these gaps. Furthermore, the policy action matrix developed and the investment portfolio compiled will support the development of future financial plans in the country.

The report exclusively covers literature published on the above topics during 2000 to 2020, and it covers the following aspects:

Section 1 introduces the country profile focusing on the status of economy, land and water resources, the use of water in agriculture, the importance of agriculture in economy and food security and rice cultivation in Zambia.

Section 2 describes the methodology used for the review of literature and mapping of water governance structure in Zambia. Systematic Literature Review (SLR), which is central in this report, is applied to review the status of paddy rice production, and the FAO tool for institutional and policy evidence-based analysis in the context of Agriculture Water Management (AgWA) is used for the mapping of water governance structure in Zambia. The section focuses on the conceptual framework, the formulation of the primary interrogation points and the methodology for gap analysis.

Section 3 describes the review result in the context of the primary interrogation points. It elaborates on the role of paddy rice in food security and the challenges and opportunity for increasing paddy rice production. The section outlines the land and water resources as the driving forces that could play a significant role in increasing rice production, water productivity and ensure food security. The section also discusses the potential of several technological interventions that could play a significant role in achieving the above-mentioned objectives. Finally, the policy support for the development of water resources and irrigation infrastructure to achieve high production capacity is discussed.

Section 4 focuses on the mapping of water governance in Zambia. Water institutions, legislations, and policies and strategies makes the basic units of water governance structure. Each of these building units is synthesized and mapped step-by-step.

Section 5 provides conclusions and recap of the analysis that is presented in the previous sections and highlights identified gaps.

1. Country profile

1.1 BACKGROUND

Zambia is a landlocked country in central southern Africa with an estimated population of 17.9 million. It is a lower middle-income country with a GDP growth rate plunged to 1.4 percent in 2019 (23.31 billion USD) when Covid-19 pandemic impacted nearly every sector of its economy. Local manufacturing, tourism, mining, services, and agriculture are the main sectors of its economy. Even before the pandemic, the country faced serious macroeconomic challenges, with GDP growth rate continuously decreased from 10.3 percent since 2010 due to low performance of domestic production, high inflation and widening fiscal deficit.

Zambia has a rugged terrain with a subtropical climate, historical temperature in winter and summer averaging at 5 and 30 degrees Celsius, respectively. The wettest regions of Zambia are located in the Intertropical Convergence Zone (ITCZ), at the juncture of the northeast trade winds, the southeasterly monsoon and the subtropical high pressure in the Southern Indian Ocean. In addition to ITCZ, Zambia receives the northwest monsoon coupled with tropical Atlantic air through the Congo basin. The highest rainfall is observed in the north, especially the northwest and the northeast; then, it tends to decrease toward the south. The driest areas are in the far southwest, the Luangwa River and middle Zambezi River valleys, considered as semi-arid. The country's vegetation is typically composed of savanna woodlands in regions of high rainfall, and tropical grassland in low rainfall regions.

The annual rainfall pattern is similar across the country between November and March, but the volume varies considerably according to agro-ecological regions. There is only one growing season as agriculture is mainly rainfed in the country, with less than 0.5 percent of its total area equipped for irrigation (only 156 thousand hectares).

1.1.1 Water resources of Zambia

Zambia has abundant water resources with large seasonal and annual variation, resulting from climate variability and change, topography, and increasing demand of resources. Zambia receives rainfall averaging 1 020 mm (768 billion m^3) per year. In the south, it is the lowest, at 750 mm, while the central parts of the country receive between 900 and 1 200 mm per annum, and the northern regions get above 1 200 mm. Rainfall totals and intra-seasonal distribution vary greatly from year to year, particularly in the south. This makes rainfed agriculture, which is easily affected by droughts, highly unpredictable.

The total renewable water resources of Zambia amount to about 104.8 billion m^3/year, of which about 80 billion m^3/year are produced internally. The renewable water resource is presented in Table 1.

Table 1: Renewable water resources of Zambia

Long-term average annual precipitation	1 020	mm/year
	767.7	10^9 m^3/year
Internal renewable water resources	80.2	10^9 m^3/year
Total renewable water resources	104.8	10^9 m^3/year
Dependency ratio	23.5	%
Total renewable water resources per capita	6 040	m^3/year
Total dam capacity	101 100	10^6 m^3/year

Notes: The total capacity of the Kariba Dam in the Zambezi River bordering Zambia and Zimbabwe is 188 billion m^3. 50% of the Kariba Dam capacity is allocated to each country, which is 94 billion m^3. That gives a total dam capacity for Zambia of 94 +12 (other dams) = 106 billion m^3.

Source: FAO. 2005. AQUASTAT Country Profile – Zambia. Rome. Cited 24 August 2022. www.fao.org/3/i9761en/I9761EN.pdf

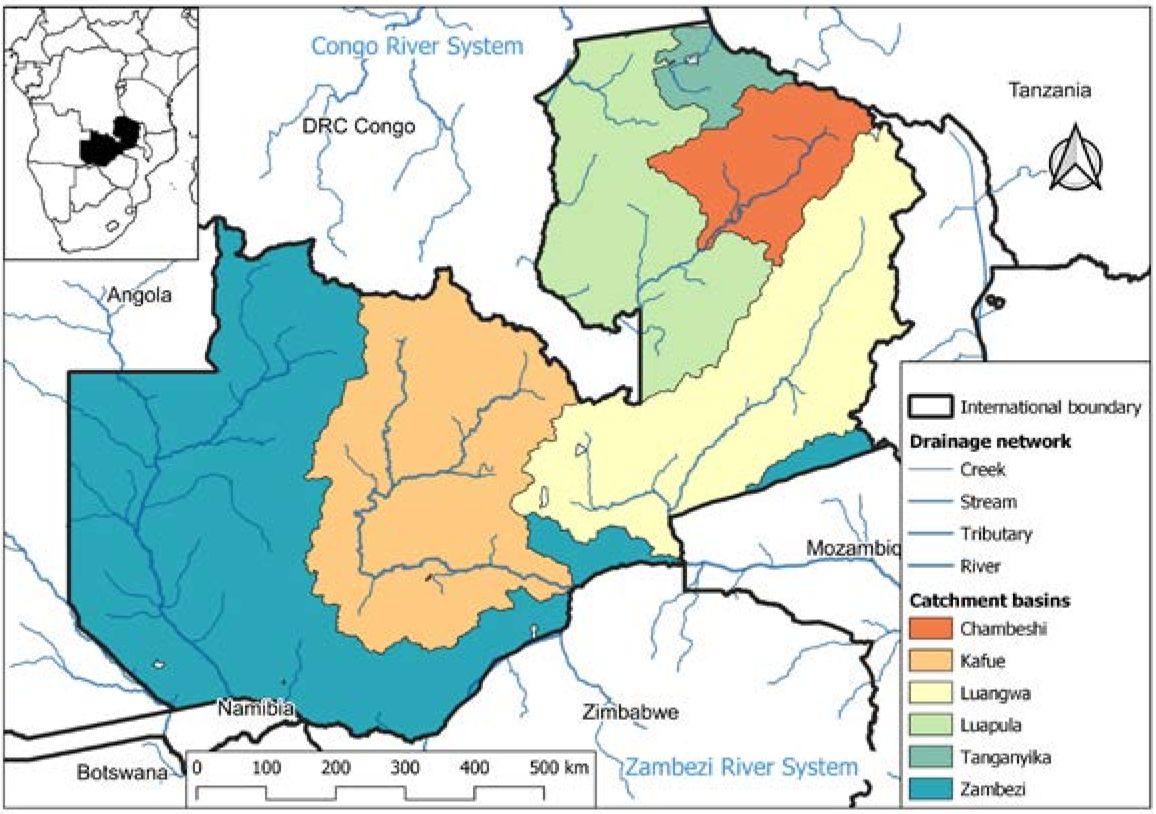
Surface water in Zambia is confined to major rivers and large lakes. Major river basins include Kafue, Zambezi, Luangwa, Luapula and Chambeshi (Figure 1). Significant lakes include Bangweulu, Mweru, Tanganyika, Mweru-wantipa and Kariba and Itezhi-tezhi. The surface water potential is estimated at 100 billion m^3 with the Zambezi River, at the confluence with Luangwa River, contributing over 60 percent. In a high wet hydrological year, the annual runoff could be as high as 130 billion m^3 and in a severe dry year, the runoff could be as low as 68 billion m^3. Table 2 shows the percent contribution of each river basin.

Table 2: Percentage contribution of major river systems

River basin	Total catchment area (km^2) (area outside Zambia)	Percent contribution to surface water potential	Annual run-off (billion m^3)
Tanganyika	15 856	1.73	1.99
Kafue	156 995	8.40	9.88
Chambeshi	44 427	7.62	8.75
Luangwa	144 358 (3 264)	19.44	22.32
Luapula	173 396	26.25	30.14
Zambezi	268 235 (418 814)	36.36	41.75
Total for Zambia	803 267 (422 078)	99.80	114.83

Source: JICA (Japan International Cooperation Agency) & Ministry of Energy and Water Development. 1995. The Study on the National Water Resources Master Plan in the Republic of Zambia. Final Report – Main Report. Tokyo, JICA and Tokyo, Yachiyo Engineering Co., Ltd.

Figure 1: River catchments of Zambia



Source: WWF-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/

Zambia has six medium-large storage dams, with a gross water storage capacity of about 188 billion m^3, mostly used for hydroelectric power generation. In addition, there are about 2 000 small dams with an estimated capacity of 1 500 billion m^3. In drought-prone areas of the Eastern, Lusaka, Central and Southern provinces, more than 2 000 low-cost earth dams have been constructed since 1991 to conserve water for livestock and crop production. However, due to lack of maintenance, most of the small earth dams require rehabilitation.

Another source of fresh water in Zambia is wetlands, including dambos, which cover about 3.6 million hectares or 4.8 percent of the total land area. Dambos are used for grazing animals in the dry season when upland vegetation is dry and has little nutritional value. They are also important for fishing, livestock-watering, hunting of small animals, collection of thatching grass and, most importantly, for dry season vegetable growing. Occasionally, water storage needs for irrigation may require the construction of a low-cost earth dam.

