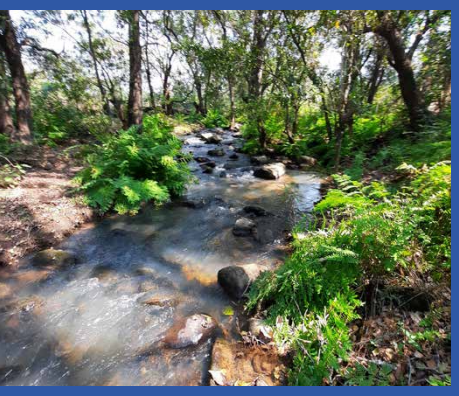
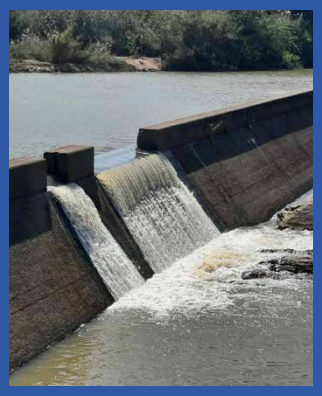
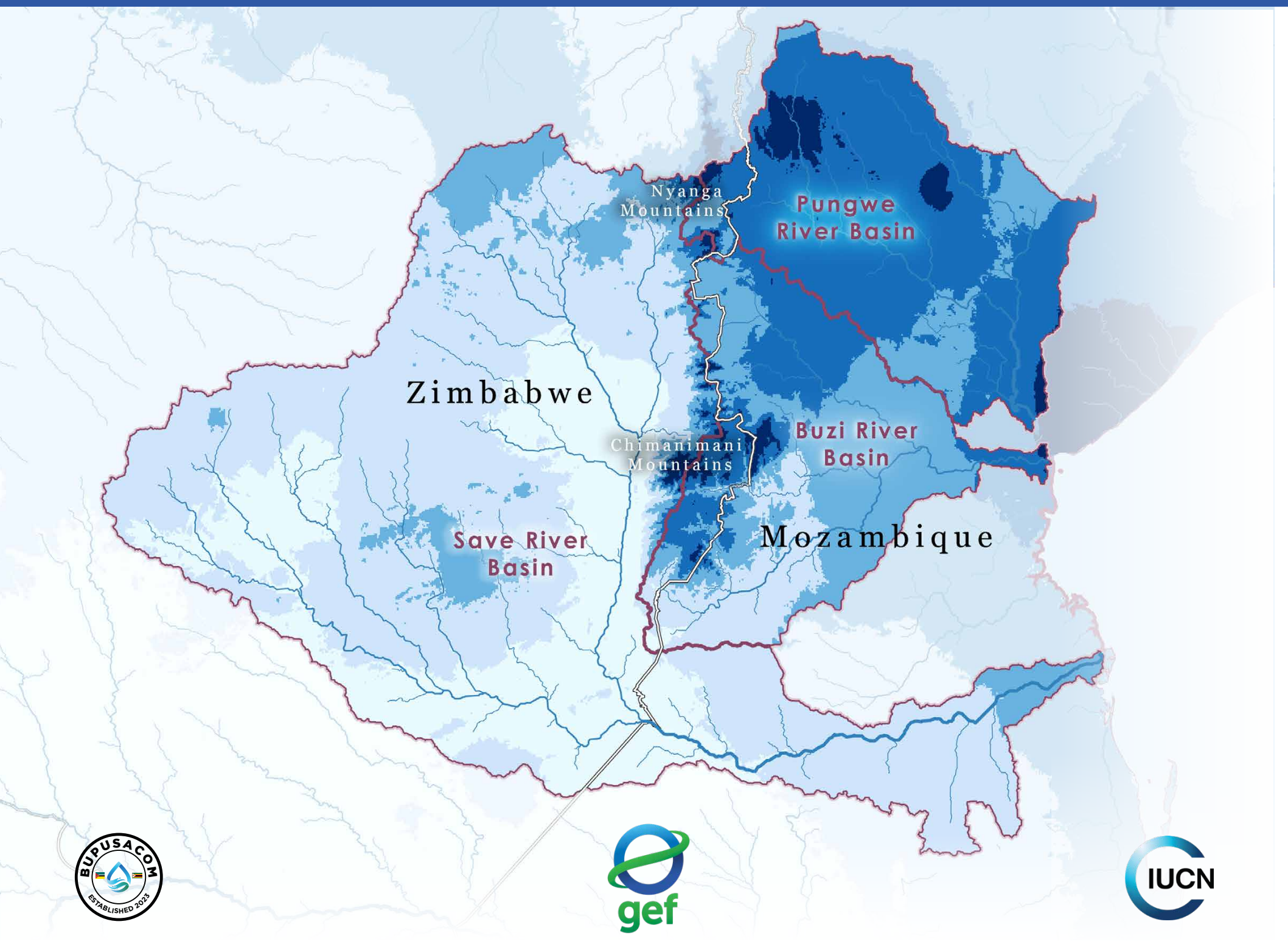






BUZI, PUNGWE, AND SAVE WATERCOURSES

Atlas of Our Changing Environment

Towards water security and climate resilience



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The Buzi, Pungwe, and Save Watercourses: Atlas of Our Changing Environment (BUPUSA Atlas) was produced under the "Management of competing water uses and associated ecosystems in Pungwe, Buzi, and Save Watercourses". The project was funded by the Global Environment Facility (GEF), implemented by the International Union for the Conservation of Nature (IUCN), with Global Water Partnership Southern Africa (GWPSA) as the regional executing partner supporting the basin's member states (Mozambique and Zimbabwe).

BUPUSACOM ESTABLISHED 2023

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Recommended Citation
GWPSA, GRID-Arendal and SARDC. 2023. *The Buzi, Pungwe, and Save Watercourses: Atlas of our Changing Environment: Towards Water Security and Climate Resilience*, GWPSA, GRID-Arendal and SARDC; Pretoria, Arendal, Harare.

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Foreword

Mozambique and Zimbabwe share at least five river basins or sub-basins; namely Limpopo, Zambezi, Pungwe, Buzi, and Save. The Pungwe, Buzi, and Save basins, collectively known as BUPUSA, are exclusively shared by the two countries. The Buzi, Pungwe and Save watercourses flow from Zimbabwe in the west headwaters through Mozambique to discharge into the Indian Ocean. The BUPUSA Tri-Basin drains an area of 161,447 km^2 towards the Indian Ocean, of which 45 percent is in Mozambique and 55 percent in Zimbabwe. The BUPUSA Tri-Basin's characteristics are very diverse, covering different climatic and topographic zones, as well as land use types, including protected areas. The BUPUSA Tri-Basin is endowed with underground water resources that are important in supplementing surface water resources.

Over the last couple of years, the BUPUSA river basins have faced similar challenges, mainly changes in flow regime, water quality deterioration, flood and drought, land degradation, loss of biodiversity, reduced availability of water, and sedimentation. It is against this background that Southern African Research and Documentation Centre (SARDC), GRID-Arendal and the Global Water Partnership Southern Africa (GWPSA), with support from the Global Environment Facility (GEF) and the International Union for the Conservation of Nature (IUCN), have developed the BUPUSA Tri-Basin Atlas to capture these changes and inform decision makers on steps needed to make this unique ecosystem more resilient.

This is the first Atlas edition of the *Buzi, Pungwe, and Save Watercourses Atlas of our Changing Environment: Towards Water Security and Climate Resilience*, it is hopefully the first of many such Atlases to be developed. The Atlas is a key knowledge resource for the Buzi, Pungwe, and Save Watercourses Commission (BUPUSACOM), which was recently established to facilitate cooperation and coordinate water resource planning for sustainable livelihoods in the shared basins. The establishment of such commissions falls under the auspices of the Revised Southern African Development Community (SADC) Protocol on Shared Watercourses, and its programmes such as the Regional Strategic Action Plans (RSAPs) on Integrated Water Resources Development and Management.

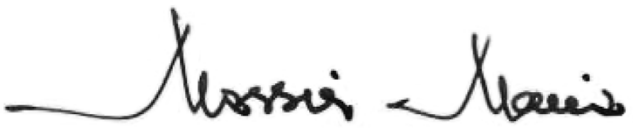
The Atlas will go a long way in enriching knowledge about the BUPUSA Tri-Basin as well as providing some of the information and data needs of the Tri-Basin. The information and data provided by the Atlas will also inform regional developmental initiatives including trans-frontier conservation, and integrated water resources management approaches. The *Buzi, Pungwe, and Save Watercourses Atlas of our Changing Environment: Towards Water Security and Climate Resilience* provides evidence-based analyses on changes in the BUPUSA Tri-Basin, including their causes and outcomes, so as to motivate policy action and the promotion of sustainable development.

The Atlas synthesizes existing information on environmental and socio-economic changes in the basin. The findings in the Atlas are aimed at raising stakeholder awareness on the impact of climate change on the basin, as well as on interventions adaptation and mitigation in order to achieve resilience. It proposes appropriate strategic actions to prevent, manage, and mitigate negative impacts of climate change, and informs sustainable use and management of the resources of the BUPUSA Tri-Basin system. The Atlas was constructed around a firm data and information development process.

Literature that was reviewed to understand issues and challenges in the basin, and to identify areas where significant environment changes have occurred, included the Buzi, Pungwe and Save River Basins, Basin Monograph Studies on the Tri basin and the BUPUSA Transboundary Diagnostic Analysis thematic reports. I hereby invite all BUPUSA Tri-Basin member states and partners to support this initiative and use the Atlas for the region's prosperity and for the successful achievement of goals as set in the BUPUSA Watercourses Commission Agreement.t.



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Preface

The water resources of the BUPUSA Tri-Basin are shared by two riparian countries-Mozambique and Zimbabwe. The Tri-Basin's freshwater is generally scarce, and seriously competed for. The competition is not only for access, but also for different needs and priorities. Such competition and differences in priorities call for a fair and balanced management approach, which ensures that water adequately provides for the economic, social and environmental needs of the riparian countries.

At regional level, the management of water resources is guided by the Southern African Development Community (SADC) Revised Protocol on Shared Watercourses of 2000, which entered into force in 2003. The Protocol aims to foster closer cooperation for sustainable and coordinated management as well as protection and effective utilisation of shared watercourses in pursuance of regional initiatives towards integration and poverty alleviation. This is also supported by the SADC Regional Strategic Action Plans on Integrated Water Resources Development and Management which seek, not only to facilitate fairness in the use and access of the basin's water resources, but also to foster coordinated planning. The main purpose of the SADC Regional Strategic Action Plans on Integrated Water Resources Development and Management is to create an environment for the joint management of trans-boundary water resources.

In pursuing the IWRM agenda, the BUPUSA Atlas will enable the Tri-Basin to meet its goals for water resources management as defined in the Dublin Principles, including goals for poverty alleviation, water conservation and reuse, agricultural production and rural water supply, and reducing water conflicts. In order to meet some local needs, the Tri-Basin also has some ambitious intra-basin water transfer schemes and plans.

The BUPUSA Atlas notes the vulnerability of the Tri-Basin to some major natural disasters and risks, including droughts, floods and cyclones and proffers strategic actions that open doors to resilience, not only for the Tri-Basin but also for the SADC region. As such, the Atlas, among other things, seeks to ensure that the state and trends of the basin are well understood through the use of a causal chain analysis framework. The evidence presented in the Atlas is clear and compelling to inform policies and decisions that affect the basin. Facts and data are not only presented in a visual way, but also in a format that clearly shows links between root/ underlying causes, impacts and responses.

Various partners were involved in the preparation of this Atlas. Through the support of the BUPUSACOM, facts were verified for clarity and correctness. The *Buzi, Pungwe, and Save Watercourses Atlas of our Changing Environment: Towards Water Security and Climate Resilience* was produced under the " Management of competing water uses and associated ecosystems in Pungwe, Buzi, and Save Basins" project funded by the Global Environment Facility (GEF), implemented by the International Union for the Conservation of Nature (IUCN), and executed by Global Water Partnership Southern Africa (GWPSA).

The Southern African Research and Documentation Centre (SARDC), through its Environment Institute the I. Musokotwane Environment Resource Centre for Southern Africa, coordinated the compilation of content for the Atlas. GRID-Arendal supported the development of visuals and design of the Atlas. This collaboration is a clear demonstration of effective partnership that exists between and among the institutions involved.

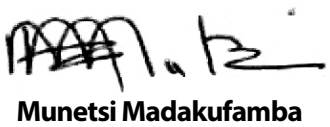


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Acknowledgements

The *Buzi, Pungwe, and Save Watercourses Atlas of our Changing Environment: Towards Water Security and Climate Resilience (BUPUSA Atlas)*, is a product of teamwork and dedication amongst various organisations and individuals. The Buzi, Pungwe, and Save Watercourses Commission (BUPUSACOM) would like to express its gratitude and thanks to all the stakeholders who contributed to the process of developing the BUPUSA Atlas, which informs and promotes sustainable use and management of the Tri-Basin resources

The process of developing the BUPUSA Atlas was made possible through collaborative efforts of the SARDC, GRID-Arendal and GWPSA with support from GEF and IUCN, who found it necessary to formulate the vision for the Atlas, which informs and promotes sustainable use and management of the Tri-Basin resources. Teir support is outlined below:

Gratitude and appreciation go to the Global Environment Facility (GEF) for providing a contracting mechanism for the lead authors, SARDC, and financially and technically supporting the engagement of experts who spearheaded the development of the various chapters and collation of the information into a dynamic product.

The International Union for the Conservation of Nature (IUCN) is specifically thanked for providing the financial assistance to support the engagement of experts who spearheaded the development of the various chapters and collation of the information into a dynamic product.

Global Water Partnership Southern Africa (GWPSA) together with the BUPUSACOM Secretariat staff are appreciated for providing guidance on key stakeholders to be targeted through the consultation process, so as to enhance stakeholder ownership of the final product. GWPSA brought together stakeholders such as, government departments, local authorities, private sector, civil society, and community leaders to review and provide input into the atlas and overall management of the whole atlas development process. GWPSA Building on the vision, the process of developing the Atlas, contracted authors and provided oversight throughout the whole development process.

GRID-Arendal provided the cartographic and satellite imagery analysis, and produced the supporting e-book, story map and video to communicate the findings of the Atlas to a wider audience. We also recognise the individual efforts that were put in the final review of this work, making this Atlas a crisp document for policy making.

SARDC, as the Lead Author, helped the partner organisations realise their vision by driving the development of technical content for the Atlas, through research that was supported by participatory interactions across the basin. We thank the authors for the research and content development for the manuscript; the reviewers and editorial teams for their sharp technical eye; and all workshop participants for their contributions in the consultative process. SARDC was instrumental in the development of cartographic and satellite imagery analysis; compilation of content material and manuscript and reviewing and editing of chapters.

BUPUSACOM is thankful to its Technical Committee, representatives from various ministries, departments, and agencies for the tremendous support they gave during the development of this Atlas by always availing themselves for consultations particularly through workshops undertaken in the process of developing the Atlas.

At each stage of the process was a professional team of experts and specialists that ensured that the Atlas is a high-quality product.

It is with gratitude that we would like to recognise the sterling contributions made by everyone involved in developing the BUPUSA Atlas. The contribution of all who provided reports and information through is also acknowledged.

Acronyms

ARA	Regional Water Administrations
ARA-Centro, IP	Regional Water Administration of the Centre
ARA-Sul, IP	Southern Regional Water Administration
BUPUSA	Buzi, Pungwe, and Save
BUPUSACOM	Buzi, Pungwe, and Save Watercourses Commission
CCA	Causal Chain Analysis
CIS	Customer Information Services
COD	Chemical Oxygen Demand
DNGRH	National Directorate of Water Resources Management
DPSIR	Driver-Pressure-State-Impact- Response
DWRPID	Department of Water Resources, Planning and Irrigation Development
ENSO	El Niño-Southern Oscillation
GEF	Global Environment Facility
GIZ	German Agency for International Cooperation
GoM	Government of Mozambique
GoZ	Government of Zimbabwe
GWPSA	Global Water Partnership Southern Africa
IKS	Indigenous Knowledge Systems
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
LIMCOM	Limpopo Watercourse Commission
MAR	Mean Annual Runoff
MLAFWRR	Ministry of Lands, Agriculture, Fisheries, Water and Rural Development NFWWCS National Framework for Weather, Water and Climate Services
NCAR	National Centre for Atmospheric Research
NCEP	National Centres for Environmental Prediction
NWC	National Water Council
PMU	Project Management Unit
RBOs	River Basin Organisations
RCP	Representative Concentration Pathway
SADC	Southern African Development Community
SADC CSC	Southern African Development Community Climate Services Centre
SAP	Strategic Action Plan
SARCOF	Southern Africa Regional Climate Outlook Forum
SARDC	Southern African Research and Documentation Centre
SDG	Sustainable Development Goals
TDA	Transboundary Diagnostic Analysis
TSS	Total Suspended Solids
UNECA	United Nations Economic Commission for Africa
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organisation
ZAMCOM	Zambezi Watercourse Commission
ZINWA	Zimbabwe National Water Authority

Executive Summary

The *Buzi, Pungwe, and Save Watercourses Atlas of Our Changing Environment: Towards Water Security and Climate Resilience* provides compelling and credible evidence of the environmental changes in the Buzi, Pungwe, and Save River Basins (also referred to as BUPUSA Tri-Basin or Tri-Basin), including their causes and impacts, that motivate for the need to urgently address negative changes and promote sustainable development. The BUPUSA Tri-Basin is shared by two Member States in southern Africa, namely Mozambique and Zimbabwe.

Based on the last available census figures, the projected population for the Buzi River Basin to 2020 was 1,583,100 people with 86 percent and 14 percent living in Mozambique and Zimbabwe, respectively (COWI, 2012). In 2020, the population of the Pungwe River Basin was estimated as 1.9 million people with 96 percent living in Mozambique and 4 percent in Zimbabwe (Southern Waters, 2023). The Save River Basin had an estimated population of 3.17 million in year 2020 with 95 percent residing on the Zimbabwean side and 5 percent on the Mozambican side (COWI, 2013).



Pungwe River Basin near its source in Nyanga National Park in Zimbabwe.
Photo: GEF-BUPUSA Project

The Mean Annual Rainfall in the Pungwe River Basin ranges from 2,000 mm/year in the mountainous western part of the catchment to about 900 mm towards the estuary (SWECO, 2006). In the Save River Basin, the rainfall ranges from 550 to 1,200 mm/year with an average of 685 mm/year (COWI, 2012). For the Buzi Basin, the rainfall is highest in the western part of the basin catchment (1,300 mm/year) and reduces to 900 mm/year in the southeast parts of the basin (SWECO, 2011).

Potential evaporation rates range from between 1,380 to 1,590 mm/year in the Pungwe Basin, 700 to 1,600 mm/year in the Buzi Basin and 1,450 to 2,500 mm/year in the Save Basin.

Table 1 gives the details of the BUPUSA Tri-Basin areas and their surface water resources expressed as the Mean Annual Runoff (MAR) in million cubic meters per year (Mm^3/yr) or millimetres per year (mm/yr).

SWECO (2011) estimated that the available groundwater resources in the Buzi River Basin were 1,559 Mm^3/yr and the available groundwater resources in the Pungwe River Basin were estimated as 1,636 Mm^3/yr. VisionRI (2020) estimated that on average, the available groundwater resources for the Save River Basin were 730 Mm^3/yr.

Zinc and titanium levels in the Lucite and Revue sub-catchments of the Buzi River Basin have been found to be higher than the recommended levels, indicating poor water quality (GWPSA, 2022). However, other pollutants are within acceptable limits. The water quality in the Pungwe River Basin is generally good and within recommended national and international standards. However, increases in iron, zinc, total suspended solids (TSS), chemical oxygen demand (COD), and biochemical oxygen demand (BOD) suggest more requirements for frequent monitoring and introduction of measures to curb pollution (GWPSA, 2022). In the Save River Basin, high levels of iron and TSS have been observed (GWPSA, 2022). Indications of cyanide and mercury have been detected around alluvial gold mining sites. Other pollutants, however, are within acceptable limits.

Future water use rates were estimated during the Pungwe Project Phase I and II, and then updated by Consultec (2013) for the short and long-terms. Water use without environmental flows is projected to increase from 810 Mm^3/yr in 2020 to 1,031 and 1,317 Mm^3/yr for 2030 and 2035, respectively, for the whole basin.

The changing environment in the Buzi, Pungwe, and Save (BUPUSA) transboundary river basins presents several challenges that need to be addressed urgently to mitigate environmental degradation and its associated socioeconomic consequences. Given the transboundary dimensions of the BUPUSA Tri-Basin, the challenges and potential strategic actions envisaged become inherently complex, particularly when considering the upstream-downstream relationships of natural resource extraction, use, and degradation. Any interventions to enhance sustainable development of the BUPUSA Tri-Basin will need to take those inherent complexities into account.

Table 1: Geographical area of the Buzi, Pungwe, and Save River Basins, and their Mean Annual Runoff (MAR)

Basin	Sub Basin by Country	Area (km^2)	Basin Area (%)	MAR (Mm^3/yr)	MAR (mm/yr)	Basin MAR (%)
Pungwe	Zimbabwe	1,461	5	1,102	753	25
	Mozambique	29,690	95	3,348	113	75
	Total	31,151	100	4,450	143	100
Buzi	Zimbabwe	3,733	13	1,201	321	21
	Mozambique	25,137	87	4,500	179	79
	Total	28,870	100	5,701	198	100
Save	Zimbabwe	84,149	83	6,822	81	84
	Mozambique	17,277	17	1,335	77	16
	Total	101,426	100	8,157	80	100
BUPUSA	Zimbabwe	89,343	55.3	9,125	102	49.8
	Mozambique	72,104	44.7	9,183	127	50.2
	Total	161,447	100.0	18,308	113	100.0

Source: GWPSA, 2023a

Introduction

The Buzi, Pungwe, and Save River Basins: Atlas of Our Changing Environment (also referred to as the Atlas) provides compelling and credible evidence of the environmental changes in the Buzi, Pungwe and Save River basins (also referred to as BUPUSA Tri-Basin), including their causes and impacts, so as to motivate for the need to urgently address negative changes and promote sustainable development. The BUPUSA Tri-Basin is shared by two Member States in southern Africa, namely Mozambique and Zimbabwe.

The Atlas covers surface and ground water quality, water demand and allocation, biodiversity and wildlife, land management, extreme events, as well as their associated impacts and possible interventions. The Atlas also highlights the key transboundary water governance and cooperation issues in the Tri-Basin. It further outlines how challenges in the basin are to be addressed with initiatives at the transboundary and Member State levels through the Strategic Action Plan. The running theme for the Atlas is "Water Security and Climate Resilience". Cross-cutting issues such as gender equity, social inclusion, culture, and indigenous knowledge systems are incorporated in the Atlas.

Framework and Approach

The Atlas uses the Causal Chain Analysis (CCA) framework model approach in order to assess the causes, state, and impacts to the environment and water resources in the Tri-Basin. The CCA framework is multi-scalable, indicating generic cause-and-effect relations.

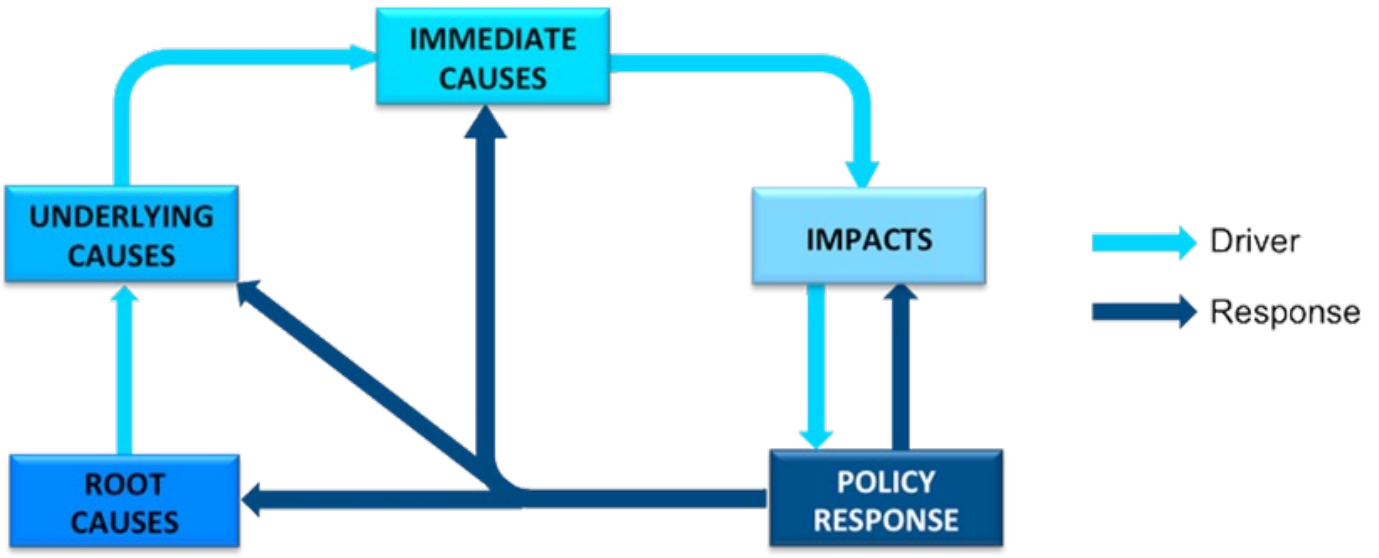


Figure 1: *Causal Chain Analysis as a component of a Policy Response System*

Process

The Atlas was developed as part of the Global Environment Facility (GEF) funded project "Management of competing water uses and associated ecosystems in Pungwe, Buzi, and Save basins", implemented by the International Union for Conservation of Nature (IUCN) and executed by the Global Water Partnership-Southern Africa (GWPSA) together with the governments of Mozambique and Zimbabwe.

The Atlas is a collaborative effort of SARDC, GRID-Arendal, and GWPSA. The development of the Atlas was directed by SARDC as Technical and Workstream Lead, while GRID-Arendal supported with the spatial analytics, that is, collecting, processing, analysing and visualising spatial data, including the development of the accompanying story map.

The development of this Atlas started off with a planning meeting involving SARDC, GWPSA Project Management Unit (PMU), and GRID-Arendal in December 2022. These partners discussed the scope and framework to be adopted in the development of the Atlas. This was followed by an inception meeting which was held back-to-back with the Transboundary Diagnostic Analysis/Strategic Action Plan (TDA/SAP) and the Causal Chain Analysis Workshop from 28 February to 3 March 2023 in Pretoria, South Africa.

The process of producing the content of the Atlas was highly consultative in nature and involved partners, Member States' representatives, and experts from the Tri-Basin and premised on the TDA findings. A team of regional experts from Mozambique and Zimbabwe were commissioned by SARDC to contribute to the Atlas. Limited online stakeholder consultations were also conducted concurrently with the literature review process in order to both obtain new information and/or verify facts.

1

OVERVIEW OF THE BUZI, PUNGWE, AND SAVE TRI-BASIN



Photo: Gwyn Lashley

1.1 Introduction

The Buzi, Pungwe, and Save watercourses constitute the BUPUSA Tri-Basin, which is shared between Mozambique and Zimbabwe. The three rivers provide drinking water for nearly 7 million people living within the Tri-Basin (GWPSA, 2023a; CRIDF, 2014; SADC, 2005), they also sustain a number of livelihood activities such as agriculture, fisheries and aquaculture, and industry. The sustainability of this Tri-Basin ecosystem is under threat due to a variety of human, as well as natural factors.



The BUPUSA Tri-Basin is home to a variety of land and marine species.
Photo: Fiona Mackay

1.2 Location and size of the Tri-Basin

The BUPUSA Tri-Basin forms the major drainage system into the Indian Ocean, between the Limpopo and Zambezi rivers. Therefore, the BUPUSA Tri-Basin is part of the Transboundary River Basins in the SADC region (Figure 1.1). The Buzi, Pungwe, and Save watercourses flow from Zimbabwe in the west headwaters, through Mozambique, to discharge into the Indian Ocean (Figure 1.2).

The BUPUSA Tri-Basin forms one of the several shared river basins which involve transboundary water management in SADC (Table 1.1).

The BUPUSA Tri-Basin drains an area of 161,447 km^2 towards the Indian Ocean, of which 45 percent is in Mozambique and 55 percent in Zimbabwe (Table 1.2).

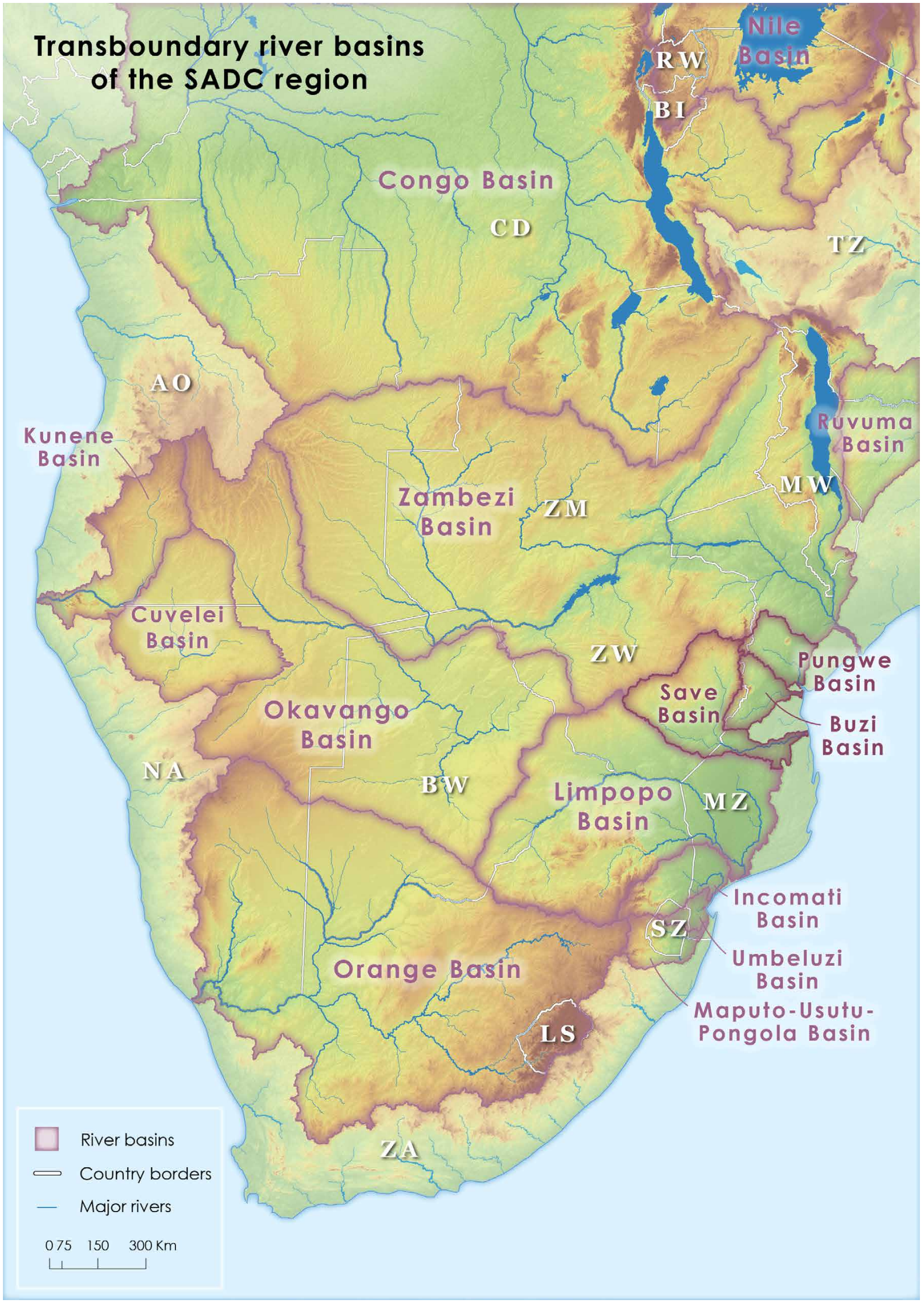


Figure 1.1 Transboundary River basins in the SADC region.

Source: CRIDF, 2014, Copyright: SARDC, GWPSA, GRID-Arendal 2024.



Photo: Moses Makwanise/IUCN

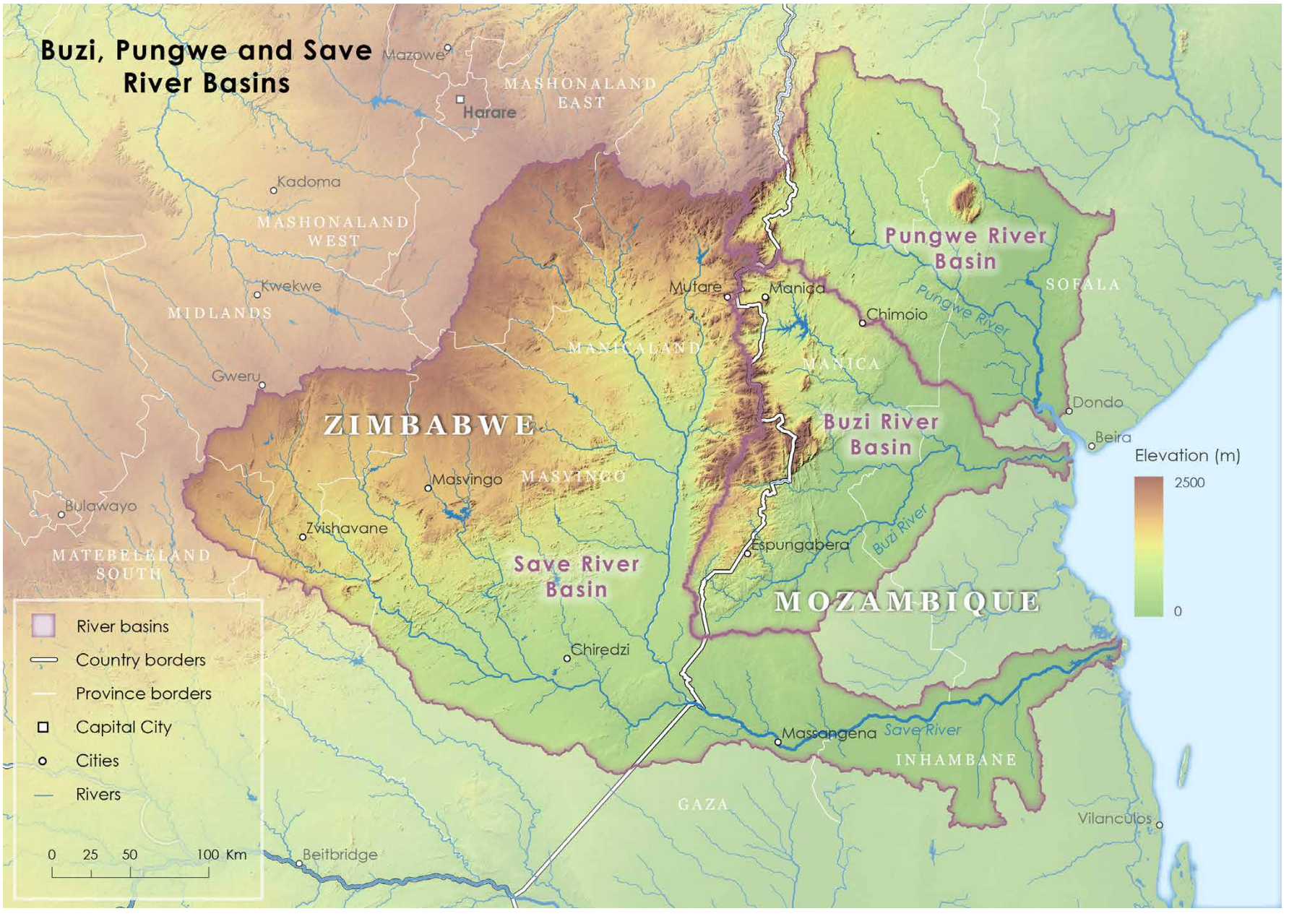


Figure 1.2 BUPUSA River Basins, which are exclusively shared by Mozambique and Zimbabwe.
Source: Copyright: SARDC, GWPSA, GRID-Arendal 2024.

Table 1.1: Transboundary River Basins in southern Africa

Shared watercourse	Catchment Area (km^2)	Annual average surface water generation (Mm^3)	Countries
Buzi	28,870	5,701	Mozambique, Zimbabwe
Congo	4,014,500	1,260,000	Angola, Burundi, Cameroon, Central African Republic, Democratic Republic of the Congo, Gabon, Rwanda, Tanzania, Uganda, Zambia
Cunene	106,560	5,500	Angola, Namibia
Cuvelai	100,000	72	Angola, Namibia
Incomati	46,748	2,000	Eswatini, Mozambique, South Africa
Limpopo	416,296	4,100	Botswana, Mozambique, South Africa, Zimbabwe
Maputo – Usutu – Pongola	29,970	1,800	Eswatini, Mozambique, South Africa
Nata	24,585	279	Botswana, Zimbabwe
Okavango	752,293	11,000	Angola, Botswana, Namibia
Orange – Senqu	972,783	11,500	Botswana, Lesotho, Namibia, South Africa
Pungwe	31,151	4,450	Mozambique, Zimbabwe
Ruvuma	152,200	15,000	Malawi, Mozambique, Tanzania
Save	101,426	8,157	Mozambique, Zimbabwe
Umbeluzi	5,458	343	Mozambique, Eswatini
Zambezi	1,320,000	94,000	Angola, Botswana, Malawi, Namibia, Mozambique, Tanzania, Zambia, Zimbabwe

Source: Hirji et al., 2002

Table 1.2: BUPUSA Tri-Basin, and the proportions of the basin areas falling within Mozambique and Zimbabwe

Characteristic	Pungwe	Buzi	Save	Total BUPUSA
Basin Area (km^2)	31,151	28,870	101,426	161,447
Area of Basin in Mozambique (km^2)	29,690	25,137	17,277	72,104
Area of Basin in Zimbabwe (km^2)	1,461	3,733	84,149	89,343

Source: GWPSA, 2023a



Photo: Gwyn Letley

Buzi River.
Photo: Gwyn Letley

Buzi River Basin

The Buzi River rises in the Eastern Highlands (or Manica Highlands) on the border of Mozambique and Zimbabwe and flows eastward through the provinces of Manica and Sofala. The river empties into Sofala Bay in the Mozambique Channel, south-west of Beira, forming a large estuary together with the Pungwe River. The Buzi River is about 397 km long, with a drainage basin of about 28,870 km^2, of which about 25,137 km^2, 87.1 percent of the total area is in Mozambique and 12.9 percent is in Zimbabwe (Ardaya, 2012). The average annual runoff is about 5,701 Mm^3/year near the mouth at Estaquinha (Consutenc, 2015; GWPSA, 2023a). The Buzi river catchment comprises three major tributaries, namely, Buzi River in the south, Revue River in the centre, and Lucite River in the north. All the tributaries originate in the Chimanimani Transfrontier Conservation Area (TFCA) near the border between Mozambique and Zimbabwe. Figure 1.3 gives geographical details of the Buzi River Basin.

