



Republic of Mozambique



Republic of Zimbabwe

DEVELOPMENT OF THE BUZI RIVER BASIN MONOGRAPH AND JOINT INTEGRATED WATER RESOURCES MANAGEMENT STRATEGY



MONOGRAPH REPORT - MAIN REPORT

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MONOGRAPH AND JOINT IWRM STRATEGY

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PREFACE

The Buzi River Basin is shared between the two countries of Mozambique and Zimbabwe. The Development of the Buzi River Basin Monograph and Joint IWRM Strategy constitutes a part of the Shared Watercourses Support Project (SWCSP) for the Ruvuma, Buzi and Save river basins. The SWCSP has been prepared by the Southern African Development Community (SADC) Secretariat and the African Development Bank (AfDB), in consultation with the Governments of Mozambique, Tanzania and Zimbabwe, within the framework of the SADC Revised Protocol on Shared Watercourses (2000), the Regional Water Policy (2005) and the Regional Strategic Action Plan on Integrated Water Resources Development and Management (2005). The SWCSP was approved by the AfDB for funding and implementation in May 2006.

The overall long term goal of the joint effort between Mozambique and Zimbabwe on the Buzi Basin is to ensure development of integrated water resources management and related physical infrastructure development that contributes to regional integration and poverty reduction.

Implementing agencies are the ARA-Centro in Beira, Mozambique and the ZINWA-Save in Mutare, Zimbabwe supported by the national Ministries responsible for water. As a transboundary project, the SWCSP including the Buzi component is managed by the SADC on behalf of the Governments of Mozambique and Zimbabwe.

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List of Abbreviations

AfDB	African Development Bank
ARA	Regional Water Authority (Mozambique)
BBC	Buzi Basin Committee
BU	Basin Unit
CAP-NET	International Network for Capacity Building in IWRM
CBMP	Community Basin Management Project
CBO	Community Based Organization
CC	Advisory Council / <i>Conselho Consultivo</i>
COP	Catchment Outline Plan
CPI	Centro de Promocao de Investimento
CSO	Central Statistical Office (Zimbabwe)
CVM	Red Cross of Mozambique / <i>Cruz Vermelha de Moçambique</i>
DDF	District Development Fund (Zimbabwe)
DEM	Digital Elevation Model
DNA	National Directorate of Water
DRM	Disaster Risk Management
DWR	Department of Water Resources
EDM	Mozambique Electric Utility Company
EFR	Environmental Flow Requirements
EKIS	Enhanced Knowledge Information System
ENSO	El Niño-Southern Oscillation
EP 1	Basic Primary School (grades 1 to 4)
EP 2	Primary school (grades 5 to 7)
ESG I	Junior high school (grades 8 to 10)
ESG II	Senior high school (grades 11 to 12)
EWS	Early Warning System
FAO	United Nations Food and Agricultural Organization
GIS	Geographic Information System
GOH	Office of Hydraulic Works
GRC	Disaster Risk management Groups
GTZ	German Technical Cooperation
GWP	Global Water Partnership
ha	Hectare
HIV	Human immunodeficiency virus
HYCOS	Hydrological Cycle Observation System
INAM	National Meteorological Institute
INE	National Institute of Statistics in Mozambique
INGC	National Disaster Management Institute
Inhab/Km ²	Inhabitants per square kilometer
IPCC	Intergovernmental Panel on Climate Change
IRBM	Integrated River Basin Management

ISARM	Internationally Shared Aquifers Resources Management
IWRM	Integrated Water Resource Management
JWC	Joint Water Commission
Km	Kilometer
km ²	Square kilometres
m ³ /s	cubic metres per second
MAE	Mean Annual Evaporation
MAE	Ministry of State Administration / <i>Ministério da Administração Estatal</i>
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
m.a.s.l.	Metres above mean sea level
MEMR	Ministry of Mineral Resources and Energy / <i>Ministério dos Recursos Minerais e Energia</i>
MICOA	Ministry for Coordination of Environmental Affairs / <i>Ministério para Coordenação da Acção Ambiental</i>
MICS	Multiple Indicator Cluster Survey
Mm ³ /year	Million cubic metres per year
MOPH	Ministry of Public Works and Housing
NGO	Non-government Organization
OCHR	Office of Civilian Human Resources
ODAMOZ	Database of Development Assistance to Mozambique
PEDD	District Economic Development Plan
PESOD	Social and Economic Development Plan
PSIP	Private Sector Investment Programme
PP2	Pungwe Project 2
PRSP	Poverty Reduction Strategy Paper
RBC	River Basin Committee
RoM	Republic of Mozambique
RSAP – IWRM	Regional Strategic Action Plan for Integrated Water Resources Development and Management
RSOP	River System Outline Plan
SADC	Southern African Development Community
SADC HGM	SADC Hydrogeological Map
SCC	Sub-catchments councils
SI	Statutory Instrument
Sida	Swedish International Development Cooperation Agency
SWCSP	Shared Watercourses Support Project
TB	Tuberculosis
TDM	Mozambican Telecom Company / <i>Telecomunicações de Moçambique</i>
TWRM	Transboundary Water Resources Management
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children’s Fund

USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WDM	Water Demand Management
WHO	World Health Organization
WMO	World Meteorological Organization
WQ	Water Quality
WRM	Water Resources Management
WWF	World Wildlife Fund
ZINWA	Zimbabwe National Water Authority
ÖEZA	Austrian Development Cooperation

1 BUZI MONOGRAPH – PURPOSE AND PROCESS

1.1 Why a Monograph?

The Buzi River Basin is a shared water course between the two countries of Mozambique and Zimbabwe. The development and management of this shared watercourse requires cooperation, under a framework that promotes interdependence and joint management. The national water law and policies of Mozambique and Zimbabwe together with international water agreements determine the governance framework within which the Buzi River Basin is to be managed and developed. The development of the Buzi River Basin Monograph and Joint IWRM Strategy is a prerequisite for further advancing the transboundary river basin management. The Monograph and the Joint IWRM strategy will comprise detailed guiding documents for the responsible river basin organisations i.e. the ARA-Centro in Beira, Mozambique, the ZINWA-Save in Mutare, Zimbabwe and the Joint Water Commission as the overseeing body.

The Buzi River Basin Monograph is intended to set the stage for future activities that will contribute to the overall goal. The purpose of the Buzi Monograph is to present baseline data on the current state of the water resources, socio-economic characteristics, environmental conditions, water demand, legal and institutional settings in the Buzi River Basin. The report further identifies priority water management issues and provides the preliminary directive focus for the subsequent project phases, explicitly the scenario development and strategy formulation phases. The immediate next step of the Buzi Project is to prepare and reach consensus on the Buzi River Basin Development Scenario (the Vision 2030) and the Joint IWRM Strategy in order to achieve the desirable scenario.

1.2 Development Process

The development of the Buzi River Basin Monograph has been undertaken as a consultancy. The specific objective of the consultancy is to develop a “Joint Integrated Water Resources Management Strategy for the Buzi River Basin, and build capacity for its implementation and upgrading”.

The Consultancy is undertaken by an association comprised of Sweco International (Sweden) and its associates: Consultec (Mozambique), Austral COWI (Mozambique), Interconsult Zimbabwe (Zimbabwe) and the expected key deliveries are:

- 1) A Comprehensive Buzi River Basin Monograph Report;
- 2) A Proposed Basin Development Scenario Report;
- 3) A Joint Integrated Water resources Management Strategy for the Buzi River Basin Report;
- 4) A Project Concept and Specifications Report for the Buzi River Basin Enhanced Knowledge and Information System (EKIS);
- 5) A Project Concept and Specifications Report for the Community Basin Management Projects (CBMPs).

During the monograph phase a considerable effort (by the Consultant together with the implementing agencies in Mozambique and Zimbabwe) was directed towards improving the knowledge base of the basin through a number of thematic studies, field work and consultations with public administrations, the private sector and people living in the basin.

The key steps of the Monograph development process can be summarised as follows: data collection (primary and secondary); data consolidation; ground control; analysis; and presentation of results and conclusions. Essential inputs to the monograph are legal documents, previous studies, hydrometeorological data, socio-economic statistics, geographical information and maps as well as insights of the stakeholders.

The overall structure of the Buzi River Basin Monograph is based on five thematic areas, each presented in stand-alone annexes (Figure 1-1). The five annexes are summarised in a Main Report, the Buzi River Basin Monograph.

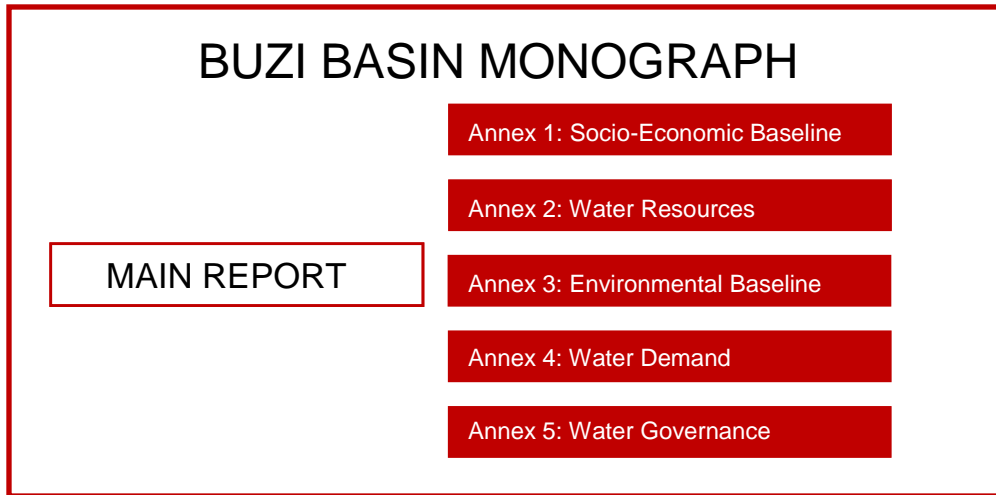


Figure 1-1 : Components of the Buzi River Basin Monograph

This Buzi Monograph Main Report presents an introduction to the Buzi River Basin and provides an overview of the key characteristics that includes a set of illustrative thematic maps that identify important features of the basin.

For the interested reader, details on the sector studies are provided in the stand-alone sector study reports presented in Annexes 1 - 5. A geographic data base has been developed and compiled in a GIS environment as a basis for future monitoring, basin planning, and management.

2 THE RIVER BASIN

This section serves as an introduction to the Buzi River Basin and provides an overview of the key characteristics, including a set of illustrative thematic maps that identify important features of the basin. The geographical description has a focus on physiography, geology, land cover and land use, eco-regions, climatic conditions, and administrative boundaries of the Buzi River Basin, all which are essential information for the general understanding of basin setting.

The maps and data presented is the result of collection, collation and analysis of readily available and existing data of the Buzi River Basin. The aim of topographical data is not to supply complete representation of all the roads, river segments, settlements, but to present enough data for users to orientate themselves. The map illustrations are not an authority on the administrative boundaries selected. Not all lines and outlines presented are based on gazetted coordinates and should be considered indicative only.

2.1 Introduction to the Buzi River Basin

The Buzi River Basin is a shared water course between the two countries of Mozambique and Zimbabwe. The upper part of the basin is located within the southeast part of Zimbabwe and the lower parts are located in the central part of Mozambique (Figure 2-1). Neighbouring river basins are the Pungwe River Basin and the Save River Basin.

Total catchment area calculated from a digital elevation model (USGS, 2004) is approximately 28,900 km². 13% (3,700 km²) of the catchment is part of the Zimbabwean territory while the Mozambican territory covers approximately 25,100 km² (87%).

Three major tributaries form the Buzi River Basin; Buzi River, Lucite River and Revue River, flow from the mountainous areas in the western part of the basin towards the east where they confluence into Buzi River, which flows into the Indian Ocean. Altitudes ranges from peaks up to 2,500 meters in the mountains down to the sea level. The eastern parts of the basin are flat plains with low altitude, these areas are prone to flooding during the monsoon season.

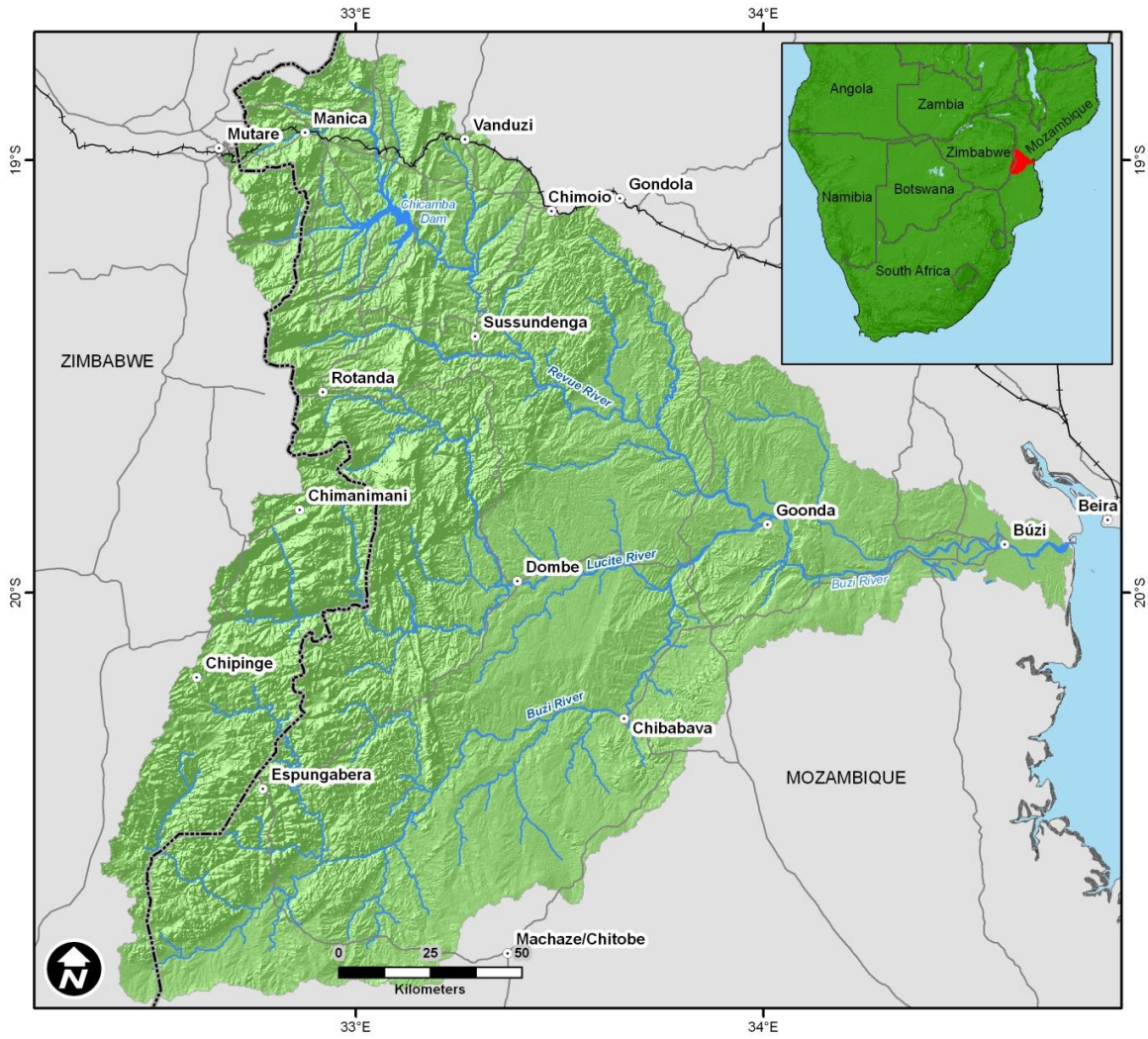


Figure 2-1 : Buzi River Basin.

2.2 Physiography

2.2.1 Topography and Landform

The basin is dominated by the mountainous upper regions to the west, and the relatively flat plains in the central end lower regions to the east. The most upstream part of Buzi River has an altitude of approximately 1 200 above sea level (m.a.s.l.). Its main tributaries, Lucite and Revue, have an altitude of around 1 500 m.a.s.l., with peaks reaching up to 2 500 m.a.s.l. Confluences of these river occur at an altitude less than 100 m.a.s.l. The most downstream sub basin is situated at low altitudes and therefore prone to floods during the rainy season (Figure 2-2). The dominant landforms of the Buzi River Basin are illustrated in Figure 2-3.

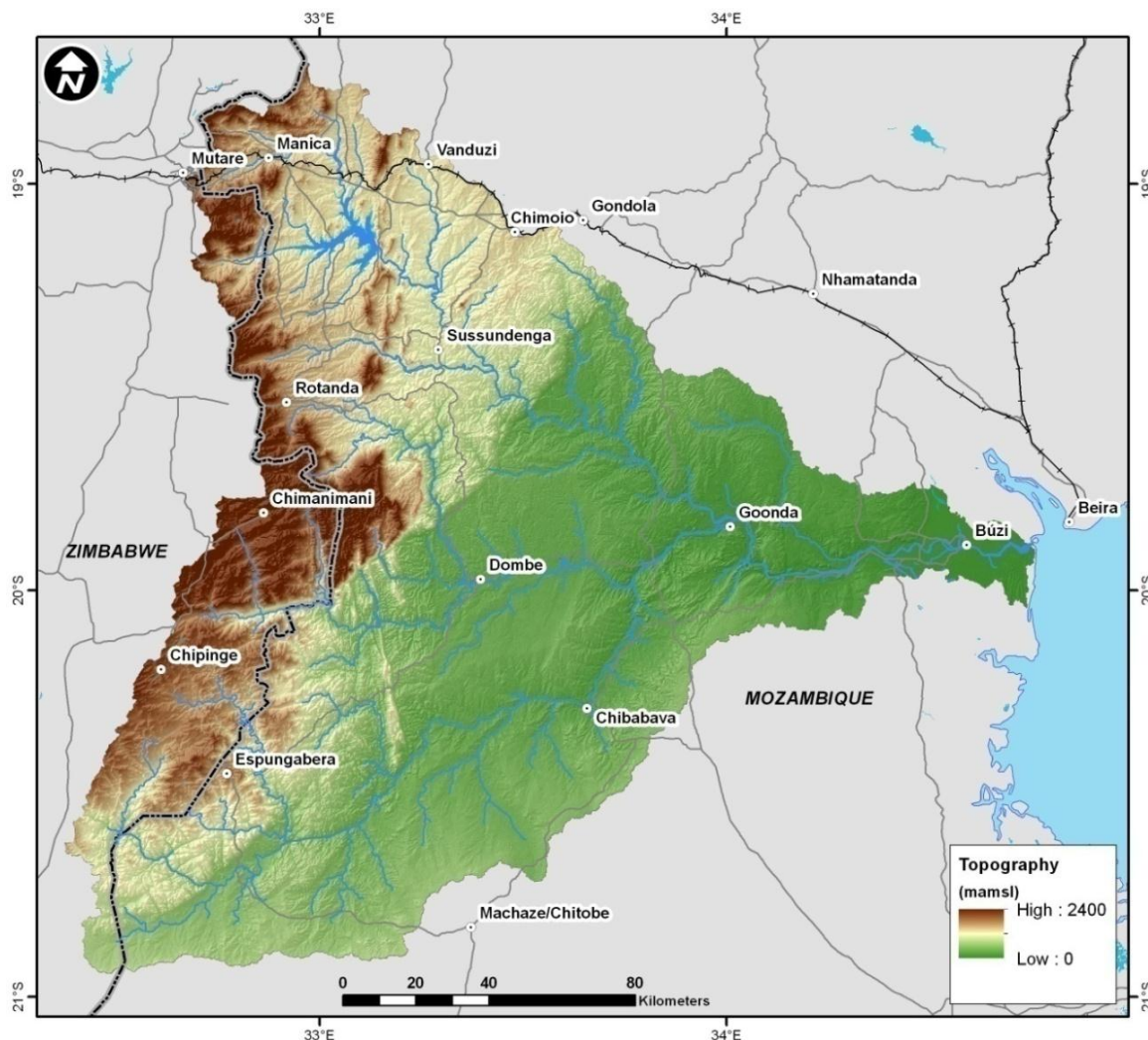


Figure 2-2 : Topography of the Buzi River Basin (generated from USGS, 2004).

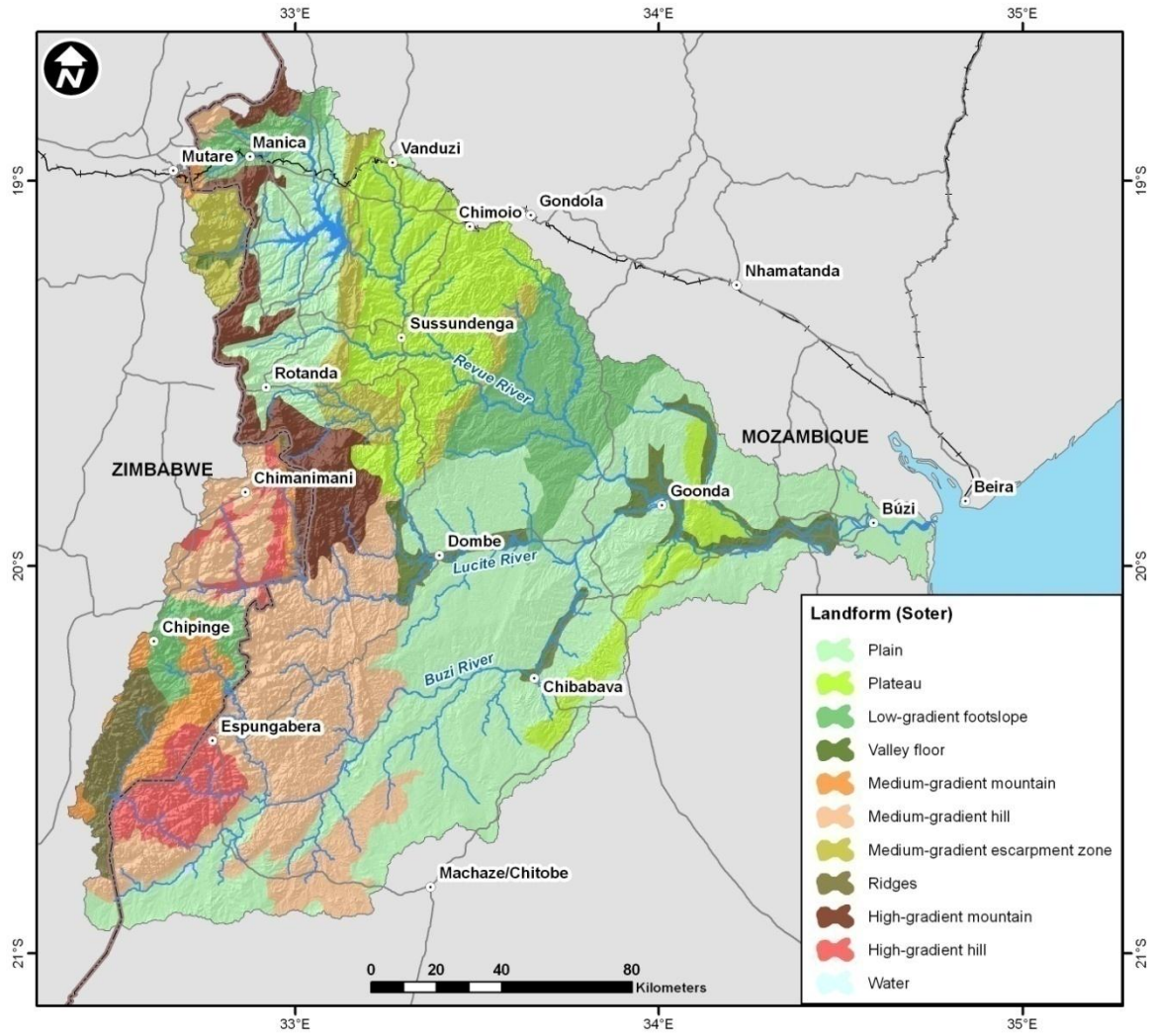


Figure 2-3 : Landform for the Buzi River Basin.

Source: FAO, 1998.

2.2.2 Buzi rivers and drainage network

Three major tributaries form the Buzi River Basin; Buzi River, Lucite River and Revue River. These three rivers are shared with Zimbabwe and originate from the western mountains. Of these tributaries the Buzi River has the largest catchment (13,760km²), thereafter Revue River (8 440 km²) and smallest is the Lucite River (6 670 km²).

Within these major tributaries there are numerous of minor tributaries. In this study only the larger tributaries crossing the international border are of interest. In the Buzi River there are only one larger tributary that crosses the border, excluding the Buzi River itself, namely Mussorize River. It should be noted that in Zimbabwe the Buzi River is called Budzi River. On the Zimbabwean side of the Lucite River, in Rusitu tributary, the river changes name to Rusitu River. Another large tributary to Lucite River is the Mussapa Pequena River, although it is not a cross border river. There is one major tributary in the Revue River catchment that crosses the border. On the Mozambican side the river is called Zonue River and in Zimbabwe it is called Zonwe River. Going upstream from the border the river divides into Zonwe River from the north and Nyamakari River from the west.

The drainage network which has been generated from the DEM (USGS, 2004), is displayed in (Figure 2-4), and major tributaries are identified by their name.

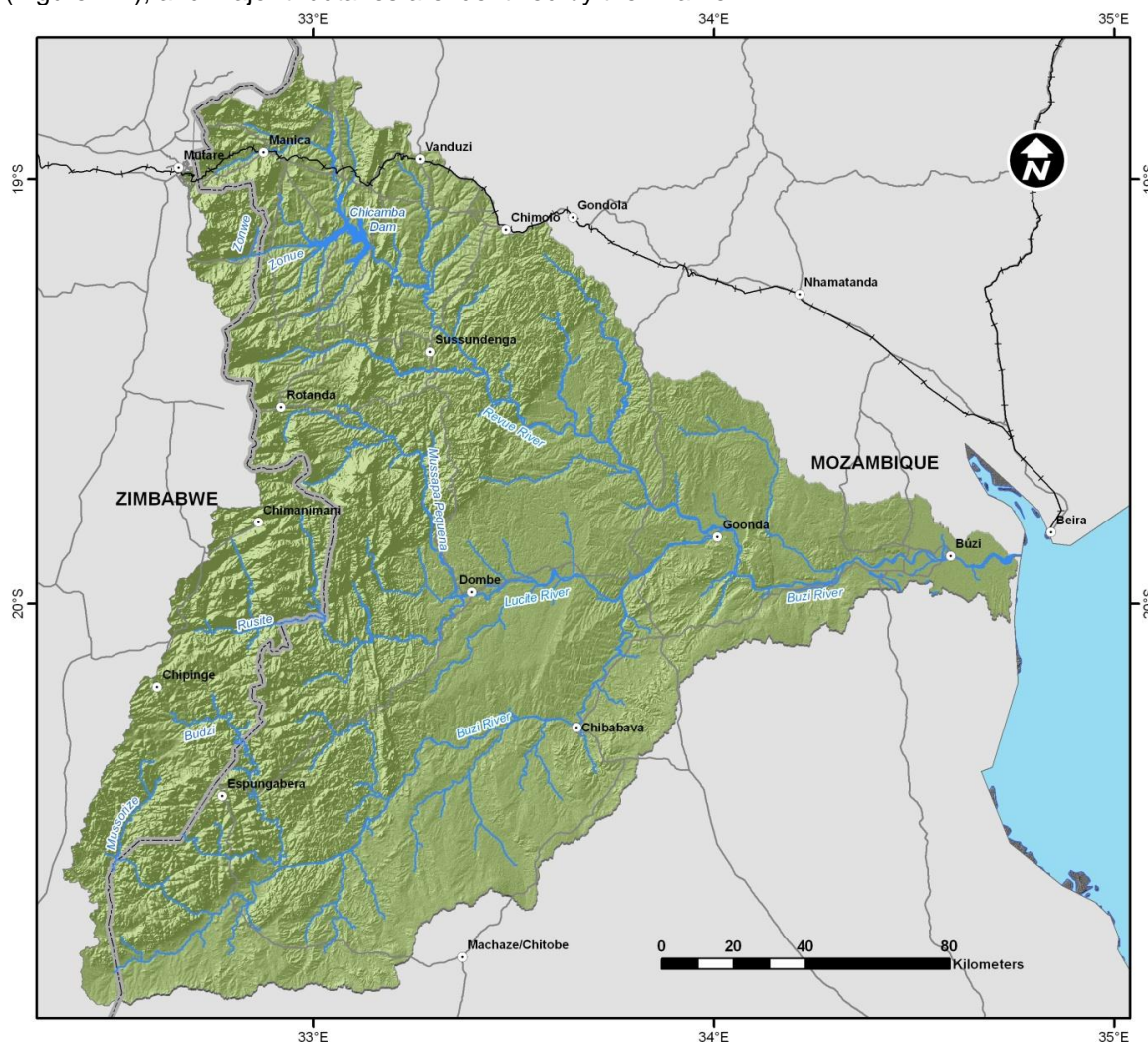


Figure 2-4 : Drainage network of the Buzi River Basin.

2.2.3 Basins

A catchment - or drainage basin - is a distinct area of land which has a common drainage system. A catchment includes both the water bodies that convey the water and the land surface from which water drains into these bodies (UNEP et al. 1997).

In the Buzi Monograph these hydrological units have been topographically delineated from a DEM – Digital Elevation Model (USGS, 2004) using GIS tools. It should, however, be noted that the identification of catchments divides are extremely difficult in the lower areas where the altitude differences are small, due to the relative crude resolution of the DEM. Hence, the estimated areas of the lower downstream sub basins, and thereby also the total catchment area, are related with some uncertainty. The Buzi River Basin refers to the total area drained by the main river and its tributaries into the Indian Ocean at the mouth of the Buzi River.

Eleven main sub basins have been defined for Buzi River Basin. The sub-basin division of the river basin has been made to enable a description of the spatial distribution of water resources within the basin and between the countries. The topographically delineated basin areas have been split into sub-basins by the border between Mozambique and Zimbabwe as a basin divide. It must be noted that all of these are not hydrological correct divisions, but it enables the possibility to compute the amount of water generated in each country. This division is also used to present population distribution within the basin (Annex 1) and to calculate and present the Water Demand (Annex 4). The delineated sub-basins are illustrated in Figure 2-5; their names and areal extent are presented in Table 2-1.

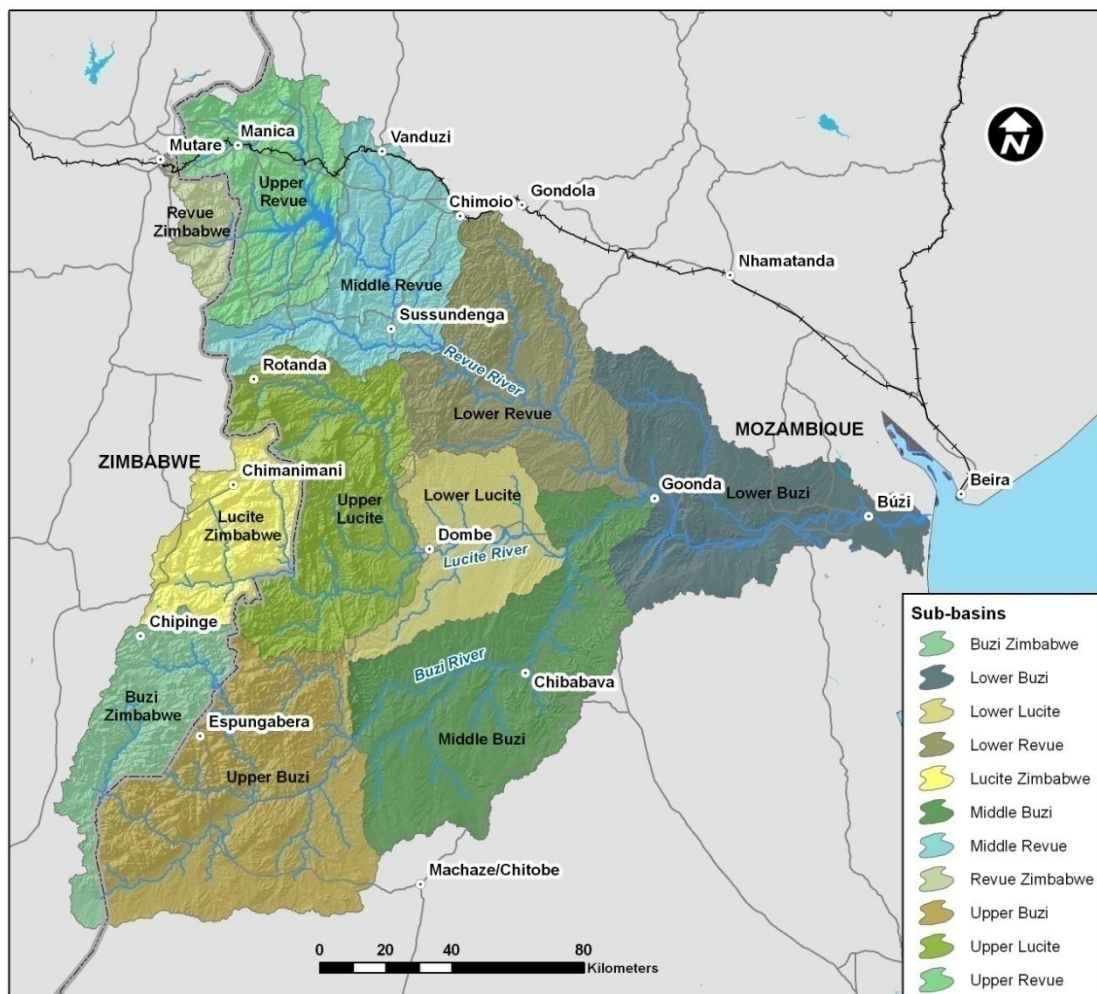


Figure 2-5 : Main sub-basins of the Buzi River.

Table 2-1: Area of each sub basin in the Buzi River Basin.

	Sub-basin	Area [km ²]
Mozambique	Upper Revue	2,333
	Middle Revue	2,463
	Lower Revue	3,139
	Lower Buzi	3,258
	Upper Lucite	3,251
	Lower Lucite	1,885
	Middle Buzi	4,332
	Upper Buzi	4,476
	Total	25,137
Zimbabwe	Revue Zimbabwe*	508
	Lucite Zimbabwe**	1,535
	Buzi Zimbabwe***	1,690
	Total	3,733

*Revue Zimbabwe corresponds to ZINWA subzone FM2 and partly FM1

**Lucite Zimbabwe corresponds to ZINWA subzone FLS

***Buzi Zimbabwe corresponds to ZINWA subzones F8 and FUZ

In addition to the above main sub basins another division has been used for the hydrological modelling. This sub basin division is based on the location of the major runoff stations as well as geographical features of the river basins. The corresponding catchment areas were calculated from the digital elevation model (Table 2-2).

Table 2-2: Calibration catchments for the Buzi River Basin.

Basin No.	Sub-basin	Runoff Stn	Local Area [km ²]	Total Area [km ²]
302	Zonwe_ZIM_US_F10	F10	34	
303	Upper_Revue_US_E277	E277	232	
311	Upper_Revue_US_E265	E265	97	
312	Upper_Revue_US_E274	E274	213	
301	Upper_Revue_US_Chicamba	-	2,270	2,846
321	Middle_Revue_US_E263	E263	650	
322	Middle_Revue	-	1,816	5,312
331	Lower_Revue	-	3,130	8,442
201	Rusito_ZIM_US_F7	F7	126	-
202	Lucito_US_E85	E85	1,854	1,980
211	Upper_Lucito_US_E246	E246	2,821	4,801
221	Lower_Lucito_US_E248	E248	1,691	6,492
101	Buzi_ZIM_US_Bangazaan Dam	-	28	
111	Buzi_ZIM_US_F18	F18	118	146
121	Upper Buzi_US_E84	E84	627	773
131	Upper_Buzi_US_E427	E427	308	
132	Upper_Buzi_US_E276	E276	2,946	4,027
142	Upper_Buzi_DS_E276	-	2,140	6,167
141	Middle_Buzi_US_E244	E244	2,497	8,664
151	Middle_Buzi_US_E456	E456	1,703	16,859
161	Lower_Buzi_US_E188	E188	1,226	26,527

2.3 Geology

2.3.1 Lithology

The north-western part of the basin is underlain by cratonic Archaean (3200 – 2500 million year old) granites, migmatites and gneisses. The Manica-Mutare greenstone belt is found in this area, just northwest and north of Manica town, surrounded by cratonic gneisses, granites and migmatites. There are also slivers of greenstone terrain, found a bit further south. These Archean rocks underlie the upper catchment areas where altitudes as from 750 to 1500 meters above sea level. Further to the east the geology changes to the gneisses and migmatites, metamorphosed sedimentary quartzites and schists of the Gairezi Group (1,800-1,300 million year old)

The geology of the south-western part of the basin is dominated by the sedimentary shale, quartzite and limestone of the Umkondo Group (1150 million year old), within which some lava also occurs. The rocks are intruded by slightly younger dolerites, both as a series of narrow dykes and as layered intrusive sills. These dolerites are relatively resistant, contributing to the high relief of the area (between 750 and 1,750 meters above sea level).

The south-eastern part of the basin is underlain by much younger sedimentary and volcanic rocks. These rocks are relatively soft and formed flat low lying areas, ranging between 0 to 250 meters in height, with some parts on the edges of the basin rising to 500 meters. The 180 million year old basalts of the Karoo Supergroup rocks lies adjacent to the Cretaceous sandstones, marls, calcareous rocks and conglomerates of the Senna and Grudja Formations, as well as the sandstone

of the Zamba Formation. Closer to the coast the edges of the basin is defined by Quaternary clays and sands, as well as alluvium. Alluvium also overlies large parts of the centre of the basin, along the main rivers.

A simplified lithological map (SADC HGM, 2010) is illustrated in Figure 2-6. A more detailed illustration of the lithology as described by the SADC Geological Map (Hartzer, 2009) is presented in Appendix 1.

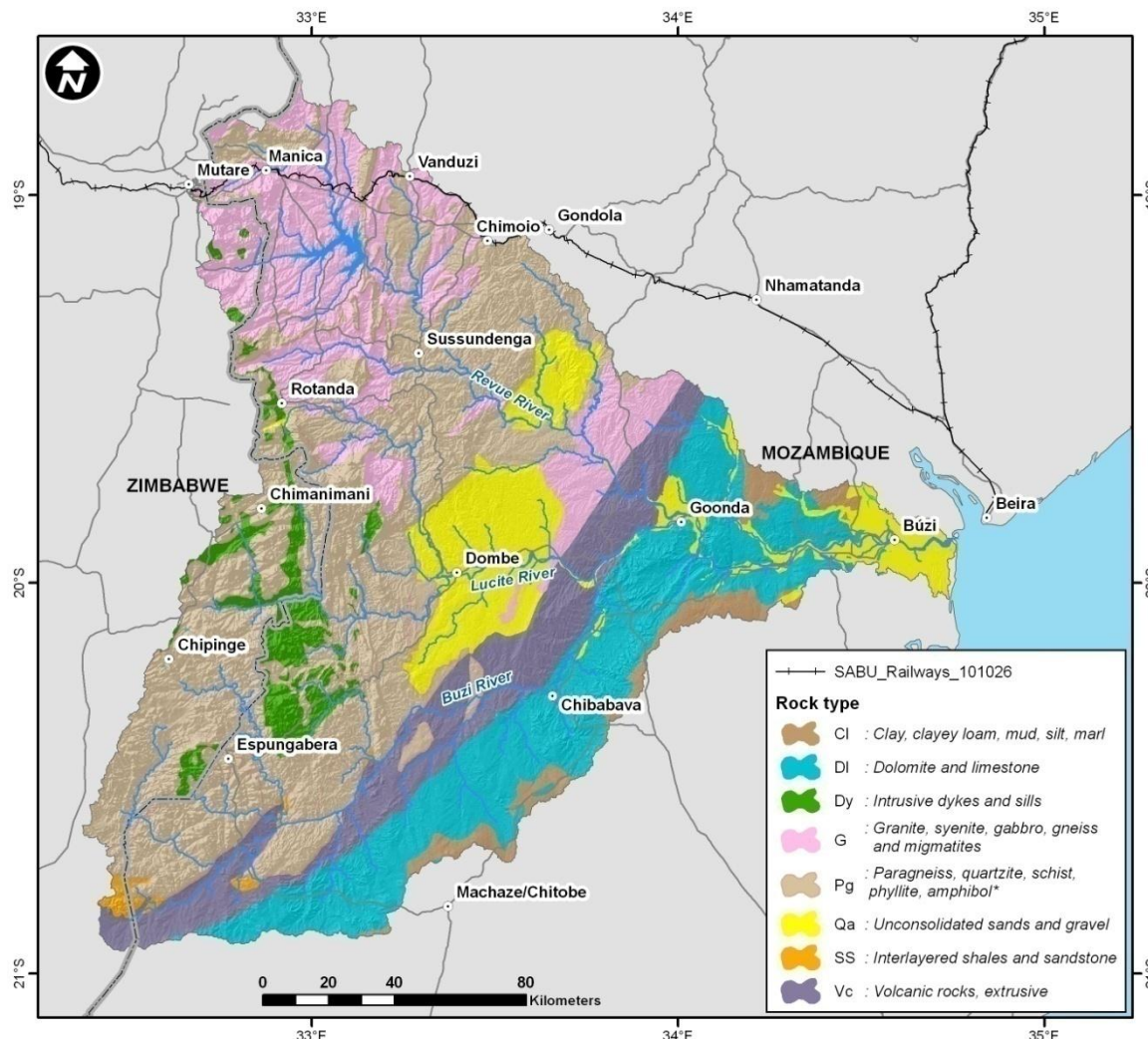


Figure 2-6 : Simplified Geology of the Buzi River Basin.

Source: SADC HGM, 2010.

2.3.2 Soils

The distribution of soils within the basin is naturally controlled by the topography and geomorphology.

The major soil types which occur within the Buzi River Basins (presented according to the FAO-system) have been described with respect to their distinguishing characteristics, drainage properties, and agricultural potential. Since surface slope and topographical position play major roles in the development of soil properties, three sub-regions have been distinguished in each basin, namely, parts of the basin occurring:

- at high altitudes – above 1,000 metres elevation
- at intermediate altitudes – above 500 metres but below 1000 metres elevation
- at low altitudes – below 500 metres elevation

Additionally, for the Buzi River Basin, the intermediate sub-region has been divided into a northern and southern area, each with slightly varying characteristic soil types.

The characteristic major soil types of each sub-region thus defined are described with respect to their frequency of occurrence as primarily (most frequent occurrence), secondly (lesser frequency of occurrence), thirdly (low frequency occurrence), or locally (minor occurrences – localized). Higher altitude areas (>1,000 m.a.s.l.) are primarily characterised by intensely weathered, very well drained tropical soil with bright red or yellow colours, and often containing ferricrete. Poor agricultural potential due to aluminium toxicity. Also typical for mountainous regions are very shallow soil over hard rock or a deeper soil that is extremely gravelly and/or stony. These are unattractive soils for agriculture but could have some potential for tree crops or extensive grazing. However, locally these areas may contain humus-rich surface layer, covered in the natural state with abundant grass or deciduous forest vegetation. These are highly arable soils.

In the northern part at intermediate elevations, between 500-1000 m.a.s.l, soils cover typically consists of a sandy horizon with an accumulation of low activity clays with base saturation in the second horizon. These are mostly free draining with a moderate agricultural potential. Secondly, sandy-textured, very well drained soils with poor soil profile development occur, containing a partially formed surface horizon low in humus and with no clay. These soils have typically low nutrient value and moderately low agricultural potential. In mountainous regions very shallow soil over hard rock or a deeper soil that is extremely gravelly and/or stony occurs. As mentioned previously, these are unattractive soils for agriculture but could have some potential for tree crops or extensive grazing. Further south an intensely weathered, very well drained, tropical soil occurs, characterised by bright red or yellow colours, often containing ferricrete. This soil has a poor agricultural potential due to aluminium toxicity.

In lower parts of the basin, at elevations below 500 m.a.s.l, soils are typically sandy-textured and very well drained with poor developed profile, containing a partially formed surface horizon, low in humus and with no clay. These are of low nutrient value and moderately low agricultural potential. Secondly, sandy upper horizons with an accumulation of low activity clays are abundant. These are mostly free draining, and with a moderate agricultural potential. Highly arable soils are the humus-rich surface layer covered in the natural state with abundant grass or deciduous forest vegetation. Locally porous (often humus rich) surface soils occurs with deeper clay or calcareous horizons, supporting forested areas or livestock farming. These soils are often of good natural fertility.

Distribution of dominant soil types of the Buzi River Basin are illustrated in Figure 2-7.

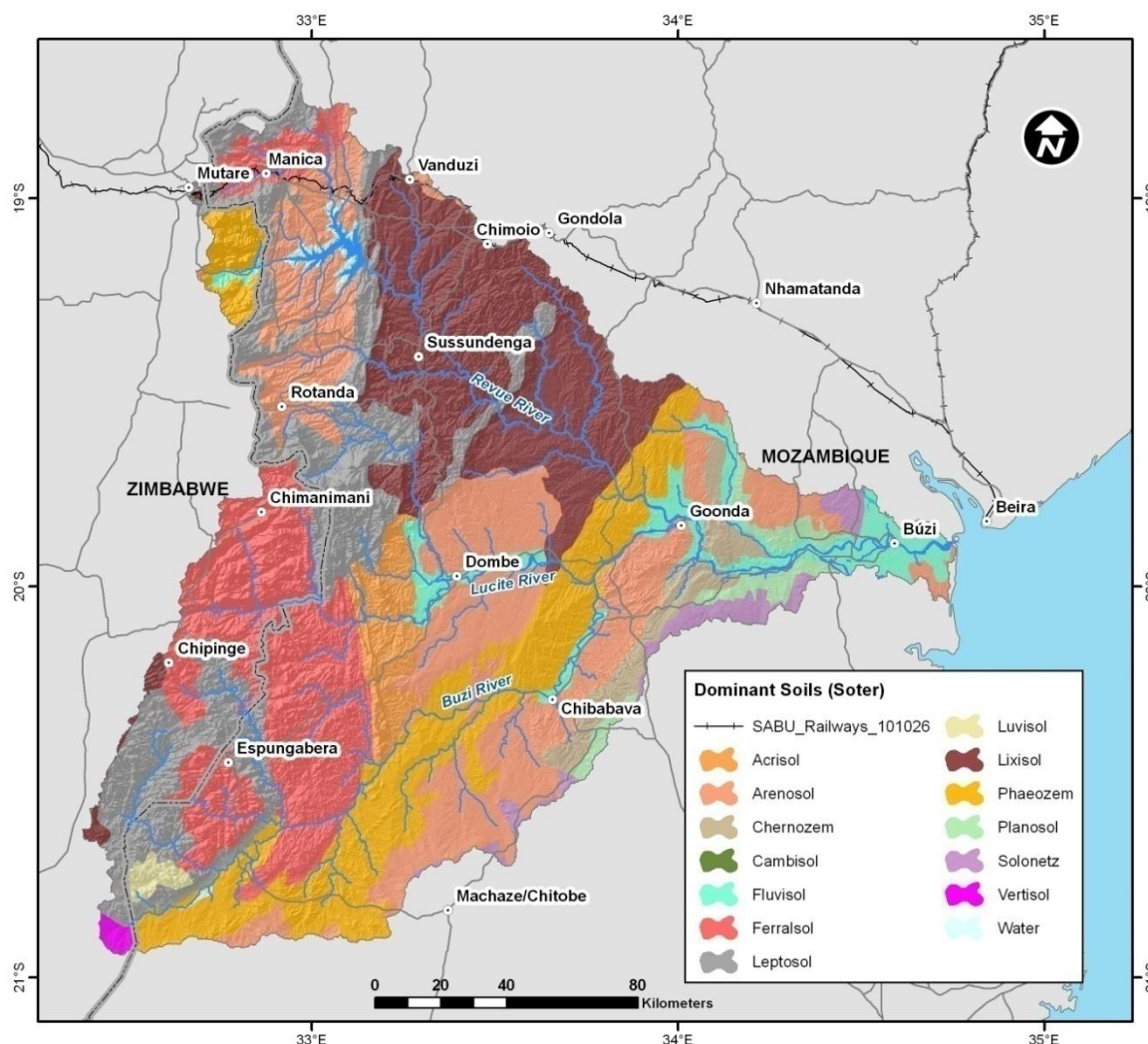


Figure 2-7 : Dominant soil types within the Buzi River Basin.

Source: FAO, 1998.

2.4 Land cover and Land use

At an early stage of the project the Consultant decided to embark on a land cover/use mapping programme to obtain a better understanding and knowledge of the basin characteristics. A basic land-cover dataset of Buzi River Basin has been generated from a combination of 2006/2007 Landsat satellite imagery. Landsat collects data with 30-m resolution in 7 bands + a panchromatic layer. The land-cover data was generated through advanced image processing techniques using the software package ERDAS Professional. A total of 22 Landsat TM scenes were obtained. Images were selected by the CSIR Satellite Applications Centre, based on data availability and cloud contamination. Imagery selected are all registered during dry season to avoid heavy vegetation that may obscure detail of the land surface.