The average renewable groundwater potential in Zambia is estimated at 49.6 billion m^3, based on an average of 8 percent of the effective precipitation. It sustains river flows during the dry season and contributes between 30 to over 90 percent of the total flows for perennial rivers and streams during the dry season. Most of the fresh groundwater at reasonable depth is found in agro-ecological region IIa and IIb, which receive more than 1000 mm of annual rainfall. Groundwater is a reliable source of freshwater during the drought years and provides 60 – 70 percent of total water consumed in Zambia. Groundwater use in Zambia was not regulated but recently the government issued an executive order to introduce a fee of 25 USD to get a domestic borehole registered. The use of first 10 m^3/day of groundwater from a domestic borehole is free of cost while every additional 30 m^3 is charged at the rate of 0.5 USD. The cost of borehole registration and excessive water use is meant to conserve groundwater in the face of climate change and to reduce contamination.

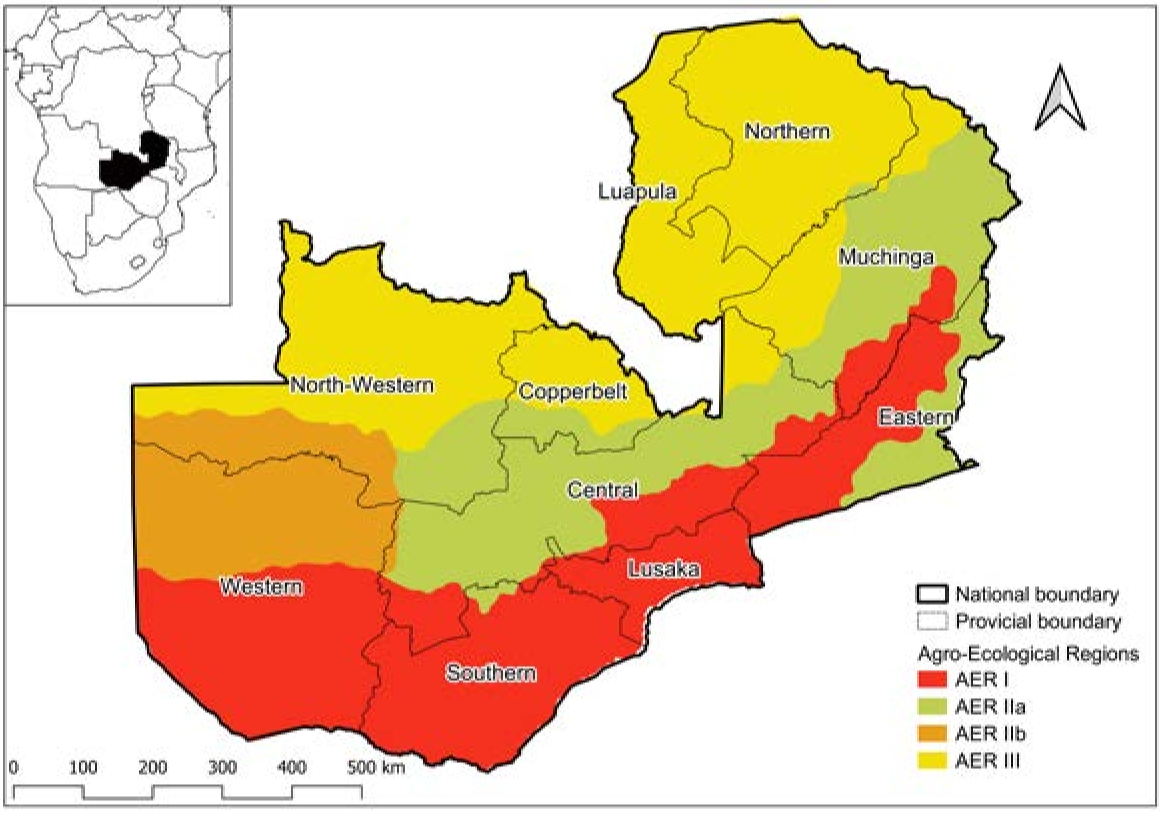
1.1.2 Agro-ecological regions

Zambia can be classified into four agro-ecological regions, based on soil characteristics and rainfall pattern, namely region I, IIa, IIb and III (Figure 2).

Agro-ecological region I makes 12 percent of Zambia's total land area covering the southern, southwestern, and eastern parts of the country. It embraces river valleys and thus has steep plains, with hot and humid climate. This region consists of loamy to clay soils in the valley and coarse to fine loamy soils on the escarpment, while on the western side the soils are shallow. The rainfall in this region is less reliable with less than 800 mm/year, resulting in occasional droughts and significant lowering of groundwater tables that affect water availability for irrigation.

Agro-ecological region II is a plateau that covers 42 percent of the country's land and is subdivided into region IIa and IIb. Region IIa covers the central, southern, and eastern part of Zambia. This region experiences a wet season of 160 to 180 days on average, with a more reliable rainfall pattern (800 to 1 000 mm) and a higher groundwater table as opposed to region I. It consists of fertile, sandy, and loamy soils that are suitable for crop production.

Figure 2: Agro-ecological regions of Zambia



Source: Reproduced by authors from the Government of the Republic of Zambia. 2016b. Second National Rice Development Strategy 2016-2020. Lusaka, Ministry of Agriculture. https://riceforafrica.net /images/stories /PDF /snrds_zambia.pdf

This region has a good potential for irrigation, particularly in the lower Kafue basin and in several dambos of the central province. Region IIb consists mainly of the western plateau, which makes up the Kalahari sand plateau and the Zambezi floodplains. It also receives annual rainfall ranging from 800 to 1 000 mm and has coarse, infertile sands.

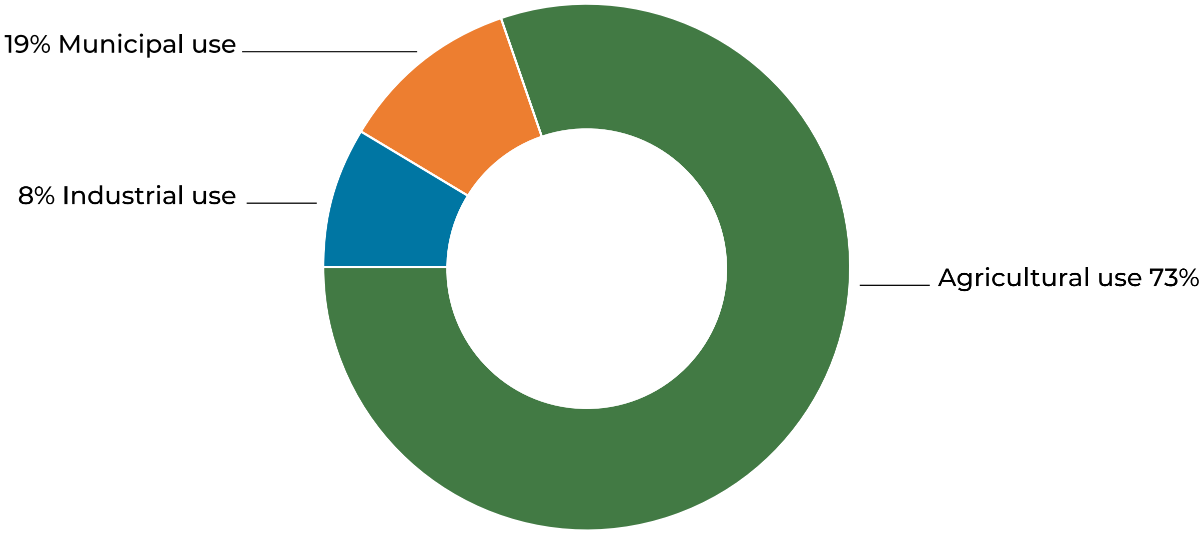
Agro-ecological region III covers the north and northwestern plateau area. It has a wet season for approximately 180 to 190 days on average and receives high annual rainfall ranging between 1 000 mm and 1 500 mm. It constitutes 46 percent of the country's land area, with well-drained acidic soils. The rainfall in this region is reliable, with minimum variability. The dry season is relatively short, and the soil holds enough moisture for crop production. Furthermore, surface water for irrigation is easily available as there are many perennial streams in this region.

1.1.3 Water use for agriculture

In Zambia, the total water withdraw was 1 579.5 million m^3 in 2017, out of which agriculture water use accounted for 1 152 million m^3 (73.2 percent), municipal water use represented 289.2 million m^3 (18.4 percent) and industrial water use accounted for 138.3 million m^3 (8.2 percent) as shown in Figure 3.

The majority of irrigated crops include sugarcane, wheat, tea, coffee, export flowers, soya beans and bananas. Most of the irrigated land lies along the railway line, adjacent to surface water bodies such as rivers and dams, and in dambos and wetlands, and owned by smallholders and emergent farmers. Irrigation is mostly applied through gravity systems (basin and furrow), buckets, low-cost and high-cost drip systems, sprinklers, rain guns and center pivots.

Figure 3: Estimate of water withdrawal by main sectors in Zambia



Source: FAO. 2022. AQUASTAT – FAO's Global Information System on Water and Agriculture. In: FAO. Rome. Cited 24 August 2022. www.fao.org/aquastat/en

The water use in paddy fields in Zambia has not been documented. In the country, the majority of rice is grown under either rainfed upland or lowland conditions, or under uncontrolled flood irrigation. Very little is grown with controlled irrigation and drainage. Only at Sefula, in Mongu district, the irrigation infrastructure for irrigated rice is functional and the main irrigation application method is controlled flooding. However, even at Sefula irrigation scheme, rice is grown under rainfed conditions.

1.1.4 Agriculture in Zambia

Agriculture is the main source of income and employment for more than 60 percent of the population, especially for women, who constitute 65 percent of the rural population in Zambia. Due to the dependence of large proportion of population, accelerated growth in the sector is thus key to reducing poverty and dependency on the mining sector, while enhancing domestic and national food security. The contribution of the agriculture sector, along with forestry and fishing, to the GDP growth is highly variable and is largely driven by the rainfall pattern. In 2020 its contribution stood at three percent of the country's GDP. The Government acknowledged the fact that agriculture is at the core of poverty reduction strategies in Zambia, but the focus has mainly been on rural areas.

The National Agricultural Investment Plan (2014-2018) of Zambia recognized that despite the stagnant rural poverty, the growth rate of agriculture, fisheries and forestry was robust, at more than 10 percent since 2009, exceeding the minimum growth rate of 6 percent recommended by the Comprehensive Africa Agriculture Development Programme (CAADP). However, over the past decade, Zambia's agricultural growth has been highly volatile. For instance, in 2005 and 2007, the growth rate was negative because of poor rainfall, highlighting the high level of dependency on rainfed agriculture. This volatility can be reduced with wide promotion of irrigated crops such as rice. However, in view of the projected world water demand, increased water use efficiency in irrigation is crucial to sustainably increase agricultural productivity. Although rice is not a staple food in Zambia, it is a major social and economic contributor to employment and income of the rural communities.