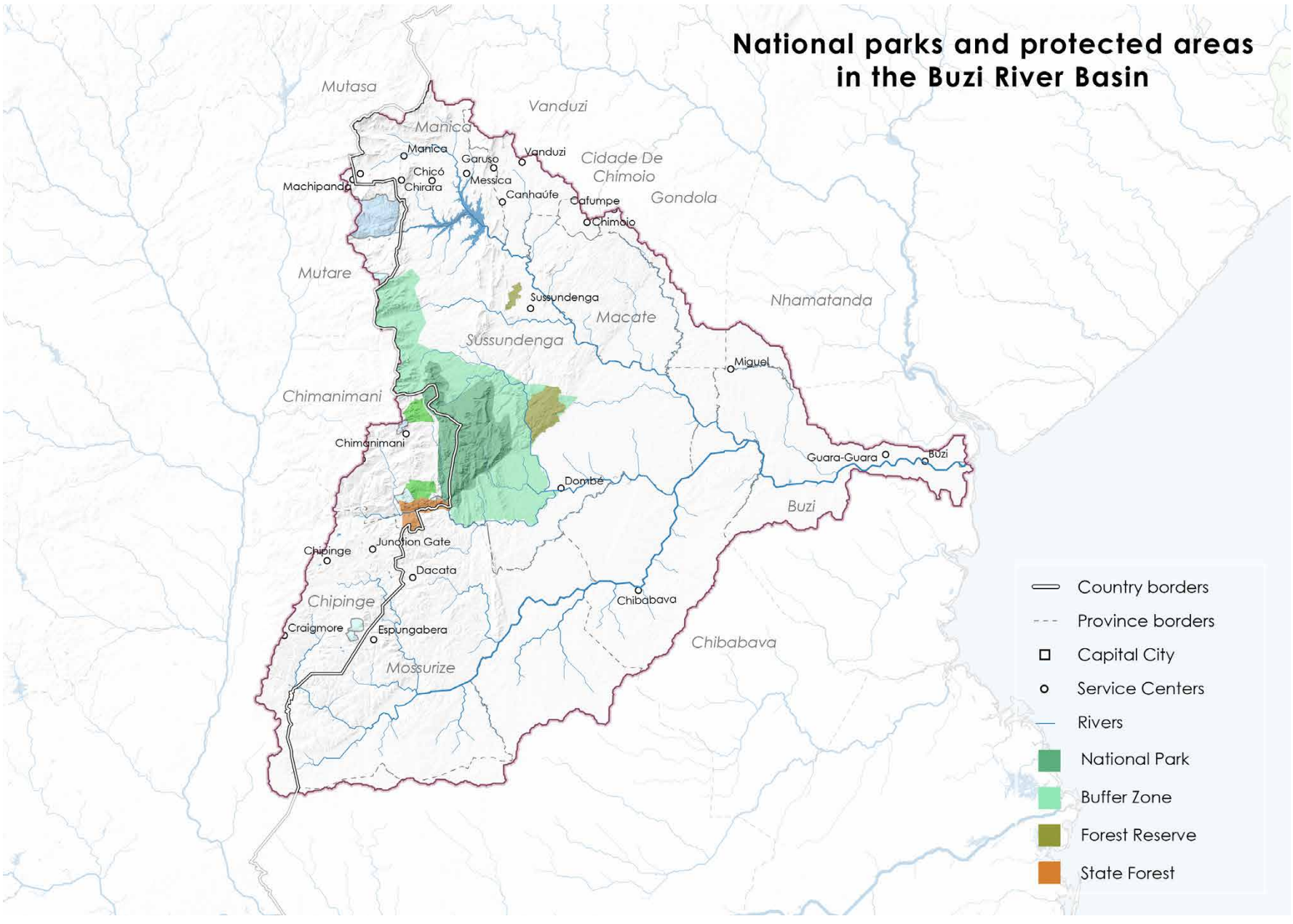


Figure 1.3 Buzi River Basin.

Source: SWECO, 2011, Copyright: SARDC, GWPSA, GRID-Arendal 2024.



Mutarazi Falls, a major tourist attraction in the Pungwe Basin in Zimbabwe.
Photo: Manicaland Tales

Pungwe River Basin

The Pungwe River rises in the Nyangani Mountains in Zimbabwe, near the Mozambique border, at an altitude of over 1,000 metres above mean sea level and ends in an estuary near the city of Beira in Mozambique. The river is 359 km long with an area of 31,151 km^2 (SWECO, 2004), out of which 95.3 percent lies in Mozambique and 4.7 percent is in Zimbabwe. The main tributaries at the headwaters in Zimbabwe are Honde on the right bank and the Nyazengu, Chiteme, Nyamhingura, Nyawamba, Nyamukombe, and Rwera rivers on the left bank (GoM, 2006). Other tributaries are Vunduzi and Urema rivers.

The average annual runoff is about 4,450 Mm^3/year (Consultec, 2013). Figure 1.4 gives geographic details of the Pungwe River Basin. The Basin traverses two national parks of global significance, which are:

- The Nyanga National Park in the mountainous part of Zimbabwe, at the headwaters. The Park hosts an important wildlife diversity.
- The Gorongosa National Park is located in the middle parts of the Pungwe River, in Sofala Province, Mozambique. The Park comprises extensive wetlands and several small rivers that flow into the park from the mountains and plateaus into Lake Urema, a complex set of floodplains and extensive wetlands, some of which are permanently flooded and others which are seasonally flooded, known as Gorongosa "tandos".

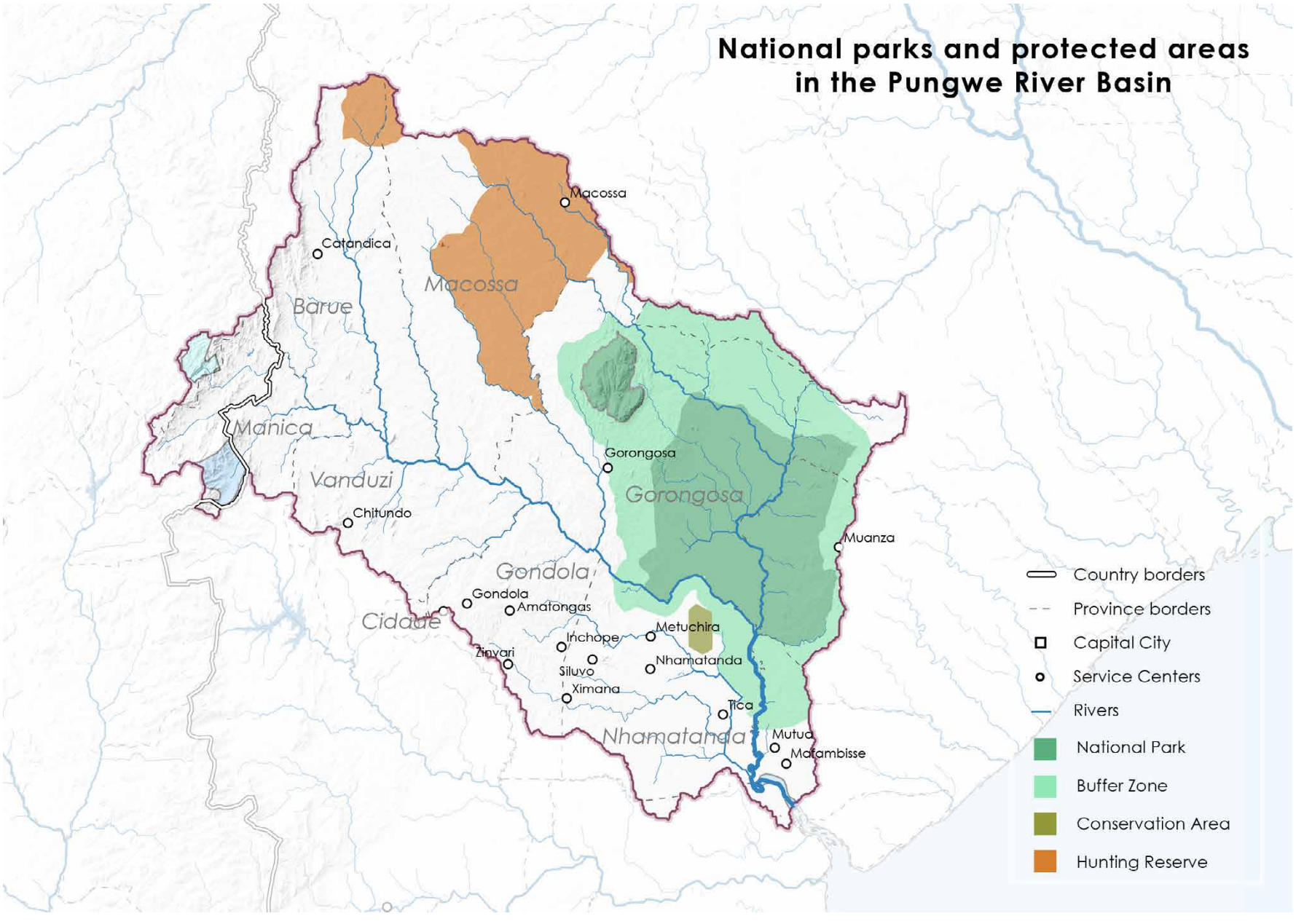


Figure 1.4 Pungwe River Basin.

Source: SWECO, 2004, Copyright: SARDC, GWPSA, GRID-Arendal 2024.



Save River Basin

The Save River is the southernmost of the three BUPUSA river basins. It rises in Zimbabwe (about 100 km south of Harare), flows south and then crosses Mozambique from west to east, flowing into the Indian Ocean. The river has a total length of 735km, of which 405km is in Zimbabwe and 330 km is in Mozambique, and a watershed of 101,426km^2, of which 84,149km^2 (83%) is in Zimbabwe and 17,277km^2 (17%) is in Mozambique. The average annual runoff is about 8,157 Mm^3/year (GWPSA, 2023a; Hydroconsult, 2017). The main tributaries of the Save River are Runde on the Zimbabwean side and Côa and Vumaóze on the Mozambican side (Lopes, 2020). The Save Basin has several important wetlands that include springs, pans, pools, lagoons, lakes and dambos. These are prominent in the Gonarezhou National Park in Zimbabwe and Zinave National Park in Mozambique, in the confluence of the Runde and Save rivers, and some associated conservancy areas (Malilangwe, Save Conservancy along the Save River). Some of these wetlands are permanently flooded whilst others are seasonally flooded and host important wildlife, including mammals and birds. Figure 1.5 gives geographical details of the Save Basin. These include national parks and protected areas and other boundary markers.

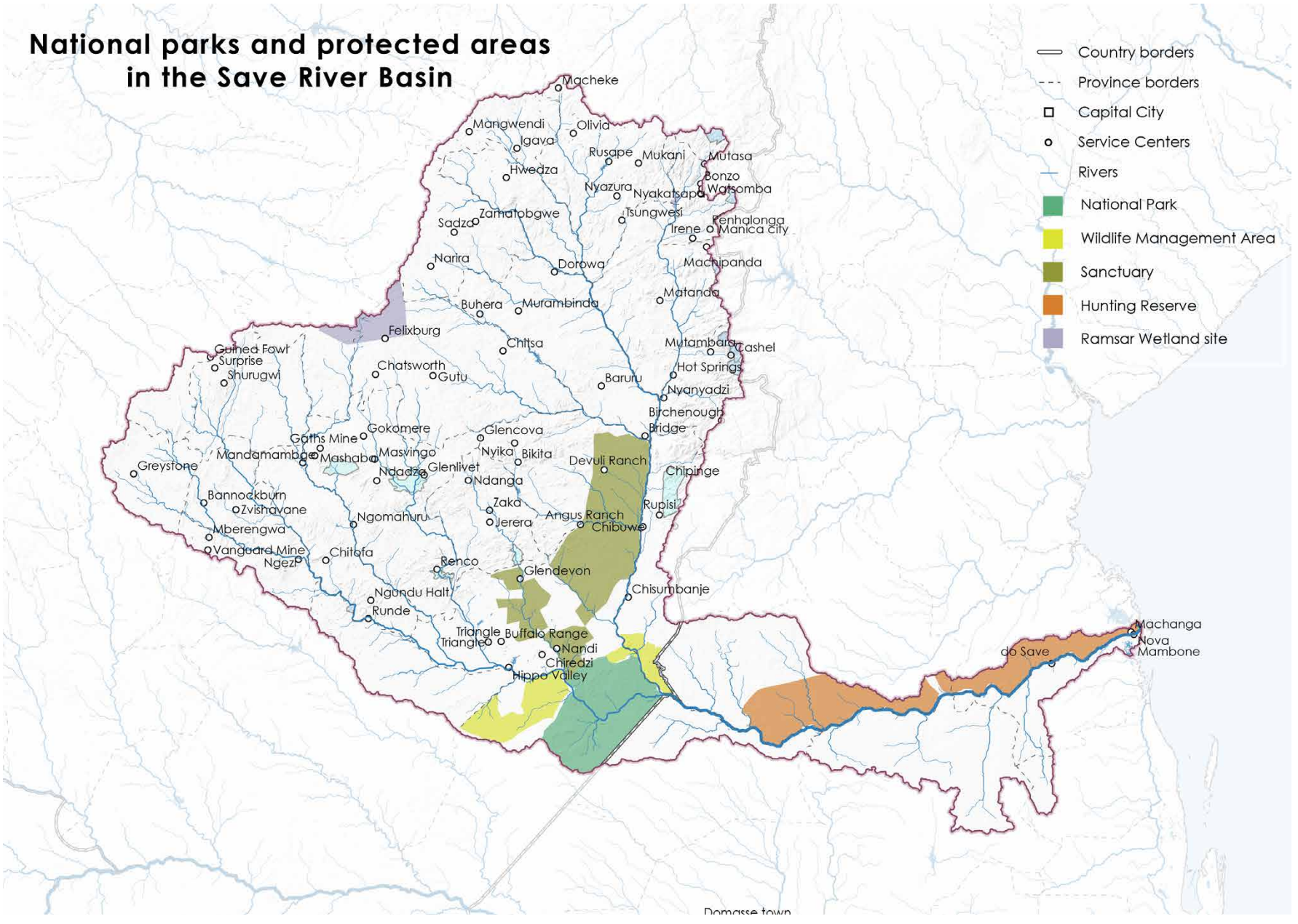


Figure 1.5 Save River Basin.

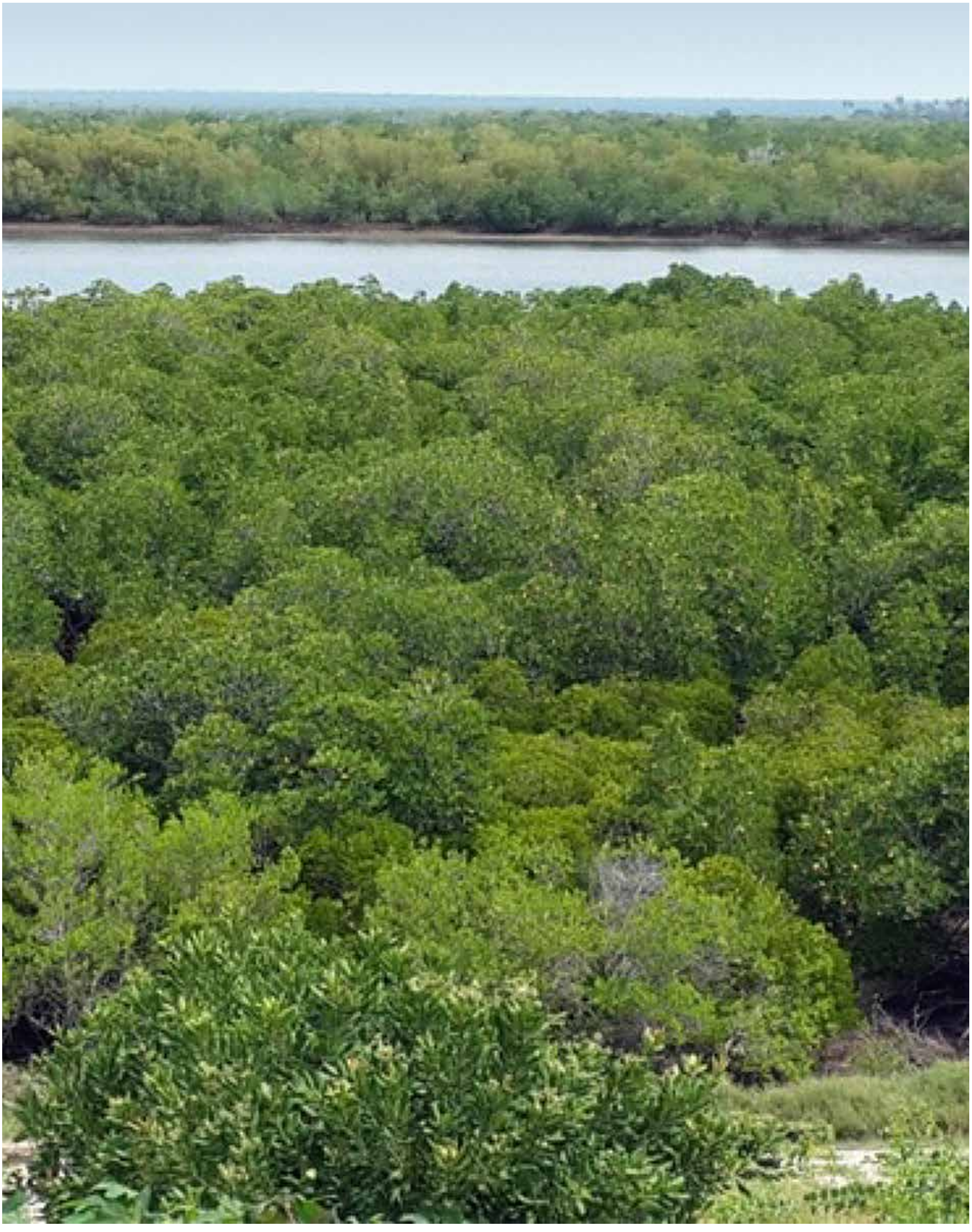
Source: COWI, 2011, Copyright: SARDC, GWPSA, GRID-Arendal 2024.

Marine Coastal Ecosystems

The coastal ecosystems are similar in all BUPUSA catchments, with the Buzi and Pungwe rivers linked together at the mouth and draining into Sofala Bay, near Beira. Mangroves are the dominant marine coastal ecosystems in the BUPUSA Tri-Basin. They are associated with tidal creeks and channels which are nursery grounds for many fish species, molluscs, and crustacea (GEF, 2020). Marine and terrestrial habitats are separated by salt marshes and periodically inundated by tides. Further upstream, outside the influence of tides, there are palustrine wetlands containing ocean-derived salts in concentrations of less than 0.5 parts per thousand.



The Pungwe Estuary, located in Beira, Mozambique - where the Pungwe River enters the Indian Ocean.
Photo: Fiona MacKay



A mangrove forest in the Buzi Estuary, at Beira, Sofala Province, in Mozambique.
Photo: Antonio Hoguane

1.3 Water Resources and Quality

1.3.1 Rainfall and Evaporation

The Mean Annual Rainfall (MAR) in the Pungwe River Basin ranges from about 900 mm/year towards the estuary to around 2,000 mm/year in the mountainous western part of the catchment (SWECO, 2006). In the Save River Basin, the rainfall ranges from 550 to 1,200 mm/year with an average of 685 mm/year (COWI, 2012). For the Buzi River Basin, the rainfall is highest in the western part of the basin (1,300 mm/year) and reduces to 900 mm/year in the southeast parts of the basin (SWECO, 2011). MAR in the Buzi River Basin is shown in Figure 1.6. In a similar fashion, MAR in the Pungwe River Basin is shown in Figure 1.7. In the same vein, the MAR in the Save Basin is shown in Figure 1.8.

Potential evaporation rates range between 1,380 to 1,590 mm/year in the Pungwe River Basin, 700 to 1,600 mm/year in the Buzi River Basin, and 1,450 to 2,500 mm/year in the Save River Basin.

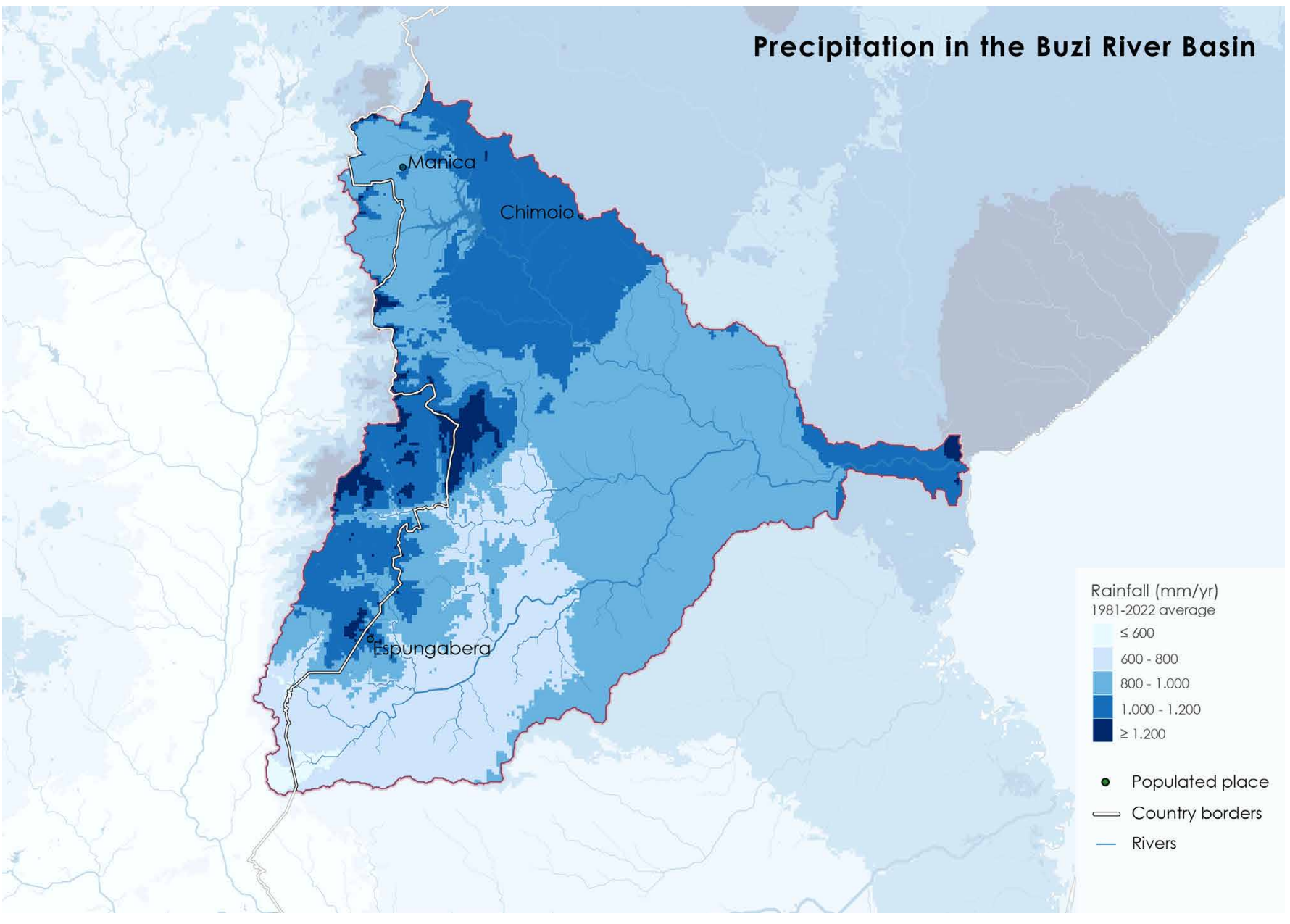


Figure 1.6: Buzi River Basin Mean Annual Rainfall.
Source: SWECO, 2011 Copyright: SARDC, GWPSA, GRID-Arendal 2024.

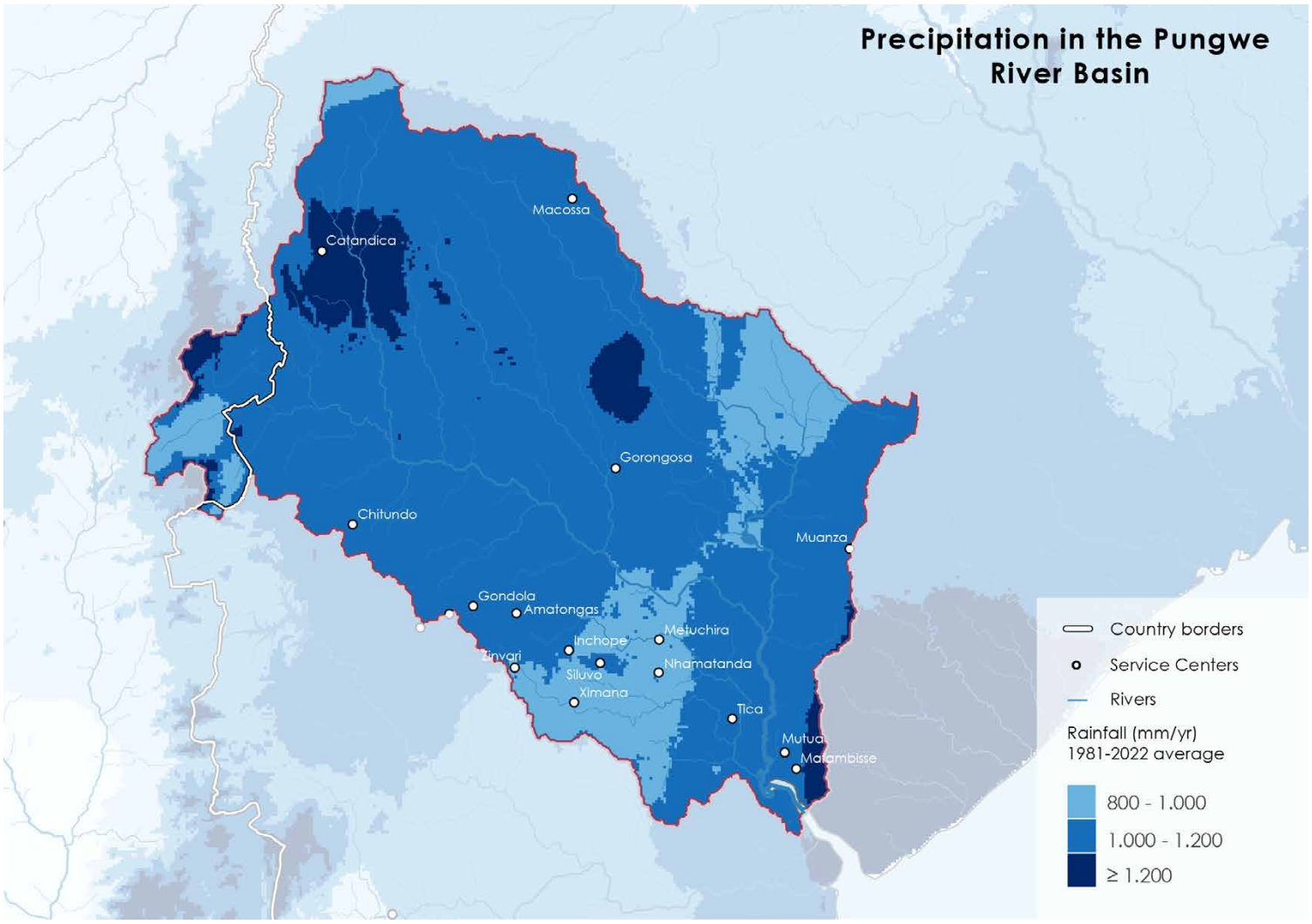


Figure 1.7: Pungwe River Basin Mean Annual Rainfall.
Source: SWECO, 2006.

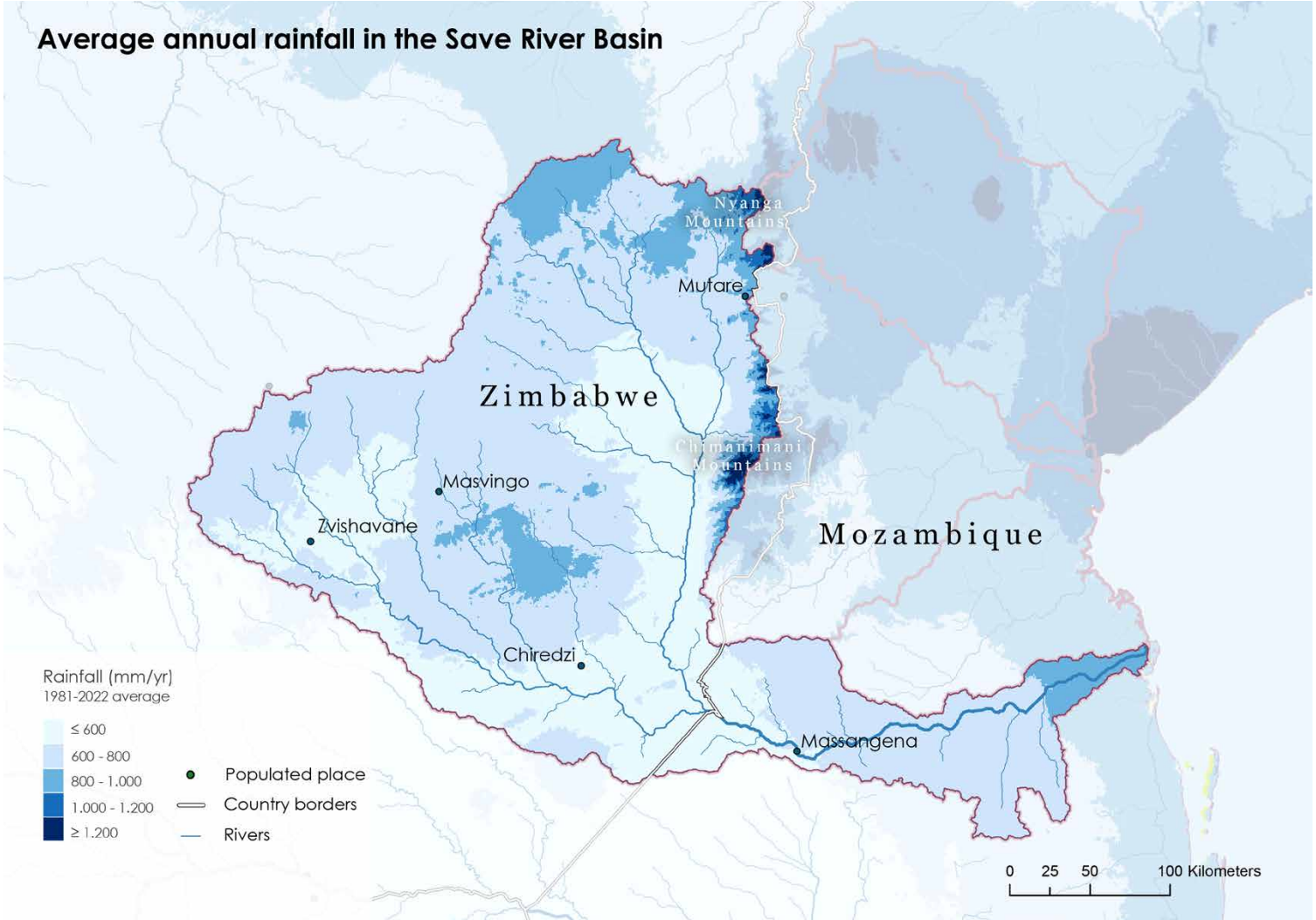


Figure 1.8: Save River Basin Mean Annual Rainfall.
Copyright: SARDC, GWPSA, GRID-Arendal 2024

1.3.2 Surface Water Resources



Photo: Piedade Alexandre

Buzi River Basin

The average surface water generation in the Buzi River Basin is 5,701 Mm^3/year (GWPSA, 2023a; Consultec, 2015). Table 1.3 gives details of the mean annual surface water generation in the Buzi River Basin.

Table 1.3: Mean annual surface water generation in Buzi River Basin

Sub-basin	Basin Area (km^2)	% of Basin Area	MAR (Mm^3/yr)
Revue, Zimbabwe	509	1.8	173
Lucite, Zimbabwe	1,539	5.3	582
Buzi, Zimbabwe	1,685	5.8	446
Sub-total Zimbabwe	**3,733**	**12.9**	**1,201**
Upper Buzi	4,487	15.5	898
Middle Buzi	4,330	15	411
Lower Buzi	3,260	11.3	189
Upper Lucite	3,250	11.3	1,124
Lower Lucite	1,880	6.5	267
Upper Revue	2,330	8.1	499
Middle Revue	2,460	8.5	451
Lower Revue	3,140	10.9	661
Sub-total Mozambique	**25,137**	**87.1**	**4,500**
Total BUZI	**28,870**	**100**	**5,701**

Source: GWPSA, 2023a; Consultec, 2015

Pungwe River Basin

The average water generation in the Pungwe River Basin is 4,450 Mm^3/year. Table 1.4 gives the details of Pungwe River Basin water generation.

Table 1.4: Mean annual surface water generation in the Pungwe River Basin

Sub-basin	Basin Area (km²)	% of Basin Area	MAR (Mm³/yr)
Pungwe, Zimbabwe	686	2.2	772
Honde, Zimbabwe	775	2.5	330
Sub-total Zimbabwe	**1,461**	**4.7**	**1,102**
Honde, Mozambique	469	1.5	200
Upper Pungwe	2,846	9.1	328
Nyazonia	1,360	4.4	442
Middle Pungwe	5,390	17.3	574
Vunduzi	3,439	11.0	499
Muda	1,336	4.3	160
Lower Pungwe	6,445	20.7	458
Urema	8,405	27.0	687
Sub-total Mozambique	**29,690**	**95.3**	**3,348**
Total PUNGWE	**31,151**	**100**	**4,450**

Source: Consultec, 2013

Save River Basin

The average surface water generation in the entire Save River Basin is 8,157 Mm³/year. Table 1.4 gives the details of Save River Basin water generation.

Table 1.5: Mean annual surface water generation in Save River Basin

Sub-basin	Basin Area (km²)	% of Basin Area	MAR (Mm³/yr)
Upper Runde	15,802	15.6	900
Lower Runde	5,802	5.7	179
Tugwi	7,947	7.8	543
Mutirikwe	7,941	7.8	477
Chiredzi	3,564	3.5	166
Devure-Nyazwidzi	8,153	8.0	768
Upper Save	17,791	17.5	2,041
Odzi	7,239	7.1	1,154
Lower Save	9,910	9.8	595
Sub-total Zimbabwe	**84,149**	**83.0**	**6,822**
Massagena	4,510	4.4	198
Conare	6,501	6.4	523
Save-Estuary	6,266	6.2	613
Sub-total Mozambique	**17,277**	**17.0**	**1,335**
Total SAVE	**101,426**	**100.0**	**8,157**

Source: GWPSA, 2023b; Hydroconsult, 2017

1.3.3 Groundwater Resources

Groundwater is mainly used by rural communities as a source of domestic water and smallholder irrigation. Groundwater availability in the entire Tri-Basin is largely guided by the existence of fractured rock or pockets of sedimentary rock. These rock types were formed across many geologic timescales, ranging mainly from pre-Cambrian to quaternary periods. The hydrogeological map of the Tri-basin is shown in Figure 1.9 below.

Groundwater availability shows quantities of 780 Mm^3/year in the Zimbabwean part of the Save River Basin, 1,257 Mm^3/year for the entire Buzi River Basin, and 1,628 Mm^3/year for the Pungwe River Basin (GWPSA, 2023a). Figure 1.10 gives the aquifer types and potential productivity levels for the Tri-Basin. These are quite variable across the Tri-Basin. For instance, Save is dominated by low productivity, but it also has areas of high productivity. However, there is need for more detailed technical studies to derive better estimates of the groundwater potential in the Tri-Basin and, more importantly, to better understand the surface water-groundwater interactions, particularly in the Save River Basin. The high levels of sedimentation and silt loads in the Tri-Basin further reinforce the need for comprehensive hydrological studies.

Unconsolidated intergranular aquifers are highly productive when they exist as extensive unconfined aquifers recharged by direct rainfall. These aquifers cover much of Mozambique, they occur in rivers, valleys, dunes, and coastal areas. The Save River Basin in Zimbabwe contains high-yielding aquifers associated with alluvial deposits. Quaternary alluvium is found in extensive floodplains of southeastern Mozambique and the infill of localised rift basins to the north. It is utilized for urban water supply in coastal areas of Mozambique. These aquifers exhibit relatively high permeability, and the water quality is deemed acceptable. With increasing proximity to the coast, there is an increasing potential for higher salinity, particularly in deep groundwater. Miocene carbonates also form suitable karstic aquifers which span approximately 25 000 km^2 south of the Save River, with the water table in this aquifer occurring at around 50m deep. However, the yields from crystalline basement rocks, volcanic formations, and indurated sediments are considerably lower, except in cases where well-developed weathered overlying layers are present.

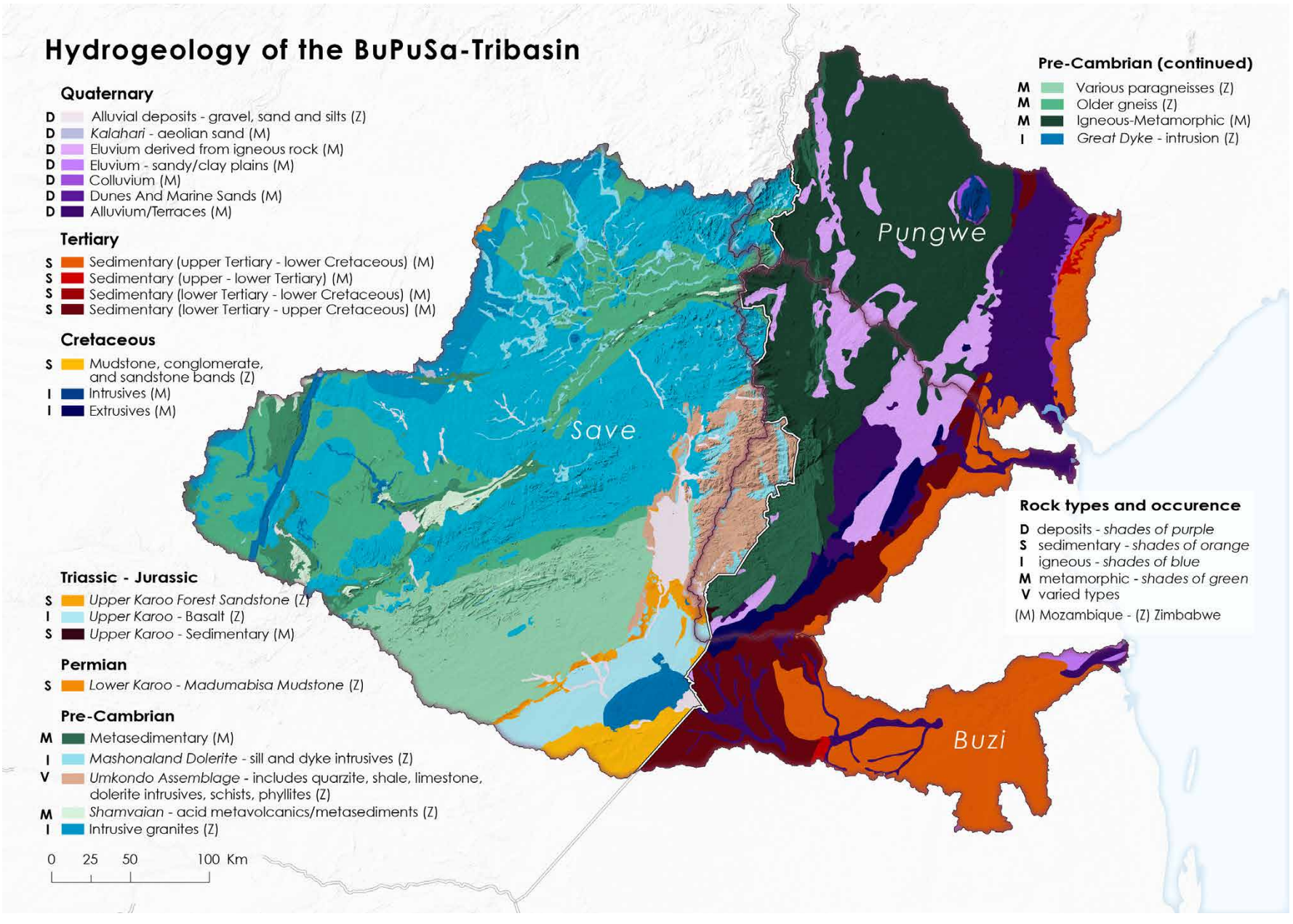


Figure 1.9: Hydrogeological map of the BUPUSA Tri-Basin.

Source: Pietersen et al., 2010, Copyright: SARDC, GWPSA, GRID-Arendal 2024.



Harnessing groundwater resources for the benefit of communities in the basin.
Photo: GEF-BUPUSA



Figure 1.10: The productivity of aquifers within the BUPUSA Basin. (L) = low productivity 0.01 – 1 litre/sec, (M) = moderate productivity 1 – 10 litres/sec, (H) = high productivity > 10 litres/sec.
Source: GWPSA, 2023), Copyright: SARDC, GWPSA, GRID-Arendal 2024.

1.3.4 Water Quality



Pollution of water resources from artisanal mining (left) and municipal/industrial wastes (right).
Photos: Piedade Alexandre and GWPSA, 2022

BUPUSA Tri-Basin water quality monitoring was largely unsystematic prior to 2000. As regular monitoring increased, trends of deteriorating water quality emerged at identified hotspots throughout the entire Tri-Basin. These hotspots are associated with large urban areas that discharge waste into public rivers or the presence of uncontrolled mining activities that may use toxic reagents to purify minerals. The parameters that are often used to determine water quality in the Tri-Basin are pH, coliforms, turbidity, ammonia, nitrates, phosphorous, nickel, copper, zinc, lead, and titanium (GWPSA, 2023a). While there are no universal standards for water quality determination, national standards or World Health Organization guidelines from either country are occasionally employed. Sedimentation is a significant concern as it diminishes the carrying capacity of rivers and water bodies. Sediments primarily result from soil erosion caused by inadequate catchment management practices. Monitoring of saline water intrusion is necessary in the estuaries of the Tri-Basin. Figure 1.11 illustrates the locations of water quality hotspots in the BUPUSA Tri-Basin, primarily attributed to land uses such as agriculture, urbanization, and artisanal mining.

Buzi River Basin

Traces of zinc and titanium exceeding the recommended standards have been recorded in the High Lucite and High Revue sub-catchments (GWPSA, 2022).