Image mapping and dataset compilation has been undertaken as a desktop mapping exercise. Ground truthing and field verification was undertaken at selected locations by team members during field work. In addition, Google Earth was sometimes used as a source to verify classification in certain areas. Mapping methodology, challenges and uncertainties are further described in Annex 3 –Environmental Description.

The data set is a valuable asset, not only in providing information on present landcover and landuse, but it may also be used as a benchmark to monitor changed patterns in landuse in the future.

2.4.1 Class Definition

The Buzi River Basin land surface has been classified into 16 different landcover/landuse categories. These are listed and defined in Table 2-3.

Table 2-3 : Identified Land-cover Classes.

No.	Name	Description
1	Mangroves	Mangroves are forests associated with marine alluvium, partially steeped in salt water (Global Land-cover 2000). Most of the identified mangroves are in the vicinity of the river mouths of the basin.
2	Forest	Areas characterized by tree cover including natural or semi-natural woody vegetation, generally greater than 6 metres tall. 2.1 Forests 2.2 A Pioneer Plantation Growth class was used to identify areas in Zimbabwe with new growth plantations. 2.3 Forest Plantation: Large estate or farm on which trees are raised.
3	Coastal forest	A chain of relic forest and thicket patches set within savannah woodlands, wetland and agricultural land.
4	Dense Woodland/ Mosaic forest	Tree canopy cover of more than 40% and canopy height of greater than 5 metres. The Miombo woodland fall within this class. Due to the similarity of spectral characteristics, open forest have been included in this class.
5	Open Woodland	Tree canopy cover of 15-40% and canopy height of greater than 6 metres.
6	Deciduous Bush	Bushland areas containing natural/semi-natural trees and thickets. Includes both indigenous and invasive plant species (i.e. thicket and bush encroached areas are included within this class).
7	Closed Shrubland	Areas characterised by natural or semi-natural woody vegetation with small stems, with small trees scattered within the class and canopy height of less than 5 metres,
8	Open Shrubland	Areas characterised by natural or semi-natural woody vegetation with a small stem diameter and canopy height of less than 5 metres (with no tree layer). This class also includes bare ground with sparsely distributed shrubs and grassland with sparsely distributed shrubs.
9	Grassland	Natural/semi-natural grass dominated areas. This class includes both open and closed grassland and temporary wet grasslands: <ol style="list-style-type: none"> 1. Closed Grassland – occurs mostly within forests or in the mountain areas of Chimanimani and appears as very luscious grass; 2. Open Grassland – patchy, dry grassland; and 3. Temporary wet grassland – this occurs on very flat ground where the soil is very moist. For example along flat broad drainage lines and floodplains.
10	Cultivation	Areas characterized by herbaceous vegetation that has been planted or is managed for agricultural purposes. The cultivation class includes both croplands and cultivation in forests. 10.1 Cultivation – includes both informal and formal agricultural practices. 10.2 Irrigated cultivation – field that have been watered by artificial means.
11	Bare Soil/Urban	Areas characterized by a high percentage of constructed materials (e.g. asphalt, concrete, buildings), bare soil, gravel, and sand, with little or sparsely distributed vegetation.

12	Bare Rock	Naturally occurring, exposed and non-vegetated rock.
13	River Alluvium	This class is distinguishable within the islands of a braided river and as bare river beds. This class also includes salt pans which are found along the beaches
14	Water bodies	All areas of open water such as ocean, rivers, dams and lakes.
15	Wetland/Swamp	Vegetated areas where the soil or substrate is periodically saturated with or covered with water.

2.4.2 Land-cover Description

A large portion (roughly 30%) of the Buzi River catchment consists of wooded/forested areas which includes the land-cover types Coastal forest, Woodland (open and closed) and Forest. Most of the Coastal Forested areas are located in the Upper Lucite sub-basin, in Mozambique. Patches of Pioneer Growth Plantations can be identified in the upper catchment of the Buzi River, in the Chimanimani Mountains, and particularly in the Upper Lucite, Lower Revue and Lucite Zimbabwe. Another dominant feature in the Buzi River catchment is the stretch of grasslands and open shrublands which follows a north-easterly to south-westerly pattern from the south of the Lower Revue sub-catchment to the south-east of the Upper Buzi sub-catchment. In the coastal area of the Buzi River catchment the vegetation is a mix of Forests, Woodlands and Grasslands.

The landcover on the basin as a whole is presented in Figure 2-8, and in Appendix 2 illustrated on a sub-basin level.

Table 2-4 and Table 2-5 below present the calculated area for land cover, both for the whole basin as well as for each sub-basin.

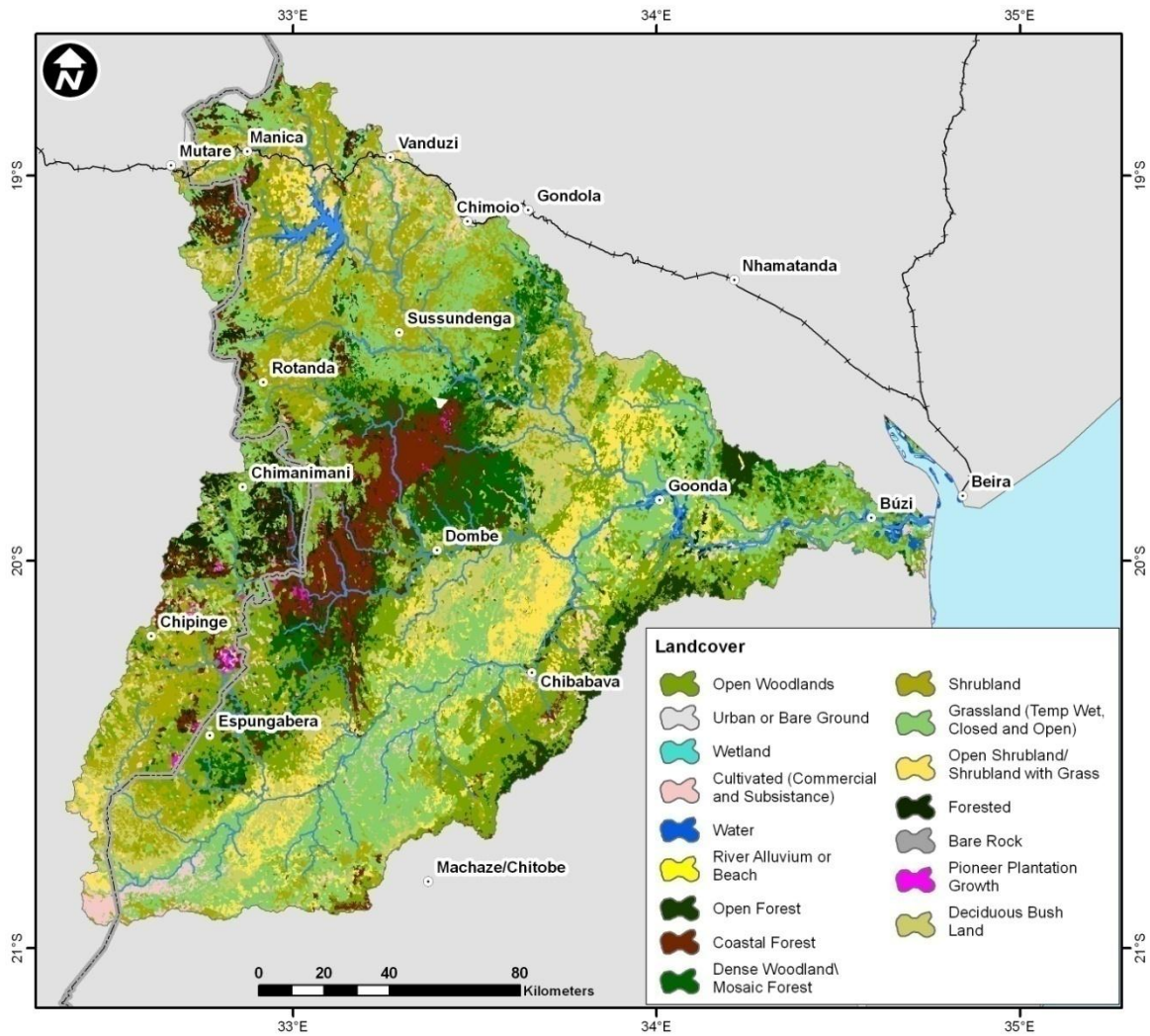


Figure 2-8 : Landcover for the Buzi River Basin.

Table 2-4 : Distribution of land cover categories in Buzi River Basin.

Category	Area (km ²)	Distribution (%)
No Data/Clouds	7	0%
Open Forest	6,399	23%
Urban or Bare Ground	49	0%
Wetland	3	0%
Cultivated (Commercial and Subsistence)	856	3%
Water	357	1%
River Alluvium or Beach	2	0%
Coastal Forest	2,125	8%
Dense Woodland/Mosaic Forest	1,798	6%
Shrubland	3,981	14%
Temporarily Wet Grassland	13	0%
Shrubland with Grass	1,807	6%
Mangroves	1	0%
Forested	763	3%
Grassland	5,578	20%
Temp wet Woodland/shrub	5	0%
Open Shrubland	381	1%
Bare Rock	143	1%
Open Grassland	531	2%
Temporary Wet Shrubland	132	0%
Pioneer Plantation Growth	89	0%
Deciduous Bush Land	3,035	11%

Table 2-5: Land cover distribution for each sub-basin. (%)

Category	Revue Zim	Upper Revue	Middle Revue	Lower Revue	Lower Buzi	Lucite Zim	Upper Lucite	Lower Lucite	Middle Buzi	Buzi Zim	Upper Buzi
NoData/Clouds	0%	0%	0%	0.23%	0%	0%	0%	0%	0%	0%	0%
Open Forest	3.00%	5.84%	2.87%	25.10%	32.51%	27.72%	33.74%	20.19%	28.42%	22.53%	22.41%
Urban or Bare Ground	1.16%	0.66%	0%	0.05%	0.51%	0.07%	0.00%	0%	0.10%	0.31%	0%
Wetland	0%	0%	0%	0%	0.07%	0%	0%	0%	0.01%	0%	0%
Cultivated (Commercial and Subsistence)	1.78%	4.76%	3.81%	0.36%	2.86%	2.87%	0.63%	0.61%	3.86%	7.99%	4.13%
Water	0.70%	6.47%	0.31%	0.26%	4.37%	0.13%	0.25%	0.63%	0.65%	0.22%	0.01%
River Alluvium or Beach	0%	0%	0%	0.00%	0.05%	0%	0%	0%	0.01%	0%	0%
Coastal Forest	22.10%	4.75%	3.06%	5.16%	0.02%	12.79%	30.44%	13.33%	1.70%	5.27%	2.82%
Dense Woodland/Mosaic Forest	2.87%	1.58%	1.85%	13.44%	5.05%	0.13%	9.62%	25.95%	0.59%	0.97%	7.17%
Shrubland	20.51%	37.78%	40.85%	13.66%	0.43%	2.96%	7.40%	0.44%	4.80%	32.54%	13.61%
Temporarily Wet Grassland	0%	0%	0%	0%	0.40%	0%	0%	0%	0%	0%	0%
Shrubland with Grass	0.43%	6.56%	0.96%	2.12%	6.34%	0%	0.10%	6.61%	18.52%	4.78%	8.87%
Mangroves	0%	0%	0%	0%	0.02%	0%	0%	0%	0%	0%	0%
Forested	12.05%	2.20%	2.40%	0.02%	0.82%	28.87%	3.60%	0.06%	0.02%	0.99%	0.13%
Grassland	23.43%	18.51%	27.91%	17.80%	20.56%	20.40%	7.60%	7.58%	32.52%	2.99%	24.82%
Temp wet Woodland/shrub	0%	0%	0%	0%	0%	0.06%	0.01%	0%	0%	0.23%	0.01%
Open Shrubland	0%	0.55%	0.89%	2.98%	4.15%	0.04%	0.03%	0%	1.77%	0.68%	0.86%
Bare Rock	0.10%	0.16%	1.54%	0.07%	0.03%	1.26%	1.79%	0%	0.08%	0.46%	0.29%
Open Grassland	0%	0%	0%	0.22%	15.51%	0%	0%	0%	0.79%	0%	0%
Temporary Wet Shrubland	0%	0.34%	0.03%	0.03%	3.63%	0.00%	0.05%	0%	0.14%	0%	0.01%
Pioneer Plantation Growth	0.49%	0.15%	0.05%	0.18%	0%	0.80%	0.75%	0.11%	0%	1.87%	0.19%
Deciduous Bush Land	11.36%	9.69%	13.49%	18.30%	2.66%	1.91%	3.99%	24.49%	6.01%	18.17%	14.70%

2.5 Eco-Regions

A science-based global ranking of the Earth's most biologically outstanding terrestrial, freshwater and marine habitats that provides a critical blueprint for biodiversity conservation at a global scale is the underlying concept of eco regions.

2.5.1 Terrestrial Eco-regions

From a terrestrial perspective, the Buzi River catchment falls within the Afrotropic Realm, and is associated with five biomes, namely:

- the Montane Grasslands and Shrublands Biome,
- the Tropical and Subtropical Grasslands, Savannahs and Shrublands Biome,
- the Flooded Grasslands and Savannahs Biome;
- the Tropical and Subtropical Moist Broadleaf Forests Biome and
- the Mangroves Biome.

In addition, the Buzi River catchment encompasses six separate ecoregions (regional –scale units of biodiversity) (Table 2-6 and Figure 2-9). Of particular importance is the fact that the East African Mangroves ecoregion located at the mouth of the Buzi Estuary with a link to the Pungwe River Estuary is listed within the Global 200 priority ecoregions for global conservation, and is listed as Critical or Endangered. Mangroves are keystone habitats in the sense that they have an inordinately strong influence on species populations and ecosystems well beyond their limited area. In addition to providing habitat and resources to a wide range of species, mangroves also protect inland habitat and shorelines from damage by damping storm waves and tidal action. Additionally, they filter sand and pollutants generated in the terrestrial habitats that would otherwise damage sea grass and corals (Olson and Dinerstein, 2002).

Table 2-6 : Terrestrial biomes and associated ecoregions represented within the Buzi River Basin.

Biome	Ecoregion
Montane Grasslands and Shrublands Biome	Eastern Zimbabwe Montane Forest-Grassland Mosaic
Tropical and Subtropical Grasslands, Savannahs and Shrublands Biome	Zambezian and Mopane Woodlands Southern Miombo Woodlands
Flooded Grasslands and Savannahs Biome	Zambezian Coastal Flooded Savannah
Tropical and Subtropical Moist Broadleaf Forests Biome	Southern Zanzibar-Inhambane Coastal Forest Mosaic
Mangroves Biome	East African Mangroves

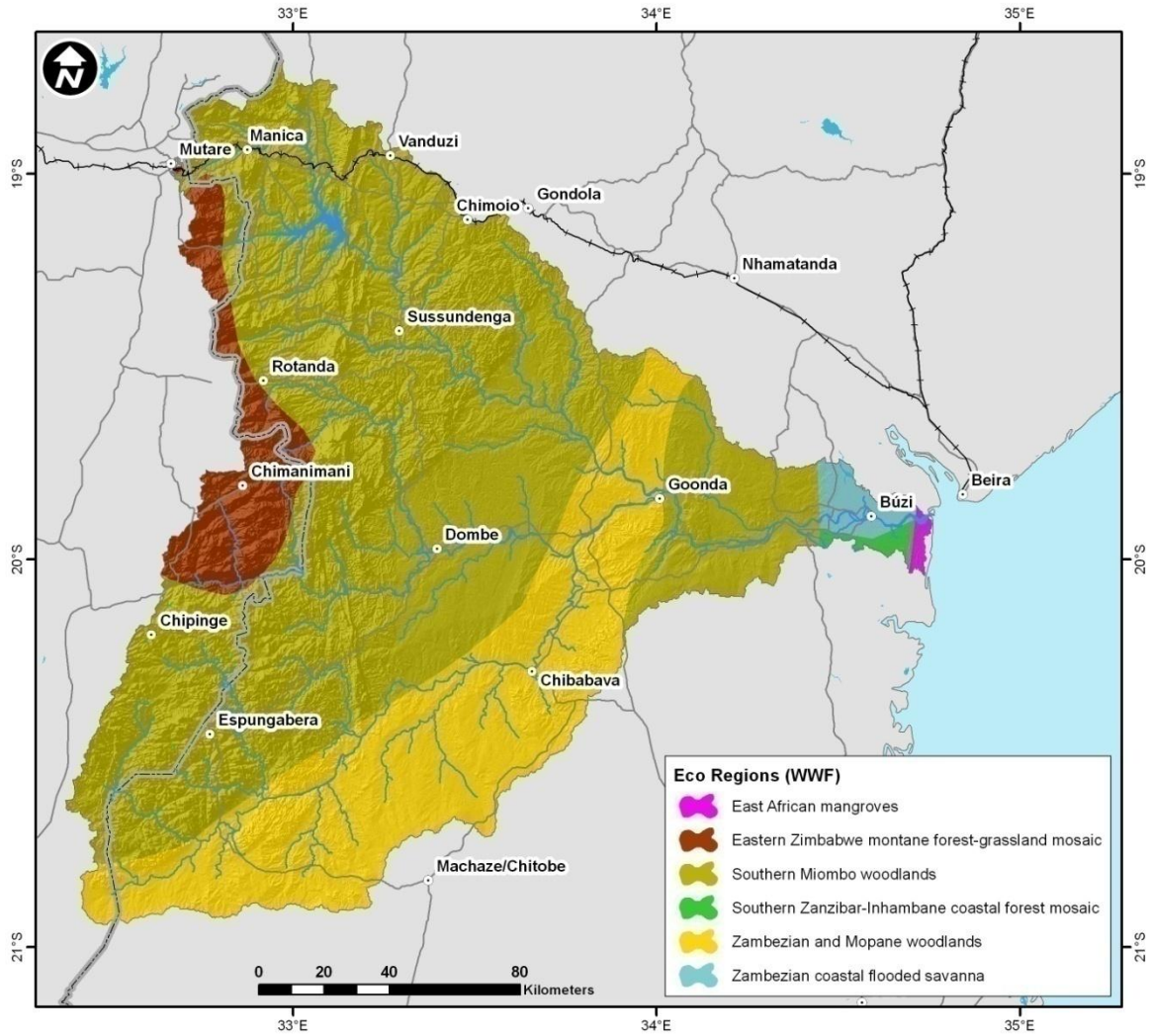


Figure 2-9 : Terrestrial eco-regions in the Buzi River Basin.

Source: WWF.

2.5.2 Freshwater Eco-regions

Unlike terrestrial ecoregions, freshwater ecoregions do not fall within realms. Nevertheless, various freshwater ecoregions are represented within the Buzi River catchment, and include the Zambezan Lowveld ecoregion, the Eastern Zimbabwe Highlands ecoregion, and to a lesser degree, the Zambezan Highveld ecoregion (Figure 2-10). The Zambezan Lowveld freshwater ecoregion is represented throughout most of the Buzi River catchment, with the boundaries extending from the south of the Zambezi Delta in Central Mozambique southwards to and including the Tugela River system in South Africa. The northern-most Pungwe, Buzi and Save rivers are seasonal rivers, with winter low-flows confined to streams within the channel and summer flows overflowing the channel into adjacent floodplains along their lower reaches. At the coast, these rivers form tidal mangrove swamps that are almost continuous, extending 50km inland at the Pungwe River mouth (FEOW, 2010).

The Eastern Zimbabwe Highlands freshwater ecoregion is well represented within the upper reaches of the Buzi River catchment, and incorporates the Chimanimani Mountains and the Vumba Mountains. Many streams within this ecoregion flow eastwards for a short distance before descending high waterfalls at the rim of the escarpment into Mozambique. Most streams within this ecoregion are oligotrophic as a result of the low nutrient input into the system typical of mountain streams, with the energy base comprising allochthonous plant material, such as leaves that fall from the riparian forests normally associated with these systems.

From a marine perspective, the Buzi River mouth is located within the Western Indo-Pacific Realm, with the associated marine ecoregion being the Bight of Sofala/Swamp Forest ecoregion. Like the

mangroves, this ecoregion is also listed as one of the Global 200 priority ecoregions for global conservation.

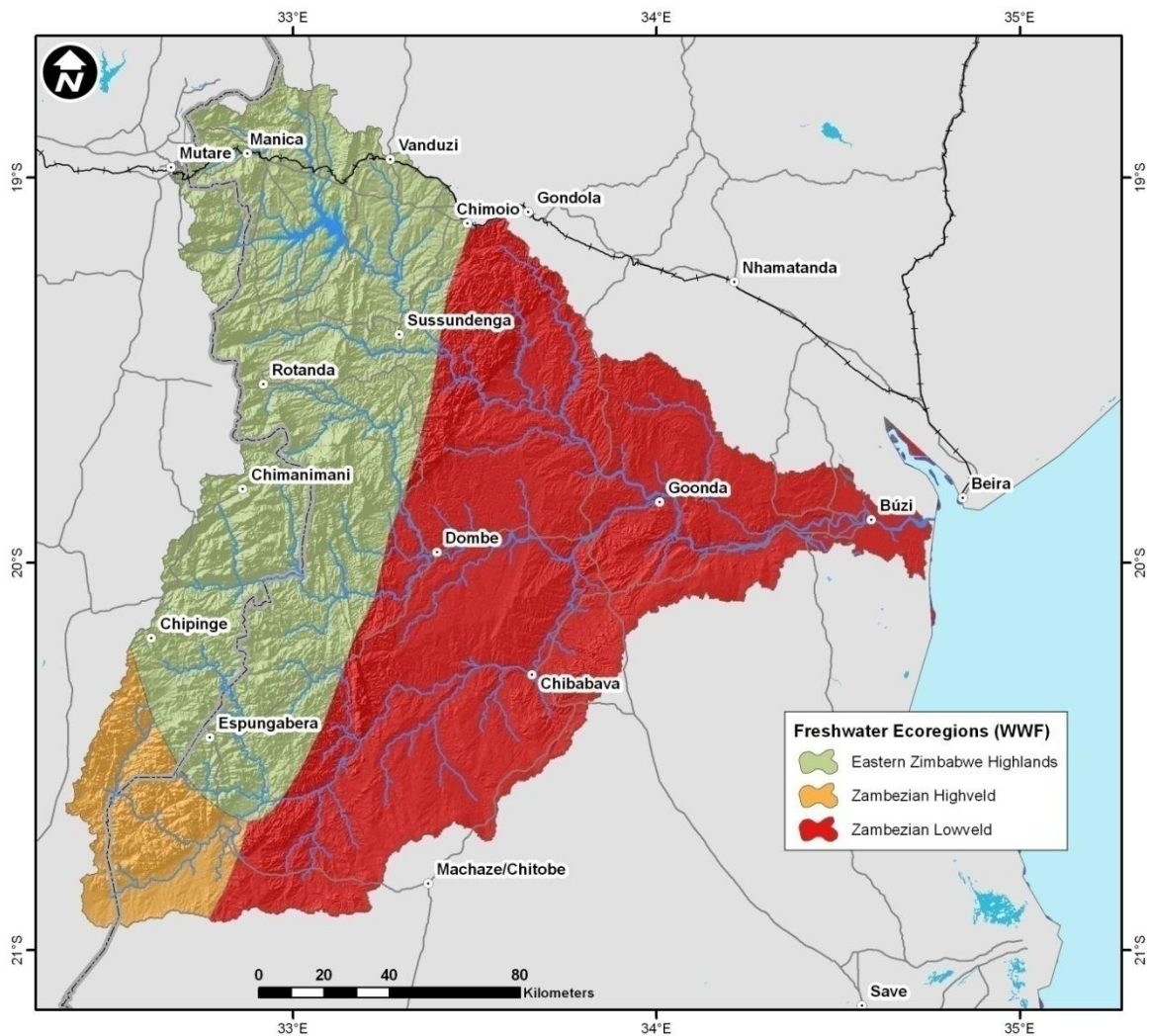


Figure 2-10 : Freshwater ecoregions associated with the Buzi River catchment (WWF)

2.6 Climate

The Buzi River Basin stretches over two climate types; humid mountainous climate and tropical humid climate. In the west the humid mountainous climate prevails due to the mountain range that is forming the border between Mozambique and Zimbabwe. In this region the mean rainfall can reach above 1,500 mm/a and the temperature is significantly lower than in the surrounding, non-mountainous areas.

2.6.1 Temperature

The annual average temperature in the basin is fairly stable but a notable difference can be found between the mountainous areas in the western part of the basin compared to the east areas. The closer to the Indian Ocean, the higher the temperature becomes.

Figure 2-11 presents a grid of the mean annual average temperature in the Buzi River Basin. Corresponding grids presenting monthly mean (Jan-Dec) can be found in Appendix 3.

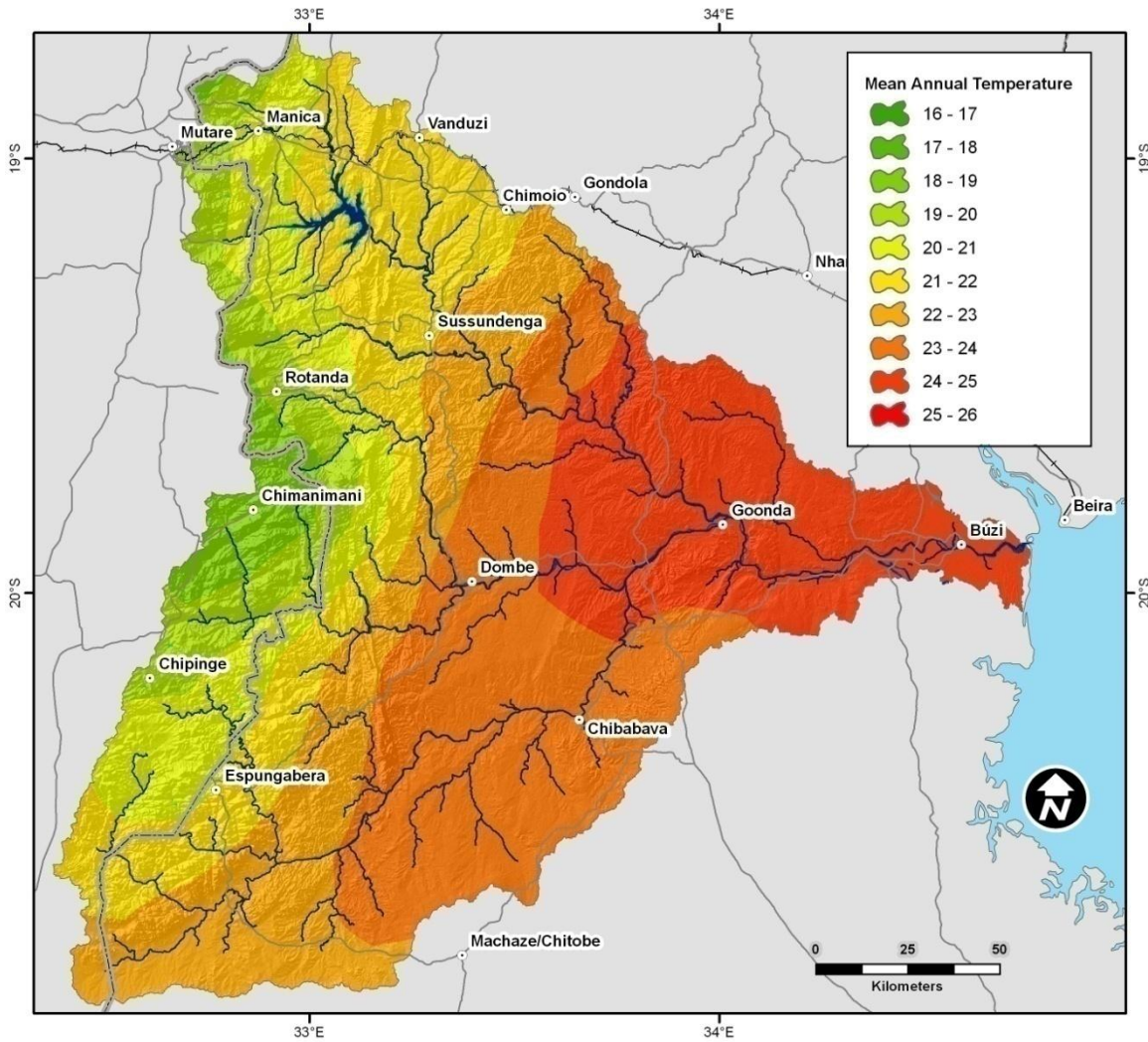


Figure 2-11 : Mean Annual temperature in the Buzi River Basin.

Source: New et al, 2002

2.7 Rainfall

Rainfall shows a distinct unimodal seasonal pattern and occurs mainly during October to November to March to April. During the winter, May to September, the basin receives very little rain. The precipitation pattern varies a bit over the basin, but within same range.

The amount of rainfall varies significantly from year to year, and during a very dry year the rainfall generates almost no runoff peaks in the rivers due to the high temperature and hence high evaporation. During a wet year large floods can occur, especially the lower reaches are exposed to flooding. Highest flooding is normally caused by cyclones from the Indian Ocean, which rarely occurs (on average one or less per year in Mozambique).

Beira receives annually about 1,500 mm, but going inland the rainfall drastically decreases to around 900 mm at the Lower Buzi sub-basin (Figure 2-5 illustrates the Buzi sub-basins). Following the Buzi tributary the precipitation keeps low until reaching the western mountains at the border to Zimbabwe, where the annual rainfall is approximately 1,000 mm. In the Zimbabwean part of the Buzi tributary the rainfall is higher due to the higher elevation and the rainfall is on average about 1,150 mm in this area.

The Lucite branch receives more rainfall than the Buzi tributary, due to a major part of the river basin covers the mountainous area, where rainfall is higher. In the Lower Lucite rainfall ranges from 900 to 1,100 mm in a north-western direction. Mountains dominate the upper part of the Lucite River and rainfall is therefore higher. On average the Upper Lucite sub-basin in Mozambique receives about 1,300 mm, with more precipitation in the northern part of the sub-basin and less rainfall in the

southern part. Upper parts of the Lucite River in Zimbabwe are partly in rain shadow from the mountains and therefore less rain is received in this part.

Rainfall in the Revue River basin is dominated by the sharp incline between the southern and the northern parts of the basin. The Lower Revue receives about 1,200 mm, while the Middle Revue receives about 1,100 mm. In the Upper Revue the rainfall is about 1,100 mm, but with much more rainfall in the sub-basins higher mountain area. In these parts, located in the northern most part of the Revue basin the annual precipitation is about 1,600 to 1,700 mm.

In 2002 the Climate Research Unit in the United Kingdom made a high resolution data set (18x18 km) of surface climate over the entire world (New et al. 2002). As input they used a DEM and data from synoptic stations around the world. Interpolation was then used to estimate different climate parameters. One of the outcomes was mean annual precipitation and by further interpolating their results a MAP distribution over the Buzi and Save River basin was attained (Figure 2-12). Interpolated grids displaying monthly mean rainfall (Jan-Dec) can be found in Appendix 4.

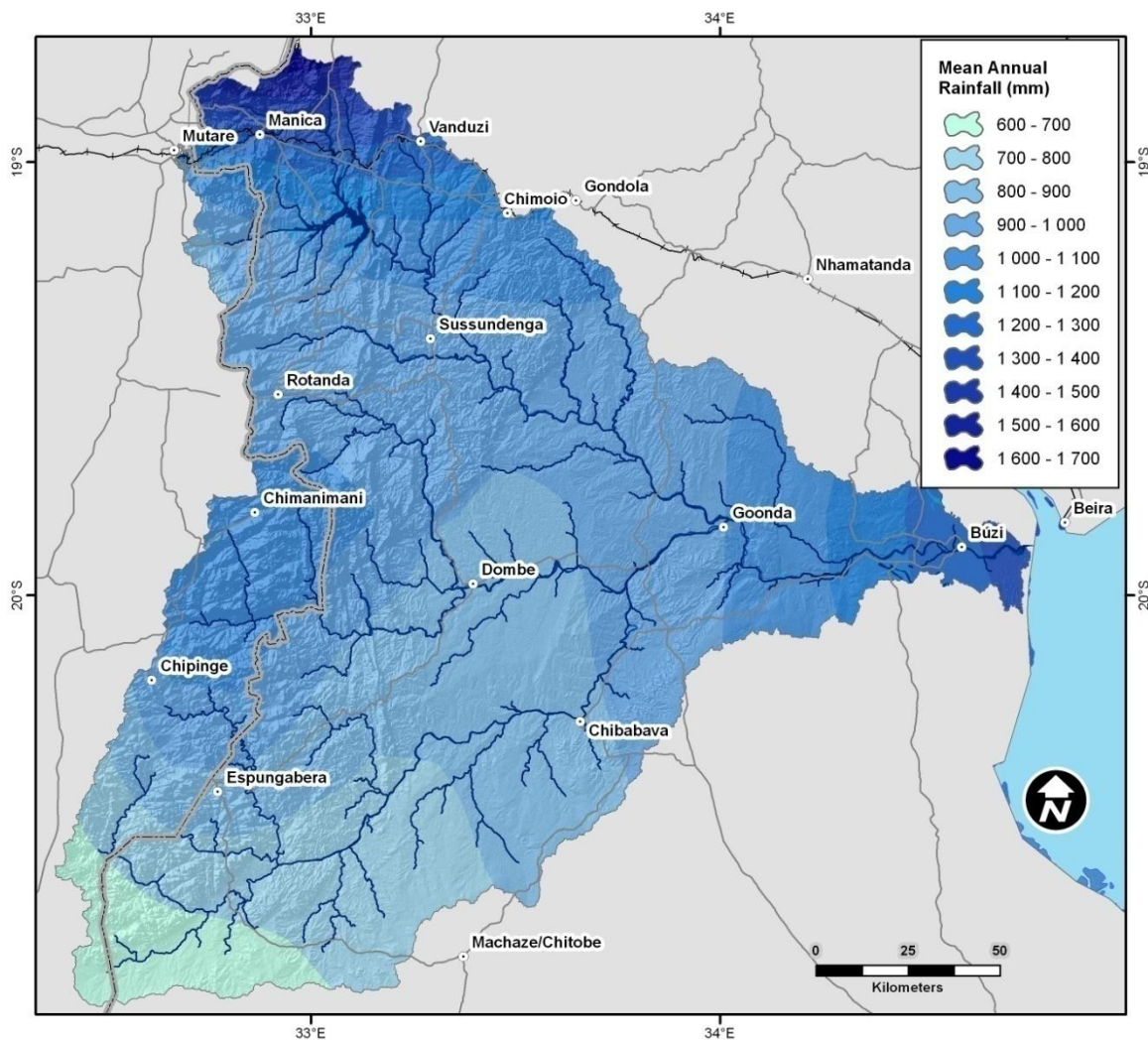


Figure 2-12 : Rainfall in the Buzi River Basin.

Source: New et al, 2002

2.7.1 Evaporation

Evaporation is mainly in relationship to the temperature, the higher temperature the higher evaporation. Since the temperature decreases with altitude the mountainous area experience lower evaporation than the coastal region.

October and September are the months with highest the evaporation and June is the month with the lowest evaporation. All the stations have more or less the same monthly variation.

Figure 2-13 shows isolines for Potential Evaporation derived by COBA (1980) based on correlation between observed pan evaporation and altitude.

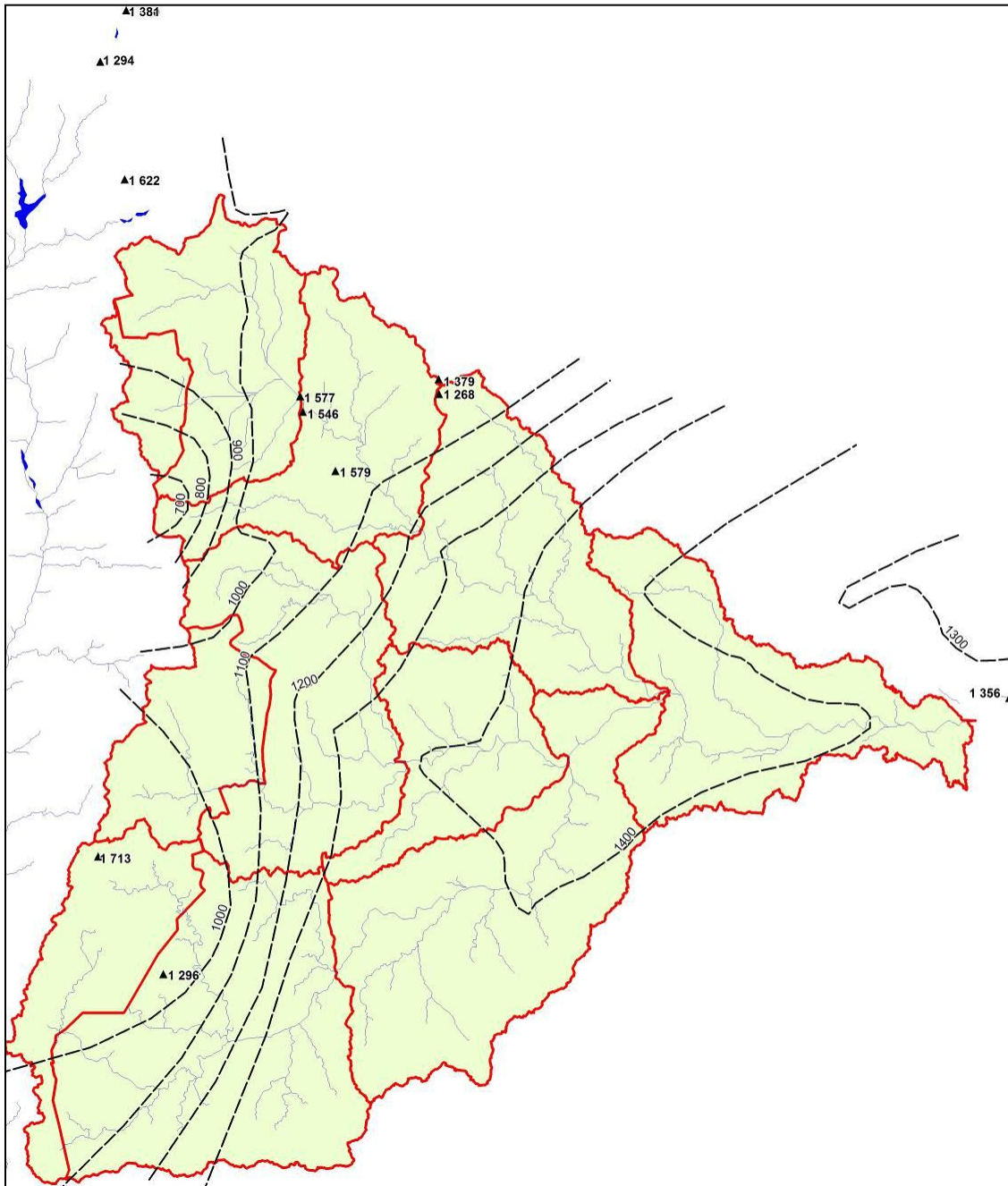


Figure 2-13 : Mean Annual Evaporation used for the catchments in the Pitman model.

2.8 Administrative boundaries

The Buzi River Basin can be administratively divided into nations, provinces/regions, districts and wards/administrative posts. Provinces are the largest administrative divisions on a national level, these are further subdivided in districts (Figure 2-14). Sub-district divisions are called wards in Zimbabwe and administrative posts in Mozambique.

In Zimbabwe, the Buzi River Basin portion belongs to Manicaland Province and is shared between three districts and 34 wards. In Mozambique the Buzi River Basin is part of the Manica and Sofala Provinces, and shared between eight districts and 27 wards.

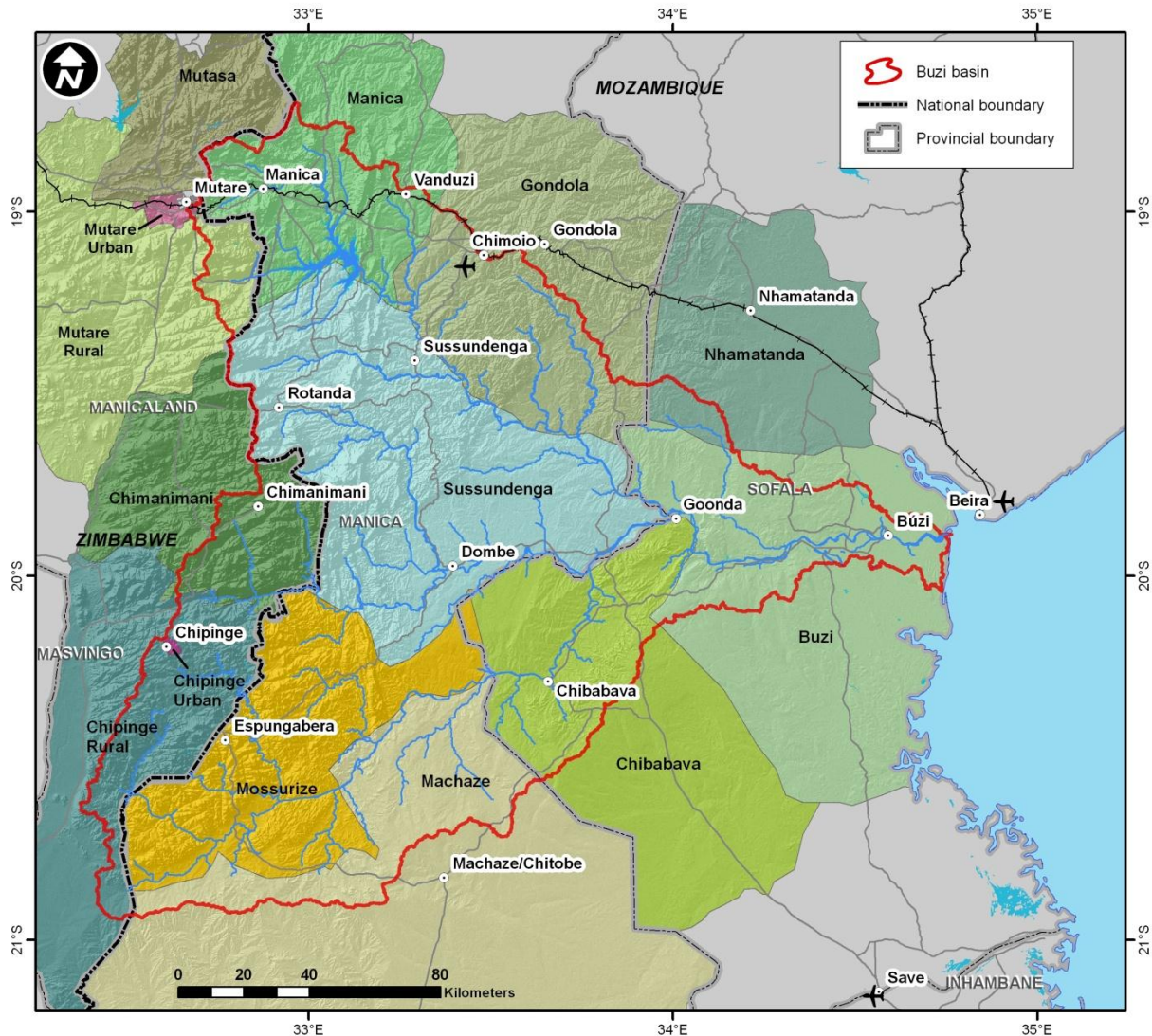


Figure 2-14 : Provinces and Districts in the Buzi River Basin.

2.9 Infrastructure

2.9.1 Dams

Major dams in the Buzi River Basin are few and limited to two hydropower dams, explicitly the Chicamba Dam (2,020 Mm³) and the Mavuzi Dam (1.8 Mm³), see Table 2-7. Both found on the Revue River in Mozambique. Chicamba Dam is the larger of them two, but Mavuzi has a higher capacity for generating power. Moreover, some 70 small scale dams for livestock and irrigation are found in the basin mainly in the Sussundenga district, of which about 50% are in good condition. However, all of them have a height less than 5 m. Many dams are found in the Zimbabwean part of the basin however, these dams are small and mainly used for irrigation purposes and water supply. Small dams in the Budzi system have a net capacity of about 3,126m³ and include the Bangazaan dam (2,825 m³) and Chako dams on the Chinyika River.

Construction of the Chicamba Dam started in 1956 and was finished in 1959. However power production did not start until 1968, prior 1968 the dam was only used as storage for Mavuzi Dam. In 1968 work began to raise the dam to present day level and this work was finalised in 1970. Today the capacity of the Chicamba Dam is 2,020 Mm³ with a full supply level of 610 m.a.s.l.

The Mavuzi Dam is located approximately 60 km downstream the Chicamba Dam. The reservoir of the dam is only 1.8 Mm³, but utilizes the storage in the Chicamba Dam and thereby increasing the capacity for power production. Actually the potential for power generating capacity is higher at the Mavuzi Dam than the Chicamba Dam, even though the reservoir is significantly smaller. Both dams are operated by the EDM and there are plans to rehabilitate the dams to increase power production even further.

Table 2-7 : Dams in the Buzi River Basin.

	Dam Capacity at FSL	Surface Area	FSL	Head	Number of Turbines	Total power generating capacity
Chicamba Dam	2,020 Mm ³	120 km ²	625 m.a.s.l	52 m	2	48 MW
Mavuzi Dam	1.8 Mm ³	26 km ²	345 m.a.s.l	160 m	5	50 MW

2.9.2 Transport network

The Buzi River Basin has a strategic location and is connected to transport links to the SADC region through national highways and to the Middle East and Asia Pacific through the Beira port.

In Mozambique, the Buzi Basin is linked by National Highways 1 and 6 that transport freight and passengers to Zimbabwe, Malawi and Zambia. There is a railway line linking the port of Beira to Zimbabwe, crossing the border at Machipanda. Currently the railroad is only used to transport freight. In addition there is a pipeline that carries fuel from the Beira port in Mozambique to Zimbabwe.

In the basin in Zimbabwe, main roads to Chimanimani, Mutare Rural and Chipinge are tarred and are generally in good condition.

However, most of the district roads linking the rural centres are in need of rehabilitation both in Mozambique and in Zimbabwe. In Mozambique, most of district roads are in poor condition and become impassable in the rainy season especially in the southern part of basin. However, the road network and road condition is better in the north part of the Buzi River Basin along the Beira Corridor. Moreover, major improvements are expected in the road network in the Beira Corridor to meet the needs of the growing population, industry, and access to markets for both people and agricultural goods in and outside the basin. The extension and rehabilitation of secondary and tertiary roads, is in progress and will improve the access of rural areas to regional markets.

In the lower part of the Basin, particularly in the Buzi District, river transportation is the main means of communication and transportation when roads are impassable during the rainy season. River is also used by cargo vessels. However, river navigation depends on the level of the river, which is influenced by tides, floods and silting of the riverbed.

In Zimbabwe, rural centres are linked to the main roads by gravel roads in varying condition. A number of access points (e.g. bridges) were damaged following cyclones (e.g. cyclone Eline) and have not been repaired by the District Development Fund (DDF) (the responsible authority for



Figure 2-15 : View from Chicamba dam.

maintaining and servicing district roads) due to the lack of finance resulting as a result of the socio-economic and political climate that has prevailed in Zimbabwe since 2000.



Figure 2-16 : Field trip. April 2010,.

2.9.1 Other basic infrastructure

In Mozambique the north part of the Buzi River Basin, along the Beira corridor is connected to the national grid receiving electricity from Cahora Bassa and Chicamba Dam. The south parts of the basin in Mozambique are largely not connected and rely on a few generators in the largest settlements. Chibabava village will probably soon get electricity as the Government's rural electrification program is expected to extend their service in the area. This will be done with a new electric station in the district.

In the Zimbabwean part of the basin electricity is not available in most households and the people in the areas rely on fuel wood. The Government of Zimbabwe has embarked on a rural electrification programme aiming to provide electricity to most of the households in the Zimbabwean part of the basin. There is today however current power supply outages in the whole of Zimbabwe that threaten to limit the effort on the programme.

The coverage of communications in the basin is in several areas very good, particularly along the major roads and the larger settlements. The southern area of the basin has the least developed communication networks. Land line phones and radio communication are used in most part of the basin, and can in some areas be accessed at schools, clinics or hospitals. Internet access can only be found in the largest cities. Two cell-phones companies are working in Mozambique (M-cel and Vodacom) and three in Zimbabwe (*Net One, Econet and Telecel*).

3 PEOPLE AND ECONOMIC ACTIVITIES

3.1 Demography

3.1.1 Population density and composition

In Mozambique, population information is based on the latest national population census in 2007. For Zimbabwe, demographic statistics are based on official census statistics from the Central Statistics Office (CSO) for 2002. The next population census is scheduled for 2012.