In order to contribute to the sustainable management of water resources and increase of agricultural productivity, it is necessary to reinforce national technical capacities and foster water use efficiency and sustainability through irrigation of paddy fields. To this end, this handbook highlights the status of agricultural water use efficiency and the existing policy gaps to improve water use efficiency in paddy fields in Zambia. The handbook also helps to increase the understanding of the status of water use efficiency and water productivity in the country and identify both limits and potentials at national level. Based on its findings, strategies and future investments in Zambia agriculture sector can be developed to ensure that the identified gaps are addressed, thereby contributing to the achievement of Sustainable Development Goal (SDG) 6.

1.1.5 Rice cultivation in Zambia

Rice cultivation is one of the oldest farming practices in Zambia. Although paddy rice production has fluctuated significantly during recent years, it has been increasing since 1970. During the 2016-2017 and 2020-2021 cropping seasons, production levels averaged 41 271 tons while demand averaged 84 271 tons, with a deficit of 43 000 tons mainly met by imports. The increasing gap between production and demand in the country indicates that the dependence on rice as a food crop is growing, and it has the potential to contribute to increased nutrition, income, and employment.

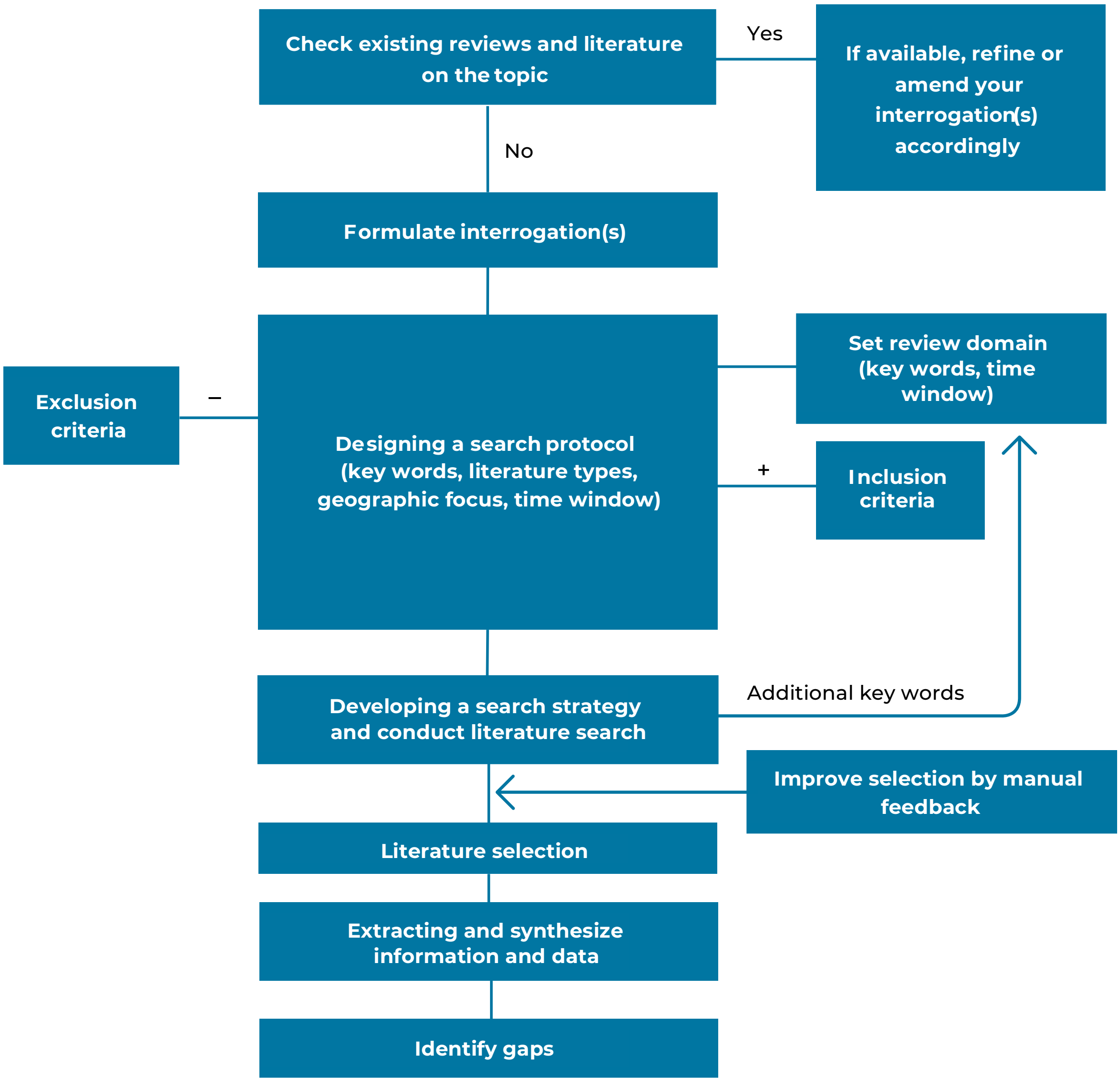
Rice production is largely concentrated in Western, Muchinga, Northern and Luapula provinces (Figure 2), where the abundance of water creates favorable conditions for rice cultivation. The major production ecologies are the flood plains of big rivers and dambos. The effects of climate change, however, pose a serious threat to rice production, both in dambos and in upland areas. In the dambo areas, the greatest challenge faced by the farmers is flooding, which often damages and washes away the rice seedlings. In the uplands, rice production is always challenged by rainfall variability. Dry spells and drought result in water shortages for all crops with a significant production constraint especially where irrigation facilities are not available. The effects of climate change on water resources availability, variability, and crop phenological processes, call for proper water management plans as adaptation measures. Therefore, a comprehensive assessment of agricultural water use efficiency and management in paddy fields is needed to identify gaps in best practices and recommend required measures for efficiency enhancement.

2. Approach

2.1 CONCEPTUAL FRAMEWORK FOR SYSTEMATIC REVIEW

The concept of Systematic Literature Review (SLR) has been used in this assessment to identify, select, and appraise the related literature in order to answer a set of clearly formulated questions. The SLR conceptual framework describes a comprehensive understanding of the available literature within the scope of investigation, develops a protocol for formulating the primary interrogation points, and sets synthesis pathway for screening and appraising the available literature to identify gaps. Figure 4 shows a graphical representation of the conceptual framework used in the assessment.

Figure 4: Conceptual framework of Systematic Literature Review (SLR)



Source: Elaborated from Moher, D., Liberati, A., Tetzlaff, J. Altman, D. G. 2009. Preferred reporting items for systematic reviews and meta analyses: the PRISMA statement. BMJ. 339:b2535. https://doi.org/10.1136/bmj.b2535

2.1.1 Primary interrogation points

Addressing the major areas of the assessment, i.e. constraints and challenges in paddy rice production, the role of natural resource for paddy rice production, potential best practices and policy support for rice production, requires setting the primary interrogation points to examine the status of agriculture water use for paddies rice production in the country. These concluded to be:

1. What are the constraints, challenges, and opportunities for improvement in paddy rice production in Zambia?

2. Which factors could be considered as the driving force for the enhancement of paddy rice production and water use efficiency of paddy rice in Zambia?
3. What are the potential best practices and improved rice production methods for improving water productivity in Zambia?
4. How are the national policies and plans support paddy rice production in Zambia?

2.1.2 Designing a search protocol

The focus of designing a search protocol is to refine the review domain by identifying paddy rice as the target crop and related key words for extended search according to the defined scope of the assessment. Additional filters are applied to define Zambia as the geographical focus of and the year 2000-2020 as the literature search time window in order to screen the large number of potential publications for the most appropriate and relatively recent knowledge and gaps. Moreover, the analysis includes only those publications that had an established relationship between improvement in water productivity/water use efficiency and at least one positive environmental impact. Finally, the characteristics and type of publications have also been considered to include only those publications in the analysis which are based on established scientific methods with certain rigor such as experimental or quasi experimental methods, having well defined geographic identity e.g., public irrigation scheme or part of national strategy or program.

2.1.3 Developing the search strategy

In reference to the developed criteria, the search strategy comprised the following three steps to systematically narrow down the search to the target domain:

1. Firstly, a limited search of the Web of Science, Google Scholar, Science Direct, Wiley Online Library, and online repositories of relevant international, regional and national organizations (e.g., IRRI, FAO, World Bank, African Development Bank, National Agricultural Library at Mount Makulu and the University of Zambia) was conducted. The key words "paddy", "water management", "rice production", "rice productivity", "water productivity", "rice yield" and "paddy irrigation" were employed to identify relevant literature containing the given key words in the title, abstract and subject descriptors.

2. Once key terms and eventual synonyms were identified, an extensive search of the literature was performed on these platforms.

3. Finally, the reference lists and bibliographies of the articles collected from those identified in stage two above were further searched for relevant literature.

Articles published over the last 20 years (2000 – 2020) were searched. Full copies of articles identified by the search, and meeting the inclusion criteria based on their title, abstracts and subject descriptors, were screened for data collection. Articles identified through reference list and bibliographic searches were also considered for data collection based on their titles and abstracts.

2.1.4 Literature assessment and selection

The literature and studies that met the search protocol were grouped as: (a) quantitative studies (i.e., experimental studies, cohort studies and case studies), (b) qualitative studies (i.e., review and interpretive studies and policy document, etc.), and (c) textual or opinion papers. Before the final selection, the methodological validity of these studies was assessed using the comprehensive selection checklist for each type of study.

2.1.5 Data collection and synthesis

Following the assessment of methodological quality and rigor of the publications, quantitative and qualitative data were extracted. Collection of quantitative data was made possible by reported tabular data sets and numerical values in the publications, while descriptive information about rice production in the literature was extracted as qualitative data. The extracted information was synthesized in the context of the developed framework to answer the given interrogation points on the constraints and opportunities in paddy rice production, resource use in rice paddies, and technological adoption for enhanced water productivity and policy support for paddy rice production.

2.2 METHODOLOGY FOR MAPPING OF WATER GOVERNANCE

The mapping of water governance structure in Zambia is based on the methodology developed by FAO in 2014 within the context of the AgWA partnership. The mapping allows the identification of:

- institutions;
- laws and regulations; and
- policies.