Pungwe River Basin

The water quality is generally good and complies with recommended national and international standards. However, elevated levels of iron, zinc, TSS, COD, and BOD indicate the need for more frequent monitoring and the implementation of measures to control pollution (GWPSA, 2022).

Save River Basin

The basin exhibits high levels of iron and TSS (GWPSA, 2022). Evidence of cyanide and mercury has been observed in proximity to alluvial gold mining sites.

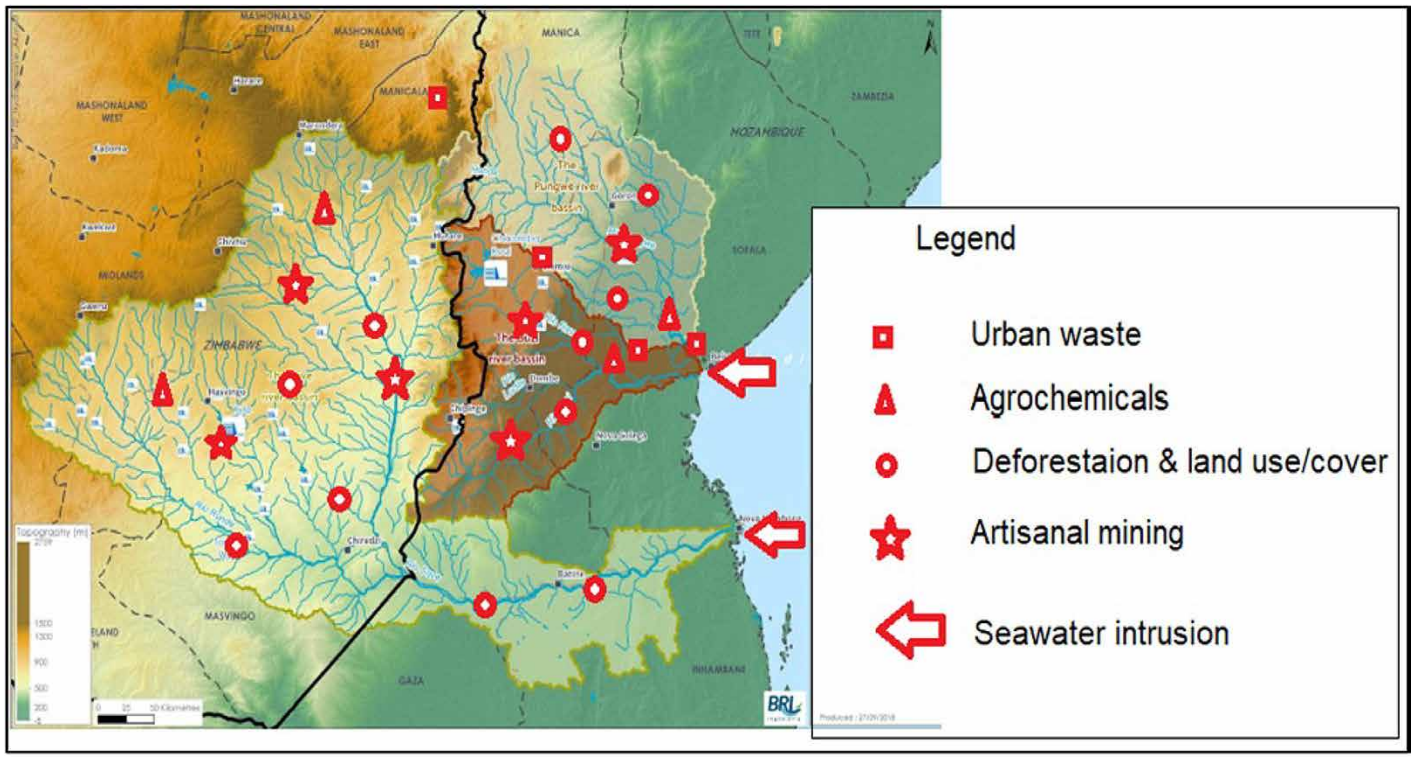


Figure 1.11: Location of Hot-spots for water quality in the BUPUSA Tri-Basin.
Source: Adapted and modified from GWPSA, 2022.

1.4 Social Characteristics

1.4.1 Population

Buzi River Basin

Based on the last available census figures, the estimated population for the Buzi River Basin in 2020 was 1,583,100 people with 86 percent and 14 percent living in Mozambique and Zimbabwe, respectively (COWI, 2012). The basin population is characterised by a moderate density and a largely rural population. The only main urban areas are Beira and Chimoio in Mozambique and two smaller towns in Zimbabwe, namely Chipinge and Chimanimani. The main population trends in the basin include: urbanization, concentrated in and around main urban centres such as Chimoio, Manica and Buzi in Mozambique and Chipinge in Zimbabwe, and around some smaller towns and district centres in the basin; and in Mozambique, migration from the south and central to the northern part of the basin, primarily to areas in and near the Beira Corridor (SWECO 2013). Figure 1.12 shows the population densities of the Buzi River Basin.



Increasing population growth will require more efficient use of available water resources in the BUPUSA Tri-Basin.

Photo: C. Mavhunga

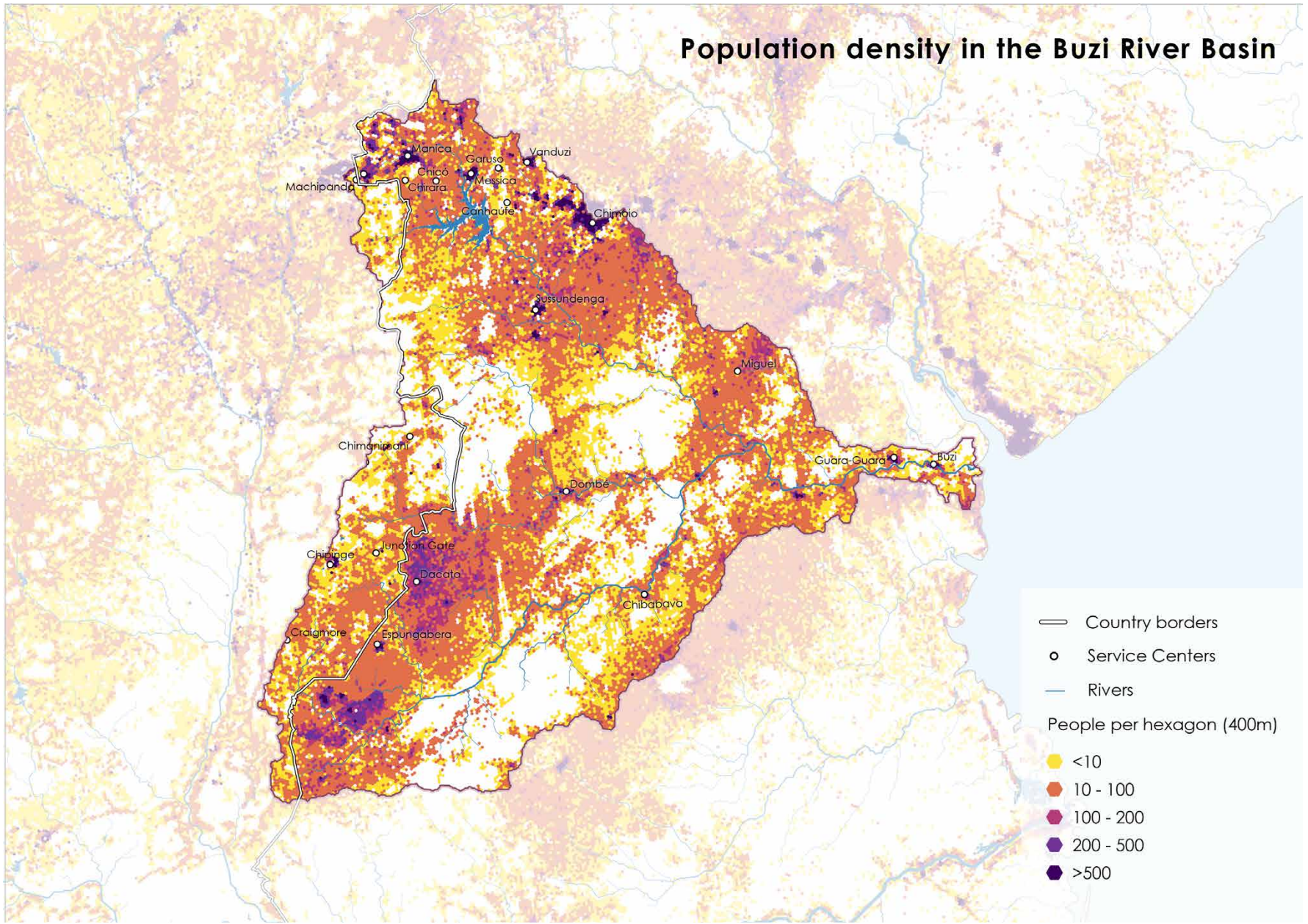


Figure 1.12: Population density in the Buzi River Basin.

Copyright: SARDC, GWPSA, GRID-Arendal 2024.

Pungwe River Basin

In 2020, the population of the Pungwe River Basin was 1.9 million, with 96 percent living in Mozambique and 4 percent in Zimbabwe (Southern Waters, 2023). Demographic analysis in the Pungwe shows that the male population is higher in the cities compared to rural areas. Some rural districts in Sofala Province such as Dondo, Inhaminga, and Muanza show higher male populations. This could be attributed to their proximity to the metropolitan area of Beira/Dondo and the presence of the Mafambisse Sugar Refinery, which provides more employment opportunities for males (COWI 2011). Figure 1.13 shows the population densities across the Pungwe River Basin.

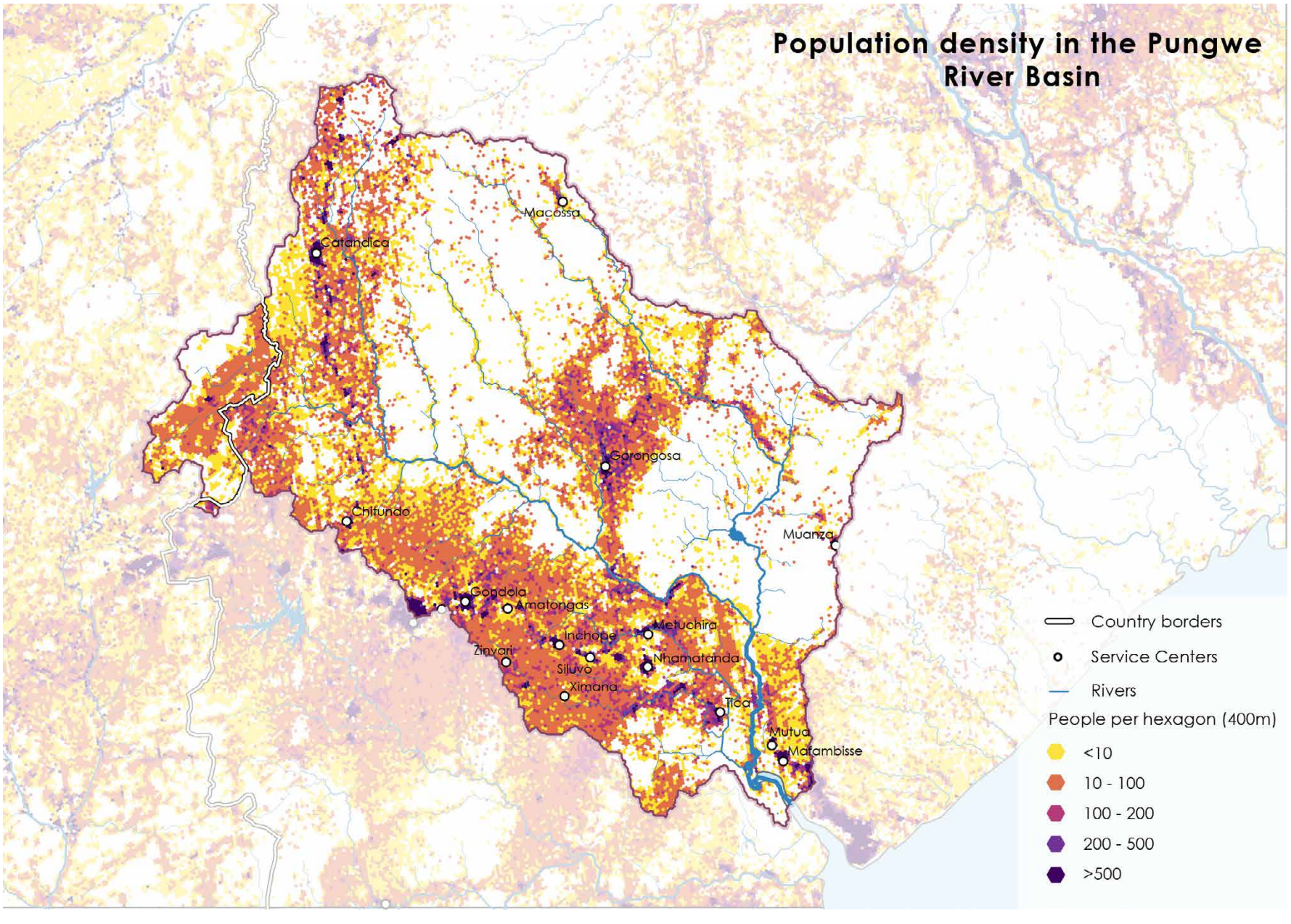


Figure 1.13: Population density/persons/km^2 across the Pungwe River Basin.

Copyright: SARDC, GWPSA, GRID-Arendal 2024.

Save River Basin

The Save River Basin had a projected estimated population of 3.17 million in 2020, with 95 percent residing in Zimbabwe and 5 percent in Mozambique (COWI, 2013). As highlighted, the majority of the population is concentrated in Zimbabwe's rural areas, with the rest found in a few service centres and larger towns within the basin. Figure 1.14 shows the population densities across the Save River Basin.

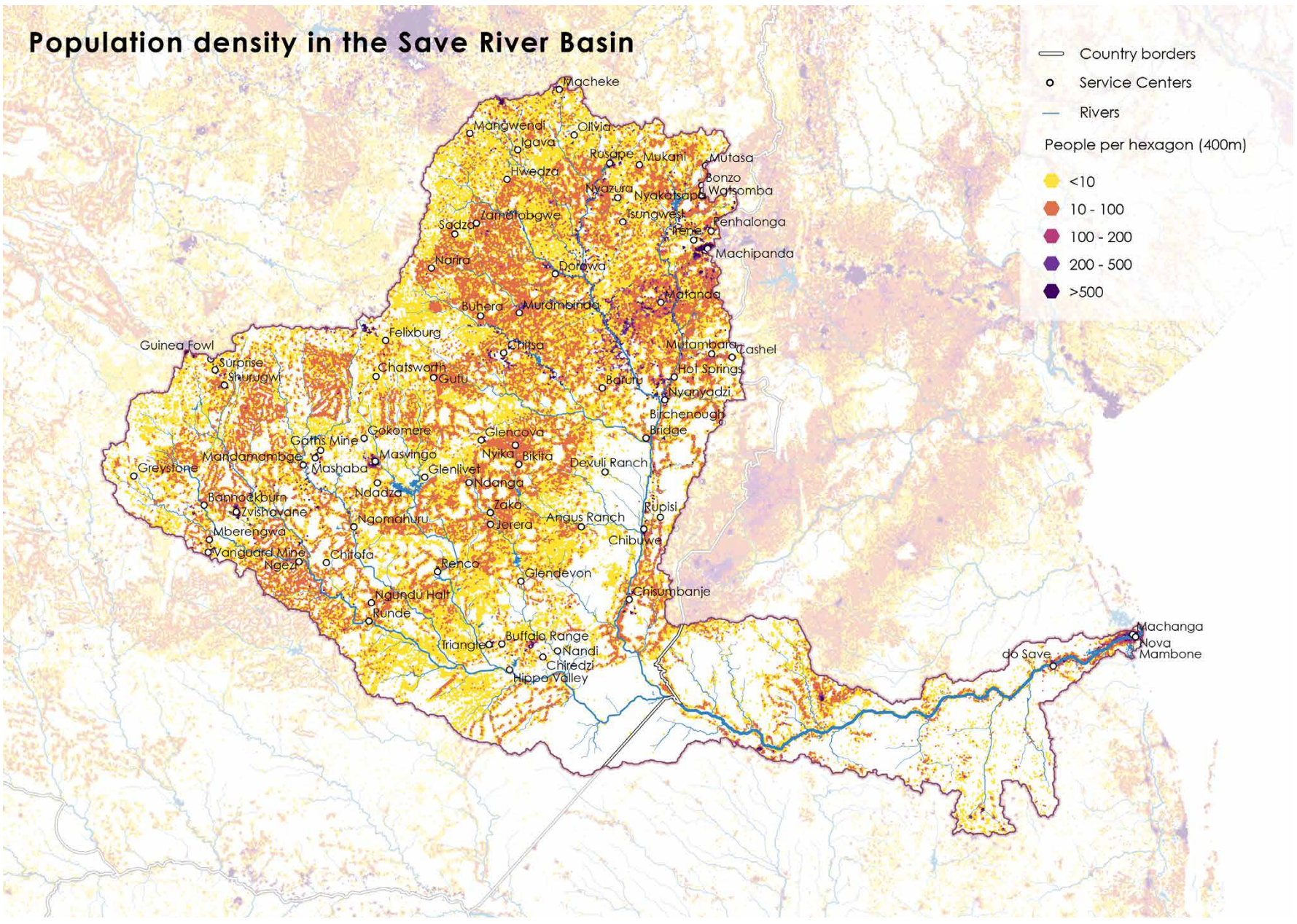


Figure 1.14: Population Densities in the Save River Basin.

Copyright: SARDC, GWPSA, GRID-Arendal 2024.

There is a sizable distribution of schools and health centres in the Buzi, Pungwe, and Save River Basins. These are shown in Figure 1.15. Most of the health centres are located in urban areas, with rural areas lagging behind in terms of access to education and health services.

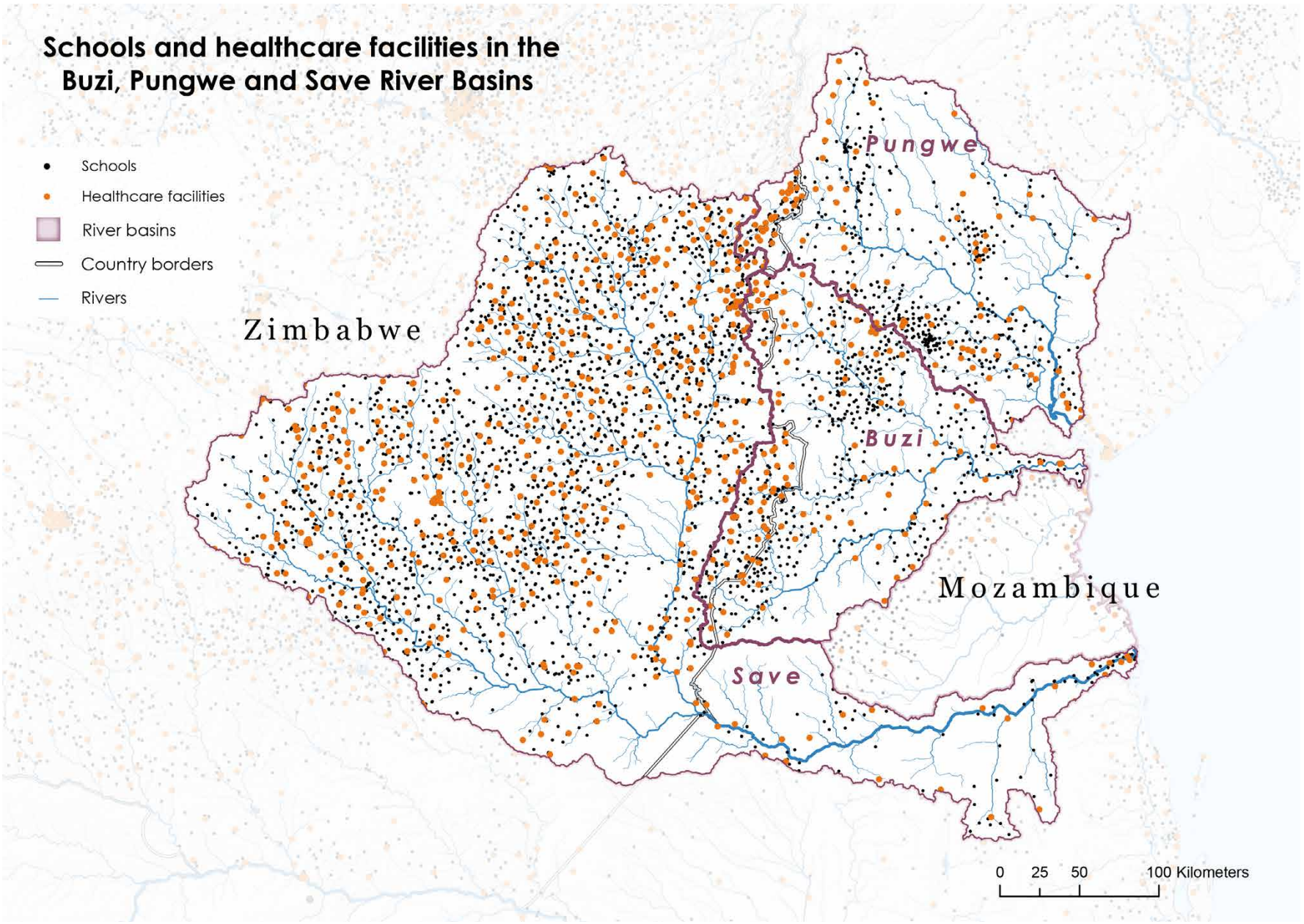


Figure 1.15: Schools and health facilities in the Buzi, Pungwe, and Save River Basins.
Copyright: SARDC, GWPSA, GRID-Arendal 2024.

1.4.2 Socio-Economic Activities



Communities derive income from sale of handcraft items in the BUPUSA Tri-Basin.
Photo: Gywn Letley

Buzi River Basin

The main socio-economic activities in the Buzi Basin are agriculture, both livestock and cropping, tourism, and industry (SWECO, 2013). For agriculture, activities are also in the form of small vegetable gardens, fruit cultivation, sugar cane farming, and vegetable production. On the Zimbabwean part of the Buzi River Basin, irrigation schemes have been established to harness high rainfall in the area and the prolonged seasonal river flows. The basin is also home to commercial coffee and tea estates, avocado pear orchards, and macadamia farming. These agricultural ventures, along with the potential for fruit canning, offer opportunities for employment to communities in Zimbabwe. The Vumba and Chimanimani mountains are major tourist attractions in the basin. Further downstream, fisheries are also a significant livelihood option. Additionally, artisanal small-scale mining has also been observed in the basin. On the Mozambican side, there is considerable untapped agricultural land with suitable soils for forestry and wildlife. Illegal artisanal mining has been identified in the lower part of the basin and there is need to formalise and regulate these activities. Large mining corporations have expressed interest in prospecting and extracting valuable minerals like gold, lime, coal, iron, asbestos, bauxite, diamonds, and natural gas. It is important to ensure that these mining endeavours contribute meaningfully to the economic development of this region within the Tri-Basin.

Pungwe River Basin

Economic activities in the Pungwe River Basin are dominated by commercial and subsistence agriculture, fishing, and forestry (Figure 1.13). Irrigated agricultural production is practiced by communities who are located adjacent to streams with perennial rivers, ensuring a year-round supply of irrigation water. Bananas, avocado pears, sugar cane, yams, beans, vegetables, and maize are the major crops which also have significant markets in the large urban centres (Southern Waters, 2023).



Home gardens planted in the floodplains as a source of livelihood in the Pungwe River Basin, Mozambique.
Photos: Gwyn Letley



A wide variety of fish are caught and sold at the fish market to raise income in the Pungwe River Basin, Mozambique.
Photos: Gwyn Letley

Besides agriculture and fisheries, charcoal production and mining contribute to the livelihood options in the area. However, it is important to closely monitor mining practices due to evidence of increasing pollution in river systems associated with these activities. Deforestation is also a concern, primarily driven by charcoal production as the predominant alternative energy source.

The Pungwe River Basin in Mozambique holds immense untapped potential that remains largely undeveloped. It has potential for irrigated agriculture, tourism, and wildlife development. Economic activities among basin communities are largely agro-based (SWECO, 2006). Currently, most of the agricultural activities are subsistence farming, although smallholder irrigation schemes are implemented in areas with reliable river flows. The activities include crop and livestock production, forestry, fisheries, gold mining, and ecotourism. Agriculture is a mixture of subsistence dryland farming and irrigated crop cultivation. Investors have recently shown interest in large-scale commercial farming within the basin. Additionally, the Pungwe catchment also forms a large part of the Beira Corridor, which experiences high regional traffic and the large number of urban settlements and rural service centres along the corridor create micro-economic activities.

The western part of the Pungwe River Basin in Zimbabwe receives very high rainfall, leading to the development of intensive commercial and small-scale agriculture in the area (SWECO, 2006). These include large-scale commercial plantations for coffee, tea, and forestry. Tourism also contributes significantly to the economy of the basin, with the Pungwe, Mutarazi Falls, and Mt Nyangani being the most popular attractions.

The central part of the basin in Mozambique is more sparsely populated. Gorongosa National Park and other wildlife safari activities generate tourism opportunities in the area. In addition to tourism potential, the lower Pungwe River Basin in Mozambique has vast sugar cane plantations, prawn industries, and fisheries.

Save River Basin

The Save River Basin is characterised by high poverty levels, ranging from between 40 to 80 percent (COWI, 2012). Most of the communities rely on subsistence rainfed farming, with maize being the dominant agricultural crop. Fishing is also a significant alternative livelihood, particularly in the lower parts of the basin. However, extreme weather and climate-related events due to climate change and variability expose most of the communities as their livelihoods are climate-sensitive.



Communal ginger farming in Chadzuka, Manica, Mozambique.
Photo: Moses Makwanise/IUCN

1.4.3 Gender, Equity and Social Inclusion

Across all the BUPUSA Tri-Basin, efforts towards social inclusion are slowly being realised. Women and children are being given more attention, although more can still be done. Studies have indicated the presence of sufficient policies, laws, strategies, and plans to promote gender equality in the assessed sectors of Mozambique and Zimbabwe. Both countries have ratified the international, continental and regional instruments, such as the Beijing Declaration on the Platform for Action (1995), the 2030 SDGs, the African Charter on Human and People's Rights on the Rights of Women, and the SADC Protocol on Gender and Development, among others. Of significance is the existence of National Gender Policies and accompanying implementation strategies and action plans (in the case of Zimbabwe) which provide specific actions for mainstreaming gender in all sectors. The only challenge noted from literature for both countries is enforcement and implementation of the stipulated provisions and actions (GWPSA 2023b). The River System Plans in both Mozambique and Zimbabwe emphasise the need for gender balance in water resources management.

The Community Based Management Projects and the Small Grants Projects awarded to communities in the Tri-Basin (COWI, 2012) are a success story which should be upscaled. Typical sites that benefited from this support include Rujeko, Chidzinzwa, Mbindangombe, and Kufandada Irrigation Schemes in Zimbabwe, and the Tica, Tambawaguta, Catandica, and Chibabava projects in Mozambique. There is need for more Community Projects through Technical Assistance and Small Grants with more bias towards women and the socially marginalised groups.

1.4.4 Culture and Heritage

Buzi River Basin

Besides dance and music, there are other aspects of culture found in the Buzi River Basin such as rock art. This is evidenced by sites at Chinhamapere and Moucondhiwa in the Vumba Mountains, where ancient rock paintings are still visible. These sites are crucial pointers of culture and heritage in the basin as they are also communication points between communities and their ancestors. Rainmaking and control ceremonies, for example, are carried out at some of the sites within the Vumba Mountains (Holzhausen, 2007).

Pungwe River Basin

The Pungwe River Basin has rich cultural and heritage values. To the west, on the Zimbabwean side, there are several sacred sites and shrines. These include the Nyanga National Park, Nyangani Mountain, Pungwe Falls, and Mutarazi Falls. The Mutarazi Falls are Africa's second highest waterfalls (Southern Waters, 2023). The Pungwe and Honde river valleys share pristine water throughout the year. Further downstream on the Mozambican sides, the Gorongosa National Park has the advantage of the Pungwe floodplains which offer rich heritage sites.

Lake Urema, along the Pungwe River in Mozambique, is also a scenic site for water sport including fishing along with safari hunting. A variety of wildlife can be viewed in this National Park. The basin also forms part of the history of the liberation of Zimbabwe as strategic bases for freedom fighters were located in the mountains along the basin. Both Mozambique and Zimbabwe governments have agreed to establish shrines around these bases.



The Pungwe Falls in Nyanga National Park, Zimbabwe.
Photo: SWECO, 2004

Save River Basin

There are several cultural and heritage sites in the Save River Basin. These are dominated by protected forest areas with diverse species such as montane forest grassland mosaic, Southern Africa bushveld and Zambezian coastal flooded savannah, as well as modest extensions of East African mangroves, Southern Zanzibar-Inhambane coastal forest mosaic which occur in the coastal area (COWI, 2012). Figure 1.16 shows some heritage and protected sites in the Save River Basin.



Spiritual dances: Espungabera (Save River Basin) Mozambique.
Photos: Bettina Holzhausen

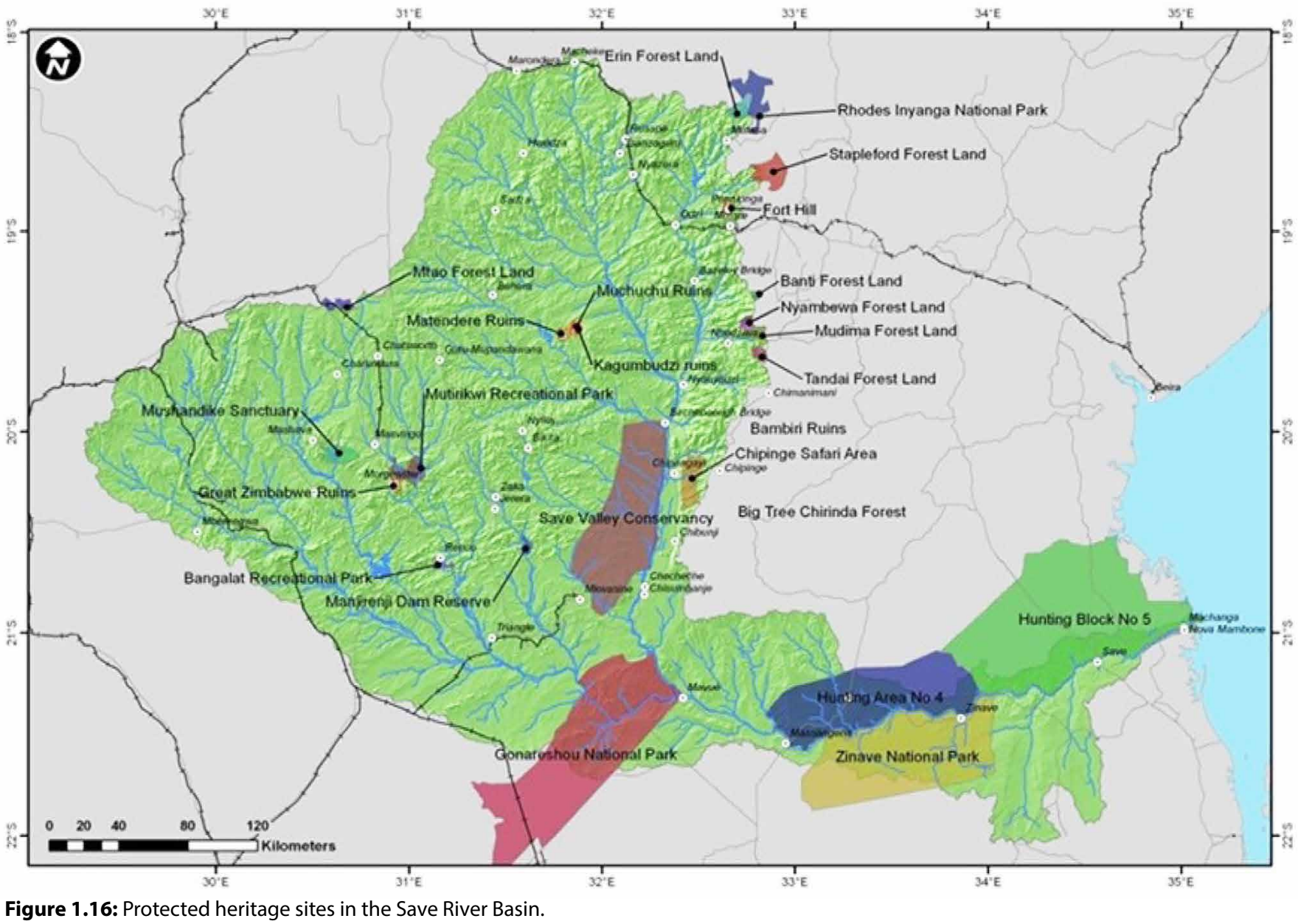


Figure 1.16: Protected heritage sites in the Save River Basin.
Source: COWI, 2012.

1.5 Institutional Set-up

Africa has 54 shared River Basins, of which 28 percent are in the SADC region. River basin water management is implemented through the SADC Revised Protocol on Shared Watercourse of 2000, with the objective to: achieve sustainable, equitable and reasonable utilization of water resources; protection, preservation and conservation of the environment; and prevention and mitigation of significant harm. This paved the way for the creation of River Basin Organisations (RBOs), with the aim to efficiently, effectively and transparently manage water resources between two or more countries. The Bi-national BUPUSA Tri-Basin projects are perfectly in sync with the vision of SADC. The BUPUSA Watercourse Commission was formerly established on 17 May 2023 when the Establishment and Hosting Agreements were signed by the Governments of Mozambique and Zimbabwe, and the BUPUSA Secretariat was formally launched on 19 July 2023 in Beira, Mozambique. The Tri-Basin governance and operational activities are predicated on existing relevant national institutions, as presented in Table 1.6.



ARA Centro IP is one of the key institutions that support water resources management in the BUPUSA Tri-Basin.
Photo: Moses Makwanise/IUCN

Table 1.6: BUPUSA Tri-Basin Governance and Operational Activities

Sub-basin	Institution	% of Basin Area	Responsibility
Mozambique	Ministry of Public Works, Housing, and Water Resources	Government arm responsible for water affairs	Oversight on matters related to water resources planning, development and management locally and internationally among others
	National Directorate of Water Resource Management (DNGRH)	Falls under the Ministry of Public Works, Housing, and Water Resources	Water resources planning and management
	ARA Centro, IP	River basin management agency	Implementing agency under DNGRH
	ARA-Sul, IP	River basin management agency	Implementing agency under DNGRH
	National Institute for Disaster Management and Risk Reduction (INGD)	INGD operates under the Prime Minister's Office	Disaster (floods and droughts) management
	Catchment and Sub-Catchment Councils	Operate under ARA-Centro, IP and ARA-Sul, IP	Delegated powers for water resources management at local level
Zimbabwe	Ministry of Lands, Agriculture, Fisheries, Water and Rural Resettlement (MLAFWRR)	Government arm responsible for water affairs	Oversight on matters related to water resources planning, development and management locally and internationally among others
	The Department of Water Resources, Planning and Irrigation Development (DWRPID)	A department within MLAFWRR	Responsible for policy direction and regional cooperation in the Ministry.
	The Zimbabwe National Water Authority (ZINWA)	Reports to DWRPID	Water resources development and management
	Department of Civil Protection (DCP)	Reports to Ministry of Local Government and Public Works	Disaster preparedness. In the event of disasters, the Department of Civil Protection steps up to coordinate disaster management efforts.
	Catchment and Sub-Catchment Councils	Operate under ZINWA	Delegated powers for water resources management at local level

Source: GWPSA, 2023c

1.6 Transboundary aspects of the Buzi, Pungwe, and Save River Basins



Photo: Gwyn Letley

1.6.1 Use of Water Resources

Buzi River Basin

The water use sectors in Buzi River Basin are rural, urban, livestock, irrigation and industry. The total water demand in the basin is 334.39 Mm^3/year as presented in Table 1.7 (GWPSA, 2023a).

Table 1.7: Estimated water demand in the Buzi River Basin in 2020 in Mm^3/year

Sub-basin	Rural	Urban	Livestock	Irrigation	Industrial	Total
Revue, Zimbabwe	0.32	–	0.29	61.00	2.40	64.01
Rusitu, Zimbabwe	1.75	0.64	0.38	89.00	1.50	93.27
Buzi, Zimbabwe	2.44	2.35	1.31	103.00	2.00	111.10
Sub-total Zimbabwe	**4.51**	**2.99**	**1.98**	**253.00**	**5.90**	**268.38**
Upper Revue	0.96	28.40	0.36	2.00	0.50	32.22
Middle Revue	0.67	–	0.34	2.00	0.30	3.31
Lower Revue	0.67	–	0.41	3.00	0.40	4.48
Upper Lucite	0.54	–	0.47	1.00	0.20	2.21
Lower Lucite	0.54	–	0.23	1.00	0.10	1.87
Upper Buzi	0.93	–	0.63	1.00	0.20	2.76
Middle Buzi	0.72	–	0.47	–	0.30	1.49
Lower Buzi	0.72	–	0.25	14.00	2.70	17.67
Sub-total Mozambique	**5.75**	**28.40**	**3.16**	**24.00**	**4.70**	**66.01**
TOTAL BUZI	**10.26**	**31.39**	**5.14**	**277.00**	**10.60**	**334.39**

Source: GWPSA, 2023a

Pungwe River Basin

The major water use sectors in the Pungwe River Basin are urban, rural, irrigation, livestock, recreation and industry. The total water demand in 2020 was approximately 810 Mm^3/year (Table 1.8).

Table 1.8: Estimated water demand in the Pungwe River Basin in 2020 in Mm^3/year

Sub-basin	Urban	Rural Water	Irrigation	Livestock & Tourism	Industry	Total
Pungwe, Zimbabwe	112	–	66	–	–	178
Honde, Zimbabwe	–	11	42	–	–	53
Sub-total Zimbabwe	**112**	**11**	**108**	**–**	**–**	**231**
Upper Pungwe	–	–	5	–	–	5
Nyazonia	–	–	75	–	–	75
Middle Pungwe	–	9	44	5	32	90
Muda	–	–	34	–	–	34
Lowe Pungwe	92	–	276	–	7	375
Sub-total Mozambique	**92**	**9**	**434**	**5**	**39**	**579**
TOTAL PUNGWE	**204**	**20**	**542**	**5**	**39**	**810**

Source: GWPSA, 2023

Save River Basin

The major water use sectors in the Save River Basin are irrigation, urban, rural, mining, and livestock. The estimated water demand in 2020 was 7,845 Mm^3/year (Table 1.9) (GWPSA, 2023a).

Table 1.9: Estimated water demand in the Save Basin in 2020 in Mm^3/year

Sub-basin	Irrigation	Urban	Rural	Mining	Livestock	Others	Total
Save Zim	1,838	14	81	5	210	25	2,173
Runde	5,190	63	54	16	153	4	5,480
Sub-total Zimbabwe	**7,028**	**77**	**135**	**21**	**363**	**29**	**7,653**
Massangena	43	4	3	40	1	3	94
Covanne & Estuary	94	–	3	–	1	–	98
Sub-total Mozambique	**137**	**4**	**6**	**40**	**2**	**3**	**192**
Total SAVE	**7,165**	**81**	**141**	**61**	**365**	**32**	**7,845**

Source: GWPSA, 2023a



Dry river bed along the Save River Basin in Chiredzi, Zimbabwe.
Photo: Melisa Matavire-Mavenge

1.7 Disaster risk and vulnerability



Infrastructure was extensively damaged as a result of Tropical Cyclone Idai in Mozambique and Zimbabwe.
Photo: Abel Muchedzi/ZINWA

Communities in the entire BUPUSA Tri-Basin have common risk factors, with varying degrees of severity.

Extreme weather events

The entire BUPUSA Tri-Basin is vulnerable to droughts, with the Save River Basin in Zimbabwe being the most susceptible. Between 1982 and 2011, drought occurred in 60 percent of the natural disasters experienced in Zimbabwe (GoZ, 2020). This is similar to experiences in Mozambique, but with less severity. The majority of communities in the BUPUSA Tri-Basin rely on rainfed subsistence agriculture as their main source of livelihood, with few alternative options. When droughts occur, their impacts are devastating and can last beyond a single season.

In general, Mozambique experiences a higher frequency of tropical cyclones and associated floods compared to Zimbabwe, with coastal areas being affected almost every year. The impacts of floods, especially those generated by cyclones, are more damaging with almost instant losses of lives and livelihoods. Flooding has also been on an increasing trend on the Zimbabwean side of the BUPUSA Tri-Basin as evidenced by Cyclones Eline (2000), Desmond (2019), Idai (2019), Chalane (2020/2021), Eloise (2021), Ana (2022), and Freddy (2023).