Table 3-1 below shows that except for the Buzi District, where population growth is relatively low (1.1% per year), all other districts have relatively high growth rates in population. However, the population density varies between the districts. Population estimates for 2010 show that most districts in the basin are experiencing large increases in both the population size and density.

Table 3-1 : Historical and projected population density and population growth for districts in the Buzi Basin in Mozambique.

District	Area (km ²)	Population 1997	Density (inhab/km ²) 1997	Population 2007	Density (inhab/km ²) 2007	Annual growth rate (%)	Estimated population 2010	Estimated density 2010 Inhab/km ²
Buzi	7,329	143,100	19.5	159,600	21.8	1.1	164,900	22.5
Chibabava	6,977	72,300	10.4	101,700	14.6	3.5	112,600	16.1
Nhamatanda	3,987	137,900	34.6	210,800	52.9	4.3	239,300	60.0
Gondola	5,739	186,400	32.5	262,400	45.7	3.5	290,800	50.7
Machaze	13,189	75,800	5.7	104,600	7.9	3.3	115,200	8.7
Manica	4,594	155,700	33.9	213,200	46.4	3.2	234,300	51.0
Mossurize	5,038	122,200	24.3	195,200	38.7	4.8	224,600	44.6
Sussundenga	7,060	92,600	13.1	129,800	18.4	3.4	143,700	20.4

Source: INE (2009) and MAE (2005); CSO, 2002

A large part of the population in the basin is young. On average, 45% of the total population is below 15 years old. The majority of the population still lives in rural areas (62%, in Sofala and 75% in Manica province). The rate of urbanization is low, less than 15 % (District Profiles, MAE, 2005).

The Buzi River Basin in Zimbabwe is mainly located in rural areas and there are no major urban centres within the basin. There are only two small urban areas, Chipinge, with a population of approximately 11,000 in 2010, and Chimanimani with a population of around 3,000 in the basin in Zimbabwe. The expected annual growth rate is therefore relatively low, approximately 1%. Using this growth rate, the population projections by district in the basin in Zimbabwe are shown in Table 3-2.

Table 3-2 : Projected population for areas in the Buzi basin in Zimbabwe by district (2010-2030).

District	2010	2020	2030
Chipinge	122,800	136,400	150,400
Chimanimani	56,600	62,600	69,100
Mutare Rural	13,800	15,300	16,900
Total	193,200	214,300	236,400

Source: Estimates based on base year 2002 population statistics (CSO), 2002

According to Utete (2003), Manicaland has the highest population density at 42 people per square kilometre. The population in the three districts in the basin in Zimbabwe show that there are more women than men, particularly in Chipinge District. A study of household heads revealed that a higher percentage of households with between 3–6 persons in all three districts were headed by females (CSO, 2002).

In Zimbabwe, inter-district migration is estimated to be less than 5% of the enumerated population in Chimanimani, Mutare rural and Chipinge districts. In Chimanimani, 4% of the population had migrated from other districts within the province and 3% from other provinces, Harare being the main destination. In Mutare Rural, 4% had migrated from other districts within the province and 2% from other provinces, Harare being the main contributor. Chipinge had 2% of the population enumerated from other districts within the province and 2% from other provinces, Masvingo being the main contributor.

The population in Chipinge, Chimanimani and Mutare Rural districts is mostly rural, i.e. 93.1%; 96.1%; and 96.9%, respectively with the remaining 6.8%; 3.8% and 3.0% residing in urban areas of Chipinge, Chimanimani and Mutare Rural, respectively (CSO, 2002).

The average household size in Manicaland is four members. Chipinge District has the highest percentage of households in Manicaland; 17.1% (61,755 households). Chimanimani District accounts for 7% (26,500 households) while Mutare Rural accounts for 13% (48,619) of households in Manicaland Province according to the 2002 census (CSO, 2002).

3.2 Population projections

The main population trends in the basin are: urbanization, concentrated in and around main urban centres such as Chimoio, Gondola, Manica and Buzi in Mozambique and Chipinge in Zimbabwe, and to a lesser extent in and around 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.

Secondary demographic trends include movement of people to areas near large-scale commercial farms to take advantage of new employment opportunities. While this internal migration is small scale at present, it is expected to increase in the future with the expansion of irrigated areas for cultivation primarily in the central and eastern parts of the basin. Other movements of people are from the basin to the growing cities of Beira, Maputo and Mutare in order to take advantage of increased employment and educational opportunities in these cities.

The urban population in the basin in Mozambique is expected to increase by an average of 3% annually between 2010 and 2030, whereas the rural population is expected to grow at a slower rate, at 2.5% annually from 2010-2020 and 1.8% annually from 2020 to 2030. The projected growth rates in the Zimbabwe part of the basin are lower, around 1% per year, based on historical growth rates.

The estimated population of the eight sub-basins in the Buzi Basin in Mozambique is shown in Table 3-3.

Table 3-3 : Population by sub-basin in Mozambique (2007-2030).

Sub-basin	2010	2020	2030
Lower Buzi	101,300	129,600	154,900
Lower Lucite	32,300	41,300	49,400
Lower Revue	111,600	142,800	170,700
Middle Buzi	55,900	68,900	82,300
Middle Revue	81,200	103,900	124,200
Upper Buzi	164,200	210,200	251,300
Upper Lucite	65,300	74,800	89,400
Upper Revue ¹	449,600	597,400	782,800
Total	1,061,400	1,368,900	1,705,000

Source: Consultant's estimate based on INE (2007)

¹ includes the city of Chimoio and the town of Gondola as they are supplied from the Chicamba Dam.

Table 3-4 shows the population in the Buzi Basin in Zimbabwe by sub-basin.

Table 3-4 : Projected population of the Buzi Basin in Zimbabwe by sub-basin (2010-2030).

Sub-basin	2010	2020	2030
Buzi Zimbabwe	104,400	116,000	127,900
Lucite Zimbabwe	75,000	82,900	91,600
Revue Zimbabwe	13,800	15,300	16,900
Total	193,200	214,200	236,400

Source: Consultant's estimates based on CSO (2002)

The total population of the Buzi Basin is shown in Table 3-5, clearly indicating that the Buzi River Basin in Zimbabwe covers a small and rural area.

Table 3-5 : Projected population in the Buzi Basin by country (2010-2030).

Country	2010	2020	2030
Mozambique	1,061,300	1,368,900	1,705,000
Zimbabwe	193,300	214,200	236,300
Total	1,254,600	1,583,100	1,941,300

Source: Consultant's estimates based on INE (2007) and CSO (2002)

In Zimbabwe, the population is considerably more rural, with 93% of the population in the basin being classified as rural. As seen in Table 3-6, which shows the projected rural and urban population in the Buzi basin in Mozambique, the urbanised population is estimated to be 37% by 2030.

Table 3-6 : Rural and urban population in the Buzi basin in Mozambique (2010-2030).

Area	2010	%	2020	%	2030	%
Rural	716,400	67.5	905,500	66.1	1,082,200	63.5
Urban	344,900	32.5	463,500	33.9	622,900	36.5
Total	1,061,300	100	1,369,000	100	1,705,100	100

Source: Consultant's estimates based on INE (2007)

The trend analysis and population projection result in a demography by 2030 that is characterised by relatively high urban population in Mozambique; and by a continued low population density in the lower reaches of the Buzi River Basin as illustrated in Figure 3-1.

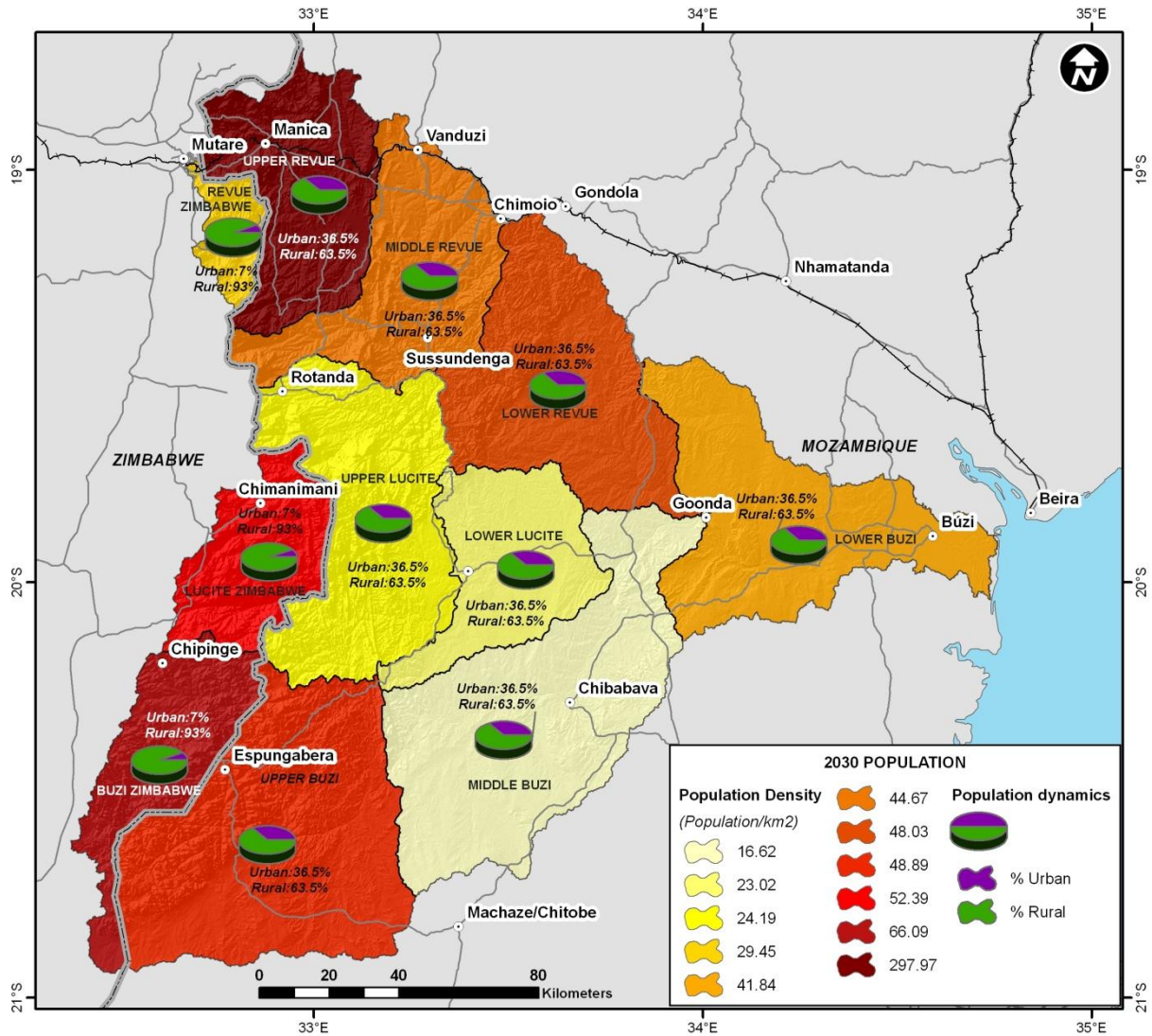


Figure 3-1: Basin demography by 2030

3.3 Social Profile

In Mozambique, a comparison of health and related indicators shows that the central region of Mozambique ranks lower than the southern region of the country, but higher than the northern region. Life expectancy in Manica and Sofala provinces is close to the national average, although Manica Province is closer to the national average than Sofala, as shown in Table 3-7 (INE, 2009).

Table 3-7 Life expectancy at birth for selected areas (2007)

Region/Province	Life Expectancy (years)
Mozambique	47.6
Southern Region	53.3
Northern Region	44.3
Central Region	46.7
Manica	49.1
Sofala	47.0

The infant mortality rate for Zimbabwe has been increasing since 1988, see Table 3-8.

Table 3-8 : Infant mortality rate by year in Zimbabwe.

Year	1988	1990	1994	1995	1999	2005/6	2008
IMR	61	66	53	80	59.7	66	63.5

Source: Ministry of Health & Child Welfare, 2008

In Zimbabwe, life expectancy has drastically dropped since 1986-1990 when the national life expectancy varied between 61 and 62 years (1988), see Table 3-9.

Table 3-9 : Life expectancy in Zimbabwe.

National/ Year	1990	2002	2008
Male	58	43	40,8
Female	62	46	46,2
Total	61	45	43,3

Source: Ministry of Health & Child Welfare, 2008

There is a high prevalence of water related diseases such as diarrhoea, cholera and malaria of the population in the Buzi River Basin both in Mozambique and in Zimbabwe. Table 3-10 presents annual cases of selected diseases in the Buzi River Basin in Mozambique and Zimbabwe. The high figures for Zimbabwe are related to the 2008 Cholera outbreak.

The most common water-related diseases in Chipinge, Chimanimani and Mutare rural are diarrhoea and dysentery and in 2008 there was an outbreak of cholera, in which Chimanimani had 1,239 suspected cases of cholera in 2008 (Ministry of Health and Child Welfare). In 2007 there were no figures for cholera. Manicaland province had the highest number of diarrhoea and dysentery cases in Zimbabwe in 2008 (Ministry of Health and Child Welfare, 2008).

Malaria is also a common water-related disease, which claimed 2,429 lives in 2008 in Manicaland Province. Mutare, Chipinge and Chimanimani districts were rated among the top 20 districts in the country with high malaria cases, with 623, 667, 262 cases per thousand, respectively (Ministry of Health and Child Welfare).

HIV/AIDS remains a threat to the economically active population in Zimbabwe. According to the Zimbabwe Health profile (2008), Manicaland Province has the second highest number of new AIDS cases out of the ten provinces in the country with 28,665 new cases (Ministry of Health and Child Welfare, 2008).

Table 3-10 : Cases of selected diseases in the Buzi River Basin

Province	District	Annual Cases or %					
		Diarrhoea	Cholera	Malaria	TB	STD	HIV/AIDS
Sofala	Buzi	3,200	136	47,400	156	7,800	42
	Chibabava	3,800	6	42,300	16	100	69
	Nhamatanda	4,300	53	27,000	163	5,000	39
Manica	Gondola	9,500	0	59,300	97	4,900	78
	Machaze	3,500	0	21,800	44	2,500	67
	Manica	7,900	0	49,700	81	4,100	65
	Mossurize	4,300	0	13,400	10	900	43
Manica land	Chipinge	13,200	529	667			28,665 total Manicaland
	Chimanimani	6,000	588	262			
	Mutare Rural	15,100	1,239	623	10,900	47,4100	

Source: MAE (2005); Ministry of Health and Child Welfare (2008)

3.3.1 Social indicators

Most households in the basin, particularly in rural areas, are without access to electricity or safe drinking water.

In 2007 only about 12.6% and 8.0% of households had access to electricity in Sofala and Manica provinces, respectively. Access to safe potable water is particularly problematic in Manica Province, where only 4% of the population is served by a safe piped water supply. It is 17% in Sofala, which is still low by national standards. The proportion of people using unprotected sources of drinking water is 50% and 70%, in Sofala and Manica provinces, respectively.



Figure 3-2 : Aguas de Chimoio drinking water treatment plant in Chimoio.

Table 3-11 shows key socio-economic data for provinces containing the basin. The table provides an overview of the social indicators and characteristics of the Buzi River Basin as previously described. The table moreover indicates major differences between Mozambique and Zimbabwe with regards to the social infrastructure and indicators. The difference is very pronounced on indicators related to literacy and education level. The coverage of basic social infrastructure is better in Zimbabwe than in Mozambique.

Table 3-11 : Key social indicators at provincial level.

Indicator	Province		
	Sofala ¹	Manica ¹	Manicaland ²
Male population (%)	48.7	48.0	48.0
Female population (%)	51.3	52.0	52.0
Population, 0-14 (%)	47.2	48.7	44.0
Population, 15-59 (%)	48.6	47.1	50.3
Population, 60+ (%)	4.2	4.1	6.1
Urban population (%)	38.3	25.3	17.0
Rural population (%)	61.7	74.7	83.0
Male index (men per 100 women)	95.0	92.2	Not stated
Population density (km ²)	27.4	22.9	42.0
Population growth rate (%)	2.4	3.7	1.0
Illiteracy rate, total (%)	43.4	43.0	4.0
Illiteracy rate, male (%)	23.0	23.8	3.0
Illiteracy rate, female (%)	61.9	59.7	1.0
Junior primary school (EP1 Mozambique)	111.0	122.3	n/a
Senior primary school (EP2) Mozambique	93.0	91.5	n/a
Junior high school (ESG I) Mozambique	46.6	43.7	n/a
Senior high school (ESG II) Mozambique	23.3	15.2	n/a
Net Enrolment Primary school Zimbabwe			91.6%
Net Enrolment Secondary school Zimbabwe			72.1%
Higher education	3.3	0.7	46.4
Average household size	4.8	5.0	4.0
Housing with access to electricity (%)	12.6	7.9	24.0
Housing according to main source of potable water (%)			
In-house connection	3.7	0.8	6.0
Yard tap	13.5	3.1	Not stated
Public tap	13.3	5.6	41.0
Well / Borehole / Borehole with handpump	19.3	19.5	27.0
Well with no pump	34.2	41.0	Not stated
River / Lagoon	15.5	29.1	31.0
Rainwater	0.2	0.1	Not stated
Mineral / Bottle water	0.0	0.1	0.1

Source: ¹INE (2007); ²CSO, 2002

3.3.2 Poverty and Gender

As Table 3-12 shows the incidence of poverty in the Buzi Basin in Mozambique is 44% in Sofala Province and 52% in Manica Province, which is below the national average of 54%. The value of household income in kind is also significant (averaging nearly 50%), mainly derived from the estimated value of owned housing.

Table 3-12 : Poverty indicators in the Buzi Basin in Mozambique.

Province	District	Indicator	
		Poverty incidence (%)	In kind (%) ¹
	Buzi	42	48
Sofala	Chibabava	45	42
	Nhamatanda	45	48
Manica	Gondola	52	52
	Machaze	52	58
	Manica	52	46
	Mossurize	52	58
	Sussundenga	52	58

Source: MAE (2005)

¹derived from the value of own housing.

Zimbabwe had a 51% increase in poverty incidence between 1995 and 2003 (PASS, 2003). In Chimanimani District 70% were classified as non-poor during the 1995 poverty survey, while in 2003 this decreased to 36%. The same trend occurred in Mutare and Chipinge as shown in Table 3-13 below:

Table 3-13 : Poverty Incidence by district in Zimbabwe, 1995 and 2003 (%)

District	1995		2003	
	Poor	Non-poor	Poor	Non-Poor
Chimanimani	30	70	64	36
Chipinge	39	61	53	47
Mutare Rural	52	48	62	38

In Zimbabwe, male-headed households in Chimanimani have relatively high poverty incidence (73%) for male-headed households compared to Chipinge and Mutare Rural, which had higher incidence of poverty for female-headed households; 58% (Chipinge) and 66% (Mutare) compared to 53% and 58% for male-headed households.

In Mozambique, there are more women than men in all districts in the basin and in some districts the difference is significant. The male index (men per 100 women) is between 79 -94 in the Sofala Province and 72-96, in Manica Province (INE, 2007). However, women lag behind men in many socio-economic indicators such as access to education and other services and literacy. According to traditional roles, men enjoy prominence in society through the practice of polygamy. This position is further reinforced by the fact that more men than women have access to economic opportunities such as employment and means of production because they tend to be better educated and have better access to influential social and business networks.

Women are predominately employed in agriculture (>90%). Only a small fraction of women (around 5%), are employed outside the agricultural sector, mainly in health care, education, informal trade and handicrafts (MAE, 2005). The lower employment rate among women may be a result of lack of interest in or opportunities to seek employment outside of the agricultural sector.

In Zimbabwe, male-headed households in Chimanimani have relatively high poverty incidence (73%) for male-headed households compared to Chipinge and Mutare Rural, which had higher incidence of poverty for female-headed households; 58% (Chipinge) and 66% (Mutare) compared to 53% and 58% for male-headed households.

In all three districts, women are more economically active than males, as shown in Table 3-14. This is particularly evident in Chimanimani and Mutare Rural districts.

Table 3-14 : Economically active population by gender in the Buzi basin in Zimbabwe (%).

District	Male	Female	Number of persons
Chimanimani	41.2	58.9	82,300
Mutare Rural	46.6	53.4	101,500
Chipinge	50.3	49.7	102,700

Source: CSO, 2002

3.4 Vulnerability and Dependence on Water

The following assessment of vulnerability and the related concept of Disaster Risk Management (DRM) include an analysis of acute and chronic vulnerability of the population in the Buzi River Basin to water-related disasters such as floods, storms, drought, waterborne pollution and associated public health hazards. A considerable amount of work has been done previously regarding vulnerability to floods and storms, particularly cyclones. Earlier analytical and field work on vulnerability and response to floods in Buzi District has been supported by GTZ and Austrian Aid, and continues at present under the auspices of the National Institute for Disaster Management (INGC). Previous studies of vulnerability of specific areas to cyclonic storms and periodic famines have been supported by the United Nations through OCHR and USAID, respectively, and more recently by the work of INGC. There are fewer studies of vulnerability to waterborne pollution and of specific human groups to water and sanitation-related diseases.

3.4.1 Vulnerability to extreme events

In recent years central Mozambique has been seriously affected by several types of water-related hazards. Triggered by the influence and activity of the El Niño-Southern Oscillation (ENSO), the central region of Mozambique is frequently affected by droughts, floods and cyclones. Whereas there have been a number of droughts in the past decade, recent rainy seasons have been characterized by flooding in the Buzi Basin.

In 2007 the devastating cyclone *Favio*, which tracked northwest across the Save and Buzi Basins, caused heavy material and economic losses on the population in the Buzi Basin. The most affected groups were rural and poorer people living close to the banks of rivers and streams.

The coastal and adjacent inland areas of the Buzi River basin are highly susceptible to flooding, both from storm surges accompanying cyclones and from floods from precipitation upstream. The human, material, social and economic impacts of floods are exacerbated by the increasing human settlements in the buffer zones and flood plains of the Buzi River estuary in Mozambique. Flood prone areas in Mozambique are: Buzi town and district, the estuary, Estaquinha and Goonda near the confluence of the Buzi and Revue Rivers, Dombe and Sussundenga District below the Chicamba Dam.

As a result of the major events in the beginning of 2000, a participatory disaster risk analysis, planning and management exercise was carried out in Buzi and neighbouring Chibabava District in Sofala Province in 2005 with support from GTZ. Coordination mechanisms and readiness and response plans were prepared. Buzi was one of the first districts in the basin to explicitly incorporate DRM in its District Development Plans. These plans contain several DRM activities, for example establishing local disaster risk management (GRC) groups, construction and repair of drainage systems by the district administration, procurement of a lifeboat, and measures to address droughts and bush fires by the District Unit for Agriculture and Rural Development (*Direcção Distrital de Agricultura e Desenvolvimento Rural*).

It is estimated that around 90% of the adult population in the Buzi Basin listen to the radio regularly. Local radio is therefore a valuable resource for creating public awareness and disseminating early warnings for disasters. Radio has played an important role during floods by broadcasting early warning alerts and information about evacuation plans and shelters. Broadcasts are both in Portuguese and local languages.

In February 2006, an earthquake of a magnitude of 7.5 on the Richter scale struck Mozambique. The epicentre was located in Machaze District in southern Manica Province. The earthquake was

felt with a particular intensity in all surrounding districts of the region, including Mossurizi (Manica Province), Chibabava and Nhamatanda (Sofala Province), Massangena, Guija and Chokwe (Gaza Province), and in south-eastern Zimbabwe. A few people were killed and more than 30 injured. Infrastructure was destroyed including houses, schools, water points, and small bridges.

In terms of vulnerability in Zimbabwe the 2010, ZimVac report estimated that 1.3 million people would be classified as food insecure at the peak of food insecurity period – Feb to March 2011. Of this population, it is estimated that 222,720 people are from Manicaland Province.

Vulnerability resulting from food insecurity has been a prominent feature in Southern Africa, predominantly as a result of the drought situation that prevailed during the previous agricultural period. Vulnerability to poverty in Zimbabwe worsened between 1995 and 2008 mainly due to the decline in the macro-economic situation which was evidenced by a hyper-inflationary environment, unemployment, foreign currency shortages resulting in declining industrial production.

In 2007, the Millennium Development Goals mid-term progress report showed that poor urban households increased from 45% in 1995 to approximately 61% in 2003 (Ministry of Labour Social Services, 2010). The number of poor rural households increased from 57% during the same period.

3.4.2 Vulnerability to water-related diseases

Another dimension of vulnerability associated with floods and severe storms is increased exposure to water, sanitation and hygiene (WASH)-related diseases. This exposure is exacerbated by the contamination of water supplies, especially surface and shallow groundwater and by the widespread displacement of people from their homes to often overcrowded and unsanitary emergency shelters and camps. Floodwaters inundate latrine pits and animal pens in villages, causing human and animal waste to contaminate drinking water in nearby wells, which poses a severe health risk. Improved breeding conditions for mosquitoes can lead to increased incidence of malaria during post-flood periods.

Added to this is the lack of access to health facilities, (those that exist may be damaged), and adequate health care (likely to be overstretched by the sheer numbers of people requiring medical attention).

The most prevalent WASH-related diseases in increasing order of mortality are diarrhoea, enteritis/dysentery, malaria and cholera. Dehydration and poor nutrition are also contributing causes of morbidity and mortality in emergencies. Trends in the incidence of these diseases during flood and storm events are closely correlated, rising over time as floodwaters recede, leaving behind destroyed and/or contaminated drinking water supplies. Children under 5 years old, the already infirm and the elderly are the most susceptible groups to mortality from water-related diseases associated with natural disasters.

UNICEF, through its “One-Million” Initiative, is promoting and supporting improved access to safe drinking water, sanitation and personal hygiene in 18 districts in Sofala and Manica provinces.

During the floods which occurred in the central and eastern sections of the Buzi Basin in March 2010, cases of cholera were reported from Manica, Sussundenga and Nhamatanda districts.

In Zimbabwe, vulnerable population without access to safe water and basic sanitation results in frequent diarrhoeal and cholera outbreaks. Diarrhoea remains one of the top ten diseases affecting children under the age of five. Manicaland province had one of the highest number of diarrhoea cases with approximately 49.3 incidences per 1,000 in 2008. Chipinge, Chimanimani and Mutare were also among the top ten Malaria districts in 2008. Also in 2008, the country experienced an outbreak of cholera in all ten provinces of Zimbabwe. Chimanimani district had 1,239 suspected cases of cholera.

3.4.3 Waterborne pollution

Vulnerability to waterborne pollution in the Buzi Basin is related to both acute and chronic processes and practices, including runoff and infiltration of agro-chemicals, i.e. fertilizers, insecticides, herbicides, etc. primarily from commercial farms and plantations. The use of agrochemicals is expected to increase significantly in the future with the establishment of new large-scale commercial farms and plantations in the basin. Runoff, an infiltration of agrochemicals into surface and ground-

water bodies can be characterized as dispersed pollution, since it originates from a number of sources spread over a large geographic area and may travel long distances in surface water bodies or aquifers, accumulating in reservoirs or confined aquifers before reaching critical levels.

An important issue in many commercial agriculture and plantation projects is that EIAs and environmental screening is not carried out at an acceptable standard. Potentially affected populations and groups include anyone using water from a source which is contaminated by excessive accumulation of agro-chemicals. At particular risk are people who drink untreated water from surface sources such as streams, lakes or wetlands adjacent to commercial farms or agricultural processing facilities.

Another potential source of waterborne pollution is the increasing number of planned large-scale mining operations in the basin.

At present, the majority of mining operations are small-scale artisanal mines whose impact on the environment and water resources are limited and usually local in scope. However, this is likely to change in the future, as a number of large-scale mining projects in the basin have recently been approved by CPI and MEMR and are likely to start with phased implementation in the near future.



Figure 3-3 : Downstream of mining area in the Buzi River Basin.

3.5 Economic Profile

3.5.1 Employment

Some 90% of the population are self-employed, working either for themselves or as employees in family businesses. Manica (16%), Buzi (13%) and Gondola (13%) districts are the only exceptions, where more than 10% employed in the formal sector. Unemployment is high in all districts, averaging 42%, while the economically active population is 55%, with the exception of Nhamatanda, where it is 33%. There are about 11 economically active adults for every 10 children and elderly in Sofala, while in Manica the ratio is close to 1:1.

The above figures underline the dominant role played by the agricultural in the Buzi Basin. A large majority of the population (84%) is employed in the primary sector, mainly in agriculture, followed by the tertiary sector (10%), mainly in commerce, while only 6% are employed in the industrial sector (See Table 3-15).

Table 3-15: Economically active population by sector in the Buzi Basin in Mozambique (%)

Province	District	Sector		
		Agriculture, forestry and fisheries	Industry, energy and construction	Commerce, transport and services
Sofala	Buzi	82	6	12
	Chibabava	91	3	6
	Nhamatanda	82	4	14
Manica	Gondola	80	6	14
	Machaze	94	2	4
	Manica	67	13	20
	Mossurize	90	5	5
	Sussundenga	89	4	7

Source: MAE (2005)

In Zimbabwe, a large portion of economic activity in Chimanimani, Chipinge and Mutare Rural is based on or heavily dependent on agriculture as shown in Table 3-16. This includes formal

employment in agricultural concerns such as estates and plantations in Chipinge and Chimanimani; communal farming; cooperative or community irrigation projects and market gardening.

Table 3-16 : Economically active population by sector in the Buzi Basin in Zimbabwe (%)

Occupation	District		
	Chimanimani	Chipinge	Mutare Rural
Commerce and Others	23.4	21.9	18.0
Transport	1.1	1.0	0.9
Services	10.1	11.6	8.2
Agriculture	65.4	65.5	72.9

Source: CSO, 2002

The sale of fruit, vegetables and maize accounts for over 40% of the total income of households in the districts within the Buzi Basin in Zimbabwe (Mushunje, 2005). Cotton is also an important cash crop, particularly in Chipinge due to the suitability of the soils. The service sector is the next main source of income and livelihood after agriculture (CSO, 2002). Artisanal mining, particularly in Chimanimani, Chipinge and Mutare, are also important economic activities.

In Mozambique, the economic performance of the central region, as measured by real per capita Gross Domestic Product (GDP), shows signs of weakness compared to the national average. Manica Province has a lower per capita GDP than Sofala Province. This may be partly due to the concentration of major industries and commercial activities in the city of Beira. (See Table 3-17)

Table 3-17: Trends in GDP per capita for selected areas in Mozambique (2007)

Area	GDP per capita
Mozambique	0.552
Southern region	0.657
Northern region	0.481
Central region	0.512
Manica	0.486
Sofala	0.607

Source: INE (2009)

The single largest sector contributing to the GDP in Manica Province is agriculture, representing 35% of the total GDP. No major structural changes occurred in the relative weight of the components of GDP between 2000 and 2007 except for a small increase in the importance of services such as electricity, construction and commerce and a modest decline in other services such as repair services, restaurants and transport.

In Sofala Province, the structure of the GDP is different, which is influenced by the role the city of Beira plays in the GDP. Without Beira, the relative weight of agriculture and other sectors in the economy in rural areas in the districts of Manica and of Sofala are similar, dominated by agricultural production, followed by trade and services. Accordingly, agriculture is still the single most important contributor to GDP in Sofala Province.

3.5.2 Economic sectors

3.5.2.1 Agriculture and Livestock

What follows is a description of agricultural, livestock and related activities in the Buzi Basin in Mozambique and Zimbabwe.

On the Mozambican side only a fraction of the total suitable area is currently cultivated. Most farms produce three main food crops, i.e. maize, beans and sorghum. Manica Province has rice, tobacco and sugar cane cultivation, while Sofala Province produces sugar cane and rice but not tobacco.

In the lower part of the basin in the Sofala Province in Mozambique, the agriculture and livestock production to be highlighted is the cashew and pineapple production (Chibabava), cattle (Buzi and Nhamatanda), cereals (Nhamatanda) and wood (Chibabava) (Sofala Provincial Government, 2008). The low part of Buzi River is a designated development node for the agricultural sector with main production investment in rice, cowpea, cassava, tomato, cabbage, pineapple, cane, banana, cashew nut, etc. A large area is occupied by *Companhia do Buzi*, which grows sugar cane, cotton and other commercial crops. Moreover, there are plans to expand the area of irrigated rice in this development node. The most important economic activities in Nhamatanda District in the middle reaches of the Buzi River Basin are agroforestry and livestock, carried out mainly by associations and families and the district is Sofala Province's second largest grain producer and first in production of vegetables.

In the upstream part of the basin in Mozambique in the Manica Province, the area is characterised by relatively favourable soil and rainfall conditions. Especially in Manica District there is favourable soil fertility and , climate and rainfall allow a large variety of crops to be grown. Cash crops in the Manica Province include cotton, tea, coffee tobacco, rice and sugar cane and commercial agriculture is beginning to expand. The potential for expanding the area for irrigated agriculture is good. The major perennial crops also include bananas, avocado, citrus and pineapple. In Macheze, cashew, is the main cash crop and accounts for about one-third of the area cultivated by family farms in the district. Other important developments of relevance for the future socio-economic development in the Buzi River Basin in Mozambique include an increasing number of investments in large-scale commercial farming projects and associated agro-industries, especially for the production of biofuels based on sugar cane and *jatropa*.



Figure 3-4 : Plantation in the Buzi River Basin 2010.

In Zimbabwe, Chipinge, Chimanimani and Mutare Rural are mainly agricultural areas. The revival of the agricultural sector in light of partial demise of this sector due to the macro-economic climate over the past ten years as well as the land reform programme, depends largely on the resolution of the issues of security of land tenure, collateral value of land, infrastructure, rehabilitation and development (MTP, 2010).

The Government of Zimbabwe is promoting the following programmes and projects related to the Buzi Basin:

- Increasing access to farmers, to agricultural services that include extension support, skills enhancement through training, new improved technologies and agricultural finance. (ensuring that women get equal access to these services);
- Supporting the establishment and strengthening of community-based farmers associations, which foster interaction, provide for research, technical, technical marketing support for farmers as well as facilitate the development of own extension services;

Crop production in rural Zimbabwe includes; maize as the main crop, groundnuts, sorghum, cowpeas, tubers, finger and pearl millet. Cotton, soya bean, tobacco and paprika are grown as cash crops. In Chimanimani and Chipinge, near the border with Mozambique, cash crops such as tobacco, citrus fruits, bananas, apples, timber, tea and coffee are also grown.

Approximately 42% of the country's land area is under communal land use; while 11% is under the new resettlement (A1) land use; 9% under old resettlement, another 9% under new resettlement (A2), and a further 9% under large-scale commercial farming; 13% under national parks; 4% under small-scale commercial farming; 2% under urban land and 2% under state farms (Scoones et al, 2010)

According to the ZimVac (2010) survey, in Zimbabwe, approximately 84% of households grew maize during the 2009/2010 agricultural season and 66% planted groundnuts, followed by tubers (40%), cowpeas (35%); round nuts (33%) and sorghum (30%)

3.5.2.2 Forestry

The Buzi basin has considerable forest resources, particularly in the central and eastern parts of the basin along the border between Mozambique and Zimbabwe.

In Zimbabwe, forest reserves constitute 45% of the land area and contribute approximately 3% of the Gross Domestic Product, largely from exotic plantations and commercial indigenous timber. Most of these are in Chimanimani, Mutare rural. The commercial forestry sector is estimate to employ approximately 14,000 people (MTP, 2010). Approximately 23% of rural household incomes depend on forest-based activities.

Natural forest areas are currently under threat of deforestation due to land clearance for agriculture, over exploitation of trees for domestic and agricultural uses, wild fires, overgrazing. It is estimated that 1.8% (320 000 ha) of Zimbabwe's indigenous forests are lost due to agriculture and other household uses that include energy and construction timber (MTP, 2010). Forests have also been affected by during the land reform programme through illegal settlers clearing plantations and research plots for settlement and agricultural purposes (MTP, 2010).

As demand for forest products and transportation and other infrastructure improve, it can be expected that the exploitation of this valuable resource will also increase in Mozambique.

3.5.2.3 Industry

There is considerable potential for the development of industries in the basin, in particular industries relating to agro-processing, transportation services and mining along the Beira Corridor and in major urban centres in and near the basin.

3.5.2.4 Mining and mineral resources

At present in Mozambique, the potential for exploitation of minerals and mining in the basin consist of an active gold mine in the Penha Langa area in Manica Province, mining of lime in the Macundane area in Machaze District and in the Mupengo area in Mossurize District, as well as potential deposits of coal, iron, asbestos, gold in Dacata Administrative Post in Mossurize District. Limited quantities of gold and diamonds have been found by artisanal miners along the Chinhica and Mossurize rivers. Artisanal gold mining is also reported to be taking place in the Chimanimani Reserve in Sussundenga District. It can also be mentioned here that exploration for oil and natural gas is taking place in the Buzi-Divinhe Block and offshore from the Buzi estuary in Buzi District in the eastern section of the basin. There are a growing number of investments in mining and associated processing facilities, especially in the central and western parts of the basin. The interest in the area has increased substantially in recent years as a result of mainly two factors. First, the increasing demand for metals and minerals and the associated price increases have led to a significant increase in investment in the sector worldwide. Second, the concerted efforts made by especially the government of Mozambique to open up its mining sector for foreign investments, and to encourage the development of national mineral sector companies.

In the basin in Zimbabwe artisanal gold mining is common. Although most of it is done illegally at night, artisanal mining is an important source of livelihood. The consequences of these mining activities have been detrimental impacts on land and water quality. There are also quarrying activities being undertaken by Jobber Crushers in Mutare rural.

3.5.2.5 Tourism

In the districts in the basin in Mozambique, in spite of having considerable potential, tourism is generally poorly developed. The Gorongosa National Park is located in the vicinity of the basin and

which has a potential to attract more tourists to the region. Future growth of tourism in the basin will depend on the development of transportation and other tourism-related services in the basin.

In the basin in Zimbabwe, Chimanimani and Chipinge districts are particularly rich in tourist attractions. There are a number of protected forests, parks and tourist areas as shown in Table 3-18.

Table 3-18 : Known areas for tourism in Zimbabwe.

District		
Chipinge	Chimanimani	Mutare Rural
Chipinge Safari Area	Chimanimani Park	Murowo Rock Paintings
Ngongonyana Forest lands	Lionshill Forest lands	Mudima Forest land
Chirinda Forest	Gwendingwe Forest	Bunga Botanical Forest
	Rusitu & Haroni Botanical Reserves	
	Bridal Veil Forest	
	Melsetter Eland Sanctuary	

3.6 Physical Infrastructure

3.6.1 Water supply

In general water resources in the basin is in need of significant improvement and expansion both in quantity and quality, to meet the present and future demand from growing population, agriculture and industry. Water supply in growing urban centres in or near the basin is expected to receive priority attention for future investments. Following is a description of the present water supply situation in the basin.

3.6.2 Access to drinking water

According to Table 3-19 below, in access to safe drinking water, Manica and Sofala provinces are close to the national average for rural areas, which is lower than urban areas. Sofala Province has generally higher access to improved sources of drinking water than Manica Province.

Table 3-19 : Main source of drinking water for selected areas (%).

Area	Improved Sources						Unimproved Sources				
	In-house connection	Yard Tap	Public tap/fountain	Neighbour's tap	Protected pump, well or borehole	Bottled/Mineral Water	Without pump	Unprotected well	Rain water	Water from lagoon/river	Other
National	2.1	5.6	9.2	6.2	19.8	0.1	4.5	36.1	0.2	16.0	0.2
Urban	6.2	16.7	19.7	17.8	9.3	0.2	6.6	20.2	0.3	2.8	0.1
Rural	0.1	0.3	4.1	0.5	25.0	0.0	3.5	43.8	0.2	22.4	0.2
Manica	0.8	1.4	5.4	1.8	22.7	0.0	5.0	36.8	0.0	25.4	0.7
Sofala	2.7	7.3	14.0	8.1	15.9	0.0	1.5	38.5	0.0	12.0	0.0

Source: INE (2009), MICS (2008)

The main sources of drinking water in Chimanimani, Chipinge and Mutare Rural districts are boreholes, protected wells and unprotected wells. Unprotected wells as a source of water is higher in Mutare Rural compared to Chimanimani and Chipinge. See Table 3-20 and Table 3-21.

Table 3-20 : Source of drinking water by district (households).

Source	District		
	Mutare Rural	Chipinge	Chimanimani
Protected well and borehole	20,775	28,207	8,596
Piped water inside the home	1,253	3,015	1,249
Piped water outside the home	4 540	7,831	8,146
Unprotected well	17,009	9,416	4,539

Table 3-21 : Per cent distribution of households by main source of water for drinking, cooking and by distance (m) to the source.

Chimanimani							
Source	On premises	<500	500 to 1000	>1000	Not known	not applicable	No. of HH
pipled water inside	100	-	-	-	-	-	1249
pipled water outside	43	53,36	3,13	0,42	-	0,03	8146
communal tap	5,05	84,45	8,9	1,54	0,05	0,03	1820
well/borehole-protected	2,15	37,4	45,56	14,88	0,01	0,01	8596
well-unprotected	2,03	65,04	29,48	3,46	-	0,03	4539
river/stream/dam	2,71	62,52	28,18	6,59	-	0,02	2033
other	18,75	44,64	34,82	1,79	-	-	112
unknown	20	-	20	60	-	24,44	5
total	19,64	50,46	23,71	6,18	0,01	0,04	26500

Chipinge							
Source	On premises	<500	500 to 1000	>1000	Not known	not applicable	No. of HH
pipled water inside	100	-	-	-	-	-	3015
pipled water outside	56,97	39,7	2,02	1,29	-	0,03	7831
communal tap	4,48	87,23	7,71	0,56	-	0,03	7708
well/borehole-protected	5,4	36,54	44,17	13,87	-	0,01	28207
well-unprotected	4,1	35,11	42,49	18,25	0,02	0,03	9416
river/stream/dam	1,73	27,37	48,39	22,5	-	0,02	5094
other	1,83	10,53	49,43	38,22	-	-	437
not applicable	-	100	-	-	-	-	2
unknown	2,22	42,22	17,78	13,33	-	24,44	45
total	15,91	40,33	32,23	11,49		0,04	61755

Mutare rural							
Source	On premises	<500	500 to 1000	>1000	Not known		No. of HH
pipled water inside	100	-	-	-	-		1253
pipled water outside	48,37	43,74	6,87	0,97	0,04		4540
communal tap	5,09	74,03	17,44	3,3	0,14		2907
well/borehole-protected	12,72	43	35,86	8,37	0,05		20775
well-unprotected	16,76	51,03	28,24	3,8	0,17		17009
river/stream/dam	1,08	48	39,97	10,84	0,1		2029
other	6,52	45,65	26,09	21,74	-		46
unknown	6,67	30	36,76	15	11,67		60
total	18,76	46,82	28,62	5,69	0,11		48619

3.6.3 Sanitation

Sanitation coverage is generally low throughout the basin. The practice of open defecation and lack of improved sanitation facilities is very common in rural areas in the basin. (See Table 3-22)

Table 3-22 : Household sanitation by type of sanitation for selected areas (%).

Area	Improved sanitation				Unimproved sanitation				
	Flush toilet	Toilet with no flush	Improved latrines	Improved traditional Latrine	Un Improved latrine	On the beach	In the bush	Other	No information
National	2.4	2.5	6.8	7.6	38.3	1.5	40.3	0.0	0.6
Urban	7.0	7.3	17.9	14.9	37.9	2.6	11.9	0.0	0.5
Rural	0.2	0.2	1.4	4.0	38.5	0.9	54.1	0.0	0.6
Manica	0.2	1.5	7.3	5.3	33.9	0.0	51.4	0.0	0.4
Sofala	3.7	5.4	7.3	5.6	23.6	0.0	54.1	0.0	0.3

Source: INE (2009), MICS (2008)

The most common sanitation facilities in the basin in Zimbabwe are flush toilets, Blair and pit latrines. In Manicaland Province, approximately 28% of households use Blair toilets, 25% do not have access to any sanitation facilities; 24% use pit latrines while 18% (mainly in Mutare Urban and Rusape), use flush toilets. (CSO, 2002)

3.6.4 Access to basic services

Table 3-23 below shows that access to basic services in the central region is influenced by the presence of urban centres such as Beira in Sofala Province and Chimoio in Manica Province. Access to sanitation (including unimproved latrines) is well below 20% except for Manica District. Access to electricity and improved sources of drinking water such as house connections and standpipes is very low in the districts in the Buzi basin.

Table 3-23 : Access to basic services by districts in the basin (Mozambique).

Province	District	Access (%)		Main source of drinking water (%)				
		Toilet	Electricity	In-house connection	Yard tap	Public standpipe	Well/ borehole	River/ lake
Sofala	Buzi	11	1	0	1	1	96	29
	Chibabava	4	0	0	0	2	44	54
	Nhamatanda	8	1	0	2	9	52	37
Manica	Gondola	18	2	1	1	4	65	29
	Machaze	4	0	0	0	4	62	34
	Manica	41	5	2	7	8	58	25
	Mossurize	17	1	0	1	19	28	52
	Sussundenga	12	2	0	0	2	37	60

Source: MAE (2005)

3.6.5 Water Supply

Following is a description of the present water supply situation in the basin.

Buzi District: According to recent estimates from DNA, around 143,152 inhabitants in Buzi District have an acceptable water supply. The drinking water supply in the district consists of 279 dispersed sources, including wells, boreholes and small piped water supply systems. According to data from the 2007 census, the water supply coverage is 84.8%, based on criteria in the National Water Policy

of 500 people per source. However, this coverage does not reflect actual reality, since not all sources are functioning, and people still have to travel long distances for drinking water.

Chibabava District: Water supply in the district is presently unsatisfactory, with many households still drinking water from unsafe sources such as shallow open dug wells, lakes and streams. There are a growing number of deep boreholes with hand pumps in rural areas of the district provided by *Agua Rural* and UNICEF's "One-Million" Initiative. There are a few small piped systems at Magul, Chissano, Macia, Chimondzo, and Praia de Bilene, but their operation and maintenance is in need of improvement.

Gondola District: There is a water supply in 159 communities in the district, benefiting more than 54,500 people. Serving the town of Gondola is a water source in Muda which is piped to a treatment plant in the town. The population in the town is currently not fully benefiting from this system due to its poor condition. The rural areas of the district are also receiving a number of new boreholes under UNICEF's "One-Million" Initiative.

Nhamatanda District: The present drinking water supply in Nhamatanda District consists of 108 dispersed sources (wells and boreholes with hand pumps), of which 89 are operational, serving 27% of the population. The district is also receiving a number of new boreholes under UNICEF's "One-Million" Initiative. Despite an increase in coverage, there are still villages where access to safe drinking water is difficult, particularly in Chiadea and Macorococho localities, where groundwater levels are very deep.

Machaze District: In Machaze District there are 85 boreholes, 53 of which are reported to inoperative due to a lack of spare parts and proper maintenance. The district is also receiving a number of new boreholes under UNICEF's "One-Million" Initiative.

Manica District: The water supply in the district consists of dug wells, boreholes equipped with hand pumps, springs and streams, mainly in the rural areas, and piped water supply in parts of Chimoio and Manica towns. FIPAG is currently expanding the piped water supply in Chimoio town. The district is also receiving a number of new boreholes under UNICEF's "One-Million" Initiative. Poor maintenance is reported to be a significant problem in water supplies both rural and urban areas in the district.

Mossurize District: There are only about 90 households with access to piped water, while over 40,000 people have acceptable access to drinking water, corresponding to an effective coverage of about 41%. There are about 90 boreholes, of which only about 30 are operational. Presently, the district is also receiving a number of new boreholes under UNICEF's "One-Million" Initiative.

Sussundenga District: The main sources of drinking water in the district are boreholes with Afridev hand pumps, hand dug wells and surface sources such as rivers and streams. The district is also receiving a number of new boreholes under UNICEF's "One-Million" Initiative. Still, the number of safe sources of drinking water is insufficient to cover the needs of the district's population, many of whom continue to drink water from unsafe sources.

In Zimbabwe, water supply for households is mainly from protected wells and boreholes, piped water inside and outside the home; rivers, dams and unprotected wells. In communal areas, the District Development Fund (DDF) with funding from the Private Sector Investment Programme (PSIP) is responsible for maintenance of handpumps, borehole drilling and rehabilitation of wells. In 2009, the DDF in Chimanimani, Chipinge and Mutare rehabilitated and repaired 235 boreholes and drilled 4, while 90 wells were rehabilitated and repaired. See also Table 3-24.

Table 3-24 : Sources of drinking water by district (Zimbabwe).

District	Boreholes rehabilitated	Boreholes repaired	Wells rehabilitated	Wells repaired	Boreholes drilled
Chimanimani	5	60	20	10	1
Chipinge	10	40	0	20	3
Mutare	10	110	0	40	0
Total	25	210	20	70	4

The Zimbabwe Water Authority (ZINWA) also maintains water supply stations and supplies water to District Service Centres, Rural Service Centres and village service centres.

