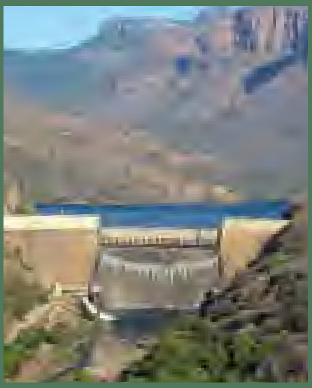
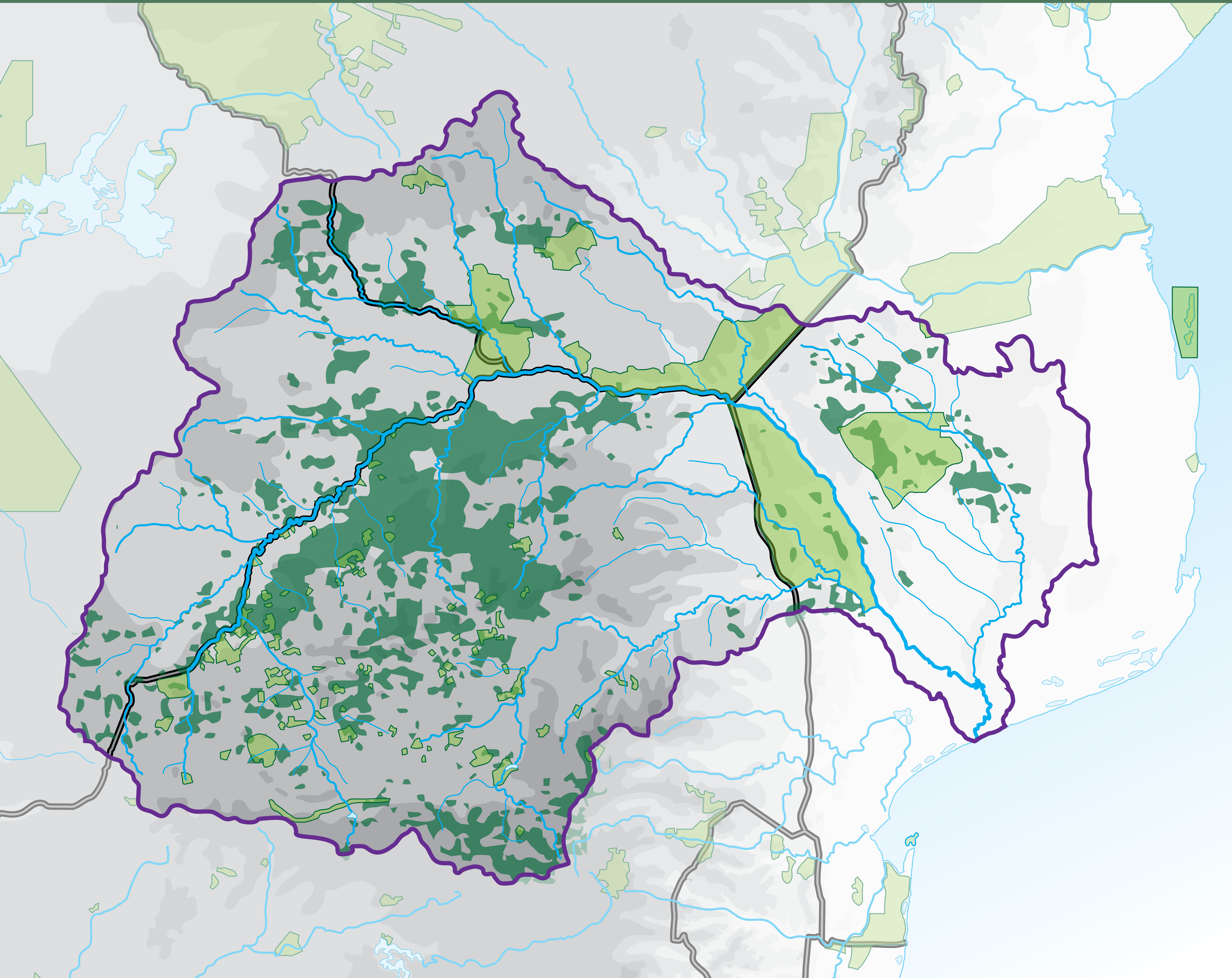



LIMPOPO RIVER BASIN

Changes, challenges and opportunities



LIMPOPO RIVER BASIN

changes, challenges and opportunities

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ISBN: 978-82-7701-166-0

This book is accessible online on the Limpopo Watercourse Commission website (www.limcom.org) with links to USAID RESILIM (www.limcom.org), GWP SA (www.gwp.org/en/GWP-SouthernAfrica/), GRID-Arendal www.grida.no and SARDC www.sardc.net

Recommended Citation
LIMCOM, USAID RESILIM, GWP SA, GRID-Arendal and SARDC. 2017. *Limpopo River Basin: changes, challenges and opportunities*. LIMCOM, USAID RESILIM, GWP SA, GRID-Arendal and SARDC; Maputo, Pretoria, Arendal and Harare.

Contents

Foreword

The Limpopo River Basin is the fourth largest in southern Africa after the Congo, the Zambezi, and the Orange-Senqu basins, and is shared by parts of Botswana, Mozambique, South Africa and Zimbabwe. The basin characteristics are very diverse, covering different climatic and topographic zones, as well as land use types, including protected areas. The basin is endowed with underground water resources that are important in supplementing surface water resources. The 1,750 km Limpopo River starts at the confluence of the Marico and Crocodile Rivers in South Africa, from where the river flows eastwards and is joined by 24 main tributaries before discharging into the Indian Ocean near Xai-Xai in Mozambique.

Over the years, this magnificent basin has seen significant environmental changes taking place. These include changes in the climatic conditions, biodiversity, land and water resources. Causes of the changes include population growth, global warming, expansion of urban areas, as well as an increase in economic activities such as mining, manufacturing and agriculture. The environmental changes in the basin are continuous and in some cases dramatic.

It is against this background that the Limpopo Watercourse Commission (LIMCOM), with support from USAID–RESILIM, GRID-Arendal and Global Water Partnership Southern Africa, has developed the Limpopo River Basin atlas in order to capture these changes and inform decision makers on future steps needed to make the basin resilient. This is the first Atlas edition of the *Limpopo River Basin: changes, challenges and opportunities*, and it is hopefully the first of many such Atlases.

The LIMCOM is one of several river basin commissions established by member states of the Southern African Development Community (SADC). The establishment of such commissions falls under the auspices of the Revised SADC Protocol on Shared Watercourses, and its programmes such as the Regional Strategic Action Plan. The Atlas will go a long way in enriching knowledge about the Limpopo River Basin, as well as providing some of the information and data needs of LIMCOM. The information and data provided by the Atlas will also inform regional developmental initiatives, including transport corridors, trans-frontier conservation, and integrated water resources management approaches.

The *Limpopo River Basin: changes, challenges and opportunities* provides evidence-based analyses on changes in the Limpopo Basin, including their causes and outcomes, so as to motivate policy action and the promotion of sustainable development. The Atlas synthesizes existing information on environmental and socio-economic changes in the basin. The findings in the Atlas are aimed at raising stakeholder awareness on the impact of climate change on the basin, as well as on the role of other drivers of environmental change. It proposes appropriate measures to prevent, manage, and mitigate negative impacts, and informs sustainable use and management of the resources of the Limpopo River Basin system.

The Atlas was constructed around a firm data and information development process. Literature that was reviewed to understand issues and challenges in the basin, and to identify areas where significant environmental changes have occurred, included Limpopo River Basin Monograph Study, Limpopo River Awareness Kit, Atlas for Disaster Preparedness and Response in the Limpopo Basin, Resilience in the Limpopo Basin programme (RESILIM) assessments, and state of environment and outlook reports for basin countries.

I hereby invite all Limpopo River Basin member states and partners to support this initiative and use the Atlas for the region's prosperity and for the successful achievement of goals as set in the LIMCOM Agreement.

Dudu Twayi
LIMCOM Chairperson

Preface

The water resources of the Limpopo River Basin are shared by four riparian countries – Botswana, Mozambique, South Africa and Zimbabwe. The basin's freshwater is generally scarce, and seriously competed for. The competition is not only for access, but also for different needs and priorities. Botswana's interests and priorities hinge on water use control, while Mozambique prioritizes flood control. South Africa is keen on water management approaches that uplift the people's standard of living, while Zimbabwe seeks to expand its area under irrigation and develop its agricultural sector. Such competition and differences in priorities call for a fair and balanced management approach, which ensures that water adequately provides for the economic, social and environmental needs of the riparian countries.

The Southern African Development Community (SADC) through its Regional Strategic Action Plan and the Limpopo Watercourse Commission seek not only to facilitate fairness in the use and access to the basin's water resources, but also to have a common regional response mechanism to climate-related disasters. The main purpose of the SADC Regional Strategic Action Plan on Integrated Water Resources Management (IWRM) is to create an environment for the joint management of regional water resources.

In pursuing the IWRM agenda, the Limpopo Watercourse Commission will enable the basin meet its goals for water resources management as defined in the Dublin Principles, including goals for poverty alleviation, water conservation and reuse, agricultural production and rural water supply, and reducing water conflicts. In order to meet some local needs, the basin also has some ambitious intra-basin water transfer schemes and plans. For example, water is transferred from Usuthu to Komati Rivers as a way of meeting the water quality and quantity needs for electricity generation in the upper Oliphants River Basin.

The *Limpopo River Basin: changes, challenges and opportunities* notes the vulnerability of the basin to some major natural disasters and risks, including droughts, floods and cyclones. Severe losses in life and property, as well as environmental damage have been incurred in the past. The frequency of these disasters continues to increase, a situation that calls for increased adaptive capacity, including community resilience, better early warning systems, and greater awareness. The Atlas, among other purposes, seeks to ensure that the state and trends of the basin's environment are well understood as a basis for better preparedness when dealing with disasters and risks.

The evidence presented in the Atlas is clear and compelling so as to inform policies and decisions that affect the basin. Facts and data are not only presented in a visual way, but also in a format that clearly shows links between causes and changes in the Limpopo Basin's environment. The Atlas does not only make a critical review of some of the basin's policy solutions, but also provides information and options to inform future policies.

Various partners were involved in the preparation of the Atlas. Through the support of the Limpopo Watercourse Commission, facts presented in the Atlas were verified for clarity and correctness. The USAID Resilience in the Limpopo River Basin (RESILIM) Program, Global Water Partnership Southern Africa (GWP SA), and GRID-Arendal provided financial and technical support, as well as leadership and coordination to the process. The Southern African Research and Documentation Centre's I. Musokotwane Environment Resource Centre for Southern Africa (SARDC IMERCSA) coordinated the compilation of content for the Atlas.

In a clear demonstration of effective partnership, the partners were able to leverage on each other's comparative advantages. They were also able to reach out to a wide network of experts. The publication of this Atlas is seen as a beginning of a much longer process of reaching out to policy makers, the media, academia and other important stakeholders. Through an elaborate outreach programme, it is the hope of the partners that important decisions and milestones for the Limpopo River Basin will be informed by the Atlas.

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Acknowledgements

The *Limpopo River Basin: changes, challenges and opportunities* is a product of teamwork and dedication amongst various organisations and individuals. We are grateful to the four partner organisations (USAID Resilience in the Limpopo River Basin Program - RESILIM, GRID Arendal, and Global Water Partnership Southern Africa – GWP SA) who found it necessary to formulate the vision for the Atlas, which informs and promotes sustainable use and management of the basin. Building on the vision, the process of developing the Atlas included the contracting of the lead authors (Southern African Research and Documentation Centre – SARDC); training of contributors on necessary skills in research and cartographic and satellite imagery analysis; development of the content material and compilation of the manuscript; validation workshops; and reviewing and editing of chapters. At each stage of the process was a professional team of experts and specialists that ensured that the Atlas is a high-quality product. It is with gratitude that we would like to recognise the sterling contributions made by everyone involved in developing the *Limpopo River Basin: changes, challenges and opportunities*.

Throughout this process, the partner organisations provided strategic, financial and technical support and guidance to the development of the Atlas, as indicated below.

USAID RESILIM is specifically thanked for providing a contracting mechanism for the lead authors, SARDC, and financially and technically supporting the engagement of experts who spearheaded the development of the various chapters and collation of the information into a dynamic product.

GRID-Arendal provided training for the contributors on necessary skills in research and cartographic and satellite imagery analysis, and connected the project with credible data providers such as the United States Geological Survey (for remote-sensing data) as a way of developing local capacities to collect, process, analyse and visualize such data.

GWP SA ensured that the whole process remained in link with relevant stakeholders such as the Limpopo Watercourse Commission (LIMCOM), government departments, local authorities, private sector, civil society and community leaders.

SARDC as the Lead Author helped the partner-organisations realise their vision by driving the development of technical content for the Atlas through research that was supported by participatory interactions across the basin.

LIMCOM through its Technical Task Team and the Executive Secretary (Mr. Sergio Sitoe) provided key reports and information from the Limpopo Monograph study that was concluded by AURECON and GIZ in 2013 on behalf of LIMCOM, and actively participated in the regional validation workshops that were organised through GWP SA and SARDC. LIMCOM also provided vital guidance on key stakeholders to be targeted through the consultation process, so as to enhance stakeholder ownership of the final product.

We also recognise the individual efforts that were put into this work, without which it would not have been possible to produce this Atlas. We thank the authors for the research and content development for the manuscript; the reviewers and editorial teams for their sharp technical eye; the coordinating team for ensuring that all moving parts were lubricated to eliminate friction; and all workshop participants for their contributions in the consultative process. A detailed list of all who contributed is provided at the end of this Atlas.

Appreciation is extended to the governments of the riparian states of the Limpopo River Basin for the tremendous support they gave during the development of this Atlas.

Acronyms

ADMP	Agricultural Drought Management Plan
AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
ARAs	Regional Water Authorities
BLIS	Baixo Limpopo Irrigation Scheme
BMC	Botswana Meat Commission
BTFPL	Brigada Técnica de Fomento e Povoamento do Limpopo
CBNRM	Community-Based Natural Resource Management
CMA	Catchment Management Agency
CPWF	Challenge Programme on Water and Food
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organization
DGS	Department of Geological Survey
DNA	National Directorate of Water
DNGRH	National Directorate of Water and Resource Management
DPSIR	Drivers-Pressure-State-Impact-Response
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EWS	Early Warning System
FAO	Food and Agriculture Organization
FEWSNET	Famine Early Warning Systems Network
FMD	Foot-and-Mouth Disease
FTA	Free Trade Area
GCM	General Circulation Model
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GLTCA	Great Limpopo Transfrontier Conservation Area
GMP	Groundwater Management Programme
GWP SA	Global Water Partnership Southern Africa
HIV	Human Immunodeficiency Virus
IFSS	Integrated Food Security Strategy
INAM	National Institute of Meteorology
INGC	National Institute of Disaster Management
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
JPCC	Joint Permanent Commission for Co-operation
JPTC	Joint Permanent Technical Commission
JWC	Joint Water Commission
LBPTC	Limpopo Basin Permanent Technical Committee
LIMCOM	Limpopo Watercourse Commission
MLG	Ministry of Local Government
MMEWR	Ministry of Minerals, Energy and Water Resources
NGO	Non-Governmental Organization
NIPIS	National Irrigation Policy and its Implementation Strategy
NSPR	National Strategy for Poverty Reduction
PMTCT	Prevention of Mother to Child Transmission
RAK	River Awareness Kit
RESILIM	Resilience in the Limpopo Basin Program
RBCs	River Basin Management Committees
RISDP	Regional Indicative Strategic Development Plan
RSAP	Regional Strategic Action Plan
RWP	Regional Water Policy
RWS	Regional Water Strategy
SACU	Southern African Customs Union
SADC	Southern African Development Community
SADC WD	SADC Water Division
SAPP	Southern African Power Pool
SARDC	Southern African Research and Documentation Centre
SSTs	Sea Surface Temperatures
TAGMI	Targeting Agriculture Water Management Interventions
TBAs	Transboundary Aquifers
TFCA	Transfrontier Conservation Area
UN OCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VCT	Voluntary Counselling and Testing
WFP	World Food Programme
WMO	World Meteorological Organization
WSA	Water Services Authority
WSP	Water Services Provider
WUAs	Water User Associations
WUC	Water Utilities Corporation
ZINWA	Zimbabwe National Water Authority

Executive Summary

The *Limpopo River Basin: changes, challenges and opportunities* is a collaborative initiative with the objective of providing evidence-based analyses on changes in the Limpopo River Basin, including their drivers and outcomes, so as to motivate policy action and the promotion of sustainable development. The Atlas is for use by policy makers, technical staff, planners and the general public to raise awareness, influence decision making and generate action and interventions towards climate resilience through adaptation and mitigation of impacts of climate change. The Atlas discusses impacts that environmental changes are having on the basin's people and resources, as well as documents the relationship between human populations and the environment.

The Limpopo River Basin is one of the 63 transboundary river basins in Africa and is the fourth largest in southern Africa after the Congo, the Zambezi, and the Orange-Senqu basins. The basin is endowed with underground water resources that are important in supplementing surface water resources. The catchment characteristics of the basin are very diverse, covering different climatic and topographic zones, as well as land use types, including protected areas. The basin represents one of the best of what southern Africa has in terms of shared natural capital. The natural capital in the basin defines the economic activities that range from agriculture, mining and manufacturing to conservation and tourism, as well as scientific monitoring and research.

The *Limpopo River Basin: changes, challenges and opportunities* contains five chapters. The chapters make use of maps, satellite images, tables, graphs, photographs and illustrative text to present the key issues in the basin.

Chapter 1 presents an overview of the socio-economic and physical characteristics of the Limpopo Basin and highlights the issues and challenges impacting on people and ecosystems. Specific socio-economic issues covered in this chapter are population, population density and distribution, population growth, people and culture, urbanization, agriculture, commercial forestry, mining, power generation, industry and tourism. Biophysical features include water resources, soils, geology, vegetation, and biodiversity.

The basin is characterized by a wide diversity of culture, languages and ethnic groups. The population of the basin continues to grow from about 18 million people in 2011 to a projection of over 20 million in 2040. With the increase in population, climate change impacts, and economic development, associated challenges faced in the basin highlighted in this chapter, and later discussed in depth in the subsequent chapters, include increase in demand for water, food insecurity, transmission of wildlife diseases as well as threats of desertification in some parts of the basin.

The basin is making efforts to address the challenges. The creation of transfrontier conservation areas allows tourists and wildlife to cross international borders with minimal difficulties, though with potential threats to contend with, including plant and animal pests and diseases, and relocation of people within conservation zones. Political stability across national borders has facilitated the expansion of environmental conservation strategies and benefits beyond community-based natural resources management in individual countries to transboundary natural resources management initiatives that are more appropriate for resources that transcend international borders.

Chapter 2 presents the key environmental and socio-economic changes taking place in the Limpopo River Basin. The chapter indicates changes in climate, land, biodiversity and water resources in the basin as well as the impacts on livelihoods and ecosystems. Causes of the changes include population growth, global warming, expansion of urban areas, as well as increase in economic activities such as mining, manufacturing and agriculture. The environmental changes in the basin are continuous and in some cases dramatic.

The maximum temperatures in the basin have increased by between 1 °C and 1.4 °C in summer months. This trend is expected to continue with a significant increase in the frequency of hot extremes in the basin and a decrease in the number of cold extremes. Long-term, average rainfall is expected to decrease by up to 15 percent. Seasonality and timing of future rainfall seasons is expected to shift due to the climate change. Late onset of rains and long dry spells are expected in the basin.

The extreme rainfall events in the basin aggravate the condition of already degraded land through increased runoff and flash floods. Frequent droughts act as a strong catalyst in the initial and progressive degradation of land. Demographic pressures have induced changes leading to more intensive use but often leading to degraded natural resource base.

A major concern in the Limpopo Basin is transboundary transmission of animal diseases, especially foot-and-mouth disease between wildlife and livestock. This is easily transmitted especially between buffalo and cattle. More than 100,000 km^2 of the Great Limpopo Transfrontier Conservation Area is without fence to separate wildlife from livestock and humans, and this poses a major challenge in managing transboundary animal diseases. Invasive aquatic species provide conditions which suppress indigenous aquatic biodiversity. There are several operational programmes in the basin countries to control alien species but the process is very expensive and takes several years to complete.

There is significant progress in the provision of water and sanitation facilities to rural and isolated communities. Over 90 percent of the population in Botswana and South Africa had access to safe drinking water supply while over 60 percent had access to adequate sanitation as of 2015. Groundwater, together with water conservation and water demand management, provides hope for increasing water supply and adaptation to climate change in the Limpopo River Basin. However, for the sustainable use of the groundwater resources good stakeholder engagement, legislation enforcement and better understanding of local and transboundary recharge and managed recharge are needed.

Chapter 3 looks at extreme events affecting the Limpopo Basin, with particular focus on floods, droughts and cyclones. The chapter provides impacts on livelihoods and ecosystems, and adaptation measures and future scenarios for these extreme events in the basin.

Rapid rises in temperatures are projected to occur over the Limpopo Basin. In association with drastically rising maximum temperatures, the frequency of occurrence of very hot days is also projected to increase due to climate change. Rainfall in large parts of the basin is also expected to decrease.

Large sections of the basin are highly vulnerable to extreme events such as floods and droughts. The semi-arid nature of large portions of the basin is likely to exacerbate the impacts of climate change as the basin is already water-constrained. The impact of drought on river flows and water availability includes water shortages, which creates competition for both water abstraction and demand for wastewater disposal. High levels of poverty and low levels of service, inadequate infrastructure and weak governance in the basin result in low levels of adaptive capacity. The most vulnerable groups to climate change impacts include women, the elderly, youth and marginalized groups.

Adaptation strategies are urgently needed to respond to the negative impacts of such change. The key adaptation strategies aim to moderate the environmental impacts as well as take advantage of new opportunities to cope with the consequences of new conditions. To better respond, countries in the basin have identified a number of adaptation strategies to be implemented at local, national and basin levels. Among other measures, basin countries are focussing on indigenous knowledge to strengthen their resilience as it is considered cost effective, participatory and sustainable. Basin States are facilitating movement of people out of areas where their livelihoods are at risk, as well as putting in place social safety nets to assist people who are vulnerable to climate change.

Chapter 4 analyses trends and impacts of the changing environment to livelihoods. It assesses demographic changes, cultural dynamics, urbanization, industrial development, as well as infrastructure development in the basin. Livelihood options and opportunities vary significantly across the basin. Although the number of people living below respective minimal standards of living is high, there has been a slight decrease in poverty incidence. The livelihoods in the basin are deemed secure and sustainable when households have ownership of, and access to resources and income-earning activities to cope with and recover from stresses and shocks, while not undermining the future natural resource base.

The Limpopo Basin has low potential for hydropower, but generates much of the thermal power that feeds into the Southern Africa Power Pool. The availability of electricity has positive benefits on human health and the environment.

The peace and stability in the region, particularly among the basin states saw increased demand for cross border trade and movement of people, resulting in increased demand for transport systems, services and facilities. The basin's road and rail networks are in different conditions, with the road network being generally good and tarred. The tourism sector in the basin remains crucial in providing additional avenue and economic diversification and poverty reduction by empowering communities through the community based management programmes. Access to education and literacy rates improved considerably in the post-independence period and both primary and secondary education are readily available in the basin.

Chapter 5 presents the key institutional and policy arrangements that exist in the Limpopo Basin. It highlights the critical importance of cooperative river basin planning and management, as well as highlights the complex political and management challenges.

The chapter notes that when institutions and policies are weak, agencies with authority over a particular economic sector can make uncoordinated decisions about water allocation and use, which lead to inefficiency and degradation of the resource. In the end, the cost of non-cooperation becomes high, including the economic cost of negative environmental impacts, suboptimal water resource development, political tensions over shared resources, and the forgone benefits of joint water resource development.

The shared water and other natural resources present an opportunity for both cooperation and conflict. Differing socio-economic contexts and the different levels of development among the Limpopo Basin countries result in uneven distribution of water. A coordinated effort for sustainable utilization is important to boost cooperation and avert conflicts in the basin. Various transboundary management arrangements exist at regional, basin and national levels that can be used to foster effective transboundary management. These arrangements range from bilateral to multi-lateral as reflected in the changing political, social, and economic, policy and institutional landscape within the region.

A common observation throughout the Limpopo Basin countries is that a plethora of institutions exist, and often with overlapping mandates thereby calling for an improvement in national and transboundary river basin management, planning and co-ordination.

The Atlas concludes by highlighting key findings and policy options for decision makers.

Introduction

The *Limpopo River Basin: changes, challenges and opportunities* provides evidence-based analyses on changes in the Limpopo River Basin, including their causes and outcomes, so as to motivate policy action and the promotion of sustainable development. The basin is shared by four countries namely Botswana, Mozambique, South Africa and Zimbabwe.

The Atlas synthesizes existing information on environmental and socio-economic changes in the basin, raising stakeholder awareness on the impact of climate change. It proposes appropriate measures to prevent, manage, and mitigate negative impacts, and informs sustainable use and management of the Limpopo River Basin system.

It packages complex environmental data into easy-to-understand but credible, science-based information, for consumption by planners and policy makers at different levels. It combines narratives, satellite images, photographs, statistics and maps in a way that is easily understood and compelling.

The Atlas is a planning tool targeted at policy makers, technical staff, planners and the general public, and it is expected to raise awareness, influence decision making and generate action and interventions at local, national and regional levels.

The Atlas fulfils LIMCOM's main objective of "advising Member States and providing recommendations on the uses of the Limpopo, its tributaries and its waters for the purposes and measures of protection, preservation and management of the Limpopo."

Framework and Approach

The Atlas uses the Drivers-Pressure-State-Impact-Response (DPSIR) framework model to assess the causes, state, and impact to the environment and livelihoods in the Limpopo Basin. The DPSIR framework is multi-scalable and indicates generic cause-and-effect relations.

Drivers are indirect or underlying forces and fundamental processes in society which result in activities having a direct impact on the environment. Pressures are 'root causes' of environmental problems and trends. State indicators show the current condition of the environment as a result of drivers and pressures, such as polluted water resources, degraded land, or deforested areas. Knowledge about the "state" and "pressures" is the starting point for planning how the environment can be influenced to improve human well-being. Impact indicators describe results from changes in the characteristics of the environment. Understanding impacts is useful in identifying policy options and actions to mitigate and address the issue. Responses indicate societal or individual actions taken

The Limpopo Basin is home to a fairly large herd of elephants, most of which are found in protected areas.

to strengthen climate resilience of communities and the sustainability of ecosystems.

Process

The preparation of the *Limpopo River Basin: changes, challenges and opportunities* was based on a wide consultative and participatory process involving Member States and experts in the Limpopo River Basin. Consensus was built around basin perspectives and priorities.

Experts from specialised organisations and from national institutions in the four countries mandated to carry out assessments in water and environment and related thematic areas were involved in providing inputs, as well as in the review of the manuscript. Technical experts in climate modelling, Geographic Information Systems (GIS) and cartography, contributed to the development of the Atlas. This ensured basin balance, scientific credibility and comprehensiveness of the report.

The Atlas was constructed around a firm data and information development process. Literature reviewed to understand issues and challenges in the basin, and to identify areas where significant environmental changes have occurred, include Limpopo River Basin Monograph Study, Limpopo River Awareness Kit, Atlas for Disaster Preparedness and Response in the Limpopo Basin, Resilience in the Limpopo Basin programme (RESILIM) assessments, and state of environment and outlook reports for basin countries. Statistics for basic indicators such as population and size of the basin were obtained from the Limpopo River Basin Monograph Study, whose development process was highly consultative in nature and is considered by the four basin states as the most recent authentic source.

Once sites or hotspots were identified, satellite images, ground photos and statistical data were collected to show any changes taking place. The Atlas uses LANDSAT data which is freely downloadable at www.earthexplorer.usgs.gov to depict environmental change. The Atlas uses other illustrations such as photographs and maps to show environmental changes that cannot be seen in remote sensing images.

The Atlas benefited from a capacity development process driven by GRID-Arendal. Areas covered in the training workshop included processing of satellite imagery and cartography.

The process leading to this Atlas started in 2014 with an inception workshop convened in Bulawayo, Zimbabwe by Global Water Partnership Southern Africa (GWP SA), initially to build the foundation through issues identification, consensus building on the ideal framework to use in the analysis as well as the key hotspots that should be included in the Atlas. Further consultations were conducted to draft the outline and finalise methodology of producing the Atlas. Commissioning of contributors, research and compilation of data for the chapters and thematic areas started in 2016.

The Limpopo Basin generally has a youthful population

The draft manuscript was then reviewed at a GWP SA convened regional workshop in South Africa to strengthen the content, visual impact of the atlas and to identity case studies and hotspots. This gave a cross section of stakeholders an opportunity to discuss the draft chapters and structure of the Atlas. Regional experts also reviewed the Atlas in a process that ran parallel to the review workshop. Comments from the reviews were used to finalise the draft manuscript.

After the extensive consultative process, a technical editor reviewed and edited the draft manuscript for completeness, coherence and to ensure it is technically sound, before undergoing the production process.

Partners in the production of the Atlas are USAID-RESILIM, Global Water Partnership Southern Africa (GWP SA) and GRID-Arendal.

The development of the Atlas content was coordinated by the Southern African Research and Documentation Centre (SARDC), on behalf of RESILIM, a five year USAID Southern Africa-funded programme to build the climate resilience of communities and the sustainability of ecosystems in the basin by improving transboundary management of the Limpopo River Basin through working with targeted populations to ensure that socio-economic benefits are derived from natural resources management, and also leveraging investments for climate change adaptation and biodiversity conservation from private and public sector Partners.

1

LIMPOPO BASIN OVERVIEW

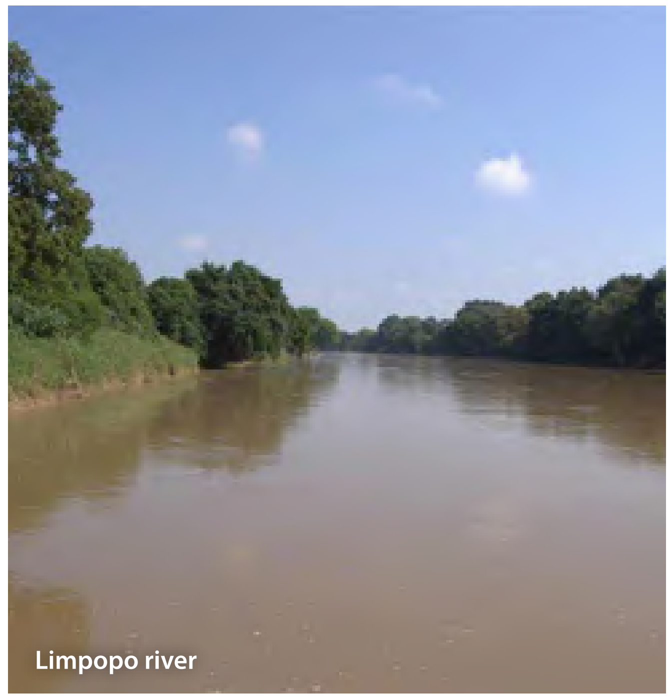
The Limpopo River Basin, which is one of the 63 transboundary river basins in Africa (UNEP 2010), is the fourth largest in southern Africa after the Congo, the Zambezi, and the Orange-Senqu basins (LIMCOM 2013). The transboundary basin is shared by parts of Botswana, Mozambique, South Africa and Zimbabwe. The catchment characteristics are very diverse, covering different climatic and topographic zones, as well as land use types, including protected areas. The basin is endowed with underground water resources that are important in supplementing surface water resources.

This chapter gives an overview of the socio-economic and physical characteristics of the basin. It highlights issues and challenges impacting on people and ecosystems.

Profile and Characteristics of the Limpopo Basin

Location

Located between latitudes 22°S–26°S and longitudes 26°E–35°E, the Limpopo River Basin has a mean altitude of 840 m above sea level and drains an area of about 408,000 km^2 (LIMCOM 2013). The 1,750 km Limpopo River starts at the confluence of the Marico and Crocodile Rivers in South Africa, from where the river flows eastwards and is joined by 24 main tributaries before discharging into the Indian Ocean near Xai-Xai in Mozambique (SADC and SARDC 2002) as Figure 1.2 shows.


Limpopo river

The Limpopo River is significant for providing political boundaries. It forms the 394 km international border between Botswana and South Africa up to the confluence of the Shashe River, which flows in from Zimbabwe and Botswana. From the Shashe-Limpopo confluence, the river runs eastwards for a further 219 km, forming the international border between Zimbabwe and South Africa before entering Mozambique at Pafuri (SADC and SARDC 2002).

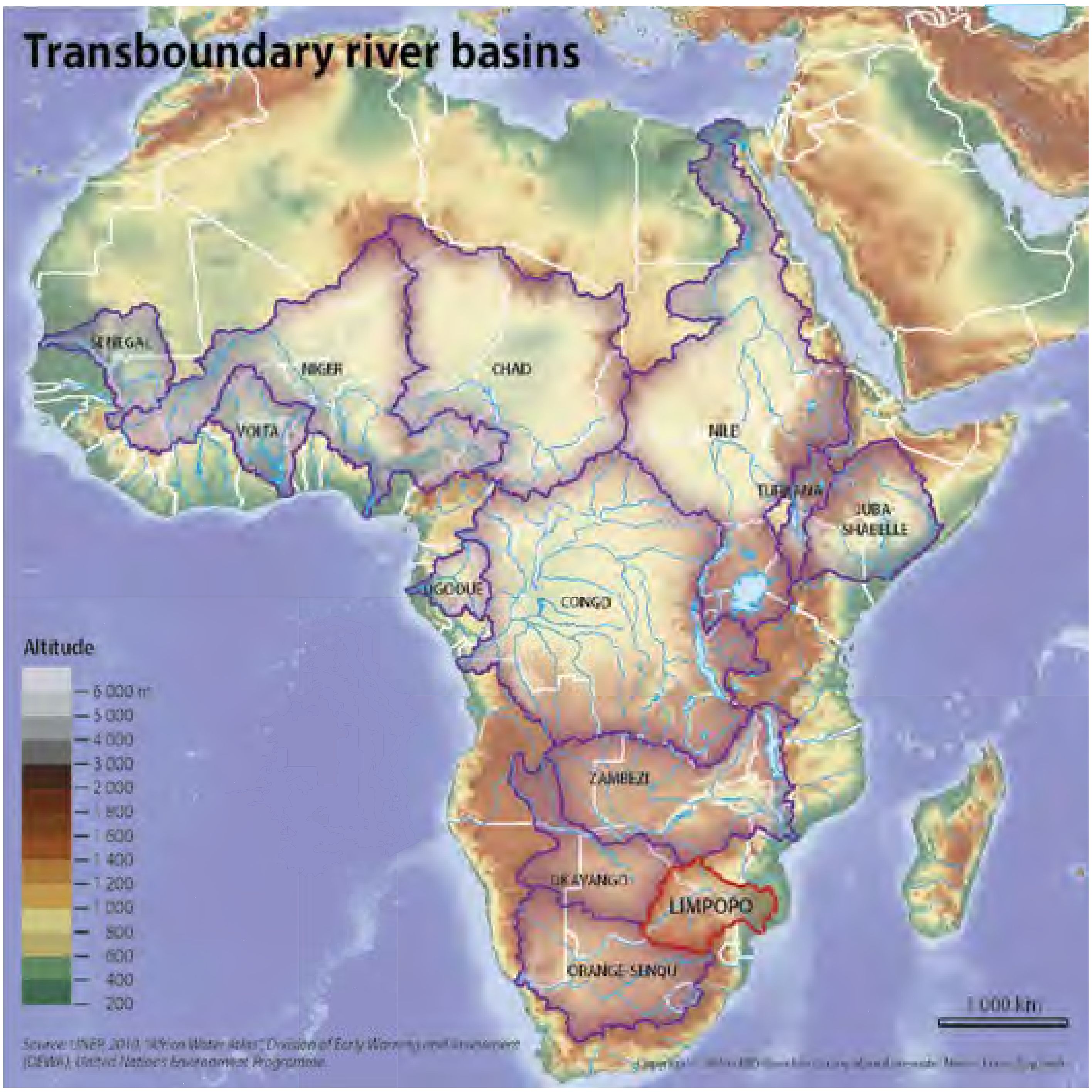


Figure 1.1 Africa's Major Transboundary River Basins

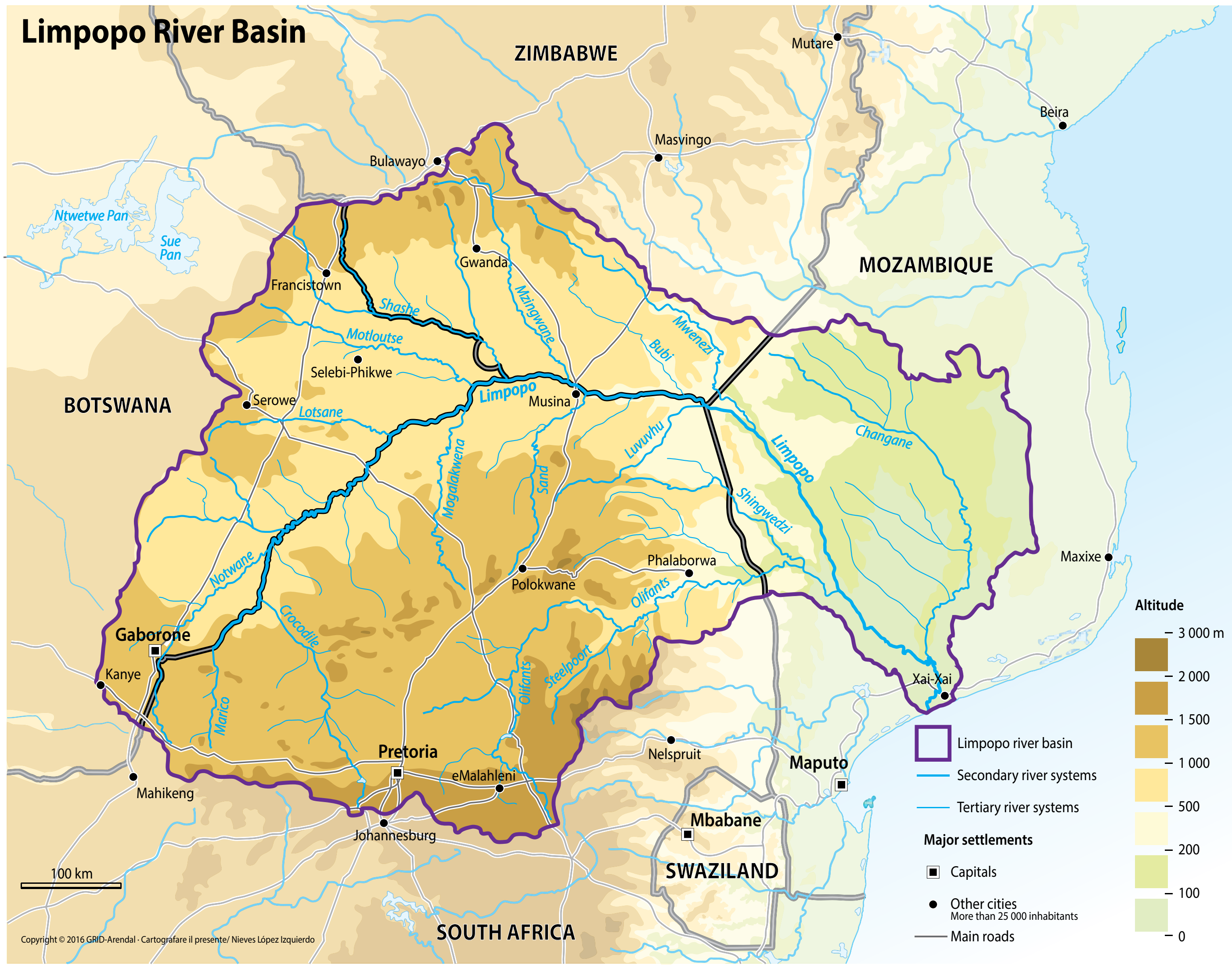
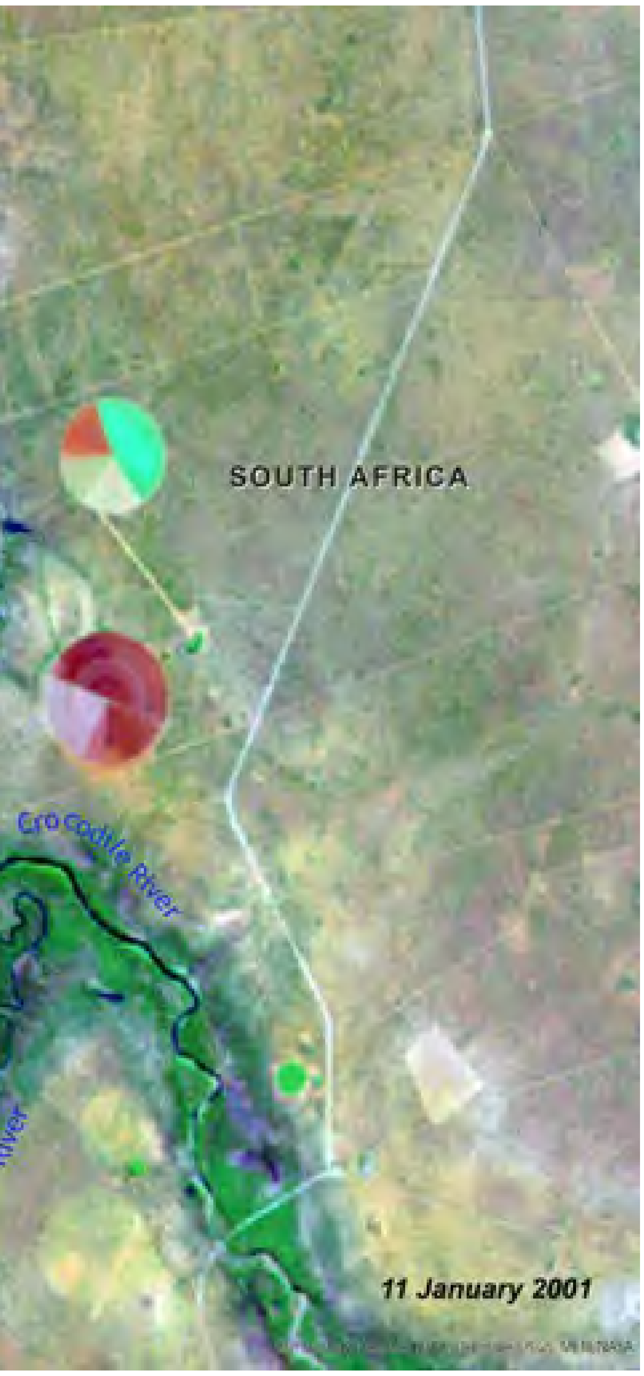


Figure 1.2 The Limpopo River Basin

This tributary of the Limpopo River is called the Luvuvhu by the Venda people, while the Tsonga call it the Rivubye River. Others call it the Levubu or Levuvhu River.

The Limpopo River starts at the confluence of the Marico and Crocodile rivers near the South Africa-Botswana border and flows northwest of Pretoria. Developments upstream on the Marico and Crocodile as well as at the Marico-Crocodile confluence have an effect on the Limpopo downstream. These images show an increase in irrigation and agricultural activity.

Marico River, also known as Maligwa in Tswana, has many dams including Molatedi, Marico-Bosveld and Madikwe Dams.



The Crocodile River, a tributary of the Limpopo, forms the full southern border of the Kruger Park.

Soils

Eleven major soil groups including Luvisols, Arenosols, Cambisols, Vertisols, Fluvisols, Lithosols (Leptosols), Ferralsols, Acrisols and Planosols are found in the Limpopo River Basin (LIMCOM 2013). These soil groups are dominated by moderately deep sandy to sandy-clay loams textures in the south, grading to shallower sandy soils in the north and deeper sandy soils in the west and east.

The soils, geology and vegetation cover of the basin have a direct influence on runoff, groundwater potential, sedimentation of surface water bodies, and agricultural potential. The deeper loam soils are important for agricultural activities and support extensive irrigation developments along many of the tributaries in South Africa, such as the Crocodile River catchment. A few extensive areas of black vertisols in the southern parts of the basin also support important agricultural developments. These soils are prominent in South Africa but few patches are found in Zimbabwe and Botswana. Vertisols are known to be of high fertility status due to high activity clay content, high nutrient level and high water storage capacity (LIMCOM undated).

Luvisols are the second most common soil type in the Limpopo Basin, particularly in South Africa, Zimbabwe and Botswana. These are well-drained, with high clay content in the subsoil when compared to the topsoil due to top-down clay migration during the soil formation process. Luvisols are moderately weathered and relatively fertile (LIMCOM undated).

Hilly or steeply sloping areas have shallow, stony soils, shown in Figure 1.3 as Lithosols, with little agricultural potential. Lithosols are prominent in mountainous areas of South Africa and Zimbabwe.