Throughout the BUPUSA Tri-Basin, flood and drought management systems are generally inadequate, which leaves communities vulnerable to the extreme events. In the recent past, Cyclones Eline and Idai are, so far, probably the worst in terms of damage and casualties. There is, therefore, a need to develop and implement robust early warning systems and disaster management plans to effectively address the diverse levels of severity of these extreme events.

Climate change and variability

Climate projections indicate increasing impacts of climate change and climate variability in the southern African region. For the BUPUSA Tri-Basin, predictions suggest an increase in the occurrence of dry spells and prolonged periods of drought, accompanied by increased frequency of floods coupled with a general rise in temperature. These projections imply a higher demand for water in agricultural practices due to higher evaporation in an otherwise water scarce region. Consequently, this increases vulnerability to food insecurity.

Illegal activities

Several hostile activities which expose communities to social vulnerability have been observed in the Tri-Basin. These include pollution of river water through dumping of pollutants, excessive use of pesticides and herbicides, uncontrolled riverbank mining, and land degradation and illegal settlements. All these contribute to loss of soil fertility, poor water productivity, and compromises human and ecosystem health. Water quality monitoring should be systematically conducted, with law enforcement measures being applied against polluters.

1.8 Energy Generation

In the BUPUSA Tri-Basin, the primary energy sources are Chicamba and Mavuzi hydropower schemes in the Buzi catchment in Mozambique, generating 44 MW and 52 MW respectively. However, the energy demand in the basin exceeds the current supply. The Cahora Bassa and Kariba Dams, on the Zambezi River, provide most of the hydropower output in the two countries. Despite this, many consumers face challenges of limited availability and affordability, leading them to rely on wood fuel to compensate for the energy deficit. This has negative environmental impacts in the medium to long term. More sustainable energy sources are mini hydropower schemes that take advantage of the steep slopes and perennial river flows, particularly along the Zimbabwean Eastern Highlands. Currently, nine mini-hydropower schemes are licenced and generate a combined 31.26 MW. Another eight schemes are planned so as to further advance the development of sustainable sources in the region.



Chicamba hydropower scheme in the Buzi catchment in Mozambique.
Photo: Kevin Pietersen

1.9 Biodiversity Hotspots



Baobab tree in Nyanyadzi, around the Save Basin in Zimbabwe a land degradation hotspot.
Photo: Moses Makwanise, IUCN

The BUPUSA Tri-Basin is rich in biodiversity which can be attributed to its diverse physiography. This ranges from high altitude in the west to the coastal region at the mouths of the three river systems and other areas of the wetlands. The highlands receive high rainfall that supports aquatic life throughout the year, while the coastal regions host a combination of flora (including mangroves) and fauna that benefit from the oceanic climate. In between are drier areas that host wildlife and dryland activities during most of the year.

More than 80 species of freshwater fish are believed to exist in the Buzi catchment (SWECO, 2011). The Pungwe catchment has the rare trout fish species while the coastal zone is rich in shrimps and prawns. Similarly, more than 500 bird species are found in the Tri-Basin. The Environmental Flows Assessment, which was conducted in parallel to the development of this Basin Atlas, aimed to explore the actual extent of biodiversity in the Pungwe River Basin. Similar assessments will be conducted for the Buzi and Save River Basins in the future.

The major threats to biodiversity and riverine ecosystems include: poor agricultural practices resulting in loss of soil and nutrients; streambed mining activities resulting in high sediment loads and pollution from heavy metals; uncontrolled settlements in sensitive areas; and poorly managed forestry activities.

Typical hotspot threat areas for biodiversity conservation include north-west Manica, south of the Chimoio-Machipanda Border, Mossurize, Estaquinha, and the Rusitu River for the Buzi River Basin. In the Pungwe River Basin, sensitive areas are found around Gorongosa and Nyangani Mountains. Similarly, in the Save River Basin, hotspot threat areas include portions of the river systems around urban centres and mines.

The coastal zone, which is home to bird sanctuaries and marine life, is also sensitive and prone to environmental damage. Siltation and sediment loads are also a major threat to water bodies in the entire BUPUSA Tri-Basin, with saline water estuary intrusions now becoming a cause for concern



Conservation efforts are required to preserve wildlife resources for future generations. An elephant spotted in Gorongoza National Park, Mozambique.
Photo: Kevin Pietersen

1.10 Economic Cooperation

Economic development between Mozambique and Zimbabwe is largely guided by the recent policy pronouncements in both countries as enshrined in the SADC Regional Indicative Strategic Development Plan (SADC, 2020) for the period 2020 to 2030. Mozambique has adopted its Agenda 2025 and National Development Strategy for period 2015 to 2035, while Zimbabwe is guided by its Vision 2030 and National Development Strategy 1 for the period 2021 to 2025 (NDS1). These aim to promote industrialisation and modernisation in both countries, which can also have a positive impact on the Bi-National BUPUSA Tri-Basin. The aspirations of both countries can be realised if strategies are developed to systematically support critical areas that drive the economies. These include tourism, mining, and agriculture. To realise economic success, investments towards energy security are critical (COWI, 2012).

The BUPUSA projects are built on the provisions of the 2002 Joint Water Commission (JWC) between Mozambique and Zimbabwe. These projects are guided by the principles of Integrated Water Resources Management, aiming to optimize the use of available water resources and unlock economic benefits for the region.

The Beira Corridor, which connects the Indian Ocean to many SADC countries, holds strategic importance for the economic development of Mozambique, Zimbabwe, and the entire region. The Corridor has excellent basic transport infrastructure which includes a highway, railway, and a fuel pipeline. These facilitate the import and export of goods for the SADC region. However, further development of the corridor is necessary to accommodate the growing socioeconomic activities in the area.



Beira Corridor of Mozambique is a natural transport corridor between the coast and neighbouring inland countries in the region.
Photo: Zitamar News

1.11 Regional Integration

On their own, most of the southern African economies are comparatively small, agriculturally based, and primary commodity exporters with only incipient industrial development (GDI, 2000). Therefore, there is need for concerted efforts to attract the necessary financial and technology resources to support a sustained industrialisation process. The BUPUSA Tri-basin is representative of the several shared watercourses in the SADC region. The Save river basin on the Zimbabwean side has the largest number of dams and there is potential for any unutilised water to be exported to other basins in the region depending on need.



Highway crossing the Pungwe River in Mozambique stretching from Beira, Mozambique to the central interior. The road links Mozambique with its neighbouring countries Malawi, Zambia, and Zimbabwe.
Photo: Moses Makwanise, IUCN

1.12 Ecosystem Services

The BUPUSA Tri-Basin has a combination of natural and manmade facilities that provide direct and indirect ecosystem services. These include wetlands, dams, national parks and coastal zones. These natural and manmade facilities support environmental management services in areas such as pollution control, silt traps, groundwater recharge, recreation, tourism, and creation of micro-climates (Southern Waters, 2023).

2

ENVIRONMENTAL TRENDS IN THE BUZI, PUNGWE, AND SAVE RIVER BASINS



Photo: GEF-BUPUSA

2.1 Introduction

Over the years, the Buzi, Pungwe, and Save River Basins have undergone significant environmental changes, encompassing shifts in water quality, climatic conditions, biodiversity, land, and land use. The drivers of these changes include population growth, climate change and variability, expansion of urban areas, as well as an increase in economic activities such as mining and agriculture. This chapter presents the state and trends of water quality, land, biodiversity, and water resources in the BUPUSA Tri-Basin, highlighting the impacts on livelihoods and ecosystems.

2.2 State and Trends

2.2.1 Rainfall

Figure 2.1 illustrates the distribution of rainfall over the BUPUSA Tri-Basin. All three basins have high inter-annual variability of rainfall, irrespective of whether a location receives low or high rainfall. The annual rainfall received can be as low as 50 percent to 60 percent of the long-term average; or as high as 120 percent to 150 percent.

On average, the Buzi, Pungwe, and Save River Basins experience a tropical storm each year, and a cyclone once every three years, all of which originate from the

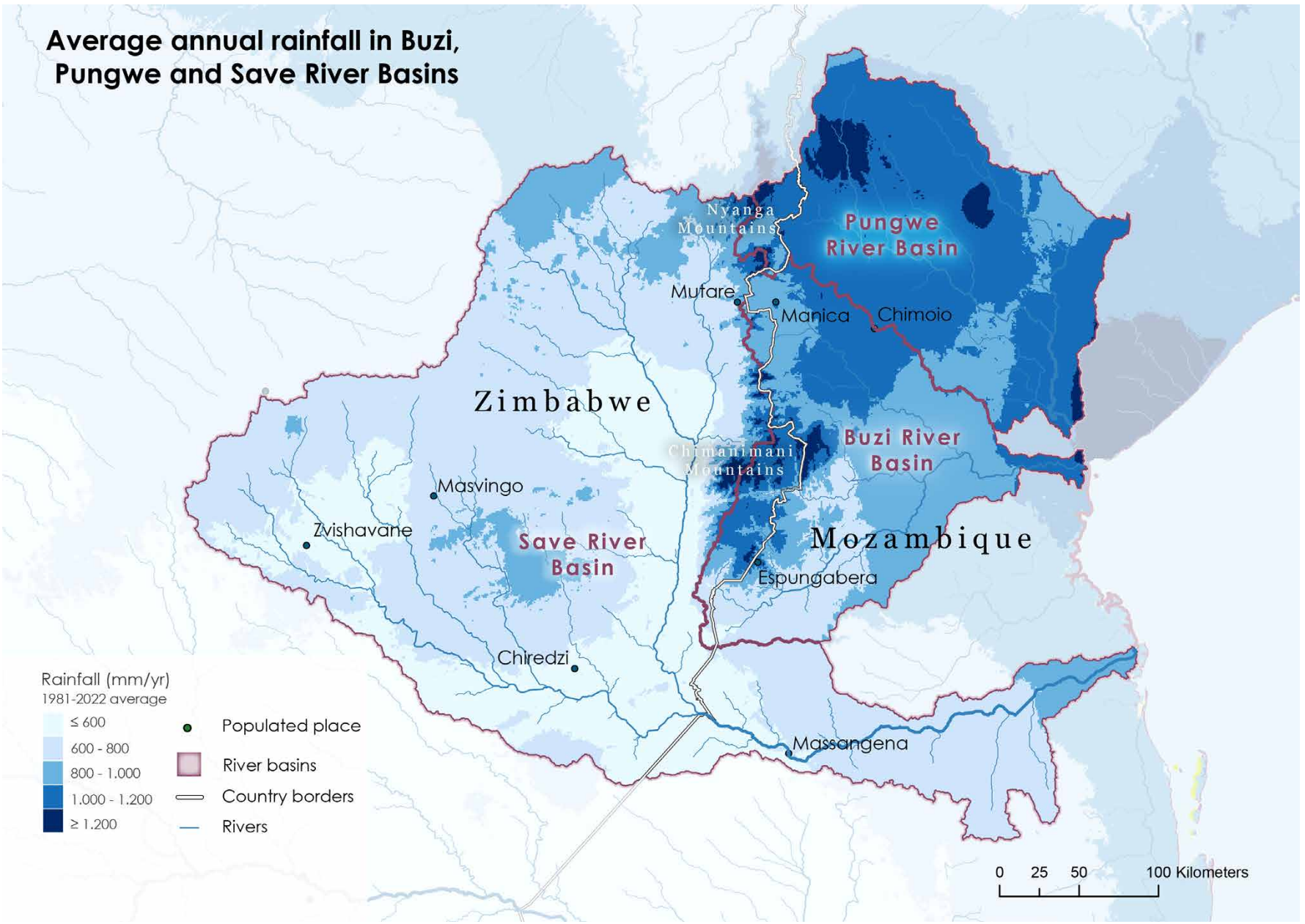


Figure 2.1: Spatial variation of average annual rainfall within the Buzi, Pungwe, and Save River Basins.
Source: GWPSA, 2023a, Copyright: SARDC, GWPSA, GRID-Arendal 2024.

South-West Indian Ocean. Extreme tropical cyclones like Eline in 2000 and Idai in 2019 resulted in up to 200 to 400 mm of rainfall within one or two days, leading to landslides in mountainous areas. Cyclone Idai caused the deaths of over 1500 people, displaced 400,000 people, and affected over 1.5 million people in Malawi, Mozambique and Zimbabwe, with the most negative impacts being in the latter two countries. The cyclone also resulted in widespread damage to infrastructure and health facilities, leading to disruption of water and sanitation services.

2.2.2 Surface Water Resources

The amount of runoff generated throughout the BUPUSA Tri-Basin varies in both space and time. Figure 2.2 illustrates the sub-basins of the Buzi, Pungwe, and Save River Basins, which are used for water resources assessment and management. For all the three basins, the highest amounts of runoff are generated on areas located on the Chimanimani, Vumba and Nyangani Mountains. The runoff coefficient varies from 30 percent to 60 percent in the mountainous areas. The Mean Annual Runoff (MAR) of a basin is commonly used as an indicator of the amount of renewable water resources available.

The BUPUSA Tri-Basin produces significant amounts of surface flows and sustains base flows during the dry season and can be considered as strategic water source areas. Mean annual runoff with most parts of the Save River Basin generating from less than 100 mm/year, and 200 to 1,200 mm/yr for the mountainous border regions, Figure 2.3.

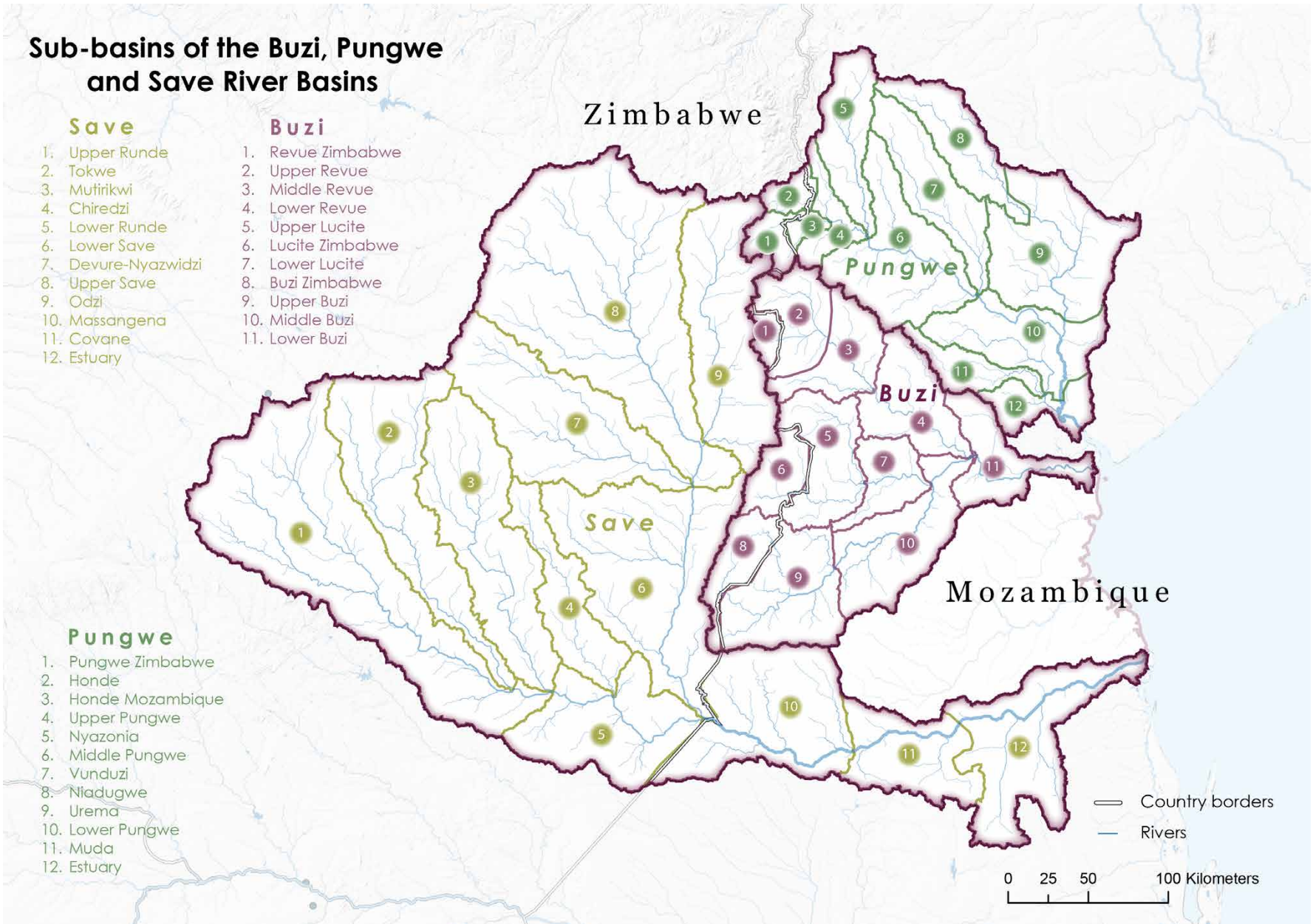


Figure 2.2: Sub-basins of the Buzi, Pungwe, and Save River Basins used for water resources assessment and management.
Source: GWPSA, 2023a, Copyright: SARDC, GWPSA, GRID-Arendal 2024.

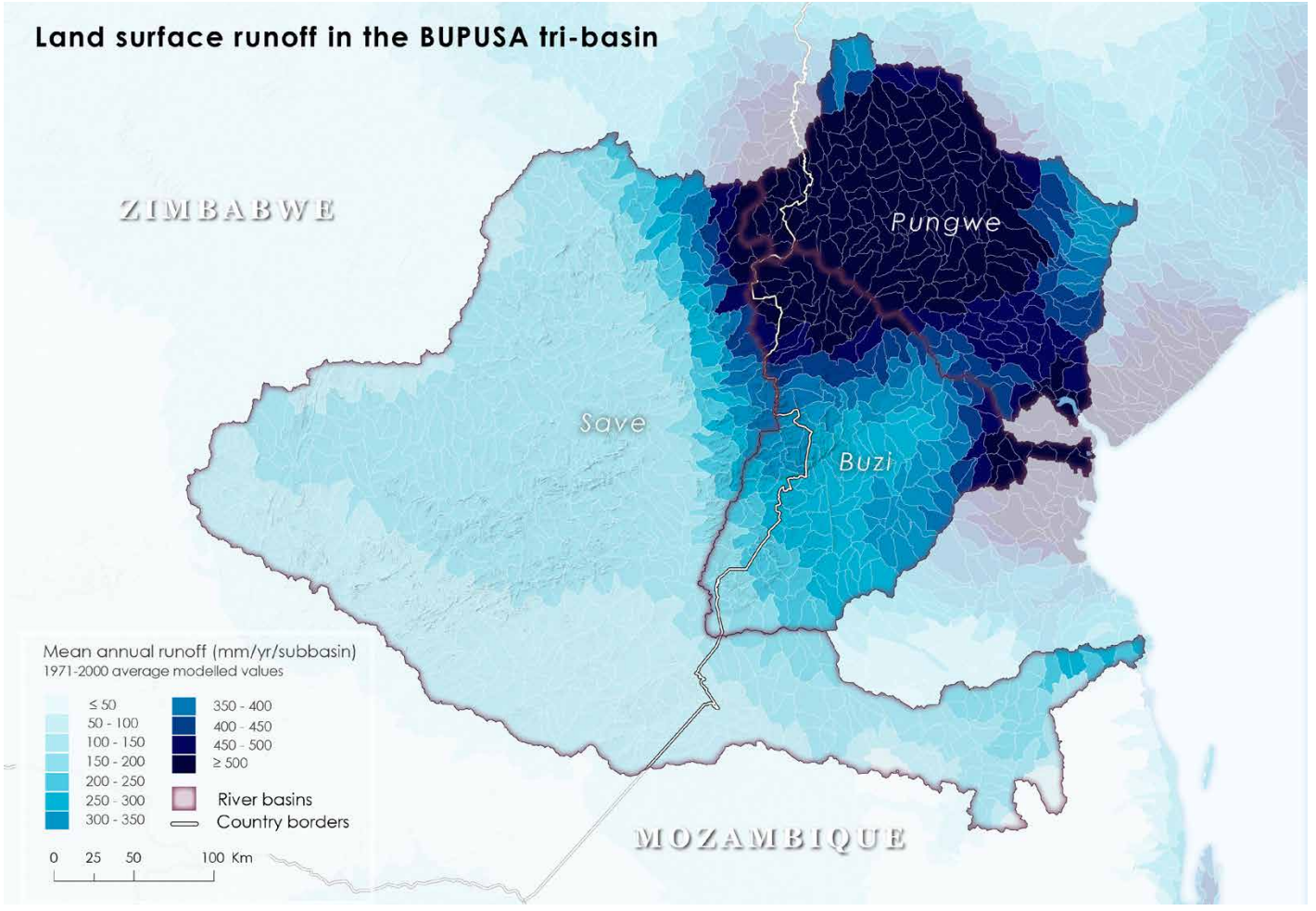


Figure 2.3: Mean annual runoff from less than 100 mm/year, and 200 to 1,200 mm/yr.

Copyright: SARDC, GWPSA, GRID-Arendal 2024.

The estimated annual average flow or Mean Annual Runoff for the Pungwe River Basin is 4,450 Mm^3/yr or 143 mm/y. The mean annual runoff of the Buzi River Basin is 5,701 Mm^3/yr or 198 mm/year. The Save River Basin has a mean annual runoff of 8,157 Mm^3/year or 80 mm/yr. The MAR details are summarised in Table 2.1.

For each of the BUPUSA River Basins, there are differences in the amount of runoff generated from each of the two riparian states. However, each of the two countries contributes nearly equal amounts to the total amount of runoff generated (18,308 Mm^3/yr) from the three basins.

Table 2.1: Geographical area of the BUPUSA Basins in Mozambique and Zimbabwe, and their Mean Annual Runoff (MAR)

Basin	Sub-Basin	Area (km^2)	% Basin Area	MAR (mm^3/yr)	MAR (mm/yr)	% Basin MAR
Pungwe	Zimbabwe	1,461	5	1,102	753	25
	Mozambique	29,690	95	3,348	113	75
	Basin Total	31,151	100	4,450	143	100
Buzi	Zimbabwe	3,733	13	1,201	321	21
	Mozambique	25,137	87	4,500	179	79
	Basin Total	28,870	100	5,701	198	100
Save	Zimbabwe	84,149	83	6,822	81	84
	Mozambique	17,277	17	1,335	77	16
	Total	101,426	100	8,157	80	100
BUPUSA	Zimbabwe	89,343	55.3	9,125	102	49.8
	Mozambique	72,104	44.7	9,183	127	50.2
	Total	161,447	100.0	18,308	113	100.0

Source: GWPSA, 2023a

2.2.3 Groundwater Resources

Most parts of the BUPUSA Tri-Basin are characterised by the Precambrian Basement Complex rocks such as granites and gneisses which may have dolerite intrusions. Unconsolidated sands and gravels are predominantly found in the lower parts of the three basins, mostly in Mozambique. Basement Complex rocks are primarily impermeable, with limited capacity to store groundwater. Productive boreholes in the Basement Complex rocks can support water supply to small settlements. Table 2.2 gives the estimated groundwater resources of the BUPUSA Tri-Basin as well as the combined available surface and groundwater resources.

Table 2.2: Estimated Groundwater Resources for the BUPUSA Tri-Basin

Sub-basin	Pungwe	Buzi	Save	Total
Basin Area (km^2)	31,150	28,870	101,426	161,446
Mean Annual Rainfall (mm/yr)	1,050	1,085	715	2,850
Mean Annual Rainfall (Mm^3/yr)	32,708	31,324	72,520	136,552
Mean Annual Runoff (mm/yr)	143	198	80	421
Surface Water Resources (Mean Annual Runoff) (Mm^3/yr)	**4,450**	**5,701**	**8,157**	**18,308**
Groundwater Recharge Rate (% of MAP)	10%	10%	10%	
Groundwater Recharge Rate (mm/yr)	105	108	72	285
Groundwater Recharge (Mm^3/yr)	3,271	3,118	7,303	13,692
Groundwater Resources (Groundwater Annually Recoverable from recharge: 50% for Buzi & Pungwe, 10% for Save) (Mm^3/yr)	**1,636**	**1,559**	**730**	**3,925**
Total Available Surface and Groundwater Resources (Mm^3/yr)	**6,086**	**7,260**	**8,887**	**22,233**

Source: GWPSA, 2023a

2.2.4 Water Demand

The current water demand for various uses was derived from water permits (in Zimbabwe) and licences and concessions (in Mozambique). These permits and licences indicate the maximum volume of water allowed for utilization by the respective holders. Volumes of water used for domestic and livestock purposes in rural areas were estimated from human and livestock population numbers and the respective per capita water consumption rates.

In the Buzi River Basin, the total water usage in 2020 was estimated to be 334 Mm^3/year. Irrigation accounted for 83 percent of the water demand. The second-largest water users were urban centers such as Chipinge and Chimanimani in Zimbabwe, as well as Chimoio, Manica, and Gondola in Mozambique. Plantation forests ranked third, with estimated water utilization of 45 Mm^3/year in Zimbabwe and 30 Mm^3/year in Mozambique. Figure 2.4 gives details of sectoral water use in the Buzi, Pungwe, and Save River Basins.

The estimated 2020 total water use in the Pungwe River Basin was 810 Mm^3/yr with crop irrigation accounting for 67 percent of this amount, followed by the urban sector, 25 percent (Figure 2.4) (Consultec, 2013). Irrigation of sugar cane plantations in the Lower Pungwe Sub-basin, for example, Mafambisse accounted for most of the water utilized within the irrigation sector. The City of Mutare in Zimbabwe relies on the Pungwe River Basin to meet part of its water requirements, while Beira and Dondo are also major urban settlements dependent on the basin for water supply. Rural water supply and livestock watering constituted 3 percent of the total water use in the Pungwe River Basin (Figure 2.4).

Crop irrigation was the largest consumer of water, amounting to 91 percent of the total water usage (Figure 2.4). In Mozambique, water for crop irrigation accounted for 61 percent of the water used in the Save River Basin. Water uses in the Runde Sub-basin in Zimbabwe, which has very large dams such as Tugwi-Mukosi (1,802 Mm^3) and Mutirikwi (1,378 Mm^3), account for about 70 percent of the total water used within the Save River Basin.

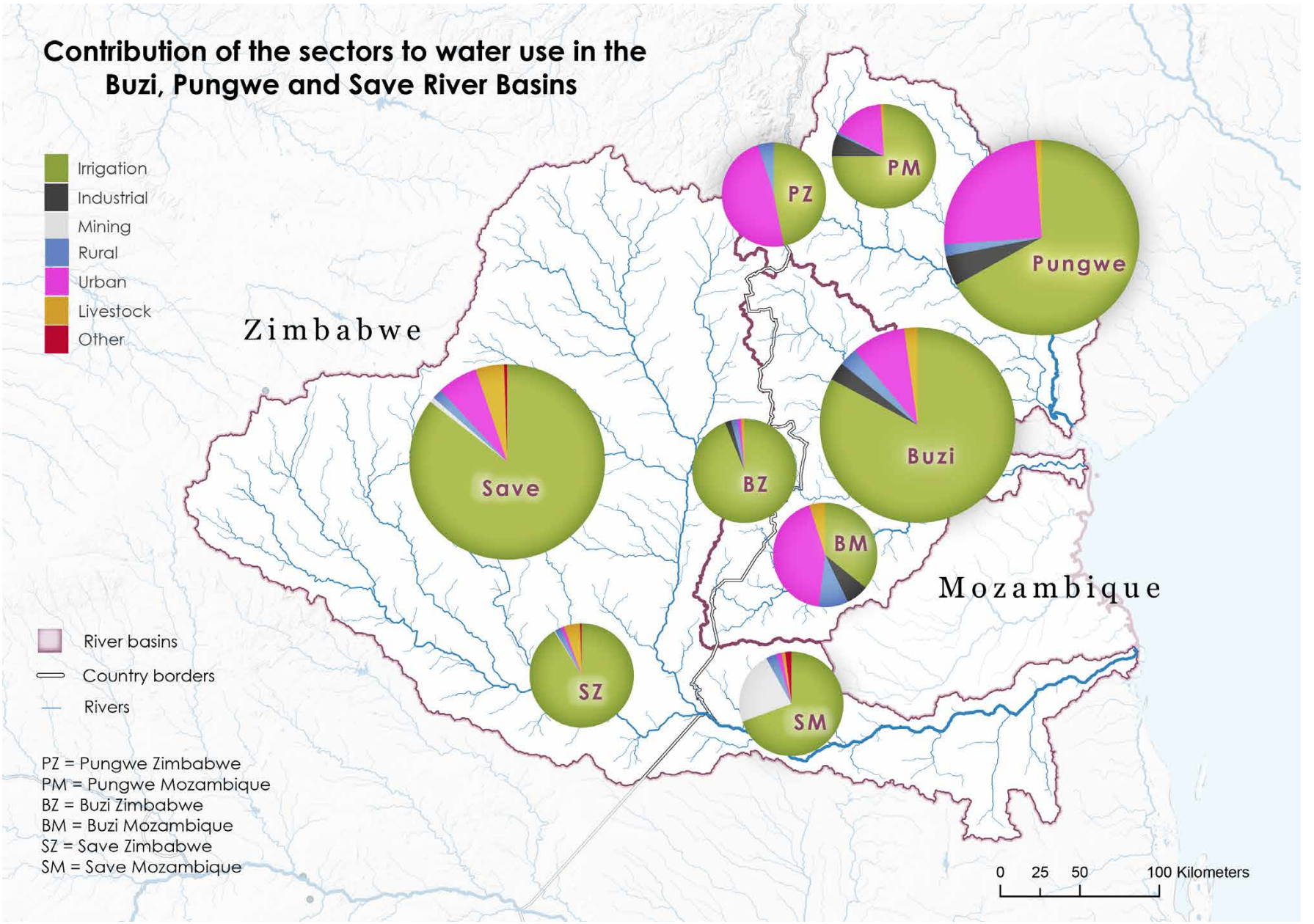


Figure 2.4: Contribution of sectors to water use in Buzi, Pungwe, and Save River Basins.

Copyright: SARDC, GWPSA, GRID-Arendal 2024.

2.2.5 Projected Water Use/Commitment

SWECO (2011b) estimated that the urban population within the Buzi River Basin in Zimbabwe (Chipinge and Chimanimani) will grow by 5 percent while water consumption will increase to 100 litres/capita/day (l/p/d). In Mozambique, the growth rate used for Chimoio, Manica and Gondola was 2.5 percent and water consumption was assumed to range between 30 and 125 l/p/d, depending on the type of water supply technology (stand, yard, or house connection). There are several irrigation schemes planned in Mozambique that have taken into account water use from 2015 to 2035. Water use with environmental flows is predicted to grow from 1366 Mm^3/yr in 2020 to 1828 Mm^3/yr in 2030. Figure 2.5 provides a comparison of the projected water demand, including environmental flows, for the period from 2015 to 2035 in Zimbabwe (ZWE), Mozambique (MOZ), and the entire Buzi River Basin.

The water allocation is based on the Buzi River Basin Water Sharing Agreement and the Mean Annual Runoff (MAR).

Future water use rates were estimated during the Pungwe Project Phase I and II, and then updated by Consultec (2013) for the short and long-terms. Water use without environmental flows is projected to increase from 810 Mm^3/yr in 2020 to 1,031 and 1,317 Mm^3/yr in 2030 and 2035 respectively for the whole basin. These projected water uses without environmental flows are equivalent to 18 percent, 23 percent and 30 percent of the MAR respectively. The Pungwe Water Sharing Agreement has a provisional environmental water allocation of 15 percent of the MAR. When this is included in the water demand in 2020, the water demand will be 33 percent of the MAR (1,477 Mm^3/yr) and 45 percent (1,984 Mm^3/yr) in 2035 for the whole Pungwe River basin (Figure 2.6).

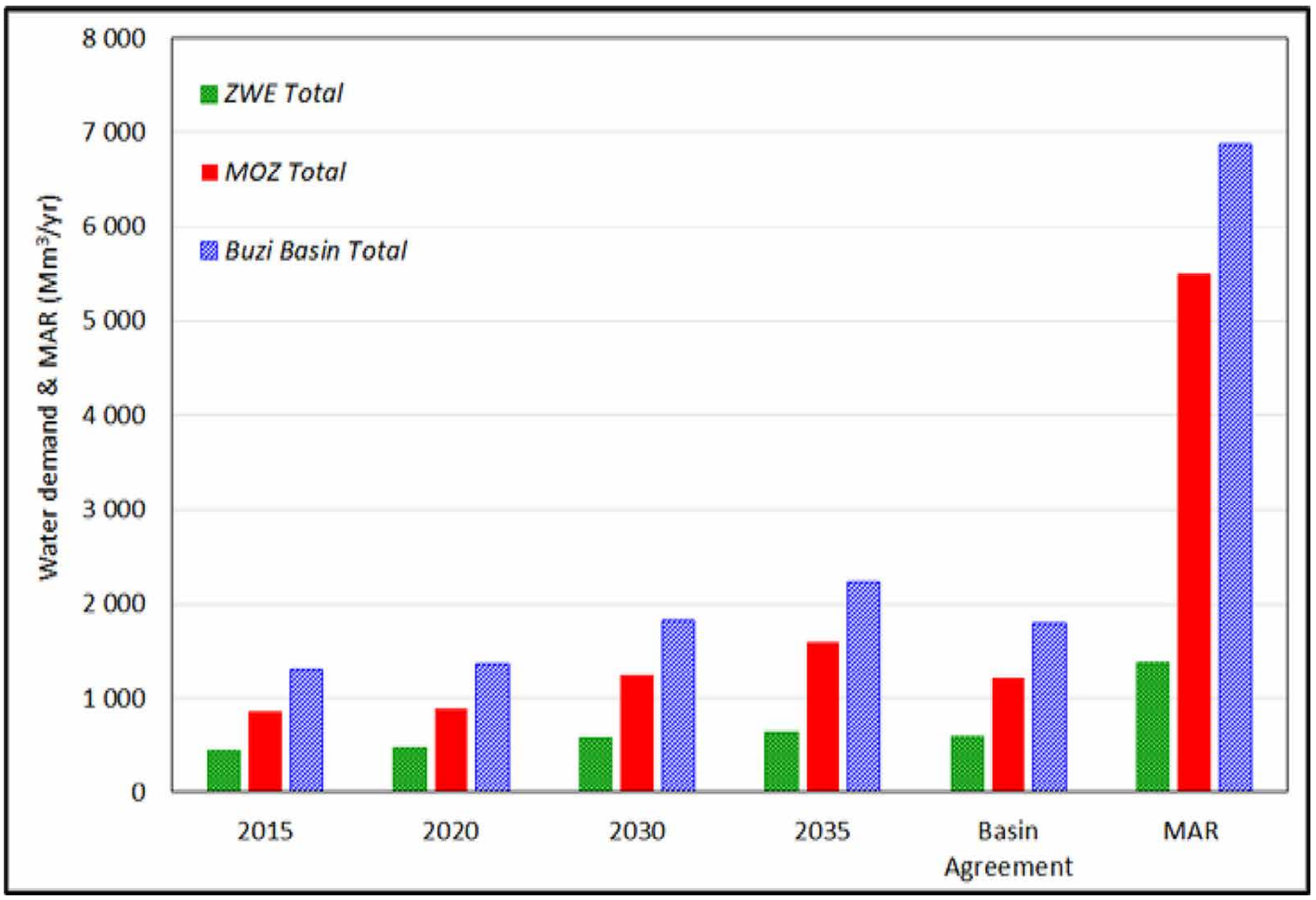


Figure 2.5: Comparison of projected water demand, including environmental flows from 2015 to 2035 in each country [Zimbabwe (ZWE) & Mozambique (MOZ)] and for the whole Buzi River Basin as per the water allocation in the Buzi River Basin Water Sharing Agreement and the MAR.

Source: SWECO 2011b.

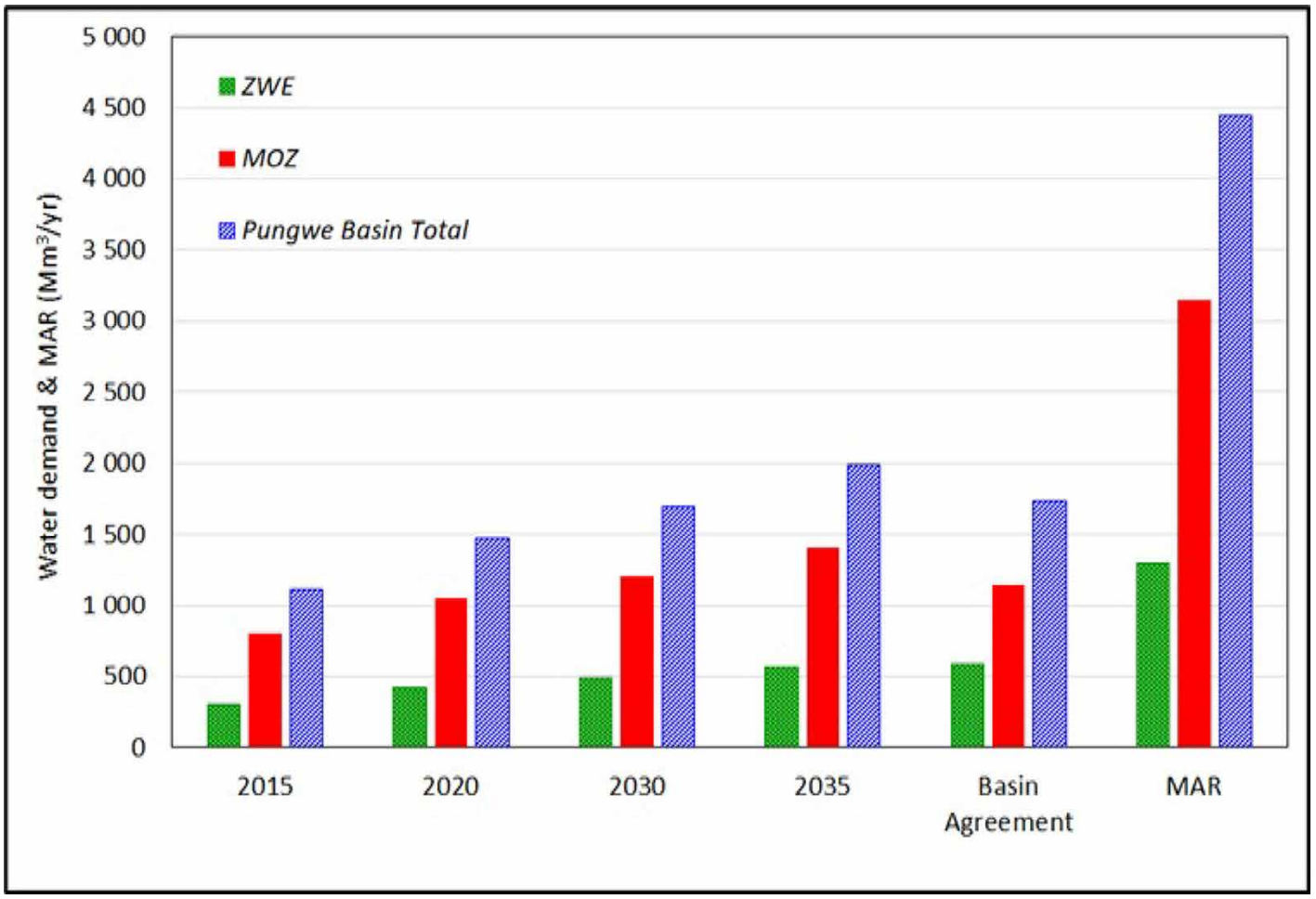


Figure 2.6: Comparison of projected water demand including environmental flows for 2015 to 2035 in each country [Zimbabwe (ZWE) & Mozambique (MOZ)] and for the whole Pungwe River Basin as per the water allocation in the Pungwe Basin Water Sharing Agreement and the MAR.

Source: SWECO 2006.

2.2.6 Water Scarcity

The proportion of current water use to the Mean Annual Runoff has been used as an indicator of scarcity of surface water resources. Most sub-basins in the Pungwe River Basin have the current water uses or water commitments being less than 25 percent of the MAR. The exception is the Lower Pungwe where water is fully committed to meet the requirements of Beira, Dondo, and Mafambise. All the water uses/ commitments in the Pungwe River Basin amount to 18 percent of the MAR (Table 2.3). Water uses/ commitments in the Buzi River Basin are equivalent to 11 percent of the MAR although the Buzi and Revue sub-basins in Zimbabwe have water uses above 25 percent.