4 WATER RESOURCES

The assessment of water resources of the Buzi River is a key component in the Buzi IWRM strategy. A sound development of the water use and allocation in Buzi River Basin is only possible if it is known how much water is available and how the surface water resources vary temporally and spatially.

The purpose of the water resources assessment is to quantify the water resources, both for surface and groundwater within the Buzi River Basin. Outputs from the study are an essential input for the feasibility assessment and design of future development projects in the river basin as well as environmental studies. Emphasis has been given to present all results on surface flow characteristic that are of interest for water resources engineering and development in the river basin.

Surface water is in volume the largest source of water in Mozambique and Zimbabwe. In order to make good decisions regarding water and to secure water supply for present and future stakeholders, basic data on river flow is necessary. Groundwater, although small in volume, is the main source of the potable water supply for a majority of people living within the rural areas of the Buzi River Basin.

This section summarises the quantitative estimates of both surface water and groundwater in the Buzi River Basin.

4.1 Surface Water Resources

Input data in the form of rainfall, pan evaporation and river runoff for surface water assessments are in generally scarce and of poor quality in the Buzi River Basin. Estimation of available water resources is therefore not straightforward and is subject to uncertainty. A detailed review of the hydrometeorological data was therefore conducted to identify the most reliable historical data to use for water resources assessment in the river basin.

To enable modelling of surface water resources an in-depth analysis of the hydrological characteristics of the Buzi River Basin was conducted.

4.1.1 Hydrometeorological Stations

Rainfall data is an important input for hydrological models and utilized to calculate runoff for points where observed runoff data are not available. Therefore a lot of effort has been put into compiling as much rainfall data as possible.

In Mozambique the main source of rainfall data has been DNA. For a selected couple of stations data also has been compiled from INAM (Instituto Nacional de Meteorologia). In Zimbabwe historical data up to 1999 were obtained from ZINWA for a number of key stations. The number of identified rainfall stations with available historical data was in total 79:

- 75 stations in Mozambique
- 4 stations in Zimbabwe

However, several of these stations only have data for a few years or have a lot of gaps in the measurements.

The rainfall stations tend to be concentrated to major infrastructures, such as main roads and larger settlements (Figure 4-1) and are therefore, not evenly distributed. The southern parts of the river basin lack adequate coverage of rainfall. However, the main problem is not only the unevenly spatial distribution but also the temporal coverage. A majority of the data records are available for the period from 1950 to 1980 and only a few stations have data available after 1990. One explanation for the long interruption of rainfall observations is the civil war in Mozambique that ravage the country between 1981 and 1992. Of the 71 DNA stations that were available for this study, only five stations are currently in operation. In the Zimbabwean part of the Buzi River Basin, data from most stations are available for a major part of the last 50 years.

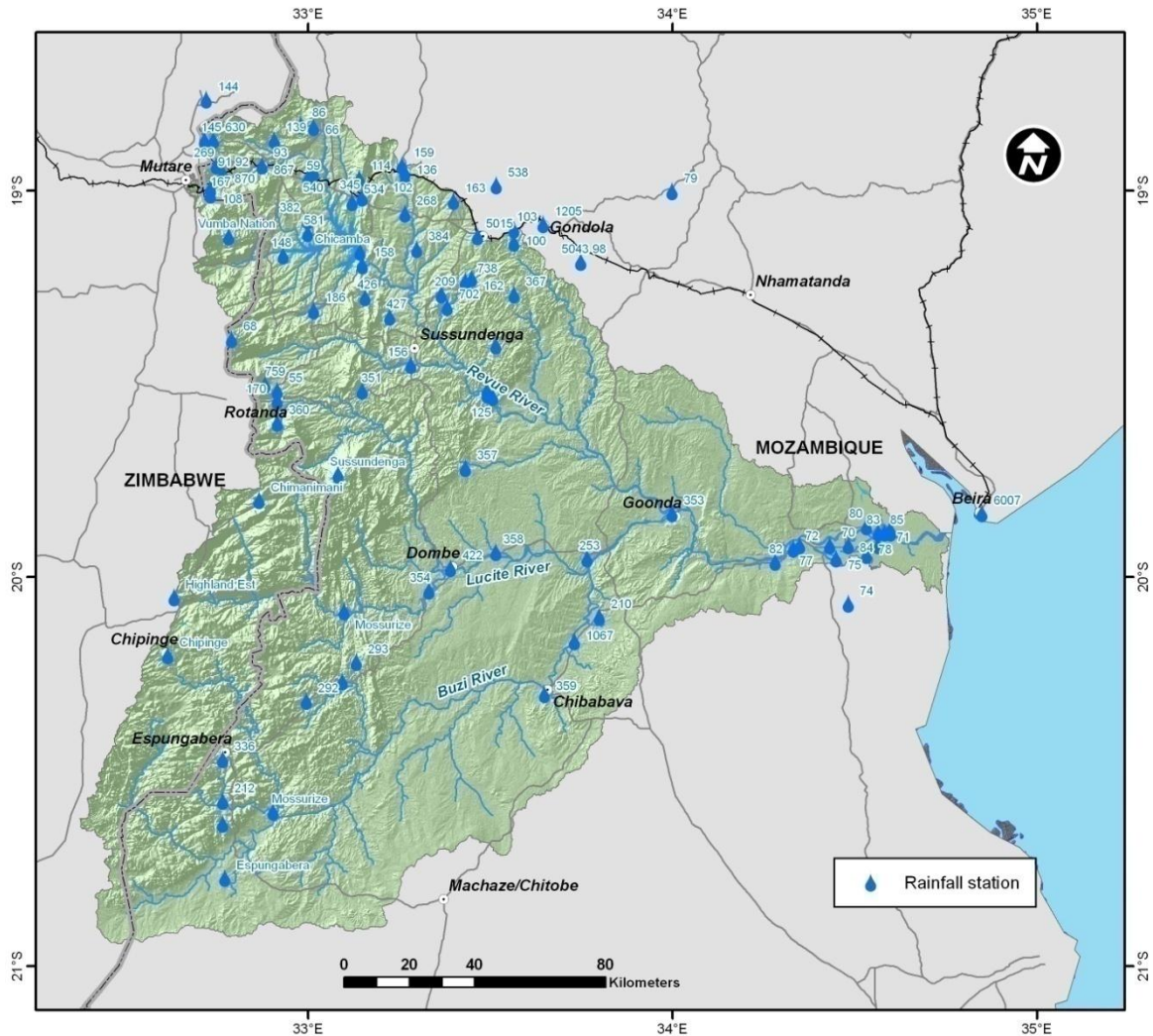


Figure 4-1 : Rainfall stations in and around the Buzi River Basin.

Source: Adopted from DNA, ZINWA and INAM data.

Data on river flows are essential for all surface water resource assessments. They comprise the source for estimations of mean annual runoff (MAR) and probability of extreme high and low flows. Runoff is also needed for calibration and validation of hydrological models, which can be used to prolong data series and thereby improve the input for water resources estimations.

According to the DNA files there are a total of 20 runoff stations in the Mozambican part of Buzi River Basin where rating curves have been established. In Zimbabwe 14 runoff stations with historical data exist within the Buzi River Basin. Location of the runoff stations can be seen in (Figure 4-2).

Most runoff data records from Mozambique are available within the period from 1960 to 1980. Few stations have any data at all before 1955 or after the early 1980s. 18 stations are currently active, in terms of having an observer and water level reading conducted more or less regularly.

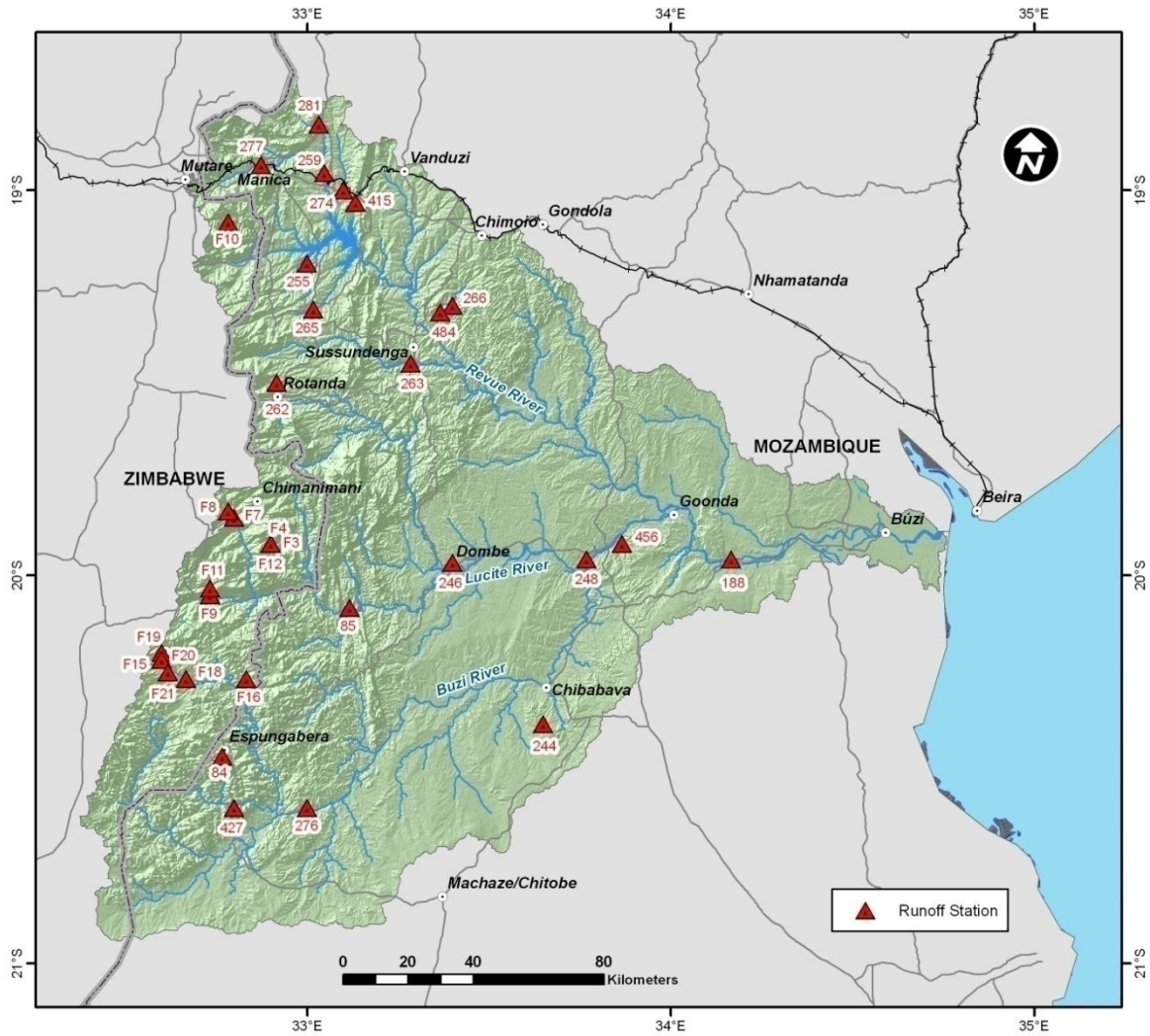


Figure 4-2 : Runoff stations in the Buzi River Basin.

Source: Adopted from DNA, ZINWA and INAM data.

Evaporation data are used to estimate losses of water from a river catchment to the atmosphere. Hydrological models normally need monthly average potential evaporation as input to calculate river flow. Data from evaporation were obtained from 14 stations, seven in Mozambique and seven in Zimbabwe. However, not all stations were within the Buzi River Basin. Stations outside the basin were also used to estimate the mean annual evaporation, due to the few available stations inside the basin.

For further information on the Hydrometeorological data for the Buzi River Basin, see EKIS Report, Annex 2.1. Hydrometeorological Data.

The following sub-sections provide the summarised water resources statistics

4.1.2 Rainfall and Evaporation

MAP varies between 1,300 and 900 mm over the river basin, see Table 4-1. The western part of the basin receives more rain, due to the mountainous area. An exception is the Rusito sub-basin where MAP is slightly lower than the downstream sub-basin, which is probably caused by rainfall shadow from the surrounding mountainous areas. Lowest MAP is found in the Lower and Middle Buzi tributary where dryer conditions prevail.

MAE varies between 1,400 and 1,100 mm, see Table 4-1. MAE decreases going westward in the sub-basin, mainly due increased altitude and thus decreased temperatures.

Table 4-1 : Distribution of mean annual rainfall and mean annual evaporation the major sub-basins in the Buzi River Basin. Based on the years 1955-75.

Sub-basin	Area (km ²)	MAP (mm)	MAE (mm)
Buzi Zimbabwe	1,690	1,150	1,200
Upper Buzi	4,476	1,050	1,250
Middle Buzi	4,332	900	1,350
Lower Buzi	3,258	900	1,400
Lucite Zimbabwe	1,535	1,250	1,100
Upper Lucite	3,251	1,300	1,200
Lower Lucite	1,885	1,000	1,300
Revue Zimbabwe	508	1,200	1,100
Upper Revue	2,333	1,100	1,200
Middle Revue	2,463	1,100	1,200
Lower Revue	3,139	1,200	1,300

4.1.3 Mean Annual Run-off

Based on the understanding of the Buzi River Basin and using the most reliable hydrometeorological data, the Pitman hydrological model was set up and configured to calculate the temporal and spatial distributions of surface water. It was judged that the Pitman model can describe the river flow volume and dynamics of the Buzi River Basin for the period 1955-76 (21 years) at an acceptable level, although care should always be taken when using the model for small river catchments with limited knowledge on rainfall.

The most probable estimate of surface water resources in the Buzi River Basin points to a total of 5,685 million m³ per year at the river mouth. In Table 4-2 the natural MAR for a number of interesting points is presented. These points include the border flows, the confluence flows, flow available for the Chicamba Dam and the flow at the estuary.

Table 4-2 : Estimated runoff at point of interests. Based on the years 1955-75.

Type	Point of interest	Area [km ²]	MAR [Mm ³ /year]	MAR [m ³ /s]
Border flow	Buzi River	535	145	5
	Musirizwi River	786	213	7
	Rusitu River	901	326	10
	Zonwe River	379	132	4
Flow at confluence	Buzi River	10,498	1,751	56
	Lucite River	6,671	1,967	62
	Revue River	8,443	1,778	56
Other	Estuary	28,870	5,685	180
	Chicamba Dam	2,841	670	21

There is a variation of the areal runoff in the basin between 58 and 379 mm/year. Most areal runoff is generated in the mountainous sub basins and declining going downstream. Most water is generated in the Upper Lucite (20%), Upper Buzi (16%) and Lower Revue (12%) see Figure 4-3.

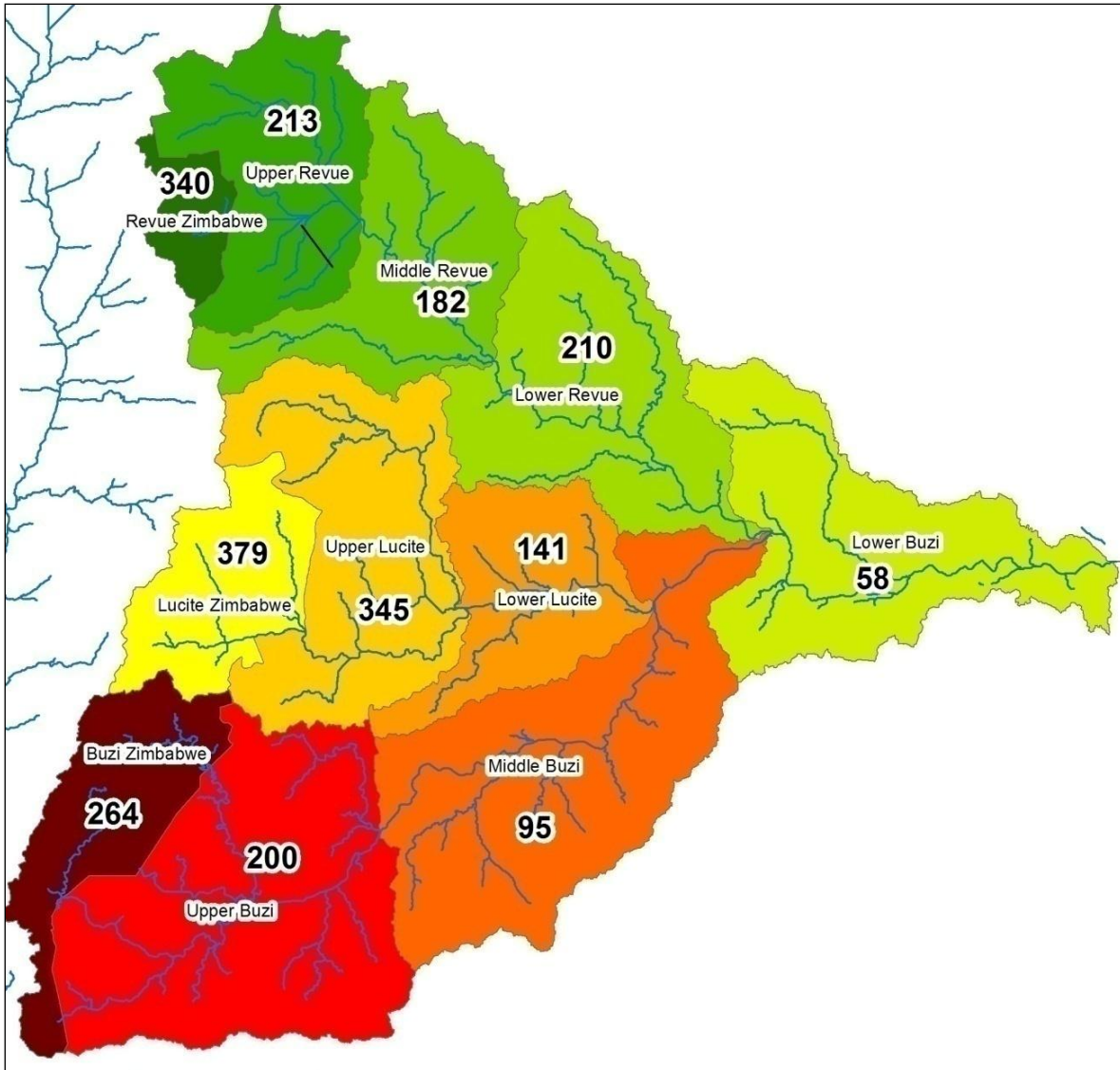


Figure 4-3 : Estimated areal runoff for the main sub basins in the Buzi River Basin based on the years 1955-75.

4.1.4 Distribution between countries

Table 4-3 gives the distribution of river runoff in the Buzi River Basin. On a sub-basin scale the specific runoff varies from 60 to 380 mm/a. Due to the higher specific runoff in the mountainous areas in the western part of the basin, the distribution of generated surface water resources between the countries are skewed relative the areal distribution. Despite only having 13% of the catchment area the Zimbabwean part generates 21% of the surface water volume.

Table 4-3: Distribution of river runoff.

Sub-basin	Area (km ²)	MAR (Mm ³ /year)	MAR (mm)	Percentage of total
Budzi Zimbabwe	1,690	446	264	8%
Lucite Zimbabwe	1,535	581	379	10%
Revue Zimbabwe	508	173	340	3%
Total Zimbabwe	3,733	1,200	321	21%
Upper Buzi	4,476	896	200	16%
Middle Buzi	4,332	409	95	7%
Lower Buzi	3,258	188	58	3%
Upper Lucite	3,251	1,120	345	20%
Lower Lucite	1,885	266	141	5%
Upper Revue	2,333	498	213	9%
Middle Revue	2,463	449	182	8%
Lower Revue	3,139	659	210	12%
Total Mozambique	25,137	4,485	178	79%
TOTAL	28,876	5,685	197	-

4.1.5 Flood Estimates

Flood magnitudes were assessed through regional flood analysis and through applying the Regional Maximum Flood. Specific flood magnitudes vary from 0.2 m³/s,km² at the river mouth to up to 0.9 m³/s,km² in the smaller mountainous areas in Zimbabwe for a 100 years return period. Corresponding magnitudes for spillway design are from 0.6 to 11 m³/s,km². Flood estimates for some of the main points in the Buzi River system are presented in the table below.

The flood magnitude estimates for smaller infrastructure are based on the regionally derived specific flows for a 10- year recurrence period, while the Regional Maximum Flood (RMF) is proposed for design of large dams. Applying the specific flood magnitudes for the specified points of interest give the values presented in Table 4-4.

Table 4-4 : Estimated flood magnitudes for points of interest in the Buzi River Basin.

Type	Point of interest	Area [km ²]	100-years flood		RMF	
			[m ³ /s,km ²]	[m ³ /s]	[m ³ /s,km ²]	[m ³ /s]
Border flow	Buzi River	535	0.8	430	9.0	4,800
	Musirizwi River	786	0.8	630	7.2	5,700
	Rusitu River	901	0.7	630	6.7	6,000
	Zonwe River	379	0.9	340	10.9	4,100
Flow at confluence	Buzi River	10,498	0.3	3,150	1.3	13,500
	Lucite River	6,671	0.4	2,650	1.8	12,000
	Revue River	8,443	0.3	2,550	1.4	12,200
Other	Estuary	28,870	0.2	5,750	0.6	17,000
	Chicamba Dam	2,841	0.6	1,700	3.5	10,000

The monthly flow distribution has been computed from the simulated monthly runoff series and presented as percentage of MAR for the points of interest. By computing the monthly flow distribution as percentage of MAR it is possible to compare flow distribution at different points, even though the magnitude of flow can differ greatly.

Duration curves have also been computed from the simulated monthly runoff series at the points of interests. Flow distribution and specific duration curves for each point of interest can be seen in Annex 2 – Water Resources.

4.2 Uncertainties and Climate Change

4.2.1 Uncertainties in assessments

In Zimbabwe the previous studies for water resources are mainly the “Blue Book” from 1984 and its update made in 2006. The 2006 study was made using a general regression relationship between MAP and MAR for the subzones in Zimbabwe.

A significant increase of the MAR is found from the 1984 to 2006 study, which can be explained by more availability of information for the latter report. In comparison with the new estimates in this study of 2010 the estimated river runoff is larger than the 2006 study (Table 4-5). The difference lies in simulated higher runoff coefficient rather than differences in assumed rainfall.

The reason for the higher values in this study is unclear but a possible explanation is that the regression relationship used by Mazvimavi (2006) has mainly been calibrated on subzones in Zimbabwe with generally dryer conditions than found in the eastern highlands. It is thus possible that this relationship would underestimate the runoff coefficient in these very wet areas. The uncertainties in estimating water runoff for these relatively small mountainous areas are, however, large and it is expected that different methods would yield different values.

Table 4-5 : Comparison with Mazvimavi (2006).

Sub-basin	Area (km ²)	MAR (mm)	Runoff coef.	Percentage higher than Mazvimavi (2006)
Budzi Zimbabwe (FB and FUZ)	1,690	264	0.23	+58%
Lucite Zimbabwe (FLS)	1,535	379	0.30	+44%
Revue Zimbabwe (~FM2)	508	340	0.28	+8%

In Mozambique COBA (1980) did a comprehensive review of the Buzi River hydrology. Two points that can be easily compared to this study are the following:

- The Chicamba Dam: 241 mm/year and runoff coefficient of 19%
- The E188 station: 234 mm/year and runoff coefficient of 20%

Norconsult (1996) also made an estimate of inflow to the Chicamba dam. Their estimate was 613 million m³/year or 216 mm/year.

Table 4-6 indicate that the updated simulated runoff for the Buzi River Basin, as summarised at the E188 station, is slightly lower than the 1980 study. For Chicamba, however, the results are similar. The similarity in result for Chicamba can probably be explained by the good data available at the dam. The Norconsult value is lower but this is probably because they have taken into account evaporation losses from the dam (which is estimated to 71 Mm³/year).

Table 4-6 : Comparison with COBA (1980)

Sub-basin	Area (km ²)	MAR (mm)	Percentage difference to COBA (1980)
Chicamba	2,846	235	-2.5%
E188	26,527	207	-11%

4.2.2 Climate change

The estimated hydrological characteristics are furthermore based on the assumption that the historical situation will prevail in the future. To get a good spatial description of the water resources in the Buzi River Basin the years 1955-75 were used to simulate the average condition and variation in runoff, rainfall and evaporation (since these years had good coverage of input data). Whether the 1955-75 period is valid for the coming planning period for water resources management of the Buzi River for 2010-2030 is dependent on the long term climate trends of the climate.

Climate change is the cause of much debate and studies in southern Africa. Unfortunately due to a general lack of conclusive results many interpretations and “guesses” can be found in the literature. The scientific advances are rapid in the climate change field and it is therefore essential to base any prediction on the latest publications. A number of recent publications are of interest for the southern Africa climate change:

- South Africa’s Second National Communication under the United Nations Framework Convention on Climate Change, Department of Environmental Affairs of South Africa, November 2010.
- Study on the Impact of Climate Change on Disaster Risk in Mozambique: Synthesis Report, National Institute for Disaster management (INGC), ed. By van Logchem B and Brito. R., May 2009.
- Climate Change Implications for Water Resources in the Limpopo River Basin, Zhu. T and Ringler, C. International Food Policy Research Institute, Paper 00961, April 2010.

These documents summarises the latest situation on climate change research and give the current best prediction of the effect in southern Africa.

One of the first notes to make is that all predictions on climate change are still based on Global Climate Change Models (GCMs), although the downscaling methods become more and more reliable. However, DEA (2010) emphasises that the GCM poorly represents escarpments and local topography that is fundamental for the local climate, especially rainfall. This is the reason why new and more complex pictures of the effects of climate change are regularly published as the downscaling techniques are improved. The idea that climate change will cause generally much drier conditions in southern Africa is now replaced with a much more diverse picture where many areas seems to get wetter conditions. However, dynamic downscaling through a Regional Climate Model is still a work in progress and we are therefore likely to see further modifications on the local effects of climate change in southern Africa.

On a general level, however, the different GCM and downscaling techniques used today agree on some basic predicted changes in southern Africa as a consequence of climate change:

- A general increase in temperature in the whole region, but mostly in the interior of the continent.
- Increased rainfall during the rainy season in the eastern part of southern Africa, while dryer conditions are expected in the interior
- Decreased soil moisture during the dry season as a result of higher temperatures and evaporation

The effects of these predictions are totally different scenarios for the three joint river basins managed by ARA-Centro and ZINWA Save/Runde. The Pungwe and Buzi Rivers are likely to get increased rainfall and runoff, while the Save River will get significantly lower water resources. The Eastern Highlands seems to be a divide for the effects of a future climate change.

INGC (2009) gives the best description of the future impact of a climate change on the Buzi River Basin. According to the INGC there is a forecasted increase in rainfall over most of Mozambique during the rainy season December to May, with higher increases in rainfall towards the coast. Rainfall is assumed to increase with 10-25% up to 2060. Figure 4-4 shows the assumed future effects on river flows in Mozambique and Zimbabwe caused by a changed climate. It indicates that especially the southern part of the Buzi River Basin will get slightly higher runoff.

However, during the dry season June-November the increases in rainfall is predicted to be less than increases in evapotranspiration, which would mean drier and possibly longer dry seasons. This would fit with the already indicated later start of the rainy season seen in observed records. In general the variability will increase during June, July and August, which may cause more severe droughts during years with low rainfall during these months. With no dams to store the water there will thus be no real use of the increased MAR caused by higher rainfall during the rainy season.

What is also very relevant for the Buzi River Basin is that both historical trends and the GCM models predicts higher intensity of cyclones that are the main cause for large floods in the central parts of Mozambique. The Cyclone Eline in 2000 created the highest flood levels since observation started in the Buzi River. Historical trends indicate also more frequent cyclones, although the GCM models contradict this.

In conclusion, a potential future climate change will most likely cause a more variable climate in the Buzi River. The estimated MAR based on 1955-75 will probably be higher in the future but rainfall will mainly be concentrated to a few months during the years. Despite the higher MAR droughts may therefore be more common and rainfall will start later after the dry season. Floods may be more severe and maybe more frequent. The effect of this is that it puts even more emphasis on the need to build dam infrastructure to store the increased rainfall during the longer dry season and to mitigate floods. In the optimisation of these dams extra safety marginal must, however, be taken in the system analysis when using the historical runoff from 1955-75 as a basis to compensate for the expected longer dry seasons. Spillway design should also be made with extra care assuming larger floods in the future.

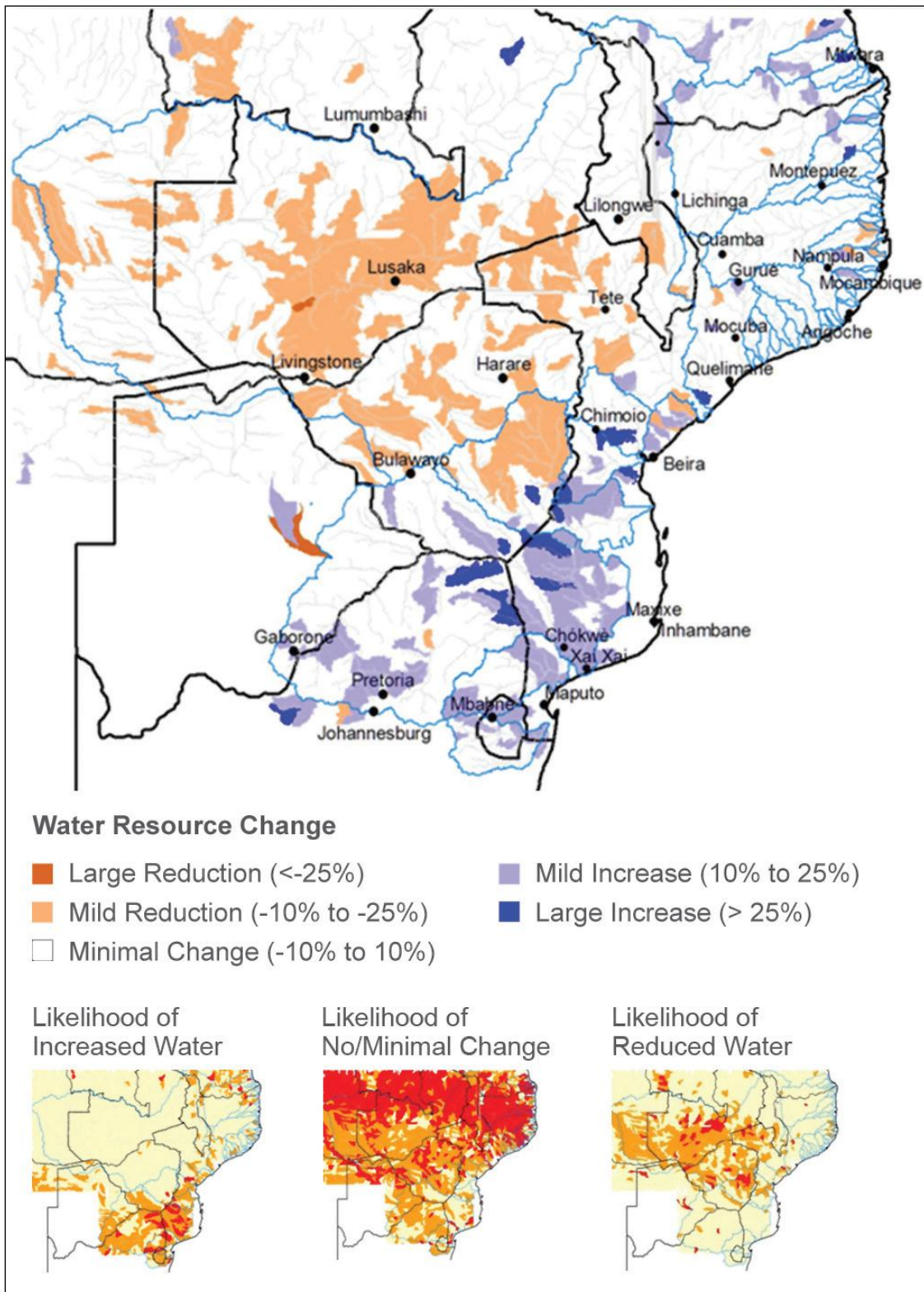


Figure 4-4 : Average changes in the river flow based on seven GCMs.

Source: INGC (2009).

4.3 Groundwater Resources

The hydrogeological conditions in the Buzi River Basin are not known in any detail despite the fact that this 'hidden' resource plays a key role for the domestic water supply for a large portion of the population within the basin boundaries.

The methodology used for this assessment was adjusted according to the available data sets. As more data becomes available, so the hydrogeological characterisation can be – and must be improved.

In general, groundwater is preferable to surface water because:

- Groundwater is less susceptible to contamination and is generally of good quality why the source requires little or no treatment
- Groundwater is less susceptible to drought due to low evaporation losses
- Groundwater resources is less costly to develop, to operate and to maintain
- Groundwater has less variable chemical properties

Moreover, new groundwater supplies can be developed in less time than larger surface water schemes as there are generally no major environmental concerns and high investments needed that may delay the process. Developing the resource can be done gradually as the demand increase and as funds become available. However, the groundwater potential in the Buzi River Basin is restricted by the natural hydrogeological setting, where the aquifer recharge and the capacity to store and transmit water are limited

From a groundwater importance perspective the following aspects need to be considered:

- I. the role of groundwater and in sustaining natural ecosystems functioning
- II. the role of groundwater and economic activities, and
- III. the role of groundwater and domestic water supply.

Therefore to address the three sectors described above the following issues are to be addressed:

- I. Groundwater recharge (i.e. how often and by how much are groundwater resources replenished or 'topped up').
- II. Geological setting with specific reference to the hydrogeological aspect in terms of groundwater storage.
- III. Groundwater quality and its suitability for use
- IV. Uses and users of groundwater (i.e. its importance for water supply, economic activities and ecological functioning).

Thus the combination of groundwater recharge, groundwater storage and groundwater quality are key components in determining the usability of groundwater by both ecosystems and mankind.

In Mozambique, the usage of groundwater increase during the dry season when surface waters dry up. No urban centres rely on groundwater, but for most villages groundwater is the main source of water. The usage of groundwater could be much higher if the borehole infrastructure was better developed. A major problem is poor maintenance of boreholes and installations which too often leads to failure and break down of systems. People will then have to rely of surface water although groundwater is preferred.

On the Zimbabwean part of the basin, groundwater is to some extent being used for small scale irrigation schemes. The largest single point abstraction within the Buzi River Basin is in Villa Manica by the Vumba Water Company. They produce bottled mineral water from the Vumba mountain springs.



Figure 4-5 : Groundwater usage in Estaquinha village, June 2010.

Groundwater flow and storage occurs in *primary aquifers* in soil pore spaces of saturated unconsolidated inter-granular deposits, such as river alluvium and weathered rocks. In *secondary aquifers*, groundwater occurrence is restricted to fractured zones of rocks with no primary porosity. Within the Buzi River Basin there are also Karst Aquifers, these are water bearing, soluble rock layers in which groundwater flow is concentrated along enlarged fractures, conduits, and other interconnected openings.

The overall objective for the hydrogeological component is to describe and provide a characterisation of the groundwater resources within the Buzi River Basin on a reconnaissance level. The description needs to describe the climatic conditions and geological setting and from this build up a characterisation of the groundwater in terms of groundwater recharge, aquifer storage and groundwater quality. The groundwater potential on a local level can only be assessed through detailed field investigations, and preferably with the availability of time series groundwater data.

To enable the hydrogeological characterisation, a Geographic Information System (GIS) was utilised for the assessment of the available data sets.

The approach followed was to assess the geology and, based on literature values from similar settings as in the Buzi Basin, a recharge percentage was assigned to each hydro-lithology. Using an area weighted approach a groundwater recharge percentage was calculated for each of the 11 sub-basins within the Buzi River Basin. This recharge percentage was then applied to the mean annual precipitation (mm/a) for the basin and a mean annual average recharge (mm/a) was obtained per catchment. It is acknowledged that groundwater recharge is influenced by many factors such as rainfall amount, intensity, seasonal timing, land cover type, surface slope angle, soil texture, soil thickness, depth to the saturated zone, presence of preferential flow paths, the material constituting the vadose zone and, the geological setting characteristics of the aquifer itself, and the presence of preferential flow paths. However, in a study of this broad scale, such detailed information is not available.

Aquifer storage and aquifer type was estimated from the geological lithologies. The groundwater recharge and storage was then combined to give an indication of groundwater potential (Mm^3/a). Once this calculation was completed the groundwater potential was determined for each of the sub-basins.

4.3.1 Groundwater Challenges

A regional groundwater assessment is dependent on site specific data, i.e. borehole data. Borehole data is the most fundamental level of detail required and forms the building blocks for further analysis. Borehole specific data includes:

- Borehole coordinates (latitude, longitude and elevation)
- Borehole depth
- Borehole construction
- Borehole geology
- Water strikes (depth, yield and quality)
- Borehole water level (measured as depth below ground level)
- Borehole water level status
- Borehole water quality
- Borehole status and
- Borehole purpose.

For borehole water quality, Electrical Conductivity (EC), pH and temperature are useful measurements. Ideally, however, this needs to be extended to include basic cation/anion analysis (pH, HCO₃, Ca, CO₂, Cl, Mg, K, Na, SO₄, and TDS) and other site specific determinants such as iron, manganese, fluoride and nitrates. Such thorough data capture is rare and in the Buzi River Basin, only limited borehole data is available.

A borehole specific programme needs to be implemented. This includes sourcing and capturing all possible borehole data into a groundwater database, followed by field verification of this data and the completion of a hydrocensus. The hydrocensus is to obtain all new borehole data. This is a mammoth task and such projects have been launched in South Africa, namely the Groundwater Resource Inventory Projects (GRIP).

Apart from borehole specific data, the data obtained during the drilling of boreholes also needs to be captured. Whilst this is a challenging task all boreholes that are drilled should have an accompanying data sheet which must include:

- Borehole position, depth, diameter and construction
- Water strike depths and yields (ℓ/s) and final air lift yield.
- Borehole geology should be logged (ideally every 1 m) and
- Water quality should be commented upon.

In addition to the above two data sets, dedicated regional monitoring boreholes need to be identified and time series data sets established of water levels and water quality (EC in mS/m and pH). This data is helpful in assessing regional groundwater dynamics, recharge rates, climate change impacts etc. Another important data set is the continuous water level and water quality monitoring (including micro-biological monitoring) of production boreholes that are utilised as a drinking water source.

The issues addressed will be further elaborated on within the component on the Enhanced Knowledge and Information system (EKIS) for the Buzi Basin, Annex 2.2 Groundwater and Water Quality Monitoring Network.

Once the above tasks are completed and continuous monitoring is put in place, it is necessary to carry out a hydrogeological analysis which includes:

- Assessment of recharge rates
- Flow dynamics
- Aquifer characterisation

- Delineation of geohydrological resource units
- Chemical characterisation and
- Estimation of the safe yield (sustainable yield) of aquifer units.

Groundwater in the Buzi River Basin can go a long way to addressing potable supplies for communities.

Further work is also required on calculating the groundwater contribution to river base flow from the hydrograph data, as this will assist in improving groundwater recharge estimates. Further work is required on mapping the extent of groundwater-dependent ecosystems (GDEs). The delineation of GDEs will assist in ensuring that groundwater is available to sustain the GDEs and this is an important component of water balance calculations. Methodologies have been developed to map the extent of GDEs using terrain modelling and remote sensing analysis with an acceptable level of accuracy.

4.3.2 Hydrogeological Setting

The underlying geology of the catchment area is relatively complex and includes a large variety of lithologies. The SADC geology map has been compiled by the South African Council for Geoscience (Hartzer, 2009). This map is based on lithostratigraphic principals with lithology being the basis of the classification. The SADC geology map formed the basis for SADC Hydrogeological Map (SADC HGM), (Sweco et al., 2010). Within the SADC HGM Project, the lithological units of the SADC Geology Map were simplified into 12 different hydro-lithological groups. This was done as a consultative process involving local experts from the SADC member states. Within the Buzi River Basin there are 8 hydro-lithological groups present which are listed in Table 4-7 together with their calculated area of coverage for each unit within the basin

The hydrogeological map of the Buzi River Basin (Figure 4-6) shows the distribution of hydro-lithological units throughout the basin. The geological setting plays an important role in determining the hydrogeological conditions within the river basin.

Table 4-7 : Lithological units, area and percentage coverage within the Buzi River Basin.

Rock type:	Area km ²	% of basin area
Paragneiss, quartzite, schist, phyllite, amphibolite	10,844	38
Granite, syenite, gabbro, gneiss and migmatites	4,781	17
Dolomite and limestone	4,446	15
Unconsolidated sands and gravel	3,242	11
Volcanic rocks, extrusive	3,099	11
Intrusive dykes and sills	1,426	5
Clay, clayey loam, mud, silt, marl	880	3
Interlayered shales and sandstone	153	1

Para-gneiss, quartzite, schist, phyllite and amphibolite

This most common grouping may host secondary aquifers. The degree of weathering can be high, the groundwater potential low, and the groundwater quality poor due to the relative ease with which these formations weather. The exceptions, however, are the quartzites. The quartzites are characteristically very competent and brittle, thus fractures and joints are typically widespread throughout quartzite. If the quartzites are folded they can be exposed at surface and these will be high recharge zones with fair hydraulic conductivities (10^{-5} m/s) and good water quality although, due to the lack of buffering capacity, the pH is low and the groundwater corrosive. Fracture flow predominates and borehole success can be highly variable. The quartzite layers have not been mapped separately in the geological data set available for this project but it can be mapped in the field and targeted as a water source. Springs may occur at the contact between the quartzites and the other more weathered lithologies.

Granite, syenite, gabbro, gneiss and migmatites

The granitic terrain may host secondary aquifers as a generalisation. Primary aquifers typically do not occur in granitic terrains, unless in deeply weathered river channels. The secondary aquifer is likely to occur as open fractures within the granites and groundwater may also occur in weathered zones at depths of up to ~80 m.

Typically granites and boreholes drilled in granites, comprise the following characteristics:

- I. Low yielding aquifers
- II. Borehole success rate can be very variable
- III. A successful borehole yield is considered to be > 1 l/s
- IV. Groundwater levels are in the order of 20-30 meters below ground
- V. Groundwater quality is typically good with an EC < 30 mS/m
- VI. Hydraulic conductivity is variable, ranging from 1×10^{-7} m/s to 1×10^{-5} m/s.

Dolomite and limestone

The geological grouping can often host the third type of aquifers, namely 'karstic' aquifers. Due to the occurrence of dissolution cavities this geological grouping often results in very high aquifer hydraulic conductivity and aquifer storage. Also spring flow can emanate from a dolomitic setting. The groundwater chemistry is also typically good although the pH is usually elevated. The main drawback with karstic aquifers is that they are very vulnerable to contamination due to the high recharge rates and hydraulic conductivity. Hand dug wells can often access the groundwater in this setting.

Unconsolidated sands and gravel

This lithological grouping comprises primary aquifers. Relatively high-yielding aquifers should be found within this grouping although the limited amount of rainfall available for recharge may be a limiting factor in the long term.

The groundwater levels are anticipated to be shallow as this is more the discharge portion of the Buzi River Basin. Hydraulic conductivity will be relatively high (10^{-3} m/s) and the water quality acceptable. The groundwater quality will not be as good as the granites as the primary aquifers are at the lower end of the catchment and with increasing proximity to the coast, so the groundwater quality is likely to become more saline, especially for deep groundwater. The primary aquifers may well support groundwater-dependent ecosystems and are most likely the most accessible for rural water supply via hand dug wells.

Volcanic rocks, extrusive

These normally comprise low-to-medium potential aquifers. Possible groundwater target zones include lava flow contacts, buried weathered surfaces and fractures. Groundwater yields of between 0.1 and 2.5 l/s can be obtained from boreholes sited scientifically. Rest water levels and groundwater quality are typically highly variable.

Intrusive dykes and sills

The intrusive dykes and sills are very important from a hydrogeological perspective. Often successful boreholes are drilled into the contact zone between the host rock and the intrusive dyke/sill. These intrusive volcanics can act as barriers to groundwater flow and thus groundwater moves down gradient along the contact zone. When targeting such geological features for groundwater abstraction, the contact zone should be intercepted at an approximate depth of 70 m to 100 m.

Clay, clayey loam, mud, silt and marl

These lithologies contain very limited groundwater and are essentially non-aquifers.

Inter-layered shale and sandstone

The inter-layered shale and sandstone can host secondary aquifers and these aquifers may also be confined. The inter-layered nature of the group generally means that groundwater recharge is low if flat lying or, if within the sandstone layers it may be quite high if there is significant folding and deformation of the layering. Alternating shales and sandstone implies high variability for all

hydrogeological parameters. The characteristics will depend largely on the tectonic history of this layer.

Typically the groundwater potential of inter-layered shales and sandstones is low as this grouping is characterised by very low groundwater recharge, very low hydraulic conductivity, low specific storage and poor water quality.

The hydro-lithological units have been further grouped into four different aquifer types, namely:

- Fissured
- Karst
- Low permeability, and
- Unconsolidated intergranular.

These aquifer types are classified based on their development potential as high potential, moderate potential, and low potential.

The '*high potential*' aquifers occur in association with the 'karst' and 'unconsolidated intergranular' aquifers, within the central and "southern side" of the Buzi River Basin. They also extend to the coast. In the unconsolidated intergranular aquifer setting groundwater can most probably be accessed by means of hand dug wells.

The '*moderate potential*' aquifers occur in association with the fissured aquifers in the central and upland portion of the Buzi River Basin. This groundwater will need to be accessed by drilling boreholes and the degree of success of drilling boreholes will be very variable.

The '*very low yielding aquifers*' are associated with the low permeability rock types which are mainly the granites/gneisses, volcanic rocks and clays. The low yielding aquifers occur extensively throughout the Buzi River Basin. Table 4-8 lists the area based percentage of aquifer type within each country and the area based percentage of the aquifer yield classes.

Table 4-8 : Area based statistics of the aquifer types and aquifer yields.

	Zimbabwe		Mozambique		Total
	km ²	%	km ²	%	
<u>Yield Class</u>					
High potential	60	0.2	7560	26	25
Moderate potential	3070	11	4,680	14	26
Very low potential	600	2	12,920	48	48.5
<u>Aquifer Type</u>					
Fissured	3120	11	4,560	14	26
Karst			4,430	15	15
Low permeability	600	2	12,920	48	48.5
Unconsolidated intergranular			3,250	10	10

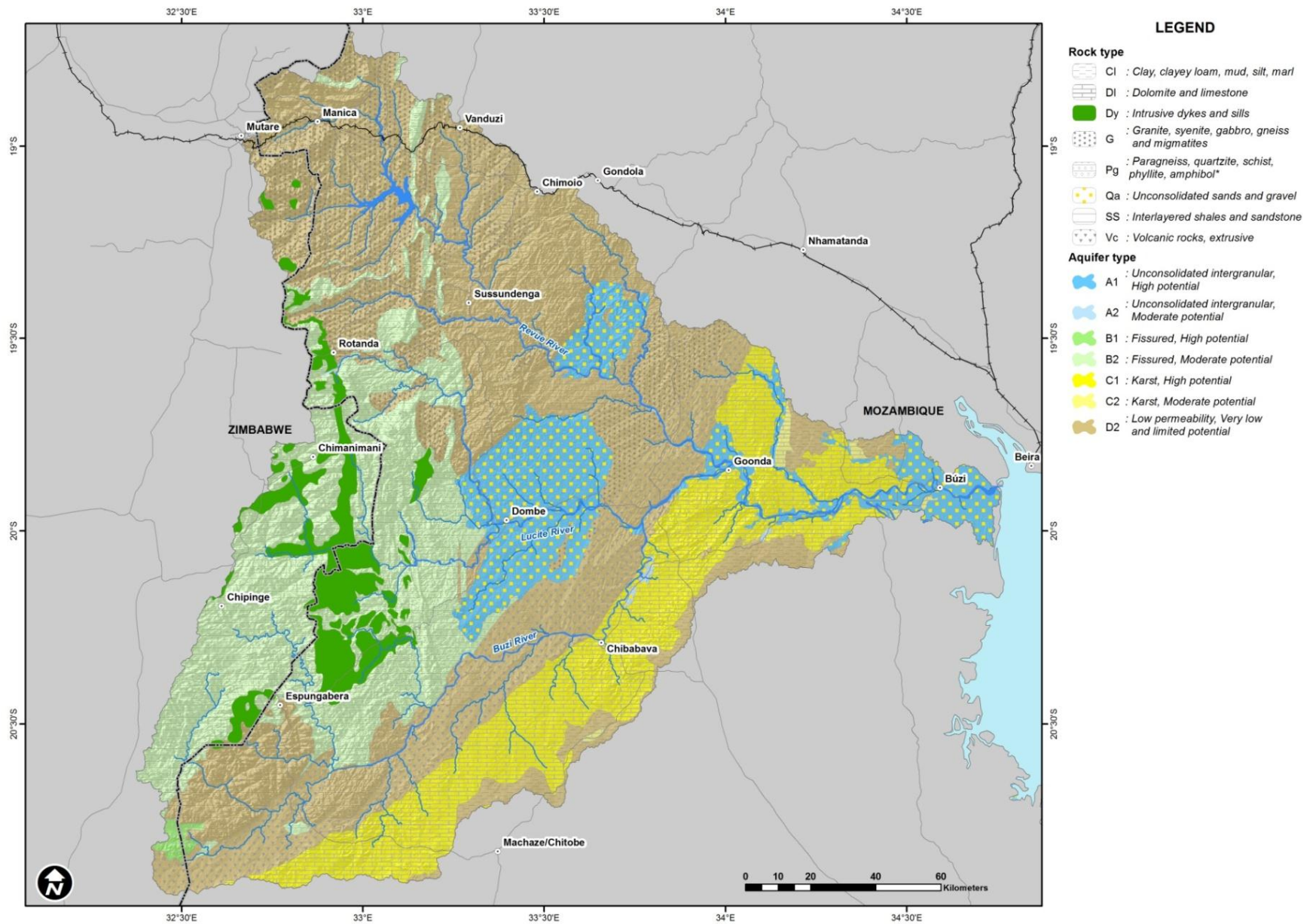


Figure 4-6 : Hydrogeology of the Buzi River Basin.(SADC HGM 2010)

4.3.3 Groundwater recharge

Groundwater recharge is a process that is influenced by many factors. Some of these factors are climatic and others relate to the physical setting – such as slope angle, vegetation cover (type and extent), soil type (texture and thickness), depth to the groundwater level, nature of the vadose zone material, preferential flow paths and nature of the aquifer material. As there are numerous factors that affect groundwater recharge and to attempt determination of groundwater recharge, best estimates (as percentages) have been applied to the hydro-lithologies occurring within the Buzi River Basin. It is acknowledged that this entails broad assumptions. The percentages utilised are based on recharge studies completed in southern Africa (Bredenkamp et al, 1995).