2.2.1 Institutional mapping

Institutions and actors are involved in the elaboration and are responsible for the implementation of regulations and laws of a predefined sector of the economy, i.e. natural resources management. They are identified at national, provincial, and local levels and their respective mandates and coverage are mapped using the following dimensions:

- Geographical level: presence and influence at the national, regional, provincial, district or village level.
- Nature of the institutions: public or private, for or not-for-profit, formal or informal.

- Mandate: brief description of the key authorizations entrusted into the institution by law to perform certain duties in order to manage the state resources for the benefit of its public. A mission statement is also a good description of the institution's mandate.
- Functions: key tasks conducted by the institution to fulfil its mandate.

2.2.2 Regulatory and legal mapping

Laws and regulations in the agriculture and water management sectors are identified through a literature review and described using the following dimensions:

- Specific targets: each of the specific objectives that the law or regulation aims at attaining, e. g. promote renewable energy sources or increase transparency in budget management.
- Measures implemented to attain defined targets: these measures may include setting up institutions, mandating participation, devolving, or centralizing responsibilities, etc.

2.2.3 Policy mapping

The policy environment in the agriculture and water sectors of the economy were mapped by identifying all relevant policies (eventually also beyond the single sector to highlight complementarities or overlaps) and describing each of them through the following aspects:

- Specific objectives: each of the specific objectives that the policy or regulation aims at attaining, e. g. economic allocation of water resources or provide sufficient water of good quality to all citizens.
- Measures implemented to attain defined objectives: these can be management, administrative, budgetary, capacity building, and accountability measures.

2.2.4 Gap analysis

The analysis of gaps in the policies and strategies in the agriculture and water sectors were guided by the OECD multi-level governance framework tool. This was used to identify the main multilevel governance challenges in the water sector and the policy instruments that governments use to overcome them. The framework is structured around seven types of gaps, as indicated in Table 3.

Table 3: OECD multi-level governance framework

Gap	Question/Problem	Proposed action / Recommendation
Administrative gap	Geographical "mismatch" between hydrological and administrative boundaries. This can be at the origin of resource and supply gaps	Need for instruments to reach effective size and appropriate scale
Information gap	Asymmetries of information (quantity, quality, type) between different stakeholders involved in water policy, either voluntary or not	Need for instruments for revealing and sharing information
Legal and policy gap	Sectoral fragmentation of water-related tasks across ministries and agencies and/or lack of appropriate regulation	Need for mechanisms to create multidimensional/ systemic approaches, and to exercise political leadership and commitment
Capacity gap	Insufficient scientific, technical, infrastructural capacity of local actors to design and implement water policies (size and quality of infrastructure, etc.) as well as relevant strategies	Need for instruments to build local capacity
Funding gap	Unstable or insufficient revenues undermining effective implementation of water responsibilities at sub-national level, cross sectoral policies, and investments requested	Need for shared financing mechanisms
Objective gap	Different rationales creating obstacles for adopting convergent targets, especially in case of motivational gap (referring to the problems reducing the political will to engage substantially in organizing the water sector)	Need for instruments to align objectives
Accountability gap	Difficulty ensuring the transparency of practices across the different constituencies, mainly due to insufficient users' commitment' lack of concern, awareness and participation	Need for institutional quality instruments
Coordination/ Cooperation gap	Lack of cooperation/coordination among various stakeholders for effective implementation of the policy	Strengthening cooperation among various stakeholders

Source: OECD (Organisation for Economic Co-operation and Development). 2011. Water governance in OECD countries. A multi-level approach. Paris, OECD Publishing. https://doi.org/10.1787/9789264119284-en

A gap is identified when there is a policy need not matched by an appropriate and effective governance response. The gap could take the form, for instance, of partial implementation of existing strategies, lack of law or regulatory provisions, poor coordination among various levels of governance, lack of governmental commitment to a specific action (deemed as necessary by stakeholders). The identification of gaps was carried out through an iterative process that involved desk research, consultation with key sector experts and wider stakeholders' engagement.

3. Review of paddy rice production in Zambia

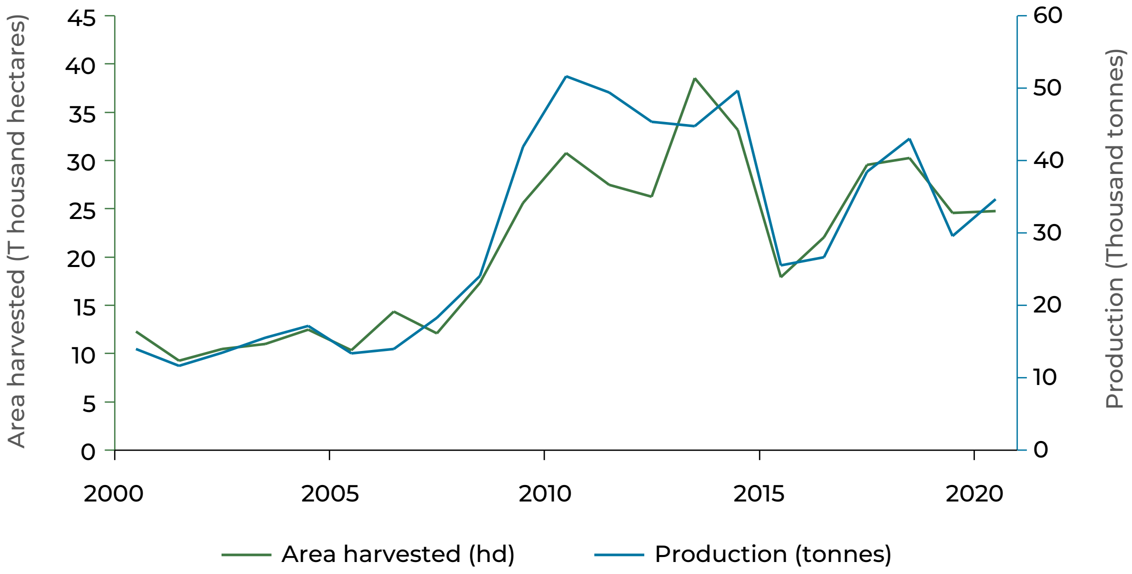
3.1 CONSTRAINTS AND OPPORTUNITIES IN PADDY RICE PRODUCTION

3.1.1 Role of paddy rice in food security

As part of its crop diversification strategy, the government of the Republic of Zambia recognizes rice as one of the strategic crops with the potential to contribute to sustainable agricultural production and food security of the country. In Zambia, rice is the third most important crop in terms of nutritional value, after maize and wheat. It is also considered one of the most profitable cash crops for smallholders, with a high potential to contribute to the increased income and employment of rural populations. This role emerges from its inclusion in the national food balance sheet. At producer level, it is a major source of income in four major producing provinces Northern, Muchinga, Western and Eastern. Rice plays an important role in the domestic food security given that farmers consume 30 to 35 percent of the rice produced domestically, while the balance is traded through different channels, including private trade at farm level.

The government developed the Second National Rice Development Strategy (2016-2020) with the objectives to address the challenges affecting the rice industry and guide the development of the sector in the quest to double rice production within a period of five years. During the first year, this intervention resulted in a moderate increase in rice production and area under cultivation; however, this growth remained volatile due to high rainfall variability (Figure 5), and other factors such as soil constraints, poor water management and low employment opportunity for young population in rice farming.

Figure 5: Trends of area harvested and paddy rice production in Zambia during the period 2000-2020



Source: FAO. 2020. FAOSTAT. In: *FAO*. Rome. Cited 24 August 2022. www.fao.org/faostat/en/#data/QCL

According to FAOSTAT, the Ministry of Agriculture and Zambia Statistics Agency crop forecasting data, Zambia has been producing on average about 38 700 tons of paddy rice per year between the 2010-11 and 2020-21 cropping seasons (Figure 5). During the same periods, paddy rice yield averaged at 1.06 tons/ha, rather low compared to other Eastern and Southern African countries with average yield between 1.5 and 2.5 ton/ha. Low yields are mainly attributed to uncontrolled irrigation, poor water management, unavailability of high yielding varieties and poor farm practices. The area under rice production averaged 36 185 ha, with 46 percent in Western, 32 percent in Northern, 13 percent in Muchinga, and less than 10 percent in other provinces. The crop is mostly grown by small-scale farmers, but the production of final commodity involves local trading and numerous processing, which makes it ideally suited to contribute to improved food security, poverty reduction and wealth creation.

3.1.2 Climate change impacts constraint rice production

Zambia has been experiencing high temperature and more frequent and intense droughts, dry spells, floods, and flash floods that have resulted in high incidences of crop failure, crop pests and diseases, increased water stress and reduced crop yields. The frequency and intensity of climate events are expected to rise in the future with negative socio-economic impacts on communities. Climate change related losses in agriculture are estimated between 2.2 and 3.1 billion USD over the next 10 to 20 years.

Adaptive measures in agriculture include improvement of early warning systems; promotion of crop insurance; introduction of climate-reliant varieties; promotion of alternative sources of livelihoods; and promotion of climate-smart agricultural technologies and practices. Farmers are aware of climate change, and they are adapting their farming practices through, for instance, the use of improved crop varieties instead of the traditional ones; introduction of new drought tolerant crops and varieties, so far less common; shifting to shorter cycle crop varieties, around three months from planting to harvesting. However, the adoption of climate-smart agriculture technologies and practices among small-scale farmers are still low.

3.2 DRIVING FORCES FOR ENHANCING PADDY RICE PRODUCTION

3.2.1 Land resources for rice paddies

According to water availability and soil suitability for agriculture, FAO estimates that Zambia's irrigation potential is 2.75 million ha. Out of this potential, it is estimated that 523 000 ha could be developed. Less than 20 percent of this land is highly or moderately suitable for rainfed rice cultivation and the country has almost reached this potential limit. In 2018, total irrigated land was estimated at 258 000 ha, according to the water permits issued by the Water Resources Management Authority (WARMA).

The major rice production ecologies in Zambia are the large flood plains like the Chambeshi River and dambos located in agro-ecological region II and III (Figure 2). These areas have abundant water resources with annual rainfall of 1 000 to 1 500 mm, and a favorable climatic condition for rice cultivation, with mean annual evapotranspiration of 1 600 mm. Specifically, there are three ecologies suitable for rice production: the rain-fed lowland and flood plains, the rain-fed upland, and the irrigated areas. Almost all the paddy rice in Zambia is grown in rainfed lowlands. The country has 20 percent of the total land suitable for rainfed rice cultivation. A very small amount of paddy rice is grown in rainfed uplands, where the rainfall is highly variable, the freely draining soils and steep slopes in uphill further restrict rainfed rice cultivation. Control irrigation schemes are very few in Zambia and they are mostly reserved to other cash crops like fruits, vegetable, and coffee. Despite large irrigation potential, there is a strong need to quantify exactly the spatial land suitability for paddy rice under irrigation regime. Even with abundance of water resources, rice production ecologies are vulnerable to seasonal and spatial variability of rainfall. Given the insufficient number of controlled irrigation infrastructures, floods and droughts can be rather frequent and negatively affect rice production.