Table 2.3: Estimated water commitment expressed as a proportion (%) of the Mean Annual Runoff

Sub-basin	Buzi	Pungwe	Save
Zimbabwe	28%	21%	112%
Mozambique	7%	17%	16%
Whole Basin	11%	18%	96%

Source: GWPSA, 2023c

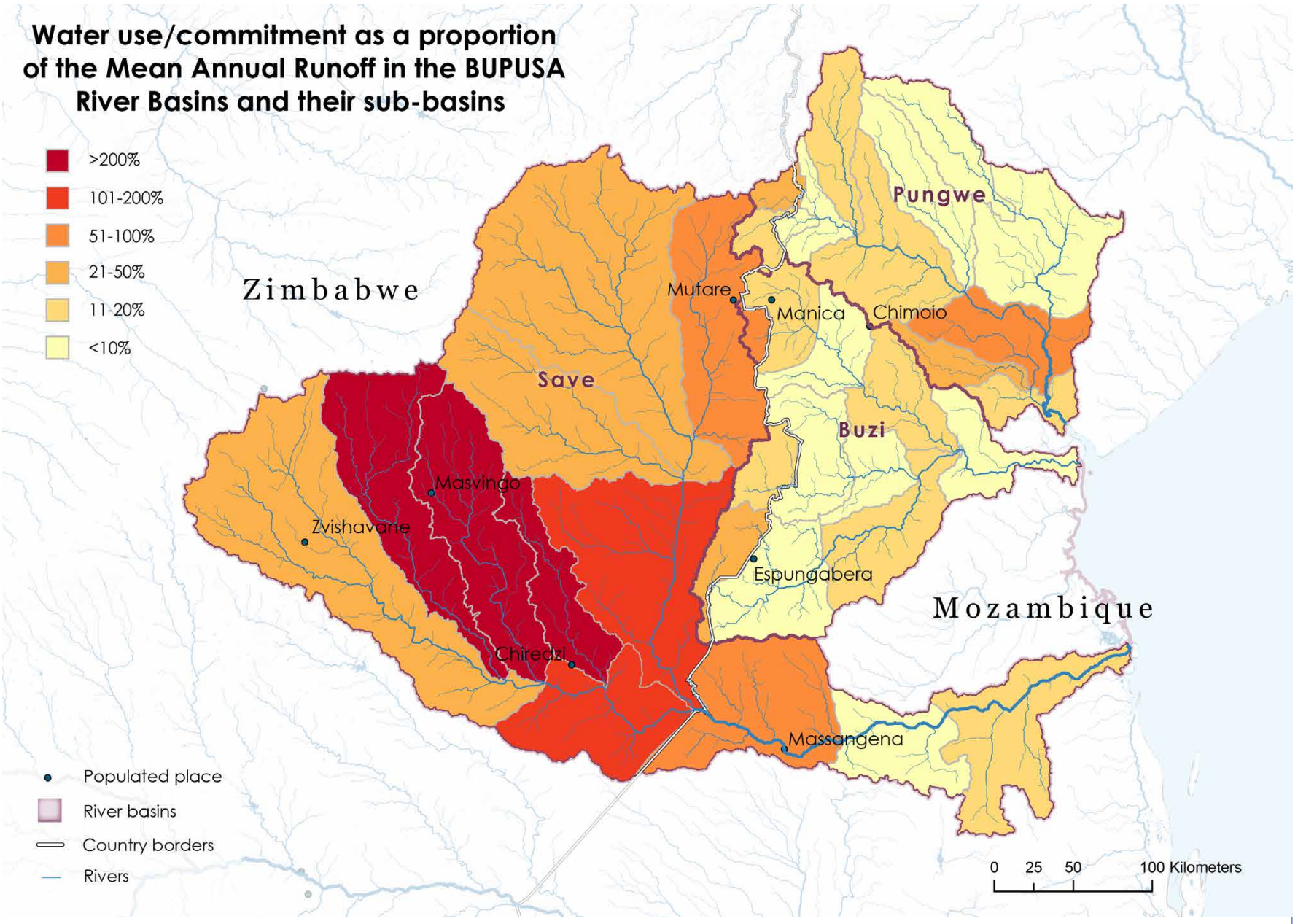


Figure 2.7: Water use/commitment in BUPUSA Tri-Basin as a proportion of the Mean Annual Runoff or annually renewable surface water resourcess.
Copyright: SARDC, GWPSA, GRID-Arendal 2024.

2.2.7 Planned Projects

The following water development projects are considered for the Pungwe River Basin in Mozambique in the medium and long term:

- Nhacangare Dam with a capacity of 140 million cubic meters (Mm^3) in the Nyazonia River Basin;
- Bué Maria or Pavua dam with a capacity of 280 Mm^3 on the Pungwe River; and
- Metuchira, Gorongosa and Chitengo small dams.

In Zimbabwe, the primary planned project is the Pungwe Falls Dam. Although the exact capacity of this dam has not been finalized, it is expected to be in the order of magnitude of 25 Mm^3. Within the Pungwe River Basin, there are also plans for several small-scale hydropower schemes to be implemented. The Buzi River Basin currently has the Chicamba Dam (2.020 Mm^3) and the Mavuzi Dam (1.8 Mm^3) on the Revue River in Mozambique. Several small-scale dams exist mainly in the Sussundenga District. Small dams are also found on the Zimbabwean part of the basin, for example, Bangazaan Dam (2.825 Mm^3) and Chako Dam on the Chinyika River.

The following dams are planned in the Buzi River Basin;

- Mirror Dam (23 Mm^3), on the Buzi sub-catchment in Zimbabwe;
- Haroni Dam (10 Mm^3) on the Lucite sub-catchment in Zimbabwe;
- Tsate (75 Mm^3) and Muenezi Dams (100 Mm^3) on the Revuè sub-catchment in Mozambique, downstream of Chicamba Dam;
- Cintura Dam (720 Mm^3) on the Lucite sub-catchment in Mozambique;
- Mweneze Dam (100 Mm^3) on the Lucite sub-catchment in Mozambique; and
- Miracuene (709 Mm^3) on the Buzi sub-catchment in Mozambique.

Zimbabwe has plans to develop a significant number of dams in the Save River Basin, with a total of 45 dams proposed. Among these planned dams, the following are the largest:

- Chipinda 1,000 Mm^3
- Chitowe 1,542 Mm^3
- Lundi-Tende 2,400 Mm^3
- Condo 3,565 Mm^3

The following dams are planned in the Save River Basin in Mozambique:

- Massangena Weir 5 Mm^3
- Jofane Dam 500 Mm^3
- Massangena Dam 7,263 Mm^3

2.2.8 Water Quality

The few sampling campaigns done in the Buzi Basin show that the water has pH ranging from 7.1 to 8.5. The Upper Lucite River has slightly acidic water with pH in the 6.5 to 7.0 range. This acidity could be due to underlying shale in some parts. Both the Pungwe and Buzi Rivers are perennial, which facilitates their respective self-purification. The major concern in both basins is the effects of artisanal and small-scale mining along rivers, which results in siltation of rivers and dams. Another concern is intrusion of saline water at the estuaries. Excavations conducted within and along rivers release substantial amounts of sediments that increase water turbidity whilst reducing the carrying capacity of rivers and other water bodies.

Some of the large rural settlements throughout the Save River Basin do not have adequate facilities for wastewater management. In densely populated areas, pit latrines contribute to groundwater contamination. Moreover, mine dumps from gold, chrome, phosphate, and asbestos mines further aggravate the situation, as runoff from these dumps has the potential to



Reduced river flow in the Save River as a result of siltation and increasing frequency of droughts.
Photo: Melisa Matavire Mavenge-IUCN



The confluence of Rusitu and Haroni Rivers in Chimanimani. Haroni River on the left is showing signs of heavy siltation upstream.
Photo: Simon Tafadzwa Mazano and Mellisa Pemhenukai

contaminate the rivers. A particular concern in the basin is the use of mercury by artisanal miners for gold recovery, which poses significant environmental and health risks.

Return flows from large-scale irrigation schemes such as in the Mutirikwi and Chiredzi sub-basins of the Save in Zimbabwe can cause elevated levels of nitrates and phosphates which lead to eutrophication of river water. Inadequate land management practices accelerate soil erosion in many parts of the Save River Basin. Runoff from these sub-basins carry large volumes of sediment deposits that result in massive siltation and, in turn, affect the carrying capacity of water bodies. Saline water intrusion at the Save River estuary also needs monitoring to facilitate mitigation measures.



Artisanal mining affecting water quality in the Revue River, a tributary of the Buzi River Basin along the Beira Road, Mozambique.
Photo: Tariro Saruchera

2.2.9 Biodiversity

The main ecoregions within the BUPUSA Tri-Basin are the following:

- Southern miombo woodlands
- Mopane woodlands
- Montane forests – grasslands mosaic
- Southern Africa bushveld

The miombo woodlands cover the largest parts of the three basins and mainly occur in the 1,000-to-1,500-meter altitude range (Figure 2.8). This region is dominated by Brachystegia spp. and Julbernardia spp. In addition, the mopane woodlands also contain species such as Acacia spp., Albizia spp., and Combretum spp. The Southern Africa bushveld in Zimbabwe is characterised by grasslands with clusters of trees and shrubs. Estuaries of both the Pungwe and Buzi Rivers have mangroves.

The Eastern Zimbabwe montane forest-grassland mosaic has areas of high biodiversity. Some of the characteristic areas include the Vumba Botanical Gardens and Reserve, Chimanimani National Park, Eland Sanctuary, and Nyanga National Park. The Chimanimani National Park is a biodiversity hotspot threat area and has more than 100 endemic plant species (Cheek et al., 2018; IUCN, 2021).

The increase in the areas with invasive alien plants in the Chimanimani, Vumba and Nyanga mountains is a threat to biodiversity. The bee bush, Vernonanthura polyanthes, is spreading on disturbed low areas (300-to-1,700-meter altitudes) in the Vumba and Chimanimani areas. Dense infestations occur along roads.

The Gorongosa National Park (GNP), which covers 4,086 km^2, boasts significant biodiversity within the Pungwe River Basin in Mozambique. The Park is home to over 6,300 species of plants and animals, with 25 of these being endemic, and 750 species on the IUCN Red List (https://gorongosa.org/biodiversity/). Restoration efforts in the GNP have led to the recovery of wildlife population numbers in buffaloes, elephants, hippopotamuses, waterbucks, zebras, blue wildebeests, and lions. The primary threats to biodiversity include deforestation for cultivation, timber harvesting, wildfires, livestock grazing and poaching.

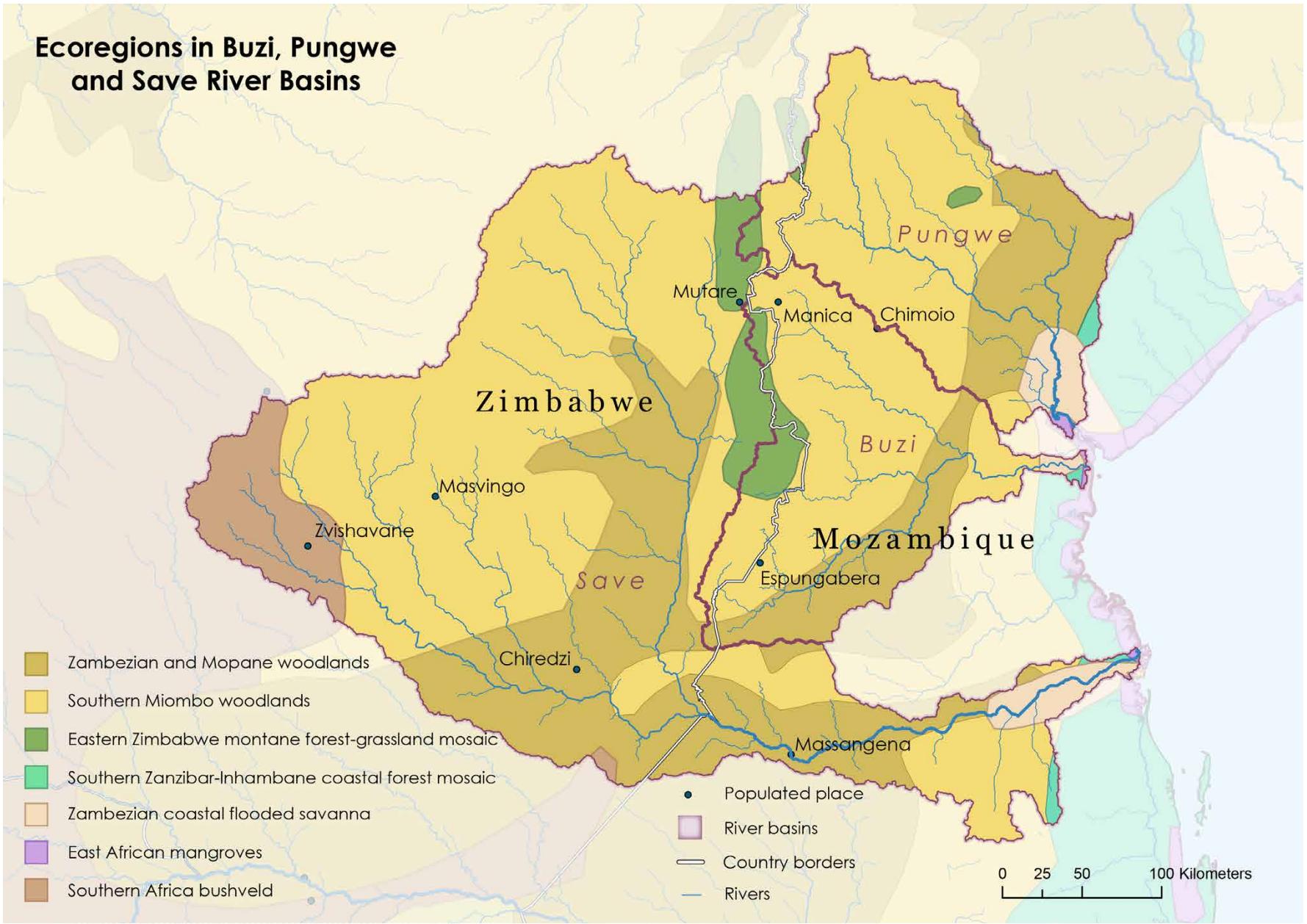


Figure 2.8: Ecoregions within the BUPUSA Basins.

Source: https://www.worldwildlife.org/publications/terrestrial-ecoregions-of-the-world) Background map: OpenStreetMap. https://www.openstreetmap.org. Copyright: SARDC, GWPSA, GRID-Arendal 2024.

2.2.10 Land Cover Changes

The dominant land cover types in the Buzi River Basin are forests and woodlands that cover 51 percent of the basin followed by grasslands (22%) and croplands (19%) (Figure 2.9, Table 2.4). In the Pungwe River Basin, forests and woodlands occupy 44% of the basin, followed by grasslands (31%), and croplands (21%). In the Save River Basin, bushlands are the most dominant land cover type occurring on 35 percent of the basin, followed by croplands (27%), and woodlands and forests (20%). The eastern part of this basin, as depicted in Figure 2.10, showcases the Middle Save irrigation areas. Additionally, the Save estuary region features mangrove forests.

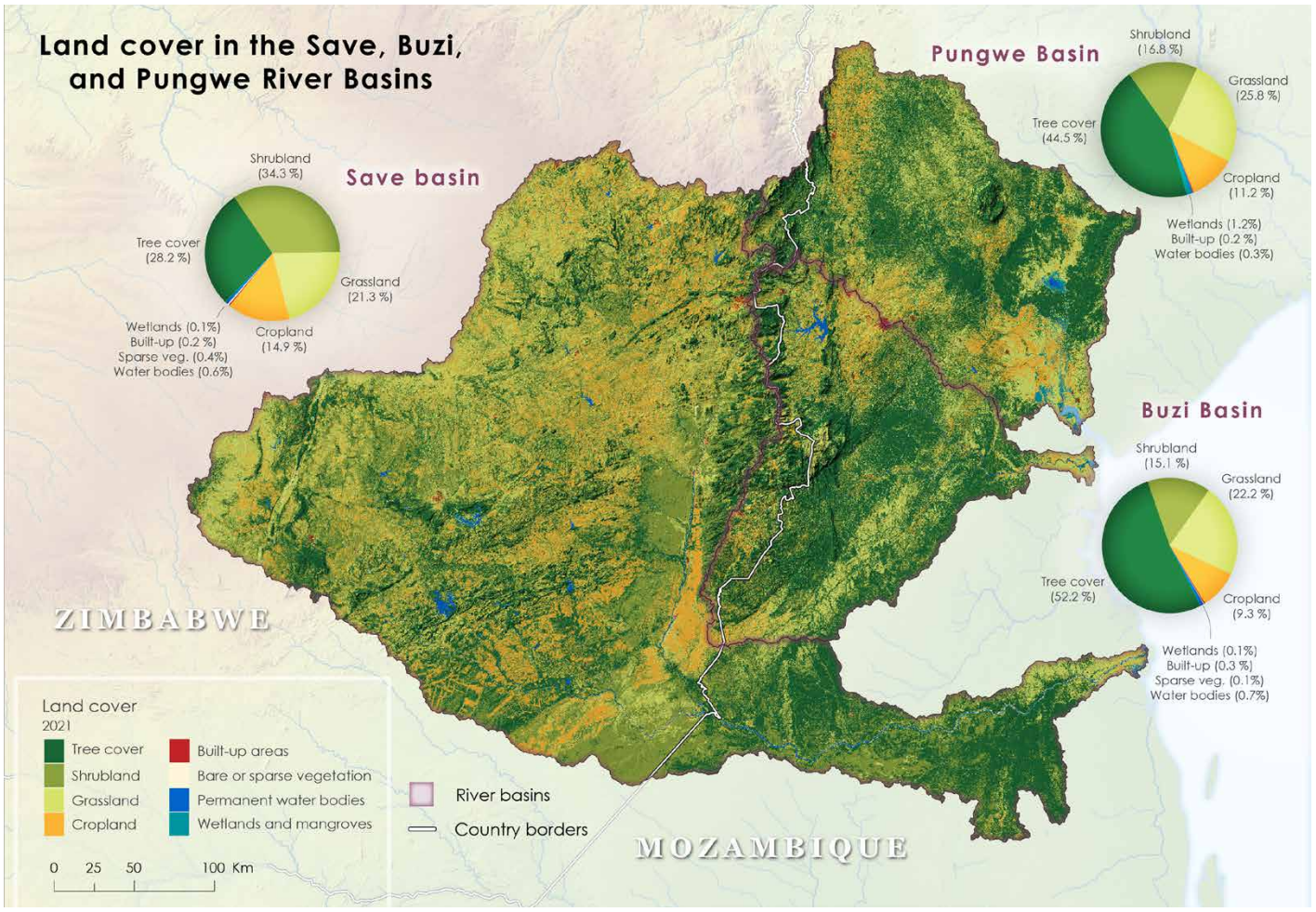


Figure 2.9: Land cover in Buzi, Pungwe and Save Basins.
Copyright: SARDC, GWPSA, GRID-Arendal 2024.

Table 2.4: Land cover types in the BUPUSA Basin

Land Cover Type: Buzi		Land Cover Type: Pungwe		Land Cover Type: Save	
Forest Areas	51%	Forest Areas	44%	Bushland	35%
Grassland	22%	Grassland	31%	Cropland	27%
Cropland	19%	Cropland	20.5%	Forest Areas	20%
Bushland	6.70%	Bushland	3.5%	Grassland	17%
Open Water	0.48%	Open Water	0.20%	Aquatic	0.41%
Aquatic	0.20%	Built Up	0.11%	Open Water	0.30%
Built Up	0.10%	Bare Areas	0.02%	Built Up	0.10%
Bare Areas	0.04%	Sparse Veg	0.01%	Sparse Veg	0.09%
Sparse Veg	0.02%	Aquatic	0.01%	Bare Areas	0.07%
Other	0.46%	Other	0.65%	Other	0.03%
TOTALS	**100.00%**		**100.00%**		**100.00%**

Source: European Space Agency classification, 2022

The main causes of land cover change are uncontrolled fires, expansion of croplands, harvesting of fuelwood, and timber harvesting. Charcoal making, which is a major driver of timber harvesting, is common in both the Buzi and Pungwe River Basins.



Charcoal sold along the roads in Buzi and Pungwe Basins.
Photo: Gywn Letley



Figure 2.10: Land cover changes due to agricultural expansion in Bumba, Chimanimani in 2000 and 2023.
Copyright: SARDC, GWPSA, GRID-Arendal 2024.

Bushfires caused 1.9 percent decrease in tree cover in the Buzi River Basin and 1.3 percent decrease in the Pungwe River Basin during the period from 2001 to 2021. During the same period, fires caused a three percent loss of trees in the Save River Basin. The expansion of cultivated areas in steep and vegetated regions of the Chimanimani, Vumba, and Nyanga Mountains has contributed to a major loss of forested areas. Figure 2.11 illustrates the expansion of cultivated areas in Chimanimani between 1986 and 2022.



Figure 2.11: Land cover types in the Buzi River Basin on 23 December 1986 and 24 December 2022.
Source: European Space Agency classification, 2022.

There is degradation of seasonal wetlands (dambos, vleis) due to extension of cultivation and overgrazing into these systems within the Save Catchment. Additionally, artisanal gold mining along rivers has caused major and rapid changes of land cover in various parts of the BUPUSA Tri-Basin. Figure 2.12 shows the land cover changes in April 2016 and May 2022 due to artisanal mining.

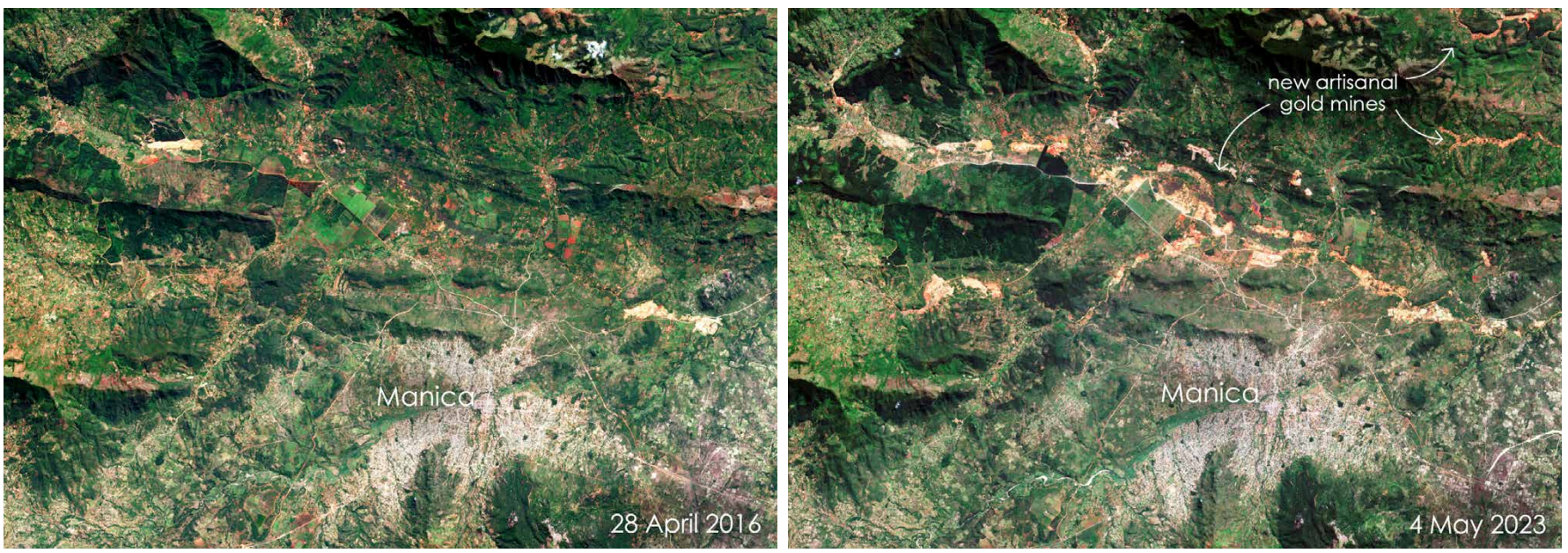


Figure 2.12: Land cover types in the Pungwe River Basin, Manica , Mozambique in April 2016 and May 2023.
Source: Chemura et al, 2020, Copyright: SARDC, GWPSA, GRID-Arendal 2024.

2.3 Causal Chain Analysis

Table 2.5 illustrates outputs of the Causal Chain Analysis (CCA) for biodiversity, land and water degradation in the BUPUSA Tri-Basin.

Table 2.5: Causal Chain Analysis for Biodiversity, Land and Water Degradation in BUPUSA Tri-Basin

Sector	Impacts		Causes		Points of Intervention (short term)
	Ecological	**Socio-economic & Cultural**	**Immediate**	**Underlying & Root**	
Water	• Loss of biodiversity (terrestrial & aquatic) • Increased local flooding • Loss of purification capacity • Increase in sedimentation	• Increased risk of conflict for available water resources • Increased risk of waterborne diseases	• Increasing overland flow • Gulley erosion • Increase in water pollution • Destruction of wetlands • Deforestation • Land clearance • Overgrazing • Veld fires	• Inappropriate land management practices. • Unsustainable floodplain and wetland agricultural practices • Cultivation of marginal/ fragile lands • Inadequate capacity in water institutions (ZINWA, DENAGECA)	• Coordinate the collection of data needed for future water resources assessments • Improved access to climate information • Improved training of water personnel • Improved extension services to small-scale farmers • Education and training on IWRM • Implementation of IWRM • Develop awareness among small-scale farmers about the causes and effects of environmental degradation
Agriculture	• Land degradation (erosion) • Loss of soil fertility and productivity • Loss of grasslands	• Increased risk of conflict for available resources • Social/moral decadence and culture of impunity • Loss of agricultural yield and income • Food insecurity • Loss of productivity • Inadequate food supply	• Increase of overland flow • Destruction of wetlands • Land clearance and preparation • Inappropriate use of agrochemicals	• Inappropriate land use practices (e.g., cultivation on riverbanks and slopes, slash and burn) • Inadequate knowledge of land use practices (soil fertility management) • Unsustainable floodplain and wetland agricultural practices • Cultivation of marginal/ fragile lands • Inequitable land tenure • Lack of agricultural extension services • Land use change and population pressure • Commercial Agriculture	• Improve productivity – climate-smart agriculture • Youth mainstreaming into agriculture • Improving marketing access through innovative communication technologies • Improved tenure security by formally registering farmers • Promotion of alternative sustainable livelihood options (e.g. apiculture or beekeeping) • Land use audits • Education, training, capacitation, and technical support for farmers • Integrated land use planning and management • Integrated pest and disease management in agriculture
Urbanisation and Mining	• Disruption of food chains • Habitat change and degradation • Loss of ecosystem services	• Increased poverty • Increased conflict human-wildlife • Loss of aesthetic and cultural values • Loss of income • Increased poverty • Increase in diseases • Increased conflict human-wildlife	• Unsustainable exploitation of flora and fauna • Uncontrolled bushfires • Extension of roads and cropping into wetlands • Uncontrolled and poor artisanal mining practices	• Unsustainable population growth rates • Lack of enforcement of environmental regulations, e.g. EIA • Limited knowledge and resources for sustainable artisanal mining practices • Lack of and/or poor enforcement of land use planning • Rapid urban growth and expansion without commensurate infra-structure and services	• Improve water quality management • Law enforcement • Enhancing the monitoring and inspection of mining activities • Land rehabilitation • Enforcement of environmental regulations • Improving the planning and management of urban expansions
Climate change	• Loss of species • Change in the natural flow regime (stream flow reduction • Increase in flash floods • Loss of ecosystem services (flood control, water and air purification)	• Loss of aesthetic and cultural values • Loss of household incomes • Loss of livelihoods	• Changes in precipitation patterns • Increased intensity and frequency of climatic events • Expansion of invasive species • Unsustainable exploitation of flora and fauna	• Increase of greenhouse gases • Unsustainable emissions of greenhouse gases • Changing climate patterns • Shifting of agro-ecological regions	• Ecosystem-based adaptation • Habitat rehabilitation • Conduct vulnerability assessments and consider for inclusion in development plans • Management and control of wildfires • Conservation agriculture • Control and management of invasive species • Education, capacity building and awareness raising • Creation and effective management of conservation areas • Climate smart agriculture • Improve access to information on climate change

Source: GWPSA, 2023a



3

CLIMATE AND ATMOSPHERIC ISSUES IN THE BUPUSA TRI-BASIN

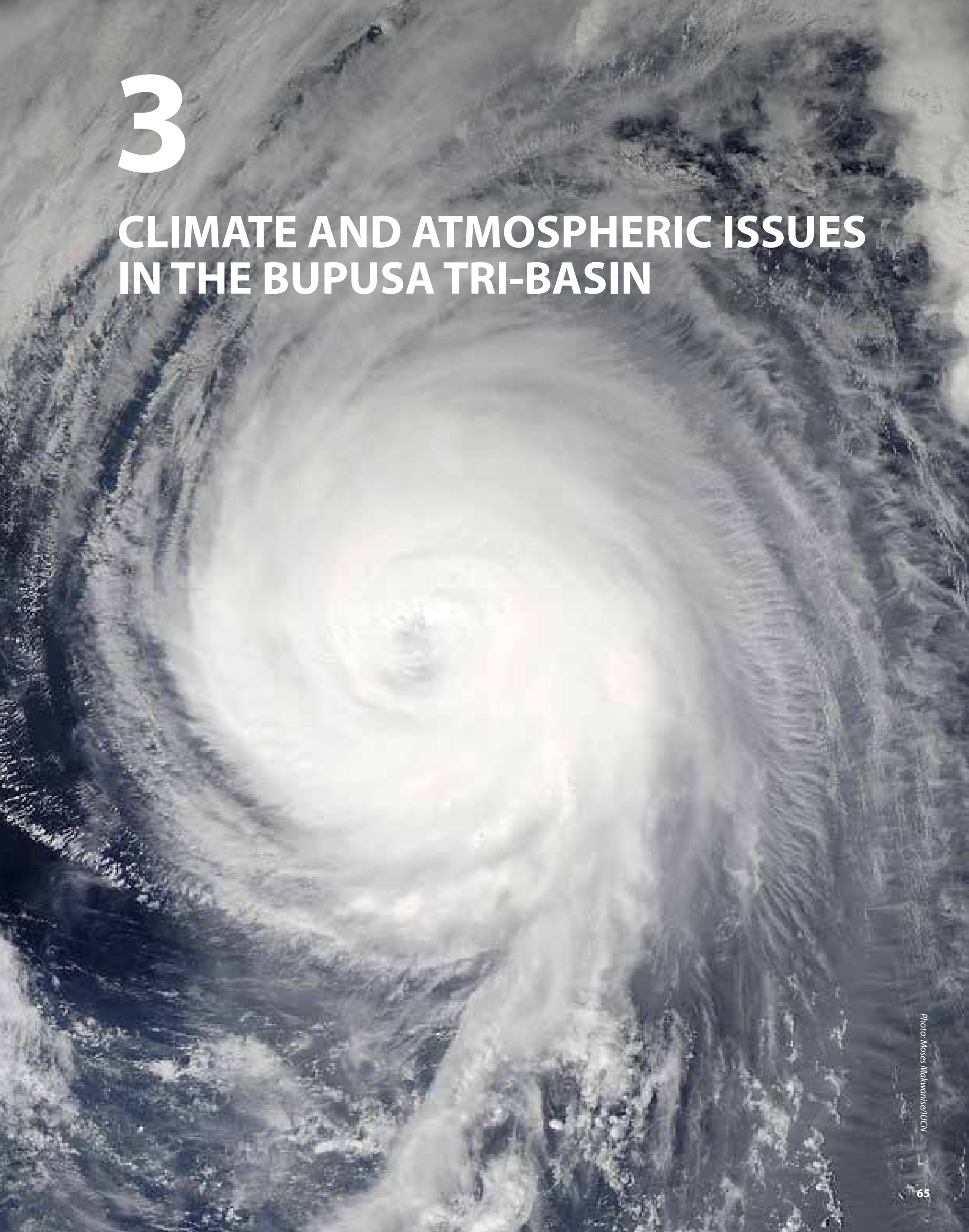


Photo: Moses Makwanise/IUCN

3.1 Introduction

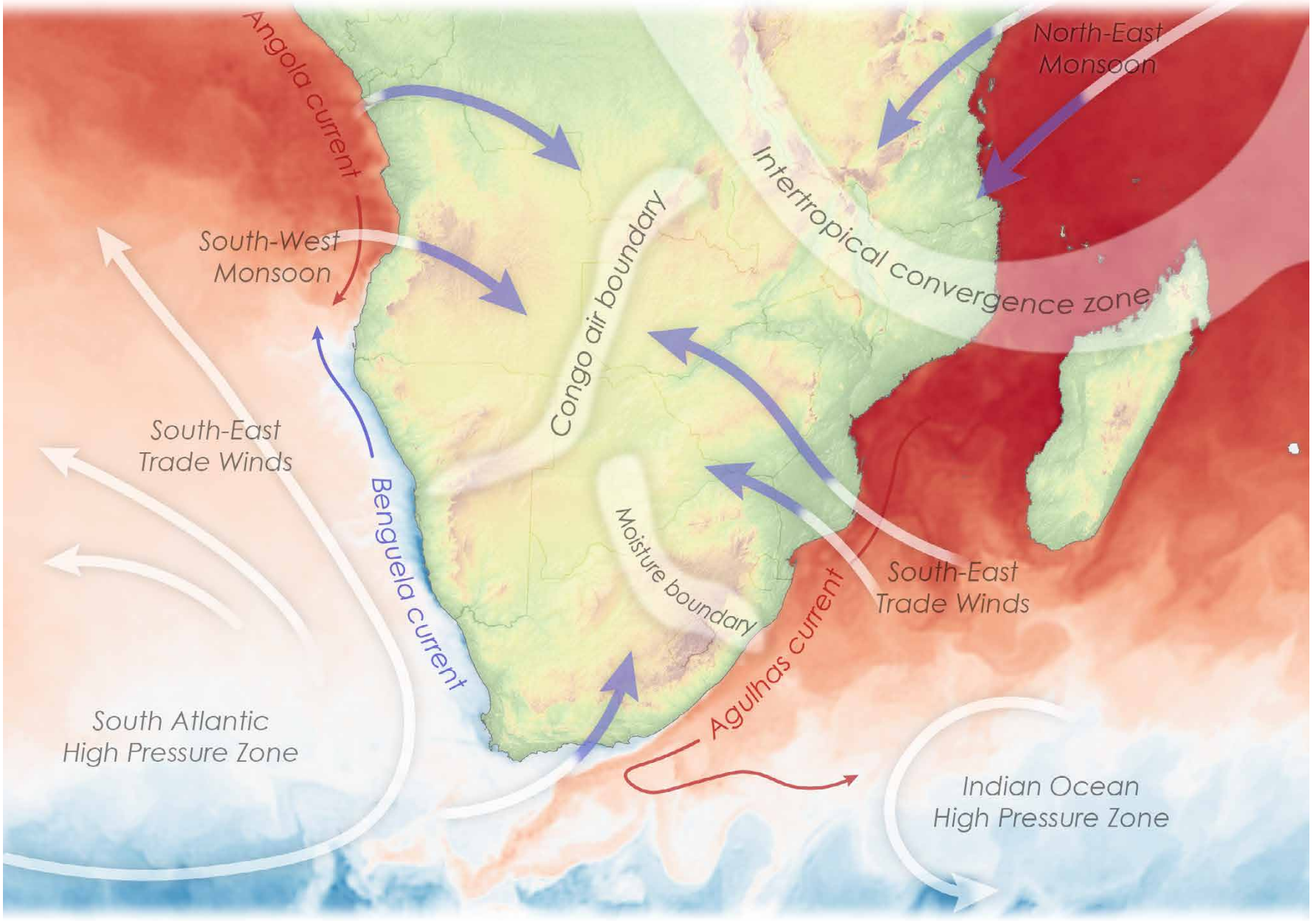
Southern Africa lies between the South Atlantic and the Indian Ocean sub-tropical high-pressure cells, and is influenced by the interaction of tropical easterly and westerly wind patterns originating from outside the tropics (Figure 3.1). The longitudinal positions of these high-pressure cells change during the southern hemisphere summer and winter, directly impacting the weather systems in the region. Precipitation occurs when there is significant upward movement of moisture from a low-pressure area at the surface to a high-pressure area in the air or at a higher elevation. Consequently, the areas of low pressure at the surface are dominated by a rain-producing monsoon trough, commonly known as the Inter-Tropical Convergence Zone (ITCZ) or the eastward-moving rain-producing cloud band areas from the Atlantic coast. The semi-arid regions of southern Africa correspond to areas dominated by subtropical high pressure at the surface. This semi-arid zone encompasses the southwestern third of the SADC region's borders. Generally, the high-pressure cells are stronger in winter, while in summer they weaken and shift towards higher latitudes, allowing the ITCZ to move southwards and bring rainfall to the region. Southern Africa experiences tropical climate in the north and sub-tropical climatic conditions in the south, with rainfall decreasing from the equatorial regions of the Democratic Republic of Congo (DRC) and Tanzania southwards to the arid sub-tropical regions of Namibia, Botswana and South Africa (SADC and SARDC, 2008).

A five-to-seven-month wet season occurs during austral (of or relating to the southern hemisphere) summer, which usually spans from October to April. Several important factors influence southern Africa's rainfall patterns, including the Inter-Tropical Convergence Zone (ITCZ), the Botswana Upper High, the El Niño-Southern Oscillation (ENSO) phenomenon, which includes its colder counterpart, La Niña, the Indian Ocean Dipole (IOD), the Quasi-Biennial Oscillation (QBO), and the Madden-Julian Oscillation (MJO). These can either work cooperatively or disruptively to produce rainfall across southern Africa. Knowledge of anticipated behaviour of ENSO, IOD, MJO and QBO phenomena in a given season can be a major resource in planning many socioeconomic activities, particularly those in the agricultural production systems.



Photo: Justine Ewart-Smith

Predominant drivers of climate patterns in southern Africa



The map shows the situation during the autral summer. Locations of drivers are approximate and simplified for illustrative purposes.

Ocean currents: The warm currents move heat to higher latitudes and create a strong temperature gradient with the surrounding ocean. This leads to large turbulent moisture fluxes from the ocean to the atmosphere.

Low-level moisture transport: horizantal movement (advection) of humid airmasses from ocean to land

High pressure zones: Large-scale circulation patterns around a high pressure area, leading to a warm and dry climate. Their position follows the seasonal movement of the sun: in winter, they move further south and are weakened in strength.

Low pressure bands: form where winds converge, leading to rising air masses (convection) and often thunderstorms and heavy rains. Both the Intertropical Convergence Zone and the Congo Air Boundary move further North during winter.

Figure 3.1: Predominant drivers of climate patterns in southern Africa.
Source: Moseki, 2021, Copyright: SARDC, GWPSA, GRID-Arendal 2024.



Photo: GWPSA

3.1.1 Inter-Tropical Convergence Zone

The Inter-Tropical Convergence Zone (ITCZ) is a zone of potential intense rain-cloud development, created when the southeast trade winds collide with the northeast winds, depending on the ITCZ being active. The ITCZ seasonally migrates north-south and vice versa across Africa, in response to the position of the sun, and its arrival generally leads to substantial amounts of rainfall. Figure 3.2 shows the northern and southern limits of the ITCZ. The red spread represents the northern limit which occurs in austral winter (July). The blue spread represents the southern limit which occurs during austral summer (January). The southward movement of the ITCZ from the equator marks the onset of the primary rainy season in southern Africa.

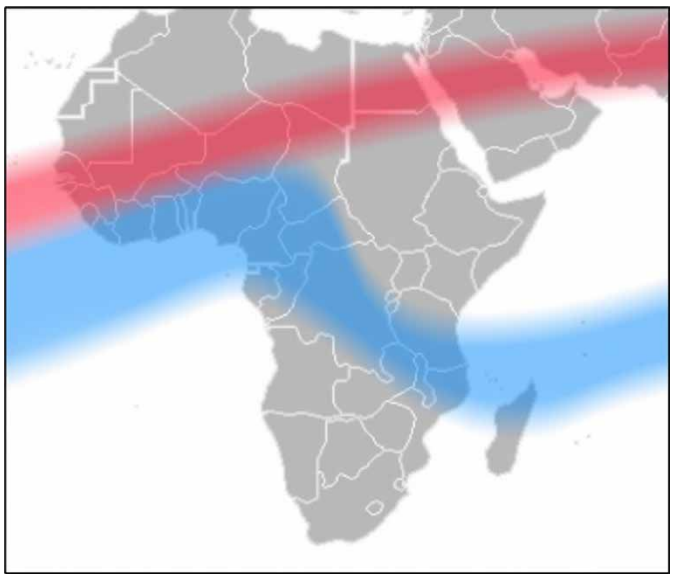


Figure 3.2: ITCZ movements: The northern limit is represented by the red spread and it occurs in austral winter (July). The southern limit is represented by the blue spread and it occurs during austral summer (January).
Source: Haldin, 2006.