Figure 4-7 shows the calculated groundwater recharge distribution for the Buzi River Basin. The groundwater recharge values (% , mm/year and Mm³/year) are listed in Table 4-12. From Table 4-12 it can be seen the recharge range is from 3- 11%, 37-114 mm/year, and 19- 386 Mm³/year.

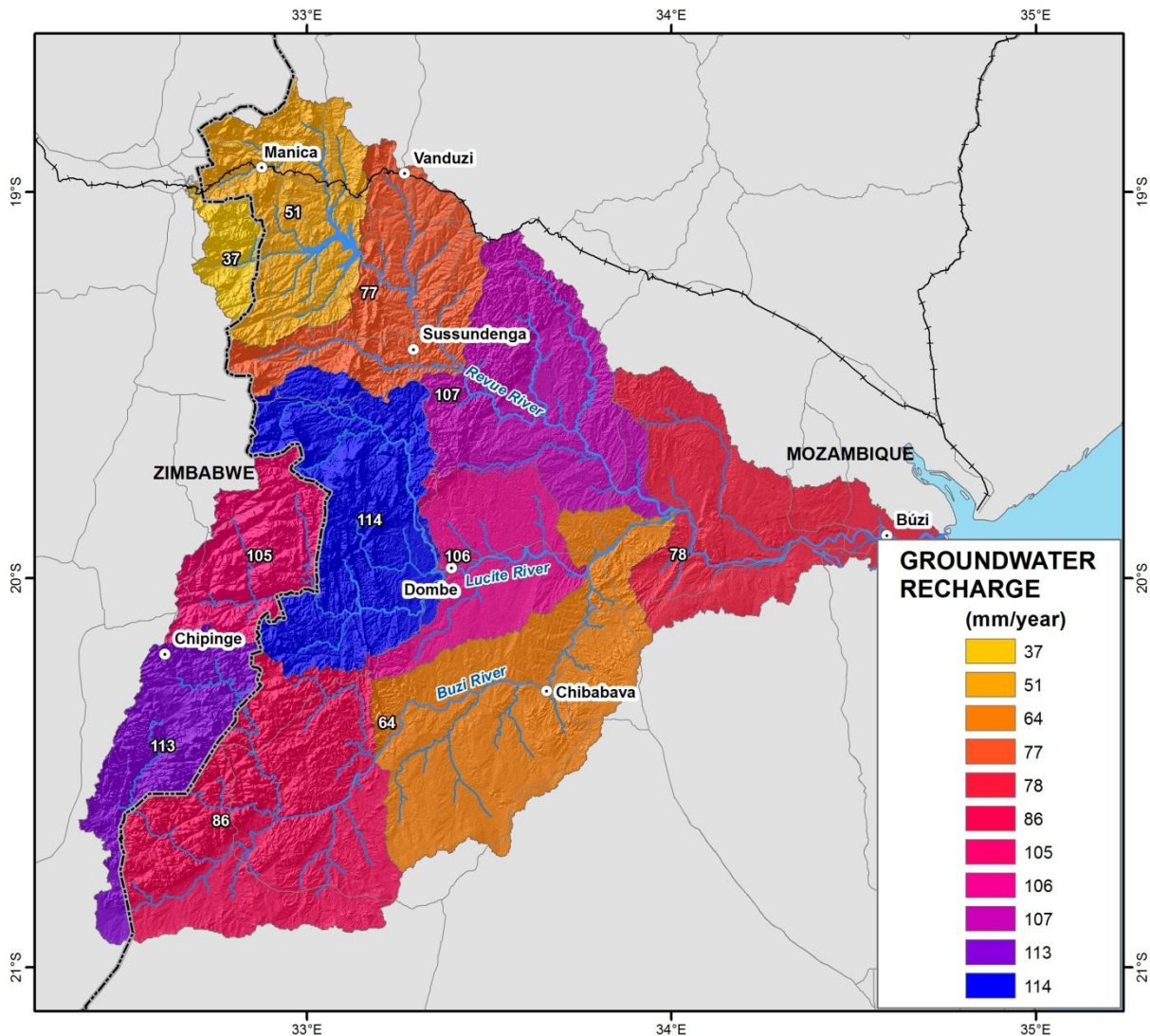


Figure 4-7 : Groundwater recharge for the Buzi River Basin.

4.3.4 Aquifer storativity

Aquifer storativity is also an important component of hydrogeological characterisation. There is very little data on storativity for the aquifers within the Buzi River Basin. However, based on the lithologies within the Buzi River Basin and average values obtained from literature (Johnson, 1967 in Domenico & Schwartz, 1990 and Howard, K. and Karundub, J. 1992), storativity values have been assigned per hydro-lithology (Table 4-9). Note that the effective porosity (sometimes referred

to as specific yield) is the yield per unit area and unit drop of the water table. The sequence of hydro-lithologies listed in Table 4-9 is from highest to lowest storativity.

Table 4-9 : Approximate specific yields and storativity per hydro-lithology.

Rock type:	Effective Porosity	Storativity	Rock type:
Unconsolidated sands and gravel	27.0%	-	Coarse sand (27%) - Johnson, 1967 in Domenico & Schwartz, 1990.
Dolomite and limestone	14.0%	-	Limestone (14%) - Johnson, 1967 in Domenico & Schwartz, 1990
Intrusive dykes and sills	12.0%		Estimated
Interlayered shales and sandstone	12.0%		Sandstone (21%) and clay (3%) - Johnson, 1967 in Domenico & Schwartz, 1990
Volcanic rocks, extrusive	10.0%		Bredenkamp et al 1995.
Paragneiss, quartzite, schist, phyllite, amphibolite	-	6.5%	Schist (26%) & granite (1%) - Johnson, 1967 in Domenico & Schwartz, 1990 and Howard, K. and Karundub, J. 1992. Approximate value assigned.
Clay, clayey loam, mud, silt, marl	3.0 %		Clay (3%) - Johnson, 1967 in Domenico & Schwartz, 1990
Granite, syenite, gabbro, gneiss and migmatites	-	1.00%	Granite (1%) - Howard, K. and Karundub, J. 1992

4.3.5 Aquifer potential

An aquifer system normally has some natural rate of replenishment or recharge, where the water is available in either its undeveloped state or in any one of several depleted states. In general, this recharge may be exploited on a perennial or sustainable basis, whereas utilisation of water held in storage or part thereof is referred to as 'mining' (Domenico et al, 1968). The groundwater held in storage has been accumulated over time due to relatively small inflows into the system. Water resources planners have a number of development options varying from exploiting the aquifer system on a sustainable basis and not utilising any of the reserves held in storage, to mining the aquifer to supply large short-term water demands, to a compromise between these two extremes. This project provides the sustainable yield of the groundwater for resource planning and development purposes and thus aquifer potential is based on groundwater recharge.

An aquifer potential is an estimate of the maximum volume of groundwater that is potentially available for abstraction on a sustainable basis and takes into consideration the volumes of water held in aquifer storage and the recharge from rainfall. The feasibility of abstracting this water is limited by many factors due mainly to the physical attributes of a particular aquifer system, economic and/or environmental considerations. One of the most important of these is the inability to establish a network of suitably spaced production boreholes to 'capture' all the available water in an aquifer system or on a more regional scale. The factors limiting the ability to develop such a network of production boreholes includes the low permeability or transmissivity of certain aquifer units, accessibility of terrain to drilling rigs, unknown aquifer boundary conditions etc. Water Systems Management (2001) state that aquifer transmissivity is the main controlling factor of an aquifer.

Water Systems Management (2001) derived a simple, qualitative approach to take into account the actual practicality of abstracting groundwater as related to the variability of transmissivity within an aquifer system, using a so-called 'Exploitation Factor' or EF (see Table 4-10). This is based on the

assumption that highly transmissive aquifers (i.e. aquifers with high borehole yields) are more efficiently abstractable, implying a potentially higher “rate of recovery” of the available groundwater.

Table 4-10 : Aquifer exploitation factor (“rate of recovery”) based on average borehole yields.

Average borehole yield (ℓ/s)	Exploitation factor	“Rate of recovery “ (%)
< 0.3	0.3	30
0.3 – 0.7	0.4	40
0.7 – 1.5	0.5	50
1.5 – 3.0	0.6	60
3.0 – 5.0	0.7	70
>5.0	0.8	80

The annual groundwater exploitation potential (AGEP) of groundwater that can be drawn from an aquifer with respect to the rate of recharge, can be estimated by applying the formula:

$$AGEP = Q_R \times R \times A_R \quad (m^3/year)$$

Where:

Q_R = the rate of recovery, i.e. the proportion of recharge that can be abstracted through boreholes (considering the geological setting). The rate of recovery is mainly governed by the interconnectivity of conductive structures, number and distribution of boreholes, and transmissivity.

R = annual aquifer recharge.

A = the area over which recharge to the aquifer can take place.

The final link required in determining groundwater potential within the Buzi River Basin is to relate the “rate of recovery” to the hydro-lithologies. Table 4-11 shows the approximate borehole yields per hydro-lithology. However, note this does not mean that every borehole drilled will yield the volume of water listed in Table 4-11. Boreholes will need to intersect favourable geological structures or weathering zones. Particularly in the metamorphic terrain many dry boreholes can be drilled if they are not carefully sited on favourable geological features. The probability of dry boreholes will be lower in the dolomite / limestone areas and unconsolidated deposits.

Table 4-11 : Approximate borehole yields per hydro-lithology.

Rock type:	Average borehole yield (m ³ /hr)	Average borehole yield (ℓ/s)	Rate of recovery (%)
Clay, clayey loam, mud, silt, marl	0.4	0.1	10
Dolomite and limestone	~ 36	3.6	70
Granite, syenite, gabbro, gneiss and migmatites	~ 6	1.6	60
Interlayered shales and sandstone	~ 3.6	1	50
Intrusive dykes and sills	~ 10.8	3	70
Paragneiss, quartzite, schist, phyllite, amphibolite	~ 2.2	0.6	40
Unconsolidated sands and gravel	~ 15	4.2	70
Volcanic rocks, extrusive	~ 7.2	2	60

The ‘rate of recovery’ has been calculated per hydro-lithology and is used to quantify the annual groundwater exploitation potential per sub-basin (Table 4-12).

Table 4-12 : Recharge, Storage and Average Groundwater Exploitation Potential for the 11 catchments.

Sub-basin	Area (km ²)	MAP (mm)	MAP (Mm ³ /yr)	MAE (mm)	MAR (Mm ³)	MAR (mm)	Rech_%	Rech (mm/yr)	Rech (Mm ³ /yr)	Storativity (%)	Storage (Mm ³)	Recover %	AGEP (Mm ³ /yr)
Buzi Zimbabwe	1,690	1,150	1,950	1,200	446	264	9.8	113	191	7.2	6,118	43	83
Upper Buzi	4,480	1,050	4,715	1,250	898	200	8.2	86	386	9.2	20,739	53	203
Middle Buzi	4,330	900	3,912	1,350	411	95	7.1	64	279	11.5	25,009	59	165
Lower Buzi	3,260	900	2,942	1,400	189	58	8.7	78	256	15.1	24,695	60	154
Lucite Zimbabwe	1,540	1,250	1,926	1,100	582	378	8.5	106	164	8.0	6,189	48	79
Upper Lucite	3,250	1,300	4,241	1,200	1,124	345	8.8	114	373	7.7	12,498	48	180
Lower Lucite	1,880	1,000	1,892	1,300	267	141	10.6	106	200	22.8	21,558	66	133
Revue Zimbabwe	510	1,200	613	1,100	173	339	3.1	37	19	1.9	483	60	11
Upper Revue	2,330	1,100	2,574	1,200	499	213	4.6	51	119	2.2	2,525	56	67
Middle Revue	2,460	1,100	2,720	1,200	451	182	7.0	77	189	3.9	4,800	50	95
Lower Revue	3,140	1,200	3,780	1,300	661	210	8.9	107	337	9.2	14,525	51	170
Total sum	28,870		31,265		5,701				2,512		139,140		1,340

4.3.6 Groundwater Quality

Based on the hydro-lithology types the groundwater quality maybe acceptable for domestic consumption (a recommended limit for domestic consumption is < 70 mS/m, with 300 mS/m being the upper limit) (SABS, 1984). However this is a generalisation and there may be specific elements that have a particularly high concentration, for example fluoride, iron or manganese. Associated with the granites problematic trace elements also occur, however this information is not known. The population in the Buzi River Basin largely uses groundwater as their source of drinking water. Thus groundwater protection measures are important as well as the complete analysis of groundwater (including microbiological content) of domestic supply boreholes on a regular basis.

Saline groundwater is a reported problem in the coastal areas where also high Nitrate content sometimes occurs. Groundwater abstraction rates must not be too high in these coastal areas otherwise sea-water intrusion may be induced.

4.3.7 Ground Water Vulnerability

Groundwater vulnerability comprises two main components. One is the vulnerability of groundwater to contamination. The second type of groundwater vulnerability relates to the vulnerability of groundwater to low rainfall and drought conditions. Tried, tested and debated methods do not exist for drought vulnerability calculations. However it is assumed that the resilience of groundwater to drought conditions will be related to the depth to groundwater, the groundwater recharge rates and the aquifer storage. Shallow groundwater levels are susceptible to “evaporative” losses and in times of high air temperatures and low rainfall, groundwater levels can naturally decline quite significantly. In addition where groundwater recharge and groundwater storage is low, especially in areas where groundwater is currently being abstracted, these aquifer systems will be significantly impacted by drought conditions. In addition intergranular aquifers will be more susceptible to impact by drought conditions, as opposed to fractured and confined aquifer systems.

For the Buzi River Basin the intergranular aquifers, with shallow groundwater levels and existing groundwater abstraction will be the most vulnerable to drought conditions. The situation will be exacerbated if natural groundwater recharge and storage conditions are relatively low for the unconfined aquifer. The more resilient aquifers in the Basin will be the higher recharged granites, gneisses, quartzites and sandstone.

With more detailed borehole and groundwater data the development of a groundwater drought vulnerability map will be feasible. This topic is also being addressed on a regional scale under the SADC Groundwater Drought Management Programme and this work, when completed, must also be taken into account in the Buzi River Basin management.

5 STATE OF THE ENVIRONMENT

The purpose of this chapter of the monograph is to produce an overview of the ecosystems and biodiversity of the study area, highlighting ecologically sensitive areas and/or species of the basin from a conservation perspective.

The section describes the basin's rivers, wetlands, lakes and estuary, their biodiversity and functioning, and how this relates to water flows and quality. An evaluation of the present ecological status of the basin's aquatic ecosystems is provided. The chapter also highlights the environmental issues in the basin and their causes. A more detailed description is provided in Annex 3 – Environmental Description.

5.1 Biodiversity of the basin

According to the IUCN (2009), the Buzi River catchment along with the adjacent Pungwe River catchment has been identified as a Key Biodiversity Area for freshwater conservation from a global perspective, based largely on the framework of vulnerability and irreplaceability criteria widely used in systematic conservation planning.

Several formal conservation areas are located in the Zimbabwe region of the Buzi Basin, but none in the Mozambique region. The conservation areas in Zimbabwe include:

- The Vumba Botanical Gardens and Reserve, Mutare District protected under the Parks and Wildlife Act, Chapter 20:15 as Botanical Reserves and Parks and Wildlife land;
- Heroin and Rusitu Forest, Chimanimani District, protected under the Parks and Wildlife Act, Chapter 20:14 as Botanical Reserves and Parks and Wildlife land. The area falls within the Ngorima Communal land and lies along the border with Mozambique south of Chimanimani Mountains and Tarka Forest area. Most of the Haroni Botanical Reserve has been cleared for banana cultivation, whilst the Rusitu Reserve (150ha) 3km upstream of the confluence of the Haroni and Rusitu rivers is the remainder of a larger forest, which is also under threat from land clearing for cultivation (Barnes, 1989). The Rusitu forest, has spiritual significance to the Ngorima people, this may be the reason why it is still relatively intact. The Tree Civet *Nandinia binotata* and Grant's Galago *Galago granti* are rare mammals found in the forest. A rare fruit bat, previously known from the forests of Tanzania was also discovered in these forests. Other special reptiles and amphibians include the Gaboon Adder *Bitis gabonica*, *Hyperolius argus*, *Leptopelis flavomaculatus*, *L. concolor*, *Afraxalus fornasinii*, *Hyperolius tuberilinguis* and *Ptychadena chrysogaster* (Barnes, 1989).
- Chimanimani National Park, Chimanimani District protected under the Parks and Wildlife Act, Chapter 20:14 as Botanical Reserves and Parks and Wildlife land;
- Bunga Forest, Mutare District, protected under the Parks and Wildlife Act, Chapter 20:15 as Botanical Reserves and Parks and Wildlife land;
- The Melsetter Eland Sanctuary, Chimanimani District protected under the Parks and Wildlife Act, Chapter 20:14, third schedule, sanctuaries and specially protected animals
- Numerous Forest Land areas namely: Banti, Tarka, Tandai, Nyambewa, Mudima, Banti, Stapleford Martin, Lionshills, Chisengu, Glencoe, Gungunyana and Chirinda. Chirinda Forest. The Chirinda forest is also the home of the globally threatened Swynnerton's Robin *Swynnertonia swynnertonii*, *Aethomys silidensis* and *Uranomys ruddi*, the shrew *Mysorex cafer* and elephant shrew, The Tree Civet *Nandinia binotata*, Sun Squirrel *Heliosciurus mutabilis*, Red Squirrel *Paraxerus palliatus swynnertonii* and the Simango Monkey *Cercopithecus mitis*. Chirinda forest contains a giant specimen of *Khaya anthotheca* which is a National Monument and is 1000 years old. The tree measures 54m high and 5.25m circumference around the base and is 1 000 years old.

There is little information known about the Forest Land areas or the Melsetter Eland Reserve (other than that the endeavours to protect a large herd of Eland).

The Vumba Botanical Gardens and Reserve and Chimanimani National Park are more well-known and are described in Annex 3.

5.2 Aquatic biodiversity and Ecological Status

Of the three main rivers of the Buzi River Basin (i.e. Revue, Buzi and Lucite Rivers), the Revue River is considered to be the most developed, and includes the Chicamba Dam in the Upper Revue catchment, operated by Electricidade de Mozambique. Of particular concern within the Upper Revue catchment is the presence of illegal gold mining activities which utilise mercury in the flocculation process to extract gold. Lagerblad (2010) determined the present ecological state (PES) of the Revue River to represent a moderately modified ecosystem with a loss and change in the natural habitats (i.e. a PES Class C).

The Upper, Middle and Lower Revue sub-basins comprise commercial agriculture, albeit to a lesser degree in the Lower Revue sub-basin. Lagerblad (2010) determined the main impacts on the Middle Revue catchment to be bank erosion and increased sediment levels, and assigned a PES Class B (i.e. largely natural with few modifications, with a small change in natural habitats and biota likely to have taken place). Similarly, the Lower Revue catchment was also determined to represent a PES Class B (Lagerblad, 2010).

The Lucite River, while not as developed as the Revue River catchment, does support several agricultural practices. It is likely that the PES will be higher than that of the Upper Revue catchment. Lagerblad (2010) assigned similar ecological states (i.e. PES Class B) to the Middle and Lower Buzi catchments, with water quality and riparian deterioration from erosion, sedimentation, human settlements, agriculture, deforestation and gold mining. The PES Class for the Upper Buzi sub-basin is likely to be higher than the other sub-basins within the Buzi River Basin due to remoteness and low level of development of the area.

Very few publications are in existence that detail the freshwater ecosystems represented within the study area and many of the freshwater taxa, particularly ichthyofauna and invertebrates, are not well studied. Nevertheless, certain assumptions based on the distribution of selected freshwater invertebrate taxa can be made. Of particular importance from a regional context is the diversity of Odonata (dragonfly) species associated with the Buzi River catchment. Of concern within the upper reaches of the Buzi River, and in particular with regards to dragonflies, is the deforestation occurring along the headwaters of the main rivers associated with the catchment.

Recent ichthyofauna collections have improved the knowledge of the country's fish species. The Buzi River system essentially has a lower Zambezi fish faunal assemblage. From a bio geographical perspective, the Buzi River system is of particular interest as it appears to form the southern boundary of several lower Zambezi species.

In terms of diversity, over 80 species of freshwater fish comprising over 36 genera are likely to occur within the Buzi River catchment, of which 60 species are presently confirmed to occur. In addition, the level of regional endemism from a fish assemblage point of view is considered to be high. In this context, the Buzi River system, together with the Upper and Middle Zambezi River systems and the Pungwe River system, contain the most diverse fish faunas within the southern African region. Consequently, a number of habitat specialist species that are unique to the Buzi River system are present, including Buzi Grunter *Amarginops hildae*, Broadtail Mountain Catfish *Amphilius cf. laticaudatus*, Buzi River Bream *Chetia brevicauda*, rheophilic catfish, kneriids, cichlids and cyprinids (IUCN, 2009).

Approximately 571 bird species have been identified to be associated with Mozambique. While the number of bird species occurring within the Buzi River catchment is unknown, a total of 25 species of international conservation concern are likely to occur within the catchment based on species distribution ranges, of which two species are listed as Endangered, 15 species are listed as Near Threatened, and eight species are listed as Vulnerable (BirdLife International, 2009).

The distribution and conservation status of the reptiles within the Buzi River catchment is largely unknown, but a number of species of conservation concern like Flat Rock Lizard *Platysaurus*

ocellatus and the Dwarf Wolf Snake *Lycophidion nanus* are likely to occur. Approximately 60 species of frogs may occur based on known distribution records, of which four are considered to be of conservation importance.

Relevant to the investigation of the Buzi River Basin, when assessing the potential of water use from a river system, is the portion of the water is allocated to the environmental needs, the so called Environmental Flow requirement (EFR). The requirement for an environmental flow in river systems is commonly regarded by stakeholders as being in direct competition with the needs of humans. However, the requirement for water that is allocated to sustain ecosystem functions is directly aligned with the ability of rivers to deliver a suite of ecosystem goods and services to the society. The environmental services of the aquatic systems in the Buzi River Basin is vitally important to the well-being of the local communities in order to maintain the ecological integrity of the aquatic ecosystems. A calculation of the EFR for the Buzi River Basin at certain points of interest have been undertaken using two different standard methods. The details are provided in Annex 5: Buzi Water Demand.

5.3 Water Quality and Threats

The economic development in the Buzi River Basin is increasing and with this the pressure on the water course. The following sources in the Buzi Basin have been identified as potential sources for changes in water quality, both surface water and groundwater:

- Agriculture (small-scale and large-scale)
- Mining
- Villages / Urban settlements
- Dams
- Afforestation
- Other Sources

Except for these activities natural fluctuations are taking place as mentioned previous. The climate in Southern Africa, with its rainy seasons and dry seasons has a large impact on the water quality and leads to major seasonal changes. The turbidity is one parameter were this is noticeable every year. The following section discusses the mining activities and assesses the associated impacts on water quality and aquatic biota

5.3.1 Mining activities

The Buzi River Basin covers areas, which have for some time been the focus of interest of mining and prospecting companies, as well as being mined by local, "Artisanal and Small Scale Miners" (ASM).

With regards to larger scale mining and formal prospecting activities, the existing laws and regulations are adequate for managing these and at present they do not have a large impact.

Mining in the basin is however completely dominated by ASM. This is mainly poverty driven, and it will continue to exist as long as there is a lack of other reasonable alternative livelihoods. ASM is currently causing nearly all mining related impacts on water quality and aquatic biota in the basin. The use of mercury in ASM is a serious issue, especially since very little efforts are being made by individual miners to avoid the introduction of mercury into nature.

Many of the estimates of the number of people involved in ASM that exist appear exaggerated and/or unreliable, and do not constitute a good enough basis for making



Figure 5-1 : Mining in the Buzi River Basin.

policy and management related decisions. Without good baseline data, initiatives to manage the situation are unlikely to be completely successful. Figure 5-1 displays the mining related sites in the Buzi River Basin.

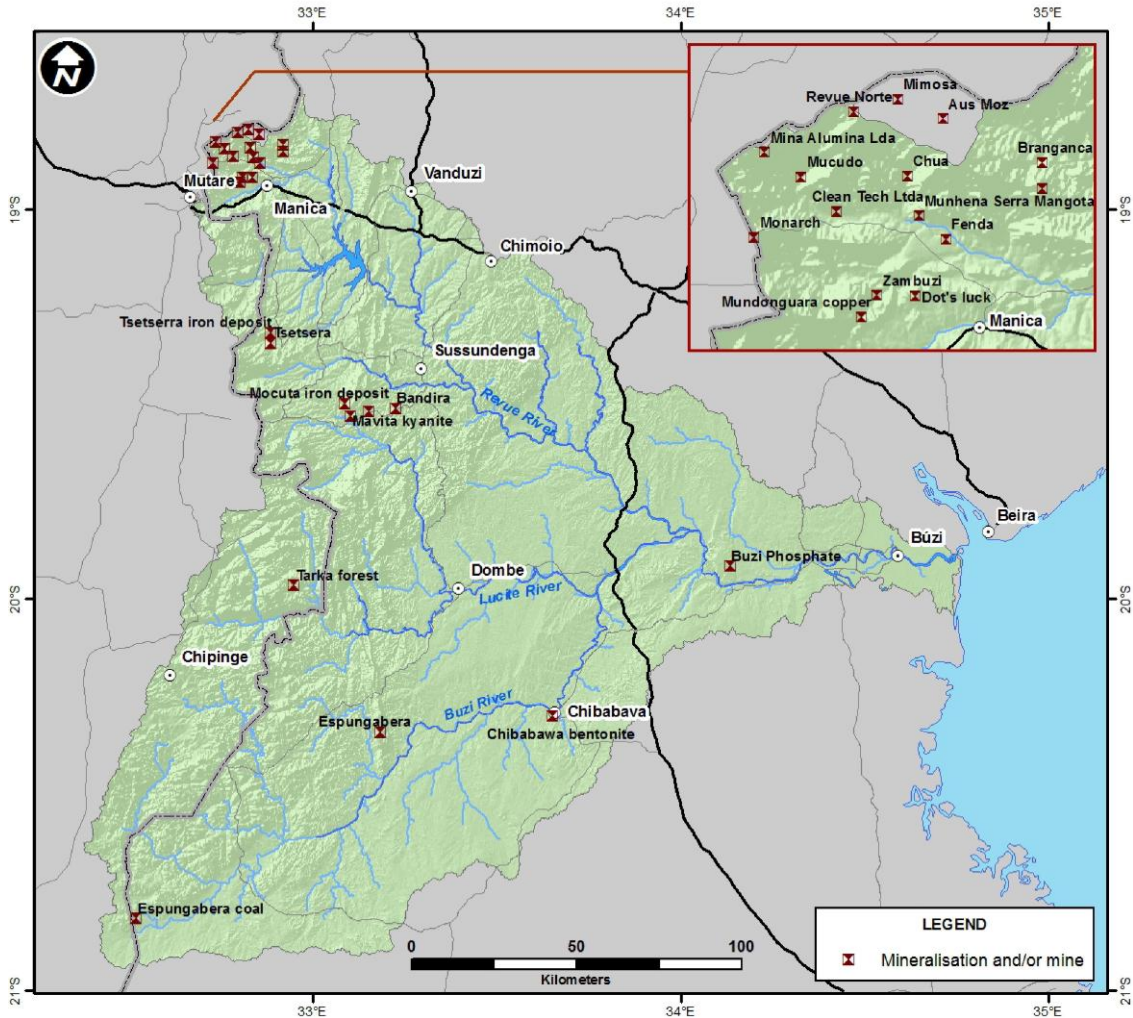


Figure 5-2: Map showing the location of the more important mineral deposits in the Buzi River Basin

The fact that exploration and mining activities may cause significant environmental impacts is well known. Such impacts may include the contamination of water resources through the discharge of processing chemicals or waste into streams and rivers. Adequate storage and control of waste and tailings is therefore usually the most important construction at any mine site, with regards to preventing downstream environmental impacts.

Impacts may also relate to the pumping of mines, with an associated lowered groundwater table. Another possible impact relates to the abstraction of surface water and associated diminished downstream flow of a stream or river. Additionally, impacts on water quality may be caused by the removal of vegetation, and opening up of new areas to erosion, which causes an increase in the sediment loading of downstream areas.

Rocks or mine tailings that contain appreciable amounts of sulphides have the potential to cause Acid Rock Drainage (ARD). ARD is generated when sulphide minerals oxidise, releasing sulphuric acid and metal ions into solution. Typically, ARD is formed in abandoned mine adits or in tailings impoundments and waste rock deposits. The serious effects of ARD upon water quality and upon aquatic biota are well known, and it has been shown that it may lead to serious problems for decades or even centuries, if the acid is generated and not neutralised. ARD will, however, not

develop in such areas where the ore or the surrounding bedrock and soils have the properties to immediately neutralise any acidity that may occur.

5.4 Priority areas for special concern

In general the water quality in the Buzi River Basin is within acceptable range and the ecological status ranging from PES class C and higher. However, there are a number of areas of concern and considering the previously discussed threats in the Buzi River Basin to the environmental integrity, the assessment has identified a number of areas where large impacts from anthropogenic sources are displayed and must be targeted and considered in the management of the basin's water resources. Table 5-1 lists the areas that are recommended to be prioritized in a monitoring program for water quality.

Table 5-1 : Suggested prioritised areas of water quality.

Area	Explanation
Northwest Manica	The area of northwest Manica is an area where mining occurs as mentioned in Section 6. Mining is a large risk to the water quality and special attention should be put on monitoring both up-stream and downstream of the mining activities.
South of Chimoio	South of Chimoio has shown higher values of Conductivity than the rest of the basin. One explanation could be discharge from the city of Chimoio as the river downstream of a city always is at risk of pollution from the city.
Border Manicaland/ Mossurize	Data indicate extremely low pH in the area and this should be monitored and assessed to conclude whether the phenomenon is natural or anthropogenic.
East Buzi – Estaquinha	The area is the location of large-scale agriculture which involves a high risk of polluting the water.
Rusitu River	The area needs urgent action as there are gold panning activities in the areas surrounding this river.

This siltation poses a serious threat to water resources nationally in Zimbabwe, also in the Buzi catchment. Some studies indicate that as much as 50 tonnes/hectares are lost annually through soil erosion and most of this would find its way into river channels. Communal areas are more prone to erosion than commercial areas.

ZINWA is mandated with monitoring river flows including sediment analyses, but has only a few monitoring stations countrywide and "the grab sampling" method widely used is not particularly accurate.

There are less than 30 sampling sites countrywide in Zimbabwe, none of which are situated in the Buzi catchment. The low number means that there is no substantive data to confirm the levels of sedimentation and siltation countrywide.

6 WATER DEMAND TODAY AND IN THE FUTURE

This section comprises a summary of Annex 4 on Water Demand. The water demand task aims to quantify water demand on a sub-basin level for urban and rural water supply, livestock, irrigation, afforestation, industrial use and mining, hydropower and ecosystem services.

6.1 Applied Methodology

An important distinction must be made when dealing with water demand, the one between demand and actual use of water. Water demand is the amount of water that is wanted by the stakeholders and, which in some cases is stated in water permits or water rights. When such figures are not available, the water demand is estimated from simplified calculations or from established characteristic values. Water use is the actual amount of water used by the stakeholders. In most cases the water use does not coincide with the water demand. For future water resources management in the Buzi River Basin it is, however, essential to apply the water demand as the guiding principle for planning. This report thus emphasises on estimation of the water demand.

In Mozambique, the estimation of water demand is mainly based on secondary information, such as population and areas of irrigation and afforestation. In Zimbabwe, the estimation of water demand is mainly based on existing water permits.

Since this study ultimately aims for a water-sharing agreement between the two countries, the water demand study outlines the different methods used in Zimbabwe and Mozambique for estimating water demand for different sectors.

Much data are available for water demand and use in Zimbabwe, before and after 1998 (when the new Water Act was introduced) as records on water rights giving allowed abstraction rates and storage as well as commencement date, records of water sold from governmental dams to irrigators, records of water sold (raw and purified as applicable) to urban centres, records of water permits allowed, abstraction rates and storage, and records of actual used water from the users (including the schemes owned by ZINWA).

For general planning purposes the water authorities use standard consumption rates for different uses. These and the main methods to calculate water demand in Zimbabwe are described in detail in Annex 4.

The available data on water demand in Mozambique are, especially in the Buzi River Basin where very few major users presently exist is, very limited. Annex 4 describes in detail the standards and main methods used to calculate water demand in Mozambique.

Methods for estimating water demand in Zimbabwe and Mozambique differ significantly, although the basic components of water consumption are the same. Well developed and accepted methods in each country form a good basis for satisfactory estimation of water demand on both sides of the border.

The main present water uses in the Buzi River basin are:

- Urban water use in Chipinge in Zimbabwe and Chimoio (taking water from Chicamba Dam) in Mozambique.
- Industrial use, dominated by Chicamba and Mavuzi hydropower dams in Mozambique, evaporation from the Chicamba Dam being the only consumptive use. One sugar cane mill in Buzi village adds to the industrial water use.
- Agricultural use mainly located in the Burma Valley and the Chipinge area in Zimbabwe, as well as the lower Buzi flood plains in Mozambique used for sugar cane.
- Livestock in Manica Province in Mozambique, although the total figure for water demand is rather small.
- Small afforested areas in Zimbabwe and Mozambique.

- Rural water supply and small villages in the river basin in both countries. Water use is, however, very low.
- Besides the conservation areas in the upper part of the basin, requirements to maintain ecological flows are mainly limited to the estuarine area.
- Neither river navigation nor wildlife are relevant in the Buzi River basin.

Future development of water demand is mainly related to agricultural expansion, predominantly in the central and lower basin in Mozambique for large scale sugar cane and biofuel development. Further development increasing water demand may also be seen along the Chimoio-Mutare road (part of the Beira Corridor) as well as in the Burma and Chipinge areas in Zimbabwe, where infrastructure is well developed.

Present water use in the Buzi River Basin is therefore generally low, with the exception of the non-consumptive use for hydropower in the Revue system. The only major threat to future water availability for the coming 20-30 year period is therefore large-scale development of agriculture in Mozambique. Besides hydropower and irrigation, the only other important water use is urban and rural water supply.

Present and future water demand has been estimated considering the administrative divisions and then allocated to the 11 sub-basins that together comprise the Buzi River Basin.

6.2 Water Use per Sector, Sub-basin and Country

The estimates regarding urban water supply for the years 2010, 2020 and 2030 are summarized in Table 6-1. Details on how the estimates are presented in Annex 4.

Table 6-1: Estimated urban water demand in million m³/year in Buzi River Basin

Town	Sub basin	2010	2020	2030
Chimoio	Upper Revue*	6.0	13.0	22.6
Vila Manica	Upper Revue	0.7	1.4	3.2
Gondola	Upper Revue*	0.4	1.1	2.8
Chipinge	Buzi Zimbabwe	3.0	4.7	9.6
Chimanimani	Lucite Zimbabwe	0.7	0.8	1.0
TOTAL		10.8	21.0	39.2

**Although not located in this sub-basin the source of water is the Chicamba Dam*

Present and future rural water demand has been studied in detail. Table 6-2 summarizes the results of this exercise.

Table 6-2: Estimated rural water demand in million m³/year in the Buzi River Basin

Sub basin	2010	2020	2030
Revue Zimbabwe	0.4	0.44	0.49
Lucite Zimbabwe	1.4	1.55	1.71
Buzi Zimbabwe	2.7	2.98	3.29
Total Zimbabwe	4.5	4.97	5.49
Upper Revue	0.34	0.73	1.49
Middle Revue	0.29	0.64	1.35
Lower Revue	0.44	0.99	2.09
Upper Lucite	0.18	0.42	0.92
Lower Lucite	0.11	0.24	0.53
Upper Buzi	0.52	1.3	3.09
Middle Buzi	0.29	0.64	1.34
Lower Buzi	0.34	0.65	1.19
Total Mozambique	2.51	5.61	12.00
TOTAL	7.0	10.6	17.5

Preliminary estimates of water demand for livestock have been calculated using the scarce available data and making some reasonable assumptions. The results are presented in Table 6-3.

Table 6-3: Estimated livestock water demand in million m³/year in the Buzi River Basin

Sub basin	2010	2020	2030
Revue Zimbabwe	0.16	0.18	0.20
Lucite Zimbabwe	0.21	0.23	0.26
Buzi Zimbabwe	0.73	0.80	0.89
Total Zimbabwe	1.10	1.21	1.35
Upper Revue	0.20	0.36	0.64
Middle Revue	0.19	0.33	0.60
Lower Revue	0.23	0.42	0.75
Upper Lucite	0.26	0.46	0.83
Lower Lucite	0.13	0.23	0.41
Upper Buzi	0.35	0.64	1.14
Middle Buzi	0.26	0.46	0.83
Lower Buzi	0.14	0.25	0.45
Total Mozambique	1.8	3.2	5.7
TOTAL	2.9	4.4	7.0

Irrigation represents the major expansion of water demand in the future. Estimates of future demand were made based on known investment projects to be developed, expected growth rates and some other reasonable assumptions as detailed in sections 8.1 and 8.2 of Annex 4. The results are summarized in Table 6-4.

Table 6-4: Estimated irrigation water demand in million m³/year in the Buzi river basin.

Sub basin	2010	2020	2030
Revue Zimbabwe	53	61	82
Lucite Zimbabwe	52	60	81
Buzi Zimbabwe	89	103	139
Total Zimbabwe	194	262	302
Upper Revue	1.6	28.8	51.6
Middle Revue	1.6	18.8	33.7
Lower Revue	2.3	22.9	41.0
Upper Lucite	1.0	14.2	25.4
Lower Lucite	0.4	8.3	14.8
Upper Buzi	0.3	7.0	12.6
Middle Buzi	0.1	15.8	28.3
Lower Buzi	6.7	287.2	514.2
Total Mozambique	14	403	722
TOTAL	208	627	1,024

Afforestation does not create a water demand per se since no irrigation is applied. However, it has been widely recognised that massive afforestation of species would result in a streamflow reduction. No standard methods have been adopted in Mozambique and Zimbabwe and no large afforestation projects are foreseen for the Buzi basin.

There is very little industrial and mining water use in the Buzi basin in Mozambique outside the urban centres. No large industries are located in the Zimbabwean parts of the Buzi River basin. Table 6-5 presents the estimates for industrial water demand.

With regard to irrigation no information about new projects could be obtained and future water demand was estimated considering the planned expansion. "

Table 6-5: Estimated industrial and other water demand in million m³/year by sub-basins

Sub basin	2010	2020	2030
Revue Zimbabwe	2.2	2.4	2.6
Lucite Zimbabwe	1.3	1.5	1.6
Buzi Zimbabwe	1.8	2.0	2.2
Total Zimbabwe	5.3	5.9	6.4
Upper Revue	0.3	0.5	1.0
Middle Revue	0.2	0.3	0.6
Lower Revue	0.2	0.4	0.7
Upper Lucite	0.1	0.3	0.5
Lower Lucite	0.1	0.1	0.3
Upper Buzi	0.1	0.2	0.4
Middle Buzi	0.1	0.3	0.5
Lower Buzi	2.4	4.9	9.1
Total Mozambique	3.4	7.0	13.1
TOTAL	8.8	12.9	19.5

In terms of water demand, hydropower is not a consumptive use as water just flows through the turbines and is discharged downstream. In the case of Chicamba dam, with a large reservoir area, the increased evaporation, in the order of 71 million m³/year, could be considered a "water consumption" that should be allocated to the hydropower production.

Regarding eco-system services and ecological flows, Annex 4 provides a review of methods that could be applied to the Buzi basin. No established standards exist neither in Zimbabwe nor in

Mozambique, however, there is a practice in Zimbabwe to consider 5% of MAR for environmental purposes and there are some recent studies in Mozambique suggesting 15% of the natural flows.

The following tables present the estimate of future water demand in Zimbabwe and Mozambique and the distribution of direct water demand (not including hydropower and ecological flows) by sub-basins.

Table 6-6: Summarised water demand in million m³/year in the Buzi River Basin.

Unit: million m ³ /year	ZIMBABWE			MOZAMBIQUE			TOTAL		
DIRECT USES	2010	2020	2030	2010	2020	2030	2010	2020	2030
Urban water supply	3.7	5.5	10.6	7.1	15.5	28.6	10.8	21.0	39.2
Rural water supply	4.5	5.0	5.5	2.5	5.6	12.0	7.0	10.6	17.5
Livestock	1.1	1.2	1.4	1.8	3.2	5.7	2.9	4.4	7.0
Irrigation	194	224	302	14.0	403	722	208	627	1,024
Industries others	5.3	5.9	6.4	3.5	7.0	13.1	8.8	12.9	19.5
TOTAL	209	242	326	29	434	781	238	676	1,107
INDIRECT USES									
Hydropower (dam evaporation)	0.5	?	?	71	?	?	71	?	?
Afforestation	~30-60	~30-60	~30-60	~28-37	~28-37	~28-37	~60-100	~60-100	~60-100
ENVIRONMENTAL FLOWS*									
Desktop Model		255			1,387			1,642	
5% of MAR		52			233			285	
Median of annual low flows		174			745			919	

* Calculated as the sum of EFR at border flows for Zimbabwe and as the EFR at the estuary minus the border flows for Mozambique.

Table 6-7: Estimated total direct water demand in million m³/year in the sub-basins of the Buzi River Basin

Sub basin	2010	2020	2030
Revue Zimbabwe	55.8	64.0	85.3
Lucite Zimbabwe	55.6	64.1	85.6
Buzi Zimbabwe	97.2	113.5	155.0
Total Zimbabwe	208.6	241.6	325.8
Upper Revue	9.5	45.9	83.3
Middle Revue	2.3	20.1	36.3
Lower Revue	3.2	24.7	44.5
Upper Lucite	1.5	15.4	27.7
Lower Lucite	0.7	8.9	16.0
Upper Buzi	1.3	9.1	17.2
Middle Buzi	0.8	17.2	31.0
Lower Buzi	9.6	293.0	524.9
Total Mozambique	28.9	434.3	780.9
TOTAL	238	676	1,107

The previous tables and Figure 6-1 below display the estimated water demand distribution between sectors, sub-basins and between the two countries as per 2010. Considering the various sectors of consumptive use, it is clear that irrigation is by far the most dominant water use sector with urban water supply as a distant second.

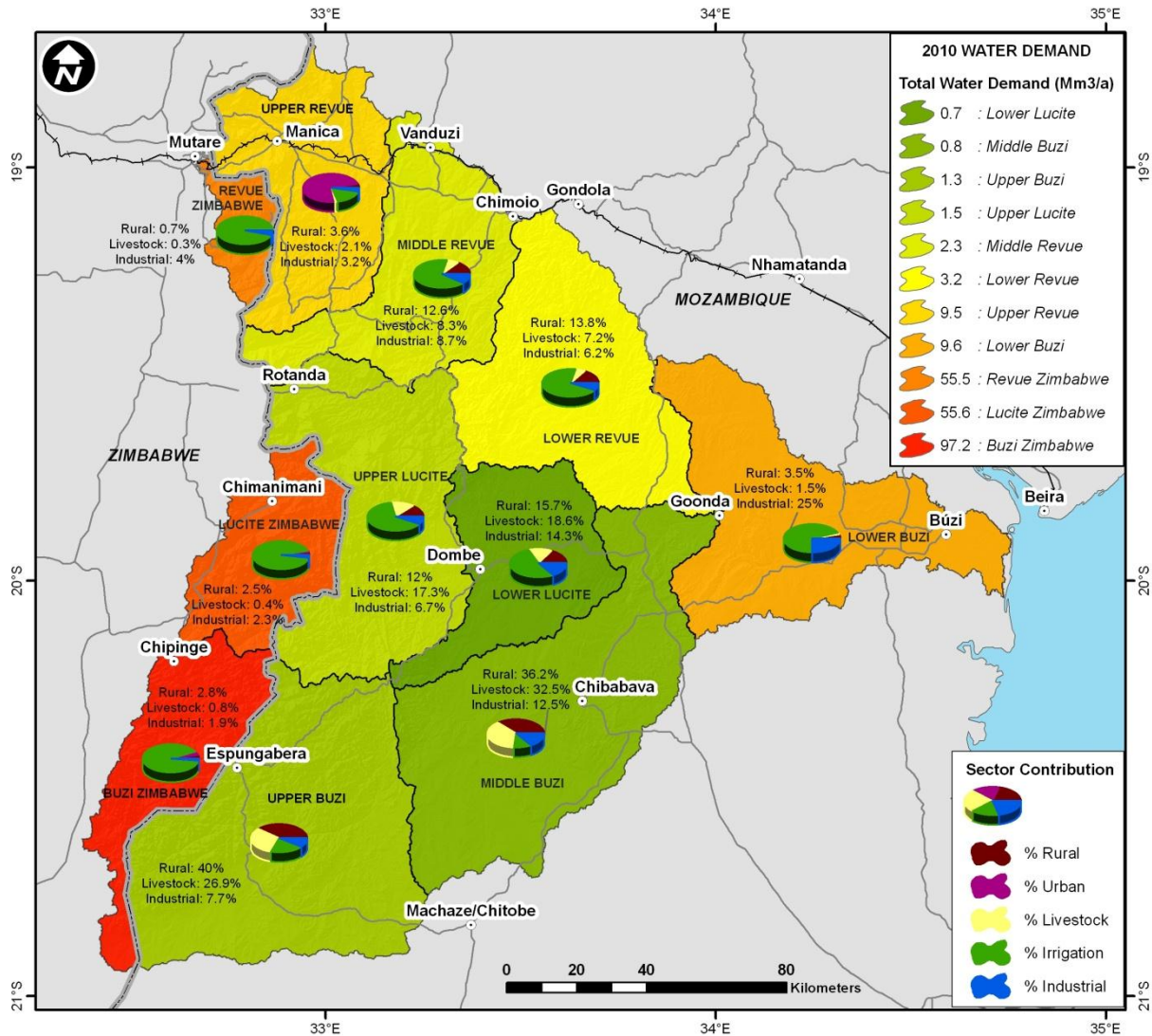


Figure 6-1: Water Demand characteristics in the Buzi River Basin 2010

A comparison of total MAR shows that in 2010 the total use of water is only 4% of MAR. This confirms the general view that water resources are presently in abundance in the Buzi River Basin. However, by 2030 the estimated demand is 19% and if environmental flow is calculated by the South African standard method the total water demand is close to 50%.

Table 6-8: Water demand contra natural MAR in the Buzi River Basin.

	2010	2020	2030
Direct uses + existing dam evaporation	4.2%	12%	19%
Including EFR (Desktop)	33%	41%	48%

Table 6-8 illustrates how the direct water demand will develop the coming 20 years. The increase is significant mainly because of large-scale development of irrigated sugar cane in Mozambique. This will create a more water-stressed river system, especially if high levels of environmental flow requirements should be fulfilled. It will also require large-scale development of dam infrastructure to ensure sufficient water demand during the dry season. This will in turn give opportunities to multi-purpose use of these dams e.g. for hydropower production.

Figure 6-2 illustrates the estimated water demand distribution between sectors, sub-basins and between the two countries by 2030.