3.2.2 Irrigation development

Zambia has an irrigation development potential of 523 000 hectares of land, but less than 200 000 hectares, mostly owned by small-scale and commercial farmers, are actually irrigated. Irrigation development is a key strategy to increase crop diversification, production, and productivity especially, for rice. Irrigation expansion in Zambia started in 1964, when the government supported the first irrigation development project at Mazabuka and developed 120 hectares of land. The intervention marked a huge success in the sugarcane production and the irrigation schemes now spans over 30 000 hectares. In addition, two large irrigation schemes for wheat cultivation, with a gross area of 3 500 hectares were also established in the Ndola region during 1980s.

Irrigation methods in the country depend on the scale of production. Generally, small-scale farmers use more traditional methods ranging from simple buckets, manual pumps, dambo recession water and gravity fed flood irrigation. Large-scale farmers, on the other hand, use ridge and furrow, border strip, pressurized center pivot, sprinklers, and drip irrigation methods. The traditional cultivation methods with flood irrigation are characterized by low productivity and water use efficiency.

For the promotion of small-scale community-based irrigation systems and small dams, the government implemented the 2004 National Irrigation Policy and established a "Project Division" with the mandate to construct these schemes. By 2014, the total area under irrigation in the country stood at 156 000 hectares, mostly under small-scale irrigation. The pace of irrigation development, however, has been stagnating for the last two decades.

Lowland ecologies are widely found in the country, whereby rice cultivation takes place on flood plains and dambos. In the latter case, rainwater is received through uncontrolled rainfall-runoff to flood irrigate the fields. Paddy rice production in Zambia is predominantly rainfed. However, the government in the recent past developed the Sefula and Chanyanya rice irrigation schemes, of 200 and 120 hectares, respectively, through the Japan International Cooperation Agency (JICA) assistance for irrigated rice production. Despite a considerable investment of seven million USD for the development of these irrigation-related infrastructures, only rainfed rice is grown in such schemes because of the absence of irrigated rice varieties and inadequate capacity of farmers and institutions to practice irrigated rice cultivation.

The Ministry of Agriculture, through its Crops Production Branch, is responsible for providing technical guidance on crop production to smallholder farmers (including on rice), while the Technical Services Branch is responsible for the technical aspect of irrigation and water management, such as dam design, construction, and rehabilitation as well as technical advice in setting up the irrigation systems. In addition, the private sector and NGOs play important roles in community mobilization for irrigation. The operation and maintenance of any irrigation scheme is the responsibility of the community, while the Ministry of Agriculture facilitates and offers extension services to the farming community.

3.2.3 Crop water productivity and water use efficiency of paddies

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. Similarly, the volume of water supplied also depends on the evaporative demand, performance of irrigation system, mineral fertilization, planting density and date, and crop protection measures. All of these are important factors for optimizing CWP.

Water use efficiency is the ratio between the volume of water used to irrigate the crop effectively 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 lost through evaporation, seepage of irrigation canals, overtopping, leakage, non-beneficial uses by weeds and bushes, and deteriorated irrigation infrastructure.

Approximately 77 percent of fresh water in Zambia is used for irrigated agriculture. Although highly inefficient, flood irrigation is the most widely used type of irrigation among smallholder farmers. Given the water shortages experienced in certain areas, particularly during the dry season, this issue has been a raising concern. The Water Resources Management Authority (WARMA) has been instrumental in advocating for improved water management and higher consideration of water use and allocation equity issues when making decisions on water rights. In addition, the National Water Supply and Sanitation Council (NWASCO) monitors the performance and water efficiency levels of the water utilities. Generally, water reuse, rainwater harvesting, and storage for irrigation are not widely practiced in the country. As a result, in spite of sufficient water availability, the persistent seasonal variation and the effects of climate change have devastating effects on the agriculture sector. For rice production, most farmers still use the traditional methods of production, such as manual and low-mechanized cultivation, uncontrolled flood irrigation, unleveled fields, broadcasting of seed, reuse of low-yielding traditional varieties, limited fertilizer application and weed infestation of paddy fields. Ultimately, poor water management practices adversely affect water productivity and water use efficiency, crop yield, and quality of the crop.

3.3 BEST PRACTICES FOR ENHANCED WATER PRODUCTIVITY IN PADDY FIELDS

3.3.1 Alternate Wetting and Drying (AWD)

Despite being a staple food for more than half of the world population, rice paddies represent a serious concern due to their greenhouse gas emission. Globally, about 30 and 11 percent of agriculture methane and nitrous oxide are emitted from rice paddies due to enhanced microbial activity under flooded condition. The employment of sustainable rice production practices not only contribute to controlling greenhouse gas emission, but they also improve water productivity of paddy fields. Growing rice in waterlogged soil or continuously flooded paddies, for instance, is ideal for microbes to produce large quantities of greenhouse gas. Farming practices should thus be improved in order to decrease methane emissions while reducing the amount of water consumed during the growing season.

Alternate Wetting and Drying (AWD) is a practice that allows the water table to drop below soil surface before re-flooding. When AWD is applied, fields are drained up to a depth of 15 cm of topsoil. The following irrigation dosage only occurs once water drops below the 15 cm level, as monitored via a perforated tube inserted into the soil. AWD is a method to manage irrigation so that water is not wasted but it aids the root growth, facilitates higher nutrient uptake, and increases land and water productivity.

Such practice is neither common nor practiced in paddy fields in Zambia, and it requires not only promotion among the predominantly small-scale rice farmers but also demands infrastructure for on-farm water management. In Zambia, paddy fields are freely flooded by rainwater without any control of runoff. Paddy fields thus need to incorporate off-farm and on-farm water management and drainage infrastructure, such as those developed at Sefula and Chanyanya irrigation schemes to facilitate AWD.

3.3.2 Dry seeding for improving water use efficiency and water productivity

Water use efficiency of rice may be improved through reducing large amounts of water loss during the cropping season and using rainwater more efficiently. In addition to AWD, dry-seeded rice technology offers a significant opportunity for conserving irrigation water by using rainfall more effectively. Weed infestation in dry seeded rice, however, is a serious issue and should appropriately be addressed. Another best practice is the aerobic rice cultivation approach, which reduces water input during the crop establishment period. Accordingly, rice is grown like an upland crop, e.g. wheat or maize, without puddling the field. Aerobic cultivation along with the application of nitrogen fertilizer increases grain yield through increased biomass and grain number.

3.3.3 Crop rotation to minimize water use

Water productivity largely varies according to the type of crops, varieties of the same crop, irrigation management, soil and weather conditions, and cultivation methods, such as intercrop or sole crop systems. The basis for intercropping involves complementarity of resource-use by the two crops and increased competition against weeds. Specific cases reported that intercropping rice with beans resulted in more than 33 percent increase in crop yield, with 65 percent reduction in weed infestation and an overall 57 percent increase in farmers' income.

3.3.4 Best agronomic practices

Increased rice production and productivity in African countries is hinged on the use of appropriate agronomic practices to maximize rice yield. Increase in total rice production could be attributed to the following main driving forces in the sub-Saharan Africa:

- Increase in cultivated area
- Mechanized cultivation of rice
- Improved crop inputs
- Improved rice varieties, especially developed for the African environment
- Commercialization of rice market

3.3.5 Row planting

Row planting is recommended as it gives optimum plant population and facilitates mechanized cultural practices, e.g. weeding, fertilizer application, harvesting, etc. In Zambia, broadcasting of rice seed is widely practiced, resulting in low plant population and making it difficult to weed the fields. Water productivity and yield increase is often associated with enhanced weeding frequency as weeds compete with the main crop for the available nutrients and irrigation water. Row planting methods are recommended in both direct seeded and transplanting, as they also facilitate the identification and quantification of un-germinated seeds and dead plant nursery.

3.3.6 Transplanting vs direct seeding

Another factor which has an important influences on water productivity is the adoption of transplanting, against direct seeding methods of crop establishment. In Zambia, direct seeding is widely used because it is simple and less labour demanding, compared to transplanting. Transplanting requires 25-50 persons per day by hectare, whereas direct seeding requires only about 5, at the most. Transplanting has several effects on water use in rice cultivation. Firstly, it reduces water use during early stage of crop growth. Furthermore, farmers can do land preparation while the seedlings are still in the seedbed. On the other hand, direct seeding increases the duration of crop growth in the field, leading to increased water use during the crop growth period. Amarasingha et al. (2017) reported that transplanting reduced water input because of substantial water savings during land preparation. However, since rice seeds fail to germinate in standing water, the best solution would be transplanting. Therefore, field observation is essential at time of planting.

3.3.7 Use of quality rice seed

Rice is a self-pollinated crop and harvested grain of high quality can be utilized as seed in the following season. Use of quality rice seed to maximize yield and to maintain quality of the harvest is encouraged. In Zambia, supplying rice seed to farmers at an affordable price at the correct time is becoming increasingly difficult, largely due to perceived low financial gain by seed companies in production of rice seed. Being self-pollinated, farmers easily reserve rice seed from one harvest to the next. Therefore, self-seeded rice production is encouraged, and farmers are supplied with mini kits of seed and new cultivars for multiplication. Private sector participation in the seed industry is also encouraged by the government.

3.3.8 Collective and timely cultivation

Timely cultivation with the onset of rains is essential to economize on the use of inputs and to maximize the use of water resources. Delayed planting affects the growth and the age of the rice crop. Farmers are encouraged to follow a uniform cultivation calendar, without any overlapping of different growth stages in a given tract. This helps integrating crop management practices on a tract basis and reduce the time spent on maintaining individual crops. Furthermore, it makes the job of extension and related supporting services easier, as well as organizing marketing and other activities properly.

3.3.9 Soil fertility improvement and sustenance

Improvement of the soil physical, chemical, and biological properties for its sustainability should be the key feature of any farming practice. The use of improper equipment for ploughing could lead to the formation of a shallow hardpan and result in poor drainage, plant growth and grain yield. The topsoil is often coarse-textured and therefore the addition of organic matter, especially rice straw or farmyard manure, and ploughing occasionally to a depth of about 20-25 cm is considered advantageous for the majority of the rice lands.