Photo: Justine Ewart-Smith

3.1.2 Botswana Upper High

During the austral summer rainfall season, the high-pressure cells typically weaken and last for only a short time, which is favourable for rainfall production. However, there are instances when a high-pressure cell strengthens, particularly over Botswana, at altitudes ranging from three to six kilometres above sea level. This high-pressure system, often referred to as the Botswana Upper High (BUH), tends to obstruct rainfall activity beneath it and in its vicinity. A typical BUH has expression at the 700 hector Pascal level, where there is a counter-clockwise wind circulation pattern (Figure 3.3). When the BUH pressure is persistent, it often results in extensive areas of reduced rainfall activity across central and south-eastern areas of the SADC region that are under the BUH pressure system.

Figure 3.4 shows the three-monthly surface winds influencing the weather patterns of southern Africa during the summer and winter periods.

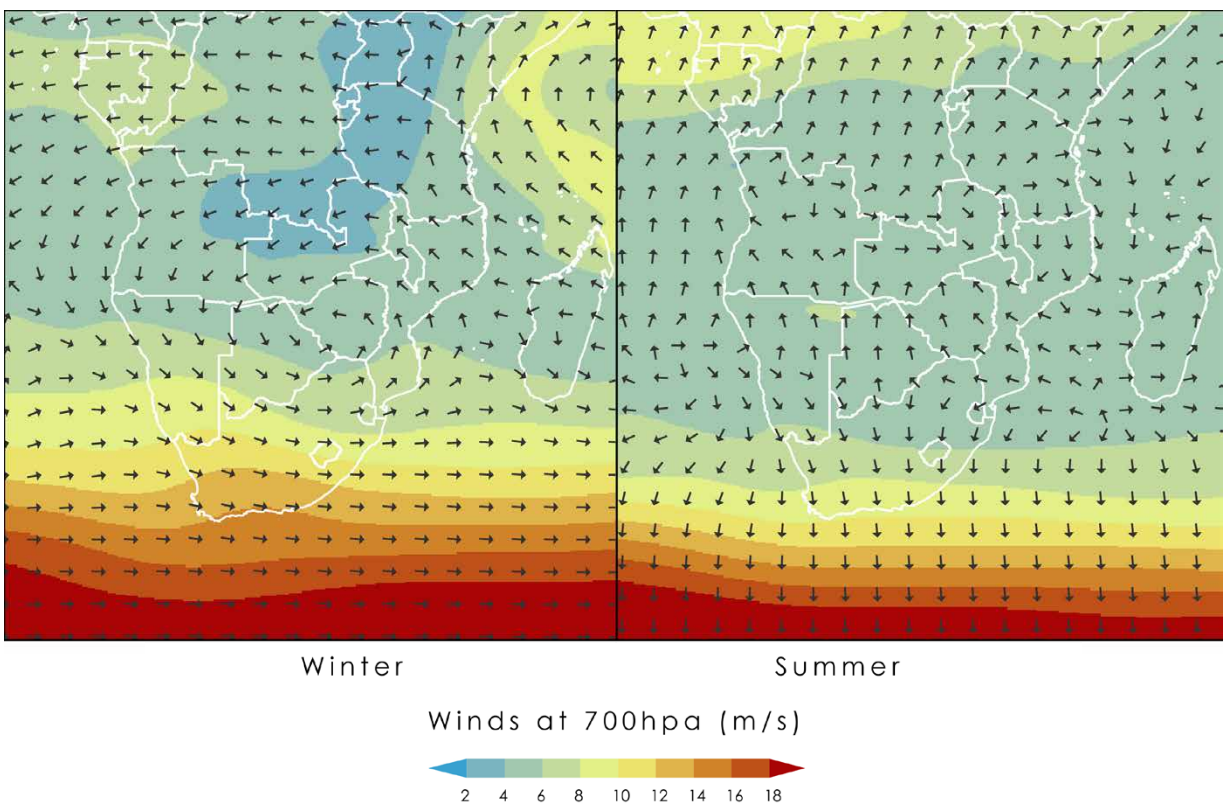


Figure 3.3: The 700 hectoPascal (hPa) wind circulation anomaly consistent with Botswana Upper High.
Source: NCEP/NCAR Reanalysis, Copyright: SARDC, GWPSA, GRID-Arendal 2024.

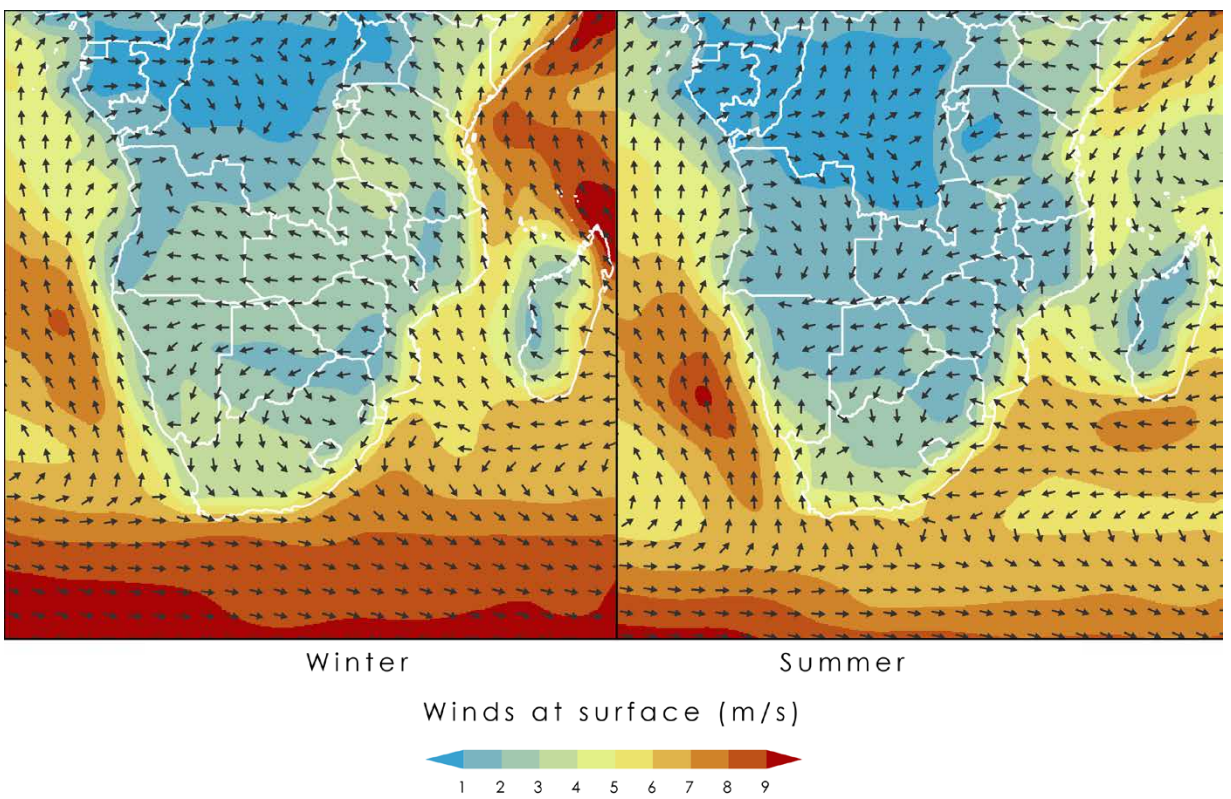


Figure 3.4: Three-monthly surface winds. Left – austral summer (December-January-February); Right - austral winter (June -July-August).
Source: NCEP/NCAR Reanalysis. Copyright: SARDC, GWPSA, GRID-Arendal 2024.

3.1.3 El Niño/La Niña and Southern Oscillation Phenomena

The El Niño/La Niña phenomenon is tied to the Southern Oscillation Index (SOI), which is the standardized pressure difference between Tahiti in the southeast Pacific and Darwin (Australia).

The twinning of the phenomena is referred to as El Niño-Southern Oscillation (ENSO). ENSO is a major contributor to the extremes in the climate system worldwide. A negative SOI indicates an El Niño episode while a positive index is La Niña. The quasi-periodic El Niño-La Niña swings are shown in the time series in Figure 3.5.1.

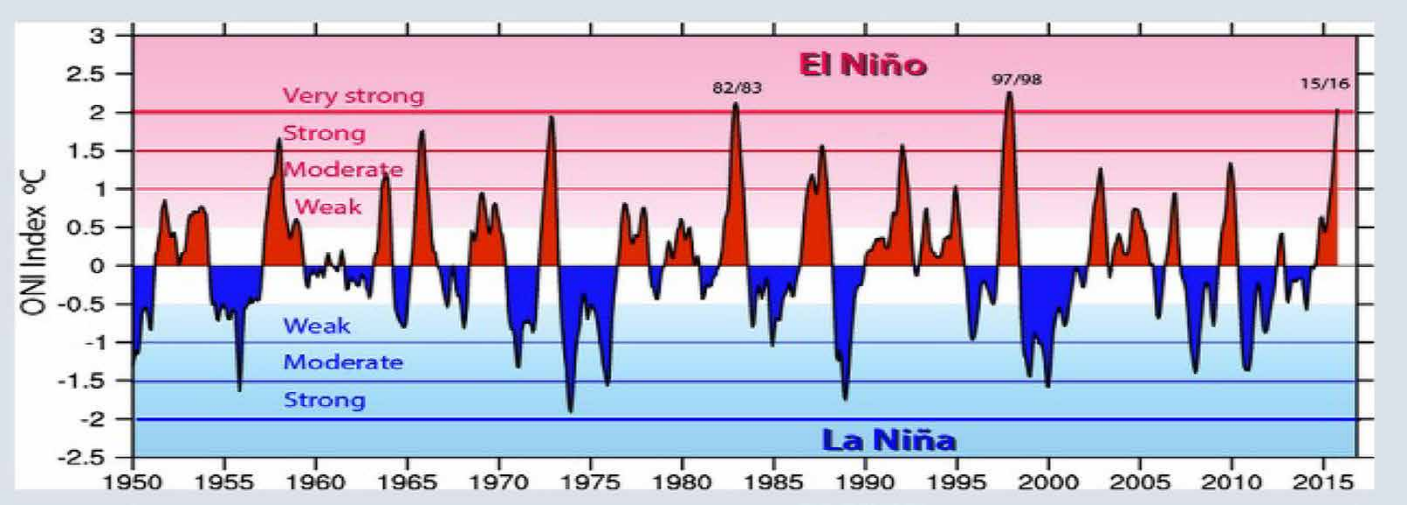


Figure 3.5.1: Standard time series of ENSO.
Source: NCAR-CDC/NOAA.

Periodic behaviour refers to a pattern that recurs at regular intervals, such as every 24 hours. Whereas, quasi-periodic behaviour is a pattern of recurrence with a component of unpredictability that does not lend itself to precise measurement. El Niño is associated with reduced rainfall across the bulk of southern Africa, while La Niña tends to be associated with above-normal rainfall over the southern portion of the SADC region. In the BUPUSA Tri-Basin, the ENSO signal affects each of the basins the same way (Figure 3.5.2). So, when there is an El Niño, all Buzi, Pungwe, and Save basins are likely to experience below normal rainfall. By the same token, when there is a La Niña, the three basins will all experience above-normal rainfall. It is important to note that other parts of SADC are dipolar, that is, having opposite responses to the ENSO signals.

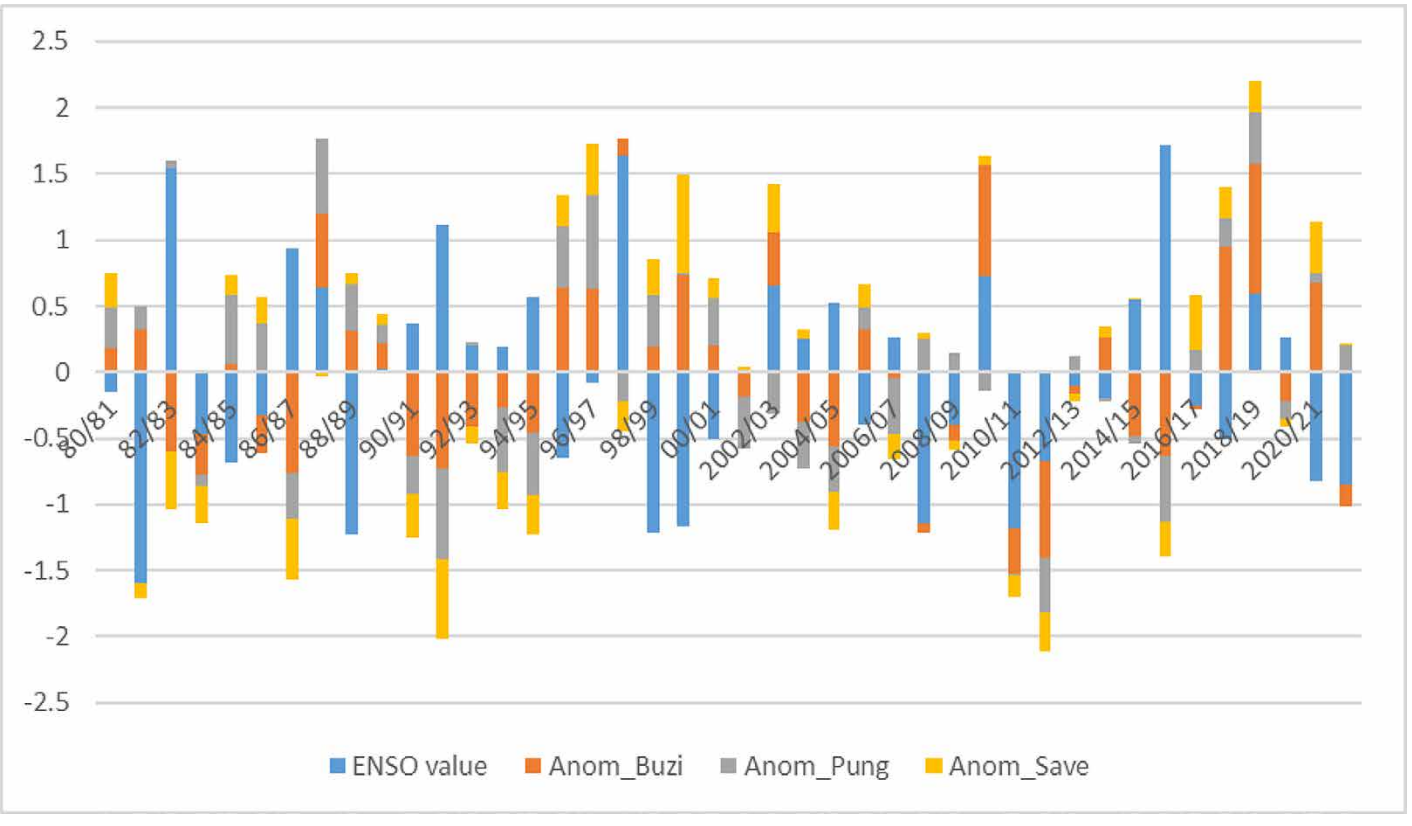


Figure 3.5.2: ENSO BUPUSA annual rainfall anomalies per basin from 1980/81 to 2020/21, blue (ENSO value), orange (Buzi), grey (Pungwe) and yellow (Save).
Source: GRID-Arendal 2023.

3.1.4 Tropical Cyclones

Tropical cyclones, also called willy-willies, typhoons or hurricanes, are intense circular storms that originate over warm tropical oceans (outside the equatorial belt i.e., 5°North to 5°South). They typically form when the sea-surface temperature is above 26.5°C. Tropical cyclones are characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining strength as long as they remain over warm water, tropical cyclones generate winds that exceed 119 km per hour.

The South-west Indian Ocean Basin serves as a region where tropical cyclones originate or move slowly through before eventually making landfall along the Mozambique coast, including the BUPUSA Tri-Basin. However, once these cyclones move inland, they tend to dissipate due to insufficient moisture supply and increased frictional drag. Figure 3.6.1 illustrates the tropical cyclones and their paths in the south-west Indian Ocean for the period 2000 to 2020. The intensity of the tropical cyclones is represented by colour shading, with deep blue indicating relatively weak cyclones, progressing through green and orange, and reaching red for stronger intensity. The BUPUSA Tri-Basin is particularly susceptible to tropical cyclones.



View of Beira on July 12, 2019, an area affected by Cyclone Idai.
Photo: Getty, Wikus de Wet/AFP

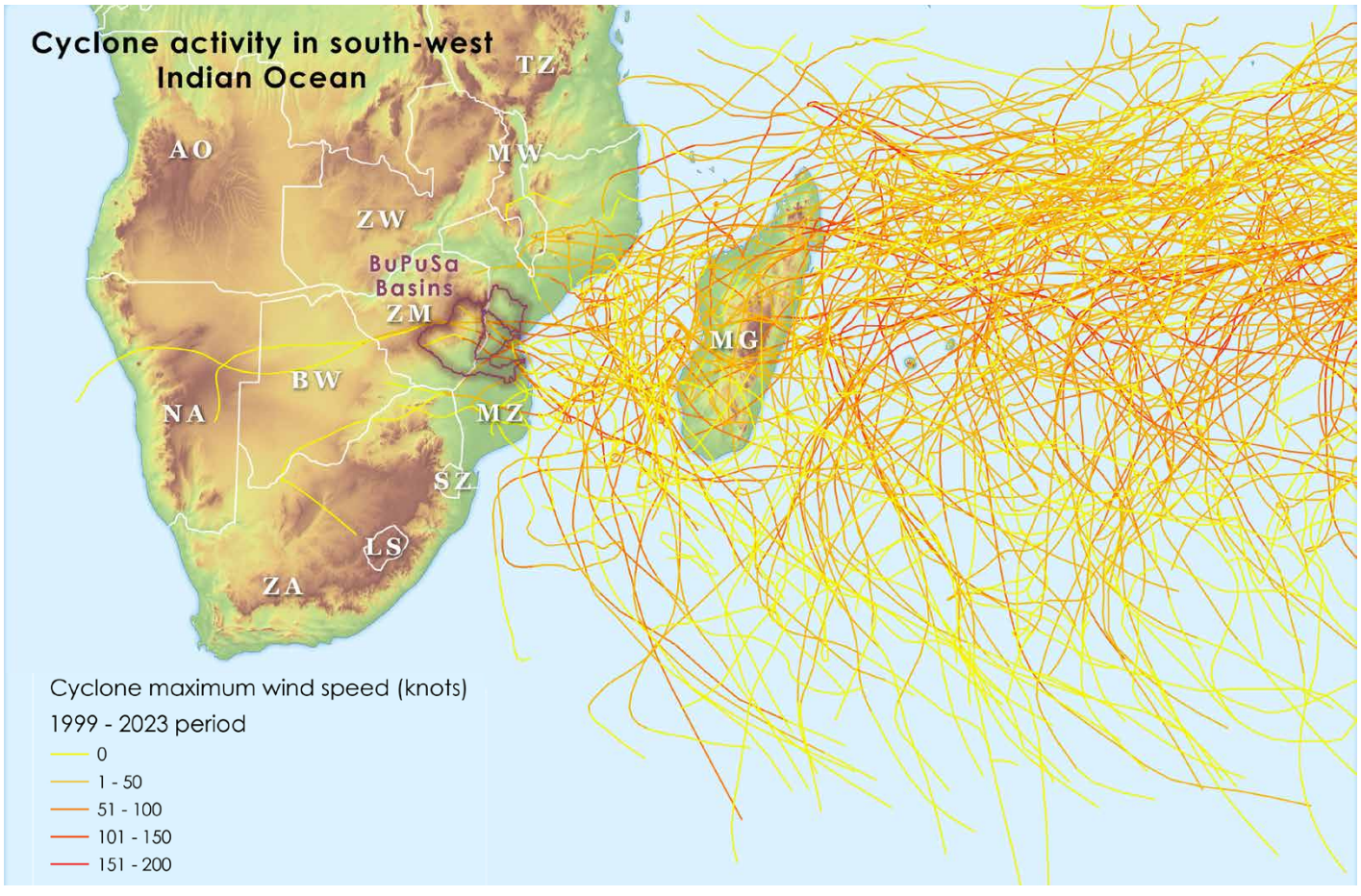


Figure 3.6.1: Geographic framework and two decades of Tropical Cyclones in the south-west Indian Ocean during the cyclonic period between 1999 and 2023. The colour of each dot indicates the cyclone intensity on a 6-hour basis.
Source: Patt et al (2021), Copyright: SARDC, GWPSA, GRID-Arendal 2024.

During the period 2000 to 2020, the number of Tropical Cyclones has an annual mean of about 10 cyclones per season, being as low as five and as many as 15. The number of these cyclones in the south-west Indian Ocean per year is depicted in Figure 3.6.2.

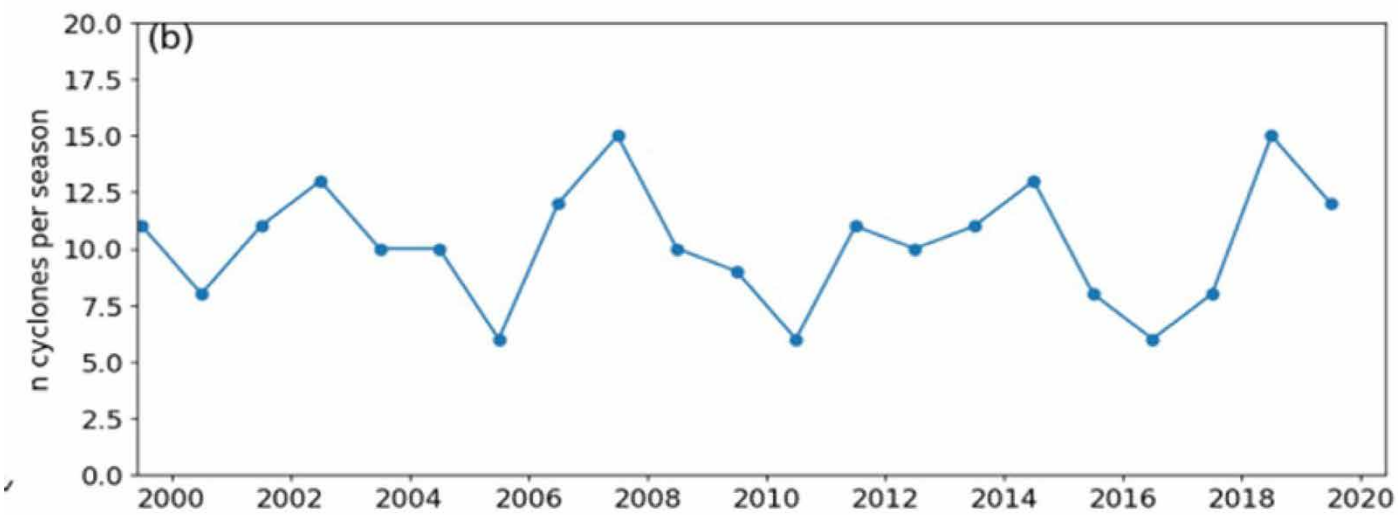


Figure 3.6.2: Number of tropical cyclones/storms, per season, between 1999 and 2020.
Source: Rindraharisaona et al (2021)

3.1.5 Rainfall

According to the Köppen world climate classification (Figure 3.7), the Buzi River Basin is characterized as a tropical rainy savannah in the littoral zone and moderately humid in the interior. The Pungwe River Basin can be divided into two primary climate types, namely, the humid mountainous climate in the western part of the basin at the headwaters and the tropical-humid in the eastern region near Beira. The Save River Basin, however, is predominantly dry in the southwest with savannah vegetation.

The rainfall variations of all the three basins, Buzi, Pungwe, and Save, show almost identical patterns every year. This demonstrates that the individual sub-basins are controlled by the same rain-producing or rain-suppression mechanisms in the same rainfall season.

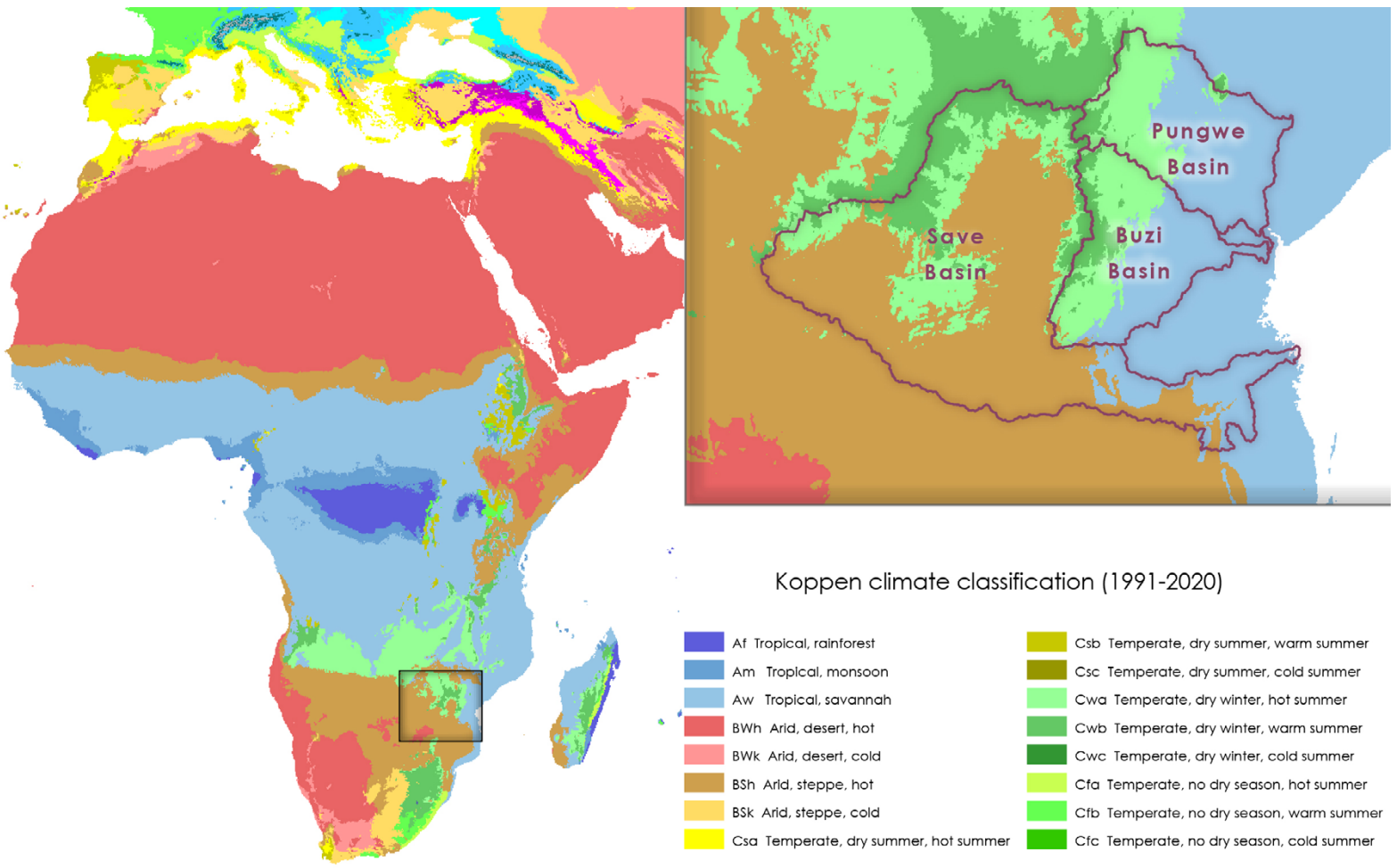


Figure 3.7: Köppen's World Climate Classification for period 1901 to 2010.
Source: http://hanschen.org/koppen. Copyright SARDC, GWPSA, GRID-Arendal 2024.

3.1.6 Surface Air Temperature

The temperatures across the BUPUSA Tri-Basin vary according to elevation and, to a lesser extent, latitude. During the peak of the austral summer season in December, January, and February (DJF), the daytime temperatures in the BUPUSA Tri-Basin vary from about 21°C over the Zimbabwean parts of the Tri-basin, to about 26°C in the low-lying estuarine areas of Mozambique (Figure 3.8).

From March to May, which are transition months from summer to winter, the BUPUSA Tri-Basin experiences declining temperatures as colder air masses begin to affect significant parts of the region. The austral winter is well established in June, July, and August (JJA). In the BUPUSA Tri-Basin, the coolest temperatures are about 18°C over the Zimbabwean parts of the Tri-basin, gradually rising to about 22°C in low-lying estuarine areas of Mozambique.

During the months of September, October and November, most of the BUPUSA Tri-Basin experiences very warm conditions characterised by clear skies and under the influence of tropical air, with temperatures greater than 26°C.

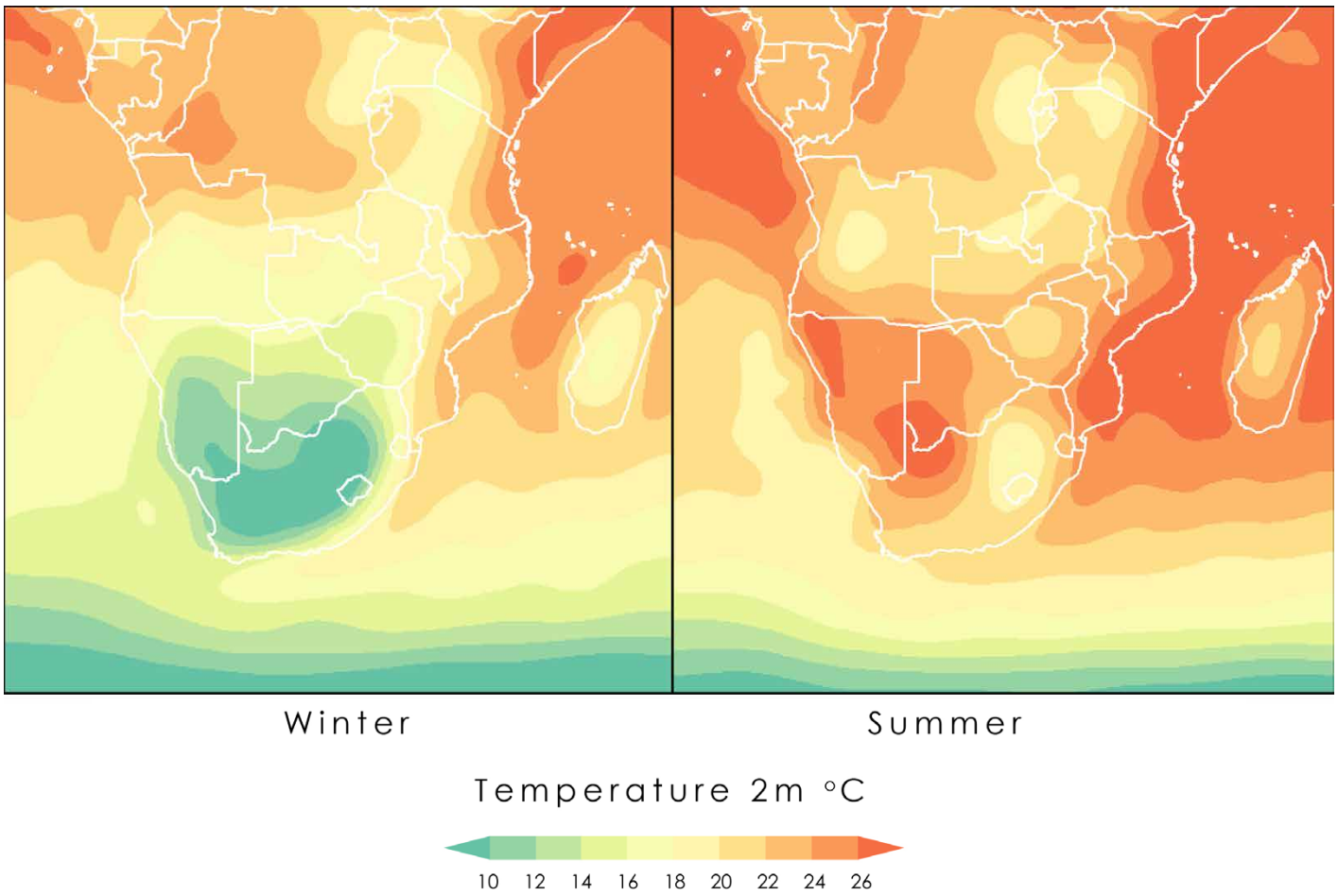


Figure 3.8: Three-monthly temperatures. Left – austral summer (December-January-February); Right – austral winter (June -July-August).

Source: NCEP/NCAR Reanalysis. Copy right: SARDC, GWPSA, GRID-Arendal 2024.

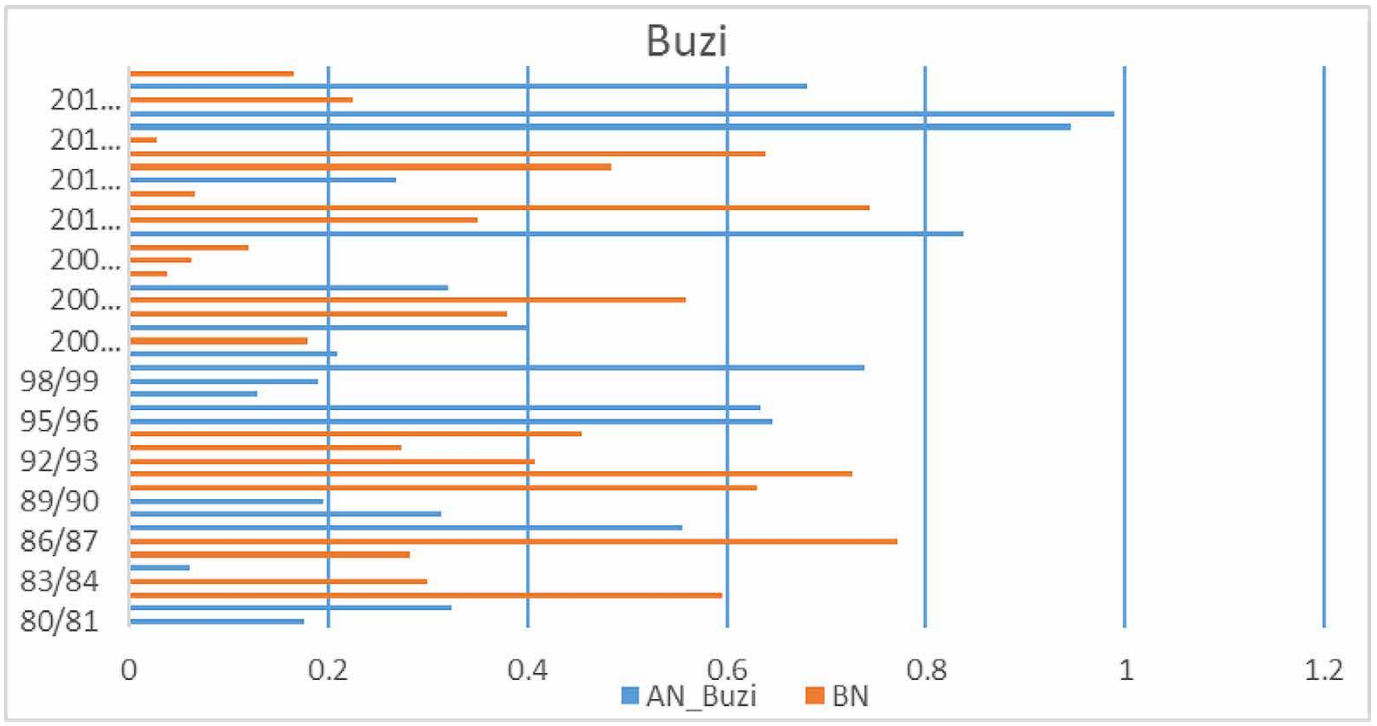
3.2 Climate Extremes: Droughts, Floods, and Tropical Cyclones

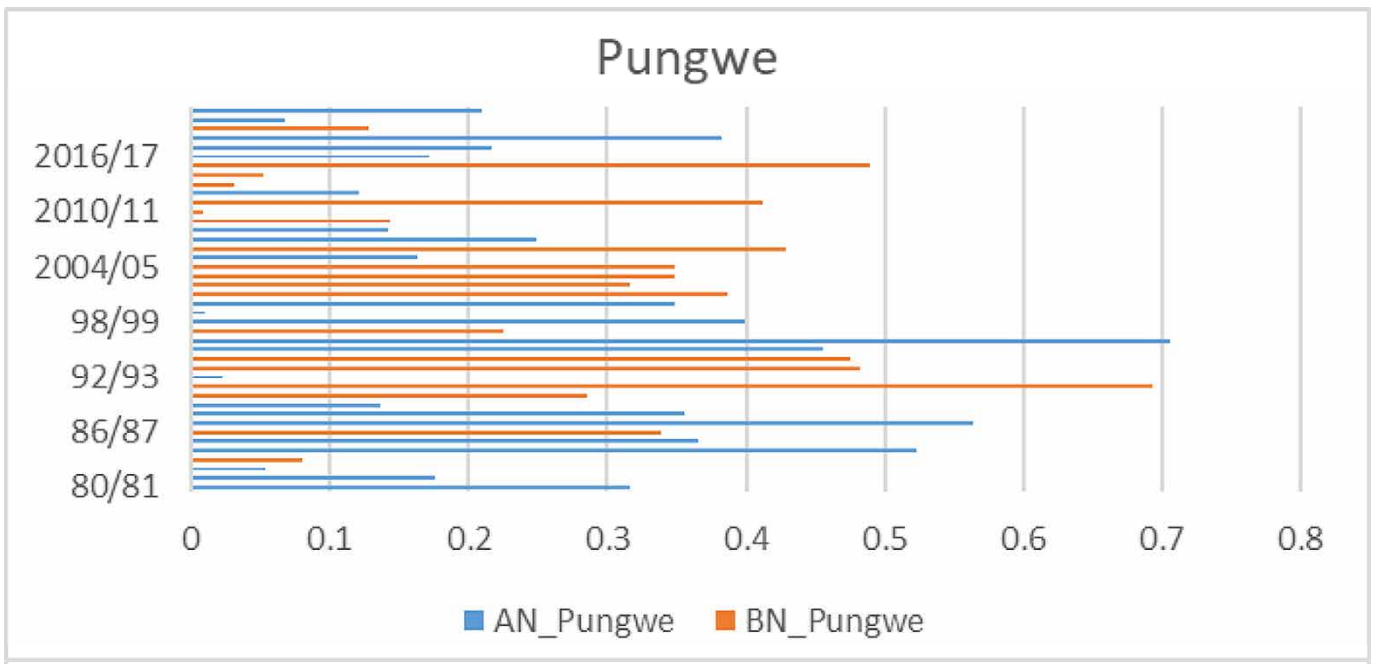
Climate extremes in the form of both droughts and floods are significant perennial challenges in the BUPUSA Tri-Basin (Table 3.1). The Tri-Basin experiences periods of drought that are interspersed with episodes of flooding. Droughts are largely associated with El Niño events, while flooding is associated with La Niña episodes that create favourable conditions for the development of active tropical cyclones in the Indian Ocean. According to GWPSA (2023), apart from the vicinity of the headwaters of the Pungwe and Buzi River Basins, especially on the Zimbabwean side, the rest of the BUPUSA Tri-Basin is vulnerable to droughts. The interspersed, above-normal (flooding) and below-normal (drought) rainfall patterns from 1980/1981 to 2020/2021 are shown in Figure 3.9. For instance, between 1982 and 2011, drought accounted for 60 percent of the natural disasters experienced in Zimbabwe (GOZ, 2020). This is similar to experiences in Mozambique.

Table 3.1: Occurrence of Extreme Events in the BUPUSA Tri-Basin

2023	Cyclone Freddy caused death and destruction, especially in Malawi.
2019-2020	Cyclones Idai and Kenneth devastated parts of SADC, resulted in over 1,500 deaths
2017	Cyclone Dineo responsible for 200 deaths in Mozambique
2015-2016	Severe drought across most of SADC Member States
2011-2012	Tropical Cyclone Funso and Tropical Depression Dando caused flooding in coastal regions.
2007-2008	Tropical Cyclones Favio and Jokwe and antecedent heavy rains devastated southern Africa, in particular across most areas in Mozambique.
2004-2005	Poor rains in most of southern Africa.
2003	Cyclone Japhet devastated the BUPUSA Tri-Basin.
2001-2003	Severe drought in the SADC region, particularly from Zimbabwe northwards.
1999-2000	Cyclone Eline hit the region and widespread floods devastated large parts of the Limpopo basin (southern and central Mozambique, south-eastern Zimbabwe, parts of South Africa and Botswana).
1997-98	Strong El Niño, but there was normal rainfall throughout the region including the north-east.
1996-97	Normal rainfall for most of the region.
1994-95	Many SADC countries were hit by the severest drought in memory, surpassing effects of the 1991-92 drought in some parts of the region
1993-94	Conditions improved.
1991-92	Severe drought in southern Africa, excluding Namibia.
1988-90	Near normal seasons.
1986-87	Drought conditions returned to the region.
1984-85	Near normal seasons, but drought strains from the previous three years were still felt in most parts of the region.
1981-82	Drought in most parts of southern Africa. In 1982, most of sub-tropical Africa experienced drought.
1974-80	This period was relatively moist over much of southern Africa. In 1974 the mean annual rainfall was 100 percent above normal throughout the region.
1967-73	This six-year period was dry across the entire region. Some records show a severe drought in 1967.