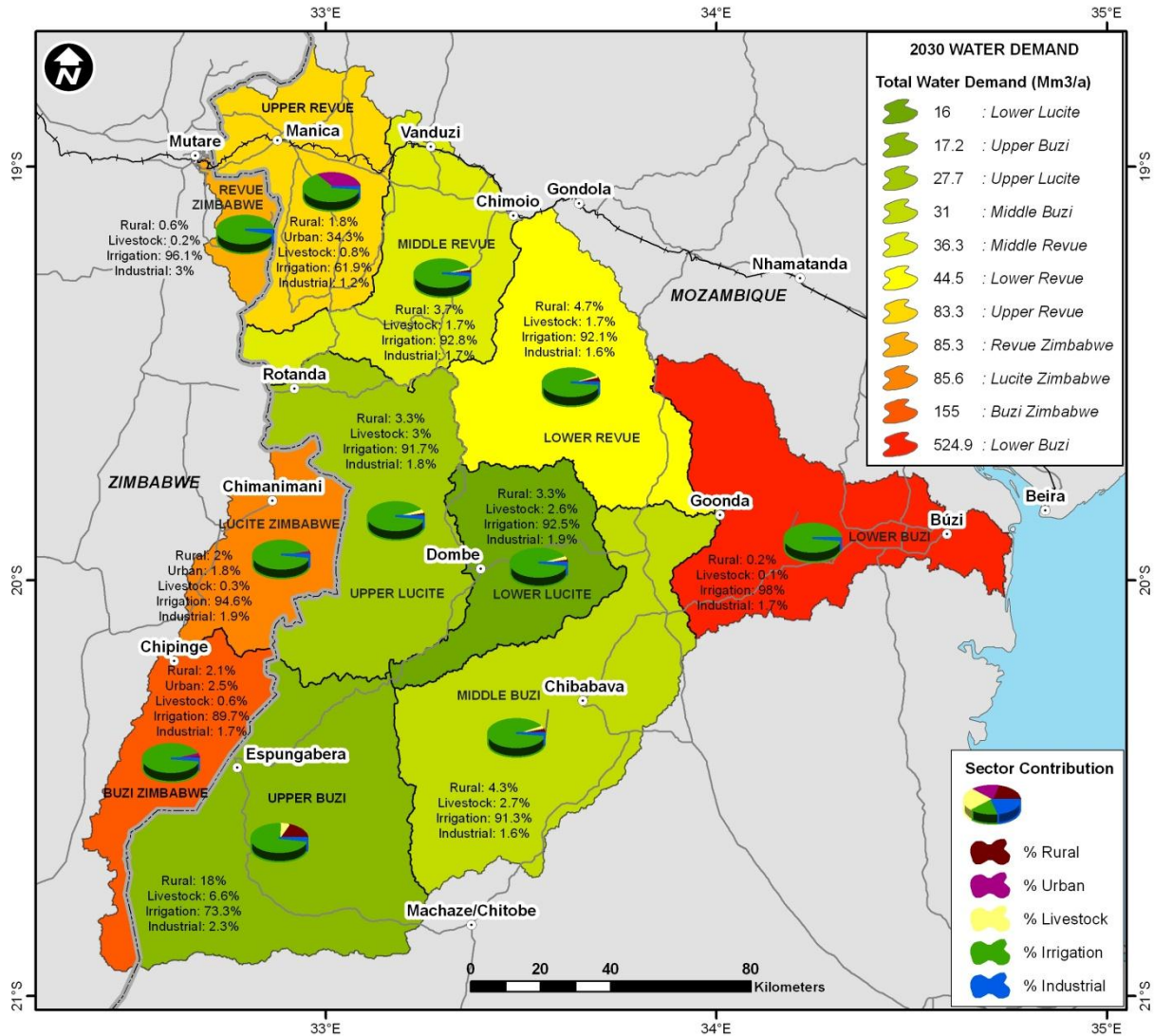


Figure 6-2: Water Demand characteristics in the Buzi River Basin by 2030

7 WATER GOVERNANCE

Water's many different users require integrated planning and development. In addition, integrated river basin management (IRBM) is generally regarded as a pre-requisite for achieving national goals related to poverty alleviation, economic growth, disaster resilience and climate change adaptation. Good water governance is furthermore a precondition for the practical implementation of IRBM policies and strategies. The fundamental requirements for good water governance are strong political will; responsibility and accountability; and inclusiveness, participation and responsiveness.

The study on the water governance of the Buzi River Basin describes the existing water governance framework and the current implementation of IRBM. The first part of this chapter gives an overview of the water sector and the enabling management framework in the two countries. The second part assesses the current efficiency of joint and integrated river basin management by the application of a set of quantifiable performance indicators. The IRBM progress review is followed by the identification of priority issues to consider for the future management of the Buzi River Basin.

7.1 Governance Framework

Mozambique and Zimbabwe share the Buzi River Basin and the development and management of this shared watercourse requires cooperation, under a framework that promotes interdependence and joint management. The national water law and policies of Mozambique and Zimbabwe together with international water agreements determine the governance framework within which the Buzi River Basin is to be managed and developed. In this section, we have collated the relevant legal and institutional background material to be considered in the joint management of the Buzi River Basin. A detailed description of the legal and institutional setting is provided and the adequacy, implementation and enforcement aspects of the current enabling framework for water governance and IWRM are discussed in Annex 5.

Table 7-1 to Table 7-3 below give an overview of the enabling framework for the joint management of the Buzi River Basin and show the links between regional and national policies, laws and institutions. The adequacy, implementation and enforcement aspects of the current enabling framework for water governance and IWRM are discussed in the following sections.

Table 7-1 : Policy and Legal Framework.

Description	Regional	Mozambique	Zimbabwe
Legal and Policy Framework			
Water Policy	SADC: The Regional Water Policy (2005)	Revised National Water Policy (2007) Water Tariff Policy (1998)	Various proclamations, no single paper e.g. Domestic Water Supply and Sanitation Policy, Final Draft, December, 2004
National Water Law		The Water Law (1991) (<i>a Draft Water Law Mozambique was prepared in 2005</i>) Regulation of Licenses and Concessions of Water (2007). Governmental decrees for urban water supply (1998)	The Water Act, 1998 The Zimbabwe National Water Authority Act, 1998 Water (Permits) Regulations, SI, 2001 Water (Waste and Effluent Disposal) Regulations, SI, 2000
International Water Law and Agreements	SADC: The Revised Protocol on Shared Watercourse Systems ¹ (2000)	Bi-lateral Agreement for the establishment and operation of a joint Water Commission (2002)	
IWRM Strategy	SADC: The Regional Water Strategy (2007)	National Water Resources Management Strategy 2005-2017 (2007)	Water Resources Management Strategy for Zimbabwe, 1999/2000

Table 7-2 : Related Policy and Legal Documents.

Description	Mozambique	Zimbabwe
Development Vision	Agenda 2025	The Millennium Development Goals (2000 to 2015)
Poverty	National Action Plan for the reduction of Absolute Poverty (PARPA II 2006-2009)	The PRSP process has been stalled due to the current political situation in the country.
Gender	Gender Policy and Strategy (2006)	National Gender Policy, 2000
HIV/AIDS	Second strategic plan for the combat of HIV/AIDS 2005-2009	National HIV/AIDS Policy (1999) and National HIV and AIDS Strategic Framework, 2000-2004
Environment	Law on Environment (1997)	The Environment Management Act (CAP 20:27), 2002
Irrigation	National Strategy for Green Revolution (2007) Strategic Plan for the Development of Agricultural Sector (PEDSA) 2010-2019 Irrigation strategy and policy- <i>under preparation</i>	Irrigation Policy and Strategy. 1994. Draft document.

¹The Revised Protocol incorporates the principles of the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (1997) and the Dublin Principles

Table 7-3: Institutional Framework.

Description	Regional	Mozambique	Zimbabwe
Council Ministers for Water	of SADC Council of Ministries for Water	National Water Council	National Water Steering Committee /Inter-Ministerial Subcommittee on IWRM
Ministry /Department of Water Responsible to oversee implementation of the SADC The Revised Protocol on Shared Watercourse Systems	The SADC Water Division, within the SADC Directorate of Infrastructure & Services	Ministry of Public Works and Housing National Directorate of Water International Rivers Office	Ministry of Water Resources Development and Management Department of Water Resources (DWR) Zimbabwe National Water Authority (ZINWA)
River Basin Institutions	Buzi Joint Water Commission	ARA-Centro	ZINWA-Save Catchment Manager
Stakeholder Institutions		ARA-Centro Management Board <i>(to be established)</i> Buzi Basin Committee	Save Catchment Council/ Budzi and Odzi Sub-Catchment Councils

7.2 Institutions and Roles

7.2.1 Regional institutions

In accordance with the Revised Protocol on Shared Watercourses, the Governments of Mozambique and Zimbabwe have signed in Harare in December 2002, an Agreement for the establishment and operation of a Joint Water Commission (JWC) for the management of joint water resources. This agreement makes specific references to the UN Convention on the Law of the Non-Navigational Uses of International Water Courses. By signing the JWC Agreement, Mozambique and Zimbabwe have committed themselves to the following principles with regard to the shared river basins:

- a) Principle of prevention of harm;
- b) Principle of precaution;
- c) Principle of co-operation; and,
- d) Principle of equitable and reasonable utilisation

The objective of JWC is to advise the two countries on conservation, development and use of shared water resources. Thus the functions of the JWC are merely advisory. All decisions of the commission are taken on the basis of consensus between the delegations. In the event the commission fails to reach consensus, the matter under discussion are referred to the two governments for further negotiations.

Buzi, Pungwe and Save River Basins are three adjacent river basins shared between the two countries and managed by the same river basin organizations i.e. ARA-Centro, ZINWA-Save and ZINWA-Runde. The Joint IWRM Strategy for the Pungwe River Basin thus recommended that upon finalisation of the Joint IWRM strategies for the Buzi and Save River Basins, a comprehensive joint agreement for the three river basins, Pungwe, Buzi and Save, should be negotiated.

The short-term priority action for the JWC pertinent to the shared Buzi River Basin is to provide strategic guidance to the SWCSP implementation through the representation on the SWCSP Steering Committee.

The medium-term priority action for the JWC would be to strengthen the JWC Secretariat, the coordinating body, with competent and adequate staffing agreed by both countries for the efficient implementation and monitoring of the Joint Buzi IWRM Strategy and “Buzi Agreement” once these are in place.

7.2.2 Mozambique

The Water Law (1991), the revised National Water Policy (2007), the National Water Resources Management Strategy (2007), the Regulation of Licenses and Concessions of Water (2007), and the Water Tariff Policy (1998) constitute the key guidance documents for Water Resources Management in Mozambique.

Regarding the water use and exploitation, the waters are classified into waters of common use and waters of private use. Waters of common use are those consumed by a family, for domestic purposes, cattle and small scale irrigation, with no use of mechanisation. Common uses of water are free and do not require any licence or concession nor is any payment of tariffs involved. Waters of private use need an authorization that can be given by law, licence or concession

The Figure 7-1 illustrates the institutional structure of the water sector in Mozambique.

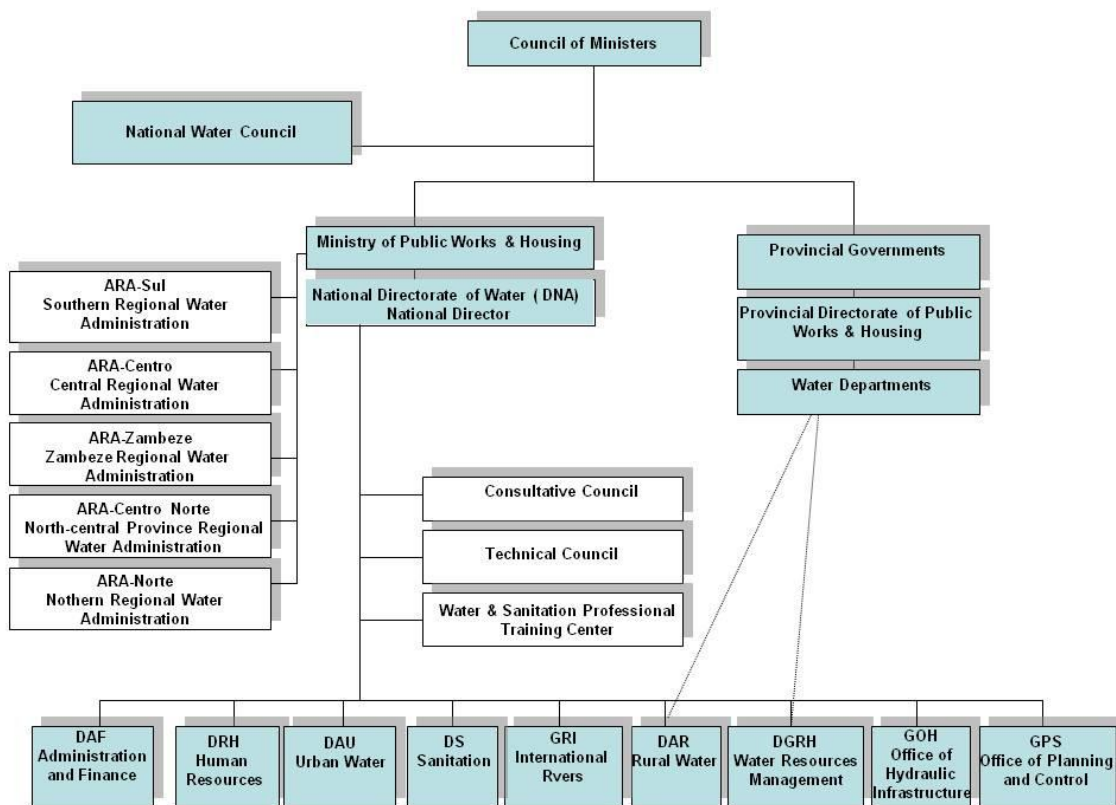


Figure 7-1: Institutional structure of the water sector in Mozambique

Source: DNA

The Ministry of Public Works and Housing (MOPH) and National Directorate of Water (DNA) have a central role in the water resources management and in the promotion of water supply and sanitation.

The DNA is the main institution responsible for the management of the water sector of the country. DNA currently assumes the responsibilities at the national level for policy, planning, and sector oversight. DNA should ensure that government policies and strategies on water resources are

followed. Among the various organs of the DNA, the following ones are of particular importance for the Buzi IRBM: the Department of Water Resources Management, the Office of Hydraulic Works and the International Rivers Office.

The Department of Water Resources Management is responsible for the inventory of water resources, the Master Plans for the river basins and technical and methodological guidance to the Regional Water Administrations. The recently established Office of Hydraulic Works (GOH) is responsible for the promotion, coordination and supervision of construction of hydraulic works and mobilising funding. The International Rivers Office has been created in recognition of the special importance of shared river basins for Mozambique. It is responsible for the liaison with the corresponding water affairs institutions in the other watercourse states and with the SADC Water Sector Division for the promotion and facilitation of cooperation on shared international water basins. Considering that the water resources cross through several sectors, inter-sectorial coordination and decision making is essential. The National Water Council, created by the Water Law, is a consulting body of the Council of Ministers and has the main objective of inter-sectorial coordination.

In Mozambique five decentralized Regional Water Administrations (ARAs) have legally been established by the Water Law in 1991 and additional laws and regulations since 1993. The ARAs answer to the Minister of Public Works and Housing while for guidance and methodological orientation and support, the ARAs are connected to DNA. The ARAs were created during a time span of 15 years. ARA-Sul was created in 1993 followed by ARA-Centro(1997), ARA-Zambeze (2000), ARA-Norte (2006) and ARA Centro Norte (2008). The ARAs are responsible for water resources monitoring, management and development. The ARAs are also responsible for issuing licences and collecting water fees. The participation of the stakeholders is promoted through the Basin Committees established and operated by the ARAs. The aim is for the ARAs to have administrative, organizational and financial autonomy but ARA-Centro is not yet at that stage and has to report to DNA which assumes responsibility for its budget and reporting to the Ministry of Finance.

Since they were created over such a long time span, with socio-economic conditions that altered significantly, the ARAs have statutes that, although in basic conformity with the Water Law, show many significant differences in areas such as management of the ARAs, basin committees, stakeholder involvement and organisation of the ARAs. The Ministry of Public Works and Housing has thus embarked on a process to come to a standard version of the statutes for all the ARAs.

ARA-Centro

The area of jurisdiction of ARA-Centro covers the three international river basins, namely Buzi, Pungwe and Save River Basins - all of which are shared with neighbouring Zimbabwe - as well as minor river basins e.g. the entirely national Gorongosa River Basin.

ARA-Centro became operational in 1998, although its statutes were only formally approved in 2004. The Internal Regulations of ARA-Centro have been elaborated but have not been approved as yet. Its head office is located in Beira and Basin Units (BUs) are planned for each of the three river basins. In 2010, a BU was established in Chimoio and a BU manager has been appointed. The purpose of the office is to host both the Basin Units for Buzi and Pungwe River Basins. With the creation of the BU in Chimoio the ARA-Centro has moved closer to the water users and stakeholders in both the Buzi and Pungwe catchments and hence stakeholder involvement is anticipated to be enhanced.

According to the 2004 statutes ARA-Centro is responsible for the water resources monitoring, management and development within its area of jurisdiction. In addition the statutes give the following general guidelines:

Management guidelines of the ARA Centro as defined by its statutes:

- *ARA-Centro shall provide a public service aiming for a rational and economic water usage, the protection of the environment and the satisfaction of the users.*
- *ARA-Centro shall promote the participation of the water users in the main decisions of the water management and shall promote coordination and exchange of information requested for the integrated water resources management.*
- *ARA-Centro shall be organised to promote an efficient, harmonious and decentralised operation to guarantee a high service quality.*
- *ARA-Centro should be organised in Basin Units for the administration of river basins.*

Source: ARA-Centro Statutes, 2004

The mission and guidelines put a strong emphasis towards integrated water management on the basin scale. Through the Basin Units the water resources should be managed in a participatory way for the main river basins under ARA-Centro's jurisdiction. The guidelines give much focus to promoting stakeholder participation as part of the integrated water resources management. A core function is the establishment and maintenance of a register of water users and other stakeholders. The registration and licensing has recently been intensified in the Buzi Basin although water permit holders are still low. In the process of establishing the Buzi Basin Committee and selecting stakeholder representatives, information of stakeholders have been gathered. A formal stakeholder data base is, however, yet to be developed.

Common to almost all functions of ARA-Centro is the need for monitoring and maintaining data on hydrometeorology and water quality. These data are fundamental for planning, licensing, enforcing authorisations, designing infrastructure and providing services such as e.g. flood warnings. The current monitoring network in the Buzi River Basin consists of 14 operational hydrometric station measuring water levels but not reliable streamflow information. However, there is one station producing reliable runoff data, which is operated by the EDM at the Chicamba dam. Five rainfall gauging stations have been confirmed as operational. It has been concluded during the Monograph study that, the extent and status of operation of the monitoring network is currently inadequate to produce meaningful hydro-meteorological data. Additionally, there is no water quality or groundwater level monitoring.

The statutes also state the mandated functions related to management and development of hydraulic infrastructure. Besides approving hydraulic works as an authority, ARA-Centro should also be responsible for the planning, design, construction, operation and maintenance of hydraulic infrastructure. However, in practise, ARA-Centro only has the capacity to undertake these functions for smaller units and is supported by the recently established Office of Hydraulic Works (GOH), which is responsible for the promotion, coordination and supervision of construction of major hydraulic works in Mozambique.

Revenue is collected from water users parallel to the funding from the central government. The majority of the large water users are licensed and pay according to the nationally set tariffs. In total 40 users are registered of which seven are located in the Buzi Basin. There are no permit holders for effluent discharge.

In 2010 ARA-Centro has a full-scale organisation including technical and financial departments although the some institutional components are still under development, namely the management board of ARA-Centro; the BU in Chimoio; and the Buzi and Save Basin Committees.

ARA Centro has a total of 34 employees, of which 19 in the technical departments and the remaining ones as support staff. In addition, there are 75 observers for the 88 hydro-meteorological stations. Out of this group 30 observers are located in the Buzi River Basin. 11 of the staff members have university degrees out of which eight are working in the technical department and three in the financial department. Seven out of 34 staff members are women of which one is in the technical department.

Considering the vast area to be covered the water resources monitoring and information management team is rather small. The consistent problems of funding has emphasised the problem of doing field work. During the last few years, very little work in the field has been conducted in the Buzi River Basin.

7.2.3 Zimbabwe

Zimbabwe does not have a single specific document that outlines national policy for the water sector. It is articulated primarily through the Water Act [Chapter 20:24] of 1998, in combination with related statutory instruments, water sub-sector policies and implementation strategies. Besides the Water Act, current water governance framework has evolved from the implementation of the following policies and strategies: The Water Resources Management Strategy for Zimbabwe, "Towards Integrated Water Resources Management" , undated circa 1999; Domestic Water Supply and Sanitation Policy, Final Draft, December 2004; The Millennium Development Goals 2000 - 2015; Public-Private Partnerships in Zimbabwe, Guidelines; National HIV/AIDS Policy, 1999 and National HIV and AIDS Strategic Framework 2000-2004.

All surface and groundwater in Zimbabwe is vested in the State. With the exception of primary water use, all other uses of water must be approved by the State.

The Department of Water Resources (DWR), the Zimbabwe National Water Authority (ZINWA) and seven catchment councils are the statutory bodies entrusted with the sustainable management of water resources. All these fall under the umbrella of the Ministry of Water Resources Development and Management. The organisational structure for water management in Zimbabwe is shown in Figure. This structure was adopted in 2010.

The Department of Water Resources (DWR) is established in terms of the Water Act Chapter [20:24] No 31/98. Its principal role is to assist the Minister of Water Resources Development and Management in carrying out the following statutory mandate:

- To develop water policies, laws and regulations, and general directions to guide the orderly and integrated planning of the nation's water resources to ensure their optimum development, utilisation and protection.
- To ensure the availability of water to all citizens for primary purposes with due regard to environmental requirements.
- To ensure the equitable and efficient allocation of available water to all users.

The Zimbabwe National Water Authority (ZINWA) was established in terms of the ZINWA Act Chapter 20:25 No 11/98. The main source of funding for ZINWA's operation are fees revenues accruing from the sale of water from rivers and water supply facilities owned or managed by ZINWA, and fees charged for technical assistance, personnel, training, information and other services to government departments, local authorities, catchment councils, in connection with the exploitation, development, management and distribution of water resources.

ZINWA's requirements for financing capital expenditure for the development of water resources infrastructure are the responsibility of the Central Government through the Public Sector Investment Programme (PSIP).

ZINWA's head office is based in Harare. Each ZINWA Catchment Office is headed by a catchment manager. The catchment manager performs his duties under the direction of the catchment council, with supervision by ZINWA. The catchment manager's office provides technical and secretarial services to the respective catchment councils. It also supplies raw and clear water to farmers, mines, towns, growth points and other community settlements.

area of jurisdiction is divided into eight sub-hydrological zones (or tributaries of the main river system).

The main functions of ZINWA Save are to exploit, manage and conserve the nation's water resources in order to ensure security of supply, and to facilitate equitable access to water by all sectors, and its efficient utilisation, while minimising the impacts of drought, floods and other hazards.

Moreover, ZINWA Save should also provide specialist advice and technical assistance to local authorities and catchment councils in matters concerning the development, management and environmental protection of water resources as well as the design and construction services for new water works, and to operate and maintain water supply facilities. An essential part of this advisory service is to operate the hydrometeorological network and to carry out hydrological and geographical surveys for the purposes of planning, development and exploitation of water resources.

Approximately 20 hydrometric of which six stations also produce run-off data estimated to be in operation in the Buzi River Basin. Four rainfall and two evaporation monitoring stations are located in the Buzi River Basin i.e. in the sub-zones FB, FUZ, FLS of the Budzi sub-catchment and the sub-zones FM1 and FM2 of the Odzi sub-catchment.

A draft River Save Outline Plan (RSOP) is in place. The RSOP is a working document within the twenty years planning horizon (2005 to 2025). It is anticipated that this RSOP shall be up-dated every five years. The RSOP is based on the aspirations and plans of the sub-catchments councils

In the Save catchment there are a total of 3,304 water permits. Approximately 800 of these are estimated to be located in the Buzi River Basin. Total of groundwater permits are 157 of which 79 in Odzi and 22 in Budzi. It is often the case that one water user holds several permits and hence the number of permit holders is less than number of permits. Moreover, there is a permit database with 203 licensed discharge facilities for the Save catchment. The frequency of monitoring these facilities varies depending on the class of the permit. Water use permits are issued by the Save Catchment Council. The Save Catchment Council consists of 14 members made up of representatives of the eight sub-catchment councils, approximately two representatives from each SCC. Sub-catchment councils have their own offices and staff and are empowered to collect fees and levies from water users. Most of these fees and levies are transferred to ZINWA, which forms part of a national Water Fund. The sub-catchment councils then submit budgets for their annual running costs to this National Water Fund (RSOP,2009).

ZINWA Save has today nine managerial or senior technical positions that require a university degree (BSc or similar). In addition 35-40 support staff work at the head office in Mutare and more than one hundred staff are employed as observers for hydrometeorological stations and as water supply operators. Two members of the technical staff are women. At the moment the positions of the hydrologists and the hydrogeologist are vacant, which seriously hampers water resources monitoring and information management.

7.3 Stakeholders and their Roles and Interests

The national guidelines place a lot of focus on promoting stakeholder participation as part of the integrated water resources management. The stakeholder participation process is essential to enable implementation of national IWRM policies and strategies. Creating awareness of the principles of water resources management is one essential component for successful implementation. Moreover, the register of water users and stakeholders enables collection of water use and discharge fees.

Stakeholder participation entails three major regular activities, explicitly:

Stakeholder mapping: Mapping and registration of stakeholders in different categories.

Stakeholder consultation: Establishing and operationalization of stakeholder institutions with a fair representation of the identified stakeholders.

Stakeholder outreach: Developing and institutionalisation of procedures for dissemination of information, mobilisation and awareness creation.

Existing stakeholder inventories have been updated, consolidated and categorised for the purpose of the Buzi Monograph based on information collected during field visits and secondary sources. The classification used for the Buzi Monograph inventory is a structural-functional one showing the category and functional role of each stakeholder. The stakeholders in the Buzi River Basin have thus been classified into four different categories:

1. Government institutions. This category comprises line-ministries that have responsibility for natural resources management related to water (agriculture, mining, environment, etc.) or are otherwise directly involved with water (e.g. health). This group is important for cross-sectoral coordination in planning and development.
2. Non-governmental organisations. This category includes associations of farmers, environmental groups, women’s organisations, and relevant NGOs, etc. This group can be characterised by the fact that it is concerned with environmental aspects, small scale users and the population groups that are highly dependent on the eco-services of the watercourse for their subsistence livelihoods.
3. Water users/Water permit holders. This group includes the major water users in the basin, represented by the institutions or individuals that are the direct managers of the water they use. This includes the water permit holders and potential permit holders e.g. water supply companies, commercial farms, agriculture cooperatives and tourist facilities.
4. Parallel projects. This group is important to map in order to create synergies and avoid gaps and overlaps for planned interventions.

Further subdivisions within these broad categories for the Buzi River Basin are:

<p>Government Institutions/Public Sector</p> <ul style="list-style-type: none"> ▪ National level ▪ Provincial/Regional level ▪ District level ▪ Municipalities ▪ Education and research institutions ▪ Water utilities/water works 	<p>Private Sector/Water Users</p> <ul style="list-style-type: none"> ▪ Agriculture ▪ Mining ▪ Tourism and commerce ▪ Environment, wildlife and conservation ▪ Forestry ▪ Livestock and fishery ▪ Energy and industries
<p>Civil Society</p> <ul style="list-style-type: none"> ▪ NGOs ▪ CBOs ▪ Associations and unions ▪ Faith organisations 	<p>Parallel Projects:</p> <ul style="list-style-type: none"> ▪ Institutional strengthening support programmes ▪ Socio-economic development programmes

Administratively, in Mozambique, the Buzi River Basin covers two provinces, eight districts and 29 wards (Administrative Posts). In Zimbabwe, the Buzi River Basin is situated in the Manicaland Province and covers the following districts: Mutare Rural, Chimanimani, Chipinge Urban and Rural. For effective coordination, the main sectors of water, physical planning, agriculture, mining and environment should be represented at each level. The inventory, as per 2010, has thus identified some 60 stakeholder representatives in Mozambique and 20-30 in Zimbabwe from government institutions to be informed and involved in the management of the Buzi River Basin.

Around 20 representatives of the civil society including associations and unions have been identified for each country. It should be noted however that in Zimbabwe all NGOs involved with water are

organised under the National WASH Cluster (Water Sanitation and Hygiene Cluster) under the lead of UNICEF and the Ministry of Water. The WASH organisation is thus regarded as the key stakeholder representative, which would be the link between the ZINWA Save and the individual NGOs and responsible to convey the aspirations of the individual NGOs.

Information of the water users that are permit holders have been retrieved from the Buzi BU of the ARA-Centro in Mozambique and from the ZINWA-Save registry of permit holders located in the subzones FM1 and FM2 (Odzi sub-catchment) and subzones FLS, FB and FUZ (Budzi sub-catchment) in Zimbabwe. From these records some 20 representatives in Mozambique and some 50 representatives in Zimbabwe of the key water users and permit holders have been identified. These constitute a representative fraction of the actual water users in the basin.

In Mozambique, there are several new private investors starting operations in the basin, mainly related to commercial forestry (mainly bio-energy and fruit), and medium size agriculture that will require regular updating and outreach activities by the Buzi BU. The involvement of private investors is crucial for the design and future implementation of the integrated water resource management strategies especially in Mozambique where there is a demand for many small and medium sized dams.



Figure 7-3 : Buzi River Basin 2010.

In the Eastern Highlands in Zimbabwe, which is characterised by very high rainfall, there are large plantations specialising in forestry, wattle, tea, and coffee, fruits, barley and potato production. The major companies being Tanganda Tea estates, Wattle Company, Border Timbers and the Forestry Commission.

The stakeholder information presented for the Buzi River Basin in Mozambique is a snapshot in time and a starting point for a more permanent and dynamic stakeholder database maintained by ARA-Centro. Also ZINWA-Save may have to update its

stakeholder database since major changes have occurred the last ten years in terms of demography and socio-economic status of the permit holders. One example of the consequence of the recent demographic change is given in the Save RSOP. It is stated that although in the 1980s and 1990s there was a high demand of water in the Save catchment, that is no longer the case. The land reform has seen most farms being subdivided into smaller plots resulting in most farmers being located away from the river system and hence the apparent increase in the demand of ground water at the expense of surface water.

7.3.1 Stakeholder Involvement in Mozambique

In Mozambique the Water Law of 1991 only provides for stakeholder consultation in water resources management. The main form in which stakeholder participation takes place in Mozambique is in the Basin Committees, which only have a consultative role. The Buzi Basin Committee (BBC) is in the process of being established. The stakeholder representatives for the BBC have been selected and the formal establishment is planned for early 2011. 20 members have been proposed with representation from the two provincial governments (Sofala and Manica); the district governmental level; civil society; the private sector (industry and commerce); and large, medium and small scale farmers.

The operational guidelines and internal regulation are not yet in place for the BBC but a similar set-up the Pungwe RBC is anticipated. The internal regulations specify the number and timing of meetings to be held on a yearly basis and the mandate and functions of



Figure 7-4 : Aguas de Chimoio. 2010

the RBC. The main purpose of the BBC will be to make every effort to optimize the water use in the basin, minimising damages and conserving the environmental balance in the basin. The BBC will mainly have an advisory role on basin planning issues but will also constitute an important channel for communication, conflict resolution and awareness creation/outreach.

One has to recognise that it will take some time to build the knowledge and experience of the BBC members to efficiently participate in the basin planning and local promotion of IWRM. A major challenge that can be expected is for the BBC to follow up on their agreed strategic actions made by the BBC. This would mainly be related to the lack of resources for monitoring trips within the sub-basins but also due to lack of confidence in the new role. To assume the new roles and responsibilities is demanding and the management change process needs institutional support, which is generally non-existent. Apart from financial support the newly established BBC will need access to information regarding the IWRM concepts legislation, rights and responsibilities of different players and water resources information.

7.3.2 Stakeholder Involvement in Zimbabwe

Stakeholder participation in Zimbabwe centres on the concept of devolution of powers to the lowest appropriate management level. The water users and stakeholders are through the CCs and SCCs part and parcel of the allocation and management of the water resources through their powers of granting and/or revoking permits, collecting fees, undertaking compliance monitoring as well as formulating catchment/sub-catchment plans. Hence, stakeholder involvement in Zimbabwe is extensive in terms of inclusiveness; fully institutionalised in terms of structures and procedures; and far-reaching in terms of powers.

Consequently, the legislation provides for wide participation of both line-Ministries and water users in actual decision-making.

Stakeholder involvement in Zimbabwe for the management of the Buzi River Basin is undertaken through the Odzi and Budzi SCCs. The Budzi and Odzi SCC are expected to consist of approximately 15 elected representatives of the stakeholder groups in their respective areas. The Odzi SCC is composed of representatives from city of Mutare, rural service centres, small scale and large scale commercial farmers, communal farmers and institutions. The Budzi SCC is composed of representatives of small scale farmers; communal farmers; large estates such as Tanganda, Forestry Commission, Wattle Co and Border Timbers; rural service centres; institutions and the town of Chipinge (RSOP, 2009). Each SCC has a chairman, vice chairman, treasurer and secretary.

The aspirations of the Odzi and Budzi SCCs have been presented in the Save RSOP. The priority concerns and interests of the Odzi SCC are the need to employ strategies to curb gold panning; develop alternative water sources that will augment supply of water to rural service centres; and to develop a strategy to effectively control pollution from Mutare City, growth points, mines and factories. For the Budzi SCC the priority concerns are the wish for exploitation of the huge ground water resources for both primary and irrigation projects; development of small projects to cater for the proposed micro- fishing and irrigation projects in communal and small scale farming as they are cheaper and affordable; implementation of strategies to curb pollution discharges from the estates and Chipinge Town. Private sector involvement in the development of water resources on a cost recovery basis is an issue under discussion.

The current challenges related to the SCC level, are the difficulty of collecting fees, undertaking compliance monitoring and catchment protection. Cooperation with police is sought to support the CC and SCCs in chasing unlawful behaviour with regards to effluents discharge, illegal logging and general environmental destruction caused by artisanal miners.

7.3.3 Summary

The concept of stakeholder involvement in the management of the water resources at basin level is supported by legislation in both countries, although only limited to a consultative role in Mozambique. Regardless of differences in designated decision-making powers of the stakeholders in water management, stakeholder mapping, outreach and consultation are part of the mandated functions of the ARA-Centro and the ZINWA-Save. Stakeholder information is dynamic and needs to be regularly updated by the basin organization and be an integral part of the future basin

Enhanced Knowledge Information System (EKIS). A major review of the stakeholders is commonly undertaken every 5-10 years.

7.4 On-going Initiatives

There are a number of on-going and planned projects, which will have a bearing on the joint management and sustainable development of the Buzi River Basin. The on-going and planned major interventions can be divided into two categories:

1. Institutional support interventions - to advance water management tools, procedures and capacities and improve water governance in general and transboundary water management in particular.
2. Development oriented projects - with direct investments on the ground. The mapping of these projects is relevant for the purpose of the scenario development which looks into future probable water situations for a period up to year 2030.

Development oriented projects and planned investments are discussed in Chapter 8: Basin Development Scenarios. This section provides details of the on-going institutional support projects with direct links to the implementing agencies, i.e. ARA-Centro and ZINWA-Save, and the transboundary management of the shared river basins.

The SADC Secretariat through its Water Division has a mandate to support and coordinate regional cooperation in water resources and support the establishment of River Basin Organisations (RBOs). The on-going implementation of the **Shared Watercourses Support Project (SWCSP) for the Buzi, Ruvuma and Save River Basins** (2007-2012) is coordinated by the SADC Secretariat under the auspices of the national water ministries and with support from AfDB. The rationale for the institutional support is the need to initiate effective cooperation between the riparian Member States to implement the SADC Protocol on Shared Watercourses. The multi-level programme addresses all focal dimensions of the RSAP i.e. water resources planning, capacity building, water governance and infrastructure development.

This on-going project builds on and is coordinated with parallel institutional support interventions. For instance, the two organisations have benefitted and are, in some cases, still benefitting from the following parallel projects i) the Pungwe Project financed by Sida (Asdi), the FEWSNET project financed by USAID, and the GTZ support to the INGC for disaster response in the Buzi Basin and the SADC HYCOS project.

Water resources management in the Buzi River Basin cannot be discussed without reference to the Pungwe Projects. In 2002 to 2007 ARA-Centro and ZINWA-Save were supported through the Pungwe Project funded by Sweden. Besides base-line studies and development of a Joint IWRM Strategy for the Pungwe River, this project was also focused on institutional capacity building. The Pungwe Project was a combination of long-term institutional support through an expatriate person stationed in Beira and international and local expertise for studies and training. The government of Sweden has in 2008 initiated the continuation of the Pungwe Project (PP2), which aims to implement some aspects of the joint IWRM strategy for the Pungwe River. This project is more focused on institutional support with five long-term experts stationed in Beira for advisory support and procurement of services.

Many of the main activities, such as training and purchase of equipment, are planned to start on larger scale in the beginning of 2011. Coordination with the parallel Pungwe project is therefore essential for the areas of capacity development and EKIS. Experience gained by the organisations on basin planning will benefit the strategic planning of the Buzi and Save Basins.

In addition to the above noted institutional support programmes, a number of technical studies and other activities to strengthen the early warning systems for floods and cyclones have been conducted for the Buzi River Basin supported by international donors (USAID, GTZ and the Munich Re Foundation etc.), e.g.: the rehabilitation of hydrometric network in Buzi for flood forecasting (Figure 7-5 and Figure 7-6); and training and implementation of flood forecasting in the Save and

Buzi rivers via (Famine Early Warning System) FEWSNET. GTZ has assisted INGC in developing detailed maps of high risk areas as well as elevated ground for emergency evacuation in the highly flood prone Buzi District in the lower part of the basin. Local Disaster Management Committees (Gestão de Risco de Calamidades – GRCs) have moreover been established in all nine communities in the Buzi District, with the role of fulfilling specific tasks in case of an emergency. Seven monitoring stations on the upper course of the Buzi and its affluents have been set up. Rainfall and the river level are measured daily using simple and robust equipment.

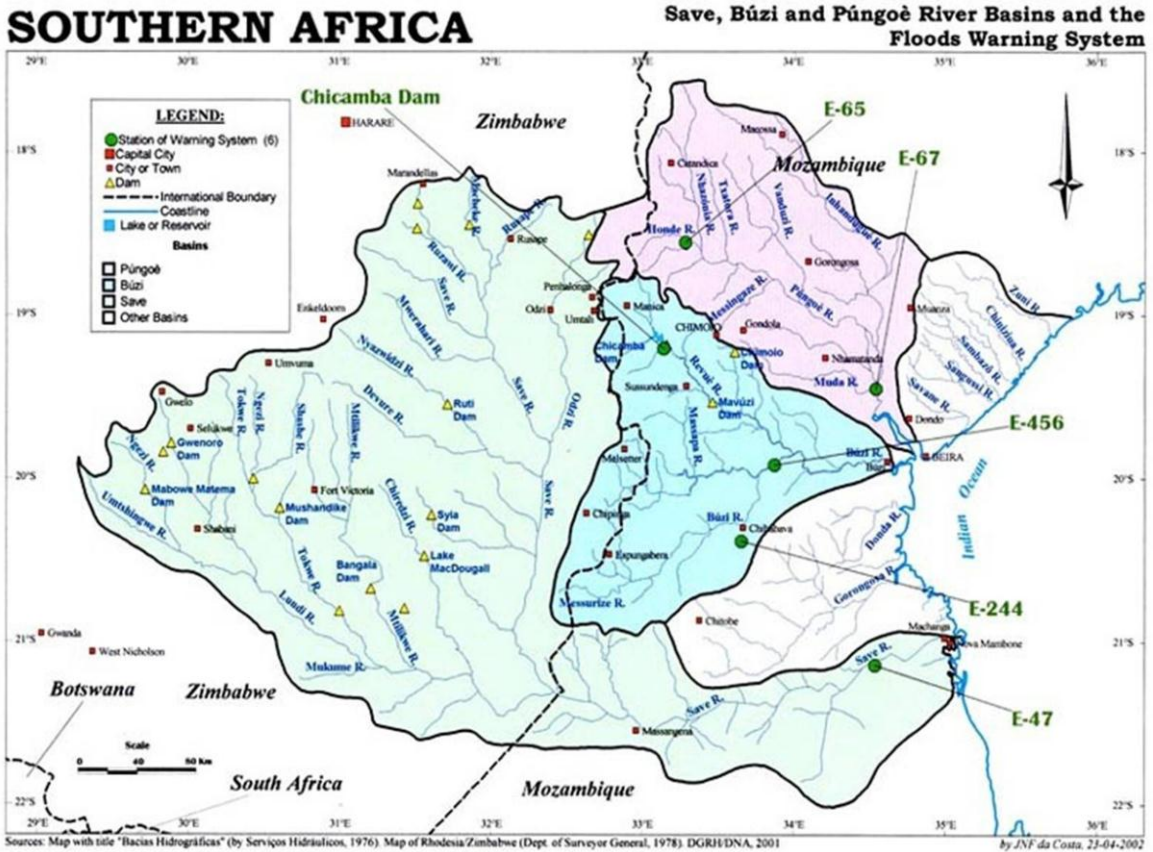


Figure 7-5: Buzi, Save and Pungwe Flood Warning System.

Source: ARA-Centro, 2010



Figure 7-6: Buzi Flood Warning System. The yellow dots are the upstream monitoring stations and the red dots are the response centres in flood-prone areas.

In Zimbabwe, the on-going institutional restructuring must be considered especially with regards to IWRM Strategy formulation phase.

7.5 IRBM implementation

There is currently a strong effort in both Mozambique and Zimbabwe to advance water management through the application of the IWRM/IRBM principles in accordance with international conventions and regional directives i.e. SADC Revised Protocol for Shared Watercourses and the SADC Regional Water Policy and Strategy. The result of this effort is reflected in the national policies and legal documents. However, practical implementation of IRBM is still a challenge. High performance of the following three dimensions is essential for efficient implementation of IWRM/IRBM, explicitly:

- the enabling environment,
- the institutions; and
- the management.

In order to review the degree of IWRM/IRBM, an analysis of IWRM related indicators have been undertaken. The indicators are divided into three categories, explicitly:

- IRBM Outcome Indicators
- Performance indicators for Transboundary Water Resources Management (TWRM)
- Performance indicators for regional water authorities

7.5.1 IRBM Objectives and Outcomes

Success in IWRM/IRBM must ultimately be measured by improvements on the ground. IWRM/IRBM objectives relates closely to progress in achieving other national goals as stated in e.g. Poverty Reduction Strategic Papers (PRSPs). It should be noted though that the progress in achieving set targets is attributed the combine synergy effect of a broad range of national actions of which IWRM implementation is one of the prerequisites .

The desirable outcomes of IWRM are to ensure:

- Water for meeting basic needs (domestic use and food security);
- Water for socio-economic development (agriculture, energy and industry);
- Water for vital ecosystems and sustained ecosystem services; and
- Reduced water related vulnerability (Extreme water related events and climate variability).

Under each objective area, indicators have been defined. Examples of measurable indicators are:

- i. proportion of total water resources used;
- ii. balance of use between states;
- iii. water efficiency index for major sectors;
- iv. economic impact of flooding and drought; and
- v. EIA performance.

Specific indicators have been defined for vulnerability. In summary, the applied indicators and baseline values obtained on IWRM outcomes indicate that increased investment in water infrastructure and improved efficiency of water resources management in the Buzi River Basin would be essential to make further progress towards the desirable outcomes of a healthy river basin system and optimal, sustainable and equitable use/access of the basin's water resources.

Moreover the review indicates that the vulnerability in the Buzi River Basin mainly relates to climatic events of flooding and cyclones, the lack of adequate levels of water storage, regulating and supply infrastructure; and low management capacity (resulting in low service efficiency). The vulnerability is amplified by the low resilience of the population due to poverty and small margins.

Table 7-4 : Vulnerability base-line of the Buzi River Basin in relation to water resources.

Indicator Area	Parameter (variability & trends)	Summary Buzi	Vulnerability indicator	Summary Buzi	
Physiographic	Climate	<ul style="list-style-type: none"> Rainfall, Evapo-transpiration 	<ul style="list-style-type: none"> MAP: varies between 900-1.300 mm/year; MAE: varies between 1,400 - 1,100 mm/year from east to west The amount of rainfall varies significantly from year to year, and during a very dry year the rainfall generates almost no runoff peaks in the rivers due to the high temperature and hence high evaporation.. The coast is a cyclone prone area Climate change trends: Forecasted increase in rainfall during the rainy season. Rainfall is assumed to increase with 10-25% up to 2060. During the predicted increase in evapotranspiration, will mean drier and possibly longer dry seasons. 	<ul style="list-style-type: none"> Water availability Desertification Storage and supply infrastructure 	<ul style="list-style-type: none"> Water availability is high although the south east part of Buzi on the Zimbabwe side generally dry Regular flooding and cyclones is a problem in Mozambique Rainfall variability high Seasonal variability will change due to climate change Low and not adequate level of storage and water supply infrastructures especially on the Mozambique side
	Ecosystems	<ul style="list-style-type: none"> Water dependency, Landcover, Landuse 	<ul style="list-style-type: none"> Medium biodiversity with high water dependency. Estimated EFR at estuary 29% Proportion of land area covered by forest and woodland areas is high (37% forest, 40% grass and shrubland.) Proportion of terrestrial areas protected (Vumba reserve (201 ha), Chimanimani Reserve (unknown)) 		
	Hydrology	<ul style="list-style-type: none"> Streamflow Storage, Quality 	<ul style="list-style-type: none"> MAR: 5,685 million m³/year at the river mouth Floods and cyclones frequent in the lower parts of the basin. Extensive flooding in 2000, 2007, 2008 and 2010 Chicamba Dam 2000Mm³ and Mavuzi dam 1,8Mm³, Mozambique. WQ locally not within acceptable range Climate change trends predict higher run-off in lower parts. With no dams it will be difficult to take advantage of this positive trend. 		
	Hydro-geology	<ul style="list-style-type: none"> Yield, Recharge 	<ul style="list-style-type: none"> 50% of the basin has a 'moderate' to 'high' groundwater potential. 50% of the basin has a 'very low' groundwater potential Recharge is approximately 2 500 Mm³/a (8 % of MAP). The Buzi River Basin groundwater potential, as a function of recharge, is approximately 1,340 Mm³/a (i.e. 53% of recharge). 		
Socio-economy	Demography	<ul style="list-style-type: none"> Population size and distribution, Water related diseases and HIV/AIDS 	<ul style="list-style-type: none"> Approx. 1 260 000 basin people: approximately 200 000 people in Zimbabwe and 1 060 000 people in Mozambique. Poverty incidence in Mozambique in 2005 was 42-44% in the Sofala Province; and 52% in the Manica Province. In Mozambique, a comparison of health and related indicators shows that the central region of Mozambique ranks lower than the southern region of the country, but higher than the northern region. 	<ul style="list-style-type: none"> Population density and growth Poverty 	<ul style="list-style-type: none"> Population density moderate Populated areas in flood prone areas Poverty approximately as national average Mainly rural population with small margins

		<ul style="list-style-type: none"> ▪ Poverty incidence in Zimbabwe in 2003 was 64% in Chimanimani, 53% in Chipinge and 62% in Mutare Rural ▪ High prevalence of malaria and diarrhoea, Manica Province, Mozambique. ▪ Manicaland province had the highest number of diarrhoea and dysentery cases in Zimbabwe in 2008. Mutare, Chipinge and Chimanimani districts were rated among the top 20 districts in the country with high malaria cases. Manicaland Province has the second highest number of new AIDS cases out of the ten provinces in the country. 		<ul style="list-style-type: none"> ▪ Demography and socio-economics have undergone recent changes on the Zimbabwe side
Economy	<ul style="list-style-type: none"> ▪ Water Demand, ▪ Water Supply, ▪ Value of Water 	<ul style="list-style-type: none"> ▪ Current water demand/ use is only 4 % of the natural MAR. Water demand is estimated to increase to 23% by 2030. Environmental Flow Requirement is estimated to 29% of MAR by the estuary ▪ Mozambique water demand/use is only 15% of the current water demand/use in Zimbabwe. ▪ Only two dams for productive uses. ▪ Access to safe potable water in the Buzi basin in Mozambique differs by district between 4-17% whilst the use of unprotected sources is between 50% -70%. In Zimbabwe the access of protected sources within 1km is as follows: Mutare Rural 60%; Chimanimani and Chipinge 75%. ▪ WDM is practiced to some extent by differentiated water pricing in Zimbabwe and Mozambique. Efficiency in water use is still low. 	<ul style="list-style-type: none"> ▪ Water use ▪ Access to water ▪ Conflicts 	<ul style="list-style-type: none"> ▪ Low level of water demand/use ▪ Low level of access to water ▪ Low level of water related conflicts

Management	Legislation	<ul style="list-style-type: none"> ▪ Policies ▪ Acts ▪ Regulations ▪ Guidelines 	<ul style="list-style-type: none"> ▪ IWRM policies, water acts, regulations and guidelines in place. ▪ International agreements transposed to national law. ▪ EIA regulations in place 	<ul style="list-style-type: none"> ▪ Adaptive capacity 	<ul style="list-style-type: none"> ▪ Low to moderate adaptive capacity ▪ Weak enforcement of water related legislation ▪ Low service efficiency and low capacity to undertake mandated functions ▪ Fragmented and inadequate water resources information
	Institutional	<ul style="list-style-type: none"> ▪ Adherence to IWRM principles ▪ Human resources 	<ul style="list-style-type: none"> ▪ Trend is positive but there is a capacity problem with regard to practical implementation of IWRM. ▪ Low service efficiency in terms of water monitoring and provision of information, water management and protection. ▪ Funding together with human resources is a major constrain. Few water permit holders in Mozambique. Low current use of water in Zimbabwe. Both ARA-Centro and ZINWA-Save operate on scarce funds at the moment. ▪ Monitoring infrastructure and related equipment are degraded and not adequate compared to WMO guidelines 		
	Knowledge	<ul style="list-style-type: none"> ▪ Literature/Reports 	<ul style="list-style-type: none"> ▪ Key information on water resource management indicators data compiled in the River Save Outline Plan in Zimbabwe ▪ Water resources information management and dissemination is not adequate for efficient integrated river basin management. ▪ Low degree of field work/presence 		

Source: Sweco review based on UNEP2005

7.5.2 Transboundary Water Resources Management

Mozambique and Zimbabwe are parties of the SADC Protocol on Shared Watercourses. To this end, the Buzi Transboundary Water Resources Management (TWRM) performance indicators give an indication of the degree of implementation with regard to the SADC Protocol on Shared Watercourses. Pertinent to the transboundary dimension, the review has thus assessed the capacity of the current mechanisms to deal with general transboundary management functions.