3.4 POLICY SUPPORT FOR PADDY RICE PRODUCTION

The government of Zambia developed the Second National Rice Development Strategy (SNRDS 2016-2020) to address the challenges affecting the rice industry and the increased emphasis put on the rice sub-sector in the national crop diversification strategy. The SNRDS was intended to guide the rice sector development during the period 2016-2020 and was fully aligned with the national and regional development plans and programmes, such as the Zambia Vision 2030, the Revised Sixth National Development Plan (R-SNDP), the Second National Agricultural Policy (S-NAP), the National Agricultural Investment Plan (NAIP) and the Comprehensive Africa Agriculture Development Programme (CAADP). The objectives of the strategy were to increase local rice production by 50 percent, expand the area under rice cultivation by 20 percent, and strengthen its competitiveness in the local market by 2020. These objectives aimed to contribute to the increase of sustainable crop production, productivity and value addition for a diversified range of competitive crops apart from maize. However, during the implementation period, production and productivity remained volatile. Some of the main reasons behind this drawback included the rainfall variation, poor farming and water management practices, floods in the lowlands, low adoption of mechanization, unavailability of improved seed varieties, and inadequate human and institutional capacity in rice cultivation and the implementation of the strategy. To overcome such a situation, one of the strategic interventions planned related to the investment in irrigation and water control technologies, along with capacity building of the relevant stakeholders. Through various projects, the Government is currently increasing its support to the development of irrigation infrastructure for enhanced crop production. However, there is limited support for specialized irrigation infrastructure for rice production in the country.

4. Mapping of water governance structure in Zambia

4.1 INSTITUTIONAL MAPPING

The water sector in Zambia involves many different institutions and authorities at various levels of policy formulation, implementation, and regulation. The Ministry of Water Development and Sanitation (MWDS) has the overall responsibility for water resources management and development. The MWDS plays its role in consultation with other stakeholders and institutions, directly or indirectly involved in water management. These institutions ensure that water resources management and development measures are integrated into respective sector policies and plans.

The Ministry of Local Government and Rural Development (MLGRD) through the local authorities and commercial utilities, is responsible for water supply and sanitation delivery services. The Ministry of Agriculture (MoA) is responsible for agriculture policy including irrigation development. All land allocations for any development purposes, fall under the responsibility of the Ministry of Lands and Natural Resources (MLNR), which is also responsible for issuing title deeds to ensure the sustainable management of natural resources.

The Water Resources Management Authority (WARMA) which is under the oversight of the Ministry of Water Development and Sanitation, was established to manage general access to water resources, including agriculture water, and provides guidance on water rights. WARMA preserves and protects Zambia's surface and groundwater resources and regulates their abstraction, allocation, use, development, and management in a sustainable manner. The Zambia Environmental Management Agency (ZEMA), which is under the Ministry of Green Economy and Environment, is responsible for the sustainable use and management of natural resources, protection of the environment, prevention, and control of pollution.

Irrigation Water User Associations (IWUAs) or Farmer Groups (FGs) are the responsible bodies once the public irrigation infrastructure is developed. Before land titles and water rights are transferred to the WUAs and FGs, the beneficiary farmers are trained in the management of the water resources within their agricultural settlement scheme and the irrigation infrastructure, and the land within the scheme is distributed to farmers on tenure basis.

Private sector entities operate in several fields related to the crop and rice value chain, while academic and research institutions study and carry out the development of water management as well as rice value chain. Non-Government Organizations (NGOs) and community-based organizations, finally, play an important role in community mobilization for irrigation and crop production in general.

At international and regional levels, organizations such as the African Union (AU) and the Southern African Development Community (SADC) provide guidelines for agricultural development and management of water resources for agriculture and other uses. Furthermore, a number of cooperating partners provide finance and technical support in the development of water for irrigation crops and rice value chain development.

The key actors involved in agricultural water management in Zambia are detailed in Table 4. The table provides a synopsis of all institutions involved in policy, regulation, distribution, and administration roles. The table also provides information on the mandate of each institution as well as its key functions.

Table 4: Institutions' mapping

Institution/Actor	Geographical level	Mandate	Functions
Ministry of Agriculture (MoA)	National, provincial, district and camp levels	To facilitate the development of a sustainable and diversified agricultural sector for enhanced income generation, and food and nutrition security	• Develop and implement policies, strategies, plans and projects for irrigation development. • Provide services to farming enterprises in irrigation, agronomy, catchment hydrology, civil engineering support and conduct water-resource assessments.
Ministry of Fisheries and Livestock (MFL)	National, provincial, district and camp levels	Apart from the portfolio functions, the ministry is responsible for several fisheries and livestock related development and training institutes and is mandated under the law to ensure implementation of the agriculture-related legislation	• Facilitate and support the development of water resources for sustainable, diversified, and competitive fisheries and livestock for food and nutrition security.
Ministry of Water Development and Sanitation (MWDS)	National, province and districts	Responsible for water policies, water resources management and development, water supply and sanitation	• Formulate and monitor policies, legislation, programmes and action plans on water development and management • Facilitate the development and rehabilitation of water resources (small and large dams), water supply and sanitation
Ministry of Green Economy and Environment (MGEE)	National, province and districts	Responsible for climate change and environmental policies, environmental protection and pollution control, green economy and industrial policy and meteorological services	• Formulate and monitor policies, legislation, programmes and action plans on environmental protection and climate change
Ministry of Lands and Natural Resources (MLNR)	National, province and district	To administer land and manage natural resources for sustainable land use and climate resilient low emission systems	• Formulate and coordinate implementation of land and natural resources policies, legislation, programmes and projects. • Coordinates climate change programmes and undertakes natural resources research and training.

Institution/Actor	Geographical level	Mandate	Functions
Ministry of Local Government and Rural Development (MLGRD)	National, province and district	To promote a decentralized and good local governance system, facilitating delivery of quality municipal services	• Oversee the implementation of delegated functions and responsibilities by the local authorities.
Water Resources Management Authority (WARMA)	National	Established in 2011 through the Water Resources Management Act of Parliament to regulate, manage, develop, protect, and conserve water resources for all users	• Carry out the identification and protection of potential sources of freshwater supply. • Ensure the conservation, preservation, and protection of the environment, in particular, wetland, quarries, dambos, marshlands and headwaters considering climate change. • Plan and promote the sustainable and rational utilization, management and development of water resources based on community and public needs and priorities, within the framework of national economic development policies. • Provide access to water resources of acceptable quantity and quality for various purposes.

Institution/Actor	Geographical level	Mandate	Functions
Zambia Environmental Management Agency (ZEMA)	National and regional	Established through the Environmental Management Act of Parliament in 2011 to "ensure sustainable management of natural resources, protection of the environment and prevention and control of pollution"	• Advise government and the private sector on environmental management and pollution control matters. • Develop standards and guidelines related to the protection of air, water, land and other natural resources and the prevention and control of pollution, discharge of waste and the control of toxic substances. • Initiate, conduct, and promote research, surveys, studies, training, and investigations in environmental management. • Review environmental impact assessment reports and strategic environmental assessment reports.
Cooperating partners (e.g. FAO, EU, World Bank, JICA, AfDB, IFAD and AGRA)	National	To support agricultural development	• Provide technical and financial support to water and rice-related programmes and projects. • Provide guidelines on agricultural water management.
NGOs and community-based organizations	National provincial and district	To support food security and poverty reduction interventions	• Operate in several fields related to rice production and agricultural water management. • Supporting farmers' mobilization.
Zambia rice federation	National, provincial and district	To coordinate stakeholders in the rice value chain	• Advocate for policy reforms in the rice value chain.
Private sector (including farmers)	National, provincial and district	To support agricultural development	• Operate (investment) in several fields related to rice. • Utilize water resources for agriculture production.
Research and academic institutions, e.g. University of Zambia (UNZA), Copperbelt University (CBU)	National, provincial level	To develop capacities and knowledge through training, research, and consultancy services	• Facilitate research and development

Institution/Actor	Geographical level	Mandate	Functions
Coalition for African Rice Development (CARD)	Regional	To raise awareness on policy coordination and share knowledge on management for rice production	• Harmonize and coordinate policies and actions between CARD and African rice producing countries. • Advocate and mobilize resources. • Facilitate human and institutional capacity strengthening. • Manage information and knowledge sharing and dissemination of technologies.
Water Users Associations (WUAs)	District and community level	To ensure equitable and efficient water resources management	• Take part in different activities of implementation and management of water resources, including irrigation.
Southern African Development Community (SADC)	Regional	Strategic planning and management of SADC through sectoral and administrative roles	• Formulate regional water policies and strategies.
African Union (AU)	Continental	To promote the unity and solidarity of the African States To coordinate and intensify their cooperation and efforts to achieve a better life for the people of Africa To defend their sovereignty, their territorial integrity and independence To eradicate all forms of colonialism from Africa To promote international cooperation, having due regard to the charter of the United Nations and the universal declaration of human rights	• Coordinate and harmonize policies between the existing and future regional economic communities. • Promote research in all fields, particularly in science and technology.

The governance of water sector in Zambia is considerably decentralized in its policy and administrative dimensions, whereby many institutions operate from national to district level. The institutions' mandate and geographical level are presented in Table 5.

Table 5: Institutions' mandates and geographical level

Geographical level	Policy	Administration	Regulation
National	MoA, MFL, MWDS, MGEE, MLNR, MLGRD	MoA, MWDS	WARMA, ZEMA
Provincial	MoA, MFL, MWDS, MGEE, MLNR, MLGRD	MoA, MWDS	
District	MoA, MFL, MGEE, MWDS, MLGRD	MoA, MWDS	
Regional	SADC, African Union		

4.2 MAPPING OF LAWS AND REGULATIONS

The water sector is regulated by various legislative provisions. The primary legislation prescribing the development and management of water resources in Zambia is the 2011 Water Resources Management Act, 2011. The Act provides for the planning, management and development of water resource, to be undertaken in an integrated, sustainable and efficient manner while taking into account climate change adaptation measures. The 2011 Environmental Management Act is the principal environmental law in Zambia. It also supports the preparation of the environmental report, environmental management strategies and other plans for environmental management and sustainable development. The 2019 Local Government Act establishes and maintains farms and allotment gardens and indicates measures for the conservation of natural resources and the prevention of soil erosion, including the control of cultivation. The 1986 Zambezi River Authority Act supports the management of the water resources in the Zambezi River mainly for shared power generation at Kariba between Zambia and Zimbabwe. It also formulates proposals for the abstraction of water from Kariba dam or any other dam that may be constructed on the Zambezi River for irrigation or other purposes. At SADC level, a revised protocol on shared watercourses is in place to promote the harmonization and monitoring of legislation and policies for planning, development, conservation, protection, and allocation of shared watercourses.