Sources: SADC and SARDC 2008; African Development Bank 2019; Action Aid International 2023; IFRC 2020; IFRC 2022; ZAMCOM, SADC, SARDC 2015





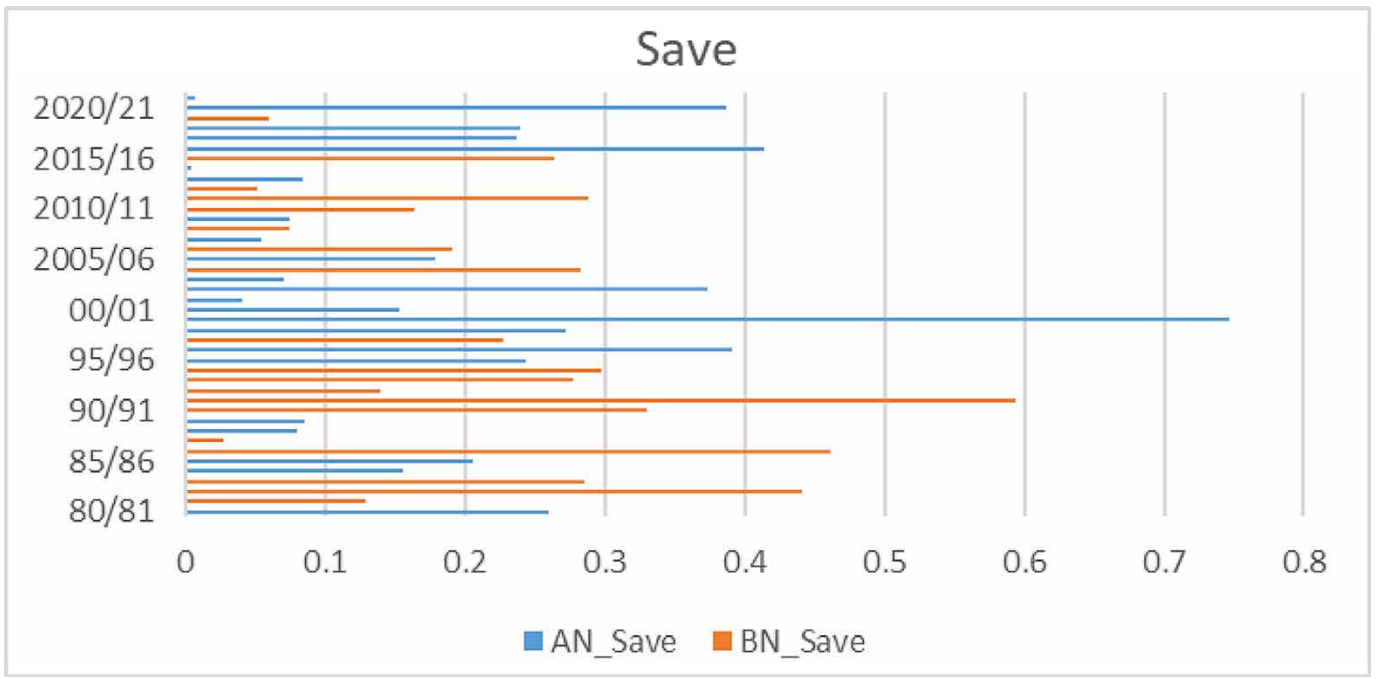


Figure 3.9: Years of above-normal (AN) (blue) and years of below normal BN) (orange) rainfall across the sub-basins.
Data Source: GRID-Arendal 2023.

The BUPUSA Tri-Basin is recognized as a flood-prone area, considering floods with 2-year, 10-year, and 50-year return periods based on 6-hour and 14-day rainfall events. Figure 3.10.1 presents maps illustrating the

flood risks associated with these rainfall events and return periods across the BUPUSA Tri-Basin. The most flood prone catchment of the Tri-basin is the Pungwe catchment, especially towards its mouth. This is the case even for a 6-hour rainfall event. Naturally the risk increases for the longer return period floods. The panels are obtained from UNESCO (2022).

As the BUPUSA Tri-Basin is susceptible to droughts, a drought risk map is an important tool for planning. The map depicts countries within the region based on their drought risk index score, based on past drought severity, water stress drought vulnerability, population, and crop and livestock density. BUPUSA is within the high-risk zone of southern Africa. The shadings on the map are such that lighter shade of red and white (Namibia and Angola) is moderate, deeper shades of red (the rest of SADC) is in the high-risk zone, Figure 3.10.2.

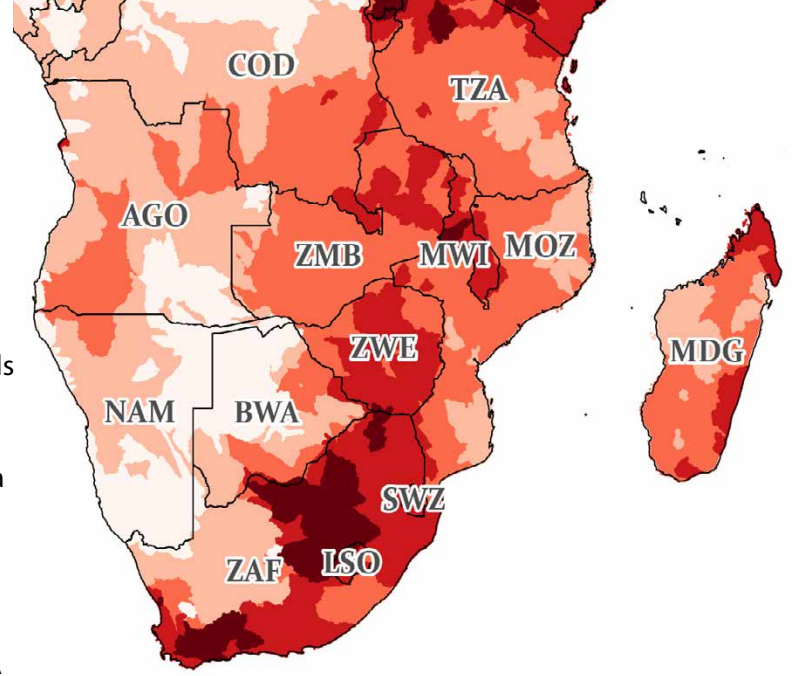


Figure 3.10.2: Drought risk map of southern Africa. Lighter shade of red and white (Namibia and Angola) is moderate, deeper shades of red (the rest of SADC) is in the high-risk zone.

Source: Aqueduct, World Resources Institute, 2019.

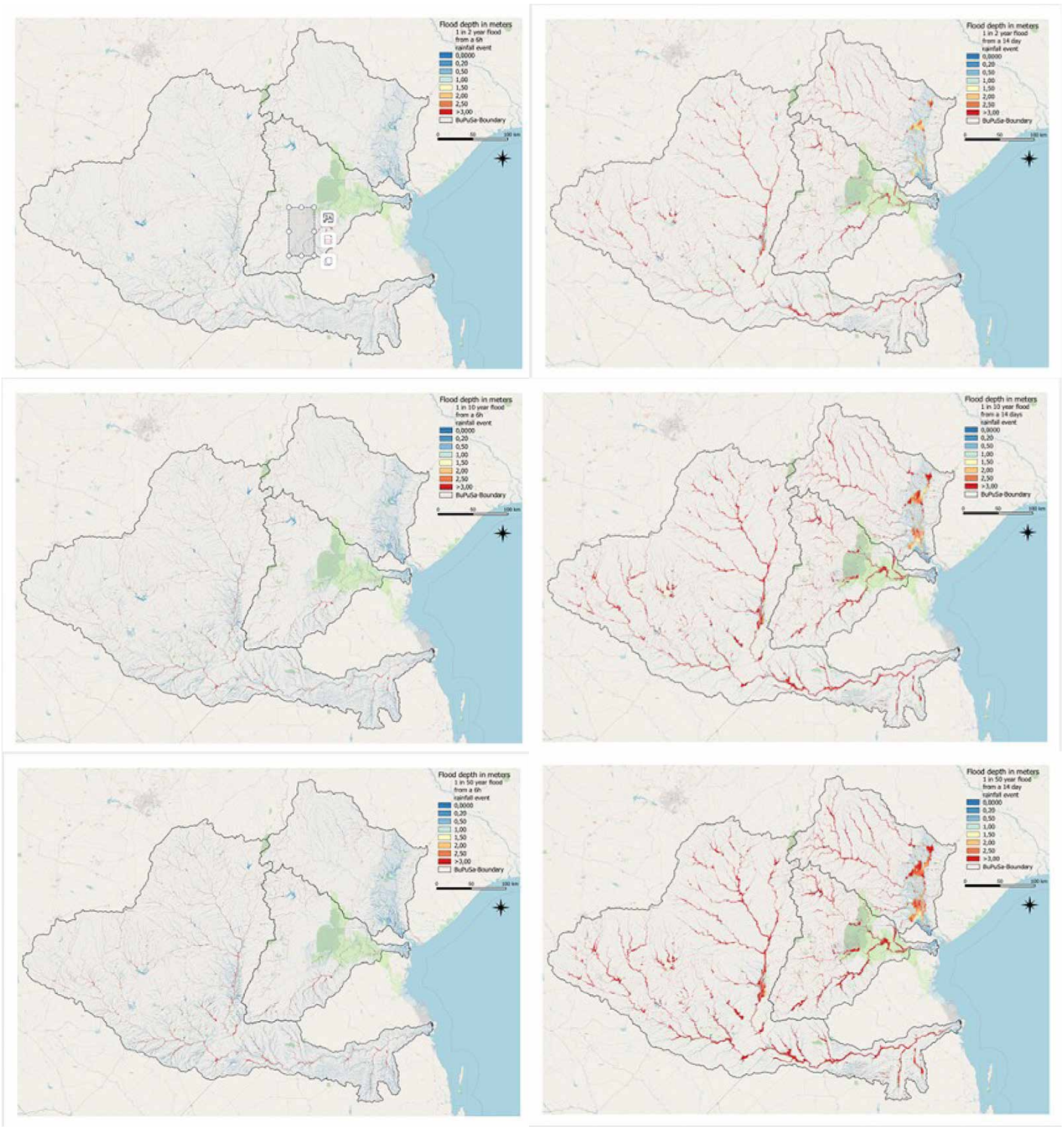


Figure 3.10.1: (a) Flood risk maps for BUPUSA (a) 2-year return period (i) 6-hour rainfall event; (ii) 14-day rainfall event, (b) same as (a) 10 year -return flood and (c) for 50 year-return floods.

Source: UNESCO, 2022.

3.3 Climate Change Outlook for the BUPUSA Tri-Basin

It is important to note that sea water level rise is not globally uniform and varies regionally. Regional differences, within ±30 percent of the global mean sea water level rise, result from land ice loss and variations in ocean warming and circulation. Along the coastal regions of the BUPUSA Tri-Basin, vulnerability to climate change stems from the combined risks of rising sea levels and the impacts of severe tropical cyclones.

3.3.1 Projections of Climate Change Scenarios

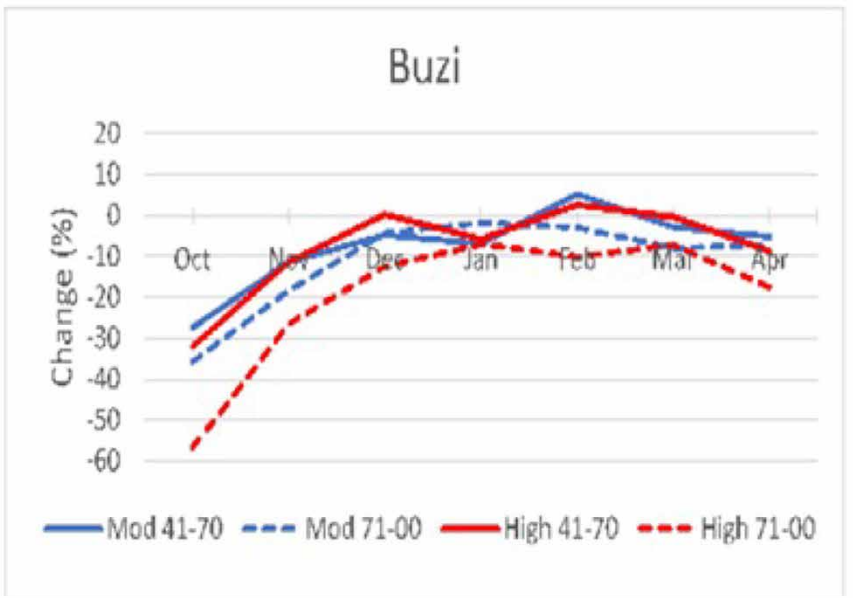
According to the Synthesis Report (2023) of the Intergovernmental Panel on Climate Change (IPCC) sixth Assessment Report (AR6);

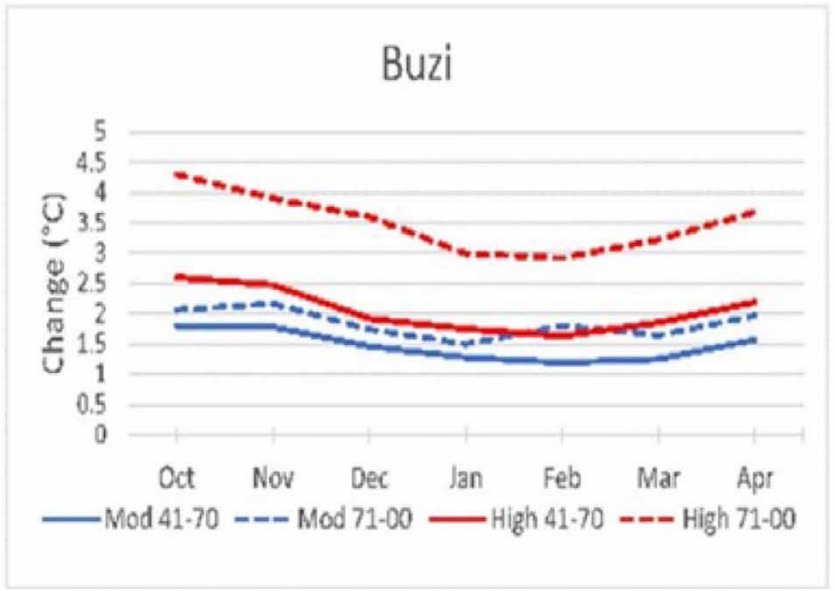
- Climate change has already caused widespread impacts and related losses and damages on human systems and altered terrestrial, freshwater and ocean ecosystems worldwide.
- Observed impacts are connected to physical climate changes including many that have been attributed to human influence such as the selected climatic impact-drivers shown.
- Observed (1900–2020) and projected (2021– 2100) changes in global surface temperature (relative to 1850–1900), which are linked to changes in climate conditions and impacts, illustrate how the climate has already changed and will change along the lifespan of three representative generations (born in 1950, 1980 and 2020).

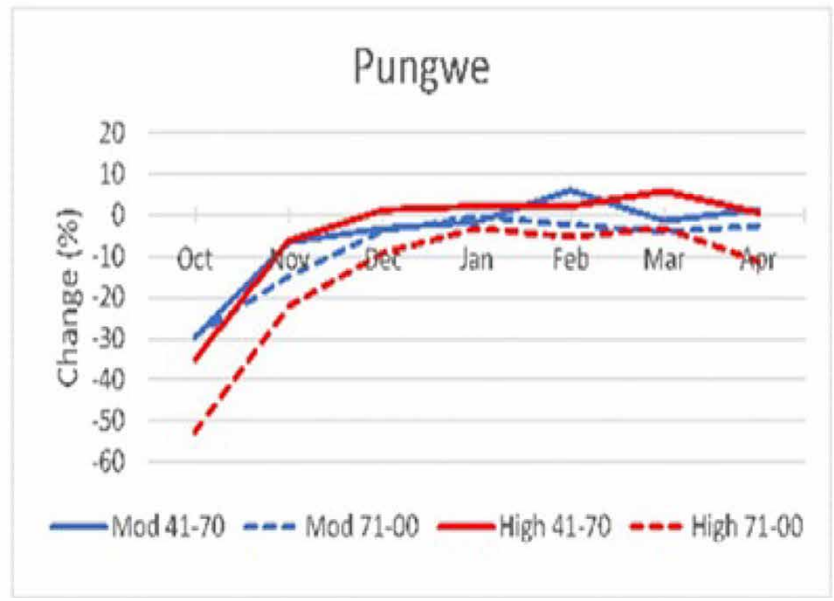
Climate change scenarios for rainfall and temperature for each basin, Buzi, Pungwe, and Save, are shown in figure 3.11.1. Each figure shows results from both the moderate (blue) and high (red) emissions scenarios for each of two future time periods, 2041-2070 (solid) and 2071-2100 (dashed), SMHI (2023). These are based on climate change scenarios for the Representative Concentration Pathway (RCP), that is, greenhouse gas concentration (not emissions) trajectory adopted by the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC).

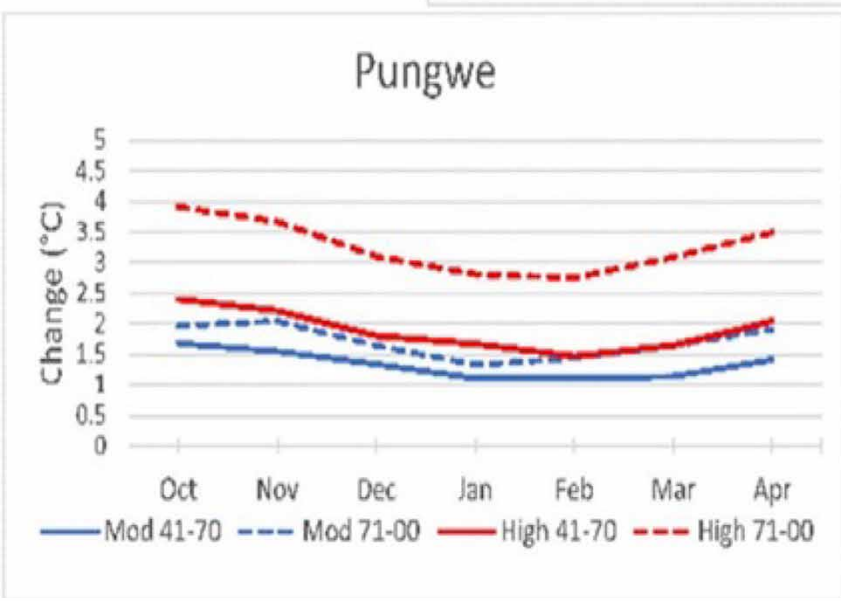
Seasonal changes for temperature and rainfall in the Buzi, Pungwe, and Save river basins show results from both the moderate and high emissions scenarios for each of two future time periods, 2041 to 2070 and 2071 to 2100 from climate projections (CORDEX-Africa, 2023). The annual climate change results indicate a steady increase in temperature over the next century for the BUPUSA Tri-Basin for both the moderate and high climate emission scenarios. Both scenarios indicate increases in temperature of just under 1°C in the near future period (2011 to 2040). For the intermediate future (2041 to 2070), temperature increases begin to deviate between the moderate scenario of 1.5°C and the high scenario of 2°C. Differences in the increasing temperatures are more pronounced for the far future (2071 to 2100), with just under 2°C for the moderate scenario compared to close to 3.5-4°C for the high scenario. Changes in rainfall are considerably more variable over time and between the two emissions scenarios. For the near future, changes in rainfall are quite small and lie mostly within natural variability for the region. Rainfall changes then become more apparent as time progresses over the projected climate period. On an annual basis, the trends are for decreasing rainfall for both moderate and high scenarios, with the largest annual decreases of some -7 to -11 percent occurring in the far future for the high scenario, compared to -4 to -6 percent for the moderate scenario (GWPSA 2023).

At mid-century, rainfall changes show decreases for both scenarios, with the moderate scenario showing more decrease at -1 to -2 percent over the high scenario at -2 to -5 percent. The changes in rainfall that appear milder at mid-century for the high scenario are most likely the results from natural variability than from the warming response. In this regard, the Climate Information Portal Models generally point towards a drier, warmer future with delayed onset of the rainy season in the BUPUSA Tri-Basin (SMHI, 2023).









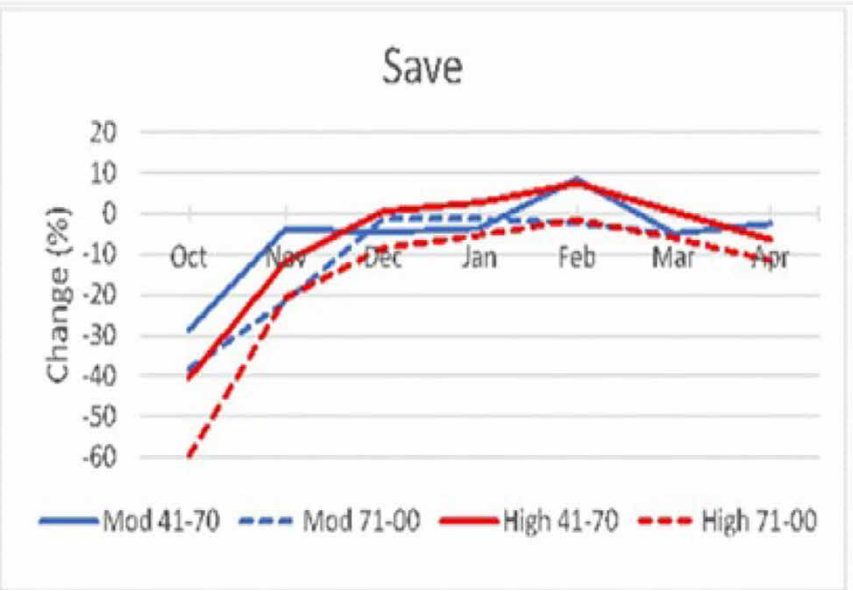




Figure 3.11: Projected climate change scenarios, solid (2040-70) dashed (2071-2100), blue moderate, red high (a) rainfall (i) Buzi (ii)Pungwe (iii) Save; (b) same as (a) but for temperature.

Source: GWPSA 2023.

3.3.2 Climate Information Service for Society

The past several decades have witnessed phenomenal advances in the understanding of the laws that govern the characteristics and behaviours of the global climate system. This has resulted in an improvement in the prediction skills, accuracy, and reliability of multi-timescale forecast products ranging from short- and medium-range, intermediate-range (sub-seasonal), and seasonal and inter-annual. Seasonal climate forecasts are predictions of the expected climate conditions for the next three to six months. These forecasts can be of great value for a number of climate sensitive sectors (e.g., agriculture, health, and water resources management). This has led to better planning of multi-sectoral socio-economic developments, yielding enormous benefits to society (Coelho and Costa, 2010).

There is an increasing need for the delivery of sector-specific weather and climate services to ensure food security, improve water and land management, facilitate disaster risk reduction, and support better health delivery outcomes in the SADC region.

With Customer Information Services (CIS) in place, the delivery of climate services will ensure that development is less vulnerable to the adverse impacts of climate change and variability.

Until recently, more weather and climate forecasting efforts had been deployed in research of short to medium-range (weather time scales) and long-range (seasonal and annual climate timescales) and beyond, as there was a gap from medium-range (10-14 days) to one to five months. In recent times, due to demands from required management decisions in agriculture and food security, water resources, disaster risk reduction, and health, there have been intensified efforts to acquire prediction capabilities for the sub-seasonal range. Figure 3.12 illustrates the value of multi-timescale forecasting and its relevance across multiple sectors. The figure showcases the temporal ranges and sources of predictability for weather and climate. In general, accuracy decreases as the lead time increases. Therefore, in seasonal forecasting, the utilization of large area and time averages is employed to enhance overall accuracy.

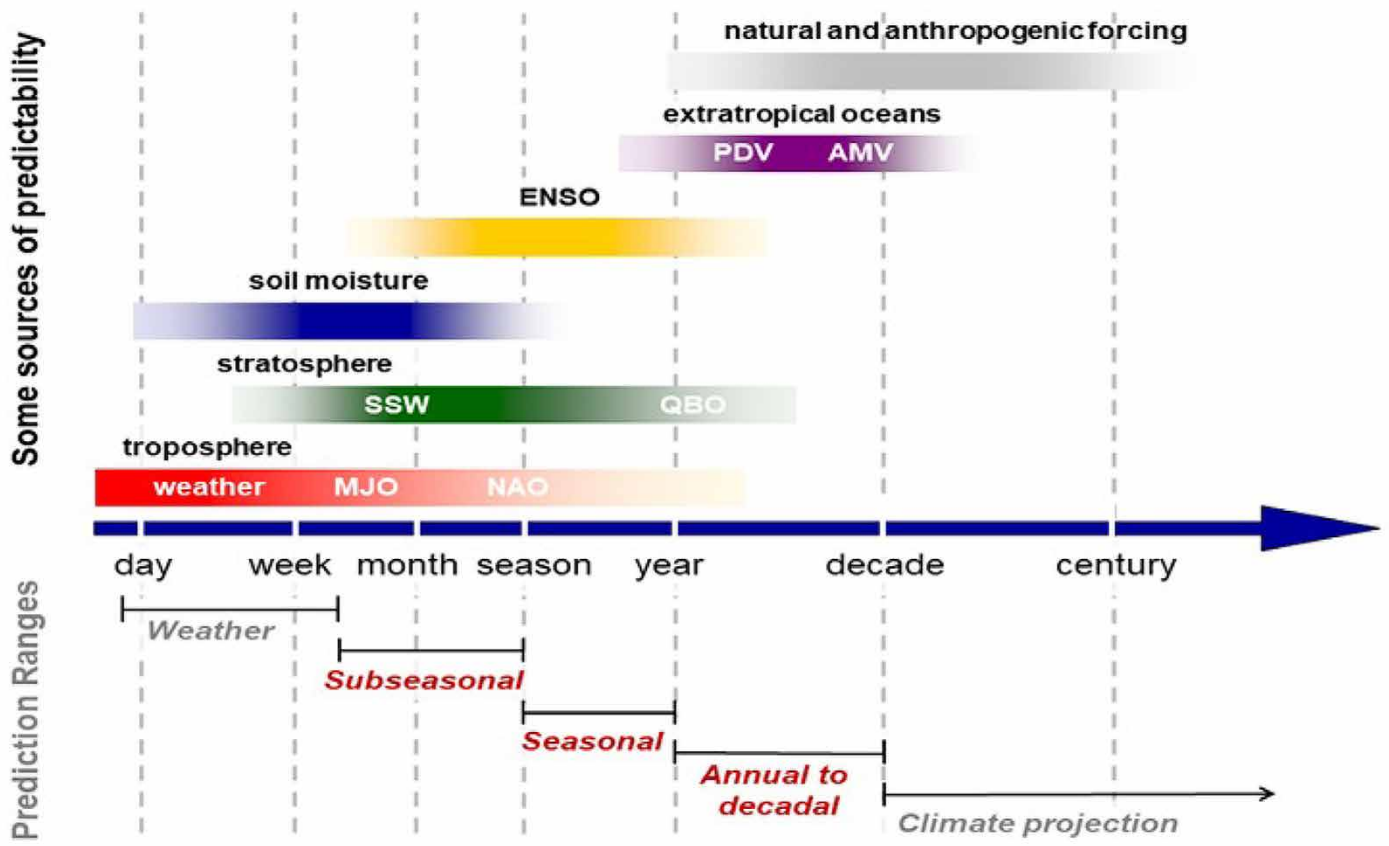


Figure 3.12: Schematic depiction of temporal ranges and sources of predictability for weather and climate.
Source: Merryfield et al. (2020).

3.4 Indigenous Knowledge Systems in BUPUSA Tri-Basin Climate Forecasting

Indigenous knowledge is the local knowledge that is unique to a given culture or society, developed and shared over time through observation and experience. It is adapted to local culture and the local environment, is dynamic and changing. Indigenous knowledge is not confined to a certain group of people. People in rural areas and urban areas have their unique knowledge. Jiri et al (2016) suggest that rural farmers in southern Africa have managed to survive the vagaries of climate change over the years due to their mastering of indigenous knowledge systems in weather and climate forecasting. Also, it is recognized that indigenous people have managed the environments in which they have lived for generations, often without significantly damaging local ecologies (Matowanyika, 1994). Greater availability and access to scientific climate information and products will help make cropping and other decisions at the local level much easier. Over-exploitation of natural resources, based on inappropriate attitudes, technologies, and climatic shifts causing loss of biodiversity, affects the reliability of the indigenous knowledge that the rural farmers have been using.

Communities in the BUPUSA Tri-Basin also rely on indigenous knowledge systems (IKS), particularly for predicting weather to plan and prepare for their agricultural activities as well as disaster management. Farmers use this knowledge that is derived from observations of atmospheric and astronomic conditions, indicator plants and behaviour of animals (insects, birds, and mammals) which signal the onset of the rainy season or indicate what type of season it will be. It is important to note that, like all other systems, IKS use in weather and climate forecasting as a climate change adaptation strategy has both its advantages and disadvantages (Chisadza et al, 2013; Chisadza et al, 2014; Chisadza et al, 2015). For instance, the advantage is that there is potential to use this framework to integrate traditional knowledge indicators with meteorological parameters, thus, enabling indigenous communities to link their knowledge with science. On the other hand, the disadvantage can be that increased climate variability and change reduces the accuracy and the reliability of traditional climate forecasting.



Local water source kept intact by applying indigenous knowledge system practices in Chadzuka, Mozambique.
Photo: Moses Makwanise/IUCN

3.5 Adaptation Strategies

From the Transboundary Diagnostic Analysis (TDA) carried out for various sectors of the BUPUSA Tri-Basin from 2022 to 2023, it was established from the climate change scenarios used that the BUPUSA Tri-Basin will likely experience more frequent hydrometeorological extremes like severe floods, severe droughts and high temperatures in all the component basins. These extremes impact the environment and other facets of socioeconomic developments in an interlinked manner. Such linkages are best demonstrated through Causal Chain Analyses (CCA) which consider root and underlying causes through sectors and impacts on biodiversity and other development processes. In the BUPUSA Tri-Basin, CCA on hydrometeorological extremes demonstrated the interplay of negative impacts on socioeconomic development and from agricultural production systems; mining; infrastructure development or lack of it; urban planning; and loss of biodiversity. The extent of flooding may be intensified due to poorly maintained embankments and structural measures, while in urban areas, poor land use planning and inadequate drainage worsen flooding. In addition to the destruction of homes and infrastructure and the loss of crops and livestock, flooding also inundates land, decreases soil fertility, and destroys fodder resources, thus limiting agricultural production.

There will be a need for investing in climate information services, including the multi-hazard early warning system (MHEWS); promoting climate-smart agriculture; afforestation; improvement of drainage systems; ensuring that mining activities are conducted within safety systems and regulations; enforcement of regulations that take into account climate sensitive design for the built environment in urban centres; and construction of climate sensitive hydraulic structures. It will be important to improve awareness and education.

There is a need to strengthen community institutions and build awareness of climate threats to promote climate-responsive planning and development, and local ownership of solutions, including the integration of indigenous knowledge systems into scientific weather and climate forecasting systems.



More resources are needed to improve flood monitoring in the BUPUSA Tri-Basin.
Photo: Kevin Piertersen

3.6 Regional Efforts

SADC established the SADC Climate Services Centre (CSC) in Gaborone, Botswana. Other Regional Centres have also been established on the continent, such as the Intergovernmental Authority on Development's (IGAD) Climate Protection and Applications Centre (ICPAC) in Nairobi, Kenya, and the African Centre of Meteorological Applications for Development (ACMAD) in Niamey, Niger, which have played major roles in the provision of climate information and prediction services through their activities, such as the Regional Climate Outlook Fora. The UN System, under the leadership of the WMO, established in 2009 the Global Framework for Climate Services (GFCS). The GFCS has five pillars: Observation and Monitoring; Research, Modelling and Prediction; Capacity Building; Climate Services Information System (CSIS); and User Interface Platform (UIP) (WMO, 2020). The GFCS will facilitate better management of the risks of climate variability and change, and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice at all levels (WMO, 2020). The main objective of the SADC CSC, as part of the network of the GFCS, is to minimize negative impacts of climatic extremes on socio-economic development in the region. This is consistent with the SADC Heads of States' prioritization of building capacities of producers of CIS and its subsequent application by end users at the SADC level. For instance, in May 2017, on a visit to the SADC CSC, the then Chair of SADC, King Mswati III of Eswatini urged the CSC to:

- Demonstrate the economic benefits of applying seasonal climate prediction;
- Ensure various departments of Governments factor climate information and prediction services in planning;
- Produce more frequent weather and climate forecast updates at multi-timescales; and
- Enhance its work in training users on applying climate information and prediction services.

4

TRANSBOUNDARY WATER GOVERNANCE AND COOPERATION IN THE BUPUSA TRI-BASIN



PHOTO: GEF-BUPUSA

4.1 Introduction

Mozambique's geographic location makes the country unique in the southern African region as it shares nine out of 15 transboundary watercourses in the region, being a downstream country in all of them. The only exception is the Ruvuma, which is shared as a border river equally with Tanzania. As much as 54 percent of Mozambique's water resources come from upstream, making the country very vulnerable in terms of water availability and degradation of water quality, as it receives a large amount of water from upstream countries. On the other hand, Zimbabwe shares six out of the 15 transboundary watercourses in the southern African region. It is important to note that Zimbabwe is located upstream in relation to its shared watercourses with Mozambique. Thus, cooperation between Mozambique and Zimbabwe is necessary to ensure avoidance, minimization, and mitigation of negative effects downstream, in order to avoid potential water conflicts. Water resources of mutual interest should serve as a vehicle for cooperation, peace, regional integration, and prosperity between the two nations.

The BUPUSA transboundary watercourses are three out of the five-transboundary watercourses that both parties share in the regional context. Figure 4.1 gives geographical details of the BUPUSA Tri-Basin as it spans the two Member States.

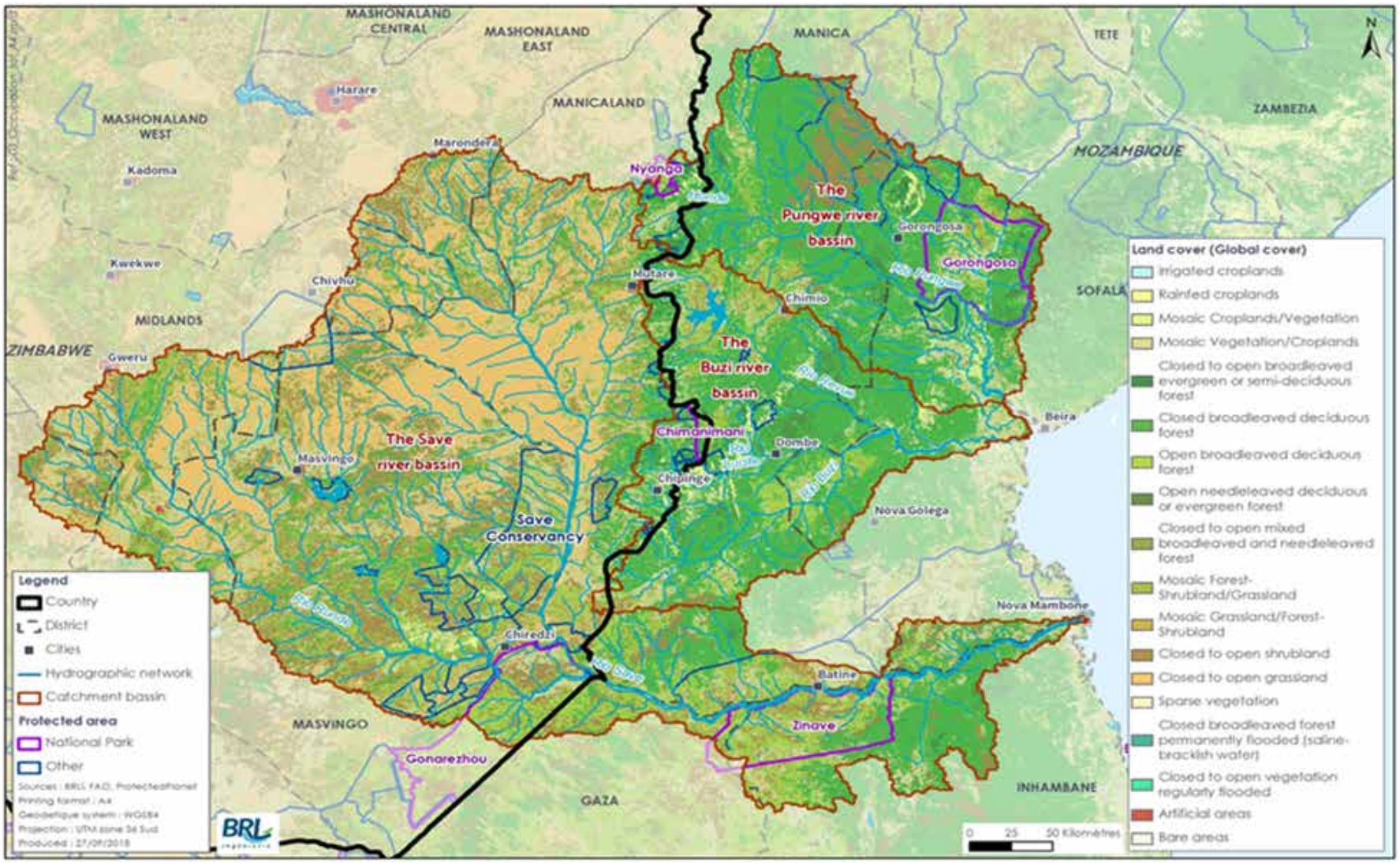


Figure 4.1: Map of the BUPUSA River Basins.
Source: GEF, 2020.

4.2 Historical Cooperation

Mozambique and Zimbabwe were independently developing their water resources projects and investments, with no coordination between the two countries concerning the development of the shared river basins. A series of droughts in the 1990s led to very low flows in the Pungwe basin in Mozambique. The City of Beira, which relies heavily on Pungwe Water Resources, experienced a huge shortage of water for industrial and domestic water use. These two events came at a time when Zimbabwe was planning an inter-basin transfer from the Pungwe to the Save basin in Mutare. This created an urgent need for cooperation between Mozambique and Zimbabwe, subsequent to which Zimbabwe proposed the establishment of an International Water Commission to regulate water resources development activities within the Save River Basin in 1995.

To date, the parties have engaged in numerous negotiations, which resulted in several agreements at both regional and bilateral levels. These agreements are outlined in Table 4.1.

Table 4.1: Regional and BUPUSA Tri-Basin Agreements, their Purpose and Status

Agreement	Purpose	Status
The Revised SADC Protocol on Shared Watercourses	To establish a common legal framework that applies the same core set of international rules to the management of shared watercourses across the region.	Signed 2000 Ratified by Mozambique. Zimbabwe yet to ratify.
Joint Water Commission Agreement	To advise Parties on the conservation, development, and utilization of water resources of common interest.	Ratified 2002
Pungwe Water Sharing Agreement	Cooperation on the development, management and sustainable utilization of the Water Resources of the Pungwe River Basin.	Signed 2016 Ratified
Buzi Water Sharing Agreement	Cooperation on the development, management and sustainable utilization of the Water Resources of the Buzi River Basin.	Signed in 2019 Ratified
Save Water Sharing Agreement	Cooperation on the development, management and sustainable utilization of the Water Resources of the Save in the Save River Basin.	Signed Awaiting ratification by both Parties
BUPUSA Watercourses Commission Establishment Agreement	Establishes the BUPUSA Watercourses Commission and defines its roles and responsibilities.	Signed in May 2023 Commission launched in July 2023 and interim institutional operational arrangements in place
BUPUSA Watercourses Commission Hosting agreement	Establish the legal status of the Commission and the terms for its hosting.	Signed in May 2023
Rules and Procedures for Data and Information	To give effect to the provisions on data sharing in the JWC Agreement, BUPUSA basin agreements, and the SADC Protocol.	Approved by JWC Undergoing Internal Legal Process before being Signed by Ministers of Water in November 2024 and is under implementation

4.3 The Revised SADC Protocol on Shared Watercourses 2000

The (Revised) SADC Protocol on Shared Watercourses 2000 (hereinafter referred to as the SADC Protocol) is a regional framework agreement that contains a comprehensive set of substantive and procedural rules for the management of shared watercourses in the SADC region. Drafted in line with the legal principles of the 1997 UN Watercourses Convention, the SADC Protocol focusses on the three key principles of international water law, that is, equitable and reasonable utilization, the obligation to prevent significant harm, and the duty to cooperate. Additionally, the SADC Protocol includes detailed provisions on environmental protection and ecosystem management. Its objective is to establish a common legal framework that applies the same core set of international rules to the management of shared watercourses across the region. While Mozambique is a Party to the SADC Protocol, Zimbabwe is a signatory but has not yet proceeded to ratifying it. Despite the absence of a formal ratification, Zimbabwe has consistently upheld and followed the principles of the SADC Protocol in the context of managing its transboundary water resources.