Deep layers of wind-blown Kalahari sands cover large areas of the western portion of the Limpopo Basin, while the sandy soils of the eastern (Mozambique) portion are derived from old, unconsolidated marine sands. These sandy soils support important hardwood

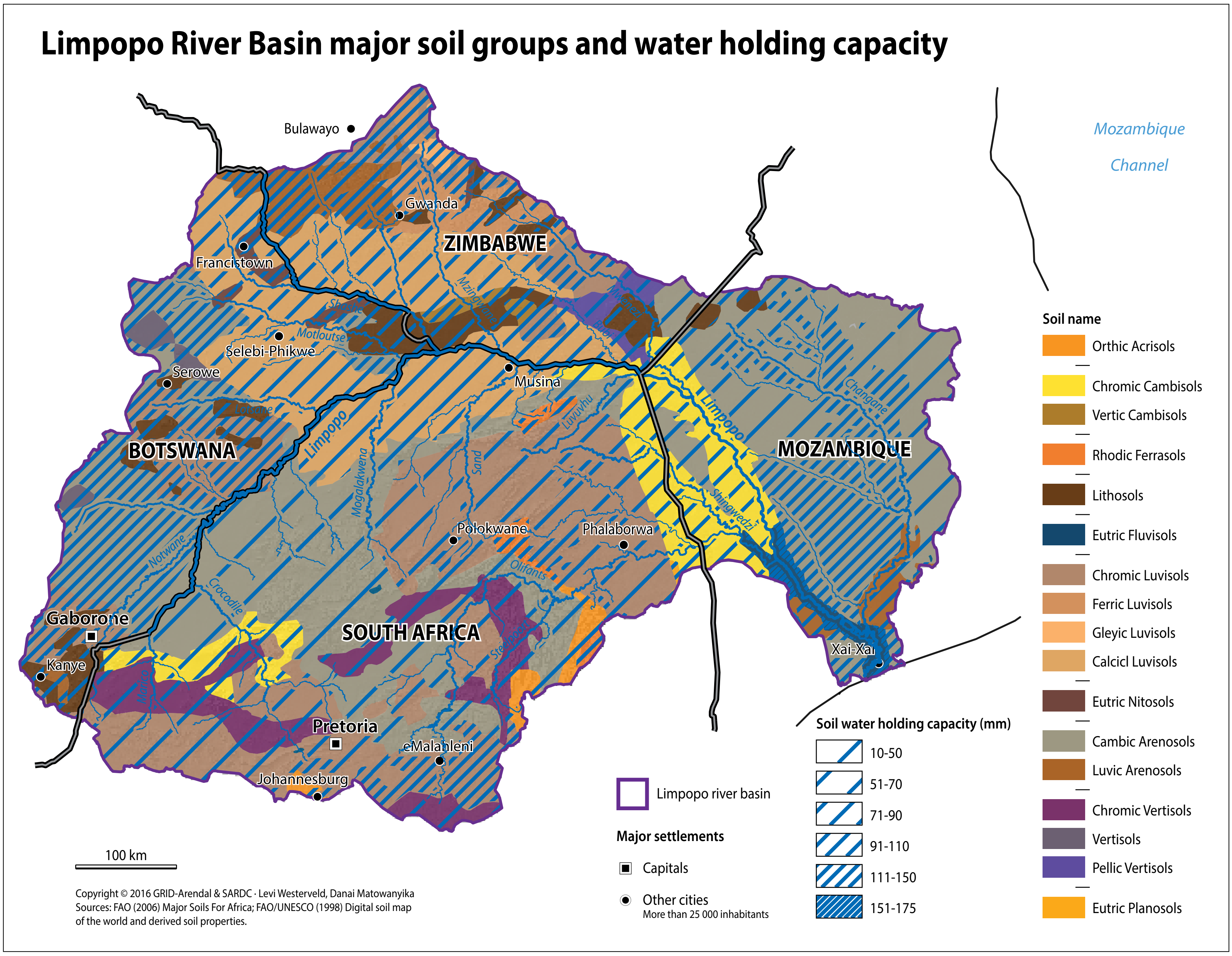


Figure 1.3 Soil water holding capacity

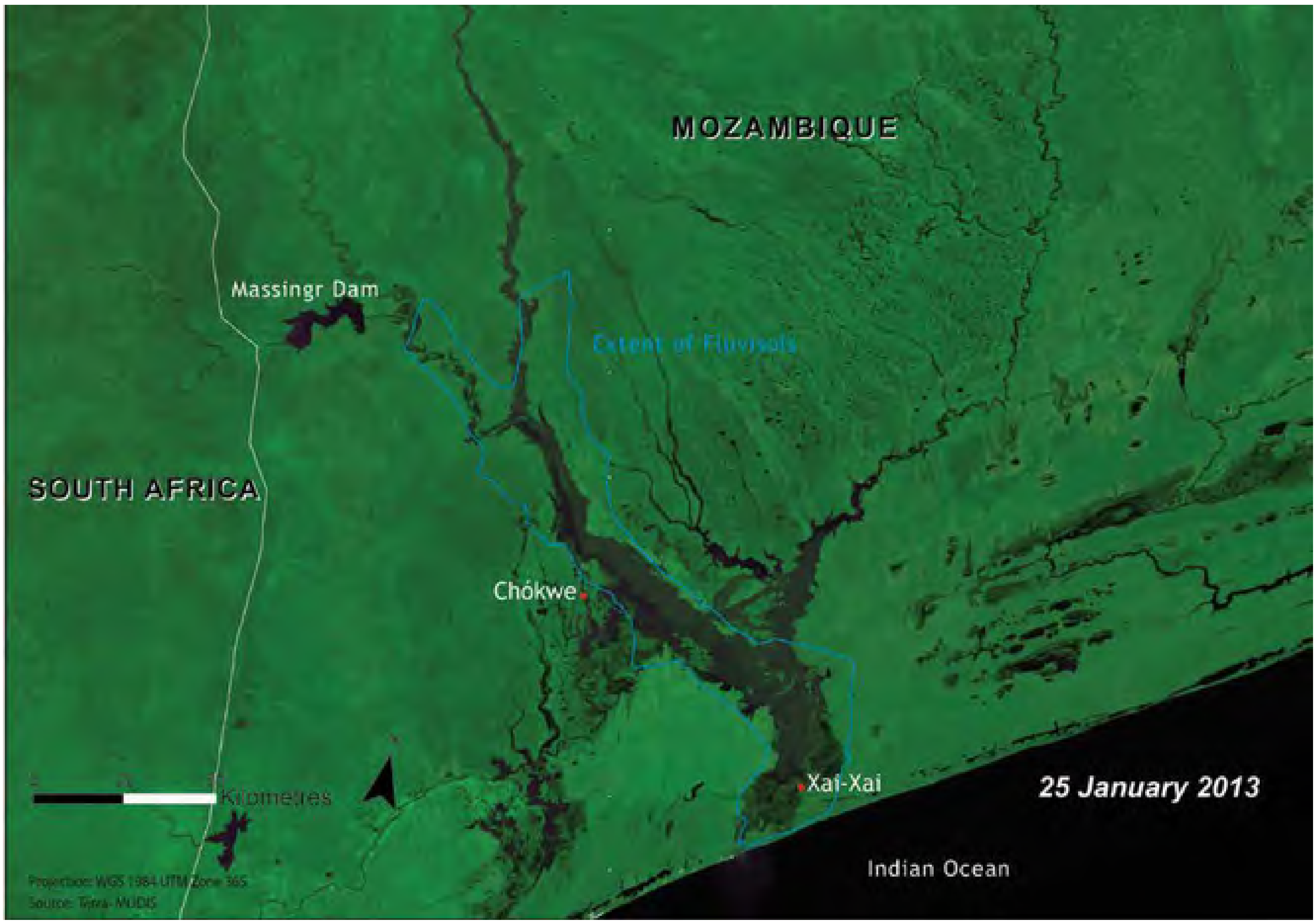
timber resources. Maize, cowpea and cassava grow well under these soils.

The valley bottom soils along all of the tributaries and the Limpopo main channels are generally of alluvial origin and support extensive areas of commercial and subsistence agriculture. In contrast, hilly or steeply sloping areas have fragile, shallow, stony soils with little agricultural potential.

Most of the Limpopo Basin has shallow sandy and loamy soils with low water holding capacities, except along flood plains in Mozambique as well as the Olifants and the Notwane sub-basins in South Africa and Botswana respectively, which contain high-capacity loams and clays (INGC, UEM and FEWSNET 2003). Figure 1.3 shows the soil water holding capacity of the Limpopo Basin.

Although the rich soils of the Limpopo floodplain are an important resource for agricultural purposes, some areas in the upper Limpopo Basin have poor soils that limit productivity.


Bladder hibiscus on vertisol in South Africa



Fluvisols, whose extent in the Lower Limpopo is highlighted in the above image, are younger soils developed from recent alluvial deposits. In the Limpopo estuary, they tend to be very wet with high clay content and influence of the extent of flooding when the river breaks its banks. Heavy rains in the month of January 2013 saw the Limpopo River spill over its banks with water spreading more than 10 kilometres across the landscape in certain places (NASA-EO 2013a).

Geology

Significant geological formations of the Limpopo River Basin include the Limpopo Mobile Belt, the Kalahari Craton, the Karoo System and the Bushveld Igneous Complex (SADC and SARDC 2002). The Kaapvaal Craton, the Zimbabwe Craton and the Mobile Belt form the southern Africa or Kalahari Craton (GTK Consortium 2006) and can be found upstream of the basin. Upstream Kalahari sands cover bedrock of varying depths, and in the form of flood-bank alluvium (Figure 1.4).

In the lower Limpopo Basin, large unconsolidated and consolidated sedimentary rocks with granitic intrusions exposed by erosion are the dominant geological feature of the landscape. The erosion plains are gently dipping towards the coast, and the coastal belt is also characterised by a dune area with an average width of 30 km. Chapter 2 provides details on the dynamics between geology and soils and surface and groundwater resources in the basin.

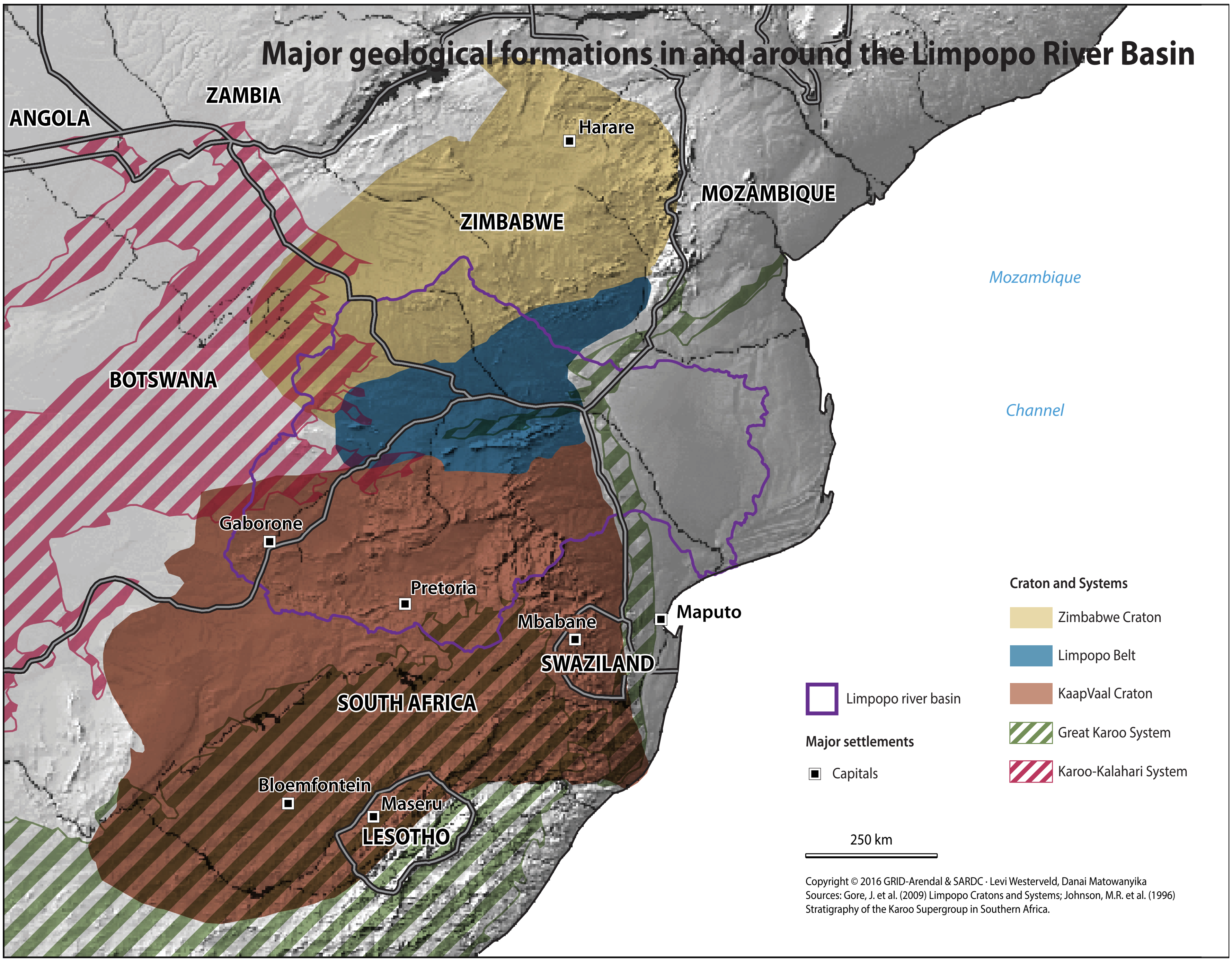


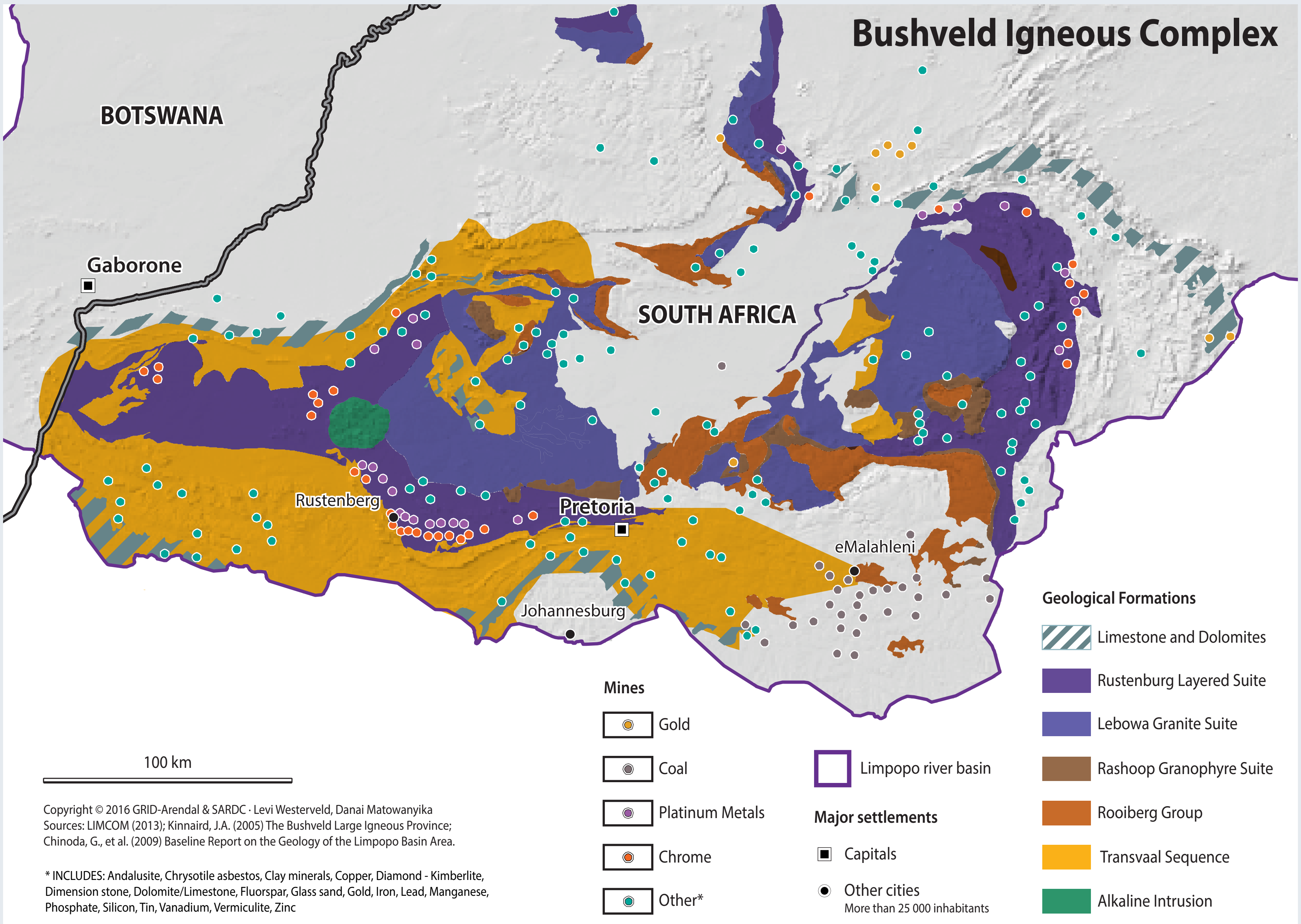
Figure 1.4 Major Geological Formations

Bushveld Igneous Complex

The South African portion of the basin contains very large coal deposits in the economically important Bushveld Igneous Complex. The extensive carbon-rich sedimentary rocks of the Karoo system are sites of intensive coal-mining activities. Basic mafic and ultramafic intrusive rocks and extensive areas of acidic and inter-mediate intrusive rocks are the main geological features, with large dolomite and limestone formations occurring at the southern and eastern periphery of this area.

Source: SADC and SARDC 2002; Petrie and others 2014

Black Chromitite and grey anorthosite layered igneous rocks at the Bushveld Igneous Complex



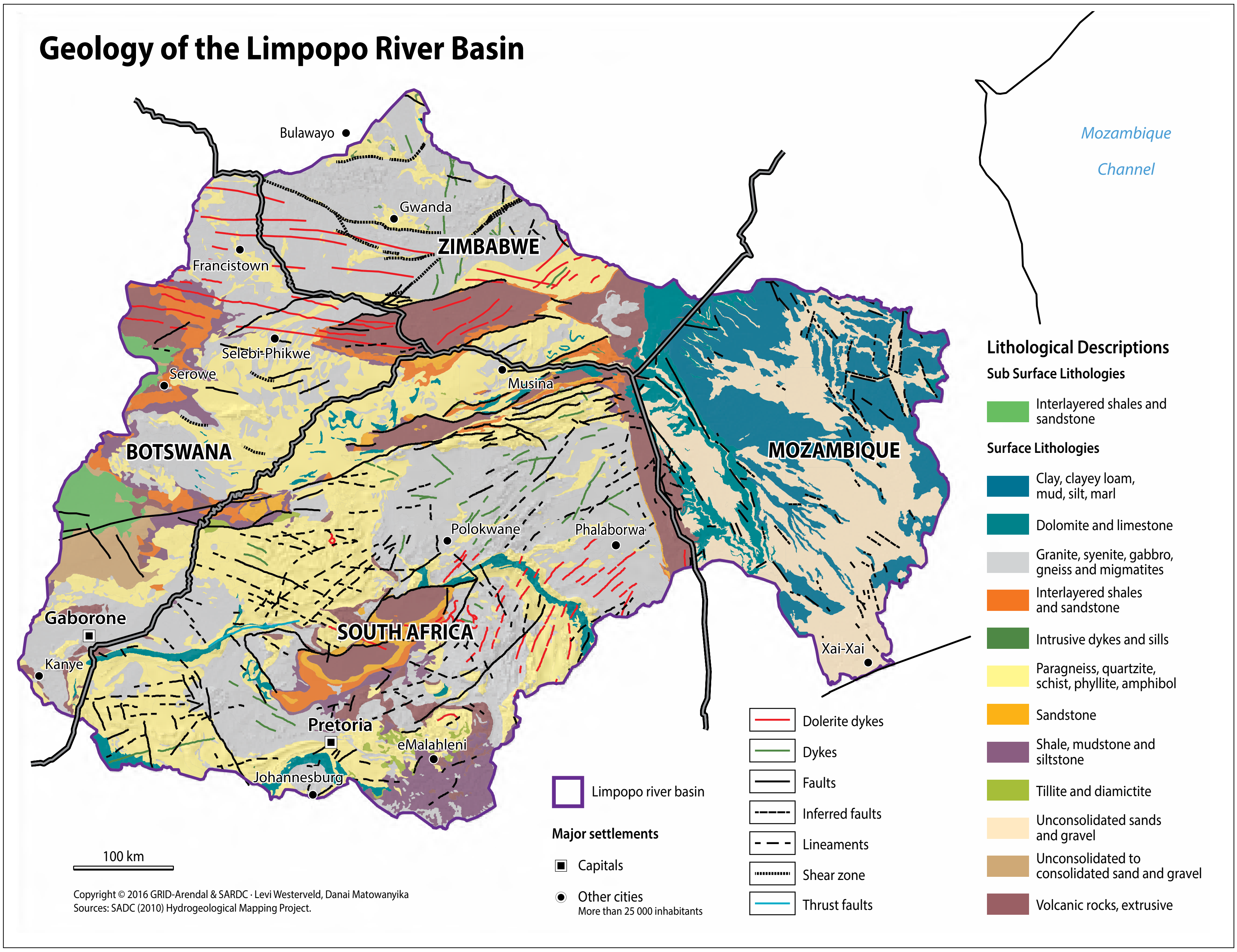


Figure 1.5 Geology of the Limpopo River Basin

Source: SADC Geological Map 2011

Vegetation

According to the IUCN classification, the Limpopo Basin is dominated by two major ecoregions – the Southern Africa Bushveld in the west and the Zambezian and Mopane woodlands in the east (Figure 1.6). The ecoregions include Kalahari Acacia woodlands in Botswana, Southern Miombo woodlands in Mozambique, Highveld grasslands in South Africa and the Southern Africa Bushveld in Zimbabwe. These ecosystems are found within and outside protected areas (Olson and others 2001).

Vegetation of the basin, Waterberg Mountains

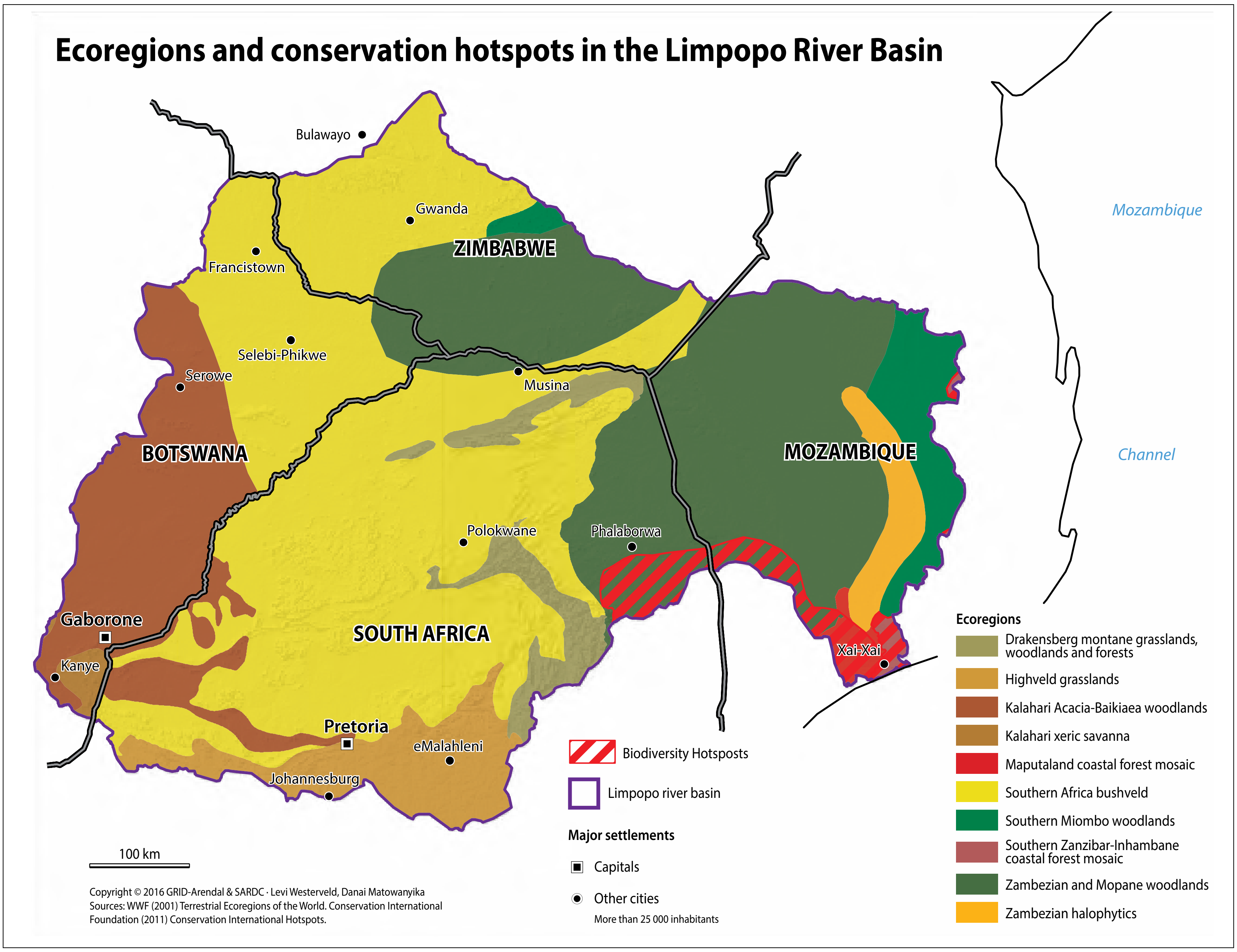


Figure 1.6 Ecoregions in the Limpopo Basin

Source: Olson and others 2001

Population and Culture

In 2011 the population of the Limpopo Basin was about 18 million and is expected to be over 20 million in 2040 (LIMCOM 2013). Major urban areas in the basin are Gaborone and Francistown in Botswana. In South Africa they include Rustenburg, Polokwane, Pretoria and part of Johannesburg. Bulawayo, Zimbabwe's second largest city is situated just outside, although it relies on water from the Limpopo River Basin. In Mozambique the town

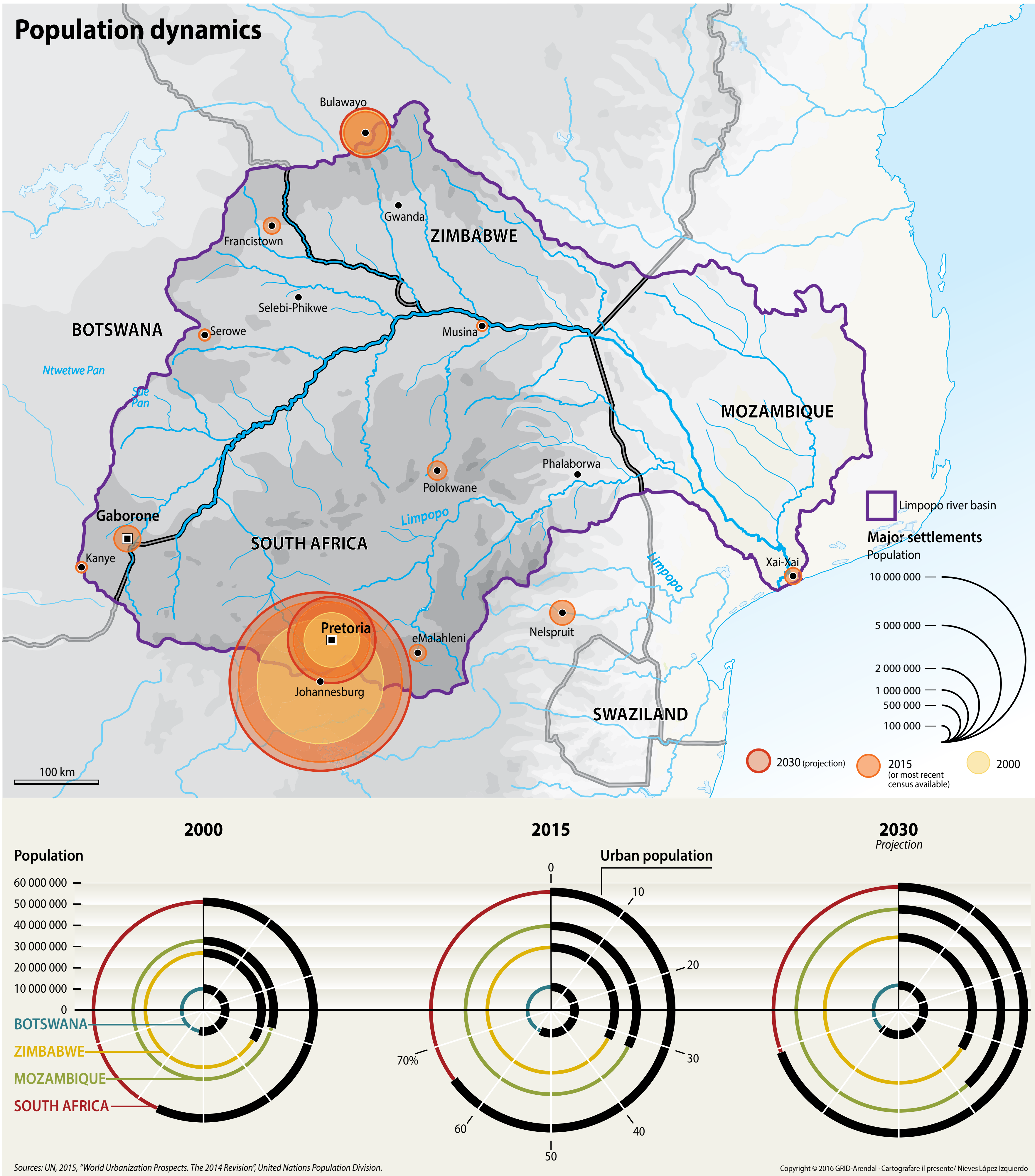


Figure 1.7 Growing Population of Limpopo Basin

Source: UN 2015

Table 1.1 Distribution of Limpopo basin area by riparian country

Country	Total country Pop (millions) 1998	Estimated country Pop (millions) 2001	Percentage in Limpopo River Basin 2001 (%)	Total country pop (millions) 2007	Percentage in Limpopo River Basin 2007 (%)	Total country pop (millions) 2011	Percentage in Limpopo River Basin 2011 (%)	Estimated Pop in Limpopo River Basin 2011 (millions)
Botswana	1.6	1.7	59	1.8	65	2.03	70	1.197
Mozambique	16.5	17.4	7	20.2	7	23.5	8	1.109
South Africa	42.1	44.6	24	48.5	25	51.7	29	15.078
Zimbabwe	11.4	11.7	6	12.3	6	12.9	7	0.831
Total (millions)	**71.6**	**75.4**		**82.8**		**90.2**		**18.21**

Source: LIMCOM 2013

Table 1.2 Limpopo Basin Population Projections

Country	2011	2015	2020	2025	2030	2035	2040
Botswana	1 197 314	1 210 365	1 222 226	1 233 226	1 239 639	1 244 722	1 249 078
Mozambique	1 109 481	1 115 139	1 119 934	1 124 862	1 128 799	1 131 847	1 134 111
South Africa	15 078 510	15 414 761	15 750 803	16 083 144	16 409 632	16 718 133	17 005 685
Zimbabwe	831 747	849 630	867 387	879 443	889 293	897 564	904 924
Total	**18 217 052**	**18 589 894**	**18 960 350**	**19 320 676**	**19 667 364**	**19 992 266**	**20 293 798**

Source: LIMCOM 2013

of Xai-Xai and the village of Chokwè are both situated in the basin. With an increase in urban migration and increase in mining activities water demand is expected to increase (LIMCOM 2013).

The Limpopo Basin population distribution is uneven. Sparsely populated areas in the basin include Mahalapye in Botswana which has the least population of 36,667 in an area of 9,023 km² (LIMCOM 2013). The basin also consists of areas which are densely populated such as Johannesburg and Pretoria, and the mining areas around Rustenburg and eMalahleni all within the Crocodile sub-basin comprising of an estimated population of 6,304,233 with an area of 29,392 km². Figure 1.7 shows population in major settlements in the basin.

As shown in Table 1.1, all basin countries have registered an increase in percentage of population living in the basin. Botswana, for example has the largest increase, from 59 percent in 2001 to 70 percent in 2011.

About 83 percent of the basin's population resides in South Africa (which can be seen in Table 1.2), accounting for over 15 million basin inhabitants, largely because of metropolitan areas of Tshwane and part of Johannesburg. Botswana largely depends on the basin for its water resources, with 70 percent of its total population residing within it (LIMCOM 2013). Widespread scarcity of water resources exist in the country, which makes the Limpopo River Basin a large attraction for human settlements and key economic activities. In addition, the basin area in Botswana has good soils ideal for arable farming as compared to poor sandy soils in the west of the country. With the exception of South Africa, most

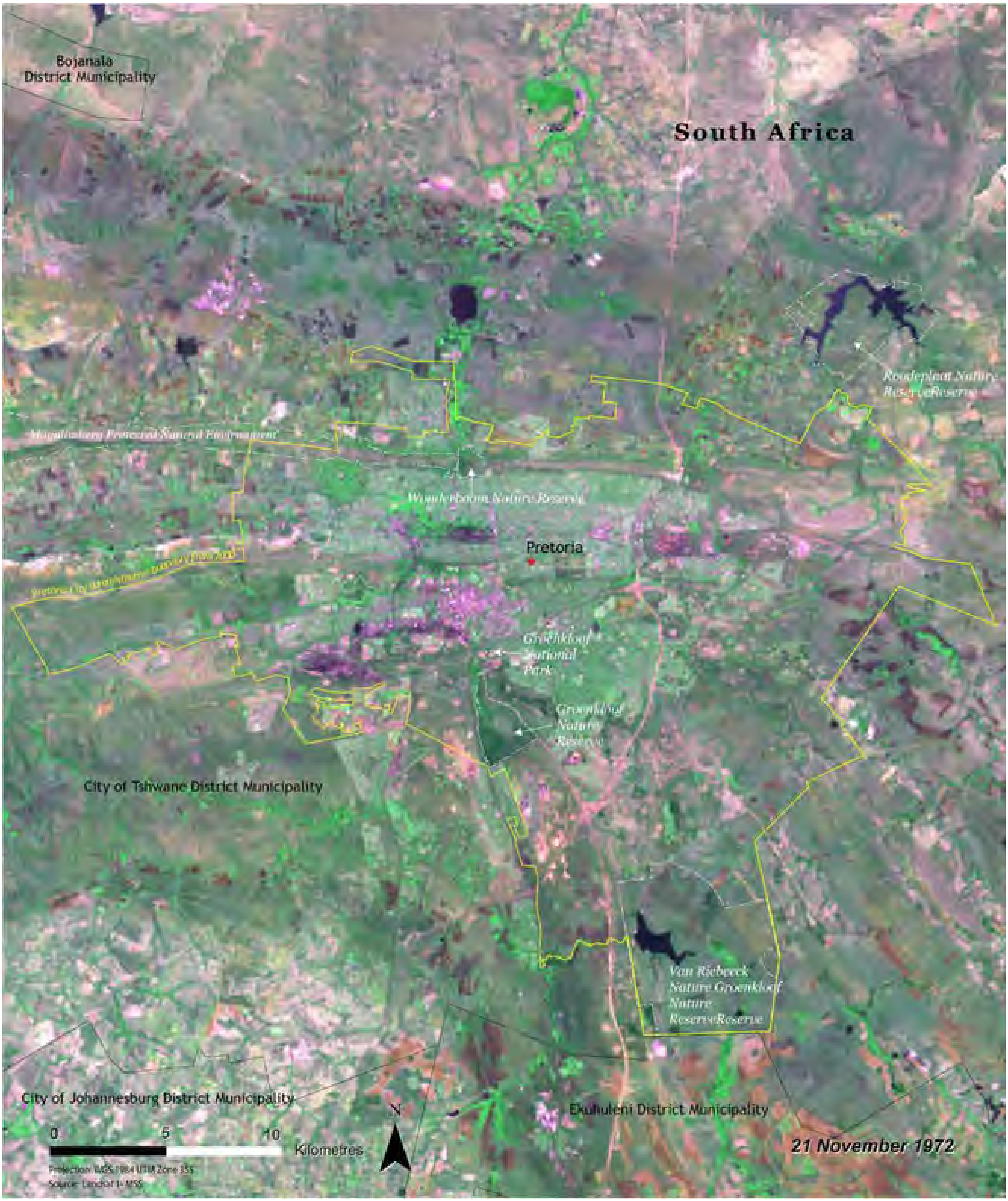
Cattle are a form of wealth in the rural areas of the basin

of the Limpopo population resides in rural areas as shown in Table 1.3 below. Large portions of the basin in Mozambique remain unsettled following years of civil conflict.

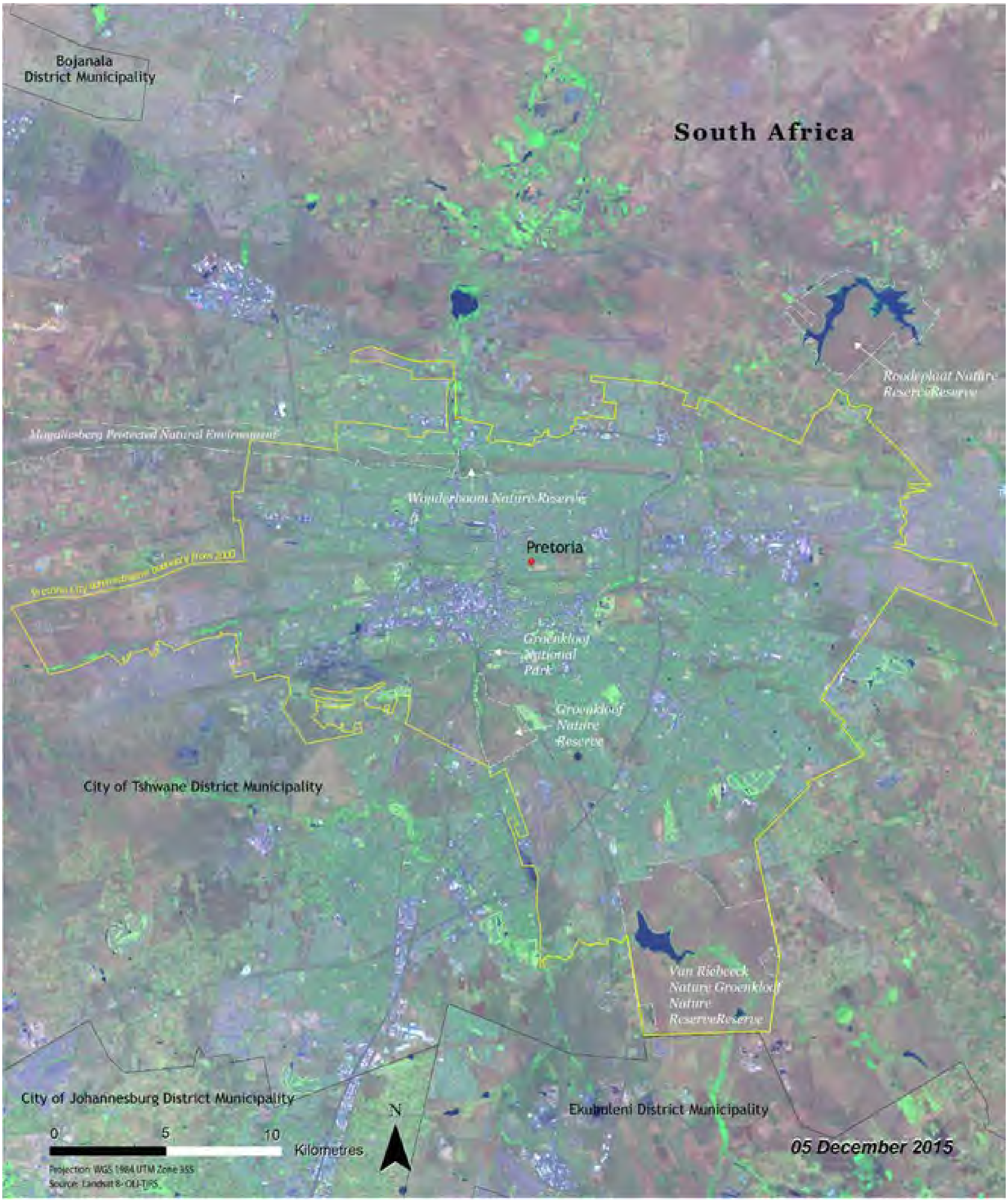
Table 1.3 Rural Population Split

Country	Urban	Rural
Botswana	34	66
Mozambique	15	85
South Africa	57	43
Zimbabwe	15	85

Source: LIMCOM 2013



Pretoria is a growing metropolis. Since 1972, urbanization (the grey and whitish areas) has expanded in all directions from the city centre, and well beyond the year 2000 administrative boundary as shown in the 2015 image.


Bojanala
District Municipality
South Africa
Roodeplaat Nature
ReserveReserve
Magaliesberg Protected Natural Environment
Wonderboom Nature Reserve
Pretoria
Groenkloof
National
Park
Groenkloof
Nature
Reserve
City of Tshwane District Municipality
Van Riebeeck
Nature Groenkloof
Nature
ReserveReserve
City of Johannesburg District Municipality
Ekurhuleni District Municipality
0
5
10
Kilometres
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Projection: WGS 1984 UTM Zone 35S
Source: Landsat 8-OLI-TIRS
05 December 2015

The spatial distribution patterns of rural settlements across the basin tend to follow river valleys, and the settlements are much denser in Mozambique and South Africa, compared to Botswana and Zimbabwe (Murwira and Yachan 2007).

The need to feed a rapidly growing population over the years has exerted pressure on land, water and natural resources in the basin. The basin's population expansion is due to natural population growth estimated at around 2.3 percent per year, as well as urban and transboundary migration, especially in Botswana and South Africa (LIMCOM 2013).

Settlement patterns in the basin are determined by a number of factors. Among the most prominent factors are land tenure, poverty and the use of environmental resources to address poverty. The national interests and priorities of the riparian countries differ in relation to water resources management, as follows:

- water use control for Botswana;
- upliftment of the lives of previously disadvantaged people for South Africa;
- irrigation and agricultural development for Zimbabwe; and
- flood control for Mozambique (LIMCOM 2013).

The Limpopo Basin is characterized by a wide diversity of culture, languages and ethnic groups, as presented in the box below.


Limpopo women

Limpopo Basin: A wide diversity of culture, languages and ethnic groups

Botswana
Botswana means 'Land of the Tswana people'. For most Tswana people, livestock rearing is a source of rural livelihood as well as a significant cultural status symbol. The dominant groups found in Eastern Botswana are the Bakalanga, Bangwato, Bakwena, Bangwaketse, Bakgatla, Batlokwa, Baherero, Balete, Barolong and the Baherero.

Mozambique
The three main groups of people on the Mozambican part of the Limpopo Basin are the Changana, the Copi and the Tshwa. The Changana are the majority, and are found in the districts of Massangena, Chicualacuala, Massingir, Chigubo, Mabalane, Guijá, Chókwe, Bilene, Xai-Xai, Cidade de Xai-Xai and parts of Chibuto.

South Africa
The languages spoken by the main population groups in the basin are Setswana, Sesotho, Xitsonga and Tshivenda. Afrikaans is primarily spoken by the white population who are scattered around the basin. The Bavenda are to a certain extent similar to the Kalanga of Zimbabwe and the Bakalanga of Botswana in terms of culture and language. Present day rural settlements of the Bavenda are found mainly in the fertile Upper Nzhelele River Valley, where the main sources of livelihood include irrigated farming and fishing. South Africa's Constitution provides for 11 official languages, namely Afrikaans, English, isiNdebele, isiXhosa, isiZulu, Sepedi, Sesotho, Setswana, siSwati, Tshivenda and Xitsonga.

Zimbabwe
The Ndebele are the largest group on the Zimbabwean side, in the Mzingwane catchment area. At around 20 percent of the national population, they are the second largest group after the Shona. Other groups found in the basin include the Sotho, mainly in Gwanda and some parts of the Bulilimamangwe district, the Venda around Beitbridge, Gwanda, Mberengwa and Plumtree, and the Kalanga found in the Bulilimamangwe and Matobo districts, and parts of Botswana. The Constitution of Zimbabwe (2013) recognizes 16 official languages: Chewa, Chibarwe, English, Kalanga, Koisan, Nambya, Ndau, Ndebele, Shangani, Shona, sign language, Sotho, Tonga, Tswana, Venda and Xhosa (Constitution of Zimbabwe, Amendment (No. 20) Act 2013).

Source: Earle and others 2006 GoZ 2013

Economic Activities

Economic activities in the Limpopo Basin include irrigation agriculture, commercial forestry, mining, power generation, manufacturing and tourism.

In Botswana mining, tourism and cattle ranching are the largest provider of employment opportunities. The irrigation agricultural sector is the largest sector in the Mozambique part of the Limpopo River Basin. The predominant economic activity in the South African sector of the Limpopo Basin is mining followed by agriculture and much lower down the scale manufacturing, eco-tourism and power generation.

In the Zimbabwe section of the Limpopo Basin, mining and irrigation agriculture are the main economic activities, with game related safari tourism also important.

The major factor that accounts for the pattern of economic activities in the basin is the availability of water (SARDC 2002). Table 1.4 shows the contribution of water to Gross Domestic Product (GDP), employment and household income per each sector.

Economic hubs in the basin include major urban and industrial centres such as Gaborone and Francistown in Botswana, Xai-Xai and Chokwè in Mozambique, Polokwane, Pretoria, Johannesburg and Rustenburg in South Africa and Beitbridge in Zimbabwe. Most manufacturing industries are concentrated in these large urban centres.

Income levels are much higher in Botswana and South Africa, and there are large disparities in terms of basin population density, proportion of rural population, adult literacy rate and mortality rates (LIMCOM 2013). See Table 1.5 below for selected social indicators.

Irrigation schemes help farmers to grow crops in the dry season

These socio-economic disparities and multiple, segmented economic sectors across the basin illustrate the complex nature of competition for essential but limited economic factors of production, such as water. For a detailed assessment of basin socio-economics and livelihoods in a changing environment, see Chapter 4.

The Limpopo River Basin faces a number of water resource challenges, which include increasing competition for scarce water resources among different sectors. Already, a large part of the catchment is threatened by water shortage (LIMCOM 2013). As such, sand dams play an ever increasing role as rivers in the basin experience desiccation and high rates of evapotranspiration.