With regards to the current legal and institutional mechanisms for TWRM it can be concluded that the enabling transboundary governance framework is in place in terms of international (general) agreements and institutions. The next step required will be to formulate and achieve consensus on the planned Joint IWRM Strategy and thereafter negotiate a comprehensive bi-lateral agreement covering the three adjacent shared rivers, explicitly the Buzi, Pungwe and Save Rivers. A specific and more precise transboundary governance framework is required for the management of the shared Buzi River Basin especially with regards to flood management, EWS, pollution control and development of water-related infrastructure. These areas call for cross-border dialogue and formulation of specific procedures. Mozambique and Zimbabwe has experience of management shared water courses and a Joint Water Commission (JWC) is in place however the joint water cooperation mechanisms would need further strengthening to practically implement the agreed procedures and functions and to undertake compliance monitoring in the Buzi River Basin.

It would be necessary to design minimal joint water management activities so as not to take resources from the national management. The water sharing agreement should thus focus on the principles of prevention of harm, precaution, and equitable and reasonable utilisation.

To this end it is recommended that the water sharing agreement provides detailed procedures for:

- Water allocation between countries and if deemed relevant also between sectors as guided by the SADC Protocol on Shared Watercourses. One “sector” of concern would be the environmental requirements;
- Water development including procedures for prior-notification of works which may have transboundary affect;
- Access to and exchange of hydrological information including procedures for compliance monitoring (flows at the borders and WQ at the borders and downstream agreed points of interest) but also for emergency situations;
- Institutional roles and procedures for communication; and
- Priority areas of cooperation e.g. related to floods and pollution control.

The two governments have also committed to harmonise national policy and related legislation in accordance with the terms in SADC Revised Protocol and Regional Water Policy. In both countries major efforts have been made to harmonise national legislation in accordance with the terms in regional, bi-lateral or multi-lateral agreements signed and ratified by the two governments. Recent national water reforms have incorporated the minimum required legal provisions necessary for TWRM i.e.: decentralisation through catchment institutions; water allocation and water licensing criteria; water pricing; water quality standards; pollution control; and EIA legislation. Zimbabwe has though not yet transposed the SADC Revised Protocol to national law.

Some further harmonization is desirable also at national level for instance considering some gaps and overlaps with regards to institutional mandates especially in Mozambique. Still, the major challenge at the moment is not so much related to further development of and harmonisation of national legislation but more so related to the coordinated enforcement of the current legislation. This is the main priority in order to be able to fulfil with bi-lateral agreements and ensure a sustainable use and development of the shared water course.

7.5.3 Performance indicators for river basin organisations

These performance indicators are directly linked to the mandated functions of the ARA-Centro and ZINWA Save and indicate degree of institutional establishment, capacity and service efficiency. The indicators furthermore give an indication of the level of IRBM implementation in practice compared

to the commitments made by the two countries through the SADC Regional Water Policy and national water policies.

The review is based on the CAP-NET indicators, which have however been adapted to the local context including the transboundary dimension. In addition, the study has addressed the degree to which cross-cutting aspects (HIV/AIDS, gender, poverty and environmental issues) are currently assumed by the basin management organizations. Thus, the functions of river basin organisations looked at in this study include: water allocation; pollution control; basin planning; monitoring; information management; economic and financial management; stakeholder participation; flood and drought management; and cross-cutting aspects (HIV/AIDS, gender and poverty). The service efficiency and practical implementation of the IWRM principles are further described below for each function.

Water Allocation

Water availability is good both in Mozambique and Zimbabwe and water licences are so far granted without any restrictions.

In Mozambique, licensing for water use is mainly the responsibility the ARAs. However, the Ministry of Mineral Resources also issue licenses that have an impact on water management, particularly regarding abstraction of sand and gravel from river beds as construction materials and abstraction of mineral water. Licensing by the Ministry of Mineral Resources of mineral water abstraction implies a previous consultation with the respective ARA but does not lead to any payment for this water use. In spite of the legal obligation of previous consultation, cross-sectoral coordination is still limited and, in this particular case (licenses issued by the Ministry of Mineral Resources) this becomes evident not only during the licensing stage but even more during the operation, when monitoring by the MRM is almost non-existent.

In Zimbabwe, water is allocated by sub-catchment councils with full stakeholder representation and allocation guidelines, to ensure sustainable and equitable use of water between sectors, are in place. The guiding principles for water allocation are stated in the Save RSOP. Maximum permit volume for each sector, within each sub-catchment, is determined in the RSOP. Guidelines for short term allocation in case of droughts are also specified in the RSOP. Moreover, ZINWA Save CC should make recommendations to declare water restriction areas if the CC is of the opinion that the use of water in the Catchment area is approaching the limit of the potential of the catchment area (RSOP, 2009).

Water allocation for the basic needs is supported by law in both countries although access is low due to poor coverage of infrastructure.



Figure 7-7 : Agriculture in the Buzi River Basin.

Pollution Control

No pollution control is undertaken in Mozambique. No discharge permits have been issued by the ARA-Centro or by the provincial arm of the MICOA although pollution control and granting of effluent permits are mandated functions given by law to both institutions. Hence the polluter-pay-principle is not enforced. The mapping of polluting activities has started but monitoring is very limited and basically non-existent.

In Zimbabwe, the major polluters are known and are managed through a permit system. The discharge permit system is based on self-monitoring. Enforcement is still a problem. Compliance monitoring requires major resources and currently field work is hampered by scarce operational funds. There has also been a discussion that the penalties are too low to act as a deterrent. It should be noted however, that prosecutions against polluters have been made where the polluter has lost the case in favour of Save catchment. The recently formed Environmental Management Agency has taken over pollution control from ZINWA. The effectiveness of coordination with the water authorities will be tested over time.

With regards to the general water quality monitoring of rivers, it can be concluded that there are no monitoring points in the Buzi part of the Odzi Sub-catchment and that three or four monitoring points are situated in the Budzi sub-catchment. No groundwater water quality monitoring programme is in place. This function has also recently been transferred to EMA.

Basin Planning

The performance objective for this function is to undertake basin planning that synthesises technical and social priorities for the basin and acts as a basis for action and accountability to the stakeholders. No such basin plans are in place for the Buzi and Save River Basins in Mozambique. In addition to the long term strategic plan, an essential tool is the three year rolling business plan which should include measurable annual targets and clear priority ranking of activities. Such plan is also not in place at ARA-Centro. In Zimbabwe, the draft RSOP has been developed based on the aspirations and concerns of the sub-catchments councils. It provides key water resources information, looks at future potential and challenges and the strategic focus for a 20 year period.

Monitoring

Knowledge on water resources is not adequate for efficient management. The limited amount of water resources information is linked to the poor monitoring network (mainly Mozambique), inadequate equipment, software, and vehicles as well as lack of procedures including monitoring programmes and data management. For river flow monitoring no functioning runoff stations exist in Mozambique. Only Chicamba dam (EDM) is producing runoff records. Major upgrading of the monitoring network is required to comply with WMO's recommendations for "minimum required network" mainly in Mozambique but also in Zimbabwe as presented in detail in the EKIS report. In terms of vehicles and equipment ARA-Centro has reached a basic level. However, considering the vast area to cover, the available human resources are in general too small. During the last few years very little work in the field has been conducted in the Mozambican parts of the Buzi Basin.

In Zimbabwe, in terms of capacity for hydrometeorological monitoring, the ZINWA Save office is currently hampered by lack of capacity in terms of human and financial resources. However, for river flow monitoring the ZINWA organisation still benefits from a long history of good water resources monitoring. Many of the runoff stations are constructed weirs, although many of them need minor repairs, and the network of observers still exist.

No groundwater monitoring programmes are in place either in Mozambique or in Zimbabwe. There is no water quality monitoring programme in place in Mozambique and there are some gaps in the monitoring programme in Zimbabwe. The transfer of the ambient monitoring program to EMA is likely to introduce problems related to disintegrated planning and management.

In Mozambique, the capacity for compliance monitoring is weak and basically non-existent and the system of self-monitoring is not practiced. In Zimbabwe, the system of self-monitoring is practiced both for water use and discharge permits. Reliable measuring devices are supposed to be installed by every water user so as to be able to know actual water consumption.

Economic and Financial Management

The management objective is that pollution is reduced and water use efficiency is increased through the use of economic and financial instruments. In Mozambique, tariffs can be negotiated at basin level but willingness to pay is low and legislation not fully supportive. The application of current water tariffs is believed to have little influence on improving the water use efficiency in the Buzi basin in Mozambique. Capacity to chase up non-payments is low. Enforcement tools are not very supportive. There is a long way to go before the management objective is achieved in the Buzi basin in Mozambique.

With regards to the economic and financial management, it can be concluded that revenues from water user fees currently constitute a token part for financing of the operational work of water resources management in the Buzi Basin. This is mainly because of the limited number of major water permit holders in Mozambique. This situation will remain for many years and governmental support will be necessary to ensure efficient implementation of IRBM and sustainable development of the Buzi River Basin for many years to come.

Zimbabwe is at an advanced level in using economic and financial instruments in the effort to achieve the management objective to reduce pollution and increase water use efficiency. In addition to the use of permit systems one instrument is the system of marginal cost pricing where the price of water is equal to the marginal cost of supplying the last unit of that water. Under conditions of scarcity, excessive water use is obviously undesirable and comes at a high social cost (RSOP, 2009). The revenues from water user fees are currently not sufficient for the operational costs. This is mainly because of the recent dip in water use and the difficulty of the permit holders to settle their invoices in Zimbabwe but also due the changed socio-economic status of the permit holders. ZINWA's billing and collection has also been affected due to institutional challenges resulting from the dip in general national economic performance.

Information Management

The objective of this function is that essential information is processed and packaged at the right level for specific managers and stakeholders to support transparent decision making and to gain commitment and political support for the decisions made. As described in detail in the parallel EKIS Concept report and here briefly summarised, the normal procedure in both countries is that the regional water authorities are responsible for the monitoring and collection of data in the field, while these data are sent to the national organisations in Harare and Maputo for further compilation and data management. The management of geographically based data and information is only available today at the national level. A general feature at both national and regional level is the lack of overall IT infrastructure and organisation to maintain it. The result of this lack of IT maintenance is that much data and information is lost. Consistent problems with virus create problems with using certain software and even some hardware such as computers and printers. The general poor capacity in IT also means that back-up is mainly conducted by individual staff rather than a central IT department.

Flood and Drought Management

Knowledge of inundation areas for different flood magnitudes is satisfactory even though it is mainly based on empirical knowledge rather than modelling. A functioning flood warning system is in place in the Buzi Basin in Mozambique. Communication procedures with Zimbabwe in case of floods are moreover in place. The challenges are at the operational level. The early warning system is recently installed with international assistance and it is essential that sufficient attention and resources are directed towards maintenance and operation of the system.



Figure 7-8 : Flood management 2010.

Water Infrastructure Development

ARA Centro has a responsibility for the planning, design, construction, operation and maintenance of hydraulic infrastructure. As previously mentioned, ARA-Centro only has the capacity to undertake

these functions for smaller units. No information has been obtained on any on-going activities related to water infrastructure development driven by the ARA Centro.

ZINWA-Save has a responsibility to provide design and construction services for new water works, and to operate and maintain water supply facilities owned or managed by ZINWA. ZINWA-Save owns and manages a few dams and a number of water supply systems for instance Chipinge is currently utilizing water from Bangazaan dam, owned by ZINWA. The only planned water infrastructure development has been identified for study area, explicitly the proposed Mirror dam, to cater for the future water requirements of Chipinge. In the wider Save Catchment, ZINWA Save operates approximately 160 water supply stations.



Figure 7-9 : Chicamba Dam.

Public-private partnership guidelines for water infrastructure development have been developed in both countries.

Cross-cutting Issues

Cross-cutting issues are not a core function of RBOs. However, it is by now generally accepted that cross-cutting aspects are interlinked with the water sector and thus need continued attention by the regional water authorities. Direct linkages between poverty and environmental degradation on the one hand, and the importance of healthy ecosystems for the subsistence livelihoods, on the other hand, are evident from many studies. Studies show that increased involvement of women in the provision of water services has a positive impact on the sustainability of such services. Access to clean water and food security can assist in keeping HIV/AIDS-affected people healthy and economically active. Setting clear indicators and targets is an important aspect of translating policy to practical implementation. Thus, specific indicators have been developed under this project to highlight important cross-cutting aspects.

Gender Mainstreaming

With regards to gender, the Statutes of ARA-Centro aim for the participation of all users which is inclusive of women. No national guidelines for the composition and gender balance of river basin committees exist in Mozambique. ARA-Centro, has prepared basin specific guidelines for the stakeholder participation in the basin which declare the importance of increased female representation. However, they give no specific targets for gender balance.



Figure 7-10 : Buzi River Basin 2010.

In Zimbabwe, specific gender strategies are stated in the draft RSOP. Still no guidelines or targets are put in writing of the desirable or compulsory proportion of staff and/or stakeholder representatives that must be women. Few water managers and stakeholder representatives at basin level are women.

Going from incorporating gender issues in policies to establishing specific regulatory provisions and standardised procedures, is a major step towards practical implementation of gender mainstreaming in the water sector and in this regard Tanzania is ahead of Mozambique and Zimbabwe. In Tanzania, national regulatory/procedural provisions state the percentage of female representation at various levels of management and decision making.

HIV/AIDS

HIV/AIDS policy linked to water resources management is in place but the degree of practical implementation and number of staff trained and familiar of HIV/AIDS policies, rights and obligation is uncertain and it is the Consultant's impression gathered from cooperation with the ARA Centro and the ZINWA Save that it is low.

It would be essential to ensure HIV/AIDS is mainstreamed into human resources, through approval and implementation of their respective HIV/AIDS policies.

Environmental aspects

The guidelines of both organisations, declare that services should aim for the protection of the environment. The baseline data in relation to these indicators show a major need for improvements. Cross-sectoral coordination with the ministries of environment, mines, agriculture and forestry is also called for to support solutions for local environmental degradation problems which have negative impacts on the water course. Cross-sectoral cooperation is also needed in order to improve the performance and effectiveness of EIAs.

Poverty, Equity and Pro-Poor Management

Meeting high professional standards in the management of the water resources of the basin does not by itself ensure that the rural poor and the vulnerable groups will benefit from excellence in water resources management. IRBM and basin planning is usually not concerned with detailed planning and management of small-scale development projects. However, water resources investments can be planned to ensure pro-poor benefits. Development planning should also consider social safeguarding policies and include mitigation measures of any negative impacts on the poor and vulnerable strata of the population.

Summary

The review and application of indicators show that initial steps have been taken towards implementation of IWRM in the Buzi River Basin in Mozambique. The Buzi BU of the ARA-Centro and the Buzi Basin Committee are under establishment and important functions have been embarked on such as the mapping, registration and licensing of surface water users and intensified stakeholder communication in the Buzi Basin. On the other hand, the indicators also show that essential parts of IWRM are still missing. Surface water monitoring, a key for efficient IWRM, is still lacking sufficient coverage. Collection and storage of hydro-meteorological data is undertaken at a very rudimentary level and is not adequate for water resources assessment and planning. Examples of important functions that are not as yet undertaken are compliance monitoring of actual use, groundwater monitoring and pollution control.

The ARA-Centro currently lacks sufficient capacity for the basic requirements set down in the statutes. The main reason is limited number of competent staff, lack of basic infrastructure and vehicles, insufficient operational funding, limited number of registered and paying water users, etc.

In summary for Mozambique, the enabling environment in terms of policy and legal provisions is satisfactory. The degree of institutional establishment is judged to have reached a basic level while practical implementation of IRBM in the Buzi River Basin is still a challenge. IWRM/IRBM requires major human and financial resources. Even though human and financial resources will slowly improve it will remain scarce for many years and careful evaluation of priority IRBM functions will therefore be important for the future institutional sustainability.

In Zimbabwe, the water law, its associated regulations and institutional structures as well as the operational guidelines are at a very advanced stage in terms of adopting the IWRM approach. Going from incorporating IWRM principles in policies to establishing specific regulatory provisions and detailed standardised procedures, is a major step towards practical implementation of IWRM and in this regard Zimbabwe is ahead of many countries. The enabling framework and institutional organisation in Zimbabwe is exceptionally conducive for practical implementation of IRBM at all management levels if fully put into operation. The current economic challenges prevailing in Zimbabwe have however resulted in weakened institutional structures and unfortunately the enabling policy and legal framework was not fully implemented before the economic crises. The institutional capacity to perform mandates has declined from a previously good service level (although IWRM implementation not fully achieved) to a currently unsatisfactory level. ZINWA Save is at the moment undertaking its functions on scarce operational funds. It must also be realized that the socio-economic landscape has changed and even through the revenue base is anticipated to improve the ZINWA Save may have to operate on scarce funds for many years to come. Another management challenge of immediate nature relates to the recent (2009/2010) reorganisation of the water sector's institutional framework. The new structure will need some time to fully consolidate. Another challenge is that the institutional memory is still available but not intact and it will take time rebuilt it.

To be able to undertake the core functions at a basic but satisfactory level, the capacity building needs and related strategic actions are discussed below.

Training and human resources development is an important pillar in institutional strengthening. ARA-Centro has benefitted from major training packages. However, in order to increase the responsiveness to absorb the training and put into practice the acquired knowledge, it is recommended focus is placed on the development of management tools and operational procedures prior to major additional training interventions.

In addition to the development of procedures, provisions of additional equipment will be necessary to ensure the undertaking of basic functions. Detailed recommendations are given in the EKIS Annex 2.2 for Buzi stressing that the primary focus must be to build a basic but well-functioning river flow and rainfall monitoring network and to build up a basic level of IT and GIS infrastructure.

In Zimbabwe, the primary focus should be to shape to operation to match the available funds and human resources and to make a strategy to secure and re-establish the institutional memory. Once the staff positions are filled, major training packages would be beneficial considering the generation shift in the staffing and the limited number of senior staff that can transfer the institutional memory,

Strategic actions for immediate attention are proposed in the Annex 5. These issues will be further discussed with the two organisations.

8 BASIN DEVELOPMENT SCENARIOS

8.1 Baseline

The desirable scenario is to meet the challenge of providing water in an optimal, sustainable and equitable manner to underpin economic development. By looking at the baseline values presented in Table 7-4, the following can be concluded for the baseline scenario.

It is evident that water resources development and utilisation within the Buzi River Basin is still at a low level. Water demand and use is much larger in Zimbabwe. The Mozambique water demand/use of direct uses is only 15% of the current water demand/use in Zimbabwe. This situation is due to the higher degree of development and commercial farming on the Zimbabwean side even though the current activity is low. The Buzi catchment in Zimbabwe is heavily exploited for agriculture and related activities. Both the Burma Valley and Chipinge area have intensive commercial farming, while a significant area of the Chimanimani Mountains is a National Park. The mid and lower reaches of the basin in Mozambique are not as intensively utilised at present. However, there are a number of new and planned developments such as biofuels and sugar cane production, which will significantly change future water demand and allocation in the basin.

Water for meeting basic needs - The coverage rate for water supply and sanitation for urban and rural areas is still far from the national goals. A large portion of the population has little access to secure water sources in both countries. Social infrastructure is generally better in Zimbabwe than in Mozambique however with the current economic difficulty most of the social infrastructure is in poor condition and the service level at a minimum. The lack of access to water is reflected by the high prevalence of water-borne diseases and general low scoring on health indicators.

Water for socio-economic development - Securing water for socio-economic development is a main water resources management challenge. Coverage of small to medium sized reservoirs for secured water supply for irrigation is not adequate compared to the aspirations of the stakeholders and the goals set in the national policies for pro-poor investments. Besides the hydropower, the middle section of the Buzi River Basin in Mozambique has so far been largely underdeveloped. This area is sparsely populated and has good potential for irrigation/commercial agriculture, agro-forestry and agro-industry development. Industrial development on the Mozambican side is hampered by the lack of reliable water supply. The private sector does not have the resources to invest in basic infrastructure that is in the national interest such as water, energy and roads. In Zimbabwe, the demographics and socio-economy of the area has undergone major changes the last 10 years and the population in the area is today no longer composed of a few large scale commercial farmers. Instead it is composed of a number small and medium sized farms which need different type of water supply infrastructure and more financial support for investments. It is recognised in both countries that public-private partnerships will be a prerequisite to meet the development challenge. Substantial investment funds will be required for the water resources management process and the necessary water infrastructure. No information has been obtained that confirms that funds have been secured for infrastructure development of small and medium dams, which is an obstacle for the planned investments in the Buzi River Basin.

Water for sustaining vital ecosystems - Terrestrial and aquatic ecosystems produce a range of economic benefits. The ecosystems depend on water flows, seasonality and water-table fluctuations and have water quality as a fundamental determinant. At the moment, there is no major problem with environmental flow however key water quality parameters are locally not within acceptable range due to urban, agriculture and mining activities. Moreover, the anticipated influx of investor's calls for coordinated and regulated development.

Water vulnerability - Water vulnerability is high. The population is largely affected by water-borne diseases such as malaria, cholera and diarrhoea. The coastal and adjacent inland areas of the Buzi River Basin are highly susceptible to flooding, both from storm surges accompanying cyclones and floodings from precipitation upstream. The human, material, social and economic impacts of floods are exacerbated by the increasing human settlements in the buffer zones and flood plains of the Buzi River estuary. The rural communities in the Buzi Basin are also extremely vulnerable to droughts because of reliance on rain-fed crops.

IWRM implementation - The progress with regards to water reforms has a positive trend towards creating the enabling policy and legal framework but lags behind on the institutional and management side. Policies, water acts, regulations and guidelines are in place whilst management efficiency in terms of water monitoring and provision of information, water management and protection is low.

8.2 Opportunities and Challenges

The Sofala Province Strategic Plan (2007-2017) has prepared a matrix presenting the strengths, weaknesses opportunities, and threats (SWOT) as a basis for the development planning of the province. The Sofala SWOT is presented below since is in some parts true for the basin as a whole.

Source: Sofala Provincial Government, 2008

Strengths:

- Good transport and communication such as the Beira-Machipanda railway, Dondo –Matize and Highway 1.
- Existence of tourism facilities and potential is in the region e.g. National Park of Gorongosa.
- Good agriculture and livestock production- the cashew and pineapple production (Chibabava), cattle (Buzi and Nhamatanda), cereals (Nhamatanda) and wood (e.g. Chibabava).
- Security and Protection of the Right for Property
- Macro-economic stability
- Rapid growth on human and economic development indexes
- Strategic location connecting the southern, centre and northern regions of the country and transport links to SADC region and the Middle East and Asia Pacific;

Opportunities:

- Corridor incentives for the development of Beira and Zambeze Valley
- Export opportunities to the USA (e.g. the Special Development Initiative)

Weaknesses and Threats:

- Infra-structure: Major part of the basic infrastructure is old and in need of rehabilitation.
- Institutional Development: Limited investment promotion at local level; limited financing and support services.
- Human Resources: Excessive bureaucracy; limited education level; dependency syndrome in some communities and low community involvement in the development process.
- Marketing: Export of raw materials rather than refined products
- Environment: Environment degradation- erosion, fires out of control, illegal deforestation, etc.; and poor health and hygiene situation (high index on cholera, malaria, diarrhea, HIV/AIDS, etc.);
- Conservation: Illegal hunting and limited resources to guarantee protection.
- Regulation and Control: Low capacity of control and supervision of economic activities; excessive application of regulations; corruption.

Considering the transboundary dimension and the specific characteristics of the Zimbabwean side of the basin a basin-wide SWOT has been prepared for the purpose of being a basis for the Joint IWRM Strategy for the Buzi River Basin. The SWOT matrix (Table 8-1) visualises key characteristics of the Buzi River Basin. It does not provide a comprehensive list of strengths, weaknesses, opportunities and threats but instead tries to visualise some of the most important characteristics of the basin having a bearing on the development scenarios.

Table 8-1 : Buzi River Basin SWOT.

<p>Strengths:</p> <ul style="list-style-type: none"> ▪ The Buzi River Basin with its good soils, low population density and good availability of water resources offers conducive natural environment for agri-related development ▪ Satisfactory level of basic supporting infrastructure such as road, electricity and communication along the Beira Corridor in the north part of the Buzi Basin ▪ Linked to national and international markets via the national highways and the Beira port ▪ The transboundary governance framework is in place in terms of international (general) agreements and institutions (JWC) 	<p>Weaknesses:</p> <ul style="list-style-type: none"> ▪ Lack of water storage, regulating and distribution infrastructure ▪ Lack of pro-poor infrastructure i.e. low access to reliable water sources for household and productive uses of the rural population ▪ Weak road, electricity and communication infrastructure in the southern part of the Buzi basin in Mozambique
<p>Opportunities:</p> <ul style="list-style-type: none"> ▪ Increasing interest in Mozambique for investments in agriculture and forestry including bio fuel, industry and mining development. ▪ Intensified national efforts to achieve MDGs with ambitious targets for urban and rural water supply; ▪ Increasing interest to invest in Zimbabwe along with Improving macro-economic stability 	<p>Threats:</p> <ul style="list-style-type: none"> ▪ Weak institutional capacity for supporting developments. Lack of investment funds and Little success of Public-Private-Partnerships ▪ Weak institutional for controlling economic activities e.g. uncontrolled mining ▪ Climate Change with more unpredictable and extreme whether events leading to a larger degree of uncertainty especially for rain fed agriculture;

The aim of the Joint Buzi IWRM Strategy will be to formulate actions to take advantage of the strengths and seize opportunities. For this purpose, it will be important for the two countries to define a desirable and most probable scenario for the basin so that support and control mechanisms can be designed to advance development towards the desired direction. Expanded interest from investors is not sufficient to trigger a chain of positive results but would depend on the national policies and strategic support packages. Similarly, integrated planning and control mechanism will be necessary to avoid uncontrolled expansion of for example the mining and industrial sectors which can result in destruction of the watercourse system.

8.3 Guidance for the Scenario Development

There are a number of on-going projects and planned investments in the Buzi River Basin.

On-going water resources development projects relevant to the Buzi in Mozambique are the rehabilitation of the Chicamba and Mavuzi hydropower schemes and the development of a new intake tower and water treatment plant for Chimoio water supply at Chicamba Dam. An on-going programme targeting small scale farmers is the PROIRI Programme implemented by the Ministry of Agriculture and financed by the World Bank. The programme covers the Manica Province, among other provinces. The objective is to boost investments in small- and micro dams for improved agricultural production of small-scale farmers.

In addition, as discussed in the Stakeholder analysis, there are new investors coming in to the basin on the Mozambican side especially in commercial agriculture and agro-forestry. Some examples of the recently approved and implemented commercial agricultural and mining projects in the Buzi Basin are:

- An 18,000 hectare bioenergy park that would provide 213 million gallons a year of ethanol. The sugar cane-based ethanol project is expected to be completed in 2013. The project will be located at Dombe, in Sussundenga District in Manica Province.
- A US\$250 million investment, by UK-based Principle Energy, in sugar cane ethanol production at a facility along the Lucite and Buzi rivers. The project includes developing 20,000 hectares for sugar cane cultivation.
- Development by the Envalor Limitade of 25,000 hectares of sugar cane, sweet sorghum and dry beans at a site in Sussundenga District, Manica Province. The project will require a reliable source of water for irrigation and for processing.
- Construction of a biofuel refinery in Buzi, in Sofala Province by Galpbuzi, by a consortium of Mozambique's Companhia do Buzi and Portugal's Galp Energia SGPS SA. The project will require 5,000 hectares of land and has commenced with the planting of 150 hectares of jatropha and 25 hectares of sunflowers on a pilot basis in Bândua.
- The farming cereals and oil seeds by the Prio Agricultura, on 9,200 hectares of land in Buzi.
- Cultivation of 5,000 hectares in Chimoi, in Manica Province by Sun Biofuels , with a view to expanding to 15,000 hectares. About 1,000 hectares have been planted.
- Establishment of a factory by Tsoza Holding to process gold in Manica Province with the capacity to process 40 kilograms of gold every four hours.

In Zimbabwe, the Save RSOP has identified approximately 30 water infrastructure development projects for dam and ground water schemes however, most of the developments are located in the Save River Basin. Similarly to Mozambique there is an on-going programme that targets small scale farming. In Zimbabwe, the project is referred to as the EU Micro-Irrigation Development Support Project.

It is indicated from the above baseline that increased investment in water infrastructure in the Buzi River Basin would be essential to make further progress towards the desirable outcome of a healthy river basin system and optimal, sustainable and equitable use/access of the basin's water resources.

COBA (1980) did a study on the potential for development of hydraulic infrastructure in the Buzi River Basin. From the studies made COBA presented thirty-two dams (see Figure 8-1) in the Buzi River Basin and its tributaries – including Chicamba Real and Mavuzi: Four are purely for irrigation; 13 are for hydropower; and 15 may be designed for multipurpose use. A cost evaluation focusing on potential hydropower production identified the most feasible dams to be: BUZ.0, LUC.4, LUC.10, REV.5, REV.6 and REV.9. To these are added the REV.3 – Mavuzi – and REV.8 – Chicamba Real – that are already constructed.

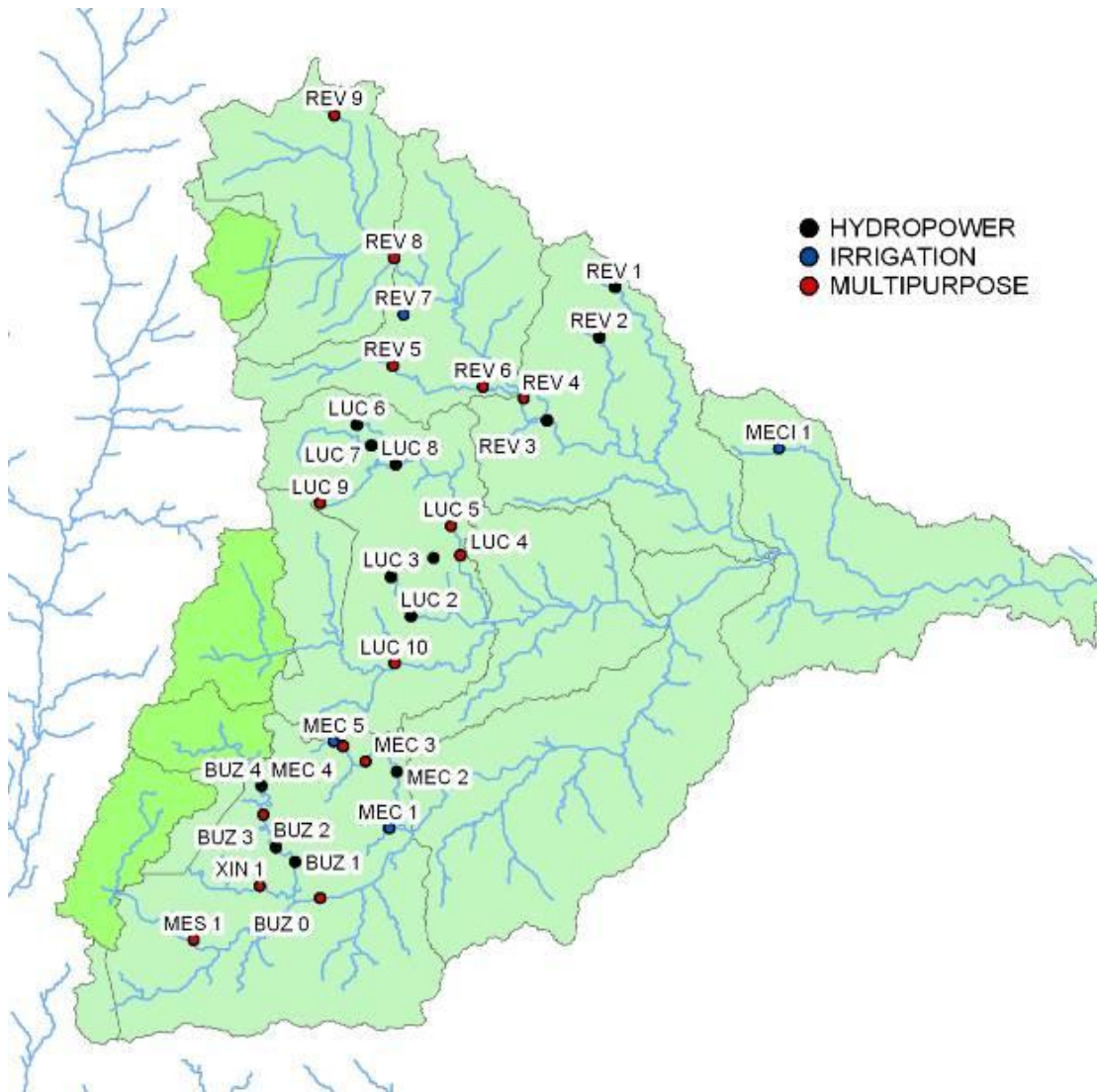


Figure 8-1: Locations of identified dams in the COBA study.

In 1997 new studies were made regarding dam sites in Buzi River Basin (Lazaro, 1997). The new studies found the most preferred dams to be BUZ. 0, LUC. 10, LUC. 5, REV. 4, REV. 3, REV.5. Why the preferred dam sites from 1997 are different from the COBA report's selection in 1980 is unclear. The study states that BUZ.0 and LUZ.10 are extra important due to their capacity to manage floods.

Lázaro (1997) suggests six dams, including the raising of Mavuzi intake dam, which would have a potential of about 880 GWh/year. The 1997 study shows that the selected dams should be able to irrigate about 81.000 ha. However, EDM (Electricidade de Mocambique) has recently decided upon rehabilitation on the Chicamba and Mavuzi stations to be used solely for hydropower production with a total regeneration of 418 GWh/yr (Norconsult, 2005). Remaining potential for the selected dam sites in the 1997 study is therefore about 630 GWh/year and about 66.000 ha irrigation.

The Buzi River Basin, with its abundant water resources, offers considerable potential for economic growth and development, provided there is coordinated and sustainable planning of interventions. Specific recommendations and ranking of potential development sectors will thus be studied during the scenario development phase from a macro-economic perspective looking at the comparative advantage of each sector (e.g. access to markets) and national priorities (e.g. regional priorities, poverty alleviation and biodiversity and conservation). Many of the planned investments previously listed, will depend on reliable sources of water.

The total combined area of additional commercial agriculture of the planned projects amounts to approximately 90,000 ha. The identified dams in the COBA and Lázaro studies show potential to supply irrigated areas of the same order of magnitude and further will give potential for multipurpose use, i.e. production of hydropower. The focus of the Development Scenario Phase will thus be to meet the need of the investors and other needs (e.g. flood management) by undertaking a review of the identified dams and determine an optimal selection.

As a first step, the Consultant proposes the following points to guide the formulation of the development scenario for the Buzi River Basin up to 2030:

1. To increase the storage volume and the regulatory functions of the river will be essential to underpin the socio-economic development in the Buzi River Basin. Further studies on the dams identified by COBA and Lázaro to determine an optimal investment strategy would thus be important. Especially important would be to further study the BUZ.0 and LUZ.10 due to their capacity to manage floods;
2. Moreover an increased focus on pro-poor investments in planning and funds mobilisation will be necessary to make progress towards national socio-economic goals. A specific strategy for the development of small dams would thus also be essential. (The Sofala Plan for 2007-2017 aims to increase the agricultural production within the family sector. One of the defined actions to reach this goal is to construct small and micro dams for irrigation, watering animal and water supply, involving the community);
3. Despite all the uncertainty that surrounds the issue of climatic change, the image that emerges from scientific analysis is that climate change will translate into an increase in the frequency and severity of floods and droughts, thus requiring detailed planning on the Mozambique side and further investment in mitigation measures. This includes not only the construction of new dams but also a review of dam safety and rehabilitation of the many small but degraded reservoirs located in the basin. Other measures are also requested e.g. to introduce restrictions on development in flood prone areas; and
4. Economic activities within the basin are expanding slowly but surely. The pressure on the protected and sensitive areas is thus increasing. Further conservation actions in protecting sensitive (Chimanimani, the Chicamba dam and the Buzi estuary) are also needed to maintain the current aquatic ecosystem integrity of the river system.
5. Water allocation to meet the environmental flow requirement is not a major problem at the moment. However, future plans do include a number of dam infrastructures and significantly increased water abstractions for mainly irrigation development and increased attention to EFR guidelines will be required. The two countries should consider commissioning a joint EFR study to determine a mutually agreeable methodology.

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APPENDICES

STRUCTURES

 Dykes

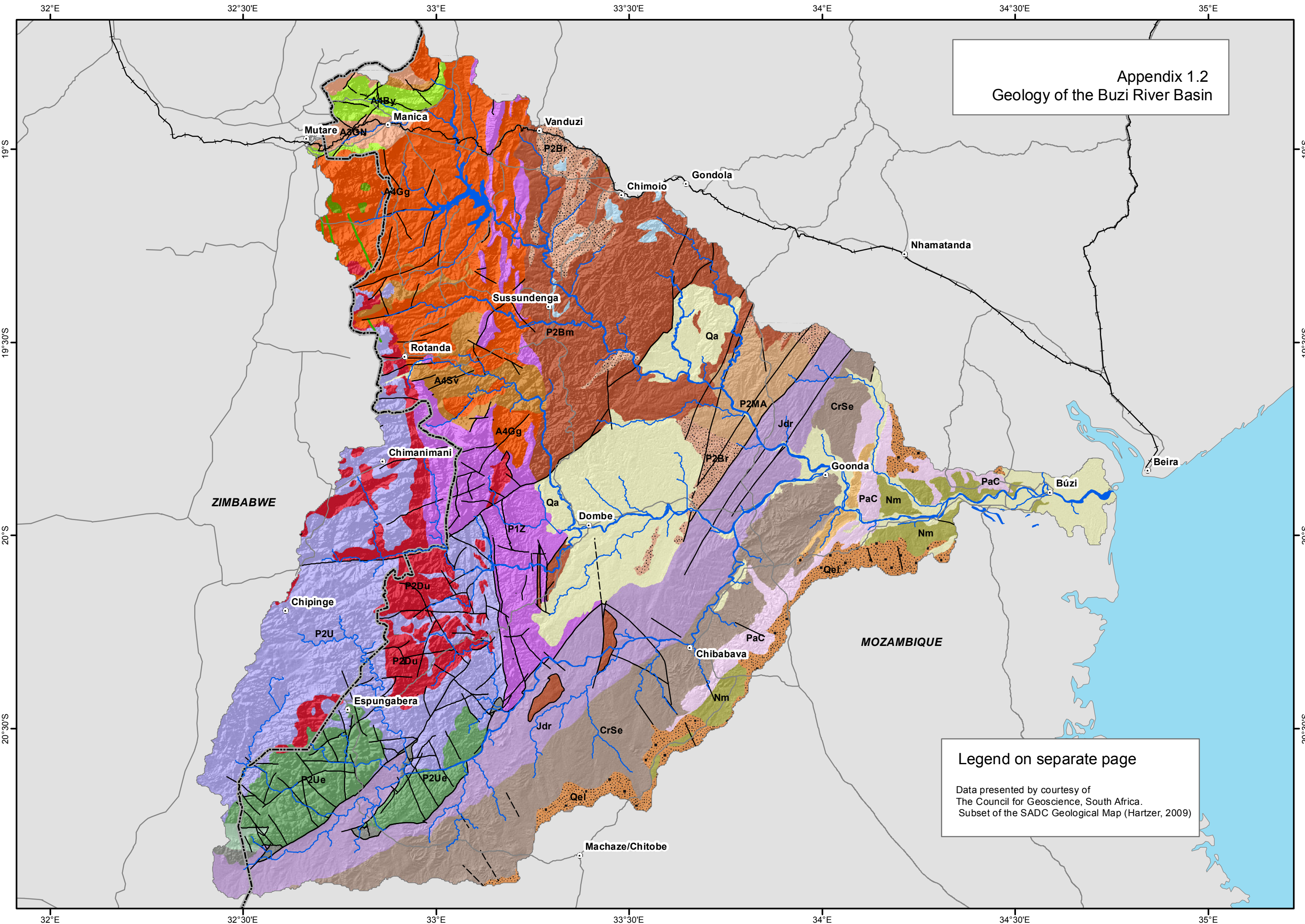
 Faults

 Faults, inferred

LITHOLOGY

	A4Gg: Biotite Granite (Zimbabwe Craton), including the Mavonde Complex [MZ], Chilimanzi Suite, Sesongwe Suite [ZB, B]
	A4By: Bulawayan Group [ZB, B], Manica Group [MZ]; felsic metavolcanic rock, agglomerate, tuff, metasandstone, diamictite,
	P2Br: B ruš Complex orthogneiss, including the Inchope Gneiss, Monte Senge Gneiss, Monte Panda Gneiss, Monte Tomonda Gnei
	PaC: Cheringoma Formation [MZ]; nummulitic limestone, glautonotic sandstone
	P2Bm: Chimoio Group paragneiss [MZ]; garnet-bearing metagranite, hornblende gneiss, amphibolite, metasedimentary rock
	Cde: Dwyka, Eccca Groups [ZB, MZ, T,]; Tillite, mudstone, coal, sandstone, sitstone
	Qel: Alluvial floodplain clayey sand [MZ, ZB]
	P2Ue: Espungabera Formation [ZB, MZ]; andesitic lava
	P1Z: Gairezi Group [MZ, ZB]; quartzite, muscovite-biotite schist, mica schist
	A3GN: Gneiss Complex (Zimbabwe Craton) [ZB, MZ, B]]; tonalitic gneiss, migmatitic gneiss
	CrG: Grudja Formation [MZ]; marl, sandstone, limestone, gypsum
	Jdr: Lebombo Group [SA, B, MZ, ZB, ML, A, L, SW, ZM], Drakensberg Group [SA], Kalkrand Formation [N], Movene Formation
	CrSe: Malvernia Formation [SA], Sena Formation [MZ, ZB]; sandstone, conglomerate, marl
	P1MD: Mashonaland Dolerite [ZB]
	Nm: Mazamba Formation [MZ, ZB, SA]; arkosic sandstone
	P2Bs: Mecossa Group metasedimentary rock [MZ]
	P2Bh: Monte Chissui Gneiss [MZ]; felsic biotite gneiss, metagranite
	P2MA: Pamassara Granite [MZ]; granodiorite, adamellite
	Qa: Quaternary sediments [A, B, D, N, ML, MZ, SA, T, ZB, ZM]; alluvium, sand, gravel, calcrete
	A4Sv: Shamvaian Supergroup [ZB, MZ]; metasedimentary rock, felsic metavolcanic rock
	P2Du: Umkondo Dolerite [ZB, MZ]
	P2U: Umkondo Group, including the Dacata Formation [ZB, ZM]; limestone, shale, quartzite, basalt, schist, orthoquartzite
	Pbu: Upper Karoo Group [SA, MZ, ZB, ZM]; granulestone, sandstone, conglomerate, siltstone

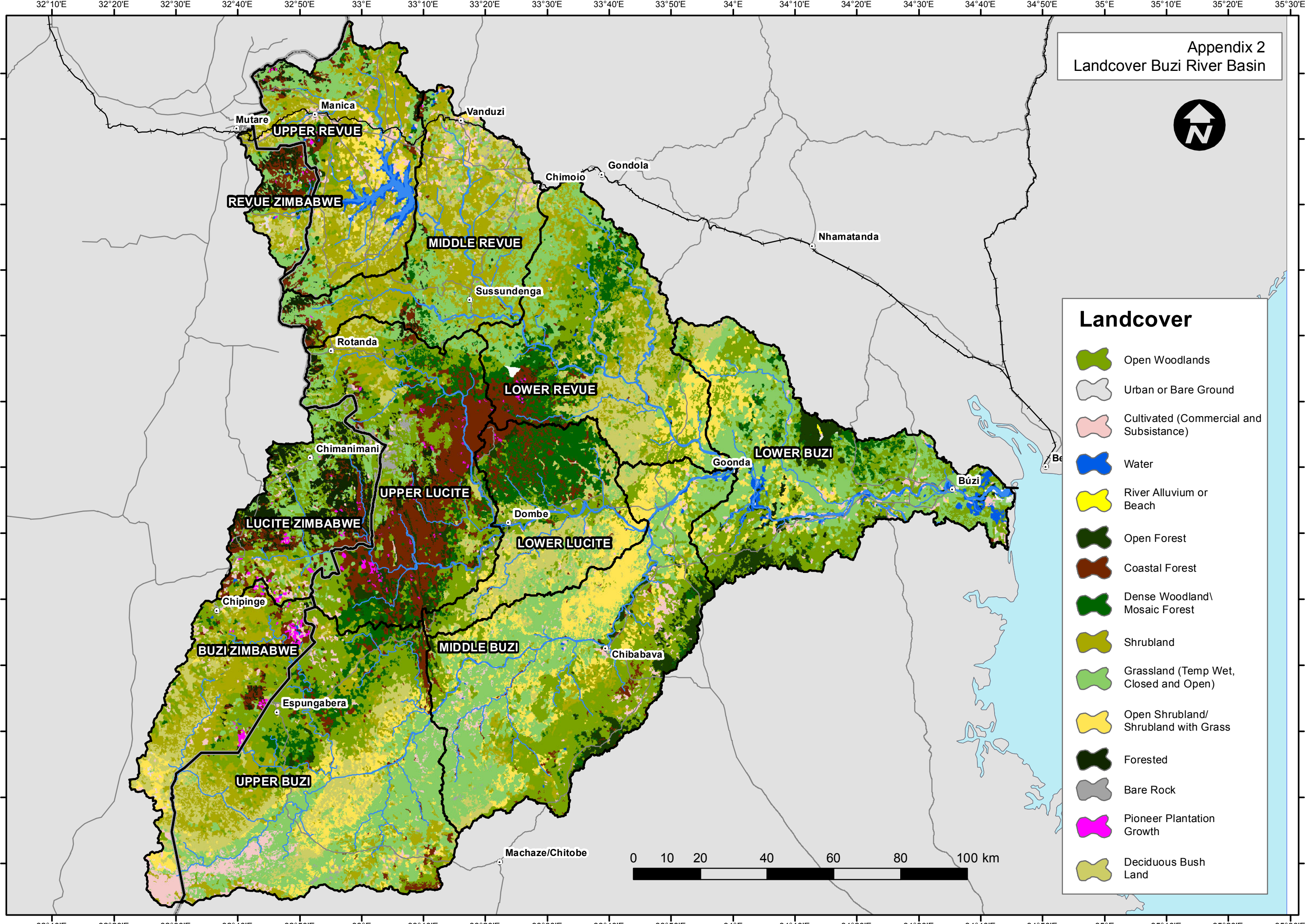
Appendix 1.2
Geology of the Buzi River Basin



Legend on separate page

Data presented by courtesy of
The Council for Geoscience, South Africa.
Subset of the SADC Geological Map (Hartzer, 2009)