In 2002, Mozambique and Zimbabwe established the Joint Water Commission. Subsequently, Water-Sharing Agreements were implemented for the Buzi, Pungwe, and Save River Basins. Furthermore, the Buzi, Pungwe, and Save (BUPUSA) Watercourses Commission was established, along with the BUPUSA Watercourses Commission Hosting Agreement (Table 4.1).



Photo: Davison Saruchera

4.4 BUPUSA Watercourses Commission

The establishment of the Buzi, Pungwe, and Save Watercourses Commission (BUPUSACOM) in May 2023 and its launch in July 2023 were significant and remarkable achievements in the history of transboundary water cooperation between the two countries. The objectives of the BUPUSA Watercourse Commission are consistent with those of the BUPUSA River Basin agreements. Article 3 of the BUPUSA Establishment Agreement embodies the principles that guarantee effective transboundary water cooperation, including but not limited to, the exchange of data and information, cooperation on the protection of the environment, equitable and reasonable use of the transboundary watercourses, and planned measures for flow regime management and criteria for water allocation.

BUPUSACOM may need to make appropriate recommendations, for instance, to improve relevance of the three signed Water Sharing Agreements to include any essential missing elements such as gender mainstreaming, climate change and variability, monitoring of groundwater quantity and quality, intra and inter-basin water transfers, environmental flows, and other related aspects.



Ministers of Water for Mozambique and Zimbabwe signing the Save Water- Sharing and the BUPUSACOM Hosting and Establishment Agreement in May 2023. The signing was witnessed by the president of both countries.
Photo: Ministry of Information, Zimbabwe, 2023

4.4.1 Lessons Learnt in the establishment of the BUPUSA Watercourses Commission

The following summarises some of the key lessons learnt in the establishment of the Buzi, Pungwe, and Save Watercourses Commission (BUPUSACOM):

- Political commitment is paramount for effective transboundary water cooperation;
- Mutual respect by the Riparian States is fundamental for cooperation;
- Involvement of permanent or semi-permanent representatives in negotiations is crucial to avoid deadlocks caused by constant changes of team members;
- Creation and maintenance of good personal relations is crucial among the representatives;
- For effective cooperation, Riparian States must know and understand each other's expectations and fears;
- Assigning timelines for the completion of transboundary water cooperation negotiations is difficult as the process is complex;
- Awareness raising is vital for finance departments in Riparian States to appreciate the funding of coordination structures for transboundary water cooperation; and
- Language differences must be understood to ensure understanding and effective cooperation.



Launch of BUPUSACOM in July 2023 in Beira Mozambique.
Photo: GEF-BUPUSA

4.5 River Flow management/Flow regime

Adequate information/data on river and aquifer flows is critical for the elaboration of strategic options for the development of transboundary-shared watercourses. Therefore, there is a need for reliable and accurate hydro-geological-meteorological information and data in both near-real-time and historical contexts. In recognition of the importance and role of data for flow management, the parties (Mozambique and Zimbabwe) agreed to commission a detailed study that will define the principles of water allocation, which will be reviewed after a period of 10 years. The parties also agreed on the selection of representative gauging stations for flow measurements, criteria for water allocation, as well as the monthly exchange of information on flow data, which includes water levels, water quality, river runoff, discharges, aquifer abstractions, and information on hydraulic infrastructures. They also agreed that in case of a foreseen inundation or the rising of the river up to the alert level, the parties should exchange information on a daily or hourly basis and undertake joint monitoring exercises from time to time.

4.5.1 Allocation of Flow Regimes

The parties of the BUPUSA Tri-Basin agreements on the shared watercourses agreed to the following with regard to the establishment of the flow regimes:

Any abstraction of waters from the BUPUSA watercourses, regardless of the use or geographic destination of such waters, shall be in conformity with the agreed flow regimes and take into account the following considerations:

- The geographic, hydrological, climatic and other natural characteristics of each watercourse;
- The need to ensure water of sufficient quantity with acceptable quality to sustain the watercourses and their associated ecosystems;
- Any present and reasonably foreseeable water requirements, including afforestation; and
- Existing infrastructure, which has the capacity to regulate streamflow of the watercourses;

The BUPUSACOM Secretariat will assist the BUPUSA Council of Ministers in ensuring the implementation of the agreed flow regime management and criteria for water allocation.

4.5.2 Environmental Flows

There is need for protection, preservation, and conservation of the environment, as well as reviewing the interim environmental flows monitored at various established key points once the current detailed studies are completed. Reaseach conducted under the GEF- BUPUSA Project indictates that indicates that predicted negative influences of E-flows on the Pungwe River will be a result of historical and ongoing unsustainable exploitation of river resources. The study also highlights that the most favourable outcomes are linked to improved natural resource management (GWPSA, 2023a). Accordingly, to mitigate climate change, protect biodiversity and communities in the Pungwe River Basin, and maximise the benefits (including water and energy) that can be obtained from the river, pragmatically-enhanced implementation of existing regulations and management plans is an obvious first step. The assessment findings suggest that, under baseline pressures, there is scope to develop the water resources of the basin in accordance with the Pungwe Basin Agreement without further compromising the ecosystem functions and biodiversity of the river, estuary and marine zone. Developments are designed, constructed, and operated with due consideration for the environment. Enhanced management measures will, however, be required to protect ecosystem functioning and biodiversity, taking into account the number of people involved in mining, fishing, and plant harvesting (including deforestation of the upper catchments). Growing dependence on natural resources is a major threat to the health of the river, estuary and marine ecosystems. Mitigating these impacts requires a multi-pronged approach such as:

- minimising developmental impacts through ecologically-sensitive location, design, and operation;
- improved natural resource management;
- direct measures to reduce the dependency of people on harvested resources; and
- sustainable management plans linked with employment-intensive activities and rural health, quality education, rural infrastructure, and services.

BUPUSACOM and its stakeholders should maintain the momentum with similar assessments for the Buzi and Save River Basins, with the ultimate goal of institutionalising EFlows and mainstreaming them in water allocation considerations.

People, both at the national and regional levels, have the perception that water flowing downstream or allocation of water for coastal areas, estuaries, nature, and the associated ecosystems that depend on specific flow regimes is a WASTE OF WATER and also FEAR that water allocation for the environment means a reduction of water availability for the other competing uses. Yet, ecosystems, through their demand for water, produce and provide a wide range of goods and services for human use such as forests, fuel, firewood, food, traditional medicines, crops, pasture, marine resources, tourism, recreation, etc.



Local communities in Mozambique sell fish as a source of income.
Photo: Gywn Letley

4.6 Early Warning and Management of Disasters

Flood forecasting and early warning systems are carried out to reduce risks in flood prone areas. The purpose of a flood forecasting and early warning system is to detect and forecast threatening flood events so that the public can be alerted well in advance and can undertake appropriate responses to minimise the impact of the event. Flood warnings are a highly important adaptive measure where protection through large-scale, hard defences is not possible.



Technicians being trained on the use of hydro-metric equipment. The equipment is meant to aid the monitoring of floods in the tri-basin to improve disaster risk preparedness.
Photo: GEF-BUPUSA Project

A Flood Forecasting and Early Warning System (FFEWS) for the BUPUSA Tri-Basin has been developed and now awaits full capacitation and implementation. The FFEWS architecture is shown in Figure 4.2.

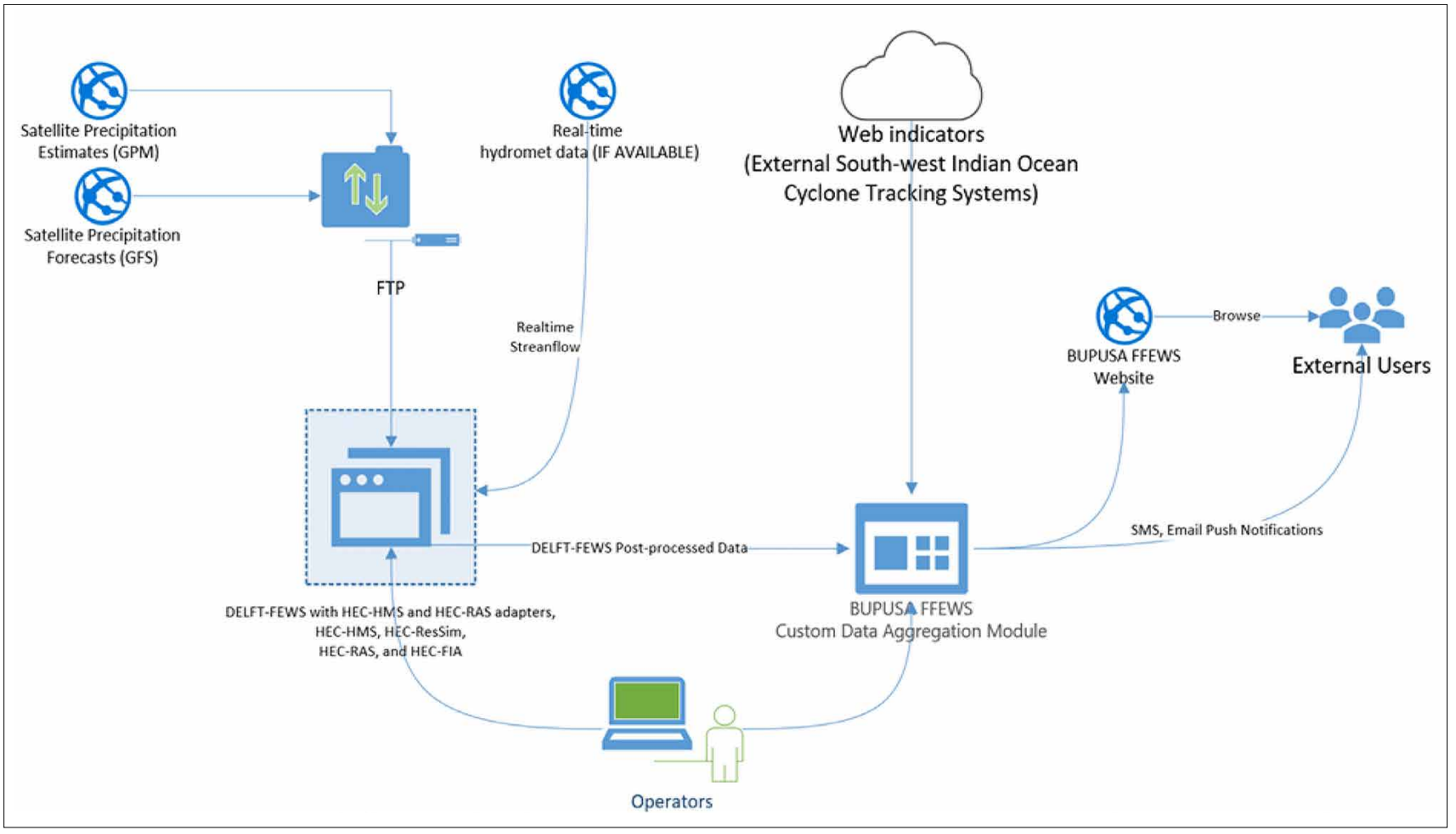


Figure 4.2: BUPUSA FFEWS architecture. Source: GWPSA, 2023.

The host of the BUPUSA FFEWS is the National Directorate of Water Resources Management (DNGRH) in Maputo, Mozambique. The host is linked to the national and regional level water resource management institutions and the catchment level water resource management offices of both Mozambique (Regional Water Administration of South (ARA-Sul, IP); Regional Water Administration of Central (ARA-Centro, IP); Buzi River Basin Management Division (DGBB); Pungwe River Basin Management Division (DGBP), Save River Basin Management Division (DGBS), Zimbabwe National Water Authority (ZINWA) - Runde and Save Catchment Offices); and the Department of Water Resources Management and Utilization as depicted in Figure 4.3.

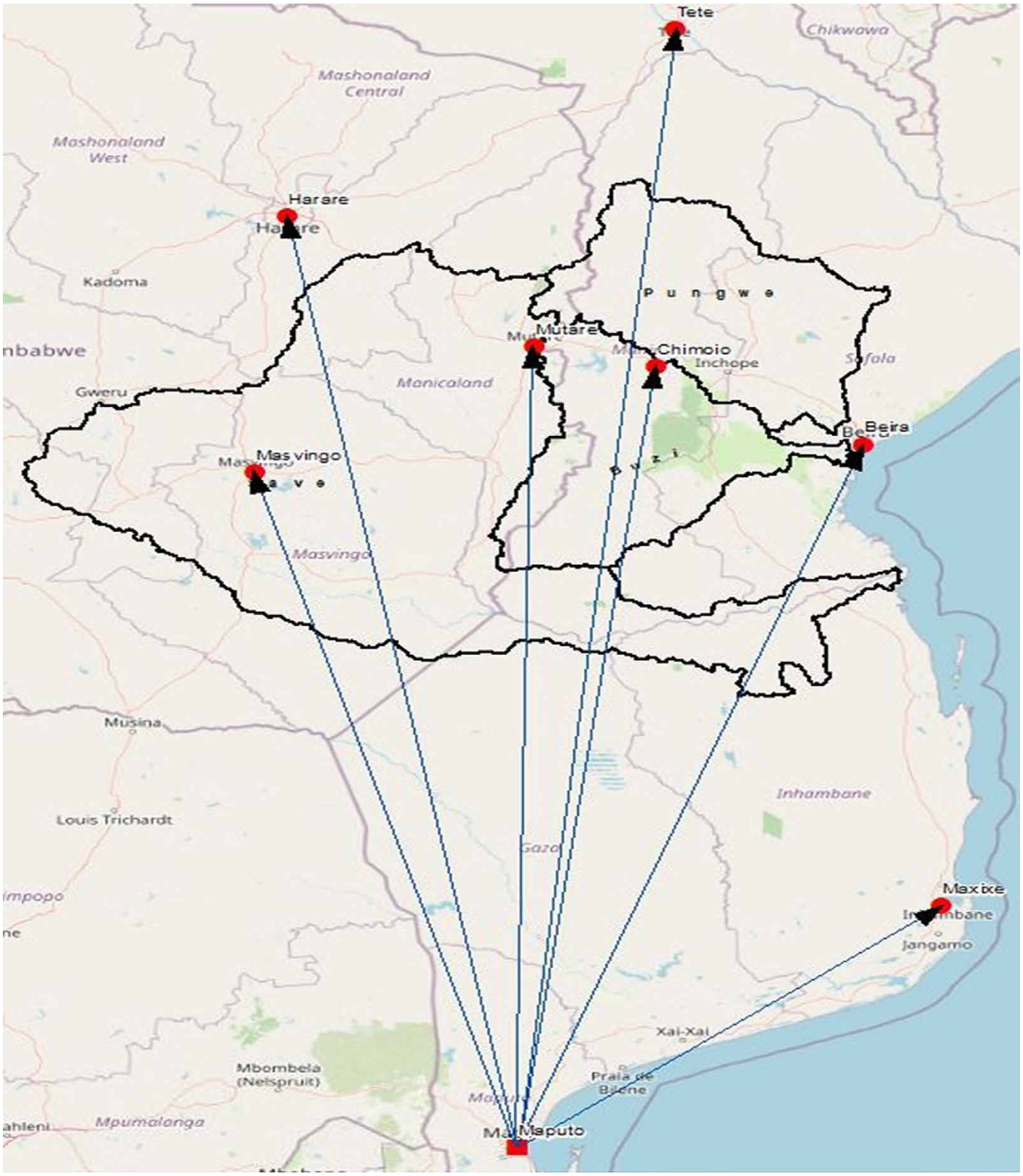


Figure 4.3: Distributed set-up of the BUPUSA FFEWS. Source: GWPSA, 2023.

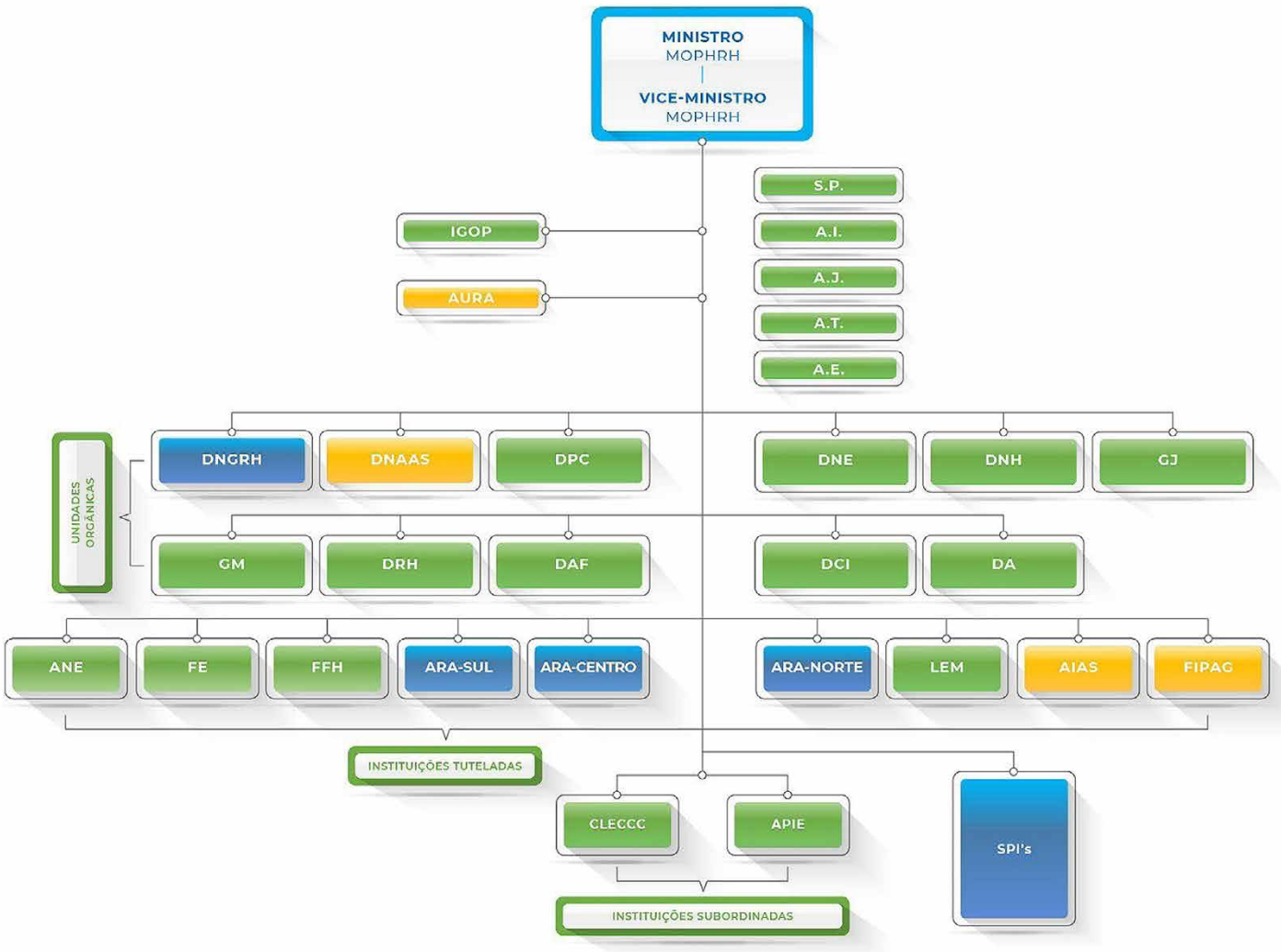
The "last mile" communication in relation to forecasts will be embedded in existing national disaster management systems in each country that are managed by specific institutions. Thus, each BUPUSA Member State will continue using its own existing sub-systems to relay the information and ensure improved communication of disaster in the context of BUPUSA FFEWS.

4.7 Key Institutions in BUPUSA Tri-Basin Riparian States

4.7.1. Water Sector of Mozambique

In Mozambique, water management is governed by the Water Law of August 1991(Water Law), also known as Water Act Lei no. 16/91, which is in line with SADC Protocols. The Water Law incorporates the basic principles and policies of water management. It stipulates that the main bodies responsible for water resource management are the Ministry of Public Works, Housing, and Water Resources (MOPHRH) and the National Directorate of Water Resources Management (DGNRH). Additionally, the Water Law established the National Water Council (NWC) for sector coordination and three Regional Water Administrations (ARAs). The NWC includes various stakeholders with an interest in water resources management. The National Water Policy, put in place is 1995, outlines the strategy that is followed by the water sector.

The highest governmental authorities in the Mozambican part of the BUPUSA River Basins are the Provincial Governments of the Sofala and Manica Provinces. The DNGRH serves as the primary Mozambican institution responsible for the planning and management of the water resources.



AIAS – Water and Sanitation Infrastructure Administration
ANE – National Road Administration
APIE – State Real Estate Park Administration
ARA CENTRO – Centro Regional Water Administration
ARA NORTE – Northern Regional Water Administration
ARA SUL – Southern Water Regional Administration
AURA – Water Regulatory Authority
CLECC – Civil Construction Contractors and Consultants Licensing Commission
DA – Acquisitions Department
DAF – Department of Administration and Finance
DCI – Department of Communication and Image
DNAAS – National Directorate of Water Supply and Sanitation
DNE – National Directorate of Buildings
DNGRH – National Directorate of Water Resources Management
DNH – National Housing Directorate
DPC – Department of Planning and Cooperation
DRH – Human Resources Department
FE – Road Fund
FFH – Housing Promotion Fund
FIPAG – Water Supply Investment and Heritage Fund
IGOP – General Inspection of Public Works
LEM – Mozambique Engineering Laboratory
SPI's – Provincial Infrastructure Services

Figure 4.4: Institutional Structure of Water Resources Management in Mozambiqu.
Source: Ministério| » Estrutura Orgânica (mophrh.gov.mz.

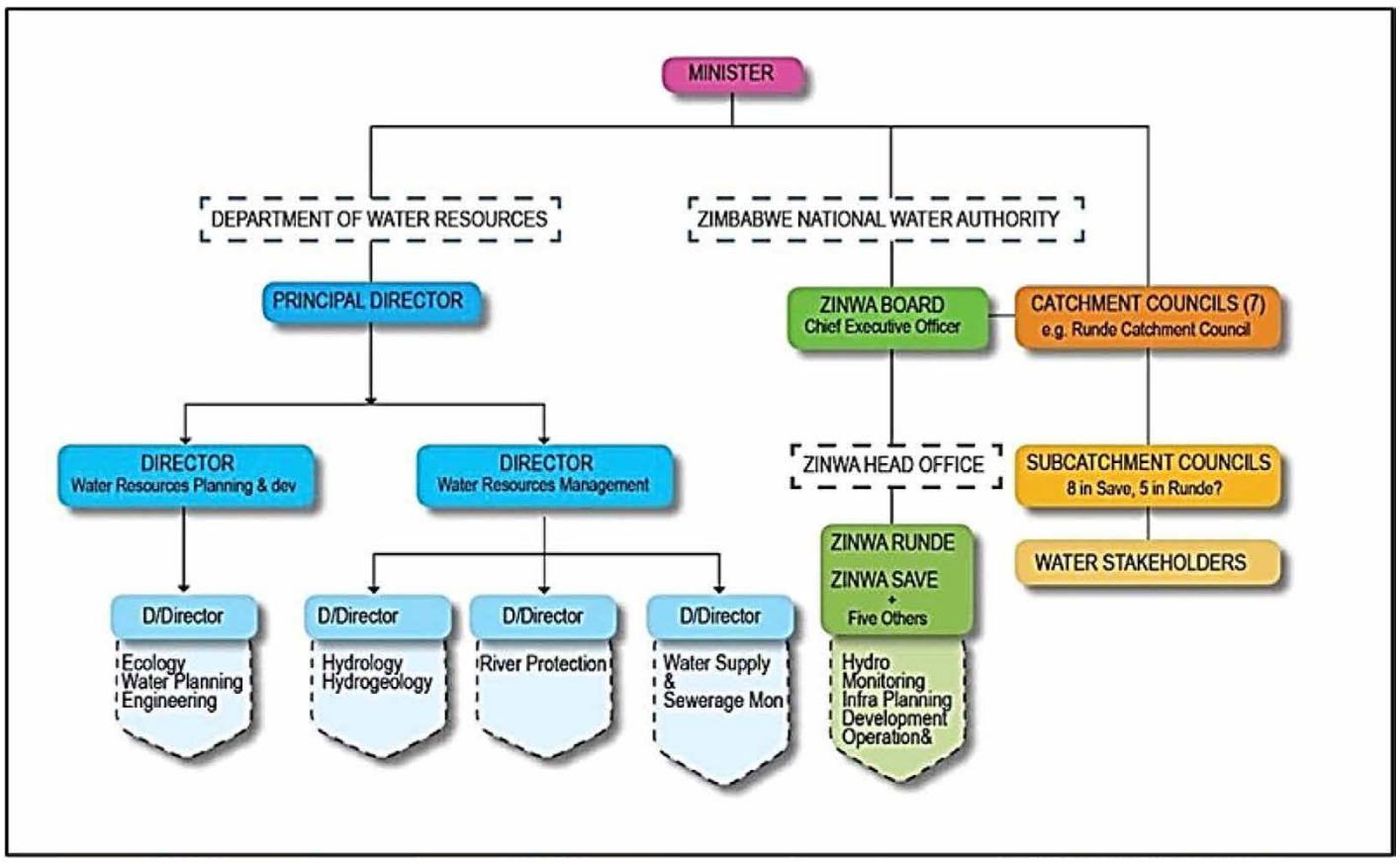


Figure 4.5: Institutional Structure of Water Resources Management in Zimbabwe.
Source: Save Basin Monograph, 2011.

4.7.2. Water Sector of Zimbabwe

In Zimbabwe, Water Resources Management is governed by the Water Act (Chapter 20:24) and the Zimbabwe National Water Authority Act (Chapter 20:25). These legal instruments stipulate that surface and groundwater in Zimbabwe are owned by the State.

The Department of Water Resources Management and Utilization (DWRMU), the Zimbabwe National Water Authority (ZINWA), and seven Catchment Councils are the statutory bodies entrusted with the sustainable management of water resources. All these entities fall under the Ministry of Lands, Agriculture, Fisheries, Water and Rural Development.

For the purposes of the management of water resources, Zimbabwe is divided into seven catchments, which are predominantly based on the major river basins. These catchments are the Save, Runde, Mzingwane, Mazowe, Sanyati, Gwayi, and Manyame. Although not physically part of the Save River Basin, the management of the Pungwe River Basin falls under the Save Catchment.

4.7.3 Stakeholders Engagement in the BUPUSA River Basins

In Zimbabwe, the role of stakeholders in important decision-making regarding water resources management has been incorporated into the Water Act of 1998. The catchment councils made up of stakeholders act as the ultimate decision-makers in the issuance of water permits in the basin.

Similarly, in Mozambique, the Water Law of 1991 also emphasizes stakeholder participation in water resources management. Stakeholder participation is ensured through the basin committees which provide a platform for consultations. The statutory governance, represented by the regional water administrations or ARAs, plays a significant role in decision-making. Additionally, stakeholders actively participate in the management boards of the ARAs.

The notion that stakeholders should have a say in the management of the water resources on which they depend is one of the building blocks of the concept of integrated water resources management. The concept of integrated water resources management, and consequently that of stakeholder participation, has found its way into the national water policies and water laws of many countries, including Mozambique and Zimbabwe.

4.8 Progress in Implementation of SDG 6

There are eight Global Sustainable Development Goals (SDGs) related to the water sector. Integrated water resources management is embodied in SDG-6. SDG-6, target 5, focuses on integrated water resources management at all levels, whilst SDG indicator 6.5.2 narrows down to transboundary water cooperation.

Indicator 6.5.2 tracks the percentage of transboundary basin area within a country that has an operational arrangement for water cooperation. There are key indicator criteria that are used to determine the operationalization of arrangements for water cooperation in a transboundary basin area within a country, which are:

- existence of a joint body;
- regular formal communication between riparian countries at least once a year;
- joint coordinated management plans or objectives; and
- regular exchange of data and information.

Mozambique and Zimbabwe are working towards fulfilling the key criteria for operational arrangements for transboundary cooperation in the BUPUSA River Basins. Jointly, the countries have met all the required criteria as follows:

- **Existence of a joint body**
  Establishment of the BUPUSA Watercourses Commission.

- **Regular formal communication between riparian countries at least once a year**
  Establishment of the Joint Water Commission (JWC) between Mozambique and Zimbabwe

- **Joint coordinated management plans or objectives**
  BUPUSA River Basins Monographs and Joint IWRM Strategy

- **Regular exchange of information and data**
  Establishment of Rules and Procedures for Data and Information acquisition and exchange

5

STRATEGIC ACTION PROGRAMME FOR THE BUPUSA TRI-BASIN: ADDRESSING CHALLENGES

Photo: GEF-BUPUSA Project

5.1 Addressing main challenges

This Chapter focuses on how to address challenges in the Tri-Basin by designing and implementing initiatives at the transboundary and national levels.

These initiatives should be guided by the Strategic Action Programme (SAP) for the BUPUSA Watercourses , which aims to mitigate adverse environmental changes and foster sustainable development in the BUPUSA Tri-Basin..

The changing environment in the BUPUSA Tri-Basin presents several challenges that require urgent attention to mitigate environmental degradation and its associated socio-economic consequences. Conversion of land for urban development, mining, and agricultural activities are typical examples of land-use change that directly and indirectly deplete ecological goods and services (Aycrigg et al., 2021).

Among others, the range of basin development issues to focus on in the BUPUSA Tri-Basin include deteriorating water quality; rising water demand; loss of biodiversity; rapid land use changes; extreme weather and climate events that are associated with both natural climate variability and climate change; saline water intrusion; soil erosion; and transboundary water governance and cooperation.

Given the transboundary dimensions of the BUPUSA Tri-Basin, the challenges and potential strategic actions envisaged become inherently complex, particularly when considering the upstream-downstream relationships of natural resource extraction, use, and degradation. Any interventions that are developed to enhance sustainable river basin development will need to take those inherent complexities into account. A summary of the main challenges, impacts and/or outcomes and the suggested strategic interventions to mitigate the identified challenges are given in Table 5.1.



Land degradation in Nyanyadzi on the Odzi sub catchment along the Save River in Zimbabwe.
Photo: Edimus Masona

Table 5.1: Summary of Main Challenges, Impacts and/or Outcomes and Strategic Actions for the BUPUSA Tri-Basin

Main challenges	Impacts and/or outcomes	Strategic Actions
Land cover changes and environmental degradation	• Drying out of wetlands. • Decreased river water flows. • Loss of aquatic and terrestrial ecosystems. • Destruction of natural habitats. • Water contamination. • Loss of land productivity. • Lower agricultural yields. • Inadequate food supplies. • Reduction of fisheries with related loss of income. • Increased health risks.	• Deploy evidence-based multidisciplinary approaches and solutions across the Tri-Basin. • Identify land degradation hotspots and implement appropriate initiatives for environmental restoration, protection, and mitigation. • Introduce climate-smart agricultural technologies. • Mobilize resources for effective environmental monitoring and inspections. • Enforce regulations for sustainable timber harvesting. • Promote alternative livelihood options in rural areas. • Ensure the involvement of communities in resource governance and ownership.
Rising water scarcity and demand	• Water shortages for domestic and commercial uses. • Reduced river flows leading to negative changes in aquatic ecosystems. • Potential increase in local water conflicts.	• Deploy water demand management approaches and tools through instruments such as water pricing. • Reduce water leakages in urban water supply systems. • Improve data and information collection, sharing, processing, and reporting. • Standardize data metrics and terminologies in the Tri-Basin. • Address skills gaps and human capacity requirements. • Increase groundwater use. • Use innovative technologies to improve water conservation. • Augment existing water supplies through water harvesting and re-cycling.
Water pollution	• Poor water quality (unsuitable for domestic and commercial uses). • Unwanted changes to aquatic ecosystems. • Increased costs of water treatment.	• Monitoring and improve urban waste management practices, including recycling and enforcement of regulations. • Promote sustainable agriculture practices to reduce pollution from farms. • Protect forests and wetlands. • Organizing artisanal miners into associations and provide them with the technical assistance they need to reduce their impacts on the environment. • Conduct periodic scientific assessments to reconfirm water resource availability and quality in various parts of the basin. • Monitor water pollution hotspots to address the main drivers of pollution. • Develop the capacity of water and land management institutions in the basin to develop integrated catchment management plans that promote sustainable use and protection of all natural resources. • Conclude and implement of the BUPUSA Transboundary Environmental Monitoring Plan.
Impacts of climate change and extreme weather events	• Increased frequency and severity of tropical cyclones, floods, and droughts. • Loss of agricultural productivity leading to inadequate food supplies. • Heavy losses of infrastructure and services such as roads, bridges, dams, and powerlines. • Unwanted changes in river water flow regimes. • Outbreaks of diseases such as cholera. • Higher water demand for crop production due to higher evaporation rates. • Rising sea water levels. • Saline water estuary intrusions.	• Climate-proof urban and rural communities through increasing the storage capacities of dams. • Introducing water harvesting practices and techniques to overcome the adverse effects of drought. • Further develop groundwater sources to augment current supplies and managing aquifer recharge. • Strengthen capacity and empower women and men from all categories especially the youth and other vulnerable communities to floods and droughts. • Practice conjunctive water uses. • Establish effective multi-hazard early warning systems. • Resettle communities and households currently located on low-lying areas that are more vulnerable to floods and landslides to less flood-prone areas. • Build climate resilient infrastructure. • Develop appropriate climate change response strategies for the basin. • Diversifying sources of livelihoods beyond rainfed agriculture. • Establish and/or strengthen decentralized grass roots structures for improved access of communities to platforms for participation and decision making.

Table 5.1 *(continued)*

Main challenges	Impacts and/or outcomes	Strategic Actions
		• Strengthen the capacity of water and land management institutions in the basin to develop integrated catchment management plans. • Pilot and demonstrating concrete climate change adaptation measures. • Help farmers to start adopting climate-smart agricultural production systems in the Tri-Basin. Implementation of the recently concluded Flood Forecasting and Early Warning System for the BUPUSA Tri-Basin.
Strengthening transboundary water governance	• Effective governance frameworks and implementation for transboundary water cooperation. • Harmonised implementation of the water sharing agreements. • Synchronised upstream-downstream water use. • Joint projects and programs for Tri-Basin development and sharing of benefits and costs.	• Strengthen transboundary basin management structures and participatory multi-stakeholder platforms. • Establish gauging stations at vital spots along the three rivers and a credible hydrological database that enables determination of equitable water allocation between the two countries. • Ensure adequate inter-country hydrological information flows to enhance strategic collaboration. • Incorporate women's participation into the institutional capacity-building process at the national, departmental, and local levels for of the basin. • Ensure formal interaction and coordination between water and environmental management government departments in each river basin. • Establish a conducive policy and institutional environment that supports the protection of natural resources and joint basin development programs. • Establish functional transboundary water resources monitoring and information system, and data sharing protocol.
Failure to utilize indigenous knowledge systems	• Exclusion of local communities from basin management decision-making processes and policies. • Lack of support from local communities for basin resource governance and protection regimes. • Loss of current and historical insights on how natural resources in the basin have been extracted, managed, and degraded. • Loss of local knowledge that could support sustainable resource management. • Active resistance from local communities for resource management practices and systems imposed from outside. • Sub-optimal resource governance decisions and outcomes.	• Use indigenous knowledge systems as a key component of sustainable river basin management and development. • Seek to understand and engage local communities as key partners in basin protection and development processes and obtain their buy-in for proposed resource management initiatives. • Use action research involving communities to unpack the basin challenges, understand current resource use practices at the local level, and identify potential solutions to the basin challenges. • Establish innovation platforms that enable local interests to be fully represented using participatory approaches to project design and implementation in the Tri-Basin.
Lack of financial and technical resources for river basin development	• Failure to implement important joint basin protection and development programs and aspirations. • Weakened basin management human capital and institutional capacity.	• Ensure that Member States make contributions to needed basin management financial and technical resources. • Develop social and gender responsive resource mobilisation strategies ensuring the financial requirements of investments that will meet the needs of the resource user communities. • Engage international funding agencies to secure funding for transboundary basin development. • Build the capacity of river basin organization staff members to develop bankable projects. • Delegate some components of basin development project implementation to the member states. • Ensure Member State in-kind contributions to the transboundary river basin organizations, e.g., seconding staff to the RBOs. • Leverage funding through blended finance instruments. • Create an enabling environment for various resource mobilization options through stable and effective legal and institutional frameworks that are crucial for any investment. • Improve donor coordination in the basin and responsiveness to country priorities that enable more institutional ownership, inclusive partnerships, and joint resource mobilization.

5.2 Policy prioritisation

The following policy issues are pertinent:

- The widespread degradation of the environment and reduced water quality suggest the need for tighter control of irresponsible resource extraction activities observed in sectors such as artisanal mining, agriculture, and urban waste disposal. The regulatory enforcement and monitoring regime should be improved significantly to address these and other sources of pollution. In general, both countries already have robust legislative and institutional regimes that are based on existing environmental management policies, customary water law and resource management practices, and formal water sector reform programmes (Nyikadzino, 2016). Therefore, what is required is effective implementation of the reforms and enforcement of the existing regulations.
- Identified gaps in knowledge point to the need for periodic basin diagnostic studies that generate credible data and help to pin-point environmental degradation hotspots. Current efforts that have produced the Transboundary Diagnostic Assessment Thematic Reports should continue.
- The governments of Mozambique and Zimbabwe should increase funding for action research in the BUPUSA Tri-Basin and make efforts to attract more funding for river basin research and development from international funding agencies.
- The cycle of recurring floods, droughts, and cyclones already experienced in the BUPUSA Tri-Basin, is a constant reminder of the need to develop frameworks for climate adaptation and mitigation, urgently and jointly. The developed FFEWS should, therefore, be implemented.



Abstraction of water for irrigation along the Pungwe River Basin in Mozambique, intercepting the flow of water.
Photo: Davison Saruchera

5.3 Current Efforts

Current efforts, which should be finalised to facilitate implementation and that are pursuant to addressing the highlighted challenges and strategic interventions, are the development for implementation of the following, amongst other previous efforts:

- The BUPUSA Tri-Basin Flood Forecasting and Early Warning Systems (FFEWS)
- The BUPUSA Tri-Basin Transboundary Environmental Monitoring Plan
- The BUPUSA Tri-Basin Strategic Action Programme
- The BUPUSA Tri-Basin Transboundary Diagnostic Analyses Thematic Studies
- The BUPUSA Tri-Basin Capacity Development Strategy and Action Plan

CONCLUSIONS

The BUPUSA Tri-Basin Atlas provides an overview of the state of the environment, taking into account the socio-economic dynamic and the physical environmental changes that both shape the current and projected state of affairs. There are observed changes with challenges that need to be addressed urgently to mitigate environmental degradation and its associated socio-economic consequences. The Atlas is a useful tool which enables best possible planning for the sustainability of the ecosystem in the Tri-Basin, and thus informs the BUPUSA Strategic Action Programme.

The Atlas, therefore, helps identify the actions that need to be implemented to mitigate environmental degradation, restore degraded landscapes, protect natural resources, improve availability of freshwater, and ensure more responsible use of the available natural resources to advance sustainable basin development in the BUPUSA Tri-Basin. All the solutions outlined require action from key actors, and financial resources as well as a fully capacitated BUPUSACOM. Significant investments in human capital, technology diffusion, and innovations for effective landscape restoration and conservation will be needed. Additionally, capacity building of river basin organization staff to prepare and submit bankable projects is also crucial.

The urgency for immediate action cannot be overstated. Allowing current environmental management trends in the BUPUSA Tri-Basin to continue might result in a scenario where land and water resource degradation, climate change, and extreme-weather events increasingly threaten livelihoods (FOLU, 2019). Therefore, significant transformation will be required in the extraction, management, and protection of natural resources within the BUPUSA Tri-Basin to realise sustainable resource governance. Political will and commitment to transboundary water cooperation, as well as sustainable management of the Tri-Basin's landscapes, water resources, and biodiversity, will also be vital.



A homestead with pole and dagga houses along the Pungwe River in Mozambique, which is common in rural Mozambique.
Photo: Gwyn Letley, Anchor Environmental

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This Atlas provides compelling and credible evidence of the environmental changes in the Buzi, Pungwe and Save River basins, including their causes and impacts. It covers surface and ground water quality, water demand and allocation, biodiversity and wildlife, land management, extreme events, as well as their associated impacts and possible interventions. The Atlas also highlights the key transboundary water governance and cooperation issues in the Tri-Basin. It further outlines how challenges in the basin are to be addressed with initiatives at the transboundary and Member State levels through the Strategic Action Plan. The running theme for the Atlas is "Water Security and Climate Resilience". Cross-cutting issues such as gender equity, social inclusion, culture, and indigenous knowledge systems are incorporated in the Atlas.

BUPUSACOM ESTABLISHED 2023

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