Table 1.4 Contribution of Water to Economic Activity in the Limpopo Basin

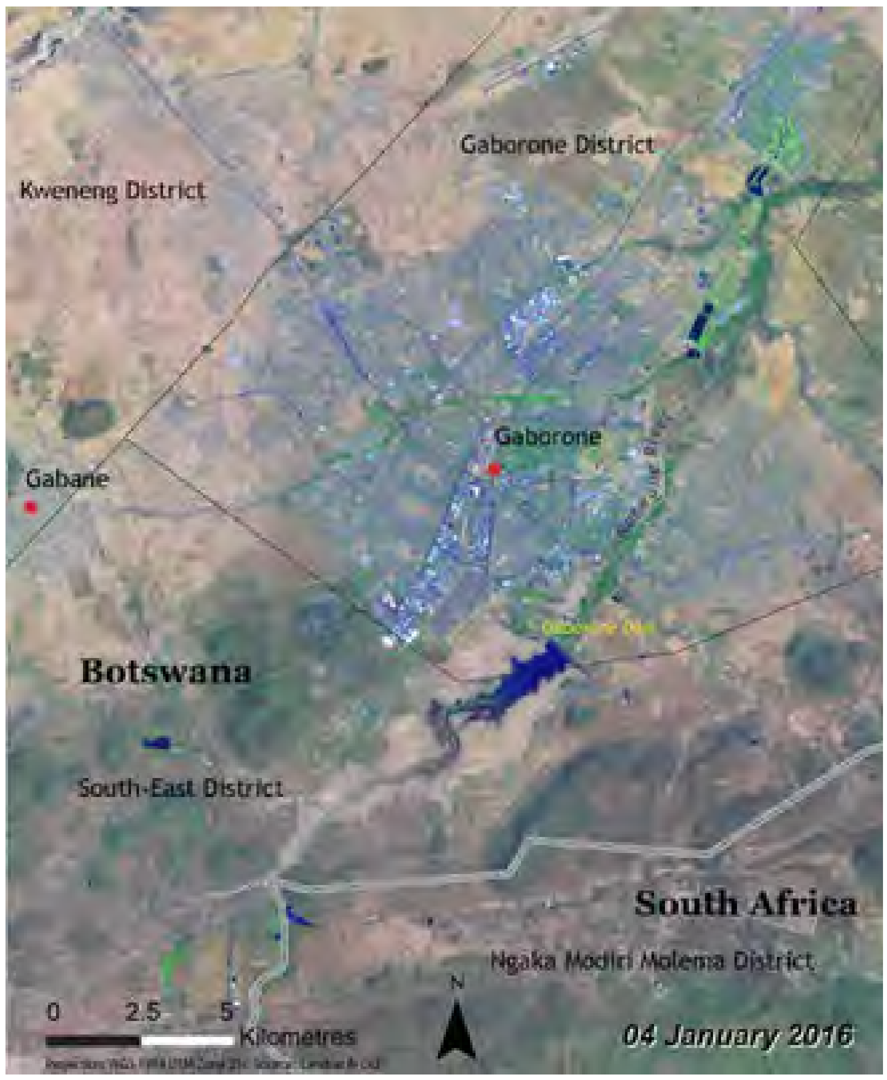
	GDP (US$/m³)	Employment (Number/million m³)	Household Income (US$/m³)
Irrigation	1.8	184.8	1.0
Commercial Forestry	1.3	130.5	0.5
Mining	145.9	4 239.7	62.6
Power Generation	29.3	727.8	11.1
Industry	469.4	4 434.4	273.2
Eco-Tourism	259.7	16 006.5	107.3

Source: LIMCOM 2013

Table 1.5 Selected Limpopo Social Indicators

	Botswana	Mozambique	South Africa	Zimbabwe
HIV Prevalence (%)	18 (2008)	26 (2010)	11 (2008)	21 (2011)
Poverty Ratio (%)	22 (2010)	60 (2008)	30 (2008)	72 (2003)
Infant mortality rate (per 1000 live births)	36 (2010)	92 (2010)	41 (2010)	51 (2010)

Source: LIMCOM 2013



A growing population and booming economy in Botswana has seen growth of Gaborone, an important economic hub in the region. The exponential urban growth over this period is seen in images from 1973, 1993, and 2016. Since 1993 there has been considerable urbanization in areas north, northeast, and northwest of Gaborone, including conversion of agricultural land to urban. Visual assessment of the 2016 image also shows falling water levels of Gaborone Dam by more than 50 percent due to persistent droughts experienced in the sub basin for years, as well as due to increased water demand in the greater Gaborone area.

Manufacturing

The manufacturing industry is well established in the Upper Limpopo Basin, and mining is the most intensive activity in Botswana. In the Middle and Lower Limpopo Basin, the Gauteng and Limpopo provinces in South Africa are the most industrialized parts of the basin, dominated by the manufacturing sector. In Bulawayo, located just outside the basin in Zimbabwe, the manufacturing sector is dominated by food processing, leather tanning, textiles and steel fabrication. The manufacturing industry in Mozambique is recovering after years of war, and the informal sector is expanding rapidly, spearheaded by trade in food, repair workshops and light furniture manufacturing, and small-scale family-based enterprises (SARDC 2002).

Irrigation Agriculture

As explained in Chapter 2, there is an increasing area under irrigation in the basin, and this is expected to increase pressure on already limited water resources. Improved irrigation equipment and management practices are expected to support increased production, but availability of water resources will negatively impact on irrigation growth.

Irrigation using water from the Limpopo river on the South Africa- Botswana border has encouraged expansion of agriculture.

Irrigated agriculture gives high yields in the usually arid Limpopo Basin.

Agriculture is key for the economies of the Limpopo Basin, supporting the livelihoods of more than 60 percent of the basin's population who are rural-based and surviving on subsistence farming (cropping, fisheries, livestock rearing and hunting/gathering). Despite an increasing area under irrigation, subsistence crop production is still mostly rain-fed and generates low incomes, with most of the smallholder farmers located in low lying areas that are vulnerable to climate instability.

Most subsistence farming occurs in rural areas that have physically degraded soils, and the small pieces of land are often located far from roads, railways and ports leading to extremely high transportation costs to markets. Financing for science-based and technology solutions is often lacking, and food productivity is low due to nutrient deficient soils, resulting in increased hunger levels and reduced resistance to the impacts of climate variability.

At national level, women play a prominent role in the agricultural sector, especially in Botswana and Mozambique. This is reflected across muh of Africa as men tend to move to mines and urban centres for formal jobs.

Commercial crop production is mainly under irrigation and involves high value crops such as sugarcane, citrus and bananas. In Mozambique, the Chokwé irrigation scheme is the hub for the production of horticultural crops including vegetables. Cereals such as rice and maize are equally important commercial crops in the irrigation scheme. The irrigation potential is compromised due to the fact that most rivers in the basin are seasonal or have reduced flows during the dry season. See Chapters 2 and 3 for a more detailed assessment of agricultural land use and role of agriculture in economic development in the basin.

Table 1.6 Women Practising Agriculture in Selected African Countries

	Agricultural share of all economically active women (%)			Women's share of economically active in agriculture		
	1980	1995	2010	1980	1995	2010
Africa	78.8	70.9	62.2	44.3	46.4	48.5
Sub Saharan Africa	79.1	72.7	65.0	46.0	47.1	48.7
Botswana	74.8	54.8	55.1	46.6	52.4	56.9
Mozambique	97.0	95.5	94.0	58.6	63.4	65.2
South Africa	15.8	8.1	4.2	37.1	31.1	29.6

Source: Amenyah and Puplampu 2013

Commercial Forestry

Commercial forestry is found in the high rainfall belt along the eastern escarpment of the Drakensburg Mountains in South Africa and some parts of Mozambique, but is constrained by unsuitable climatic conditions in the rest of the Limpopo Basin (SARDC 2002).

Rural communities in the basin are dependent on forests and trees for food, timber, fodder, medicine, shelter and construction material. The mopane worm, for example, is an important source of protein around the Gwanda area of Zimbabwe, and in north-east Botswana.


Site in Selati Game reserve

Fisheries

Various types of wetland ecosystems such as the Limpopo floodplains in Mozambique, riverine systems and human-made lakes support productive fisheries, an important source of protein in rural areas.

Fishing in the upper and middle Limpopo River is very limited because it is a border river with significant security concerns. Subsistence fishing is carried along the lower Limpopo River. This supplements household incomes and provides an important source of protein for rural communities. Commercial fishing is carried out at the Massingir dam reservoir and the estuary. Transportation and deposition of sediments is one of the major threats to fisheries in the basin. The Limpopo River, which is highly vulnerable to soil erosion, has a significantly higher sediment yield compared to other major rivers in Southern Africa such as the Zambezi and the Congo (see Table 1.7).

Table 1.7 Sediment Load in Major Southern African Rivers

River	Sediment yield (t/km^2/yr)	Measuring location
Limpopo	80.5	near outlet
Orange-Senqu	89.0	Bethulie
Zambezi	36.9	near outlet
Congo	11.3	near outlet

Source: Vanmaercke and others 2014


Fisherman in the Limpopo Basin

Water Resources

In Chapter 2, details are provided on how availability of and access to both surface and groundwater resources are changing as a result of challenges that include increasing demands and quality degradation from economic activities, as well as from physical and economic water scarcity in the Limpopo Basin.

The Limpopo River Basin is divided into 27 major sub-basins for management purposes (Figure 1.8). The larger tributaries in the basin exhibit marked seasonal cyclical patterns of high and low flows, with many of the smaller ones entirely seasonal or episodic (SADC and SARDC 2002; SARDC 2002). Its 13 mm unit runoff at the mouth (see Table 1.9) is one of the lowest in comparison to other major rivers in southern Africa, such as the Zambezi (5 times more) and the Congo (25 times more) (SADC and SARDC 2008).

The relative scarcity of river channels in the western portion of the basin is due to the arid conditions characteristic of Botswana. The largest tributaries to the Limpopo main-stem river are the Crocodile and Olifants Rivers in South Africa; the Mzingwane River in Zimbabwe and the Changane River in Mozambique. The Changane tributary has significant wetlands associated with it (LIMCOM 2013).

Disaster Risk and Vulnerability

The Limpopo Basin is characterized by high biodiversity and supports 5,200 human settlements located mostly in flood-prone areas close to river valleys. The basin has an extremely variable climatic and hydrological regime characterized by floods and droughts (Murwira and Yachan 2007).

Only two out of every five agricultural seasons in the Limpopo Basin's largely arid climate produce reasonable crop yields (Earle and others 2006). Rainfall is highly variable within and between seasons, and the rain season is short but intense. High rates of evapotranspiration ensure that most of the rainfall does not contribute to river flow or groundwater

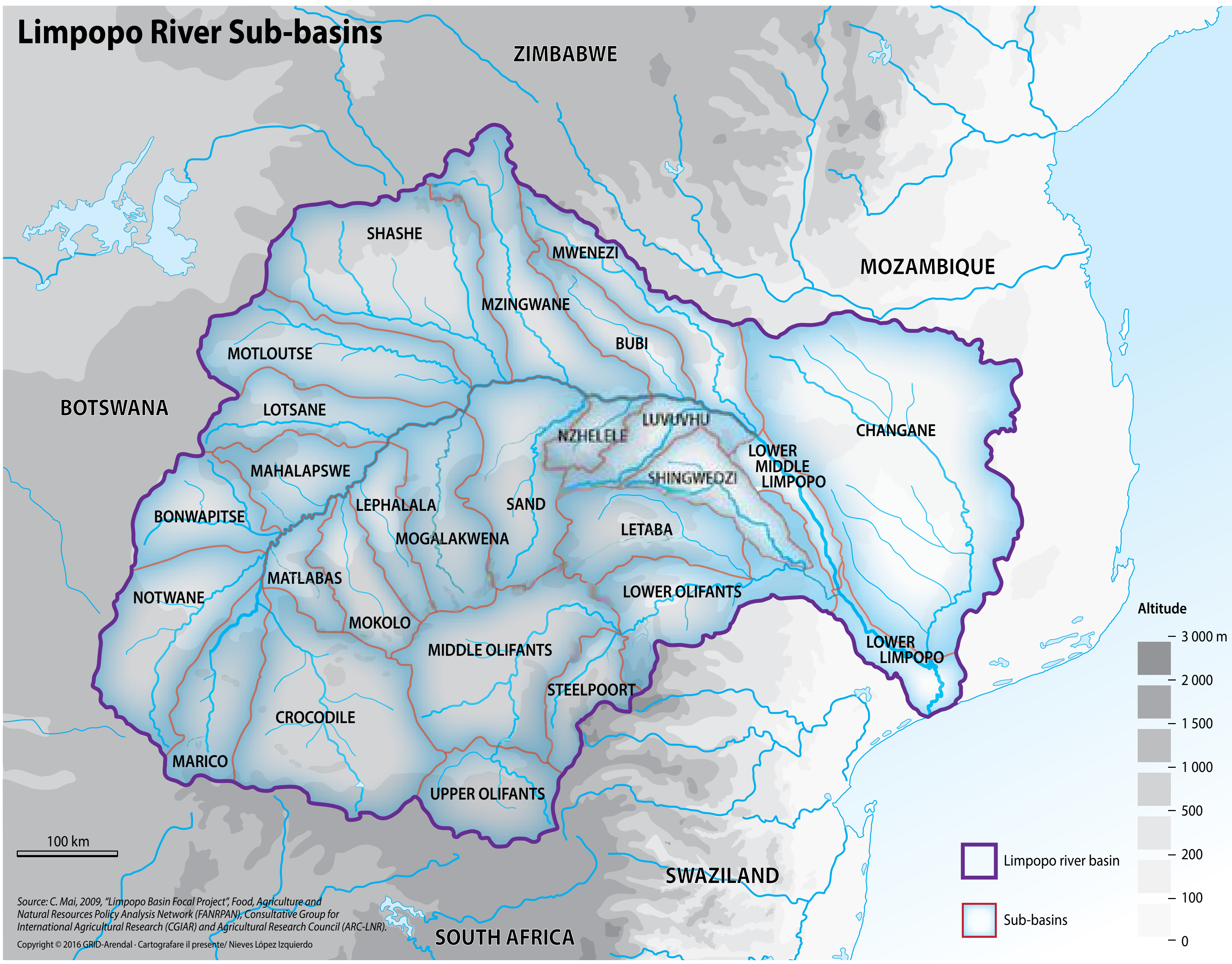


Figure 1.8 Sub-basins of the Limpopo River Basin

Source: LIMCOM 2013

Table 1.8 Mean Annual Runoff for Selected River Basins in Africa

River Basin	Basin area (km^2)	River length (km)	Mean Annual Runoff at mouth (106 m^3/yr)	Unit runoff (mm)
Congo	3 669 100	4 700	1 260 000	330
Cunene	110 300	1 050	5 500	52
Limpopo	411 000	1 750	5 500	13
Okavango	708 600	1 100	11 000	19
Orange-Senqu	947 700	2 300	11 500	13
Save	116 100	740	7 000	76
Zambezi	1 388 200	2 650	94 000	67

Source: Hirji and others 2002, LIMCOM 2013

recharge. A highly fragile catchment area, huge sediment loads, and extremely variable flow in the Limpopo River makes it very unreliable to harvest water for irrigation purposes. Food security is highly constrained by the threat of desertification in the extremely degraded portions of the basin, especially in the densely populated communal areas of South Africa (FAO 2004).

People are less vulnerable to disasters when their livelihoods are secure, meaning assured ownership of, and access to resources and income-earning activities, and less prone to shocks such as floods, cyclones, droughts, disruptions of food assistance and market price changes (Magombeyi and others 2013). Major livelihood challenges in the Limpopo Basin include food insecurity, poverty, market access, and droughts and floods.

River at sunset in the Limpopo Basin

Heavy torrential rains in January 2013 in Chokwé, Mozambique caused the Limpopo River to flood its banks, inundating homes and irrigation schemes, affecting 150,000 people and resulting in 70 deaths. The flooding occurs 3 to 4 times every 10 years. The images above compare the situation in 2013 as compared to a non-flood year in 2005.

Source: Adopted from NASA-EOb 2013

Vulnerability Hotspot Case Study: The Mzingwane Catchment Area

Mzingwane district catchment area supplies water to the city of Bulawayo and surrounding areas. Five water supply reservoirs are found in the area (Mzingwane, Upper Ncema, Lower Ncema, Inyankuni and Mtshabezi), located on the Mzingwane, Insiza and Mtshabezi Rivers. The area experiences erratic rainfall and high temperatures, and drought is inevitably the main climatic driver. Both legal and illegal alluvial gold panning activities are rife along these rivers, posing a high risk of rapid siltation, soil erosion, flooding and drying up water reservoirs. In addition, the area is also hampered by governance issues, due to a variety of actors involved in uncoordinated management of the catchment. The Mzingwane Catchment Council, mostly comprised of influential farmers represented through the Rural District Councils (RDCs), manages the catchment area. However, the catchment area is extensive, falling under different districts and provinces, and thus requires greater coordination and consideration of various interests and activities. To date, other stakeholder groups, particularly those of the 'lower tiers' (e.g. communal or resettlement farmers) have had minimal participation in sub-catchment management, and are not effectively represented, lacking capacity and water monitoring skills. By late 2013 the Inyankuni and Upper Ncema dams had been decommissioned because they had dried up and are no longer able to supply water to the district.

Source: Petrie and others 2014

The Mzingwane River, also called Umzingwane River, is a major tributary of the Limpopo. Its source is in the Matobo District of Zimbabwe.

Biodiversity Hotspots and Riverine Systems

Most rural people in the Limpopo Basin depend on the wide range of available natural resources to survive and develop. Protected areas play a crucial role in biodiversity conservation, and maintain the integrity of these rich and precious heritage/historical areas.

The Limpopo River Basin is rich in biodiversity. In the South African part of the basin, areas of key biodiversity importance include Waterberg, Strydpoortberg, and Kruger National Park. Tswapong Hills in Botswana, protected areas such as Gonarezhou and Matobo National Parks, and the Limpopo-Mwenezi Flood Plains in Zimbabwe, and mangroves and coastal vegetation in Mozambique are vital ecosystems.

There are three Ramsar sites found on the South African side of the basin. Since 1998 when the 3,970 ha Nylsvley Nature Reserve was designated a wetland of international importance under the Ramsar Convention, the total area of Ramsar designated sites in the basin has increased to 12,618 ha with the addition of the 5,891 ha Verloren Valei Nature Reserve in 2001, and the 7,757 ha Makuleke Wetlands in 2007 (Ramsar 2014).

Wildlife in the Limpopo Basin

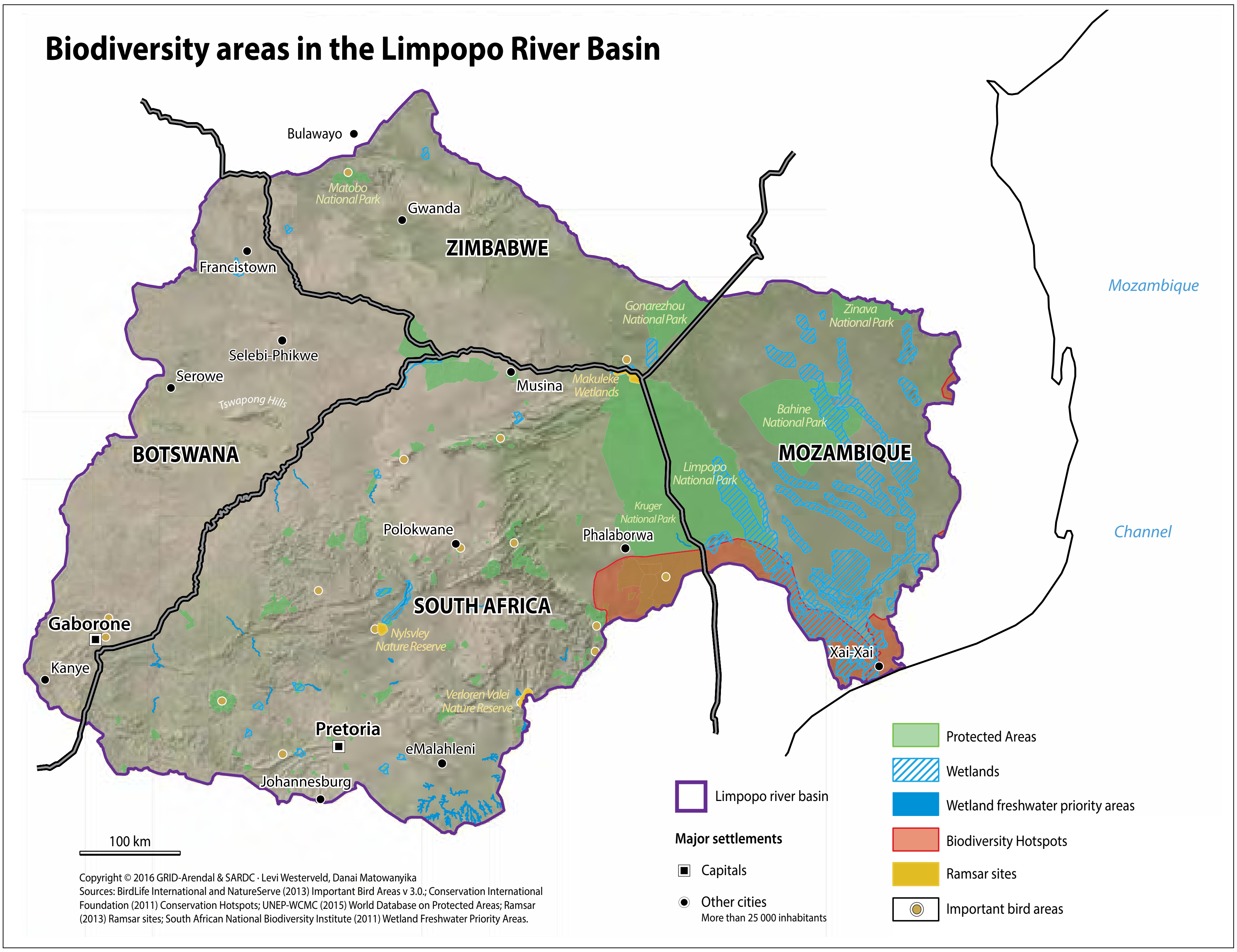


Figure 1.9 Biodiversity Areas in the Limpopo River Basin

Importance of the Basin to People and Ecosystems

Economic Development Corridor

Natural and human-made assets play a central role in facilitating the economic development of the Limpopo basin countries, as well as enhancing trade across the rest of southern Africa. Road and rail transport networks linking the riparian nations are generally well-developed, although Mozambique is still recovering from the infrastructure damage due to severe floods and a 16 year civil war which ended in 1992 (SARDC 2002). See Chapter 4 for an assessment of transboundary economic opportunities through development corridors in Sub-Saharan Africa.

There is considerable potential to boost economic development through additional infrastructural developments and water use efficiency improvements. Although development of storage dams is already substantial in the basin, hydrological data shows additional dam and irrigation development potential on the Mozambique side of the basin (LBPTC 2010). Management of existing dams also needs improvement to better control water flows and mitigate the impact of drought and floods (Leira and others 2003).

Regional Integration

There is huge potential to make southern Africa food secure and support vibrant economies both within and with other regions through sustainable management of natural resources (FAO 2015). Regional integration and poverty alleviation are priority SADC goals. Through the Revised Protocol on Shared Watercourses, the regional grouping aims to "foster closer cooperation for judicious, sustainable and coordinated management, protection and utilization of shared watercourses" (SADC, SARDC and others 2012).

Fishing is a source of livelihood in the Basin

Benefits from aquatic ecosystems that accrue to people of the Limpopo Basin and the rest of southern Africa include waste assimilation; recreation; aesthetic values; livelihood provisioning to communities; biodiversity maintenance and provision of habitats to biota (Hirji and others 2002).

Political stability across national borders has facilitated the expansion of environmental conservation strategies and benefits beyond community-based natural resources management in individual countries to transboundary natural resources management initiatives that are more appropriate for resources that transcend international borders (SADC and others 2012).

Ecosystem Services

The Limpopo Basin's diverse range of plants, insects, fish and wildlife are found in terrestrial, freshwater and riverine ecosystems.

The SADC Protocol on Wildlife Conservation and Law Enforcement defines a transfrontier conservation area as "a component of a large ecological region that straddles the boundaries of two or more countries encompassing one or more protected areas as well as multiple resource use areas" (SADC 2012). These areas allow for the co-existence of both humans and wildlife in the same space, and facilitate the cooperative management of transboundary natural and cultural resources, leading to improved biodiversity conservation and socio-economic development (SADC 2012).

Transfrontier conservation areas (TFCAs) in the Limpopo Basin include the Great Limpopo Transfrontier Park (Mozambique, South Africa and Zimbabwe), the Great Mapungubwe Transfrontier Conservation Area (Botswana, South Africa and Zimbabwe) as well as some ongoing transboundary initiatives that could potentially lead to formalised TFCAs such as the Sengwe-Tshipise Wildlife Corridor efforts. Over two million people visit the Great Limpopo Transfrontier Park per year (Great Limpopo Transfrontier Park 2016).

The creation of transfrontier conservation areas allow tourists and wildlife to cross international borders with minimal difficulties, but there are potential threats to contend with, including plant and animal pests and diseases, and relocation of people within tourism zones. Climate variability will also increase risks of the basin biodiversity through expected shifts in the range, population size and resilience of animals and plants (Leira and others 2003; FAO 2015).

A detailed assessment of human impacts on biodiversity is provided under the Biodiversity section in Chapter 2.

Institutional Framework

To promote economic development and regional integration through the utilization of shared resources such as water, the Southern African Development Community (SADC) has established an innovative institutional set-up for overseeing the joint management of natural resources, including challenges related to climate change, and addressing benefit sharing.

The Revised SADC Protocol on Shared Watercourses focusses on setting rules for the joint management of water resources (SADC 2003), while the Regional Strategic Action Plan for Integrated Water Resources Development and Management addresses key issues in managing surface and groundwater. Proposed tools for implementing Integrated Water Resources Management (IWRM) include establishment of institutions at national and regional levels; capacity building; stakeholder participation; water resources information management; implementation of IWRM plans; conflict resolution; and, environmental management (SADC and others 2012).

A multilateral agreement between the riparian countries led to the establishment of the Limpopo Watercourse Commission (LIMCOM) in 2003, and the development of its capacity (LBPTC 2010). The objectives of the commission include advising the riparian countries and providing recommendations on the protection, preservation and management of the Limpopo River. LIMCOM is linked to national climate adaptation plans through national governments and catchment management agencies (LIMCOM 2003; SADC 2005). All countries in the region have signed the SADC Revised Protocol on Shared Watercourses whose principles are key for cooperation and joint management of water resources (LBPTC 2010).

Horticulture in Chiaquelane Village in Chókwé

Within the Limpopo Basin, institutions operate at the regional, transboundary and national levels. These play major roles in terms of water allocation, resource protection and disaster management (LIMCOM 2013). Table 1.9 shows institutional framework for the Limpopo Basin.

A more detailed assessment of institutions at multiple scales and governance issues is provided in Chapter 5.

Table 1.9 Institutional Framework for the Limpopo Basin

Scale	Botswana	Mozambique	South Africa	Zimbabwe
Regional	SADC Council of Ministers for Water SADC Directorate of Infrastructure and Services	SADC Council of Ministers for Water SADC Directorate of Infrastructure and Services	SADC Council of Ministers for Water SADC Directorate of Infrastructure and Services	SADC Council of Ministers for Water SADC Directorate of Infrastructure and Services
Transboundary	LIMCOM	LIMCOM	LIMCOM	LIMCOM
National	Department of Water Affairs (DWA) Water Apportionment Board	National Water Council Directorate of Water (DNA)	Department of Water and Sanitation	Water Steering Committee Department of Water Resources (DWR & ZINWA)
Hydro-"provincial"/Water Management area	Water Management Area Bodies	Regional Administration for Water (ARAs)	Catchment Management Agencies	Catchment Councils
Localised/ Stakeholder Involvement	Village Water Development Committees Kgotlas	River basin management institutions (UGBs) Basin Management Committees (CGBs)	Catchment Management Committees Water User Associations Catchment Management Forums	Sub-Catchment Councils

Source: LIMCOM 2013

2

BASIN'S CHANGING ENVIRONMENT

Over the years there have been environmental changes taking place in the Limpopo River Basin. These include changes in the climatic conditions, biodiversity, land and water resources. Causes of the changes include population growth, global warming, expansion of urban areas, as well as an increase in economic activities such as mining, manufacturing and agriculture. The environmental changes in the basin are continuous and in some cases dramatic. This chapter highlights changes in climate, land, biodiversity, and water resources in the Limpopo River Basin, and their impact on livelihoods and ecosystems.

Atmosphere and Climate

The climate in the Limpopo River Basin varies from arid in the west, semi-arid and temperate areas in central zones to semi-arid in the east, with a few sub-humid pockets in the centre. Southern Zimbabwe and most of the South African portion of the basin experience warm temperatures with a dry season in winter and a hot-wet season during summers. Further west near the border with Botswana, the climate changes to a dry, hot steppe climate.

Basin climate is moderated by the high altitude, proximity to maritime influence from the Mozambique Channel, influence of the mid-continental high pressure (the Botswana upper high) and the volatile, warm, moist conditions of the Inter-tropical Convergence zone (ITCZ) which in some years moves sufficiently far southwards to influence rainfalls in the northern parts of the basin as Figure 2.1 shows.

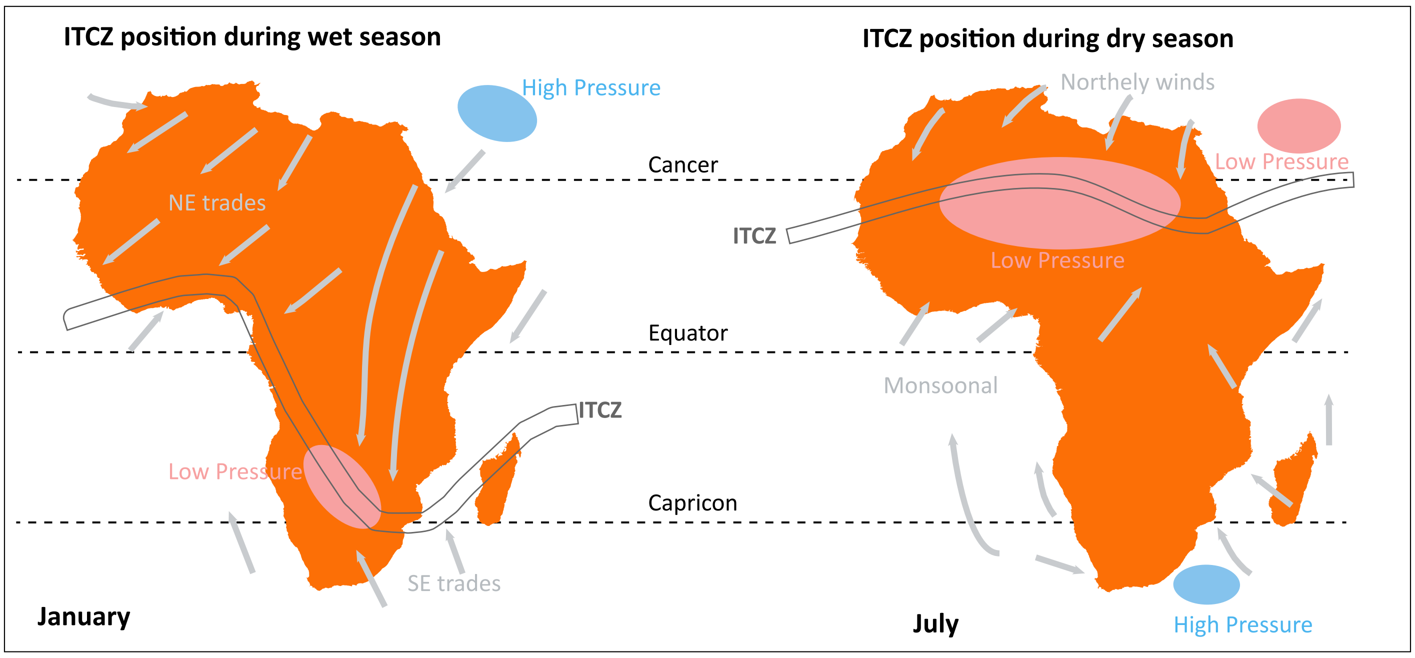


Figure 2.1 Influence of ITCZ

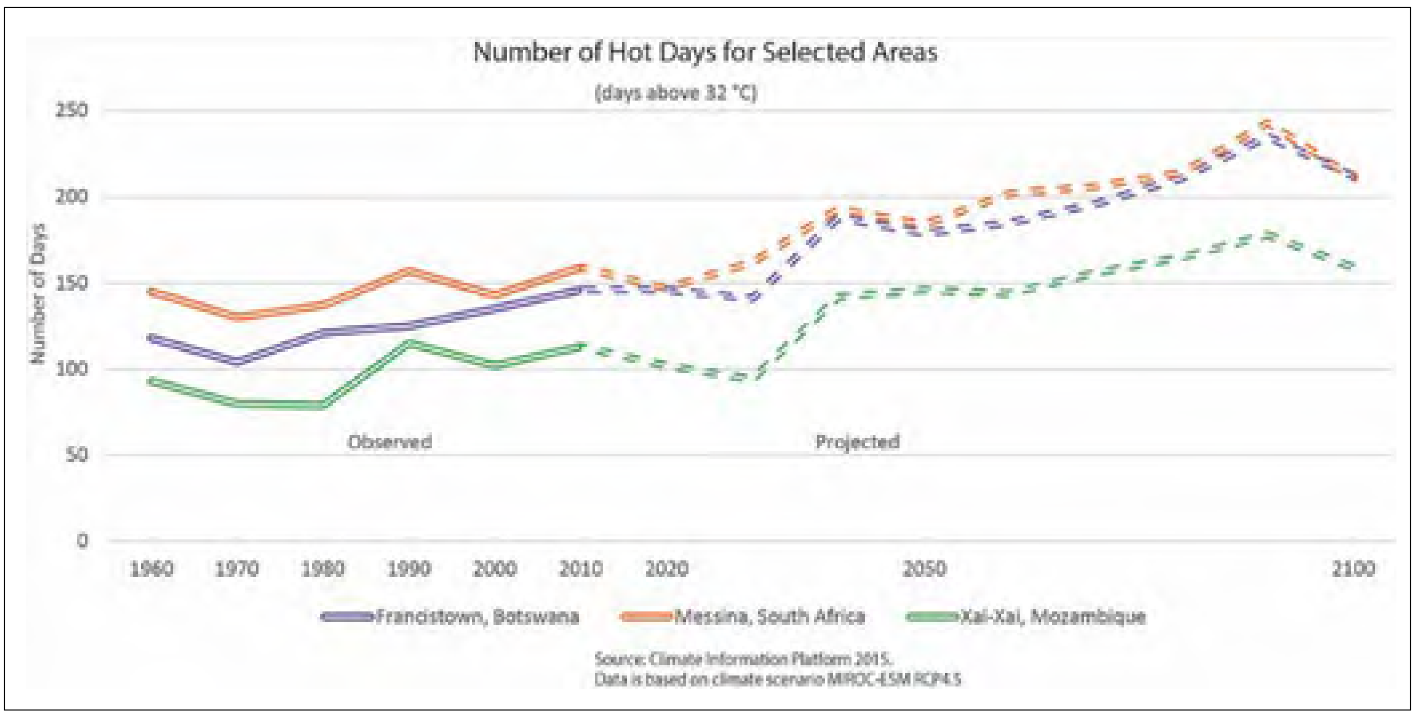
Source: INGC, UEM and FEWSNET 2003

Temperature

Temperatures across the basin show a marked seasonal cycle, with highest temperatures recorded during the early summer months and lowest temperatures during the cool, dry winter months (SADC and SARDC 2002, Figure 2.2).

In summer the high altitude areas of Matobo in Zimbabwe and the Highveld of South Africa are between 5 and 10 °C cooler than temperatures in the central portion of the basin (temperatures typically 25 to 30 °C). Interestingly the low altitude eastern portion of the Limpopo Basin in Mozambique has higher summer temperatures (about 30 °C) than the arid parts of Botswana (around 25 °C). This pattern is similar for the winter daily average temperatures although absolute temperatures are much lower (ranging from 6 to 20 °C) (LIMCOM 2013).

Table 2.1 Number of Hot Days for Selected Areas (days above 32 °C)



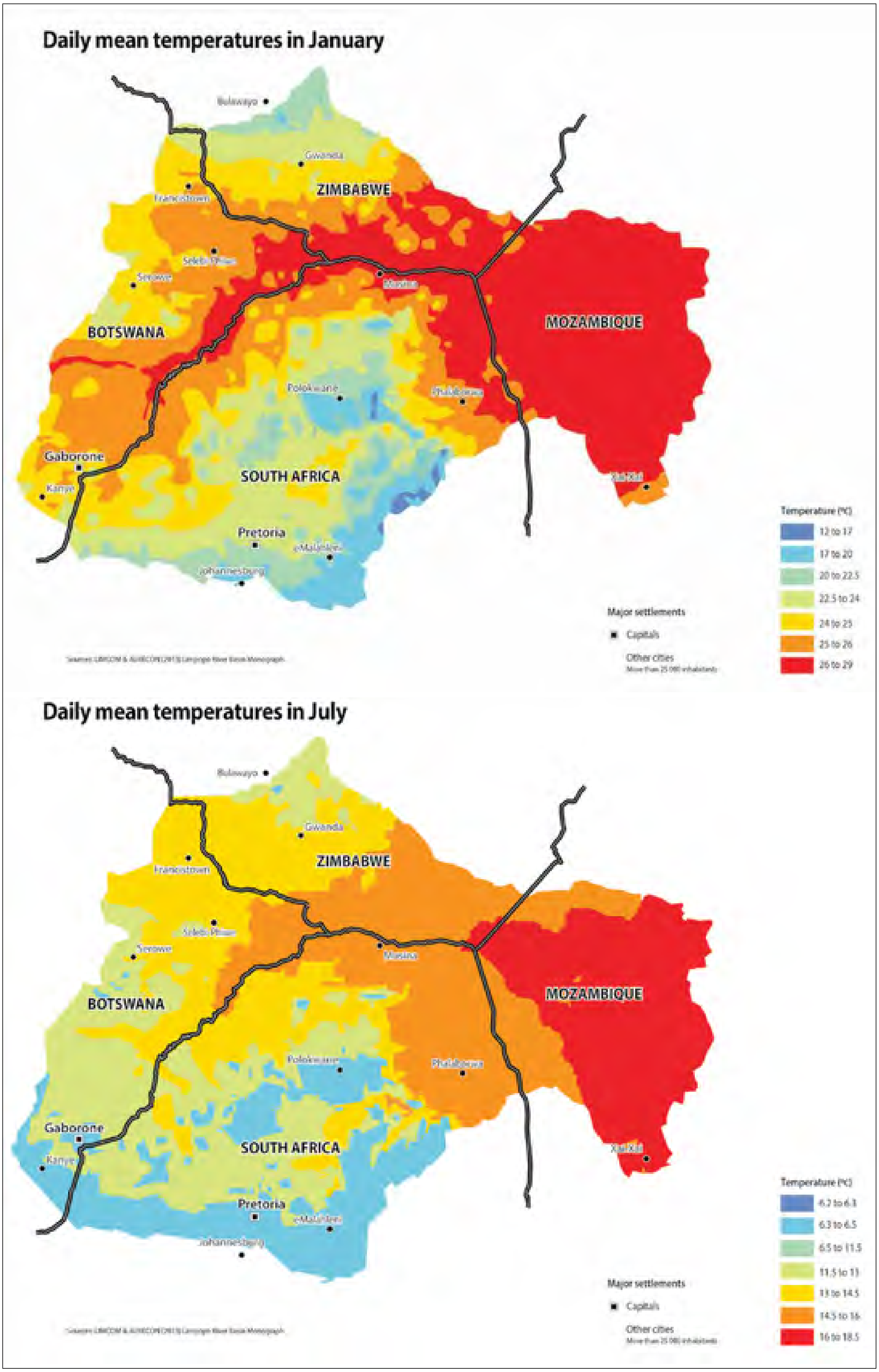


Figure 2.2 Daily mean temperatures in January (top) and July (bottom)

Source: LIMCOM 2013

Maximum temperatures in the Limpopo Basin have increased by between 1 °C and 1.4 °C in summer months since the 1960s. This trend is expected to continue with a significant increase in the frequency of hot extremes in the basin and a decrease in the number of cold extremes (Petrie and others 2014). It is expected that temperature rise is likely to increase evaporation of water resources as well as increase demand for water.

The number of hot days in the basin are expected to increase. Projections for selected sites in the basin between 1960 and 2100 indicate an increase of 66 hot days for Messina and Xai-Xai, while Francistown the hot days will increase by 94 (Table 2.1).

Increasing Temperature and Economic Activity

In the Shashe Sub-Basin the number of very hot days is projected to increase by 40 to 60 days per year in the long term, with the highest increases in the northern part of the basin (LIMCOM 2013). In this sub-basin, economic development related to mining and energy production might be significantly undermined due to decreased availability of surface water.

Nylsyley nature reserve with a wetland

Rainfall

Average rainfall decreases uniformly westwards and north-south towards the Limpopo River (see Figure 2.3). Rainfall varies from a low of 200 mm in the hot dry areas to 1,500 mm per year in the high rainfall areas with rare occurrences of snow and ice precipitation in areas that are 3,000 metres above sea level. The majority of the basin receives less than 400 mm of rainfall per year and it is unevenly distributed (SADC and SARDC 2002).

There has been an increase in rainfall intensity, accompanied by an increase in the duration of dry spells. General projections indicate a reduction of rainfall in March, April and May (the autumn months) (LIMCOM 2013). In the long-term, average rainfall is

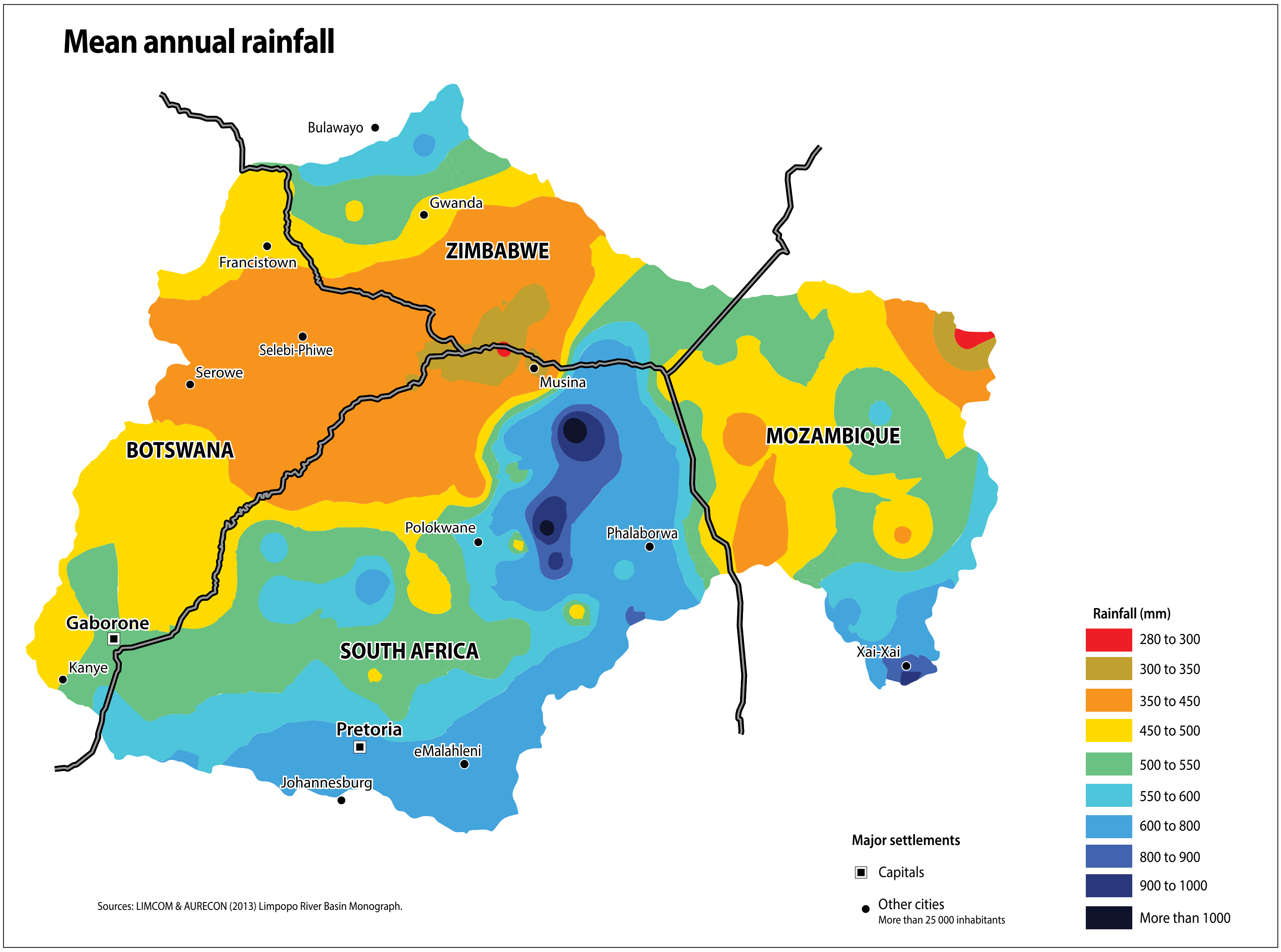
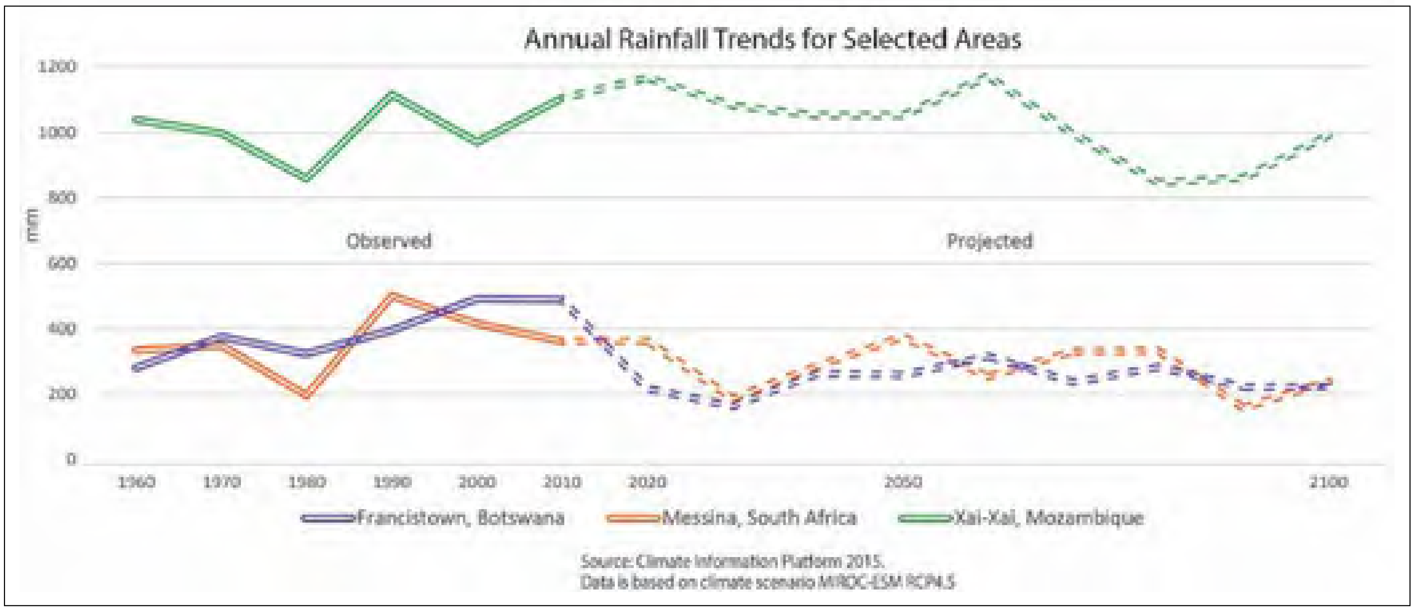


Figure 2.3 Mean annual rainfall

Source: LIMCOM 2013

Table 2.2 Annual Rainfall Trends for Selected Areas (mm)



expected to decrease by up to 15 percent and in the north-eastern side of the basin, rainfall is expected to reduce by as much as 20 percent in summer by 2100 (LIMCOM 2013). Table 2.2 indicates an average decreasing trend of annual rainfall for selected sites, between 1960 and the projected 2100.