Appendix 2
Landcover Buzi River Basin

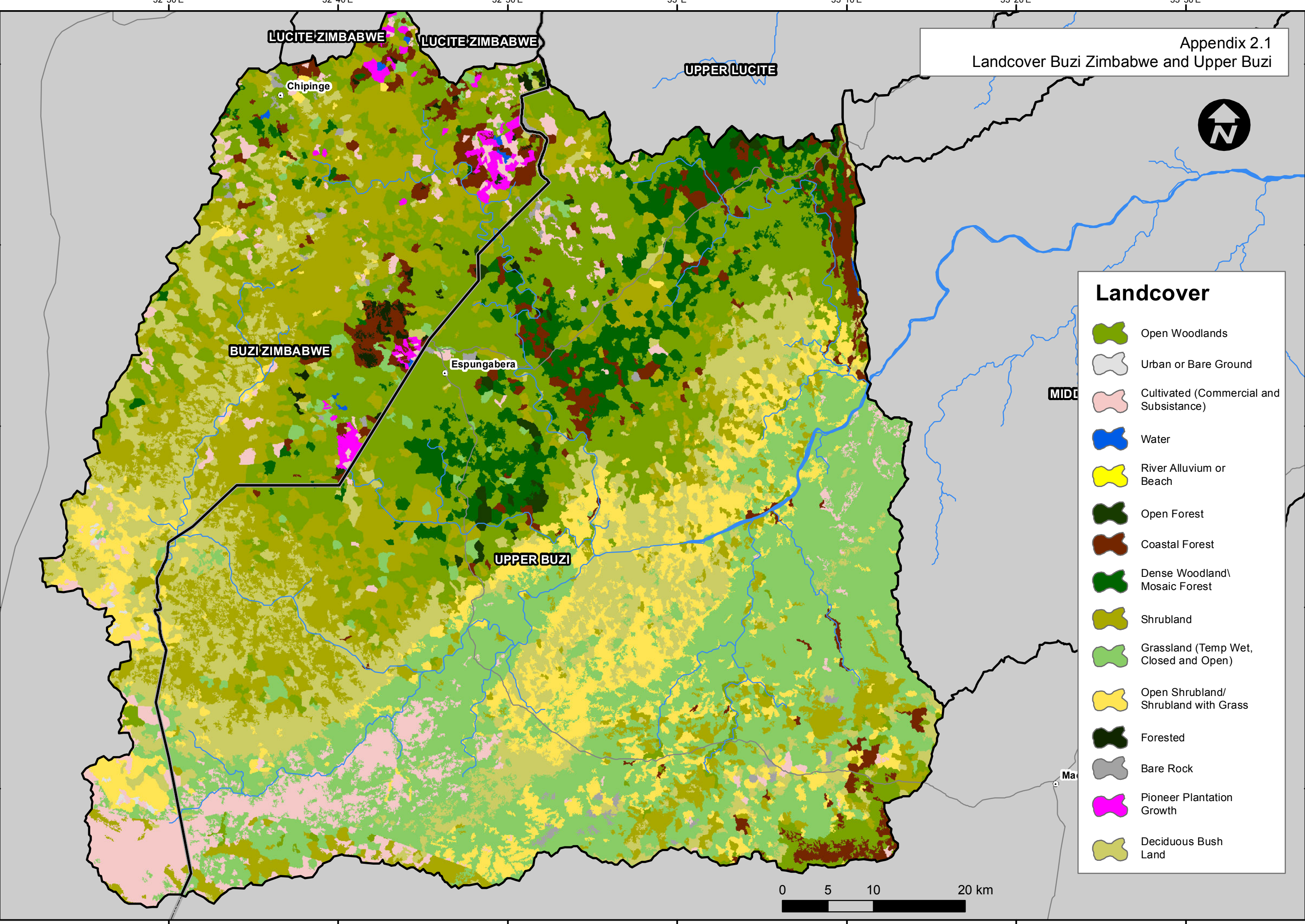


Appendix 2.1
Landcover Buzi Zimbabwe and Upper Buzi



Landcover

- Open Woodlands
- Urban or Bare Ground
- Cultivated (Commercial and Subsistence)
- Water
- River Alluvium or Beach
- Open Forest
- Coastal Forest
- Dense Woodland\ Mosaic Forest
- Shrubland
- Grassland (Temp Wet, Closed and Open)
- Open Shrubland/ Shrubland with Grass
- Forested
- Bare Rock
- Pioneer Plantation Growth
- Deciduous Bush Land



32°30'E 32°40'E 32°50'E 33°E 33°10'E 33°20'E 33°30'E

20°10'S

20°20'S

20°30'S

20°40'S

20°50'S

20°10'S

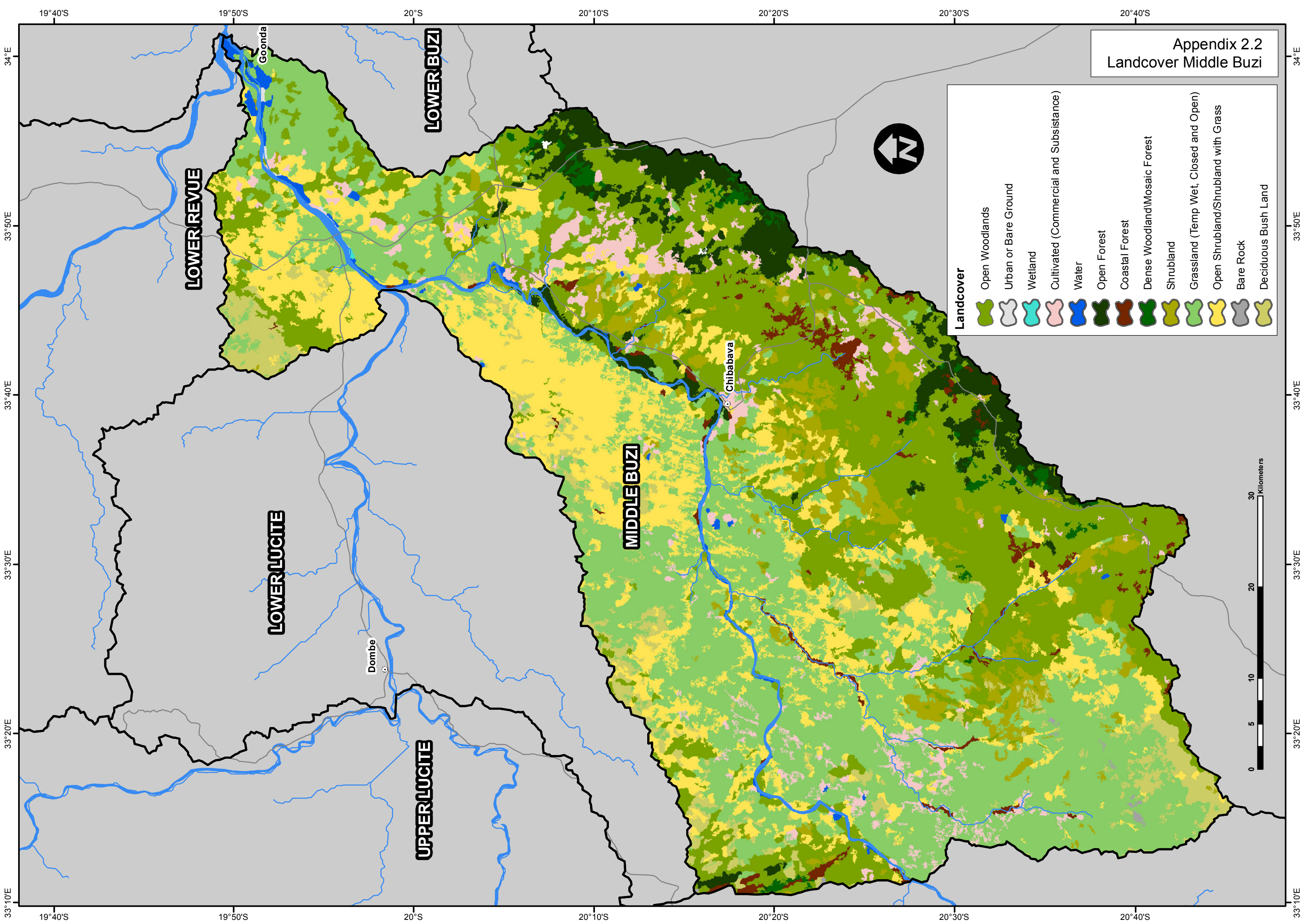
20°20'S

20°30'S

20°40'S

20°50'S

32°30'E 32°40'E 32°50'E 33°E 33°10'E 33°20'E 33°30'E



Appendix 2.2
Landcover Middle Buzi

Landcover	Symbol
Open Woodlands	
Urban or Bare Ground	
Wetland	
Cultivated (Commercial and Subsistence)	
Water	
Open Forest	
Coastal Forest	
Dense Woodland/Mosaic Forest	
Shrubland	
Grassland (Temp Wet, Closed and Open)	
Open Shrubland/Shrubland with Grass	
Bare Rock	
Deciduous Bush Land	



LOWER REVUE

LOWER BUZI

LOWER LUCITE

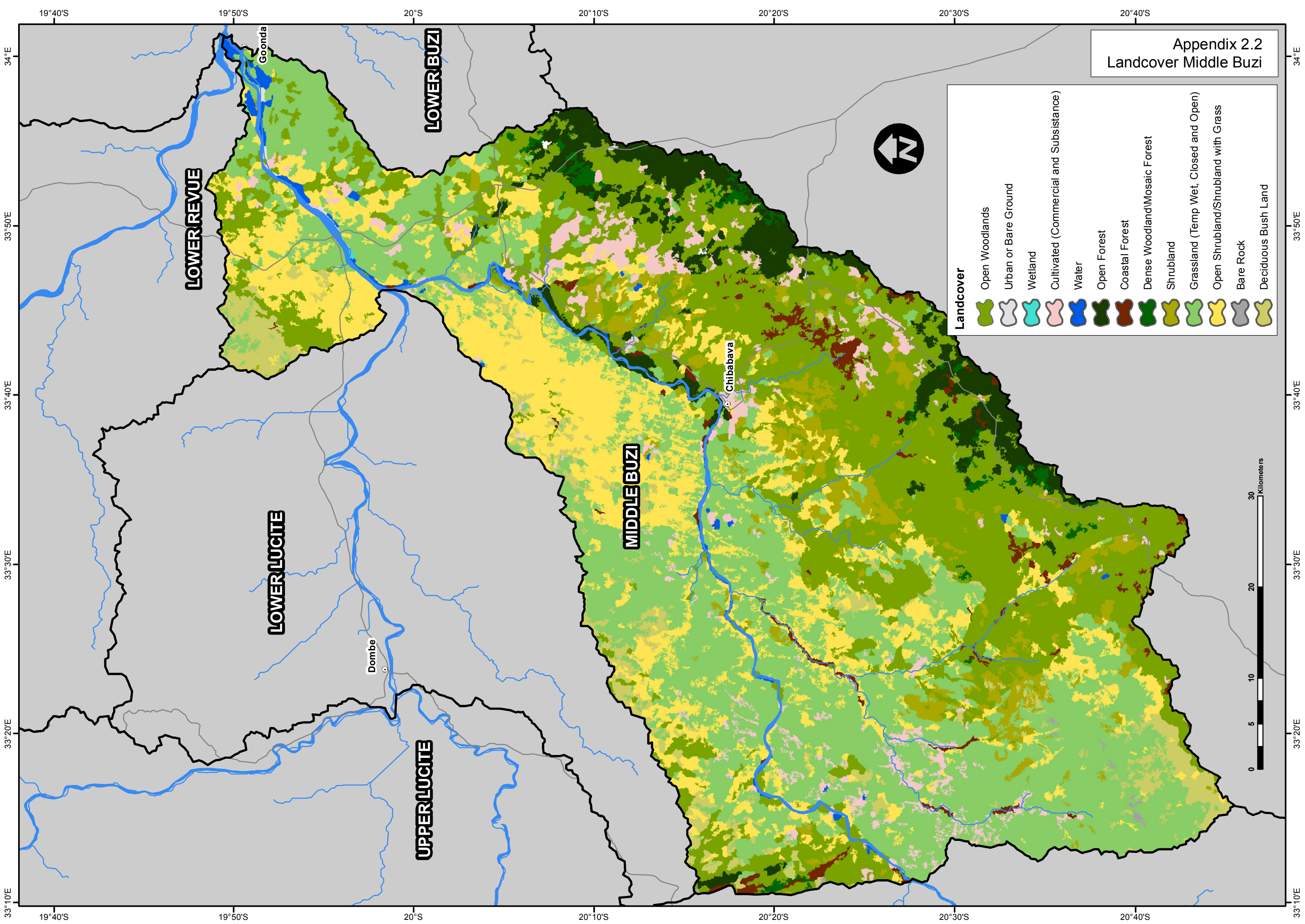
MIDDLE BUZI

UPPER LUCITE

Goonda

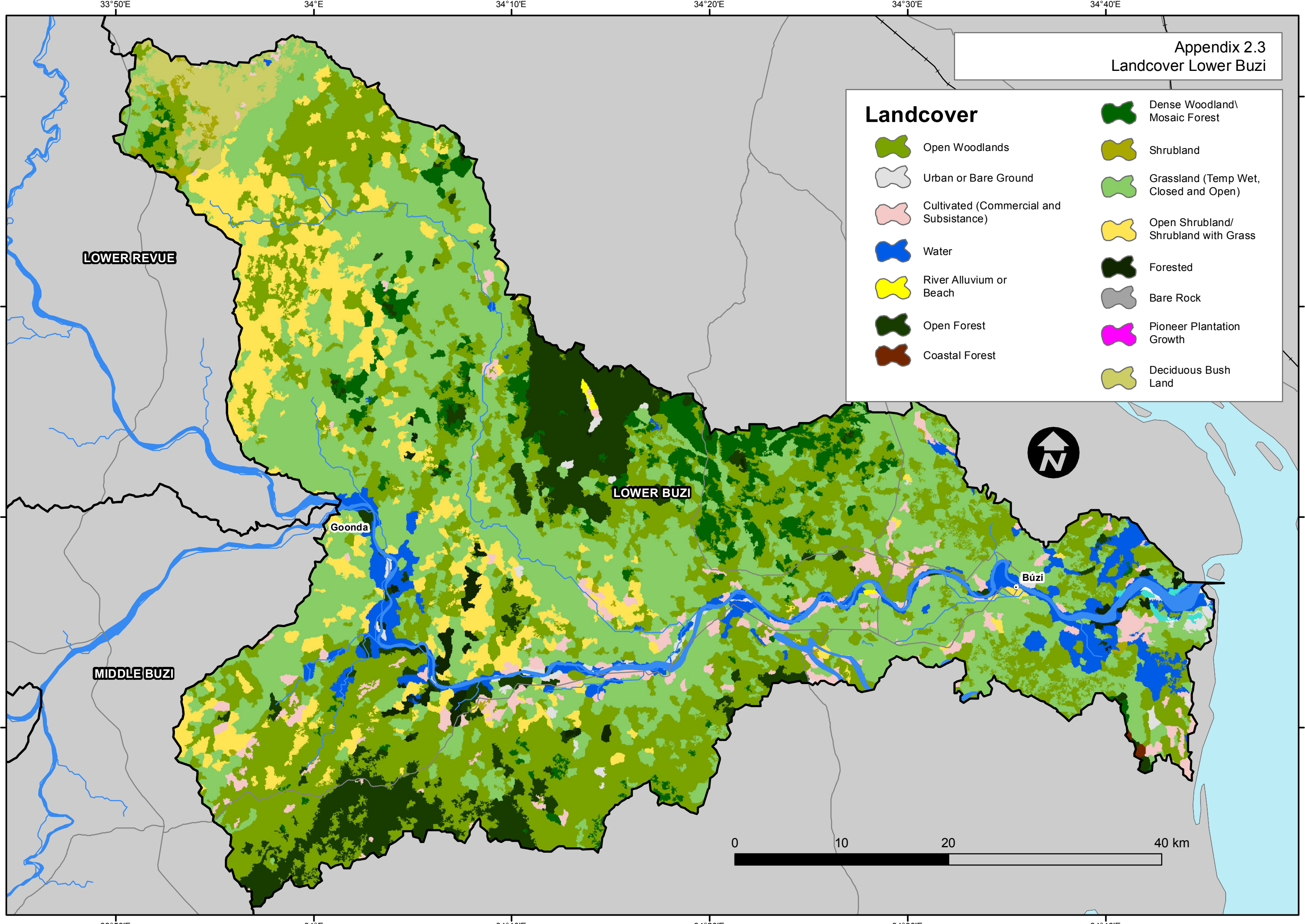
Dombe

Chibabava



Appendix 2.3
Landcover Lower Buzi

Landcover



LOWER REVUE

LOWER BUZI

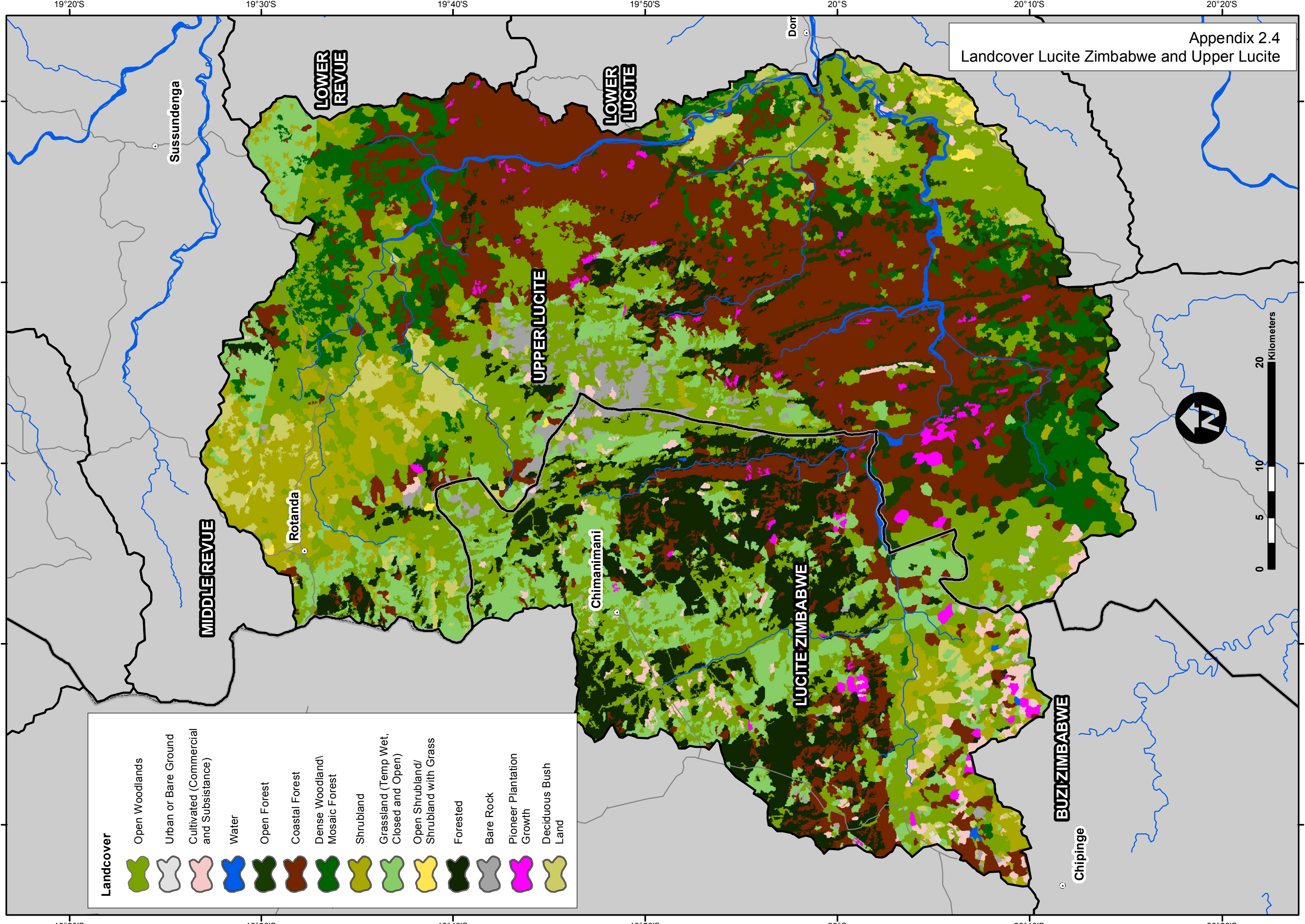
Goonda

Búzi

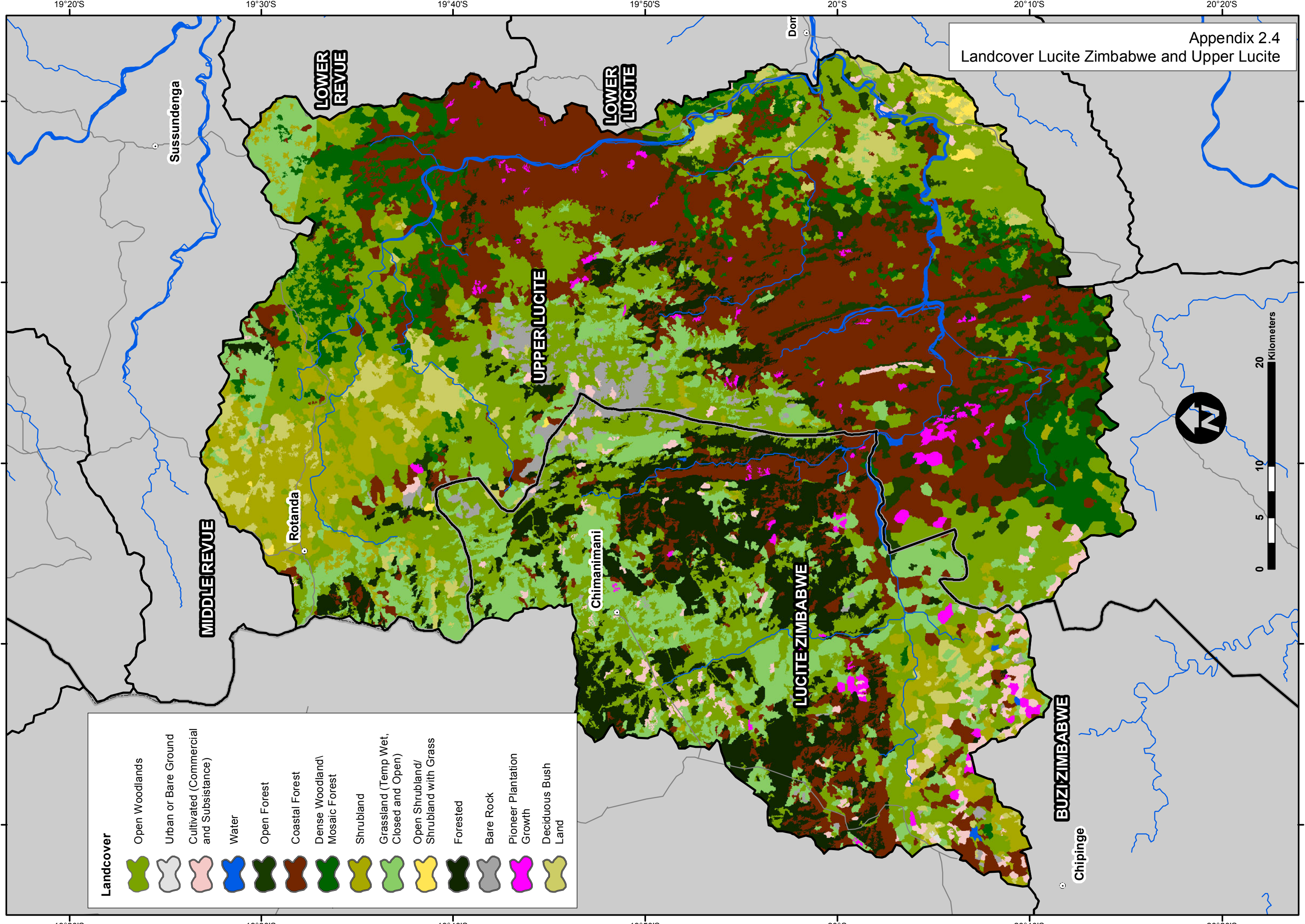
MIDDLE BUZI

0 10 20 40 km

Appendix 2.4
Landcover Lucite Zimbabwe and Upper Lucite

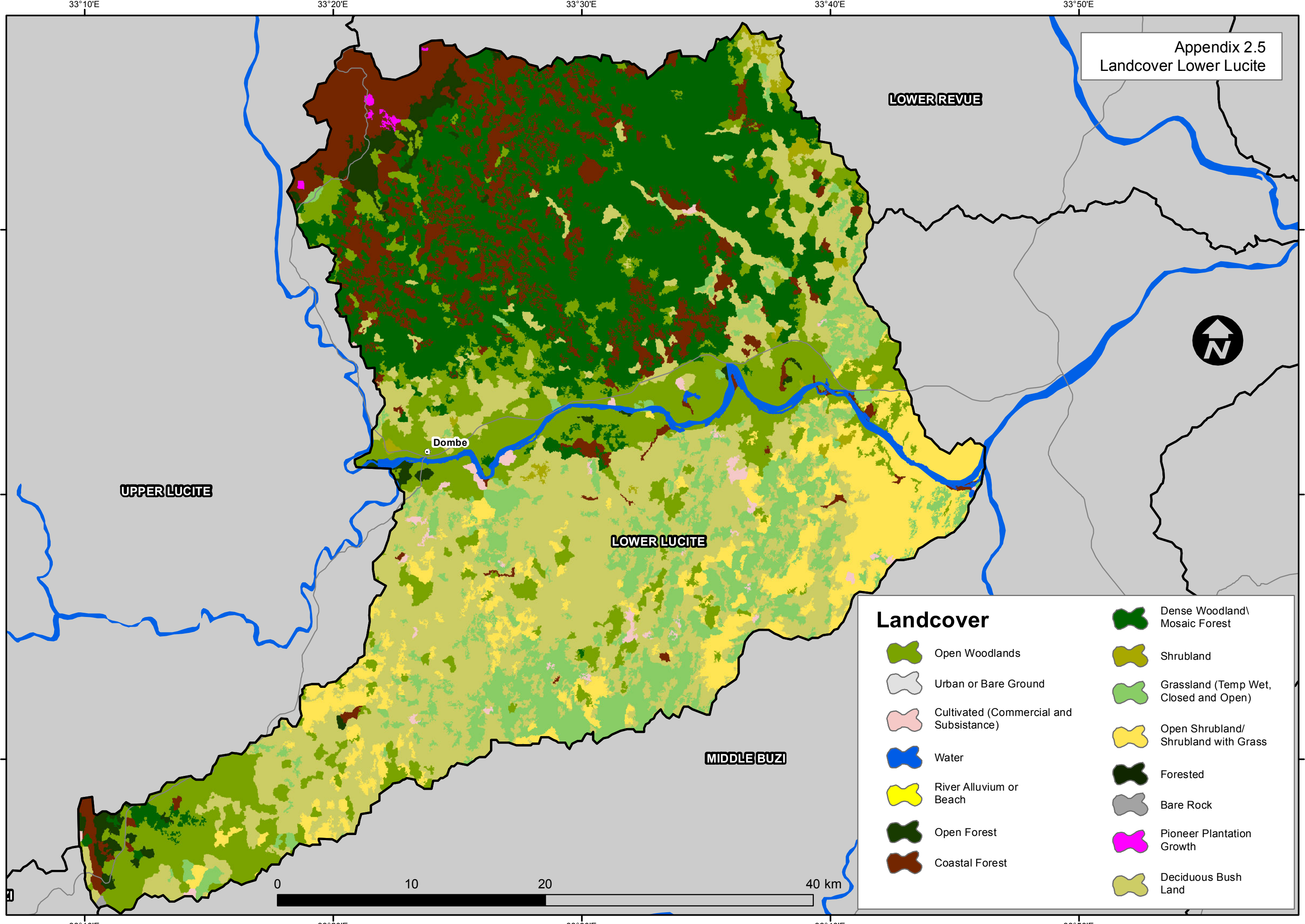


Landcover	Open Woodlands	Urban or Bare Ground	Cultivated (Commercial and Subsistence)	Water	Open Forest	Coastal Forest	Dense Woodland/ Mosaic Forest	Shrubland	Grassland (Temp Wet, Closed and Open)	Open Shrubland/ Shrubland with Grass	Forested	Bare Rock	Pioneer Plantation Growth	Deciduous Bush Land




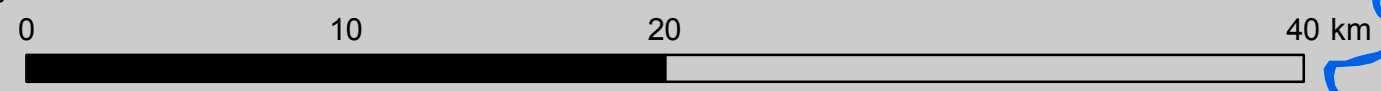
Landcover	Open Woodlands	Urban or Bare Ground	Cultivated (Commercial and Subsistence)	Water	Open Forest	Coastal Forest	Dense Woodland/ Mosaic Forest	Shrubland	Grassland (Temp Wet, Closed and Open)	Open Shrubland/ Shrubland with Grass	Forested	Bare Rock	Pioneer Plantation Growth	Deciduous Bush Land

Appendix 2.5
Landcover Lower Lucite



Landcover

	Open Woodlands		Dense Woodland\ Mosaic Forest
	Urban or Bare Ground		Shrubland
	Cultivated (Commercial and Subsistence)		Grassland (Temp Wet, Closed and Open)
	Water		Open Shrubland/ Shrubland with Grass
	River Alluvium or Beach		Forested
	Open Forest		Bare Rock
	Coastal Forest		Pioneer Plantation Growth
			Deciduous Bush Land



UPPER LUCITE

LOWER LUCITE

LOWER REVUE

MIDDLE BUZI

Dombe

33°10'E

33°20'E

33°30'E

33°40'E

33°50'E

19°50'S

19°50'S

20°S

20°S

20°10'S

20°10'S

33°10'E

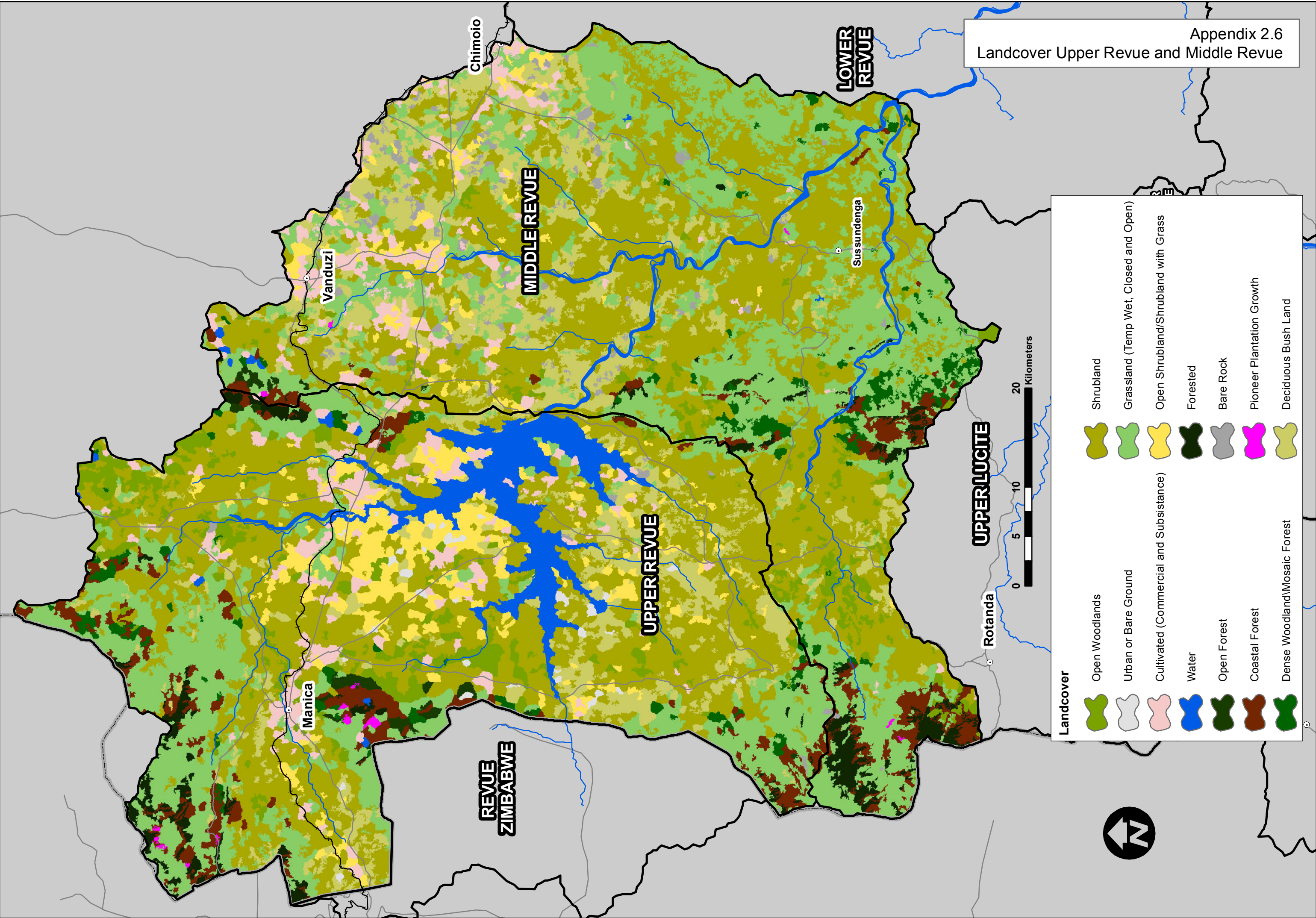
33°20'E

33°30'E

33°40'E

33°50'E

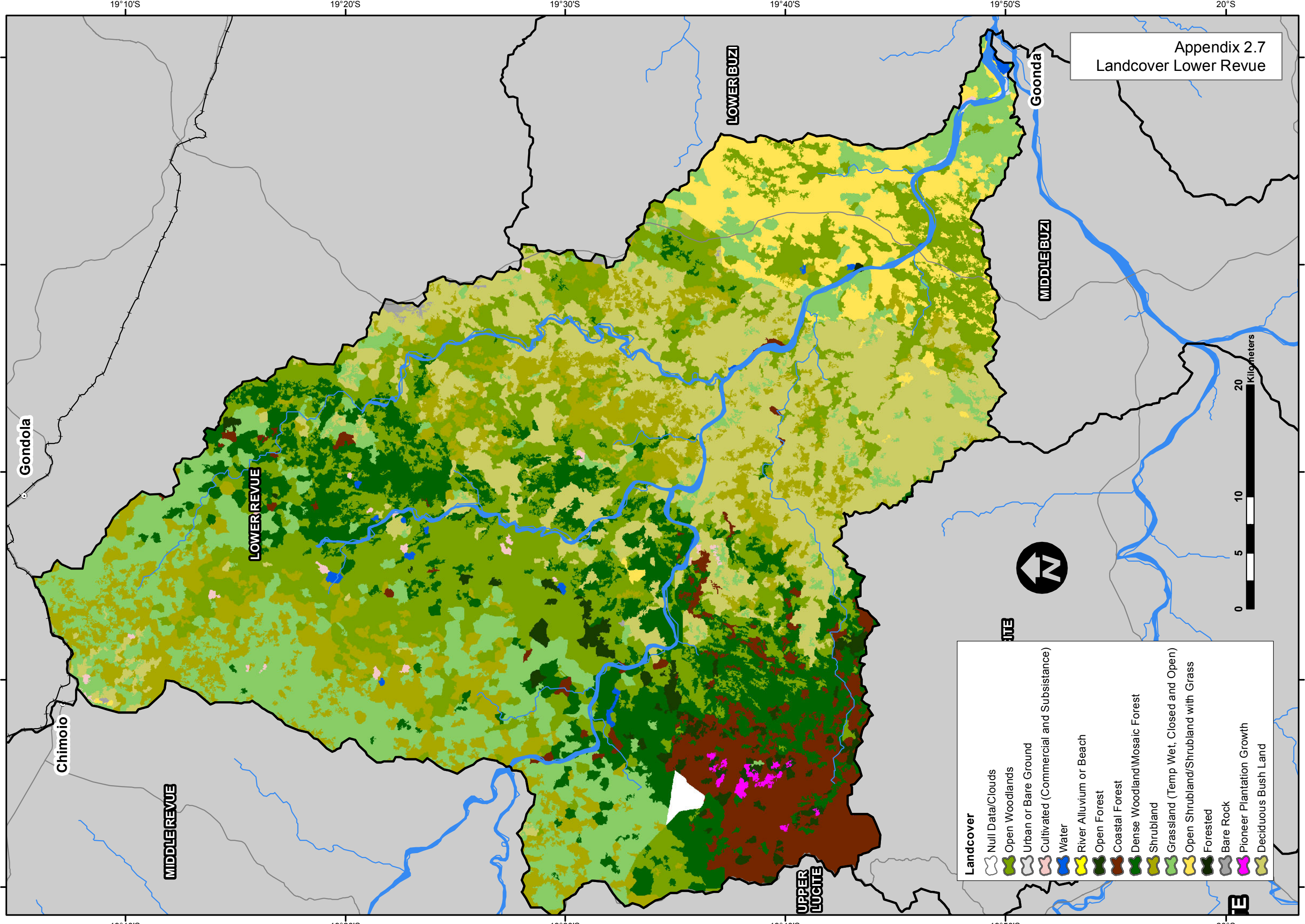
Appendix 2.6
Landcover Upper Revue and Middle Revue



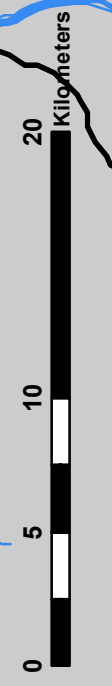
Landcover

	Open Woodlands		Shrubland
	Urban or Bare Ground		Grassland (Temp Wet, Closed and Open)
	Cultivated (Commercial and Subsistence)		Open Shrubland/Shrubland with Grass
	Water		Forested
	Open Forest		Bare Rock
	Coastal Forest		Pioneer Plantation Growth
	Dense Woodland/Mosaic Forest		Deciduous Bush Land

Appendix 2.7
Landcover Lower Revue



Landcover	Description
Null Data/Clouds	Null Data/Clouds
Open Woodlands	Open Woodlands
Urban or Bare Ground	Urban or Bare Ground
Cultivated (Commercial and Subsistence)	Cultivated (Commercial and Subsistence)
Water	Water
River Alluvium or Beach	River Alluvium or Beach
Open Forest	Open Forest
Coastal Forest	Coastal Forest
Dense Woodland/Mosaic Forest	Dense Woodland/Mosaic Forest
Shrubland	Shrubland
Grassland (Temp Wet, Closed and Open)	Grassland (Temp Wet, Closed and Open)
Open Shrubland/Shrubland with Grass	Open Shrubland/Shrubland with Grass
Forested	Forested
Bare Rock	Bare Rock
Pioneer Plantation Growth	Pioneer Plantation Growth
Deciduous Bush Land	Deciduous Bush Land



19°10'S 19°20'S 19°30'S 19°40'S 19°50'S 20°S

34°E 33°50'E 33°40'E 33°30'E 33°20'E

Chimoio

Gondola

LOWER REVUE

LOWER BUZI

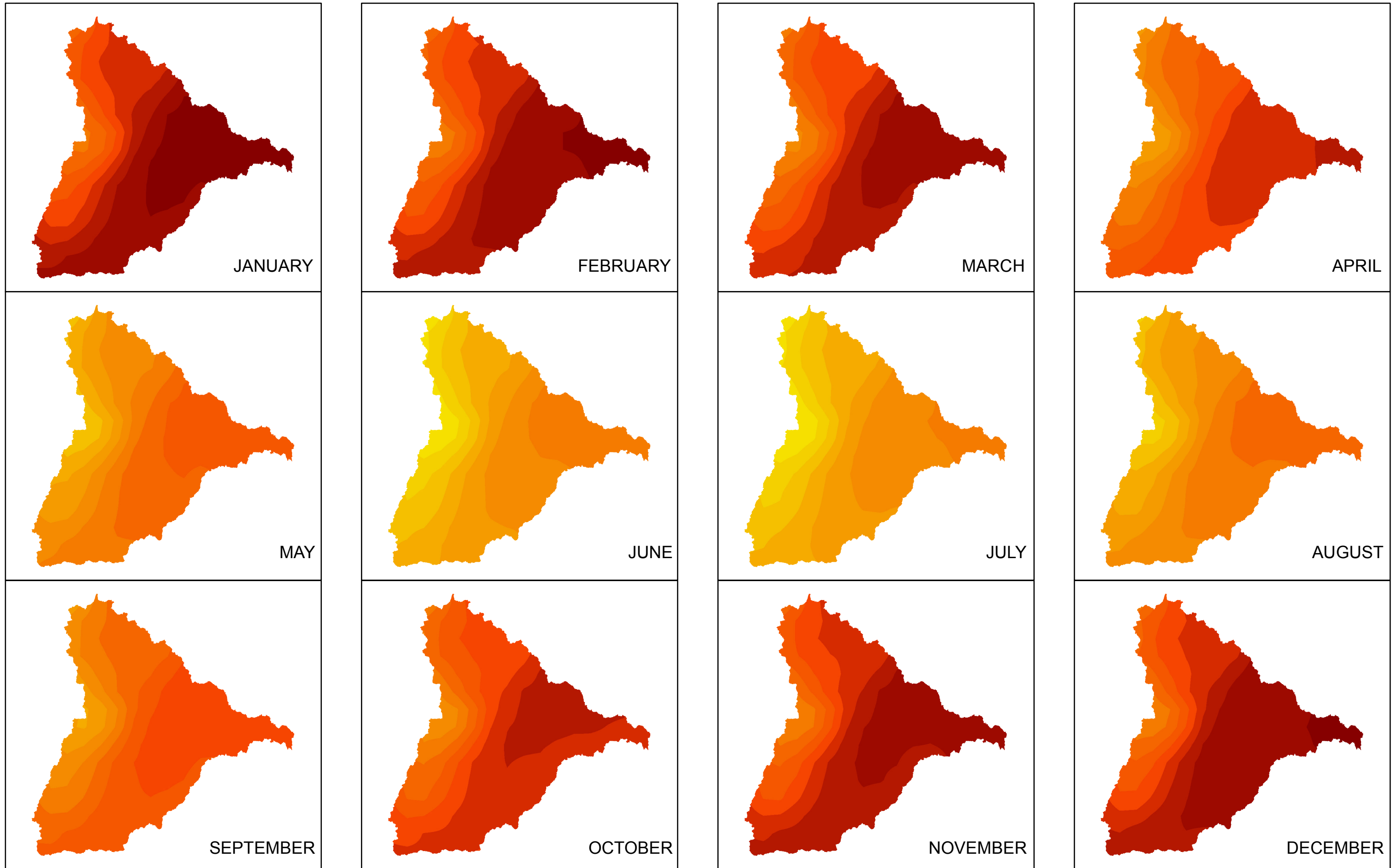
MIDDLE BUZI

UPPER LUCITE

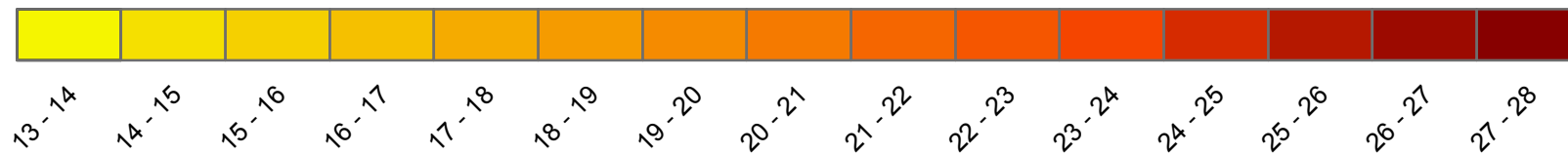
Goonda

0 5 10 20 Kilometers

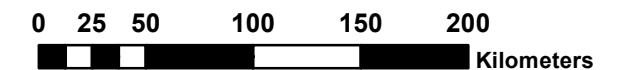
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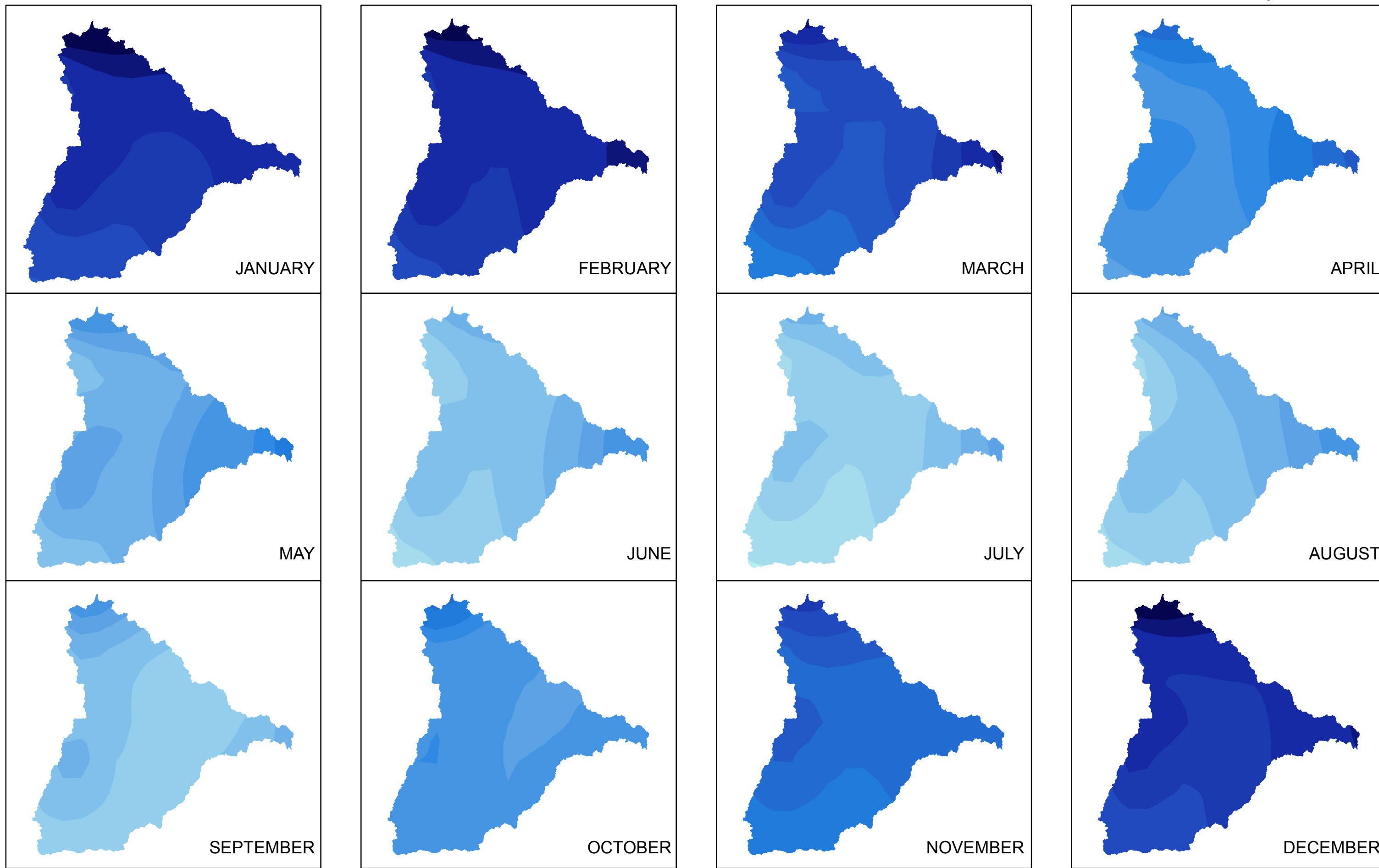


Mean monthly temperature (°C)

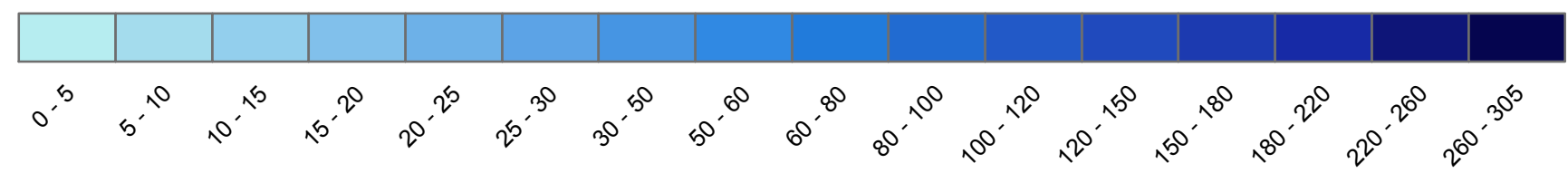


Source: New et al., 2002
Climate Research Unit, UK





Mean monthly rainfall (mm)



Source: New et al., 2002
Climate Research Unit, UK