The key laws and regulations in the agriculture and water sectors are presented in Table 6.

Table 6: Laws and regulations in the agriculture and water sectors

Primary legislation	Specific targets	Measures to attain targets	Responsible institution
The water act chapter 198, 1949	Consolidate and amend the reference law with respect to the control, ownership, and use of water. Govern the regime of water rights for primary, secondary, and tertiary purposes and for mining, railway, and urban purposes. Establish the water board for the administration of water rights and further contain provisions on applications of water rights, easements, mandate of the Minister, and miscellaneous provisions.	Ownership of all water is vested in the President. Landowners have the right to take free of charge the water flowing across their land.	Ministry of Legal Affairs
Water Resources Management Act, 2011	Establish the water resources management authority. Provide support in the management, development, conservation, protection and preservation of water resources and its ecosystems. Ensure equitable, reasonable, and sustainable utilization of the water resource. Ensure the right to draw or take water for domestic and non-commercial purposes, and that the poor and vulnerable members of society have an adequate and sustainable source of water free from any charges. Create an enabling environment for adaptation to climate change. Support the constitution, function and composition of catchment councils, sub-catchment councils and water user associations. Provide support for international and regional cooperation in, and equitable and sustainable utilization of, shared water resources. Provide support for the domestication and implementation of the basic principles and rules of international law relating to the environment and shared water resources as specified in the treaties, conventions and agreements to which Zambia is a state party. Repeal and replace the 1949 Water Act.	Water resources shall be managed in an integrated and sustainable manner. Water resources shall be used efficiently, sustainably, and beneficially in the public interest. The management, development and utilization of water resources shall take into account climate change adaptation.	Ministry of Water Development, Sanitation and Environmental Protection

Primary legislation	Specific targets	Measures to attain targets	Responsible institution
Environmental Management Act, 2011	Provide support for continued existence of the environmental council, renamed "Zambia Environmental Management Agency (ZEMA)". Ensure integrated environmental management, protection and conservation. Sustainable management and use of natural resources. Support in the preparation of the state of the environment report, environmental management strategies and other plans for environmental management and sustainable development. Provide support to conduct strategic environmental assessments of proposed policies, plans and programmes likely to have an impact on degradation of environment. Ensure public participation in environment related decision-making and access to environmental information. Support the establishment of the environmental fund. Ensure support for environmental audit and monitoring. Facilitate the implementation of international environmental agreement and conventions to which Zambia is a party. Repeal and replace the 1990 environmental protection and pollution control Act.	Development of sector-specific environmental management strategies and application of strategic environmental assessment of legislation, policies, plans and programmes that may be determined to have an impact on the environment across all sectors of national development.	Ministry of Water Development, Sanitation and Environmental Protection, Zambia Environmental Management Agency

Primary legislation	Specific targets	Measures to attain targets	Responsible institution
Local Government Act, 2019	Provide support to an integrated local government system. Implement the decentralization of functions, responsibilities and services at all levels of local government. Ensure democratic participation in, and control of, decision making by the people at the local level. Revise the functions of local authorities. Conduct the review of tariffs, charges and fees within the area of a local authority. Support the proceedings of the council and committees. Constitute the role of traditional leadership in democratic governance. Repeal and replace the 1991 Local Government Act.	Establishment and conservation of farms and allotment gardens. Provision of measures for the conservation of natural resources and prevention of soil erosion, including the control of cultivation.	Ministry of Local Government
Zambezi River Authority Act, 1987	Provide support for the management and utilization of the Zambezi River between Zambia and Zimbabwe for economic, industrial and social developments.	Evaluate proposals for the abstraction of water from the Kariba dam or any other dam that may be constructed along the Zambezi River for irrigation or other purposes.	Zambezi River Authority
Revised protocol on shared watercourses in the Southern Africa Development Community, 2000	Foster closer cooperation among Member States for protection, management, and use of shared watercourses in the region.	Promote and facilitate the establishment of shared watercourse agreements and institutions for the management of shared watercourses Advance the sustainable, equitable and reasonable utilization of shared water course Promote the harmonization and monitoring of legislation and policies for planning, development, conservation, protection and allocation of shared watercourses. Promote research and technology development, information exchange, capacity building, and the application of appropriate technologies in shared watercourses.	Southern African Development Community (SADC)

4.3 MAPPING OF POLICIES AND STRATEGIES

The key policies and plans on agriculture and water management are presented in Table 7.

Table 7: Policy regulations, plans and strategies

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
Vision 2030 (2006)	An efficient, competitive, sustainable and export-oriented agriculture sector that assures food security and increased income by 2030	Increase agricultural productivity and land under cultivation by 2030. Increase exports of agricultural and agro-processed products by 2030. Preserve the agricultural resource base by 2030. Increase land under cultivation to 900 00 hectares by 2030. Increase land under irrigation to 400 000 hectares by 2030.	Increased agricultural productivity and production; export-oriented agricultural sector; conservation of agricultural resource base; mechanization and irrigation development as key results areas of the agriculture sector in Zambia. In 2018, land under irrigation was estimated at 258 000 hectares. Area planted to 13 major crops was 2 678 826 hectares.	Ministry of Agriculture
	Clean and safe water supply and sanitation for all by 2030	Fully integrated and sustainable water resource management.	The country has adapted an integrated and sustainable approach to management of water resources.	Ministry of Water Development and Sanitation ZEMA

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
Second National Agricultural Policy (2016))	Increase agricultural production and productivity	Promote investment in appropriate, affordable and cost-effective irrigation technologies and infrastructure suitable for different agro-ecological regions. Promote the efficient use of available water resources for irrigation. Promote high value irrigable crops among small and medium scale farmers. Improve the management of smallholder irrigation schemes. Promote the establishment of irrigation schemes especially for smallholder farmers.	All measures are being implemented.	Ministry of Agriculture Ministry of Fisheries and Livestock
	Promote the sustainable management and use of natural resources	Develop and promote rain water harvesting, storage and management of infrastructure.		
	Mainstream environment and climate change in the agriculture sector	Promote and strengthen climate change resilient agricultural production methods. Promote awareness on climate change adaptation.		

Policy/ strategy (year)	**Specific targets (each of the specific objectives that the policy or regulation aims at attaining)**	**Measures to attain the objectives**	**Progress made against each policy/ strategy**	**Responsible institution**
National Water Policy (1994)	Promote sustainable water resources development with a view to facilitating an equitable provision of adequate quantity and quality of water for all competing users at acceptable costs and ensuring security of supply under varying conditions	Promote an integrated management approach for water resources. Water is considered fit for irrigation if it does not cause soil degradation, enhances high crop yield and profitability and ensures sustainability of production.		Ministry of Energy and Water Development
National Water Policy (2010)	Manage and develop water resources to support the development of a sustainable and well-regulated agricultural sector which will ensure food security and income generation at household and national levels and maximize the sector's contribution to gross domestic product	Develop and manage water resources to support the agricultural sector, particularly irrigation. Support the development of the agricultural sector through the establishment of a fair, efficient and transparent water allocation system. Facilitate conservation of national water resources through dissemination and awareness on sustainable water and soil conservation measures. Collect, process, and disseminate information on water resources to facilitate development of agriculture.	All measures are being implemented and the policy provided a comprehensive framework for sustainable development, management, and use of water resources	Ministry of Water Development, Sanitation and Environmental Protection

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
National Policy on Environment (2007)	Promote environmentally sound agricultural development by ensuring sustainable crop and livestock production through ecologically appropriate production and management techniques, and appropriate legal and institutional framework for sustainable environmental management	Prevent or minimize the environmental impact of cultivation and other developments on marginal lands (steep slopes, 'dambos', swamps and areas vulnerable to flooding) through improved cultivation and agricultural production. Promote research into appropriate and sustainable soil and water conservation techniques.	All measures are being promoted	Ministry of Tourism, Environment and Natural Resources
National Policy on Climate Change (2016)	Promote and strengthen the implementation of adaptation and disaster risk reduction measures to reduce vulnerability to climate variability and change	Promote the adoption of appropriate Climate Smart Agriculture (CSA) technologies for different agro-ecological zones, including lower water use irrigation systems. Promote the protection of water catchment areas, including the development of environmentally friendly infrastructure for bulk water transfer (water ways), storage, management and utilization of water resources.	All measures are being promoted	Ministry of National Development Planning Ministry of Lands and Natural Resources
Irrigation Policy and Strategy (2004)	Increase the productivity of rainwater through water harvesting Promote sustainable utilization of dambos	Demonstrate and disseminate appropriate water harvesting technologies. Demonstrate options for sustainable high value dambo production models.	All measures are being promoted	Ministry of Agriculture

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
Seventh National Development Plan 2017-2021 (2017)	A diversified and export-oriented agriculture sector	Improve production and productivity. The strategy includes programmes such as irrigation development and productivity-enhancing technology development.	All measures are being promoted	Ministry of Agriculture
	Improved water resources development and management	Enhance rainwater harvesting and catchment protection. Promote local and transboundary aquifer management. Promote inter-basin/ catchment water transfer schemes	All measures are being promoted	Ministry of Water Development, Sanitation and Environmental Protection
Ministry of Water Development, Sanitation and Environmental Protection 2018-2021 Strategic Plan (2018)	Increase national water security to ensure water resource availability for various socio-economic uses, including agriculture	Improve knowledge on water harvesting. Improve water harvesting facilities. Develop climate smart water harvesting technologies.	All measures are being promoted	Ministry of Water Development, Sanitation and Environmental Protection
Ministry of Agriculture Strategic Plan 2019-2021	Improve agricultural development services Enhance partnerships in agricultural development	Enhance promotion of irrigation development. Promote climate smart agriculture technologies and practices. Develop climate change resilient technologies and practices.	All measures are being promoted	Ministry of Agriculture