Seasonality and timing of future rainfall seasons is expected to shift due to climate change. Late onset of rains and long dry spells are expected. These patterns differ across the basin (Malherbe and others 2012) with the most significant decrease in rainfall expected over the summer and autumn months.

Figure 2.4 gives an overview of the predicted changes in mean annual rainfall and mean monthly temperature between 2000 and 2050. The mean annual rainfall is expected to change by between 50–100 mm while mean monthly temperature is expected to change by between 1.5–2 °C (Hachigonta and others 2013).


Limpopo-Shashe river confluence, a hot spot area for decreasing rainfall in the basin

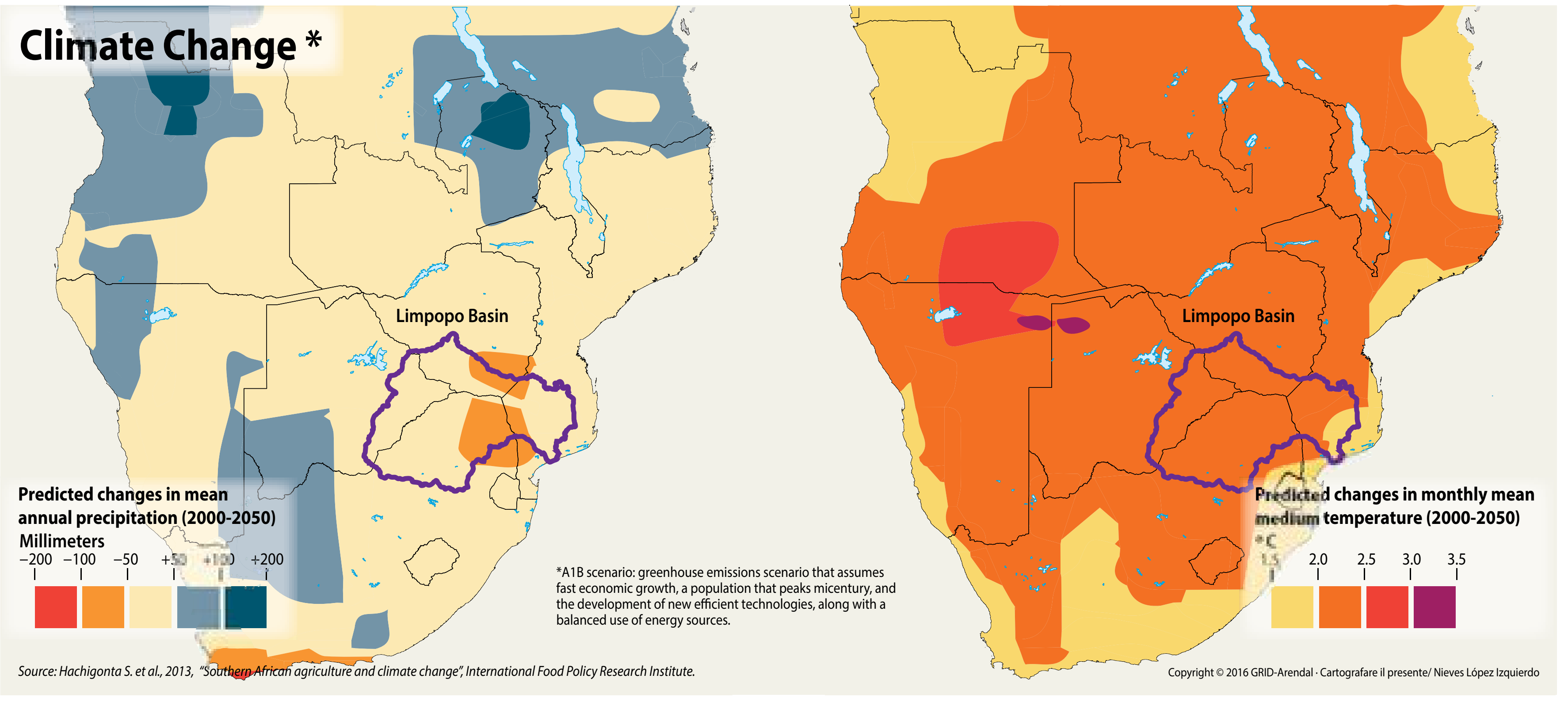


Figure 2.4 Predicted Changes in Mean Annual Rainfall and Temperature for the Period 2000–2050

Source: Hachigonta and others 2013

Impacts of the Changing Climate in the Limpopo Basin

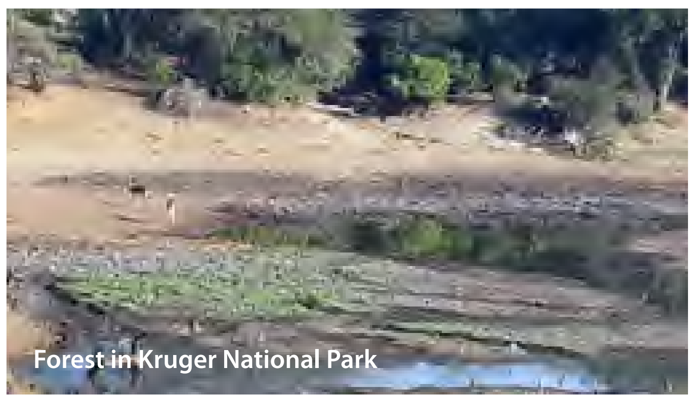
The rural part of the Limpopo River Basin is highly vulnerable to climate change and related variability due to high poverty levels and low adaptive capacity (LIMCOM 2013).

The impacts of changes in temperature and precipitation on the local population include:

- Reduced contribution of agriculture as a livelihood and/or commercial activity;
- Poor performance of agriculture is likely to impact negatively on the economy of the basin and its future development;
- Reduced employment opportunities in climate sensitive sectors;
- Change in water available for household use and other livelihood activities; and
- Limited extent of commercial agricultural production if there is a reduction in bulk water availability for irrigation.

Eutrophication results in the proliferation of water weeds in the Limpopo Basin

Most rural water sources are vulnerable to contamination



Forest in Kruger National Park

Site in Selati Game reserve

Land use and Land Cover Changes

Land use in the Limpopo Basin is shaped by its unique biophysical features (soils, geology, underground aquifers and minerals) and social history of the last several decades. In addition to colonial legacy throughout southern Africa, the history of apartheid in South Africa, heavy use of river systems such as the Olifants and Marico, development of large scale conservation areas especially the Great Limpopo Transfrontier Conservation Area (GLTCA), mining for gold in the Gauteng area, and diamonds in Botswana, the civil war in Mozambique, and large scale land resettlement in Zimbabwe all impact land use activities and changes in the basin. As Figure 2.5 shows, there is significant amounts of land for agriculture in the basin.

Agriculture a major landuse in the basin

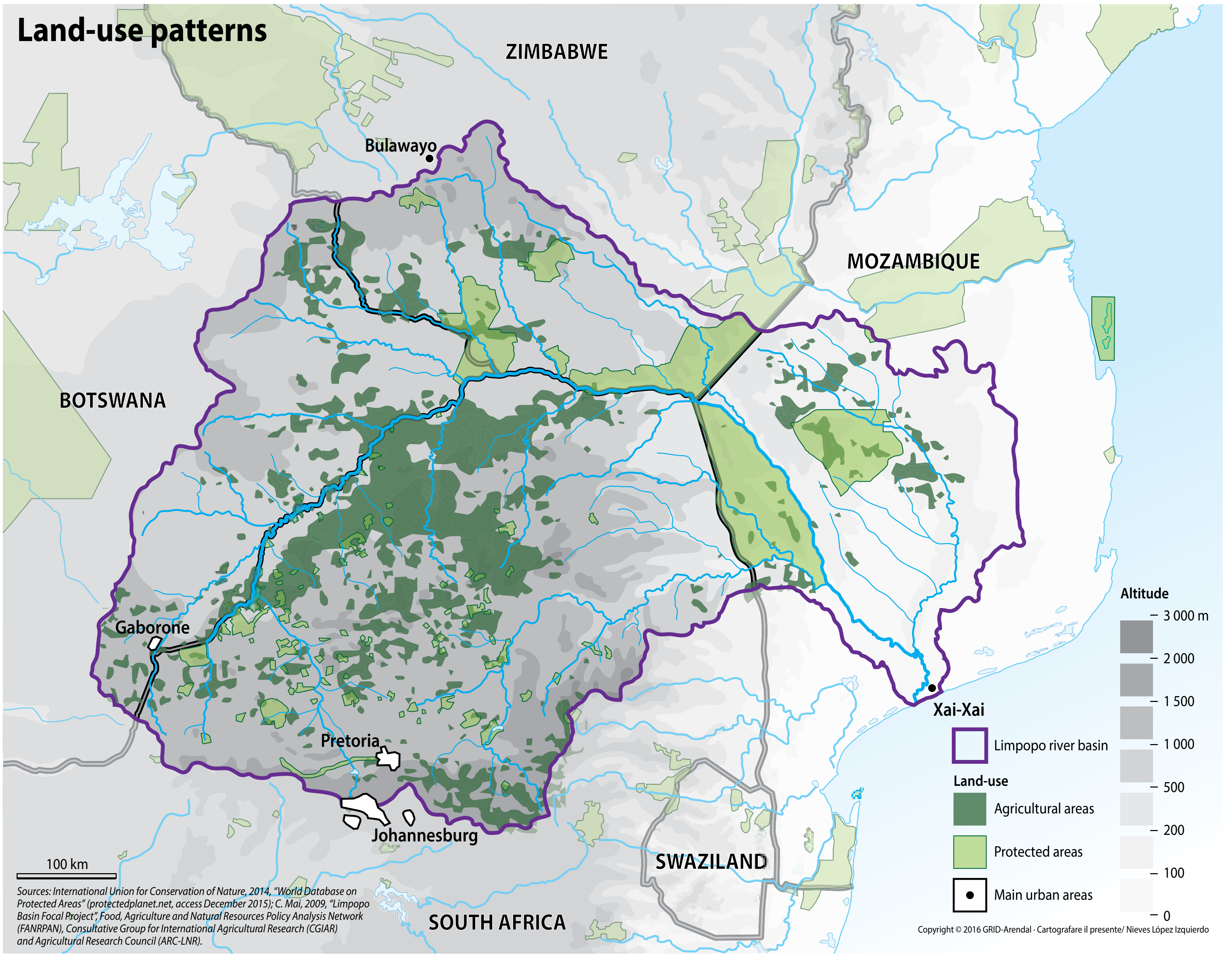


Figure 2.5 Land use patterns in the Limpopo Basin

Source: IUCN 2014

Agricultural and Land Use Trends

Agriculture remains a major contributor to the local economies in the Limpopo Basin. Women represent by far the majority of agricultural producers in the basin, and yet are most insecure with respect to access to land and other resources (FAO 2004). Small to medium scale agriculture dominates in the Botswana, Mozambique and Zimbabwe parts of the Limpopo Basin. Large scale agriculture is more prominent in South Africa, even though the area under maize production has declined since 2000 (Figure 2.6). The decline can be attributed to unfavourable weather conditions experienced in the basin as a result of climate change. Extensive cattle ranching is common in arid areas of the basin, particularly in Botswana and Zimbabwe. The Zimbabwean part of the basin is also characterised by several wildlife conservancies.

Productivity is highly variable as exemplified by maize yields, the main crop. Average yields are 3,600 kg/ha with yield reaching more than 8,000 kg/ha in commercial areas and being less than 1,000 kg/ha in many rural areas. Average yields are 250 kg/ha in Botswana and around 800 kg/ha in Zimbabwe (Sullivan 2013). Other crops in the basin include sorghum, millet, pulses, wheat, barley and some tree crops.

The conventional land use systems are largely low input systems based on extensive management and utilization of agro-ecological potential and natural resources. Climate variability and increasing aridity have a profound accelerating effect on land degradation, the extent of which is shown in Figure 2.7. Extreme rainfall events aggravate the condition of already degraded land through increased runoff and flash floods. Frequent drought also acts as a strong catalyst in the initial and progressive degradation of land. Demographic pressures have induced changes leading to more intensive use but often leading to degraded natural resource base. Typical of this is when grazing livestock have declined because of population pressure with small ruminants replacing cattle. Peri-urban agriculture, consisting of intensive use of land, labour and capital, and characterized by large-scale commercial or market-oriented production in poultry, pigs, dairy, beef feedlots, and horticultural products, has also emerged near urban centres in response to urbanization at the fringes of the basin in Botswana, South Africa and Zimbabwe. Highly intensive use of the land in the delta area is also prevalent.


Baobab trees can tolerate arid conditions

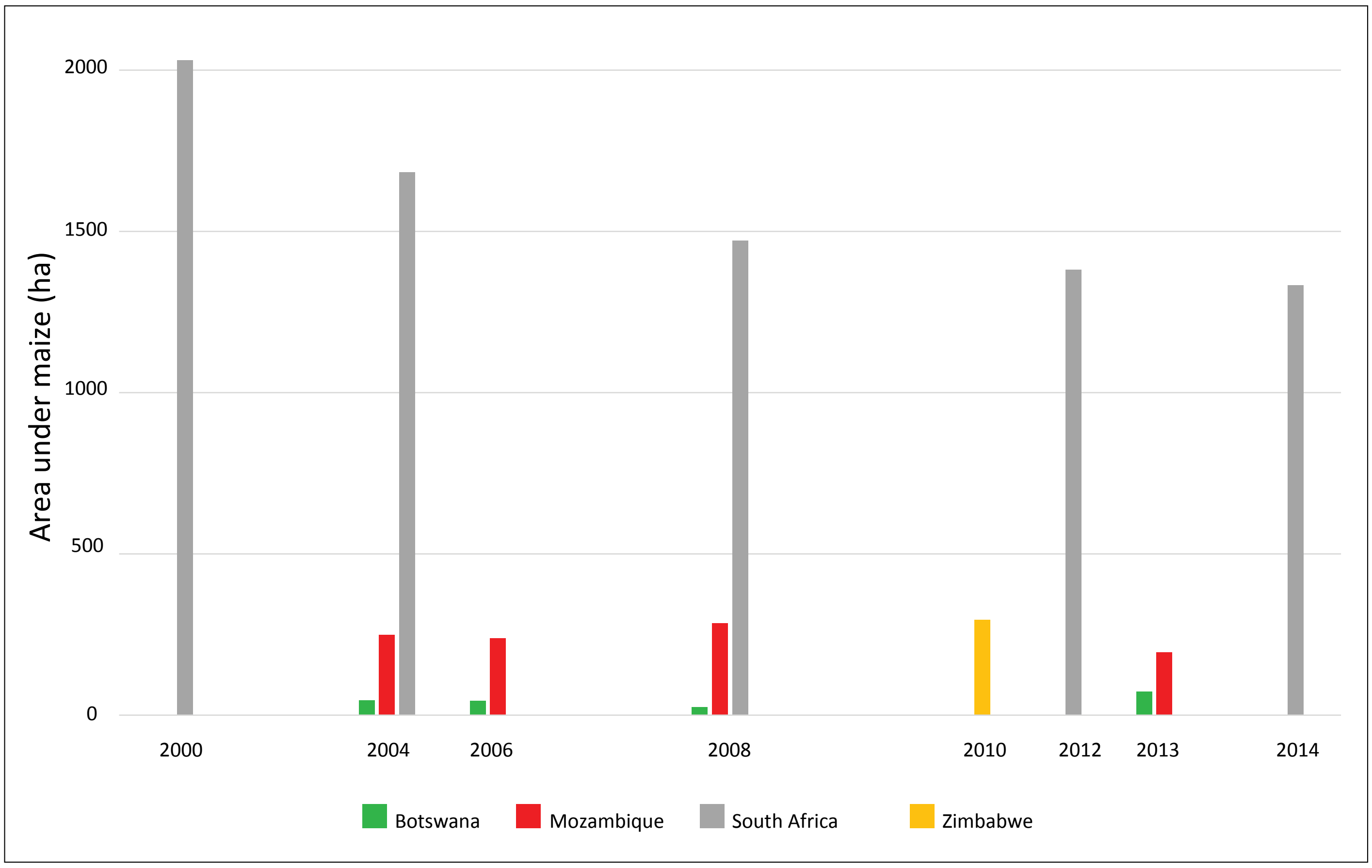


Figure 2.6 Area under maize in the Limpopo Basin

Compiled from national agricultural survey reports

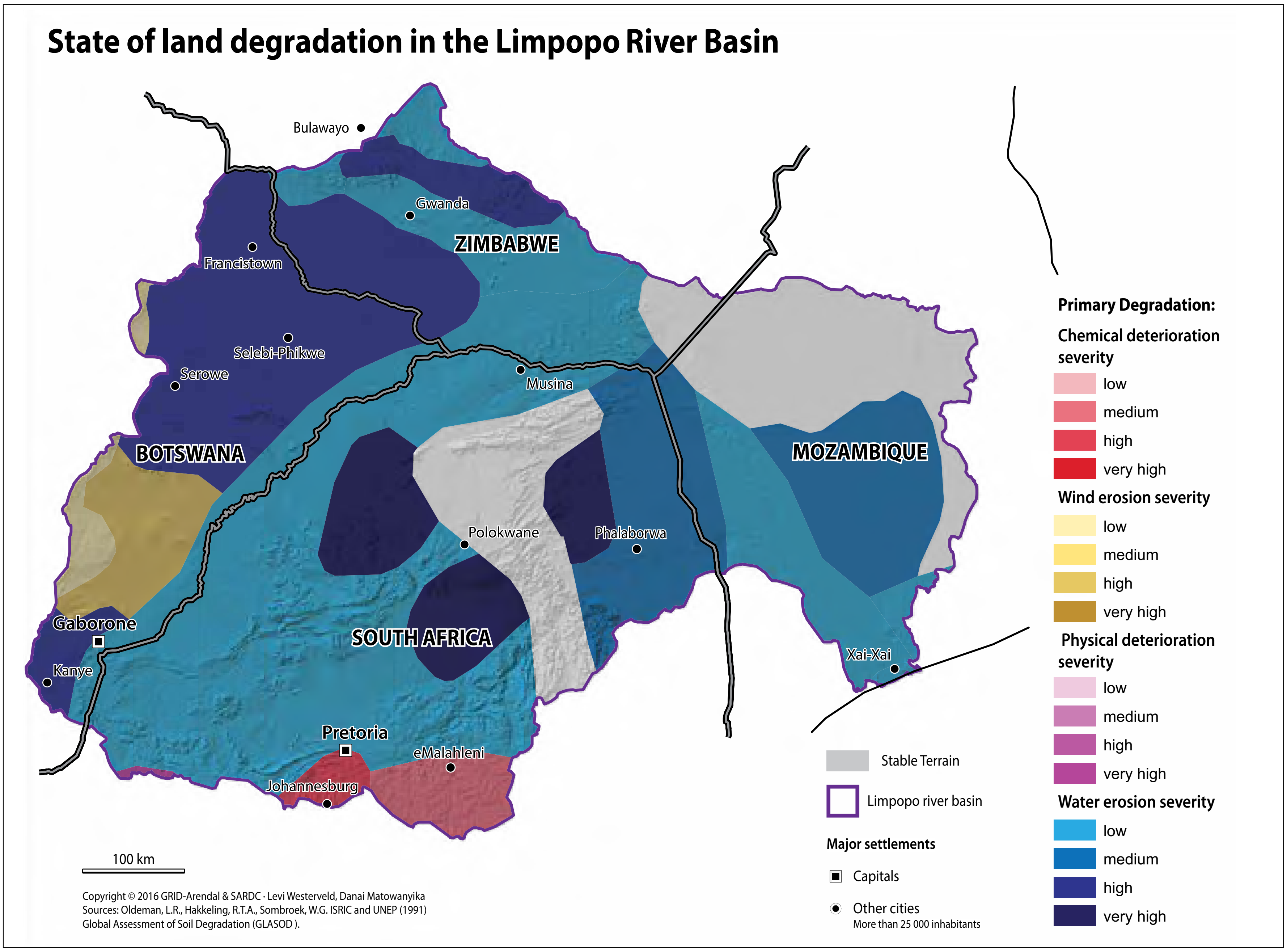


Figure 2.7 State of land degradation in the Limpopo River Basin

Source: FAO 2004

Using different Niches for Agriculture in Lower Limpopo Basin

The Limpopo River is divided into three reaches: the Upper Limpopo, which is the border between Botswana and South Africa; the Middle Limpopo, which is the border between South Africa and Zimbabwe and the Lower Limpopo, which is entirely in Mozambique (Boroto and Görgens 1999).

In the Lower Limpopo, Baixo (lowland riverbed areas) and Alto (highland above flood line niches) areas allow for complex management of the Limpopo River regime by rural peasants. In the Baixo, three cropping seasons are the norm and in the Alto, two seasons are common. To hedge their chances, many farmers have pieces of land in both so that if there are floods, farmers have some food source and when there is drought, then they depend on the lower lands irrigated from the river.

Population densities are also different between the Baixo and Alto areas. A concentrated demand for agricultural labour occurs during four critical times of the year: first season clearing in September; first season weeding in November or December; second season clearing in March or April; and second season weeding in May or June. Harvest labour tends to be supplied by the household, except in the Baixo areas during the peak vegetable harvest times.

Three seasons are the norm for many households in the Baixo areas who rely on locally owned portions of the irrigation scheme to supply water to their fields. In this way Baixo households benefit financially from three selling seasons, making a good proportion of their money from the January tomato harvest (when tomato production and prices are high). Farmers are busy throughout the whole year with agricultural activities, and do not count on the post-harvest period common in many agricultural areas in Africa.

Source: Magombeyi and others 2013

The Nylsyley reserve is rich in biodiversity

A major concern in the Limpopo Basin is transboundary transmission of animal diseases, especially foot-and-mouth disease (FMD) between wildlife and livestock (Jori and others 2016). The emergence of the Great Limpopo Transfrontier Conservation Area has seen growing incidences of FMD cases with significant economic impacts such as restricted exports of beef to Europe. FMD is easily transmitted between wildlife, especially buffalo and cattle. More than 100,000 km^2 of the Great Limpopo Transfrontier Conservation Area are without fences to separate wildlife from livestock and humans, and this poses a major challenge in managing transboundary animal diseases. The proposed Greater Mapungubwe Transfrontier Conservation Area in the Limpopo-Shashe Corridor Area between Botswana, Zimbabwe and South Africa poses similar challenges especially as the countries depend significantly on beef production and exports. The land use mosaic similarly presents major challenges of managing the interests of protected areas, private land owners and communal land dwellers. Uncontrolled movement of livestock causes challenges as livestock moves in search of water and pastures. Figure 2.8 shows the Shashe Limpopo Corridors where wildlife cross national parks and game reserves boundaries.

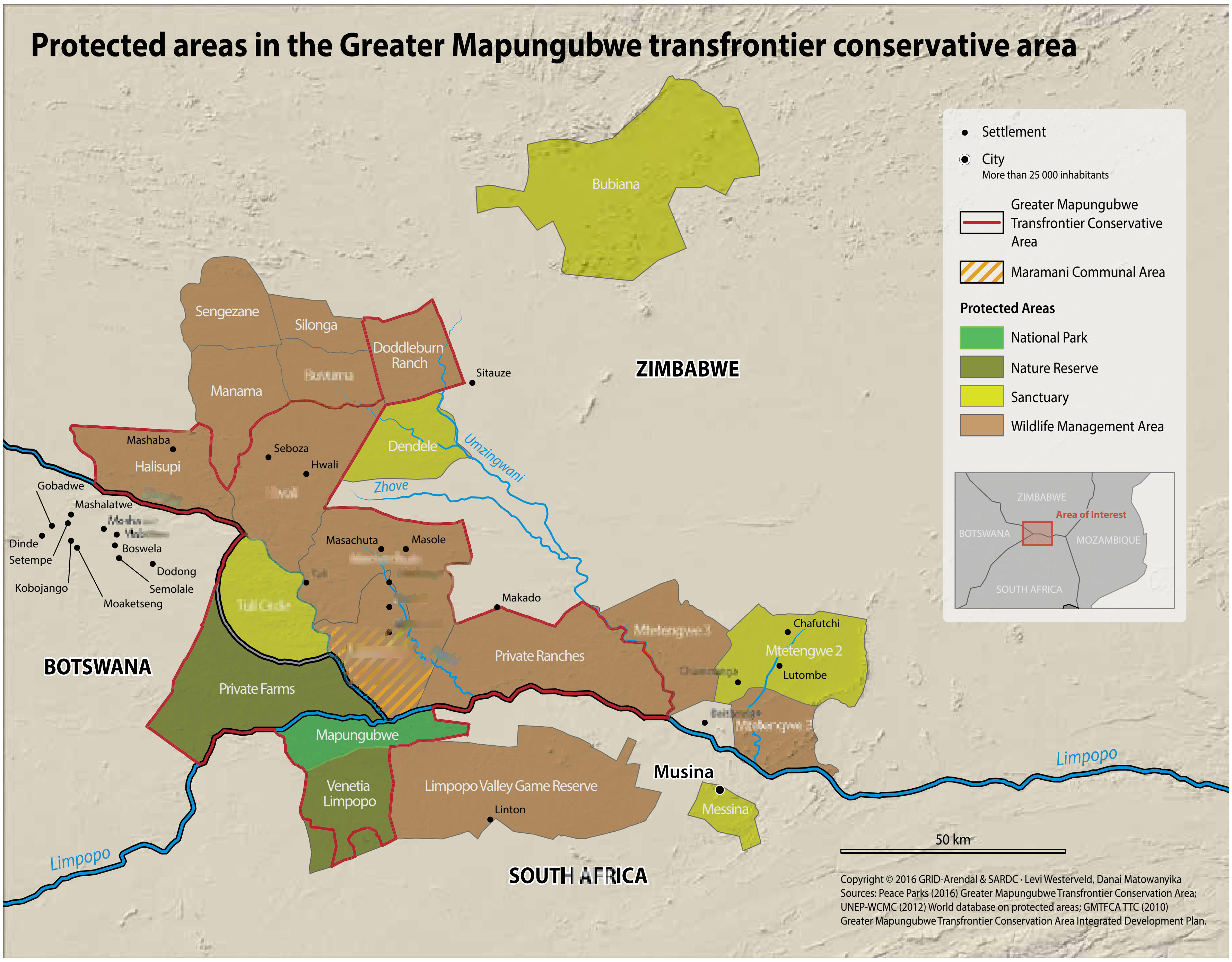
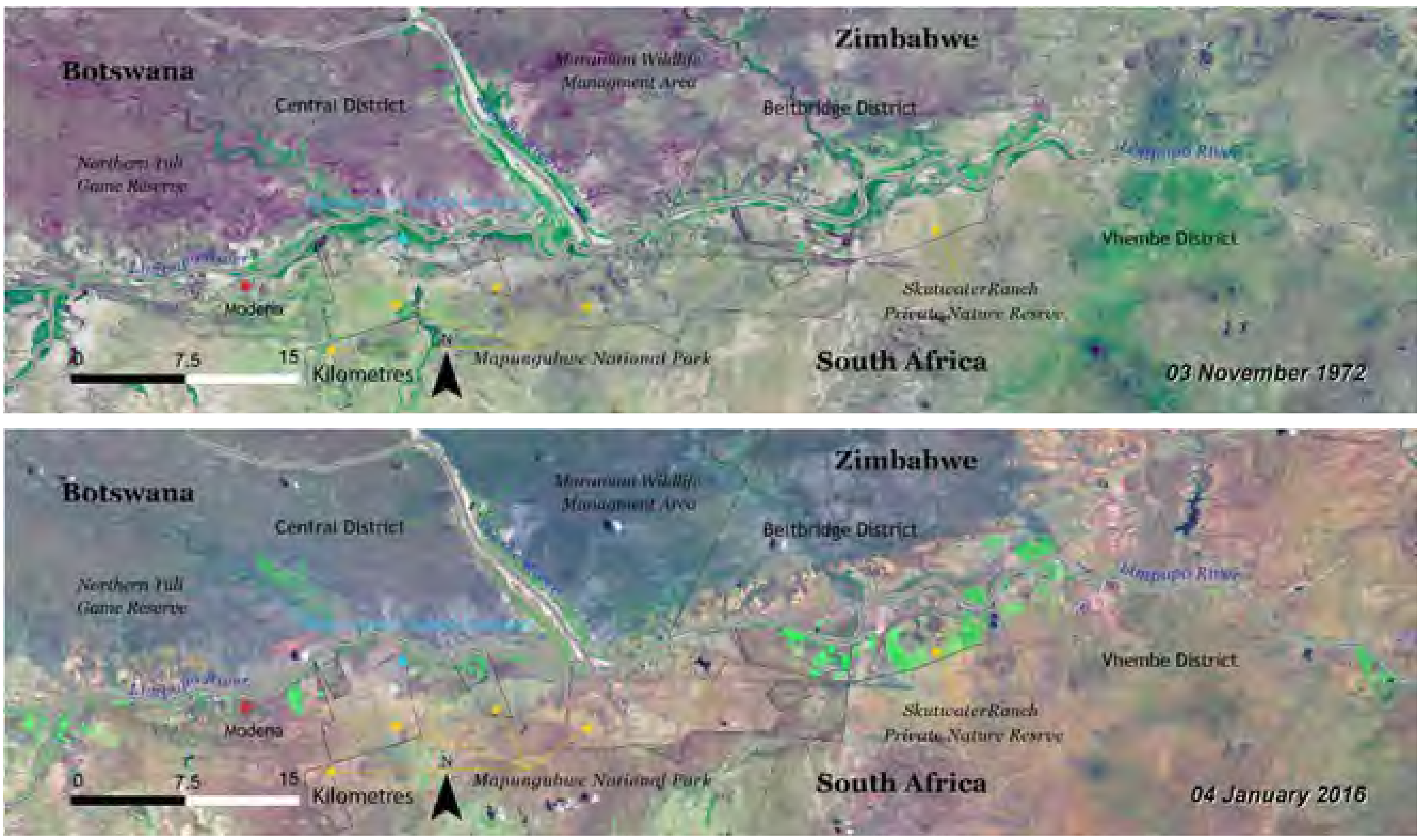


Figure 2.8 The protected areas to be included in the Greater Mapungubwe Transfrontier Conservation Area

Agricultural landscape, South Africa



The 1972 and 2016 satellite images above clearly show the increase in agricultural activity in part of the Limpopo-Shashe Corridor, which runs across the Botswana-South Africa-Zimbabwe borders. Large parts of the Limpopo Basin face water shortage challenges. Irrigated agriculture is increasingly becoming a major user of water. This is resulting in increased competition over the limited available water resources. Impacts of irrigated agriculture include siltation and water pollution.

Biodiversity

Biodiversity is essential to the economies of Limpopo Basin countries and to livelihoods. Important biodiversity and riverine ecosystems are under increasing pressure from constraints that include climate change and unsuitable utilization as a result of population growth, poor management practices, and lack of alternative resources. Rural people who live adjacent to protected areas are dependent on exploiting natural resources for their livelihoods, and most smallholder farmers rely on biomass fuels for energy (GoZ 2014).

Ecosystem Diversity and Distribution

The major areas of biodiversity significance in the basin include the Tswapong Hills in Botswana; Limpopo and Banhine National Parks in Mozambique; Kruger National Park, Waterberg and Strydpoortberg in South Africa; Gonarezhou and Matobo National Parks, and the Limpopo-Mwenezi Flood Plains in Zimbabwe. In Mozambique the mangroves and coastal vegetation are also a vital ecosystem in the Lower Limpopo.

The upper and lower reaches of the basin are highly impacted by human activity, apart from the upper reaches

The black kite is a common species in the Limpopo Basin

of the Motloutse and Lotsane sub basins in northwest Botswana. Large tracts of land in lower reaches of the basin remain (in Mozambique) less impacted (see Figure 2.9).

This is due to urban settlements and intensive agriculture in the broad strip of land from Johannesburg, north into Zimbabwe. Swathes of land in the Lower Limpopo and Changane sub-basins remain relatively uninfluenced.

Dominant issues in the upper Limpopo River Basin include infestation by invasive alien plants, surface and groundwater abstraction, damming of rivers (especially in South Africa and Zimbabwe), and pollution of water from mining activities and commercial agriculture.

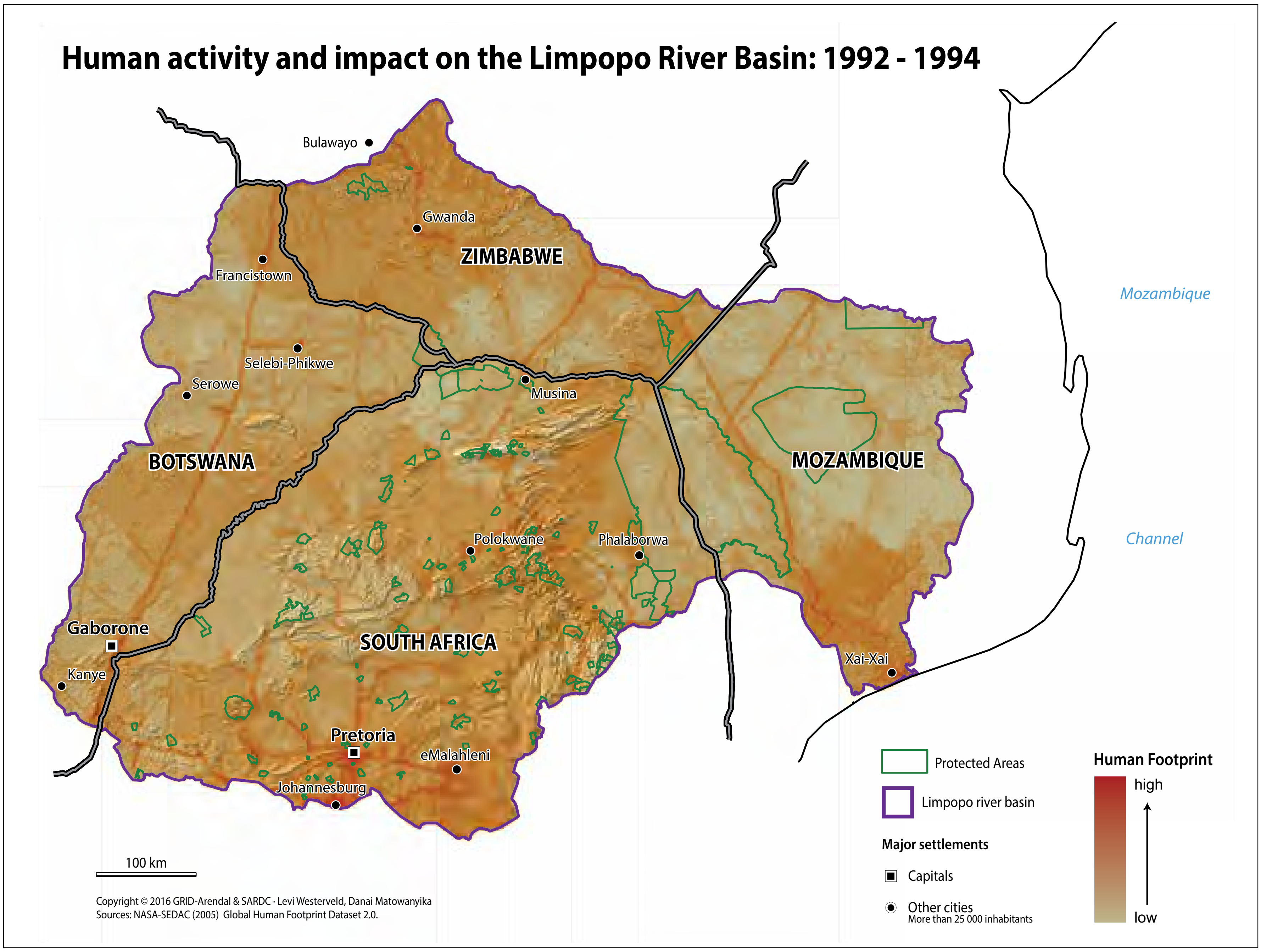


Figure 2.9 Human activity and impact on the Limpopo Basin 1992–1994 (above) and 1994–2004 (right)

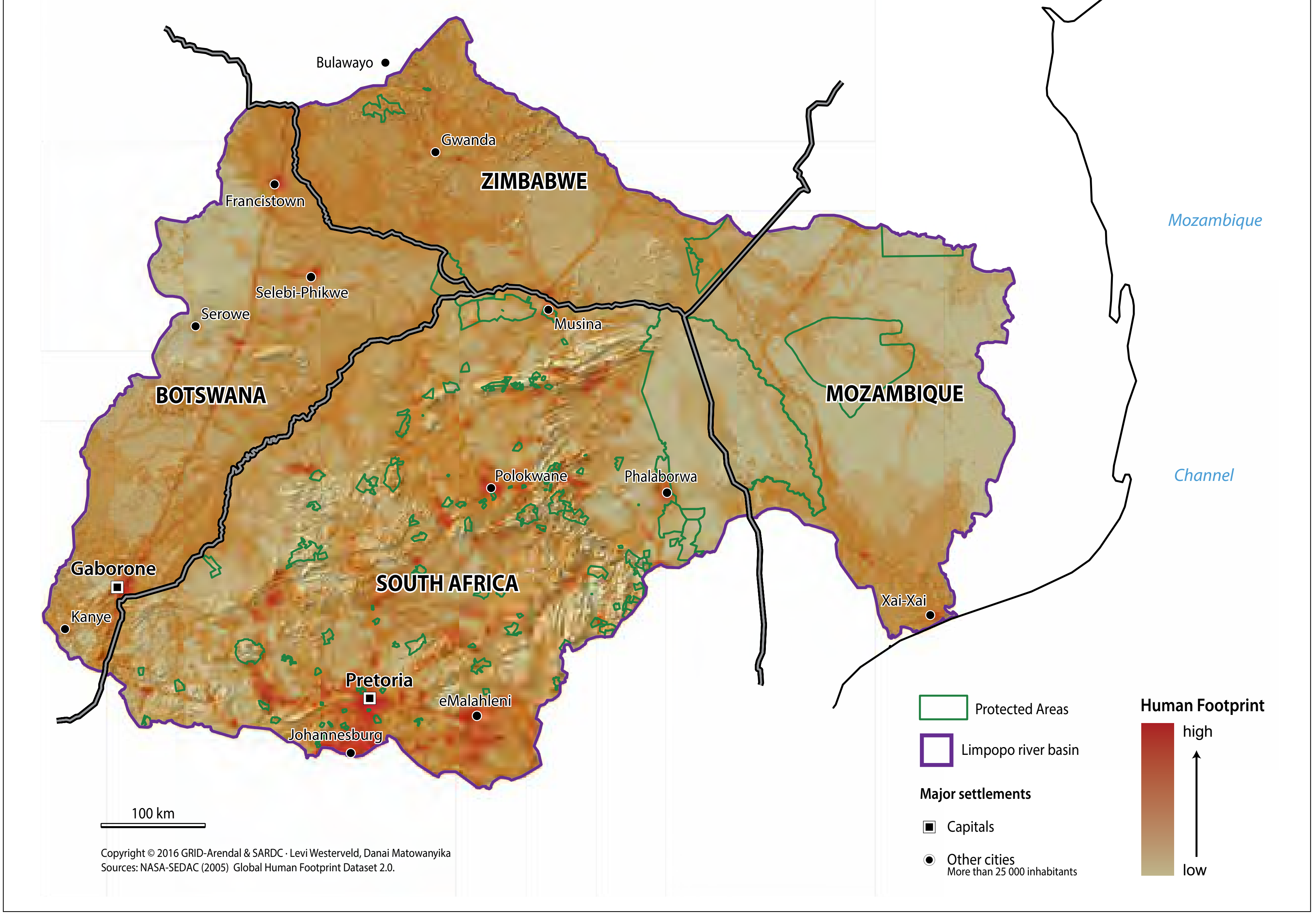
Matobo Hills

Matobo Hills lies about 25 km south of Bulawayo in Zimbabwe. The hills are made of granite rocks forming inselbergs that are interrupted by grasslands and vleis. The hills provide the catchment areas for ten rivers and stretch for 90 km, with the greater part of them lying within rural areas (Childes and Mundy 2001). The rocks have provided human shelter for hundreds of years, and they hold a huge collection of rock paintings. Many of the hills are national monuments and in addition to that local communities use the areas as sacred shrines. As such, the Matobo Hills are one of Zimbabwe's World Heritage Sites.

Water that runs off from the inselbergs create a variety of habitats at the base of the Matobo Hills. These include vleis, woodlands and grasslands and they support a diversity of plant and grassland species. Tree species that occur in the area include Common Commiphora (*Commiphora* spp), pod mahogany (*Afzelia, Kirkia*), Almond (*Terminalia* spp), Wild syringa (*Burkea afrikana* spp) and Round-leaved bloodwood (*Pterocarpus* spp). Mopane and Msasa woodland are also found in small patches in some areas. The grassland areas have several species with the key ones in less degraded areas being Narrow Leaved Turpentine Grass (*Cymbopogon plurinodis*), Spear grass, (*Heteropogon contortus*), and fine thatching grass (*Hyparrhenia filipendula*).

The Matobo Hills together with the Matobo National Park are an Important Bird Area (IBA). The area has a high density and species richness of raptors, including 75 pairs of Black Eagle (*Aquila verreauxii*) (Childes and Mundy 2001). The Black Eagle and other raptors nest on rock cliffs and so does the Black Stork (*Ciconia nigra*). The area is also important to other species. The Matobo honeysuckle-tree (*Turraea eylesii*) is endemic to the Matobo Hills, and the Matobo bitterberry (*Strychnos matopensis*) is only found in this area in Zimbabwe, although it occurs in Mozambique and Zambia as well (Coates Palgrave 2002). The national park is an Intensive Protection Zone for both species of rhinoceros, the black rhinoceros (*Diceros bicornis*) and the white rhinoceros (*Ceratotherium simum*).

Human activity and impact on the Limpopo River Basin: 1994 - 2004



Ecosystem Disturbances

Threats to valuable biodiversity areas in the Limpopo Basin include deforestation, over-fishing, soil erosion and veld fires (Hirji and others 2002). Life is generally hard in these areas due to high population densities, especially in the urban centres, and severe flooding from both cyclones and heavy upstream rainfall. Other impacts of flooding include increased infrastructure repair costs and reduced income from tourism along the coast. In addition, the movement of people fleeing from floods has given rise to unplanned peri-urban settlements and ramifications that include reduced food security and increased risks of cholera, malaria and diarrhoea (Petrie and others 2014).

The Limpopo River estuary provides the local community with essential resources that include a significant source of fish for protein and building materials including mangroves. Changes in the freshwater flow regimes altered the extent of saline penetration to the lower riverine reaches resulting in changes to mouth functions of provisions of the ecological goods.

Following the floods of the year 2000 that led to widespread devastation of the estuarine mangroves, efforts are underway to restore them. Figure 2.10 shows the state and distribution of mangrove forests between 2005 and 2014. As shown in the 2014 image, there has been a considerable decrease in area coverage by mangroves, as a result of degradation resulting from anthropogenic activities.

Planting of mangroves

State and distribution of mangroves in the Limpopo River Basin estuary

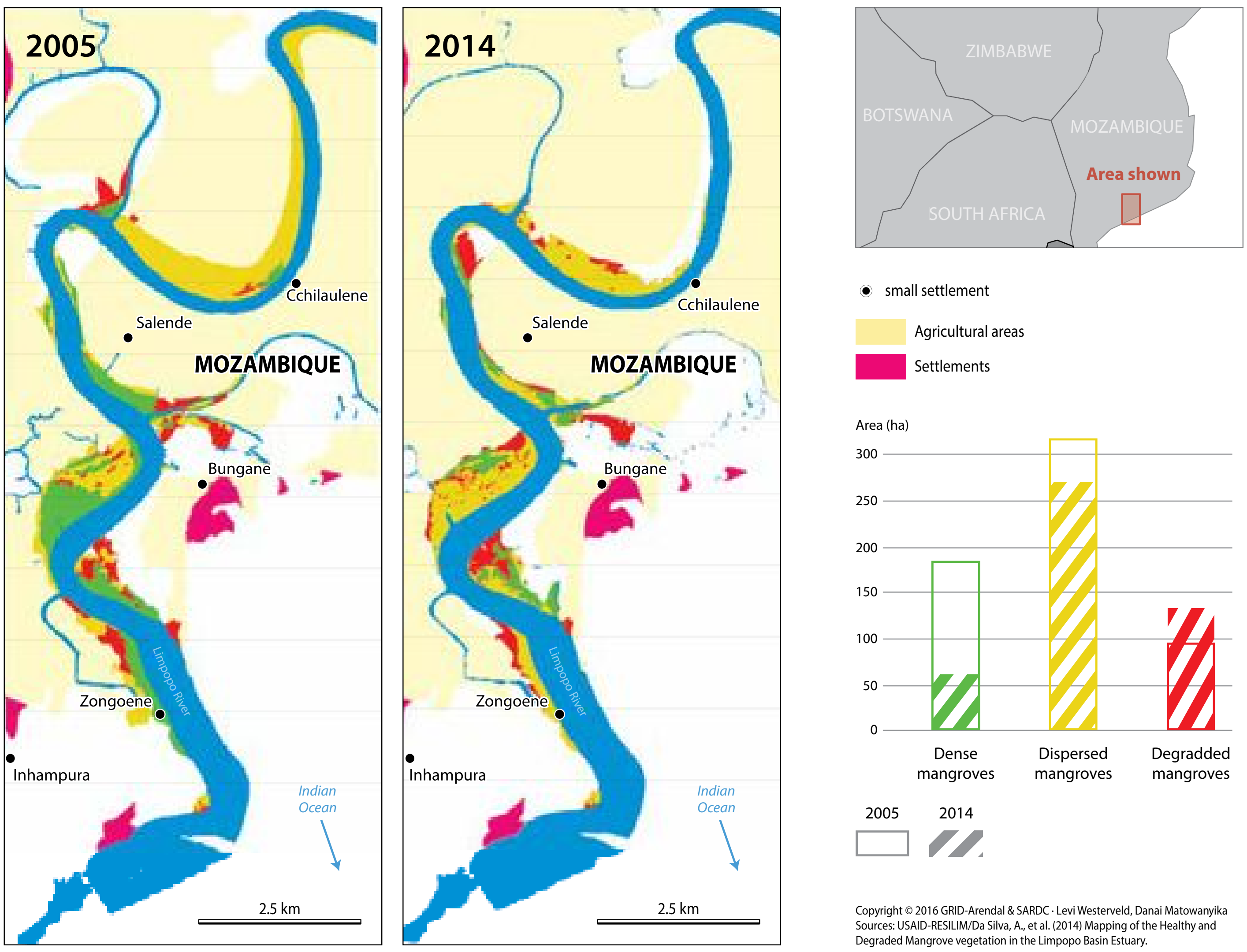
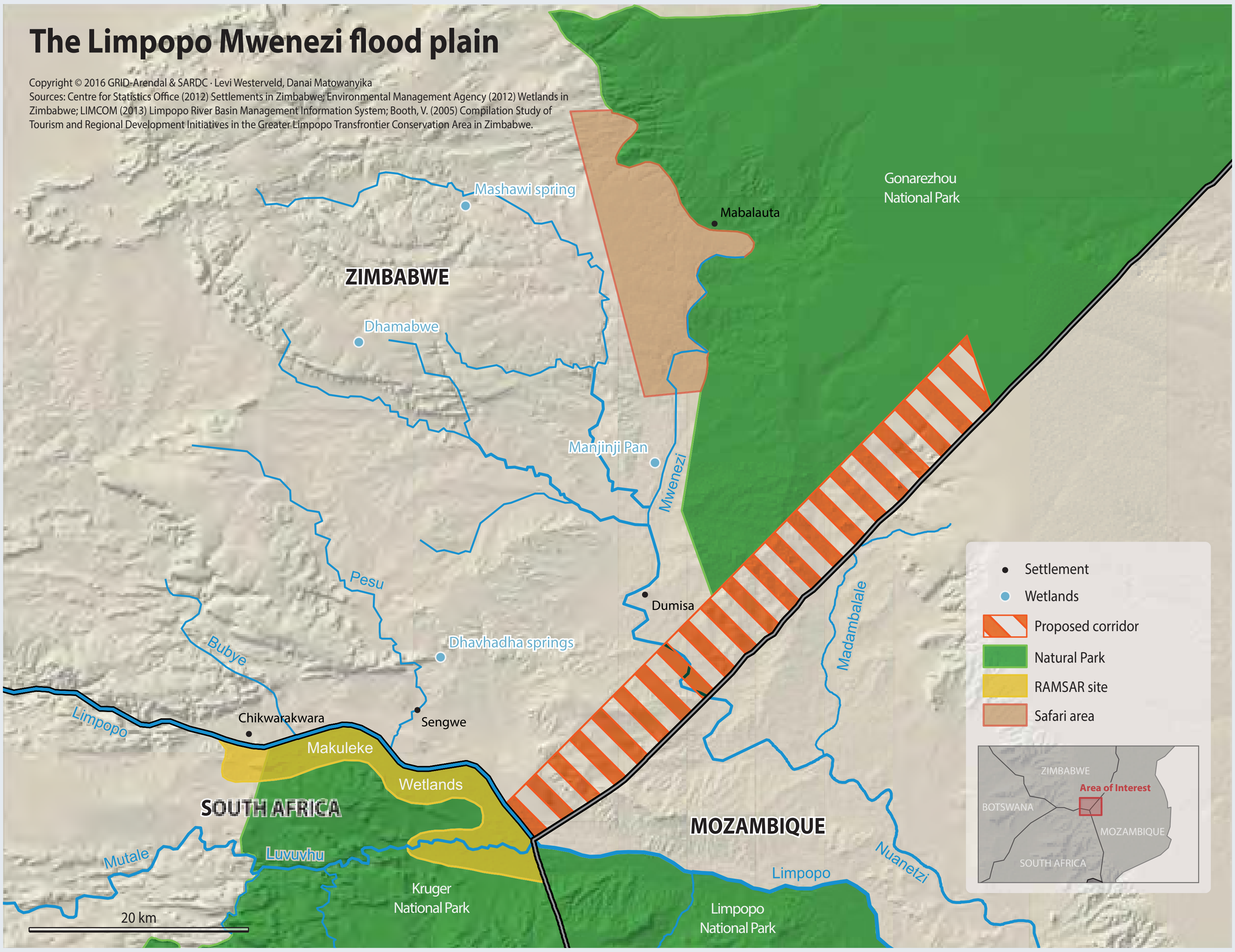


Figure 2.10 State and distribution of mangrove forests 2005 and 2014

Source: Da Silva 2014

The Limpopo-Mwenezi floodplain



The Limpopo-Mwenezi floodplain and pans are a designated Important Bird Area (IBA) – an area identified using an internationally agreed set of criteria as being globally important for the conservation of bird populations (Evans and Fishpool 2001). One of the important wetlands in this IBA is the Manjinji Pan which lies in a rural area. It is a sanctuary under the Parks and Wild Life Act and is dominated by Mopane and Terminalia woodland, and surrounded by fever tree thorn *Acacia xanthophloea*. Key bird species found in this area include the Lemon-breasted Canary *Serinus citrinipectus*, the Plain-backed Sunbird *Anthreptes reichenowi* and the Cape Vulture *Gyps coprotheres*. Manjinji Pan attracts flocks of waterbirds during the wet seasons. Manjinji Pan is locally protected by communities as it is considered a sacred place.

The local people practice subsistence agriculture and pastoralism with cattle and goats. The major threats in Limpopo-Mwenezi floodplain and pans have been recorded as habitat disturbance from smallholder irrigation farming; water drawn from the Manjinji Pan; smallholder grazing; pollution from agricultural effluent; invasive alien plants (especially water hyacinth) and flooding (Birdlife Zimbabwe 2010).


Mwenezi river

Veld Fires

Veld fires continue to alter ecosystems throughout the basin. Natural fires sustain ecosystems by rejuvenating grasses and shrublands to prevent the development of dense woodlands and forests, and they help recycle nutrients contained in dead organic matter. However severe and frequent fires destroy the environment. Uncontrolled fires are more common in resettlement areas in Zimbabwe due to slash and burn land clearance for crop cultivation and lack of firebreaks. In Zimbabwe veld fires affect an average of 900,000 ha of the country's land annually. In 2010, a total of 79,000 ha of indigenous forest were burnt by fire. Areas adjoining protected areas are the major source of fires in national parks and conservancies. The Zimbabwe government, through the Environmental Management Agency, works with communities and the general public in fire prevention campaigns but they have not managed to significantly reduce the incidences of fires. There is need to create firebreaks in both protected areas and communal lands.

Uncontrolled fires a cause of biodiversity loss in the basin

The long dry season from May to October provides favourable conditions for veld fires. In South Africa and Zimbabwe the peak fire season occurs during the September to December period, with natural fires prevalent during October and November when thunderstorms are experienced (SARDC and UNEP 2009) (See figure 2.11).

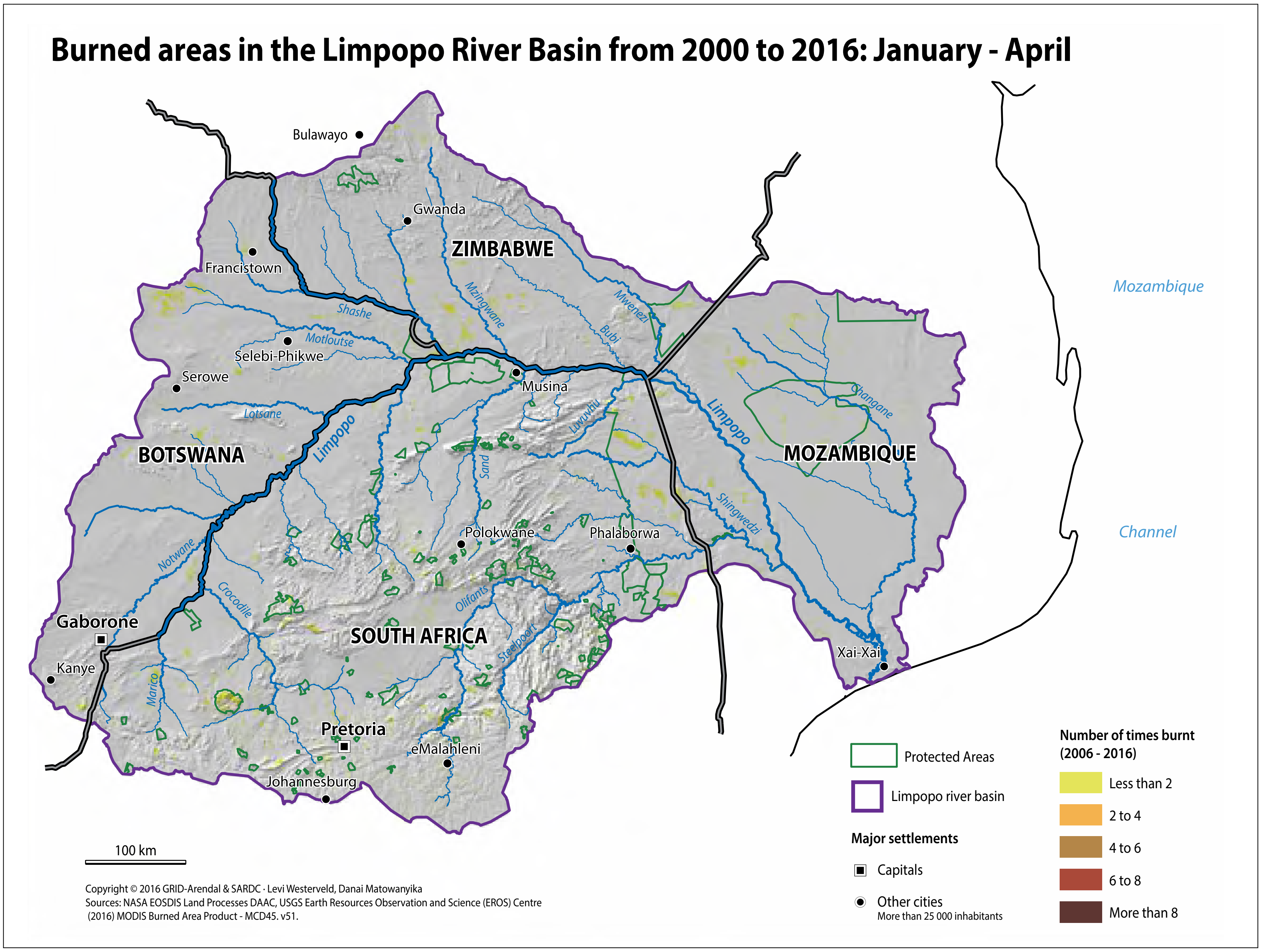
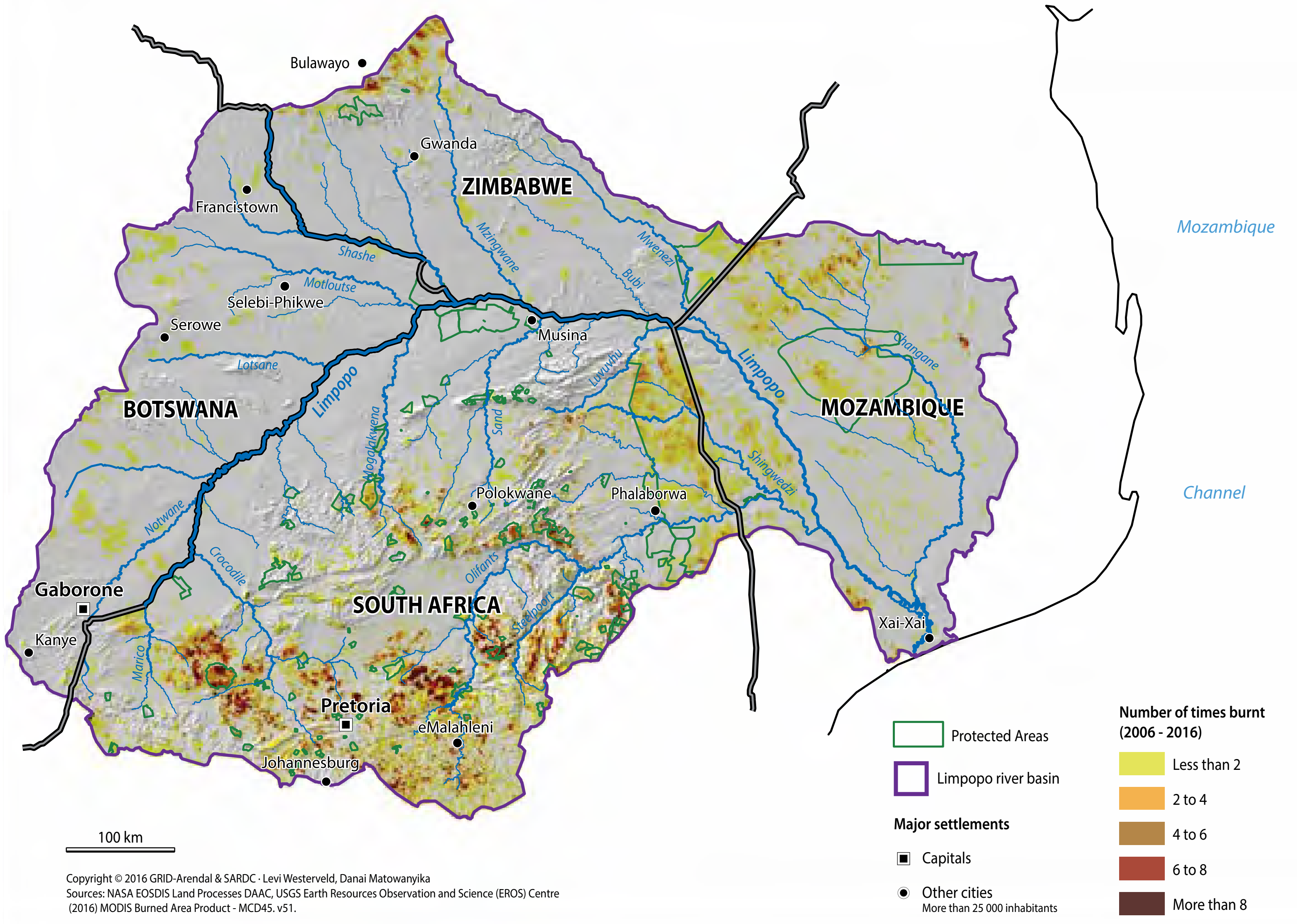
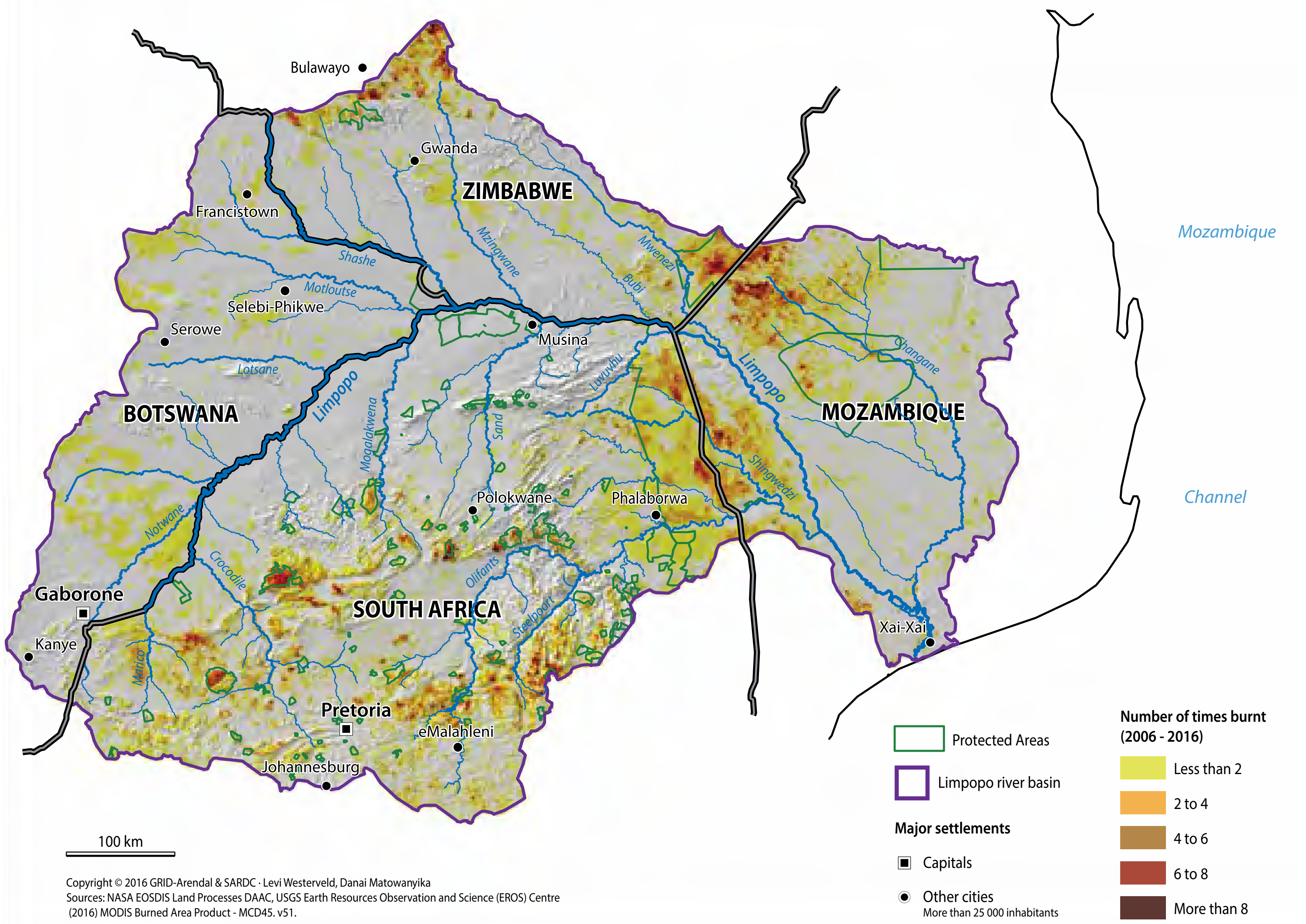


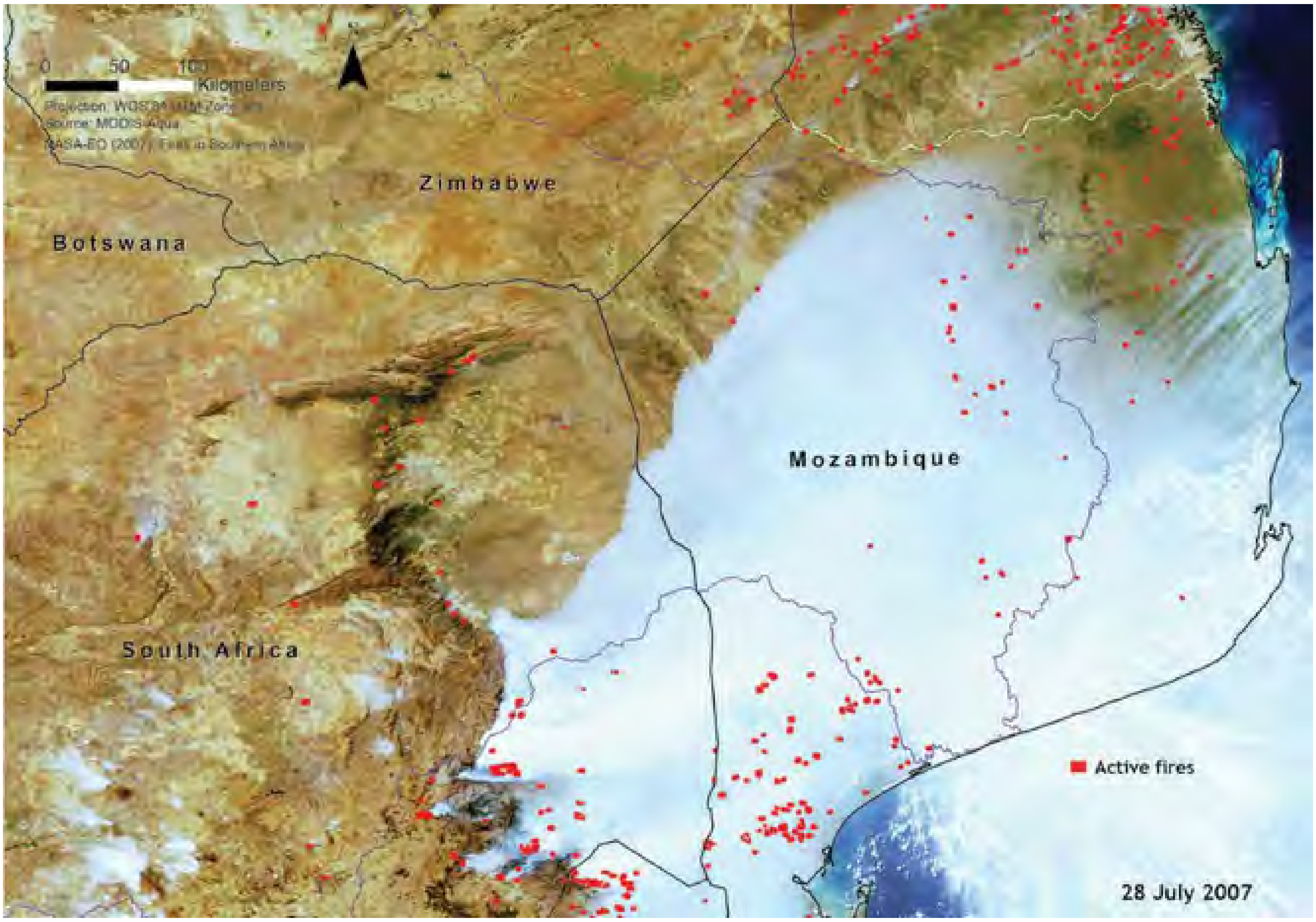
Figure 2.11 Areas burnt 2000 to 2016: January–April (above), May–August (top right) and September–December (bottom right)

Burned areas in the Limpopo River Basin from 2000 to 2016: May - August



Burned areas in the Limpopo River Basin from 2000 to 2016: September - December





Intense fires occurred in South Africa during the dry winter period of July 2007, leading to widespread damage and loss of life. Many more active fires were burning in the eastern part of the basin but could not be detected because of thick smoke. Large sections of South Africa's forestry sector located in the Mpumalanga province and mountainous areas were affected by the veld fires.

Veld fire in South Africa

Conservancies in the Limpopo River Basin

There are a number of conservancies in the Limpopo River Basin and these include Malilangwe, Bubiana and Chiredzi conservancies. Save Valley Conservancy is further north of the basin. These conservancies are home to a range of wildlife including some of the country's endangered species including the black rhinoceros. The species are monitored in a relatively small piece of land, which is easier to manage.

Conservancies have assisted in the conservation of endangered species such as the black rhinoceros. The black rhinoceros is listed as endangered on the IUCN red list as it is declining rapidly across its range due to poaching. The horn of the rhinoceros is a popular ingredient in traditional far Eastern remedies (De Alessi 2000) and this has resulted in increased poaching of the species. To try and cab poaching, the Zimbabwe government facilitated the formation of conservancies in the 1990's and many of the black rhinos in national parks were relocated to private land. The aim of the relocation programme was to find suitable habitat that was large and secure enough to protect the rhinos and where private funds could be used to maintain this

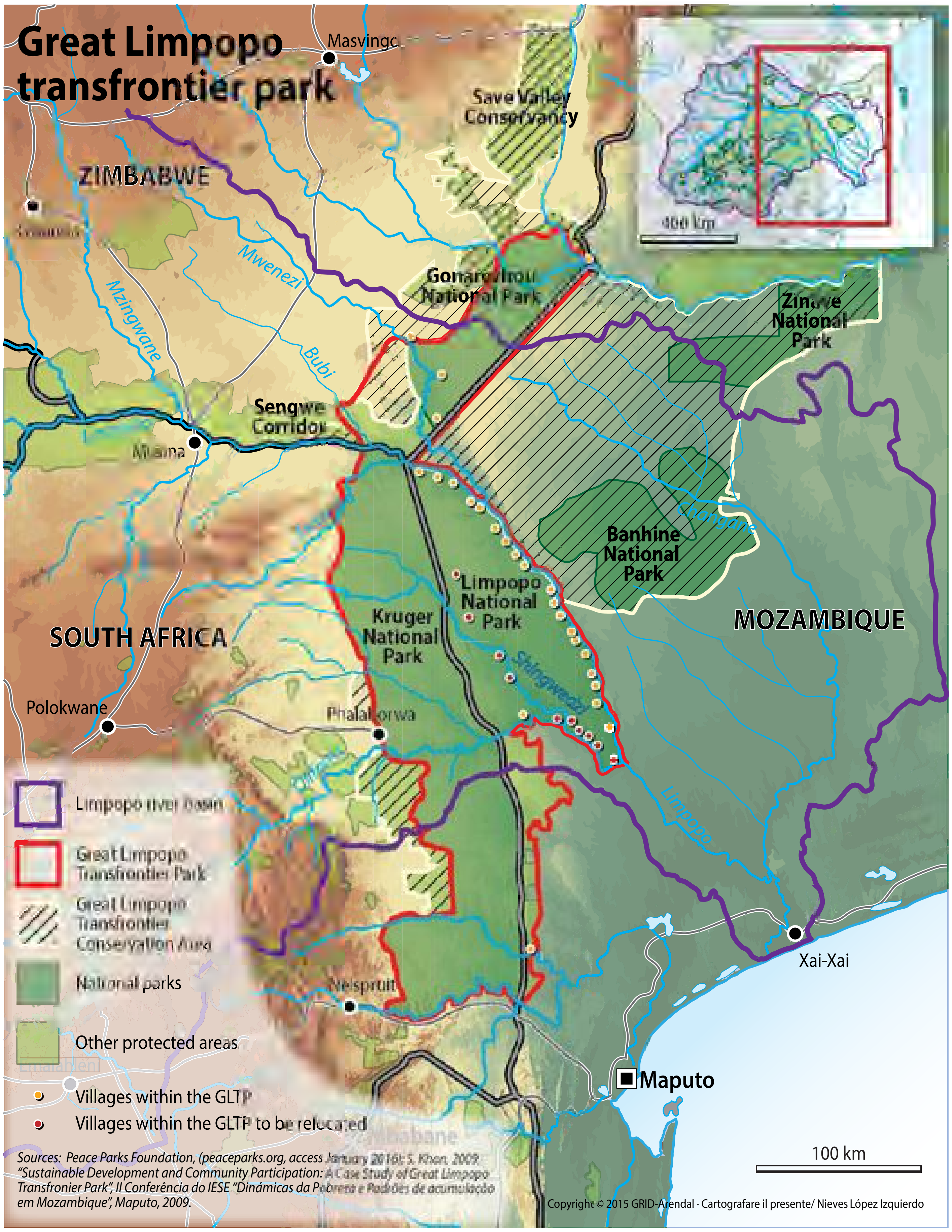


Figure 2.12 Settlements in the Limpopo River Basin

Source: Murwira and Yachan 2007

security (De Alessi 2000). Cases of poaching of the rhino in conservancies have been few and isolated, compared to previous cases in protected areas.

Settlement densification has occurred on the main stem of the Limpopo River in Mozambique (Murwira and Yachan 2007). Of note are the dense settlements which sandwich the areas surrounding and set aside for the GLTCA (see Figure 2.13). Managing smallholder agriculture, wildlife and tourism needs is of high importance for the success of the GLTCA.

The Zimbabwe government's wildlife-based and forest-based land reform policies tried to encourage resettled farmers to venture into wildlife conservation, but this has been limited largely by lack of capacity and skills. Most of the conservancies are surrounded by communities and there have been attempts to include some of them in the running of these areas.

Wildlife conservancies are extensive, and incomes are dependent mainly on safari hunting, with major source markets being the US and Europe. A decline in safari hunting impacts on long term sustainability of conservancies.

The current opportunities for local people are mainly menial and include crafting and sculpturing activities, as well as selling of vegetables and fruits. Considering the importance of conservancies there is need to come up with a long term model that ensures benefits accrue to local communities and reduce poaching and human-wildlife conflicts.

Species Richness

The large herbivore species in the Gonarezhou National Park include the African buffalo (*Syncerus caffer*), waterbuck (*Kobus ellipsiprymnus*), plains zebra (*Equus quagga*), blue wildebeest (*Connochaetes taurinus*), and the African elephant (*Loxodonta africana*). The large carnivores in the park include the cheetah (*Acinonyx jubatus*), lion (*Panthera leo*) and spotted hyena (*Crocuta crocuta*) (Gandiwa 2012). There are at least four species of vultures that are found in the park, in addition to other bird species.

The main aquatic species in the basin that have been studied include fish, crocodiles, hippo and amphibians and, to a lesser extent, aquatic plants. Fish are an important part of the diet of local people as well as being a source of income. Table 2.3 shows some of the species found in South Africa.

The Olifants River originates in the Highveld region of South Africa, and flows north-east into Mozambique. The South African part of the Olifants River basin covers 74,500 km^2 and is home to close to 4 million people. The Olifants River flows through Kruger National Park before entering Lake Massingir in Mozambique.

The biodiversity of the Olifants River catchment is affected by both the treated and partly-treated effluent that comes from the mining and industrial activities upstream. The African sharptooth catfish (*Clarias gariepinus*) is an important aquaculture species in the catchment area and it is increasingly being affected by metal contamination from mining activities upstream. There is evidence that metals are accumulating in the tissue of *C. gariepinus* and have appeared to have increased in the last two decades (Jooste and others 2015).

The Olifants River system is important for conservation of freshwater biodiversity in the Limpopo River Basin. The river has a range of freshwater species that occur along its course and these include Sidespot barb (*Barbus neefi*), chubbyhead barb (*B. anoplus*), banded tilapia (*Tilapia sparrmanii*), and shortspine suckermouth (*Chiloglanis pretoriae*). These species can be used as indicators for biodiversity conservation of the river and its catchment. These indicators can complement those used at the regional level and assist in the development of a comprehensive conservation plan for the basin. Whilst the Olifants is important for freshwater, the greater catchment provides habitats for terrestrial species and birds, as well as providing ecosystem services for the more than 4 million people who live in the area.

Only three species are known to be endemic to the basin and treur river barb (*Barbus treurensis*) is the only threatened species. Some species such as tilapia (*Tilapiine cichlid*), brownspot largemouth (*Serranochromis thumbergi*), and longfin tilapia (*Oreochromis macrochir*) were introduced in Zimbabwe from the Zambezi River system. Other fish species include cyprinids (*Schilbe* spp.), substrate-brooding tilapias (*Tilapia* spp.), catfish (*Clarias* spp.), mouth-brooding tilapias (*Oreochromis* spp.), brown trout (*Salmo trutta*) and the introduced trout (*Salmo trutta*). However, opportunities exist for increasing fish production and supply through fish farming wherever soil and water availability conditions permit. This is in more perennial tributaries and dams in the basin. The productivity of the coastal brackish water area for fish and shrimp production is enhanced by flows in the river mouth.

Table 2.3 Species Taxa in South Africa

Province	Urban	Rural	Total
Gauteng	6 911 000	260 000	7 171 000
Northern Province	490 000	3 638 000	4 128 000
North West	1 060 000	1 983 000	3 043 000
Mpumalanga	1 014 000	1 631 000	2 645 000

Source: IUCN 2014

The contribution of fisheries to the economy and nutrition of the livelihoods of the people in Botswana and Zimbabwe is currently insignificant but significant in lower reaches of the river in Mozambique.

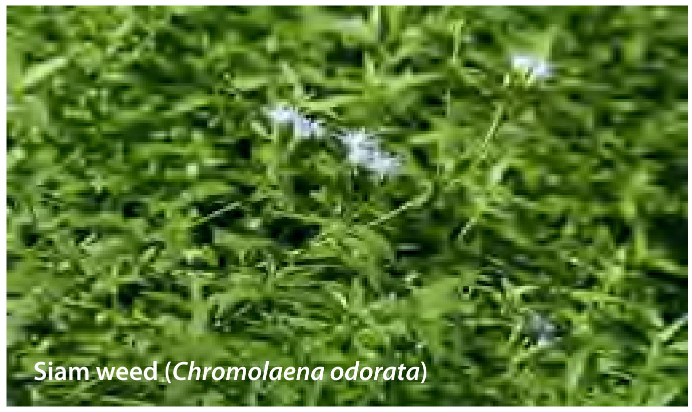
Table 2.4 below shows trends in the status of threatened species in the Limpopo Basin countries from 2000 to 2015. The number of threatened species such as birds and reptiles has increased in almost all the Limpopo Basin States.

Table 2.4 Trends in Status of Threatened Species at National Level

Mammals								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	12	11	8	9	9	9	9	10
South Africa	–	–	23	24	24	24	–	25
Mozambique	15	15	11	12	12	12	15	13
Botswana	5	7	6	7	7	7	5	8
Birds								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	10	10	11	15	14	15	14	17
South Africa	–	–	35	41	40	41	–	45
Mozambique	16	16	21	25	24	25	25	29
Botswana	7	7	7	10	10	10	10	13
Other invertebrates								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	–	–	–	5	5	5	3	–
South Africa	–	–	137	45	134	140	–	180
Mozambique	5	5	5	55	55	64	8	64
Botswana	–	–	–	–	1	–	–	–
Reptiles								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	–	–	–	–	3	3	3	3
South Africa	–	–	19	3	21	21	–	21
Mozambique	5	5	5	5	8	8	8	12
Botswana	–	–	–	–	–	–	–	–
Fishes								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	–	–	3	3	3	3	3	3
South Africa	–	–	65	17	87	87	103	–
Mozambique	3	–	45	53	55	54	63	54
Botswana	–	–	2	2	2	2	2	2
Molluscs								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	10	10	11	–	–	–	–	14
South Africa	–	–	24	–	21	22	22	–
Mozambique	16	16	21	4	3	3	3	27
Botswana	7	7	7	0	0	0	0	10
Amphibians								
Country	**2000**	**2003**	**2008**	**2010**	**2011**	**2013**	**2014**	**2015**
Zimbabwe	–	–	6	6	6	6	6	6
South Africa	–	–	21	0	20	19	19	–
Mozambique	–	–	3	3	3	3	4	3
Botswana	–	–	–	–	–	–	–	–

Note: Dashes indicate that no data is available


River infested by water weeds


Siam weed (*Chromolaena odorata*)

Invasive and Exotic Species

Several species have been introduced in various ecosystems of the basin. Invasive aquatic species, such as water hyacinth (*Eichhornia crassipes*), red water-fern (*Azolla filiculoides*) and parrot's feather (*Myriophyllum aquaticum*) provide conditions which increase the prevalence of water-borne diseases, adversely affect water quality and aquatic life, and block river courses, increasing the damage done by floods (UNEP 2002). The impacts of alien (terrestrial) plants include crowding out the native riverine vegetation, displacing or affecting populations of aquatic organisms, trapping sediment, using more water than the natural vegetation that they replace, depleting soil moisture, and reducing groundwater recharge, spring flows and river base flows (Le Maitre and others 2000; Environmentek, CSIR 2003). The most aggressive invader, siam weed (*Chromolaena odorata*) is rapidly spreading northwards in South Africa and southern Mozambique. The Limpopo River and many of its South African tributaries have also been invaded by Australian wattles (*Acacia* spp.), guava (*Psidium guajava*), bugweed (*Solanum mauritianum*), lantana (*Lantana camara*), jacaranda (*Jacaranda mimosaefolia*), syringa (*Melia azedarach*), amongst others (Le Maitre and others 2000; Environmentek, CSIR 2003). These species are likely to have been widely dispersed by the floods of February 2000 (Environmentek, CSIR 2003). There are several operational programmes in the basin countries to control alien species but the process is very expensive and takes several years to complete.

From the 1920s to the 1960s, the Rhodesian Angling Society maintained a hatchery at the Matopos Dam from which they stocked exotic fish into dams in the Limpopo headwaters (Marshall 2011). At least five exotic species have been introduced into the system. This includes the common carp (*Cyprinus carpio*), the largemouth bass (*Micropterus salmoides*), the yellow-belly bream (*Serranochromis robustus*), the longfin tilapia (*Oreochromis macrochir*) and Nile tilapia (*Oreochromis niloticus*). The Nile tilapia is now becoming dominant in the Limpopo River Basin. Some species that were introduced then like the smallmouth bass (*Micropterus dolomieu*) are now thought to be extinct in Zimbabwe, although there is always a chance that some still survive somewhere in the region. Species like the largemouth bass breed rapidly, posing a threat to commercial fish species such as the red-breasted bream. Other species of concern are the Nile tilapia and Australian red claw crayfish (*Cherax quadricarinatus*) which was mainly restricted to the Zambezi valley but has now been recently detected in one of the rivers in the Limpopo Basin. This is potentially a serious threat to fish species. The extent and scale of its spread has not been assessed across water bodies in Zimbabwe (GoZ 2014).

A survey by Zimbabwe's Environmental Management Agency in 2013 revealed that the most common invasive alien plant species in the country is *Lantana camara*. Lantana is found to be prevalent in moist areas, unlike other invasive species that invade degraded land. The study recorded incidences of occurrence of 99 percent in Mashonaland Central, 96.95 percent in Midlands and 43.8 percent in Matabeleland South where the Limpopo Basin occurs. Lantana is also prevalent in Gonarezhou National Park, and studies have shown significant differences in soil and vegetation variables, which suggest that *L. camara* is altering soil properties and native vegetation structure and composition in the park to the detriment of wildlife management (Chatanga 2007).

The cholla cactus (*Opuntia fulgida*), is mainly found in Matabeleland South, predominantly in the districts of Beitbridge and Gwanda, with isolated cases recorded in Insiza, Bulilima and Matobo. In Matabeleland South, other invasive cactus species include Jointed cactus (*Opuntia aurantiaca*), Tree Chola (*Opuntia imbricate*) and the night-blooming cactus (*Harrisia martin*). *Opuntia fulgida* has reduced the quality of rangeland for grazing animals and has invaded approximately 3,000 ha in that province. In the Beitbridge and Gwanda districts, 2,355 ha were infested, affecting approximately 500 households.

There have been attempts to control the cholla cactus through burning but this has not been successful. Biological control of the species seems to be succeeding on the South African side and there is need for the two countries to engage each other in the control of this specie.

The Indian Mynah, an exotic bird species, is common in South Africa and it is expanding its range northwards into Zimbabwe. The common myna has been independently introduced into South Africa in the 19th century (Peacock and others 2007). This species competes with indigenous birds for food and nesting sites, and they have been reported to evict Crested Barbets from nest holes. Indian mynahs are currently undergoing a rapid and extensive range of expansion in southern Africa, especially into Botswana and Zimbabwe. The bird has been sighted on the Beitbridge and has spread to as far as Bulawayo.

Changes in Water Resources

Water Towers

The water source areas in the South African part of the basin include:

- Mpumalanga Drakensberg escarpment (main rivers are Elands; Sabie; Crocodile and Olifants). This water source area supplies water to parts of Mpumalanga (Nelspruit; eMalahleni; Middleburg); Phalaborwa in Limpopo Province.
- Wolkberg (Middle Letaba; Ngwabitsi, Olifants – protected areas include Wolkberg (Serals) Wilderness Area; Legalameetse Nature Reserve; Bewaarkloof Nature Reserve; Wolkberg Caves Nature Reserve). This headwater supplies freshwater to the Olifants catchment, which is impacted by acid mine drainage from abandoned old coal and gold mines.
- Soutpansberg (rivers include Luvuvhu; Little Letaba; Mutale; Mutamba; Nzhelele). Lake Fundudzi, one of South Africa's largest freshwater lakes is located in this area. This mountainous water source area is a hotspot of biodiversity and unique species.

Water sources from other countries include Upper Limpopo in Botswana and South Africa, where the highly sensitive ecosystem relies on the dolomitic aquifers, associated springs, and wetland systems sustained by groundwater from the upper catchment of the Groot Marico River. Mozambique water sources areas depend on the upstream area in Zimbabwe, Botswana and South Africa and the area upstream of Massingir Dam.

A basin-wide comparison of Mean Annual Runoff (MAR) for current-day versus natural conditions is presented in Figure 2.13. The net impacts of consumptive use on the surface water resources vary widely amongst the sub-basins and range from less than 1 percent in the Bonwapitse, Mahalapswe and Changane sub-basins to over 50 percent in the Upper and Middle Olifants sub-basins and nearly 70 percent in the Lower Olifants sub-basin (LIMCOM 2013).

The Mean Annual Runoff at the mouth of the Limpopo River is 4,072 million cubic meters per year.