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
Integrated Water Resources Management and Water Efficiency 2007-2030 (2008)	To achieve equitable use, development and management of water resources for wealth creation, socio-economic development and environmental sustainability by 2030	Integrated management of water resources in the catchment areas. Improve water resources planning and management. Improve water use and allocation and efficiency. Develop water infrastructure to harness the country's water resources in a sustainable manner and make it available in the required quantity and quality to enhance its utilization for economic growth.	All measures are being promoted	Ministry of Water Development, Sanitation and Environmental Protection
National Agriculture Investment Plan (NAIP) 2014-2018 (2013)	Sustainable natural resources management	Increase availability of water for multi-purpose use. Ensure efficient water-use and irrigation.	All measures were promoted, and evaluation is ongoing to assess its results	Ministry of Agriculture Ministry of Fisheries and Livestock
Second National Rice Development Strategy (SNRDS, 2016-2020) (2016)	Investment in irrigation and water control technologies	Rehabilitation and construction of irrigation structures. Improving water management skills among farmers. Construction of rainwater harvesting and storage structures. Develop and adapt appropriate water management technologies	Measures on irrigation were not implemented	Ministry of Agriculture

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
Regional Water Policy (2005)	Water for development and poverty reduction	Promote sustainable irrigated agriculture in all member states with suitable water and land resources. Promote improved tillage and rainwater harvesting techniques to optimize the use of water in rainfed agriculture. Promote affordable and sustainable techniques for small-scale irrigation Promote measures to increase water use efficiency in agriculture.	All measures are being promoted	Southern African Development Community
Africa Water Vision 2025	Equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and the environment at African level	Strengthen governance of water resources. Improve water wisdom. Respond to urgent water needs. Strengthen the financial base for the desired water future.	All measures are being promoted	African Union

Policy/ strategy (year)	Specific targets (each of the specific objectives that the policy or regulation aims at attaining)	Measures to attain the objectives	Progress made against each policy/ strategy	Responsible institution
Comprehensive African Agriculture Development Programme (CAADP) (2003)	Extending the area under sustainable land management and reliable water control systems	Increase the area under irrigation and improve land management in the same area.	All measures are being promoted	African Union
Framework for Irrigation Development and Agricultural Water Management in Africa (2020)	Adopt and scale out sustainable irrigation and agricultural water management	Agricultural water management in rainfed farming; farmer-led irrigation; scheme development and modernization; and waste-water recovery and reuse.	All measures are being promoted	African Union

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5. Gap analysis

The analysis of gaps in the policies and strategies in agricultural water use efficiency and productivity was guided by the OECD Multi-Level Governance Framework. This was used to identify the main multilevel governance challenges in the water sector and the policy instruments that governments use to overcome them.

A gap was identified when a policy need is not matched by an appropriate and effective governance response. There exist different types of gaps, such as the partial implementation of existing strategies, lack of law or regulatory provisions, poor coordination among various levels of governance, lack of governmental commitment to a specific action deemed as necessary by stakeholders.

Through the development of the gap analysis matrix, various types of gaps were identified and possible solutions to bridge these gaps are proposed as shown in Table 8.

Table 8: Gap analysis matrix

Gap	Question/Problem	Status	Proposed actions / Recommendations
Administrative gap	Coordination and integrated planning of agricultural water infrastructure projects are not well organized	There is an over reliance on a top-down approach to the planning agricultural water infrastructure projects	Establish and strengthen coordination committees related to water at grassroots, district, provincial and national levels Create a semi-autonomous irrigation development agency
Information gap	Inadequate information system to provide accurate hydrological data and other relevant information about storage, optimum allocation, access, abstraction, withdrawal, and utilization of water among all users Inadequate demand and supply of information on water use efficiency in paddy fields	Inadequate and fragmented information system Limited information on water use efficiency in paddy fields, due to low demand	Establish and operationalize an Integrated Information Management System (IMIS) and strengthen institutional systems Create demand for information and support studies related to water use efficiency in paddy fields Promote irrigated rice to create demand for information related to water use efficiency in paddy fields Promote use of digital tools for information purposes
Legal and policy gap	Integration of water management policies with focus on agriculture, to increase agricultural (rice) production and water efficiency	The revised irrigation policy is in draft form. The strategic plans and projects being implemented do not encourage water efficiency. The country has no irrigation master plan	Finalize and launch the irrigation policy and its implementation plan to harness the utilization of water resources for agriculture Develop and implement an irrigation master plan Promote efficient water use in agriculture

Gap	Question/Problem	Status	Proposed actions / Recommendations
Capacity gap	Inadequate capacity on planning, construction, and management of agriculture water infrastructure projects Inadequate capacity to undertake studies related to efficient agriculture water use in paddy rice Inadequate capacity in Research and Development (R&D) and Extension Services in relation to production of rice	Inadequate human resources and institutional capabilities with regards to research, extension, construction and management of agriculture water infrastructure and production	Need to build capacity of ministries and institutions to ensure that staff acquire the technical abilities to plan, construct and manage agriculture water infrastructure Need to build capacity to conduct studies and production Strengthen Research and Development (R&D)
Funding gap	Insufficient funding for the use of water resources in agriculture	Funding for utilization of water resource for agriculture is limited especially for water harvesting and irrigation infrastructure	Need to increase public budget on irrigated rice production Establish Public-Private Partnerships (PPP) to leverage private sector resources
Objective gap	Objective focuses on water use efficiency in agriculture, in general and not specific to paddy fields	The focus of the Second National Agriculture Policy, Water Policy and Irrigation Policy is on water use efficiency in agriculture in general and not specific to paddy fields. As a result, water use efficiency in paddy fields is seemingly neglected	Develop strategies and guidelines for improved water use efficiency in paddy fields
Accountability gap	Inadequate monitoring system to supervise the planning, implementation, operation, and maintenance phases of the policies and programmes	Inadequate monitoring system for water management Monitoring system for agriculture sector does not track water use in crop production including paddy rice	Strengthen the national monitoring system for water management Establish a framework for monitoring water use in paddy rice production
Coordination/Cooperation gap	Inadequate cooperation/ coordination among various stakeholders for effective implementation of the policies	There is inadequate coordination in planning and implementing agriculture water infrastructure among the institutions	Establish and strengthen coordination committees at grassroots, district, provincial and national levels

There is an over reliance on a top-down approach for the planning of irrigation water infrastructure. As a result, there is limited ownership of some infrastructure projects. This situation is worsened by inadequate institutional coordination in the planning and implementation of irrigation water infrastructure projects.

The Second National Agricultural Policy of 2016 and Water Policy of 2010 provide a good foundation for a coordinated approach to planning and implementing irrigation water infrastructure projects. The Irrigation Policy of 2004 is under revision while the National Irrigation Master Plan is yet to be developed. So far, the emphasis for most policy frameworks is on water use efficiency in agriculture in general, without any specific focus on paddy fields. As a result, water use efficiency in paddy fields is seemingly neglected.

Water resources for water harvesting, irrigation infrastructure development and rice production are not yet fully developed due to limited funding. There are also inadequate human resources and institutional capabilities with regards to research, extension, construction and management of agriculture water infrastructure projects, and rice production.

The water resources information system that is supposed to provide accurate hydrological data and other relevant information about storage, optimum allocation, access, abstraction, withdrawal and utilization of water among all users is inadequate. The irrigation water monitoring system is also insufficient and does not effectively track water use in crop production, including paddy rice.

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6. Conclusions

Zambia has abundant water resources with seasonal and annual variation, largely resulting from climate change and increased demand for the resource. Zambia receives rainfall averaging 1 020 mm (768 billion m^3) per year. The total renewable water resources of Zambia are estimated at 104.8 billion m^3/year, of which about 80 billion m^3/year are produced internally. Surface water is confined to major rivers and lakes. Rivers include Kafue, Zambezi, Luangwa, Luapula and Chambeshi. Significant lakes include Bangweulu, Mweru, Tanganyika, Mweru-wantipa and Kariba and Itezhi-tezhi. The surface water potential is estimated at 100 billion m^3, while average renewable groundwater potential is estimated at 49.6 billion m^3 and is based on an average of eight percent rainfall.

The total water withdraw was 1.572 billion m^3 in 2017, out of which agricultural water use accounted for 73.2 percent (1.152 billion m^3), municipal water use represented 18.4 percent and industrial water use accounted for 8.2 percent. Zambia's irrigation potential is 2.75 million hectares, out of which about 258 000 hectares (small scale and commercial farmers combined) are irrigated.

Most irrigated crops include sugarcane, wheat, tea, coffee, export flowers, soya beans and bananas. Most of the irrigated land lays along the line of rail, adjacent to surface water bodies such as rivers and dams, and in dambos and wetlands for smallholders and emergent farmers. The main irrigation technologies include gravity systems (basin and furrow), buckets, low-and high-cost drip systems, sprinklers, rain guns and center pivots.

A two-step approach was used to map policies on agricultural water management. The approach consists of a mapping exercise and a gap analysis matrix. The mapping includes a review of policies, laws, regulations, and institutional frameworks in a specific context, while the gap analysis helps assessing and visualizing the policy, institutional, and regulatory needs that are not matched by appropriate and effective governance responses.

The governance of the water resource is crucial, and the Government adopted an integrated approach to the management of water resources. The governance structure includes the government ministries and departments who are responsible for policy formulation and enactment of legislations and regulations. Key ones are the MWDS, MoA, MLDRD, MFL and MLNR. The lead institution is the MWDS. Regulatory institutions such as WARMA and ZEMA are responsible for regulations for water quality and abstraction, and pollution control.

The private sector (farmers, industries) utilizes water resources for different purposes and contributes to the management of water resources through the establishment, in some areas, of water management committees (WUAs). Academic and research institutions facilitate research and development in water management as well as rice value chain. NGOs and Community Based Organizations play an important role in community mobilization for irrigation and general crop production. Regional and international institutions provide guidelines for agricultural development and management of water resources for agriculture and other uses. Furthermore, there are cooperating partners that provide finance and technical support in the development of water for irrigation and rice value chain development.

Overarching policies and legislations are the National Water Policy of 2010 and Water Resources Management Act of 2011. Others include the Environmental Management Act of 2011, Local Government Act of 2019, Zambezi River Authority Act of 1986, Vision 2030, SNAP, the National Policy on climate change and the National sector development plan and strategies.

The overarching policy environment is supportive to the use of the water resources for agricultural purposes and includes strategies related to water use efficiency in agriculture. However, challenges such as the lack of irrigation master plan, inadequate funding, low coordination, inadequate information and M&E systems and human resources and institutional capabilities need to be further addressed if the country aims to fully develop and utilize agricultural water resources for paddy rice production. The current policy formulation has been skewed to irrigation in general and not addressing the specific needs of the rice value-chain. Reduced investments in irrigation infrastructure, increased competition for water and large water withdrawals from groundwater bodies have not sufficiently promoted irrigated rice production. The main irrigation technology used in rice production is controlled flooding mainly at Sefula, Mongu district.

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