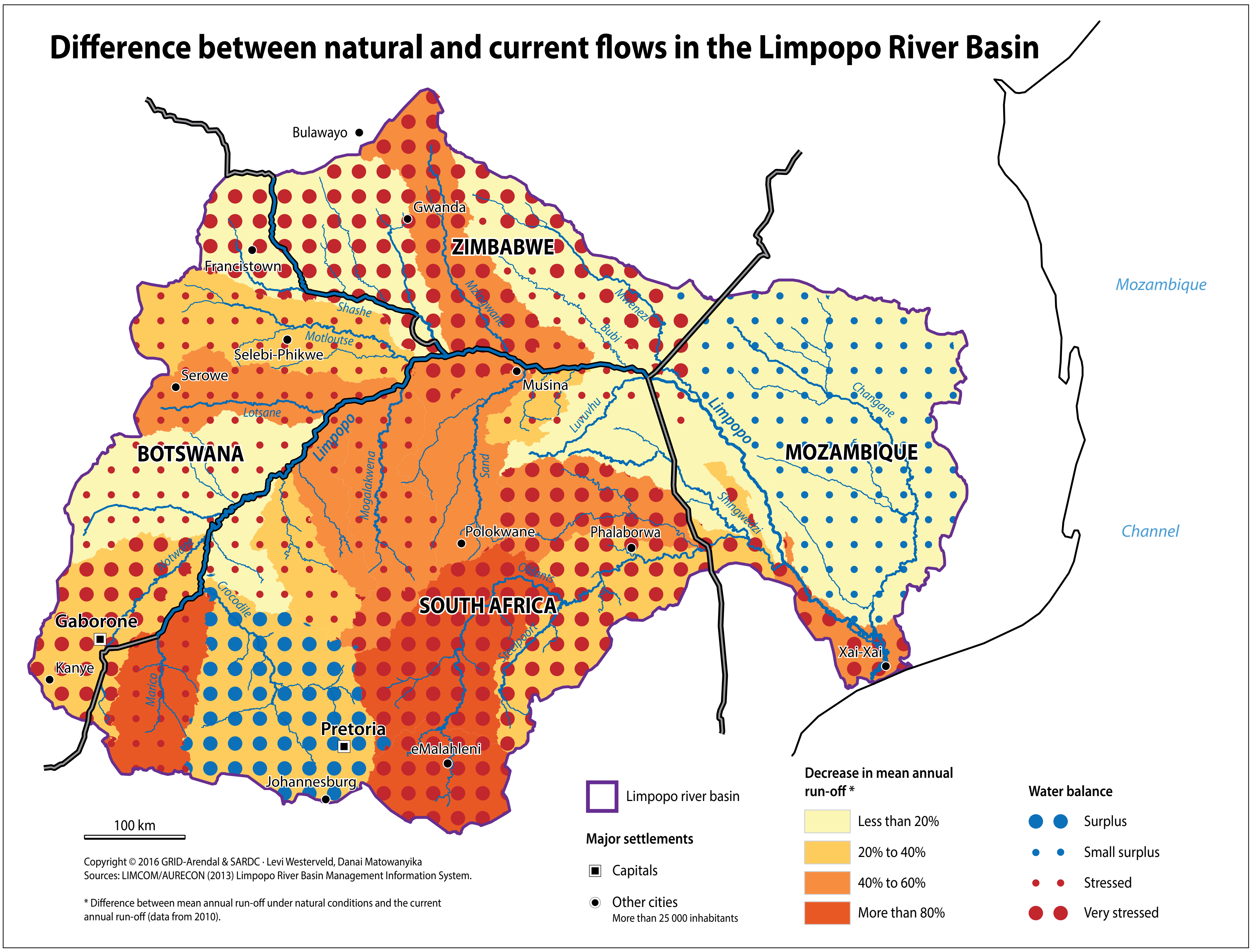
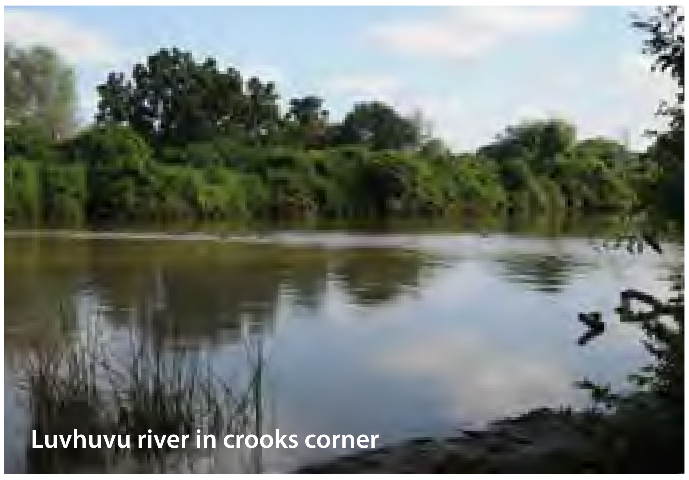


Figure 2.13 The Difference Between Natural and Current Flows in the Limpopo River Basin

Source: Data from LIMCOM 2013



The consumptive water use ranges from 0.5-0.9 percent of rainfall and 27–34 percent of natural flow. For the natural scenario, the modelling was done with no human impacts present in the catchment configurations. For the current-day scenario, all existing land-use, water-use and bulk water resource infrastructure were super-imposed on the natural conditions at 2010 levels of demand and land-use, including transfers into and out of the Limpopo Basin (LIMCOM 2013).

There are transfers from outside the basin into Crocodile and Upper Olifants of 288 and 120 million cubic metres respectively, while there is a transfer out of the basin from Mzingwane sub basin of 60 million cubic metres. Under the Komati Water Scheme Augmentation Project (KWSAP), water is transferred from the Vaal Eastern Subsystem to address supply problems for Duvha and Matla power stations located on the Upper Olifants sub-basin. Bulawayo, Zimbabwe's second largest city, relies on Mzingwane Dam for its domestic and industrial water needs.

Sub-basins with small percentage difference between natural and current flows have not experienced huge developments, while those with huge difference indicate that they have undergone major infrastructure developments and are at risk of water stress and water scarcity. With climate change the current flow will continue to decrease resulting in water stress and shortages in future.

The risk of water shortage in the Limpopo sub-basins depends on the water demand imposed on the available resources.

Water Demand and Use

Irrigated agriculture accounts for a large share of water use in the Limpopo Basin countries. Water used for irrigation doubled from about 1,400 million cubic meters per year in 2000 to about 3,000 million cubic meters per year in 2012 (Figure 2.14). There has also been an increase in the share of water used by industry and power generation. An increase in water use for power generation can be a result

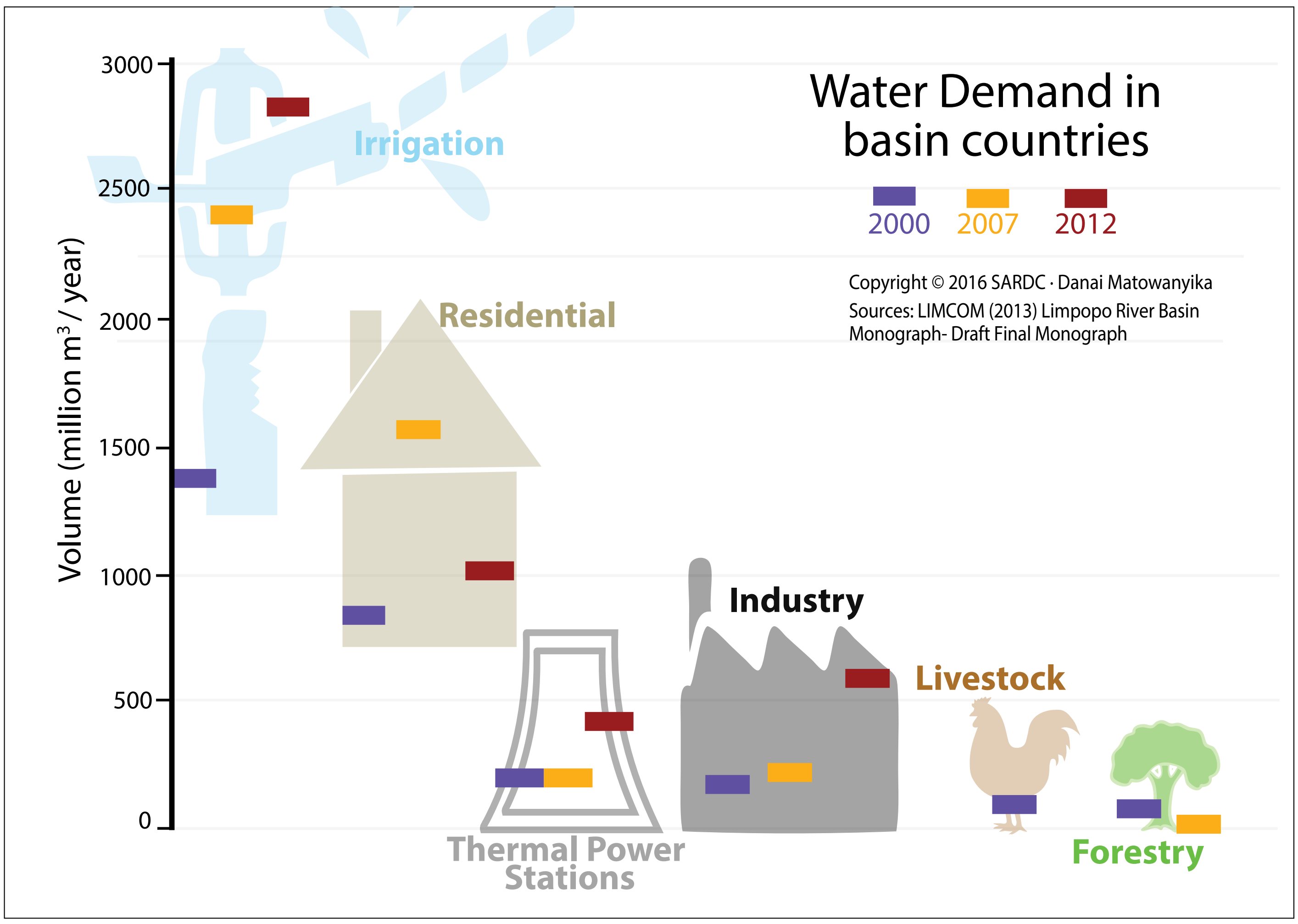


Figure 2.14 Water Demand in Basin countries

Source: LIMCOM 2013

of reopening of the Komati Power Station after 2010, as the power plant was put out of service in the late 1980s due to surplus capacity and increasing maintenance costs of the older plant (ESKOM 2016).

There is a decrease in water use in Mozambique by 36 percent and in Zimbabwe by 73 percent, while there is a significant increase in water use by 46 percent for South Africa between 2007 and 2012 (Figure 2.15). Botswana water use was stable. Overall the basin water use increased by seven percent between 2007 and 2012. For Zimbabwe, combined water demand for domestic, mining and industry in 2007 and 2012 was 690 and 28 million cubic metres per annum, respectively. The total basin water use for 2012 is about 5,088 million cubic metres, of which 87 percent is used in South Africa and seven percent in Zimbabwe, while Mozambique and Botswana use four and two percent, respectively. Irrigation is still the highest water user with 56 percent dropping from an average of 70 percent in 1999 (SADC 1999) followed by domestic water use with 20 percent. The high irrigation water use suggests that each Limpopo Basin riparian country relies heavily on food grown within its borders to meet national goals of food security. There is an increase of irrigation water use attributed to rehabilitation of irrigation schemes in the basin and plans to use treated effluent from wastewater treatment works (LBPTC 2010).

Presently, rural water supply is sustained by groundwater abstraction and projections for year 2025 indicate a total demand of about 20 million cubic metres per annum.

In South Africa, the two sub-catchments with largest water use are Crocodile River and Olifants River, with 40 and 30 percent of water demand, respectively in the South Africa portion of the basin. A number of new mining projects with a total water requirement of about 40 million cubic metres are being planned for the next five years in South Africa that include Sekolo Coal mines, Ithabimetsi Exaro Coal Mines, Makhado Coal mines, Sefateng Chrome Mines and Kusile Coal Supply Mines (LIMCOM 2013).

In Zimbabwe, highest water demand is found in the upper part of the basin in the Upper Mzingwane River (including Bulawayo which is slightly outside, but depends on the Limpopo Basin for its water requirements) and the Mwenezi River sub catchments. Water demand projections for agriculture, urban, industry and mining and rural water demand are 1,000; 810 and 6 million cubic metres per annum, respectively for the year 2025 (LBPTC 2010). Part of this water demand will be met by a combination of water demand management and future water supply sources (for example, utilisation of many small dams in irrigated agriculture, and water transfers from Gwayi and Zambezi Rivers for Bulawayo).

In Mozambique, the total irrigation water demand is projected to increase to about 1,200 million cubic metres per annum in the future. Irrigation area in Chokwè is 22,000 ha (only 8,000 ha is in use and 7,000 ha is under rehabilitation), while Xai-Xai has 4,000 ha that were recently rehabilitated and a further increase of 5,000 ha are planned for rehabilitation in the future. Irrigation in Chokwè and Xai-Xai accounts for most of the irrigation water demand, while combined urban and industrial water demands for Chokwè and Xai-Xai is relatively small, estimated at 4 million cubic metres per annum. Water demand from the Limpopo River will increase due to new projects such as PROCANA that intends to develop 30,000 ha of sugarcane on the banks of the Olifants River and a major mining project to extract heavy mineral sands that is planned for the Chibuto area, although currently on hold.

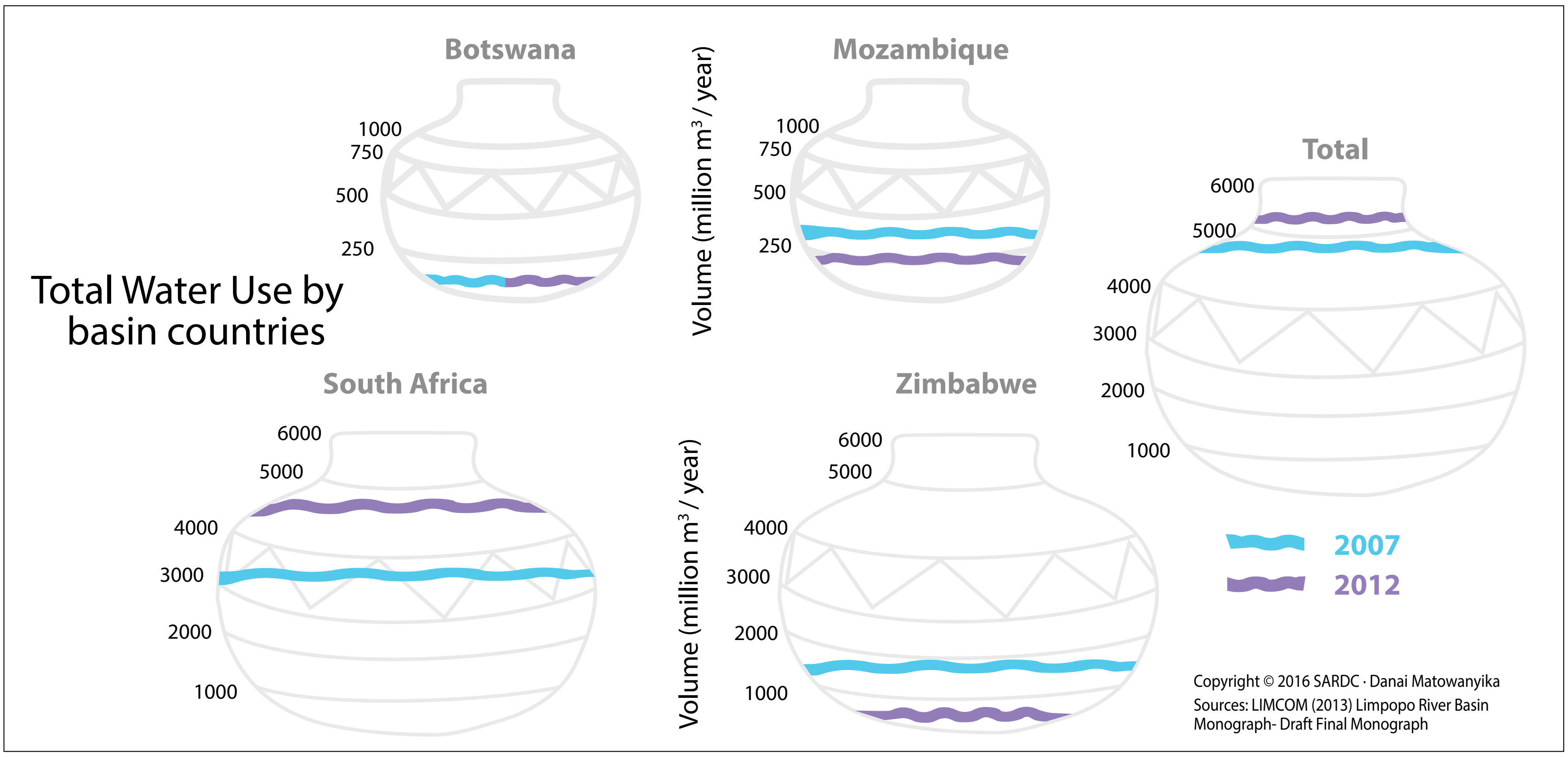
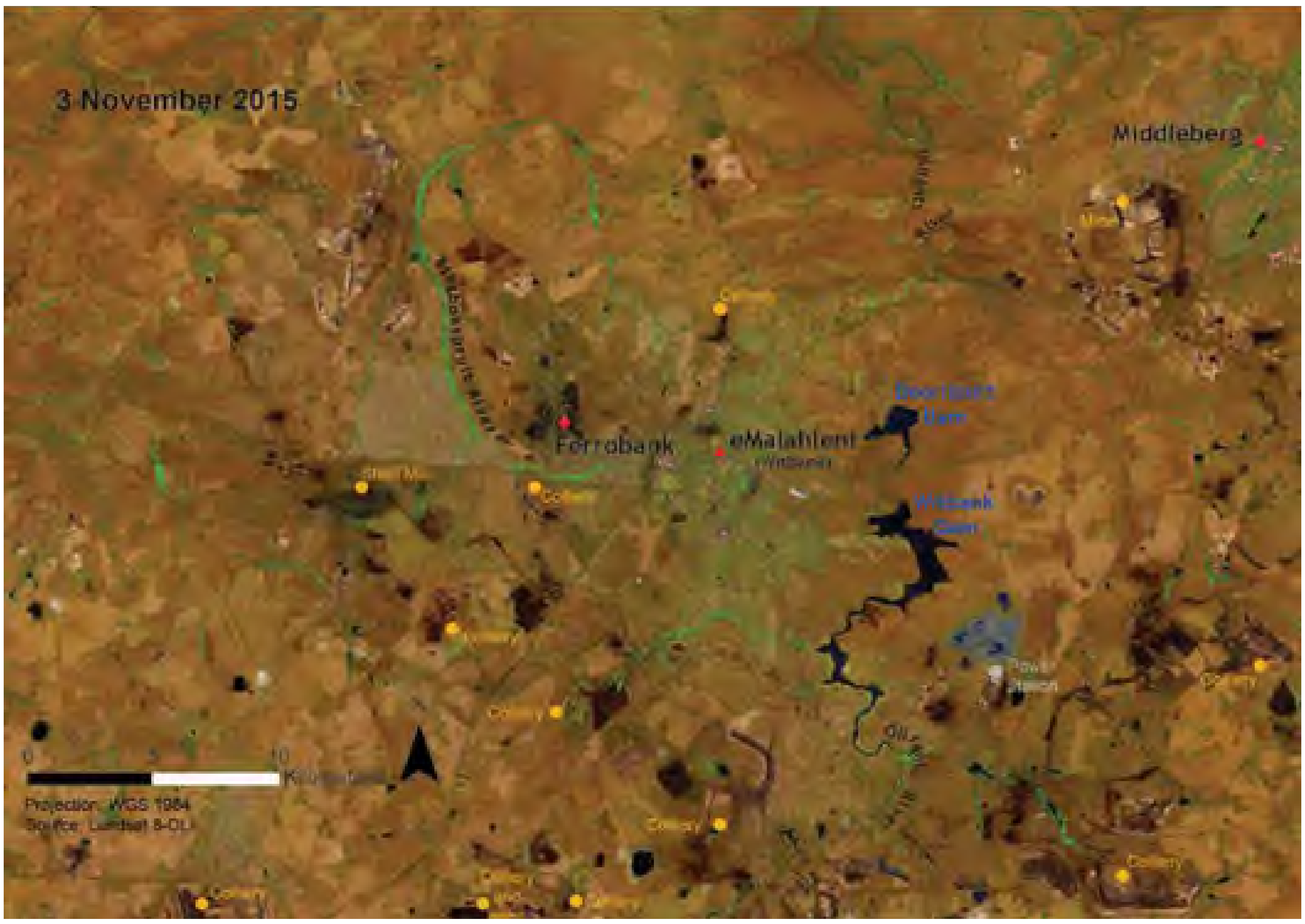
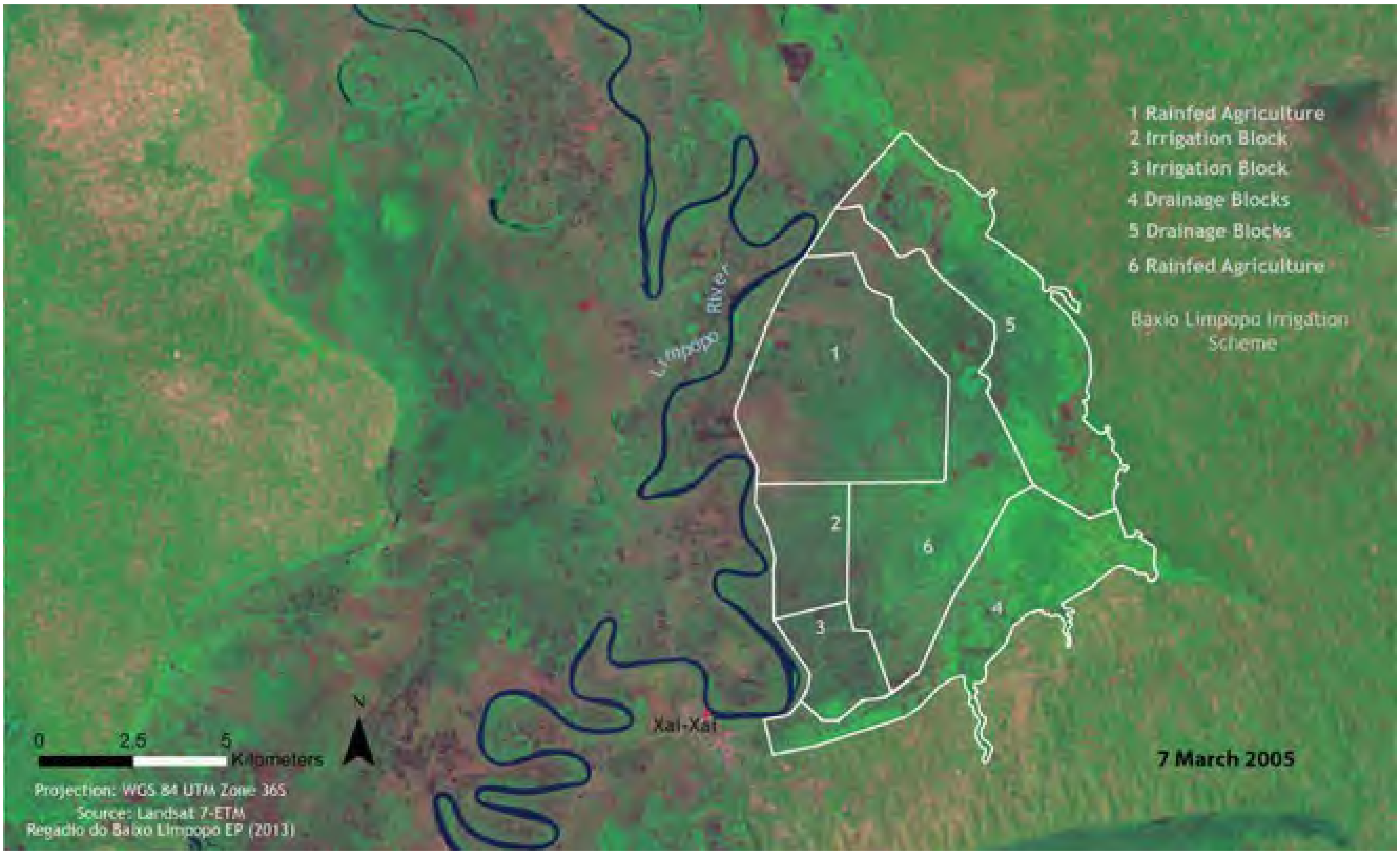
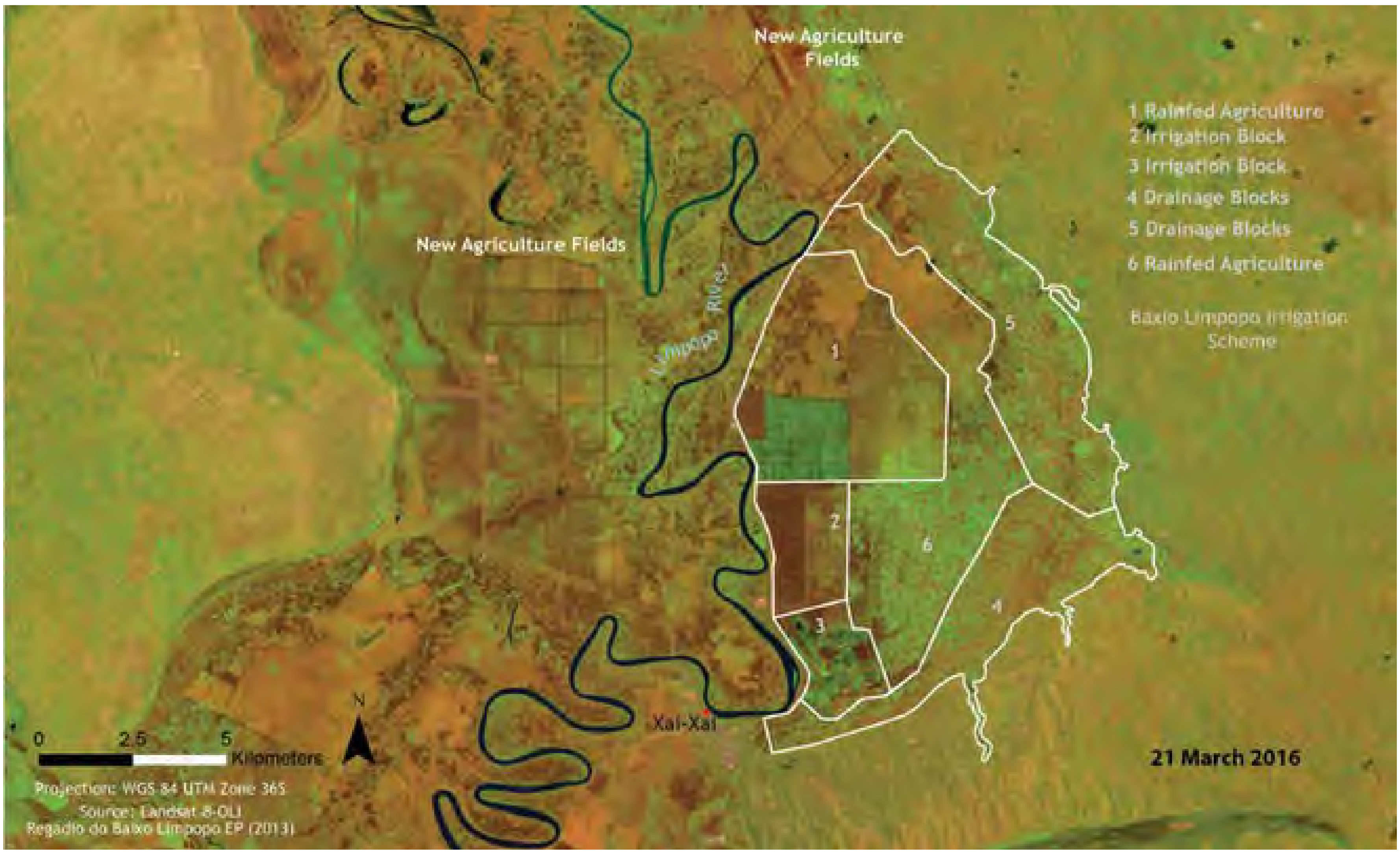


Figure 2.15 Total Water Use by Basin Countries
Source: LIMCOM 2013



Extensive coal mining activities in the Upper Olifants sub-catchment and establishment of steel industry, chrome and platinum mining has resulted in the expansion of eMalahleni, Mpumalanga Province, increased influx of mine workers, water requirements and water pollution (DWA 2011). There are 24 mines in the upper Olifants sub-basin. The mining water use is 285 million cubic meters per year, and it is expected to increase with planned Kusile Coal Supply Mines with water requirements of 14.2 million cubic meters per year. The population size of the province increased from 3,123,869 in the 1996 census to 3,365,554 in the 2001 census and to 4,039,939 in the 2011 census. This represents a 22,7 percent increase, 1,1 percent higher than the national population increase of 21,6 percent over the same period (Statistics South Africa 2014).





The Baixo Limpopo Irrigation Scheme (BLIS) extends along the Limpopo alluvial plains and is supplied by the Limpopo River and surrounding tributaries (Regadio do Baixo Limpopo EP 2013). With a total area of 70,000 ha, the BLIS has the potential to boost agricultural production and improve livelihoods, with direct benefits to many smallholder farmers in the area (AfDB 2012).

Implementation of water demand management in the Chokwè Irrigation Scheme is key as the present water use is very high (LBPTC 2010).

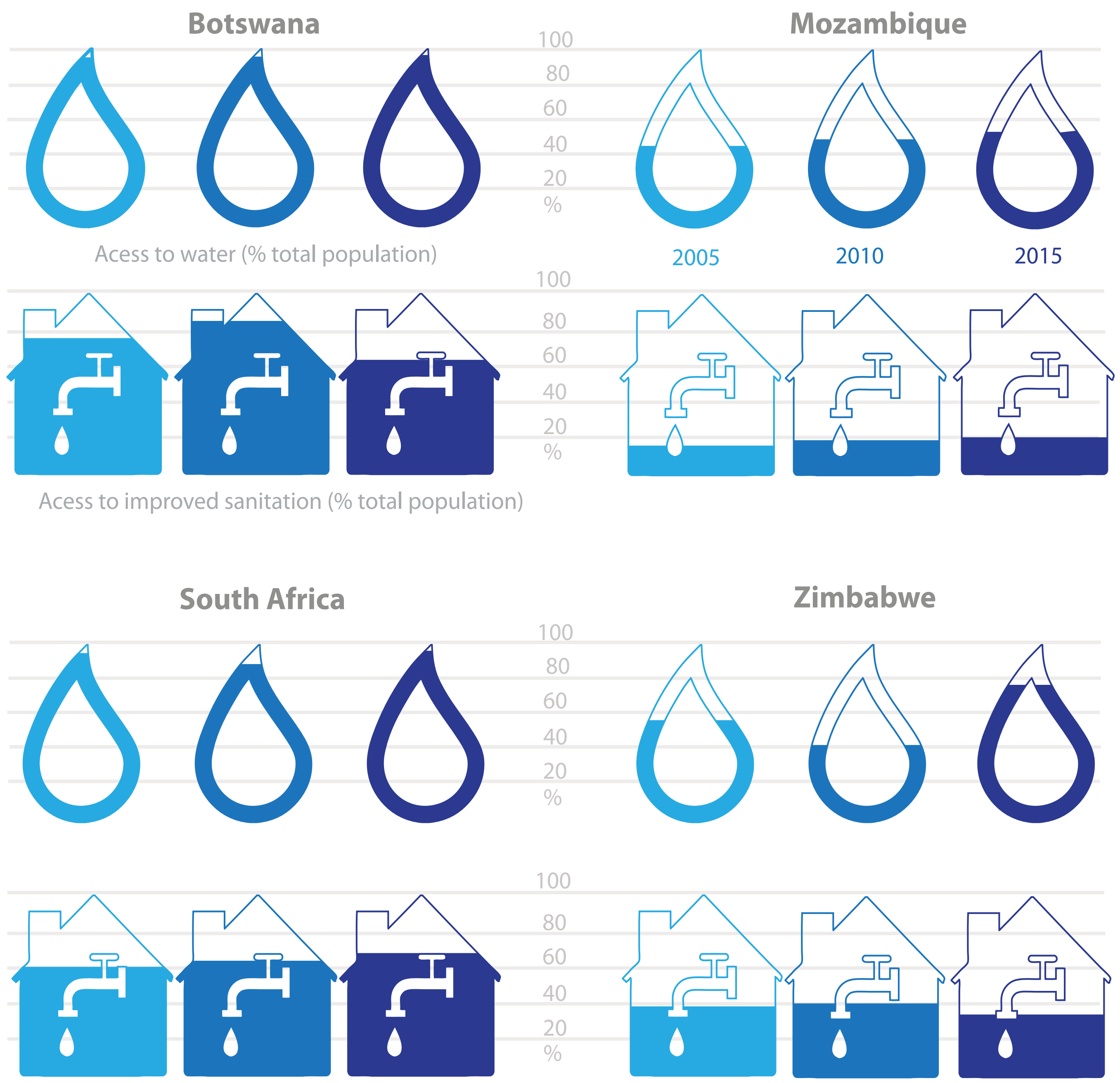
Many water uses generate return flows that may be available for other uses, although they are often of an inferior quality than the water originally abstracted, thus may pose risks to public health and the environment. Non-consumptive use of water is limited to the 2.6 Megawatts (MW) hydro-electric power plant in operation for the town of Lydenburg in the Steelpoort Sub-basin in South Africa, the only one in the Limpopo River Basin. Two hydro-electric power plants are planned at Massingir Dam (Lower Olifants) with generation capacity of 28 MW and water requirement of 2,488 million cubic metres per second and at Manyuchi Dam (Mwenezi) with a capacity of 5 MW (LIMCOM 2013). Other non-consumptive uses include fisheries, canoeing, boating, swimming, sport and navigation.

Water demand is currently so high that the system has become 'closed,' meaning that there is little water left to allocate to additional new uses. Hence, climate change is making water more scarce in the future. This high demand threatens livelihoods, economies, environmental flows and biodiversity.

Trends in Water Access

National level data shows that governments of the four basin states have made significant progress in the past decade towards the provision of water and sanitation facilities to rural and isolated communities. Botswana and South Africa have the highest percentages of people with access to water and sanitation (Figure 2.16).

Access to Water and Improved Sanitation



Sources: Zimbabwe Millennium Development Goals Progress Report 2012 (GoZ and UN-Zimbabwe 2012); Millennium Development Goals: Status Report-Botswana 2010 (GoB and UN-Botswana 2010); Report on the Millennium Development Goals- Republic of Mozambique (GoM 2010); South Africa Millennium Development Goals: Country Report 2013 (GoS 2013); Global Health Observatory- Public Health and Environment: Water, Sanitation and Hygiene (WHO 2015); Zimbabwe Food Security Brief (FEWS 2014); A Situational Analysis on the Status of Women and Children's Rights in Zimbabwe 2005-10 (UNICEF 2012); Impact evaluation of drinking water supply and Sanitation interventions in rural Mozambique (UNICEF 2011)

Figure 2.16 Access to Water and Improved Sanitation

The relatively high density of population, the existence of major towns and cities in the basin, and the development of a large number of dams to service urban areas, industries, agriculture, energy generation, mining and recreational activities such as boating, swimming, fishing and hiking sites, all exert significant pressure on the water resources. This pressure will increase under future climate change.

Reservoirs and Water Infrastructure

Storage dams in the Limpopo River system provide reliable supplies of clean water to people in both rural and urban settings, but can also have negative impacts on the environment or other demands if not properly managed (Limpopo Briefing Note 2015). A total of 97 dams (total storage of 7,528 million cubic metres) of various sizes in the basin are reported by LIMCOM (2013). Massingir Dam on the Olifants sub-basin in Mozambique has a capacity of 2,200 million cubic metres and annual discharge of 1,800 million cubic metres and is the largest water body in the basin (Mainuddin and others 2010). Majority of dams with capacity of between 100-1000 millions of cubic metres are found in South Africa (Figure 2.17).

Massingir dam wall

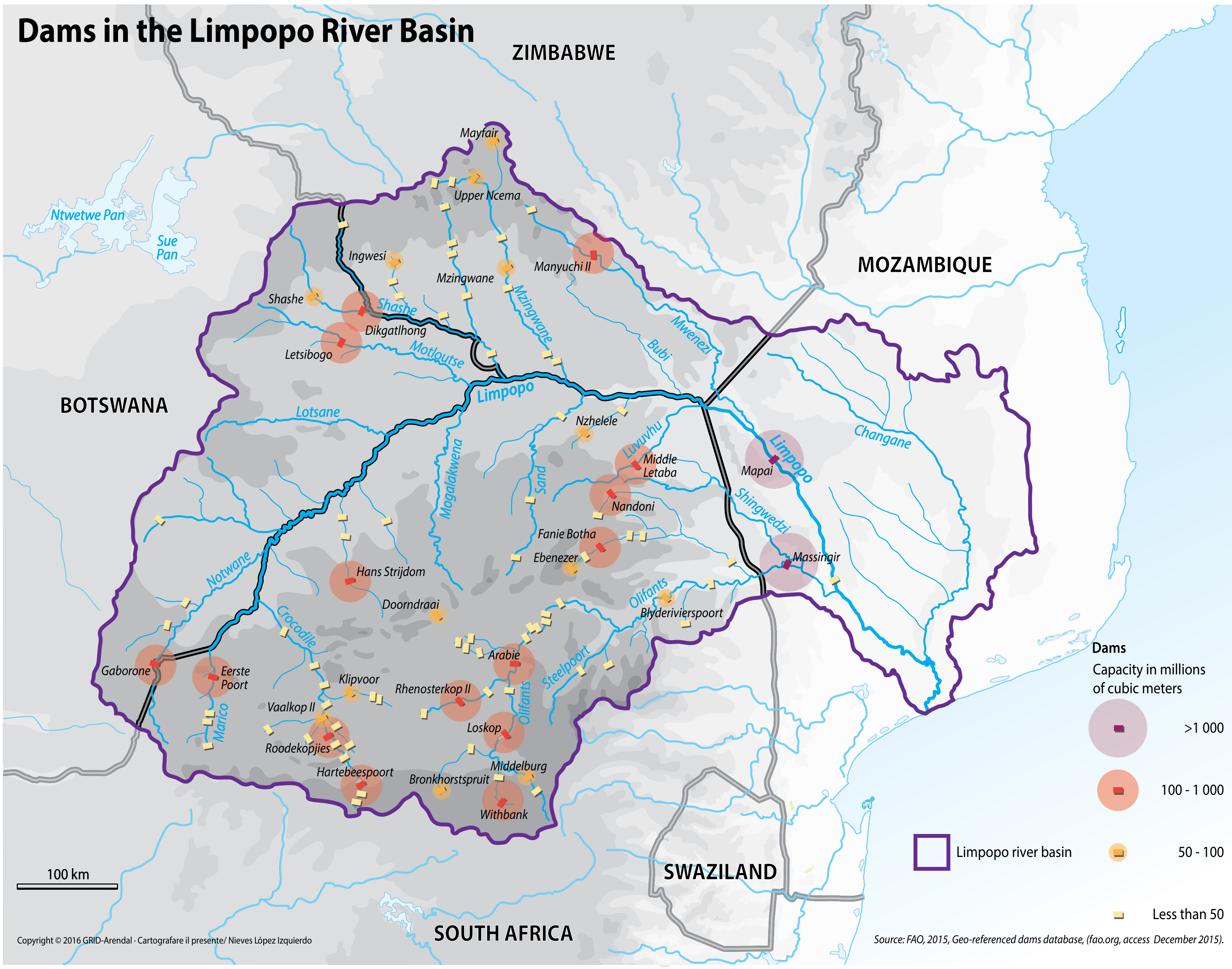
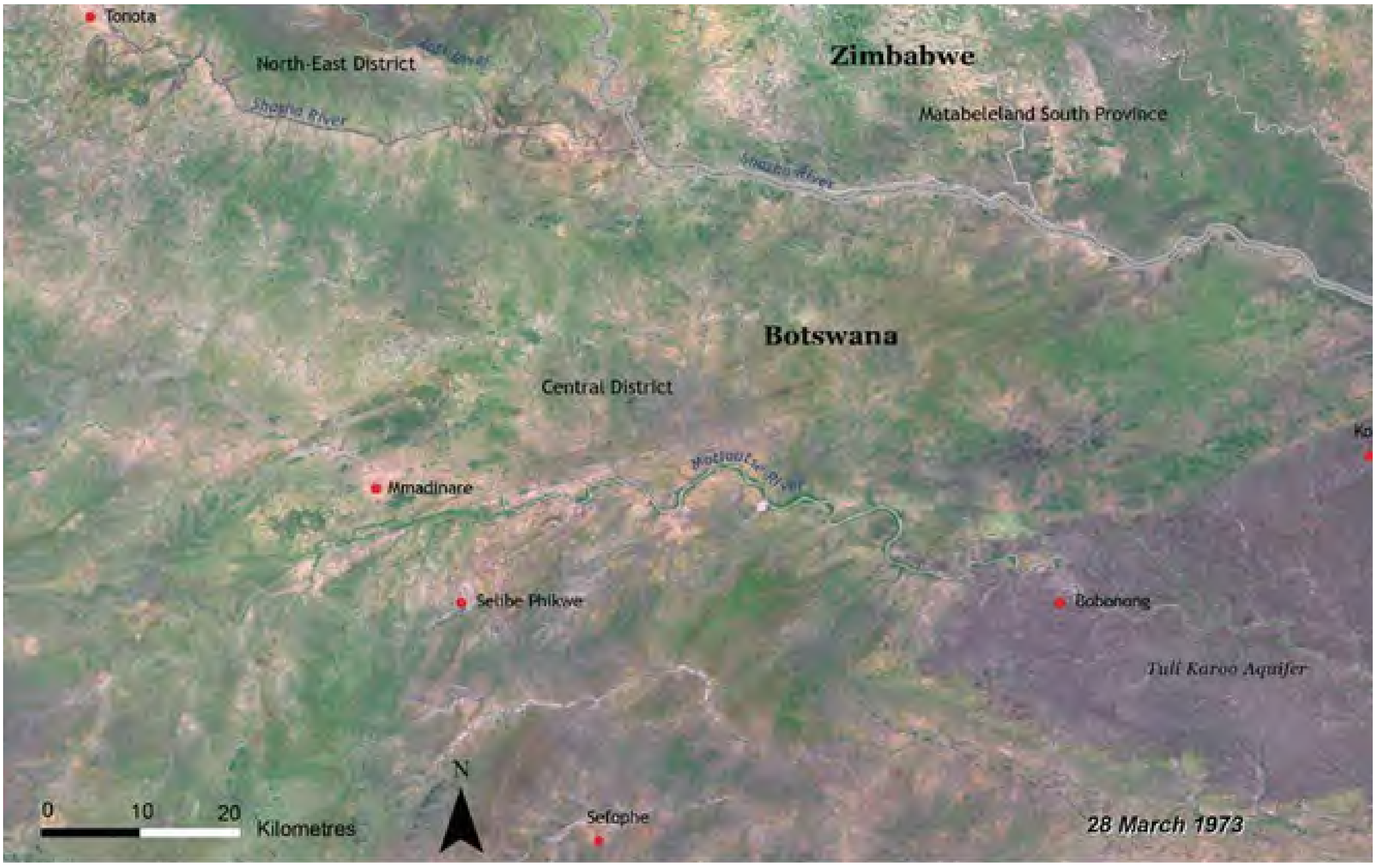
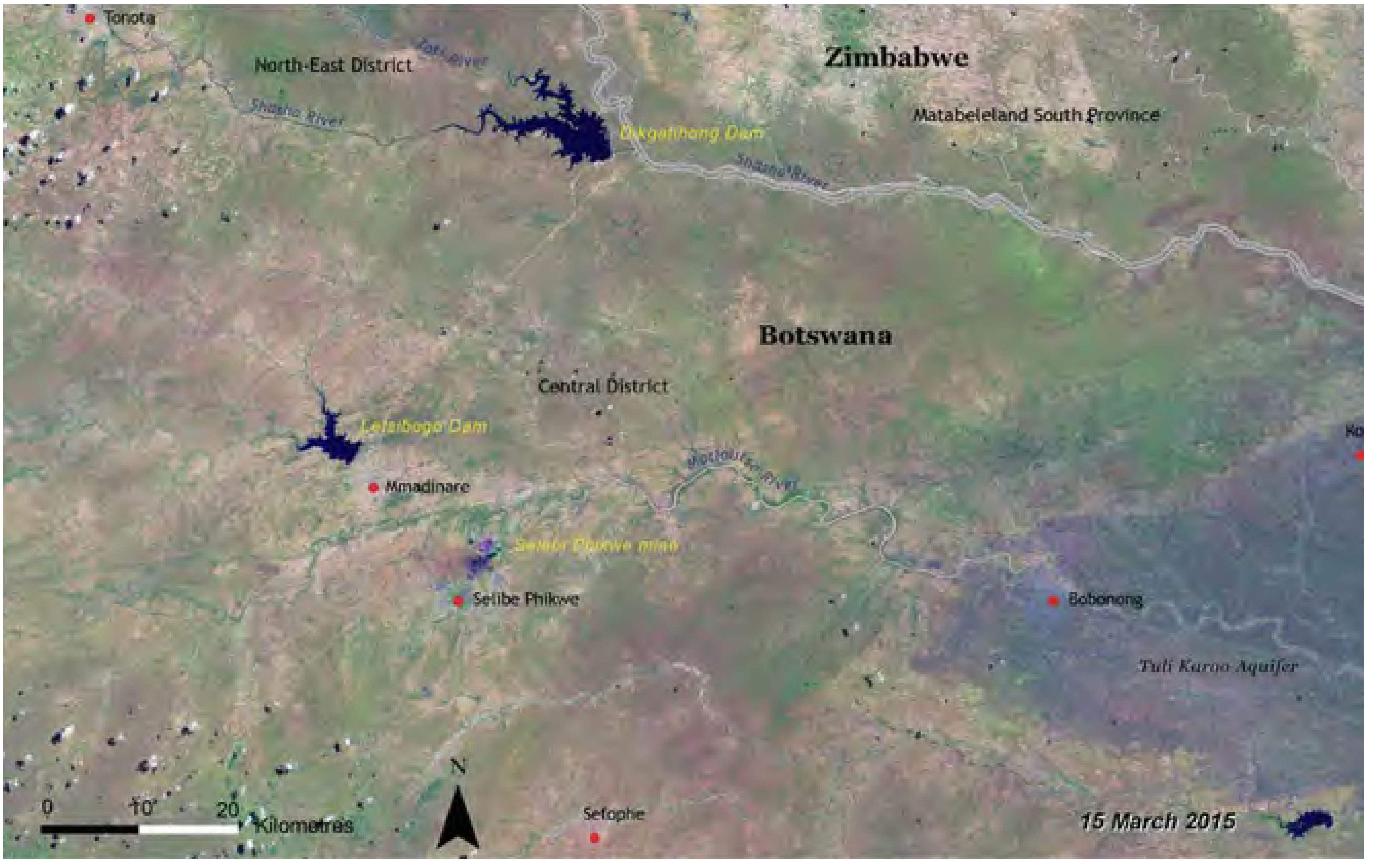


Figure 2.17 Dams With a Storage Capacity of More than 30 Million Cubic Metres and Related Bulk Infrastructure for Water Supply in the Limpopo Basin

Source: FAO 2015





Increase in dams and water infrastructure to supply needs in Botswana (1973 versus 2015).

Most dams in the Limpopo Basin have a small capacity. The majority of the dams were built before 1990 (Figure 2.18).

Evaporation losses from dams are quite high due to the large open surface water area and should be considered in water balance calculations (e.g., for Massingir it is 291 million cubic metres per annum). The development of numerous dams has altered the hydrology of the Limpopo River (Boroto and Görgens 1999; Ashton and others 2001; Environmentek, CSIR 2003).

Future water supply sources from Gwayi and Zambezi Rivers are being considered for Bulawayo, while Mapai Dam with a capacity of 11,200 million cubic metres is planned for irrigation water supply in the Lower Limpopo in Mozambique (LIMCOM 2013). Mapai Dam will be the largest in the basin. In Botswana, the Dikgatlhong dam, with a full supply storage capacity of 400 million cubic metres was constructed between 2008 and 2012 and is the largest in the country (Department of Water Affairs 2014). Located in the North-East of Botswana on the Shashe River, it provides water to the North-South Carrier to augment supply to the Greater Gaborone area and feed central region places such as Serowe, Palapye and Mahalapye. Other reservoirs are Lotsane completed in 2012 with a capacity of 40 million cubic metres and Thune with a total storage capacity of 70 million cubic metres (Department of Water Affairs 2014).

Figure 2.19 shows large dams in the Limpopo River Basin, as defined by the World Commission on Dams. The total storage of all dams is estimated at 7,528 million cubic metres.

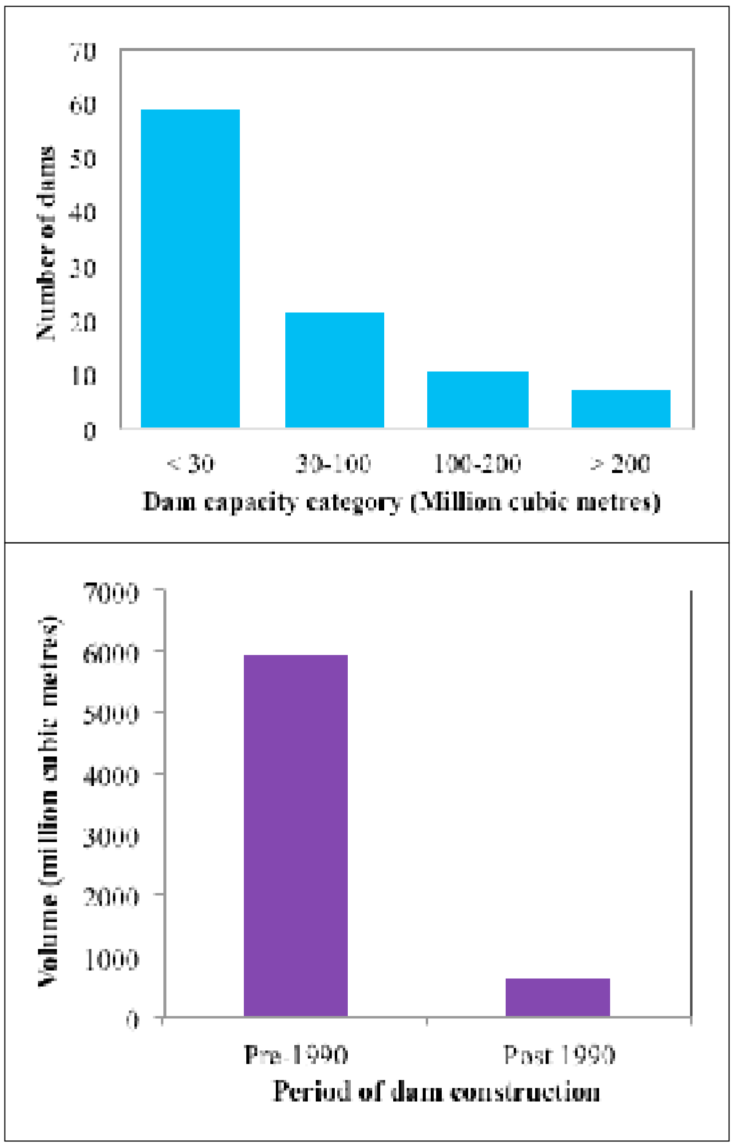


Figure 2.18 Dams With a Storage Capacity of More than 30 million Cubic Metres

Source: LIMCOM 2013

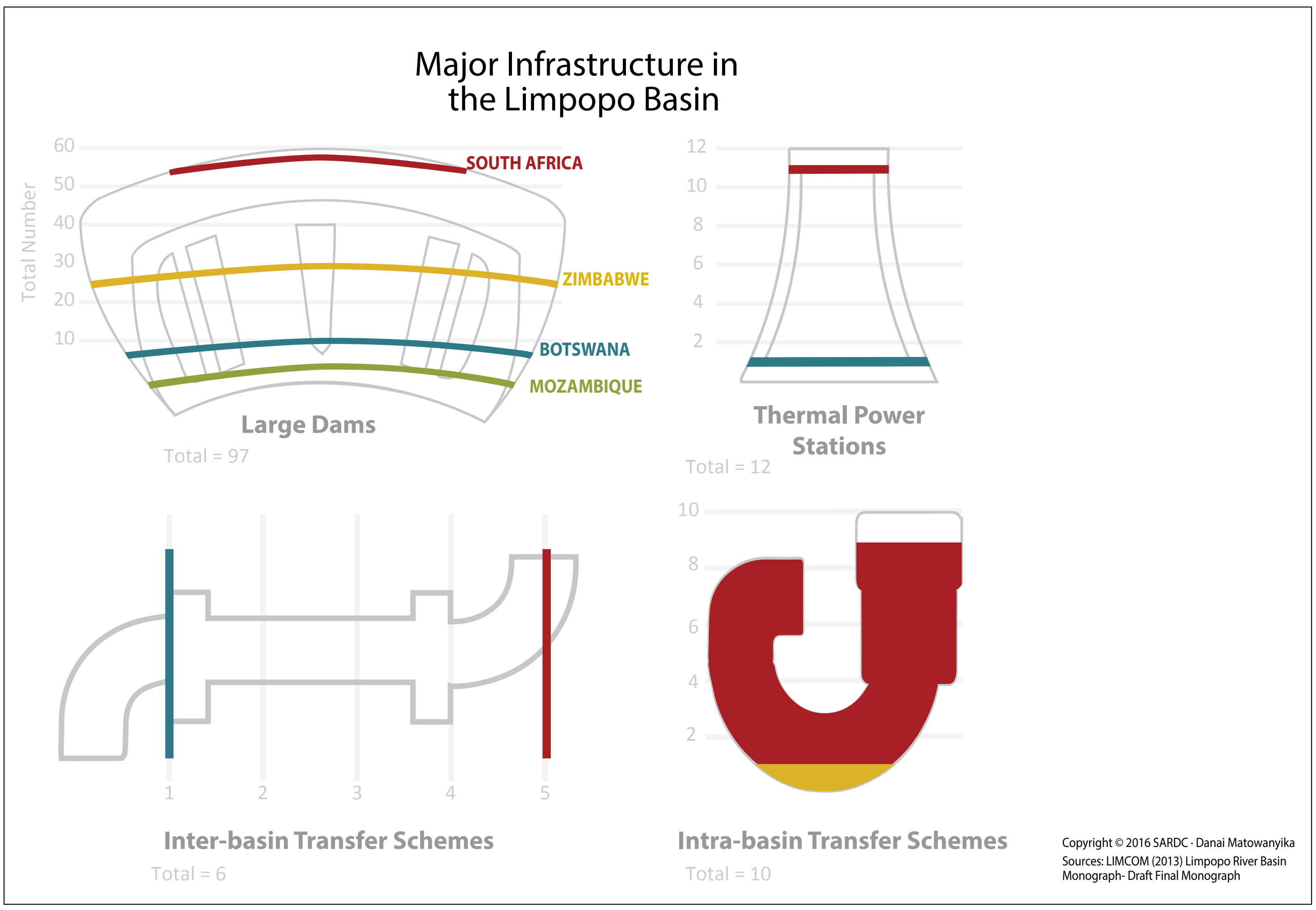


Figure 2.19 Infrastructure in the Riparian Countries

Source: LIMCOM 2013


Tuli-Makwe dam, Zimbabwe

Small reservoirs and the improvement of livelihoods in the Limpopo: Sibasa Dam, Mzingwane Catchment

The middle reaches of the Limpopo Basin in Zimbabwe contain some of the country's disadvantaged communities, whose livelihoods are threatened by recurrent droughts. Use of an integrated water resources management approach is necessary to balance food security, economic and environmental needs in the allocation and development of water (Love and others 2005). One of the most common interventions by government and NGOs is construction of small dams. It is estimated that there are approximately 1,000 small reservoirs in the Mzingwane Catchment in south-western Zimbabwe.

An example is the Sibasa Dam in the upper Mzingwane Catchment constructed in 1954. Although the capacity of the dam is 30,000 cubic metres, variable rainfall has led to variations in its water storage. Between 1991 and 2005 storage ranged from 10,000 to 35,000 cubic metres. The dam is mainly used for domestic water supply, and livestock watering in the dry season.

Recent water quality analyses from the dam showed that nitrate, phosphate, conductivity and hardness levels of the dam are in acceptable ranges for natural waters and World Health Organisation drinking water guidelines. The good water quality of the dam could be related to limited upstream development and good vegetative cover, both of which should be maintained to ensure the integrity of the aquatic ecosystems.

Managing the upstream land use, vegetation cover and soil integrity, as is currently promoted through IWRM practices, will assist in protecting storage and water quality of the dam. Limiting land use change upstream and discouraging abstraction of groundwater will ensure that sufficient groundwater recharge occurs to maintain the dam's perennial status.

Customary laws have been used to govern water resources management at Sibasa. Traditional leaders (the chief and headmen) preside over all water-related issues. They are responsible for setting up the rules governing the water resources, demarcating specific areas around the water sources, and managing conflicts. The traditional water management practices are found to be quite effective for sustaining food production, because everyone is allowed to access as much water as they need. The chief regulates the uses to which the dam may be put, restricting livestock during the wet season, when other water sources are available. However, legally the dam is managed through the Upper Mzingwane Subcatchment Council. Neither the sub-catchment council nor the Zimbabwe National Water Authority (ZINWA) seem to be exercising any controls. Should either the council or the authority wish to exercise their statutory powers, there is potential for conflict with the traditional structures.

Source: Sawunyama and others 2005

Groundwater

The Limpopo River Basin offers a wide spectrum of aquifers from local aquifers, regional and transboundary aquifers (see Figure 2.20). The transboundary aquifers (TBAs) identified in the basin, are the Tuli Karoo Basin and the Ramotswa Dolomite Basin. The Tuli Karoo Basin is the most extensive of the two and is shared by South Africa, Zimbabwe and Botswana, while the Ramotswa dolomite basin is a karstic aquifer and is shared by South Africa and Botswana.

Groundwater, together with water conservation/water demand management provides hope for increasing water supply and adaptation to climate change in the Limpopo River Basin. However, for the sustainable use of the groundwater resources good stakeholder engagement, legislation enforcement and better understanding of local and transboundary recharge and managed recharge is needed.

Olifants River in Kruger Park – dykes can channel groundwater to or away from the river

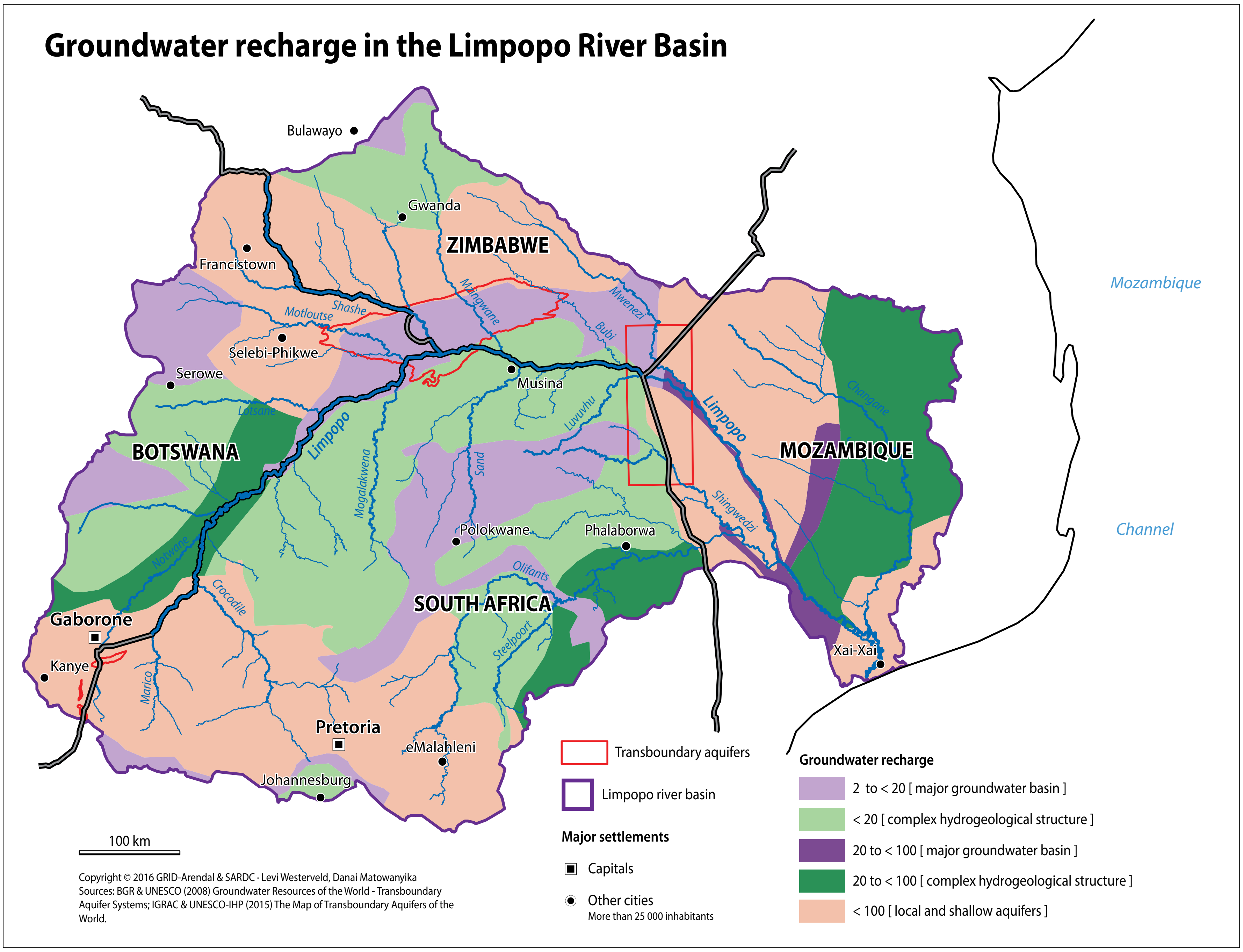


Figure 2.20 Groundwater recharge

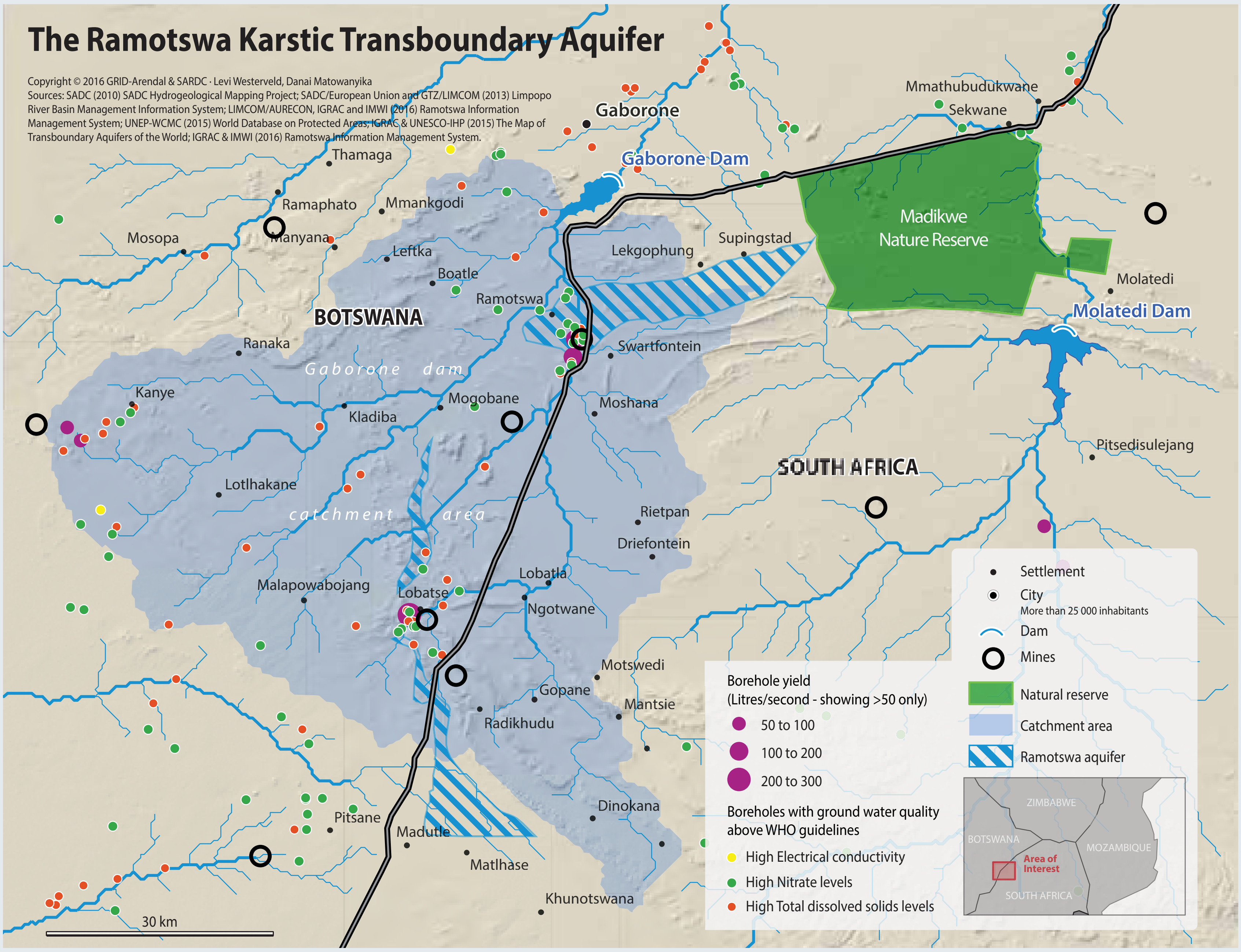
Source: WHYMAP 2016

Ramotswa Karstic Transboundary Aquifer

With a semi-arid climate, Botswana predominantly relies on groundwater resources and as a result has experienced groundwater management challenges due to increased economic growth, population growth, environmental and climatic conditions. One of the most important transboundary aquifers shared between Botswana and South Africa in the Limpopo Basin is the Ramotswa transboundary dolomite aquifer (Staudt 2003) with an estimated total area of 3,200 km² and supplying water to about 135,500 people. Nonetheless, international agreements dedicated to the protection and governance of transboundary groundwater are not available, despite the existence of both the Limpopo River Basin Commission (LIMCOM) and SADC Regional Groundwater Management Programme (GMP) which are appropriate for facilitating coordinated management of transboundary water resources (Beetlestone 2005).

The Ramotswa Dolomite Aquifer which extends over an area of more than 29 km² in Botswana includes part of the Ramotswa Village under Bamalete tribal authority and Bamalete Land Board (Staudt 2003). The Ramotswa area is located within the South East District upstream of the Gaborone Dam (capacity of 144 million cubic metres) in the Notwane catchment. The areas covered include Tlokweng, Ramotswa, Lobatse and Mogobane and boasts of good health services comprising of hospitals and health clinics and high standard transportation and communication infrastructure.

Water use ranges from small-scale to large-scale commercial farming and tourism entities. Commercial farming activities include poultry, beef production, feedlots and horticulture, while small farmers are restricted to small stock farming. The Botswana Meat Commission (BMC), owned by the government is one of the major beef exporters in Southern Africa to the European Union markets. It purchases cattle from farmers, slaughters them and exports the beef to Europe. Commercial farmers use private boreholes, while small-scale farmers depend largely on the farm dams within the catchment. Water demand is estimated to increase by up to 85 percent by year 2020, making groundwater resources important to meet this demand.



Groundwater Contamination in Ramotswa Aquifer

The main environmental issues in the Ramotswa area are:

- Groundwater and surface water contamination due to proliferation of pit latrines in the late 1990s and intensive commercial agriculture, including livestock production;
- Reduction of water inflows into the Gaborone Dam due to presence of upstream farm dams;
- Siltation of farm dams due to lack of maintenance and large scale land acquisition that lead to deprivation of land resources for local people (ACT4SSAWS 2014);
- Overgrazing, soil degradation and siltation as the current livestock stocking rates are 12-14 livestock units per ha, while the recommended rates are 3-6 livestock units per ha (Staudt 2003);
- Leaking fuel tanks in the industrial complex of Tswana Steel that pose an environmental hazard.

Several groundwater quality parameters were used to gauge water quality based on the World Health Organisation (2011) guidelines. Results show that electrical conductivity varied from 258- 6,070 micro Siemens per metre, where values above 2,000 micro Siemens per metre are indicative of pollution, while in contrast, sulphates were below the acceptable limit of 250 milligrams per litre. Chloride was higher than the acceptable limit of 200 milligrams per litre around the industrial complex, while iron exceeded the 0.3 milligrams per litre as recommended by World Health Organisation (2011). Bacteriological contamination and nitrates from natural geology and from anthropogenic activities such as domestic (septic), industrial, agricultural and municipal wastes are some of the major pollutants common in contaminated groundwater (Owens and others 1992).

Research has found that high nitrates cause low blood oxygen in infants, a condition known as methemoglobinemia commonly known as blue baby syndrome that lead to shortness of breath, dehydration and diarrhoea, while causing digestive disturbances in adults (Lockhart and others 2013). The nitrate levels in the Ramotswa wellfields (a peri-urban area which lies within the radius of 10-15 km in the southern part of Gaborone city) in 1996 had reached alarming rates of 65-188 milligrams per litre (more than four times above the recommended limits of 45 milligrams per litre (Botswana Water Quality Standards Guidelines 2000) and 50 milligrams per litre (World Health Organisation 2011) mainly due to septic and pit latrine leakage into groundwater in Ramotswa. Subsequently these wellfields were decommissioned in 1997. Drawing from this, it is clear that the hydrogeological conditions of dolomite and karst in Ramotswa are not suitable for sanitation practices such as pit latrines and septic tanks. The estimated 146 septic tanks that were in use in 1985 were replaced by connections to a sewer system by 2001, except for a few in the industrial area. However, nitrates contribution from pit latrines was still huge at 142 milligrams per litre in 2001 (Staudt 2003). In 1991 an estimated 2,432 pit latrines were in use by 66 percent of the households and this number of pit latrines has increased with population increase as no sewer has been constructed to enable decommissioning of these pit latrines.

In 2013 the Ministry of Minerals, Energy and Water Resources in Botswana took a decision to rehabilitate the wellfields to augment water supply within the Greater Gaborone area owing to severe water shortage in the south eastern part of the country as the Gaborone Dam was only five percent full with no withdrawal from the dam (ACT4SSAWS 2014), even as at 2015. However, groundwater, once polluted, takes a long time to be cleaned. Hence, water from the Gaborone Dam is only used to blend the nitrate contaminated groundwater from the wellfields before this water could be supplied to the communities for domestic use.

Despite the limited knowledge on groundwater in the Ramotswa area, this is the only reliable water source to mitigate the effects of climate variability and climate change. As such the areas relying on groundwater may significantly increase post 2015, as the rate of extraction is increasing by three percent annually and that surface water resources are increasingly being polluted and/or over utilized. This calls for the need to raise the groundwater resource debate to regional and international levels, integrate groundwater and surface water resources and implement water demand and conservation management to improve the water supply situation. Water conservation/water demand management is vital given the increasing water losses in the Ramotswa area which rapidly increased from 35.5 percent in 1999 to 57.4 percent in 2004 before decreasing to 44 percent in 2008 (Kholoma 2011).

It is envisaged that both countries sharing the aquifer should learn from each other and optimize the use of shared groundwater resources in order to reduce poverty and inequalities, enhance food security and livelihoods under climate variability and change. A formidable challenge is the protection of these vulnerable groundwater resources from further pollution by establishment of joint transboundary groundwater protection zones and strictly observing them, monitoring, conjunctive use and harmonized aquifer recharge management schemes, using wastewater, floodwater and storm-water, enforcement of existing and possibly new laws, and appropriate maintenance of sewer systems, septic tanks and pit latrines.

Water Quality

The physical, chemical and biological characteristics of water in the Limpopo Basin is highly affected by human activities (LIMCOM 2013).

Rivers originating from South Africa have greatest impact on water quality in the Limpopo River. For example, the Crocodile River is affected by sprawling urban areas of the Johannesburg/Pretoria metropolitan areas and high volumes of wastewater discharges, resulting in high nutrient and bacterial concentrations. The Olifants River is affected by coal mining activities and acid mine drainage in the sub-basin (LIMCOM 2013).

Rivers originating in Botswana are largely seasonal and have insignificant impact on the quality of the Limpopo River.

Sub-basins in Zimbabwe have low water quality concerns, though eutrophication related problems may occur.

Areas of significant water quality concerns in the basin are shown in Figure 2.21.

The acidic decant from defunct coal mines on the Mpumalanga Highveld must be neutralized, and few plants are available that are treating decant to portable levels. Small-scale gold panning is also contributing to water pollution. New mining prospects and mining activities in this region require close regulation to protect the people and environment. Improved quality of water in the river systems will release more quantity of water for maintaining aquatic ecosystems and for abstraction and use in domestic and farming systems.

The impact of these pollutants on the aquatic ecosystems and groundwater is an area of potential joint study in the Limpopo Basin. Developing a common water quality guideline and programmes through joint efforts by the basin countries is imperative to enhance water quality management as currently there is no common water quality guideline.

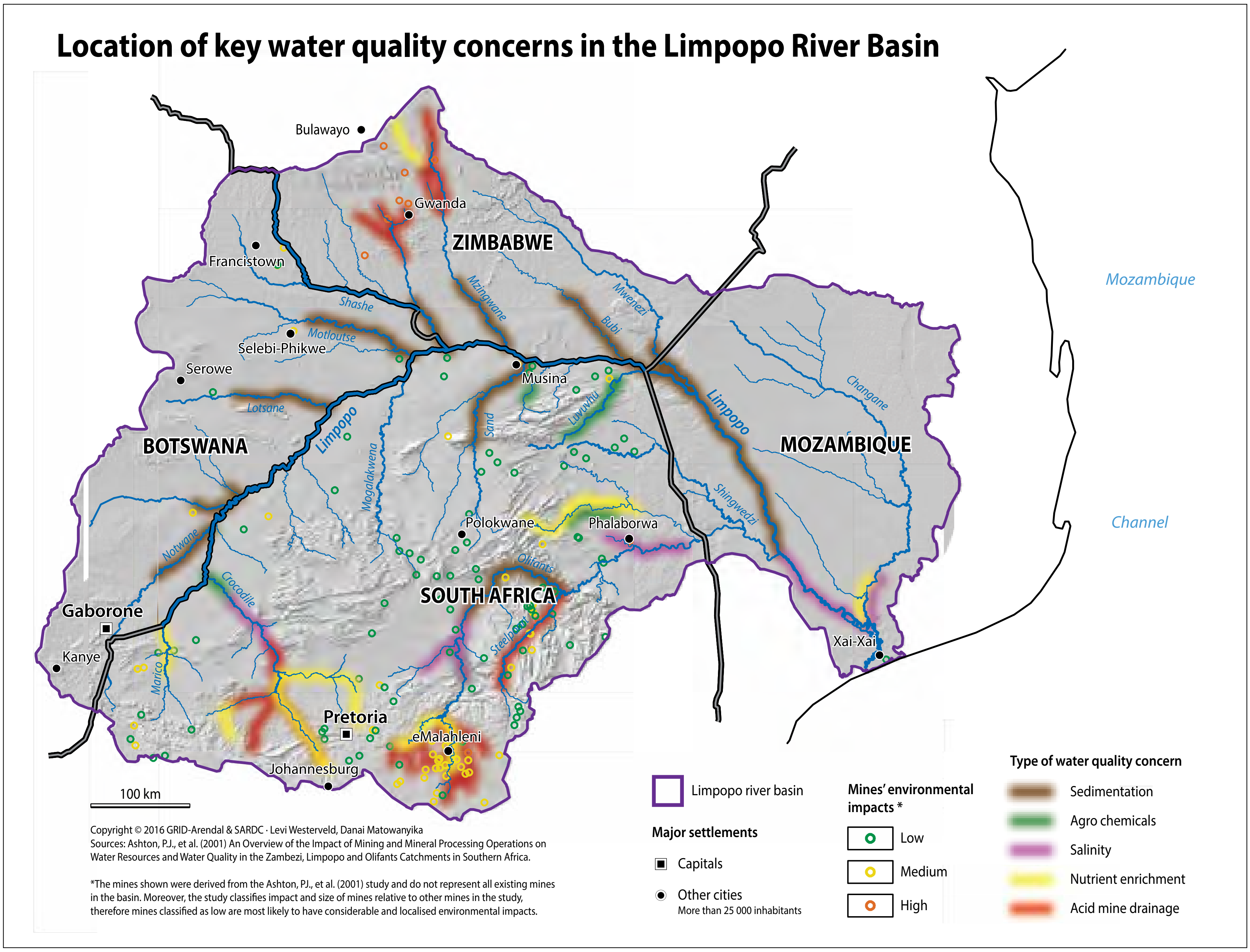


Figure 2.21 Location of Key Water Quality Concerns in the Limpopo River Basin

Source: LIMCOM 2013

Large irrigation projects spread throughout the basin increase salt and agro-chemical concentrations in receiving rivers, and high sediment loads occur during flood events in non-perennial rivers (LIMCOM 2013). Nutrient loading into the Limpopo River from agricultural activities has resulted in proliferation of water hyacinth. Joint efforts by Botswana and South Africa to remove water hyacinth have managed to clear up significant amounts of the weed (JPTC 2016).

Hartbeespoort Dam is renowned for extremely high levels of algal blooms as a result of discharges from the urbanised and industrialised areas within Gauteng.

Approximately 16 sewage works and many industries discharge wastewater effluent from the densely populated Johannesburg and Pretoria area into the

Crocodile River, the main river flowing into the dam. Poor water quality has also resulted in the increase of bottom dwelling exotic fish, and this is causing a drastic decrease in aquatic biodiversity in the catchment (Matthews and Bernard 2015; Mosoa 2004; Venter 2004).

3

EXTREME WEATHER EVENTS IN THE LIMPOPO BASIN

Most of the extreme events that occur in the Limpopo River Basin are climate related. As such, the basin continues to experience a myriad of challenges including violent storms, droughts and floods. Large sections of the basin are rural, and are highly vulnerable to extreme events.

Communities in these areas derive livelihoods from climate sensitive sectors such as agriculture. Poverty is prevalent in rural areas of the basin, and insufficient public and private sector resources are directed to the area. The Limpopo Basin is highly vulnerable to shocks such as resource shortages and climate-related risks (Petrie and others 2014). The semi-arid nature of large portions of the basin is likely to exacerbate the impacts of climate change as the basin is already water-constrained (LIMCOM 2013).

This chapter looks at extreme events affecting the Limpopo Basin, with particular focus on floods, droughts and cyclones. Impacts on livelihoods and ecosystems, and adaptation measures are assessed, and future scenarios for these extreme events are also provided.

Flooding in the Limpopo River Basin

Flooding is a significant climate challenge in the Limpopo Basin. Table 3.1 outlines trends and extent of flooding damage across the basin. The largest impact of flooding historically has been in the Mozambican Floodplains Zone, because of cyclone activity (LIMCOM 2013). The worst of these was the Cyclone Eline in February 2000, which caused heavy rainfalls throughout the Limpopo River Basin. Rain gauges in the Botswana sections of the basin received over 1,000 mm in a single storm event (which is more than the average annual rainfall total) (WMO 2012).

Mozambique is most devastated by hazards such as floods and droughts which occur on a yearly basis.

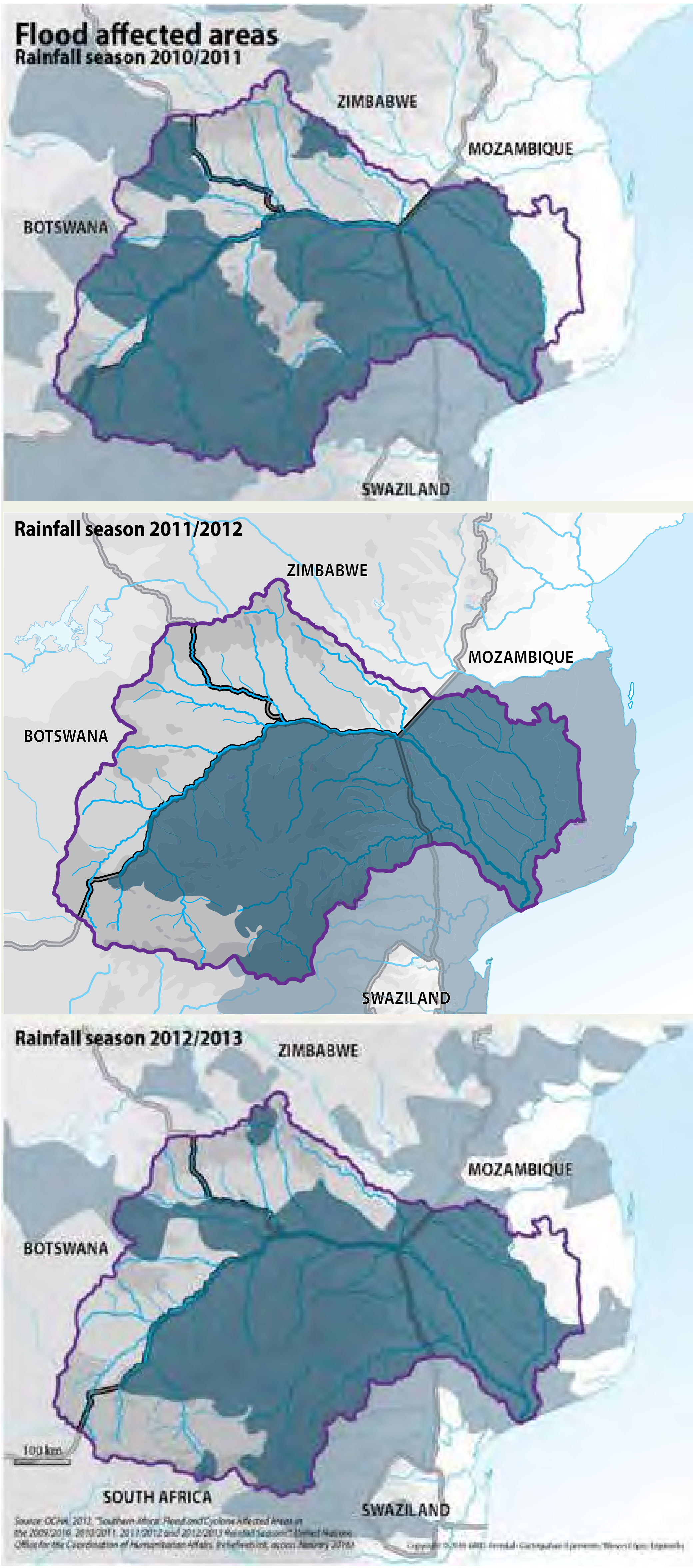
Flooding in the recent past (see Figure 3.1) has illustrated how inter-related livelihoods, environment and climate are, as seen in the knock-on effects for human health, water availability and sanitation, and the degradation of biodiversity (Petrie and others 2014). For the household level, flood disasters can worsen poverty levels when household assets are washed away or damaged, or in worst cases when lives are lost.

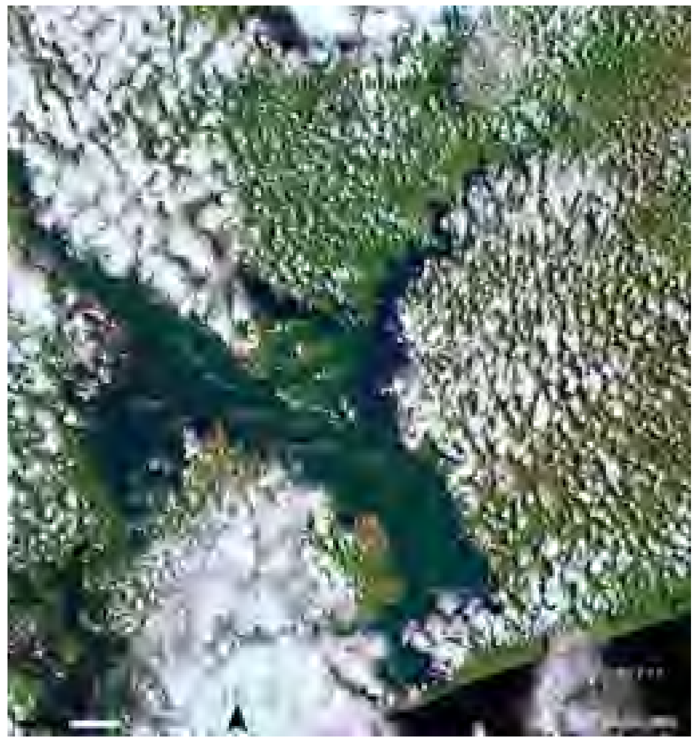
Chokwe city, Mozambique affected by floods in 2013

Table 3.1 Historic Floods in the Limpopo Basin

Year	Affected areas and further details
2014–2015	Tens of thousands of people in Mozambique and Zimbabwe were severely affected by floods caused by Tropical Storm Chedza which started in December and continued through February 2015. In Mozambique alone, more than 150,000 people were affected and 6,000 in Zimbabwe even though some of these people resided outside the basin.
2014	North-Eastern parts of South Africa experienced heavy and extended rainfall during March 2014. The most affected provinces were Limpopo, Mpumalanga, North West and Gauteng. The Government of South Africa confirmed 32 deaths and overall 7,000 people were affected, including 3,525 people who were displaced with large-scale damage to infrastructure.
2013	Following days of torrential rains throughout January the lower Limpopo River in Mozambique was flooded over its banks in late January leading to inundation of part of Xai-Xai. Multiple villages and agricultural areas around Xai-Xai were also inundated by the floods. Among the areas hardest hit by the floods was Chókwé, situated west of a bend on the Limpopo River. Week long heavy rains in Central parts of Botswana triggered floods in Tutume and Tonota Sub Districts. At least 842 families were affected with close to 400 people displaced. The torrential rains destroyed homes and roads, flooded dams and fields, and destroyed livestock and livelihoods.
2011–2012	Continuing effects of the 2011 La Niña phenomenon saw heavy rains in December 2011 through to January 2012.
2007–2008	La Niña induced rains brought some of the "heaviest rains in living memory" in most countries in Southern Africa by the end of 2007. Preliminary figures released by national authorities estimated that the number of people affected by rains and floods since October 2007 in southern Africa was more than 190,000.
2003	The extensive dry 2002-2003 season was followed by heavy rainfall in March as a result of Cyclone Japhet, and this severely affected Mozambique and southern parts of Zimbabwe, some of which lie within the Limpopo River Basin.
1999–2000	Heavy rains from December 1999 continued into January 2000. Southern Mozambique experienced flooding in the Umbelúzi, Incomati, Limpopo and Maputo Rivers. February saw Cyclone Connie drop record rain increasing the severity of floods in the Umbelúzi, Incomati and Limpopo Rivers as well as flooding in the Save, leading to widespread damage. Towards the end of February the Limpopo River in Mozambique had reached record water levels since the 1977 flood. Towards the end of February going into March Cyclone Eline hit the region and widespread floods devastated large parts of the Limpopo basin (southern and central Mozambique, south-eastern Mozambique, parts of South Africa, Botswana and Zimbabwe). Limpopo, Maputo, Umbeluzi, Incomati, Buzi and Save rivers were severely flooded. More than 500,000 people were displaced and affected by flooding. The last set of floods came in March after Cyclone Gloria added more rain in the Maputo River and also saw the Limpopo River in Mozambique water levels surpass those of the floods of the previous month, a new record high of water level was set again. In Mozambique alone this affected 2 million people with 650,000 forced to abandon their homes.
1996	Floods on all southern rivers of Mozambique, including the Limpopo River – 200,000 people were affected in Mozambique alone.
1985	Floods affected 9 southern provinces of Mozambique including sections of the Limpopo River Basin.
1981	Floods on Limpopo River affected 500,000 people.
1977	Limpopo River in Mozambique was completely flooded. At least 300 people died and 400,000 were affected.

Sources: Christie and Hanlon 2001; DREF 2009; DREF 2013; DREF 2014; Hellmuth and others 2007; Mozambique News Agency (AIM) 2016; NASA-EO 2016a; NASA-EO 2016b; SADC and SARDC 2008; SADC- Regional Remote Sensing System 2005; SANF 2008; SARDC and UNEP 2009; WMO 2012; ZAMCOM, SADC and SARDC 2015





Flooding was experienced during the 2000 rainfall season throughout the basin in Botswana, South Africa, Zimbabwe and Mozambique. In Mozambique, the Limpopo River swelled up to 20 km wide in some sections, inundating farmland and drowning more than 20,000 cattle (WMO 2012). The two images above shows the impact of the floods in 2000 and the normal condition without floods.

Figure 3.1 Flooding in the 2010/2011, 2011/2012 and 2012/2013 Rainfall Seasons in the Limpopo Basin

Data source: UN OCHA 2013

Road damage following floods

Floods often maroon people due to the inadequate dissemination of early warning messages

Floods also damage infrastructure, including roads, bridges, telecommunication, farms and buildings. This can disrupt communications, business and delivery of services. The WMO (2012) suggests that the impact of floods is more significant on three main groups:

1. Vulnerable communities and general public living or having business in the flood prone areas;
2. Government ministries and departments responsible for monitoring and issuing flood warnings and taking responsibilities in the development and implementing flood preparedness, mitigation, response and recovery; and
3. Donor community and NGOs that assist in the development and implementation of flood preparedness, mitigation, response and recovery programmes.

Flood waters (brown areas) from the torrential rains of January 2013 flood of the city of Xai-Xai and surrounding areas.

Drought in the Limpopo River Basin

Drought has had serious impacts in the Limpopo River Basin, with some of the worst droughts occurring in 2003, 2002, 1995, 1994, 1992, 1991, 1987, 1984, 1983, 1981 and 1980 (WMO 2012). Table 3.2 below shows historic droughts in the Limpopo Basin.

Drought impacts on river flows and water availability, include water shortages, which create competition for both water abstraction and for wastewater disposal. This has led to conflicts of interest among users in the past and is likely to get worse if the frequency and intensity of drought increase, as expected. Figure 3.2 shows the relative drought hazard index for the Limpopo River Basin.

The environment provides many ecosystem services, such as water provision and purification, raw materials and food. Given that many rural low-income households rely on these services, degradation of the ecosystem and impact from climate change are likely to impact on household poverty. Conversely if households are able to maximize benefits from the ecosystem services, poverty levels may get reduced.

One of the most important ways that people's livelihoods in the basin are linked to the ecosystem through agriculture. Many of the crops grown in the basin, including sorghum, millet, beans, sunflowers and maize, rely on rain-fed agriculture. Therefore, decreases in precipitation are likely to have a negative impact on these crops and consequently on local food security.

Dry Bubi river bed as a result of drought

In the rural areas of Mozambique and Zimbabwe, crop failures after drought have led to people moving to urban centres in search of food (LIMCOM 2013). Maize and sorghum yields are expected to reduce by between 10 and 35 percent in Botswana up to 2050 (Chipanshi and others 2003).

April marks the end of the rainy season and the beginning of harvest. Poor rains of 2004/2005 rainy season in southern Africa left close to 10 million people in need of food assistance until the following harvest season (SARDC 2005).

Table 3.2 Historic Droughts in the Limpopo Basin

Year	Affected areas and further details
2015–2016	The strong El Niño that affected southern Africa resulted in parts of the Limpopo Basin experiencing driest conditions in 35 years. Flow in the Limpopo River was very low in February 2016 and at that time, extra water was being released from the Massingir Dam (on the Olifants River, a tributary of the Limpopo) to provide water for rice in the Limpopo Valley.
2005	Prolonged dry spell persisted from January to March developing into a drought affecting, northern South Africa, southern Mozambique, and Zimbabwe. Outside the basin, the drought also affected parts of Tanzania, Malawi and Zambia. Very high temperatures exacerbated the effects of the prolonged drought conditions. These impacted negatively on production and hence the food security situation of the Limpopo Basin and beyond.
2002–2003	Drought period for most of rivers on the southern east coast of Africa with some parts of Limpopo Basin affected. More than 43 districts affected in Mozambique, including those in Limpopo River Basin.
2001–2003	Severe drought in the Limpopo Basin.
1994–1995	Many basin countries were hit by the worst drought in memory, surpassing the 1991–92 drought in some parts of the region. In Mozambique alone more than 1.5 million were affected. The basin experienced major crop failure and an outbreak of cholera epidemic in several parts.
1991–1992	Extensive drought in southern Africa countries and some 1.32 million people were severely affected, including residents of the Limpopo River Basin.
1983–1984	Most of Mozambique was affected by the drought. A cholera epidemic caused many deaths, and this further worsened the suffering of the people from civil war.
1981–1983	2.46 million people were affected in south and central parts of Mozambique.
1980	Southern and central parts of Mozambique were affected.
1967–1973	The six-year period was dry across the entire basin, with some records showing a severe drought in 1967.

Sources: Christie and Hanlon 2001; DREF 2009; DREF 2013; DREF 2014; Hellmuth and others 2007; Mozambique News Agency (AIM) 2016; NASA-EO 2016a; NASA-EO 2016b; SADC and SARDC 2008; SADC- Regional Remote Sensing System 2005; SANF 2008; SARDC and UNEP 2009; WMO 2012; ZAMCOM, SADC and SARDC 2015

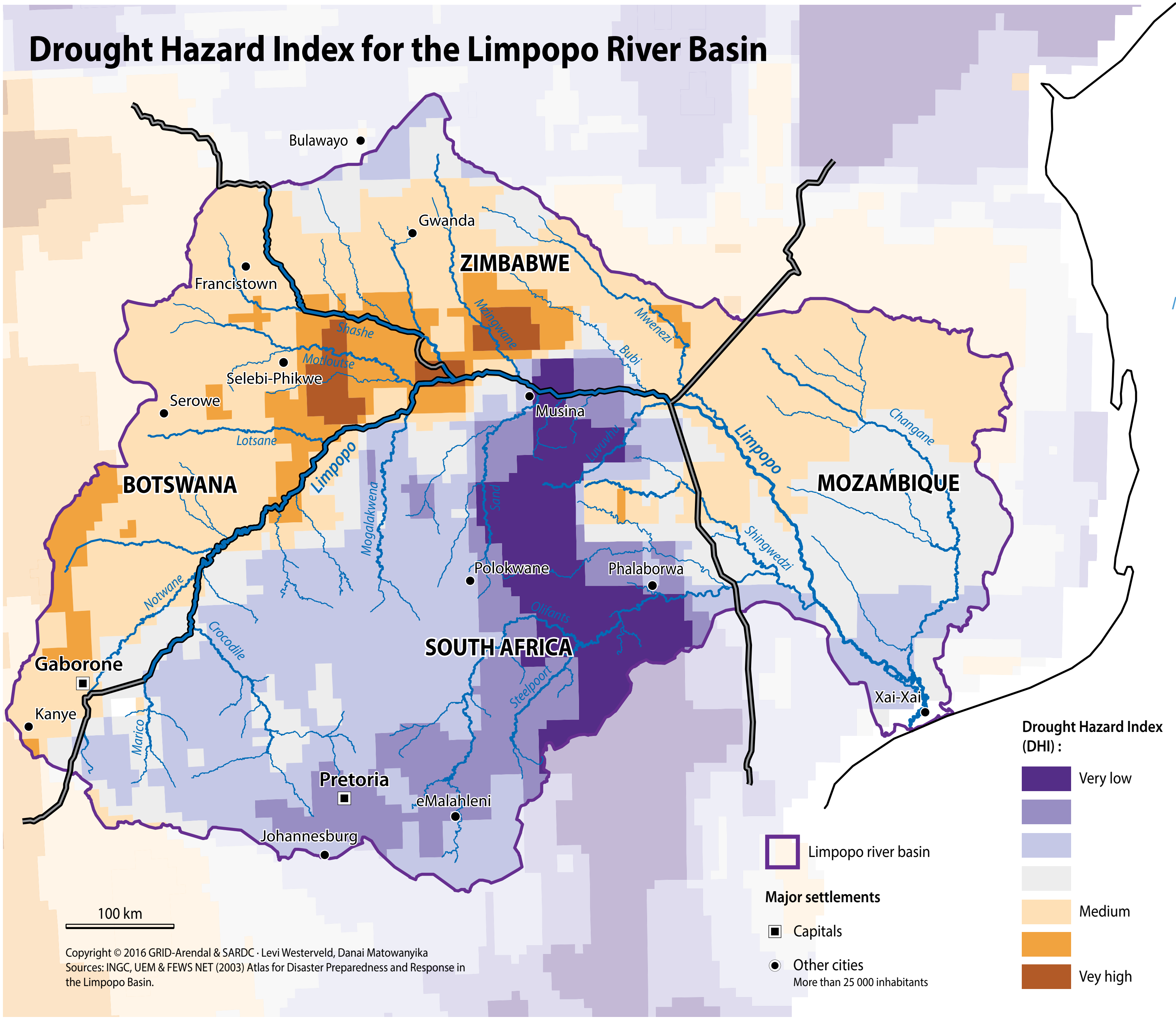


Figure 3.2 Relative Drought Hazard Index for the Limpopo River Basin

Data sources: INGC, UEM and FEWNET (2003)

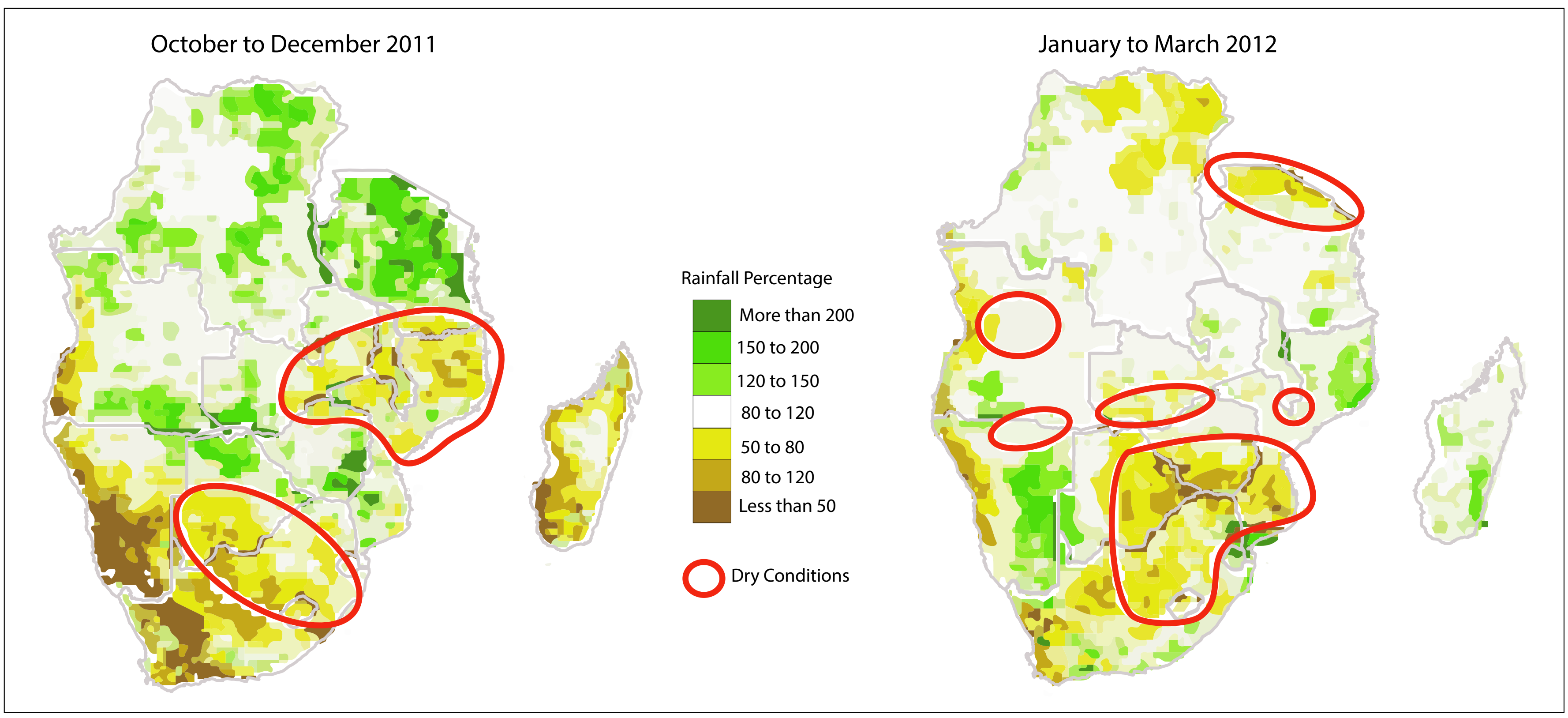


Figure 3.3 Overview of 2011/2012 Rainy Season

Source: SADC 2012

These images show vegetation in green. The lack of green in the image taken in 2005 shows the widespread dryness in the region opposed to 'normal' rainy season of 2004, indicating the severity of drought.

The 2011–2012 rainy season was characterised by late onset of rains, leading to reduction in area planted (SADC 2012) (see Figure 3.3).

The negative impacts of climate on agriculture also led to reductions in both direct and indirect employment. For example, the irrigation agriculture sector is the second largest employer in the Limpopo Basin with 251,194 direct employment opportunities (38%) and 404,618 employment opportunities when considering direct and indirect opportunities.

Drought years and reductions in water availability therefore result in the reduction in employment opportunities. The El Niño phenomenon in the 2015/2016 rainfall season, the strongest in 35 years, had serious impacts on food security both in the Limpopo Basin and the rest of southern Africa (see timeline of events below).

Livestock is central to many households in the basin. One of the key threats to livestock during drought seasons has been foot-and-mouth disease. In 2012, Bobirwa District of the Botswana reported an outbreak of foot-and-mouth. Market restrictions were imposed to address the problem and this significantly reduced household incomes that were reliant on livestock (SADC 2012).

Table 3.3 Tracking 2015/2016 El Niño

Date	Event	Impact and responses
Oct 2015	Southern African Regional Climate Outlook Forum predicted below normal rainfall	13.4 million food insecure people in the Southern African region.
Nov 2015	Provinces in South Africa declared state of drought	North West, KwaZulu-Natal, Mpumalanga, Limpopo and the Free State bore the brunt of the water crisis due to the El Nino.
Dec 2015	Survey conducted in Zimbabwe by the Consumer Council of Zimbabwe	The view by the council based on an urban low-income earner for a family of six revealed that, in the month of December 2015 food basket in Zimbabwe had increased by 3.31 percent in the commodity pricing from US$109.62 in November 2015 to US$113.25 by end of December 2015.
Dec 2015	Some areas in Mozambique experienced heavy rains and hailstorms which resulted in cholera outbreaks and armyworms that destroyed crops	In Mozambique 176,000 people faced acute food insecurity and 575,000 people were at risk of food shortage.
Feb 2016	Zimbabwean Government declared a state of disaster emergency in most rural parts of the country severely hit by the El Niño-induced drought	Close to 26 percent of the Zimbabwe population needed food. 12,000 boreholes in Zimbabwe dried up.
Feb 2016	Assistance to affected people throughout Southern Africa	17,000 livestock deaths in Southern Africa. Food and cash transfers provided to over 800,000 people in southern Africa, 70 percent of them children.
March 2016	Disaster areas declared in various parts of the basin	Southern Africa in the grip of a severe El Niño-induced drought. Zimbabwe and Mozambique declared national drought disasters and called for urgent international assistance, and so did other countries outside the Limpopo Basin, including Zambia, Malawi and Lesotho.
April 2016	Mozambique response in affected areas	People affected by food insecurity reached 1,493,928 and among these people, 315,000 received food aid in Mozambique. More than 220,282 people were affected in Gaza Province.
April 2016	Low rainfall impacts negatively on dam levels in South Africa	According to the Department of Water and Sanitation the combined average dam levels were at 54.8% during the month of April 2016, a figure that is lower than the average of 79.8% of a comparable period during the same period in 2015.
May 2016	Mozambique and Zimbabwe respond to the drought	Government of Zimbabwe issued Drought Disaster Domestic and International Appeal for assistance which included micronutrient/under-five feeding and school feeding. In Mozambique and Zimbabwe, Humanitarian Country Teams responded by appealing for US$60 million and US$359 million respectively, of international aid.
May 2016	South Africa Department of Water and Sanitation responds to water shortages in South Africa	The Department of Water and Sanitation spent R78 million approximately (US$5,5 million) on drought relief and R38 million (US$2,6 million) was spent on water tankers and repairing reservoirs throughout South Africa.
May 2016	SADC responses to the El Nino by preparing a regional drought appeal for assistance with the aim of mobilising resources to meet the needs of people	The SADC El Niño Response Team analysed and communicated the regional extent of the impacts of El Niño and the financial and logistical requirements for an effective response to mitigate the impacts of the El Niño event of 2016.

Sources: WFP 2016; WMO 2016; OCHA 2016; Thomas 2016; AfDB 2016; South African News Agency 2016a; South African News Agency 2016b; South African News Agency 2016c; SADC 2016

These images show vegetation in green. The lack of green in the image taken in 2005 shows the widespread dryness in the region opposed to 'normal' rainy season of 2004, indicating the severity of drought.

Drought-induced aridity in Mapungubwe

Cyclones in the Limpopo River Basin

Recent trends in IPCC observations and long-term modelling outcomes suggest that climate change will affect the characteristics of tropical cyclones in the south-western Indian Ocean (IPCC 2014). According to Davis (2011), tropical cyclones occasionally make landfall on the Mozambican and South African coastlines, bringing significant rainfall and associated flooding to Mozambique, the northern parts of South Africa, and Zimbabwe. Figure 3.4 to 3.6 show cyclone activity in southern Africa for the period 2012-2015.

The 1999-2001 rainfall seasons were dominated by active tropical cyclone activity, which caused considerable human suffering across parts of the SADC region (SADC and SARDC 2008). An INGC study of 2009 indicates that of the 56 tropical cyclones that developed in the Mozambique Channel in the period 1980-2007, 15 (25%) affected the coast of Mozambique (SARDC and HBS 2010).

Following La Nina conditions of 2011, two powerful storms, Tropical Cyclone Funso and Tropical Depression Dando, caused flooding in coastal regions early 2012. Subsequent flooding throughout parts of Southern Africa that was experienced affected many lives and destroyed property and infrastructure, including many areas within the Limpopo River Basin.

Chokwe was inundated by flooding following the cyclone Eline-induced heavy rains

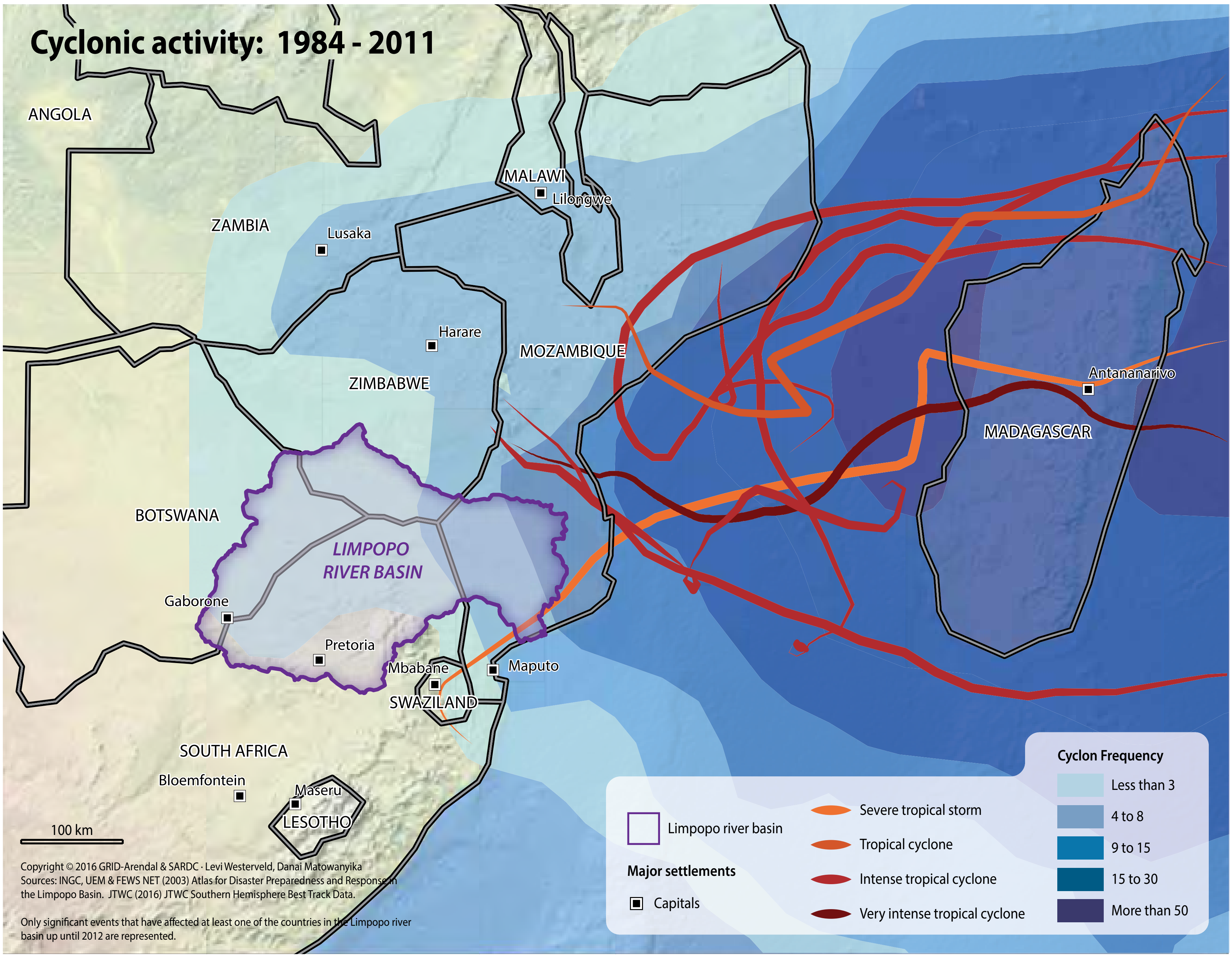


Figure 3.4 Cyclonic activity 1984 to 2011

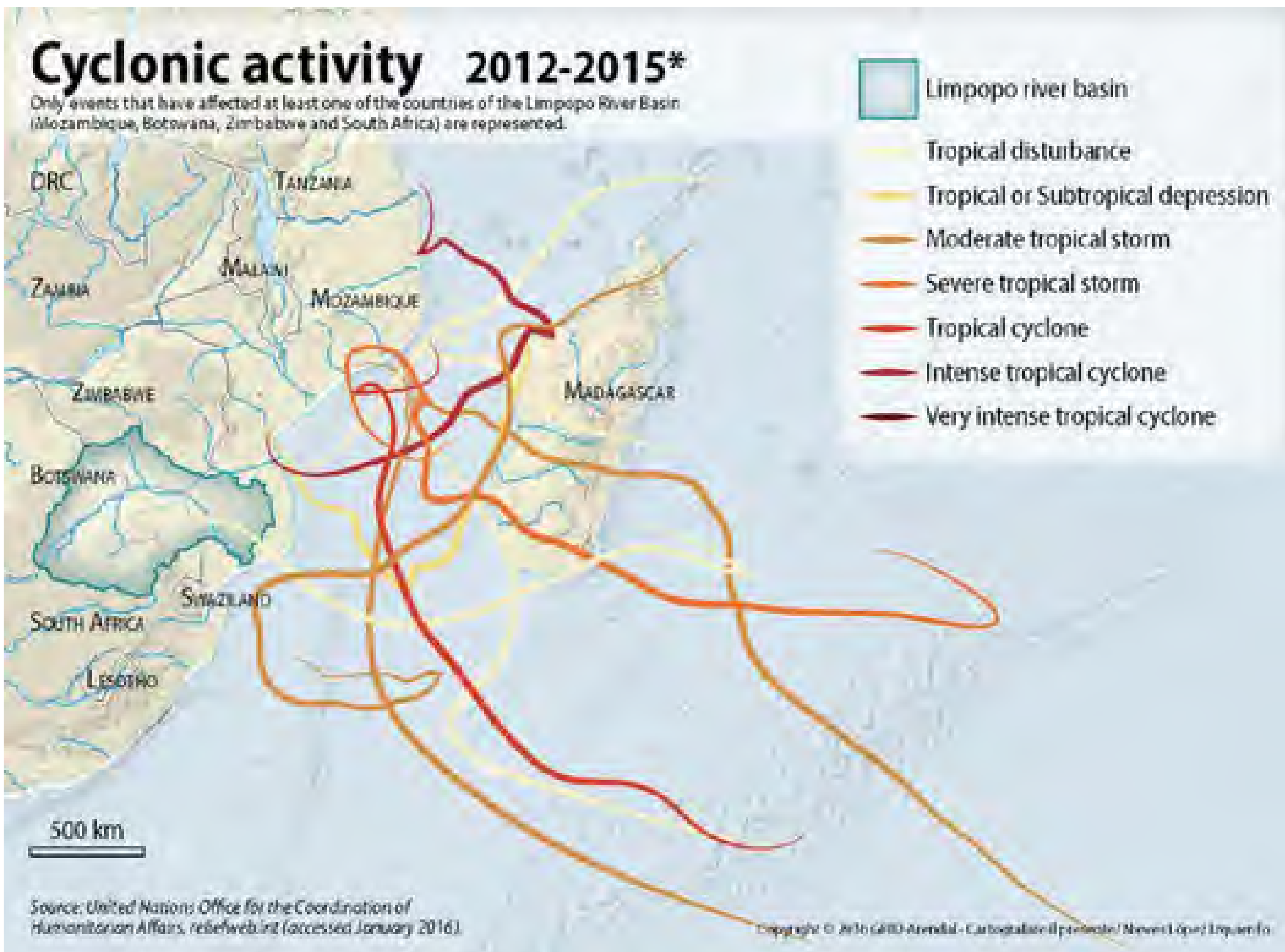


Figure 3.5 Recent Cyclone Activity (2012-2015)

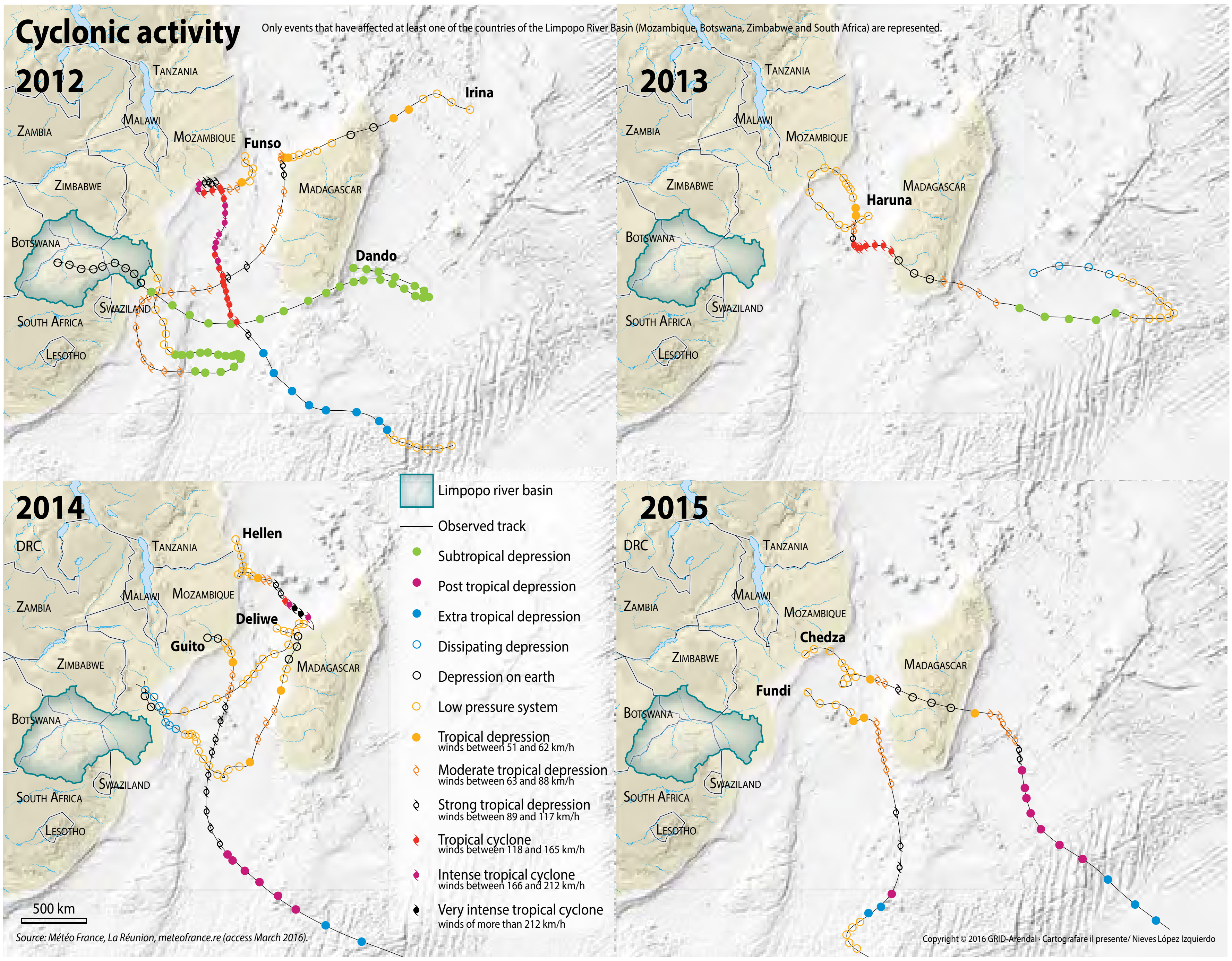


Figure 3.6 Significant cyclones between 2012-2015

Impact of the 1999/2000 floods

The 1999/2000 Cyclone Eline induced floods in southern Africa affecting over 150,000 families and 200,000 ha of farmland. Many roads in Mozambique were destroyed, including important links between the north and the south and the vital route to South Africa, where only light traffic was able to pass.

The floods caused extensive damage to the state-owned Mozambique Ports and Railway (CFM) operations. It was estimated that the company was losing about $50,000 a day as the floods paralyzed the rail system. The most damaged line was the Limpopo, which links Maputo to Zimbabwe. Four kilometres of the line were submerged and a further four kilometres were hanging over huge gullies. Repairing one kilometre of rail-track costs between US$300,000 and US$400,000. The state-owned electricity company EDM estimated that the damage caused to transmission lines from Cahora Bassa dam was about US$ 1 million.

It was estimated that a quarter of Mozambican agricultural produce was destroyed. According to the UN World Food Programme (WPF), the country lost at least a third of the staple maize crop and 80 percent of its cattle. The government required financial assistance to sustain a long term food aid programme.

Source: SADC and SARDC 2008

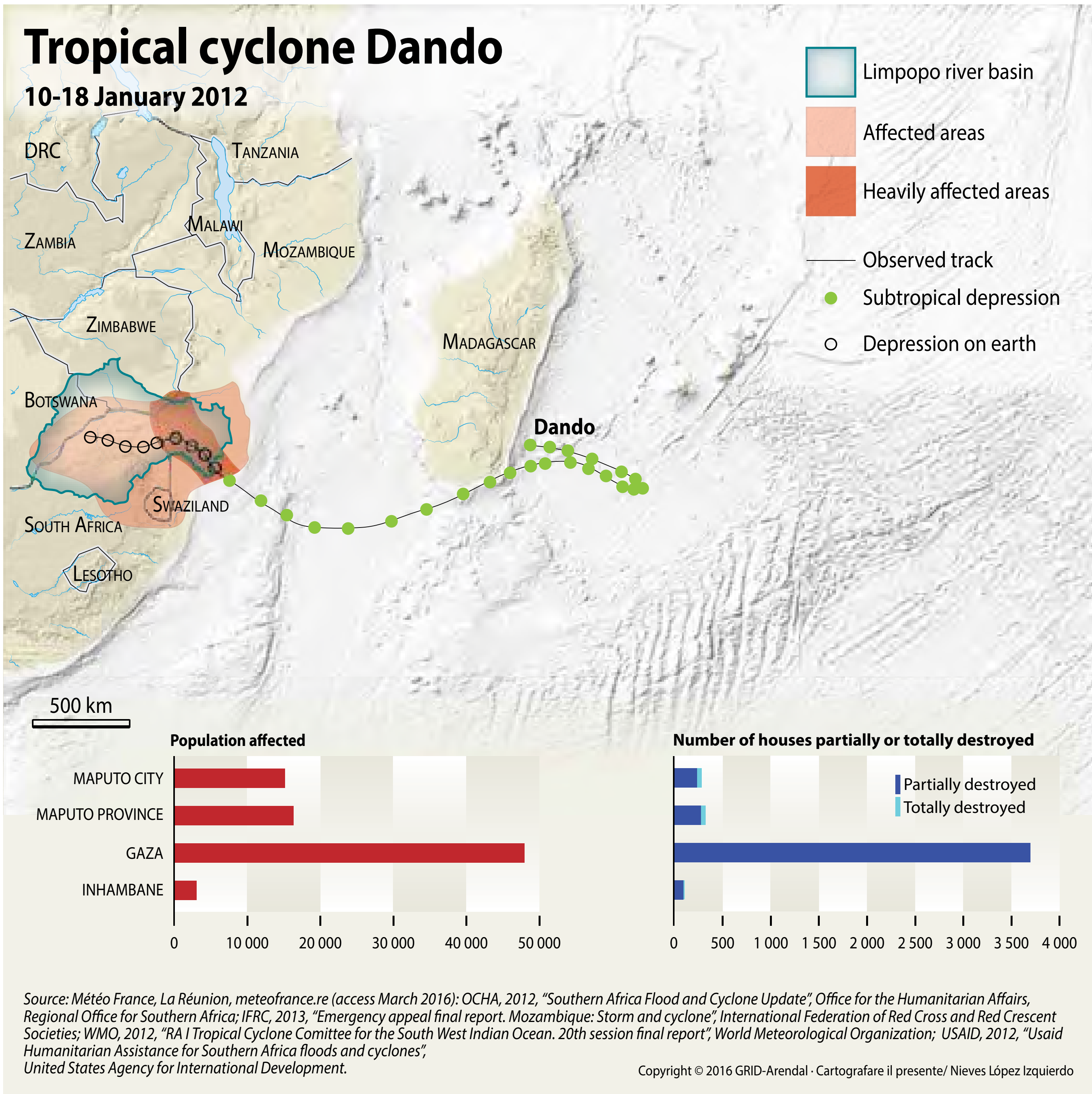
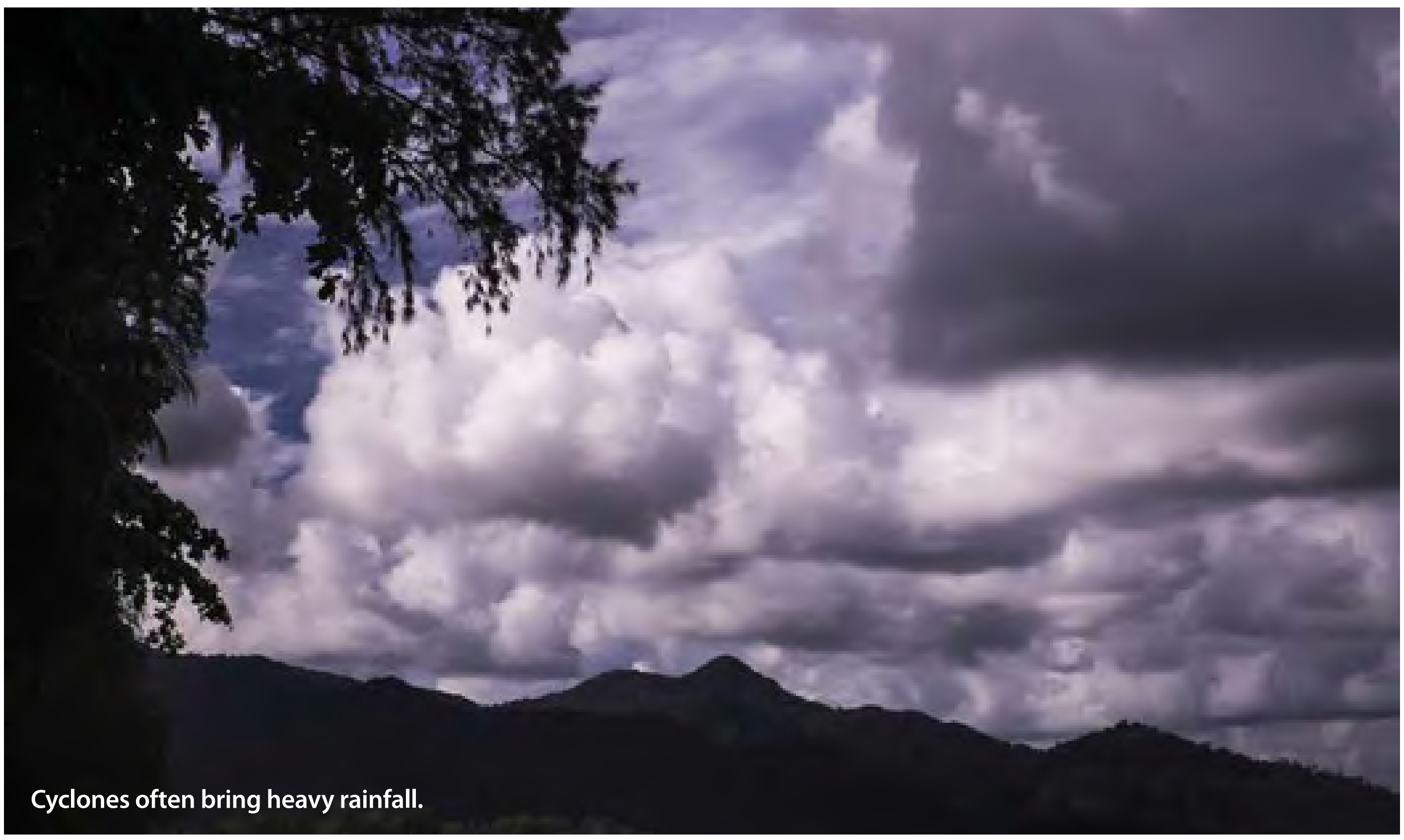


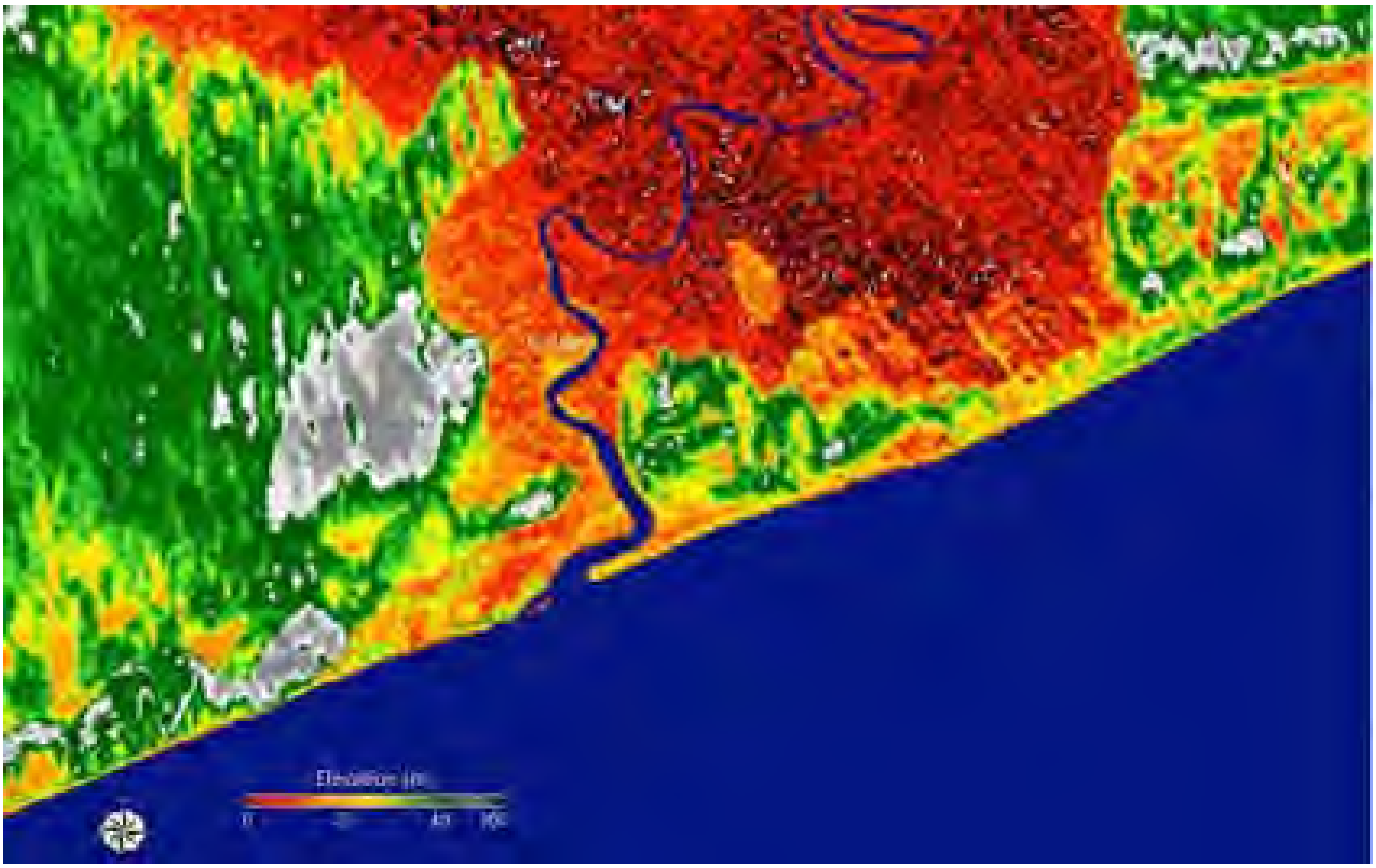
Figure 3.7 Impact of Tropical Cyclone Dando 2012



Cyclones often bring heavy rainfall.

Coastal Risks and Hazards

In order to provide a broad indication of vulnerability to climate change, an elevation map indicating the five metre contour along the coast can be used to show the areas at risk both from a sea level rise of 5m and from the impact of an intense tropical cyclone. Though the rivers south of Mozambique are not as big as those in the centre, there is the possibility of disruption of communication links owing to flooding. The flood plains of the lower Limpopo River south-east of Xai-Xai, the lower Incomati River north-east of Maputo, the estuary at Maputo and the lower Maputo River are likely to be particularly affected (INGC 2009).



Elevation map indicating the 5 m contour line for the coastal zone of the South. Source: INGC 2009

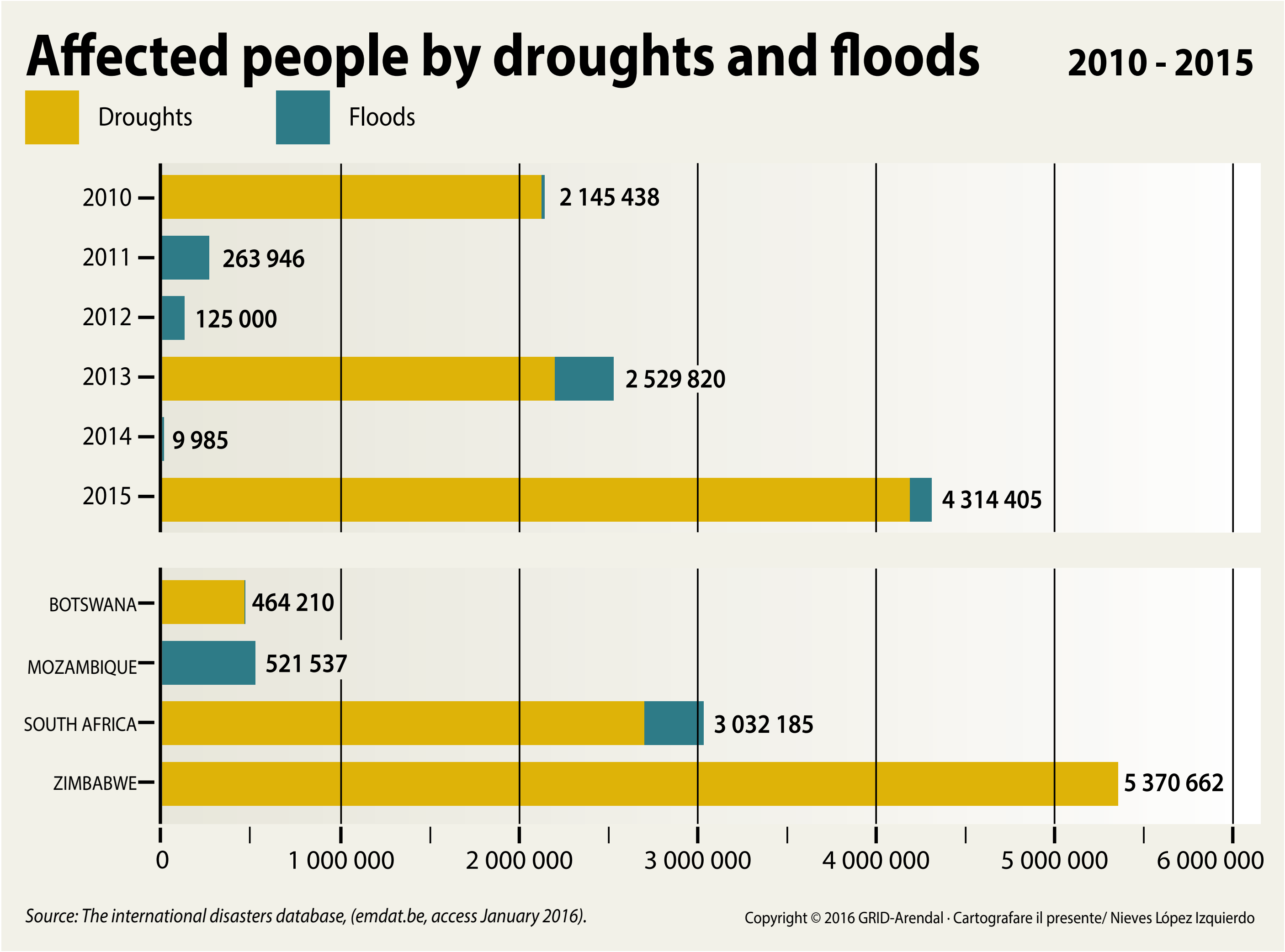


Figure 3.8 People Affected by Droughts Between 2010 and 2015

The widening of the lower flood plain will increase the vulnerability to tropical cyclones through the narrowing of the natural coastal areas where the river enters the sea.

Rapid urbanization is putting a significant strain on urban water resources. In addition, there are unlikely to be sufficient economic opportunities to support the increasing migration of people to urban centres (LIMCOM 2013). Bulawayo, which draws some of its water from the Limpopo Basin, is the most threatened city by water shortages.

High levels of poverty and low levels of service, infrastructure and governance in the basin result in low levels of adaptive capacity. Given the basin is expected to experience significant climate impacts on top of its current semi-arid climate and the high sensitivity of activities to climate impacts, the Limpopo basin and its inhabitants are particularly vulnerable to climate variability and change. Within this myriad of vulnerabilities women, the elderly, youth and marginalized groups are often more vulnerable than other groups (ASSAR 2015).

It is therefore critical to explore responses or adaptation to climate variability and change. The SADC vulnerability report produced after the 2011–2012 food crisis, outlined some of the strategies that people were using to cope with the changing climate. The short term coping measures included reduction in number and size of meals, expenditure switching and consumption of less preferred foods, increased reliance on casual labour and self-employment and increased sale of assets particularly livestock (SADC 2012). Although these activities were widespread during the food crisis, they are now occurring in many households across the basin every year. Given the future pressures of struggling economies alongside climate change, it is important that adaptation across the region is prioritised to ensure that households and economies are better suited to deal with climate risks in the future.

Between 2010 and 2015, Zimbabwe had the highest number of people affected by droughts among the basin countries (see Figure 3.8).

Climate Change Impacts on Livelihoods and Environment

Climate variability impacts on water resources and agriculture directly, making these two sectors critical in understanding the impact of climate change on economic activities and livelihoods. In addition, climate impacts on health, infrastructure and energy, illustrating the complex nature of understanding potential impacts, vulnerability and adaptation to climate change. Therefore it is important to understand a range of social, environmental and economic issues, as well as the regional vulnerability to climate impacts and some of the historic livelihood impacts.

The large percentage of people in the basin living in rural areas has implications on livelihood security, as livelihoods are more likely to be directly exposed to climate risk. Given most households' livelihoods are relatively undiversified, it is hard to buffer the impacts of climate for many. Unfortunately there are also insufficient public and private resources in many parts of the basin (Petrie and others 2014).

Other health risks are also a concern under changing climate conditions. There is a particular concern about the increased occurrence of vector-borne diseases. In Botswana, there is likely to be a significant increase in the proportion of the population living in malaria prone areas by 2021 (Urquhart and Lotz-Sisitka 2014).

Local communities are affected the most whenever there are floods or droughts

Adapting to a Changing Climate

Due to vulnerability of the Limpopo River Basin to climate change and variability, adaptation strategies are urgently needed to respond to the negative impacts of such change.

Key adaptation strategies aim to moderate the environmental impacts as well as take advantage of new opportunities or coping with the consequences of new conditions. The capacity to adapt depend on the region's socio-economic and environmental situation as well as the availability of information and technology (Davis 2011).

In order to better respond, the Limpopo River Basin countries have identified a number of adaptation strategies to be implemented at local, national and basin levels.

Smallholder irrigation technologies are one of the interventions at the local scale. These include water harvesting technologies and drip irrigation rather than depending on rain-fed agriculture alone. Research in Limpopo Basin, showed how smallholder farmers were improving their ability to cope with climate variability and use seasonal climate information, but their lack of access to markets was inhibiting their ability to sell their produce (Ziervogel, Bharwani and Downing 2006). It is these interlinkages between climate and other stresses that are important to explore (Ziervogel and Taylor 2008).

Countries in the basin are particularly focussing on indigenous knowledge to strengthen their resilience as it is considered cost effective, participatory and sustainable (SARDC and HBS 2010).

Manjinji irrigation scheme

Ecosystem-Based Adaptation

Significant research has shown the importance of protecting ecosystems because of the services they provide around water, land, fauna and flora. Specifically for the Limpopo Basin is the importance of ensuring the biological integrity of high altitude catchment areas that determine waterflows lower down in the basin (Petrie and others 2014). This has implications for transboundary water use and national relations. Middleton and Bailey (2008) suggest that upstream water producing areas can generate up to 100 times more runoff per unit area than lower-lying rainfall areas.

Apart from the responses mentioned above, the Risk, Vulnerability and Resilience study proposes a number of adaptation measures for up-scaling (Petrie and others 2014), including:

- Continuous implementation of proven best soil and water management practices, such as conservation agriculture;
- Implementing measures to control erosion and siltation caused by mining and poor land management;
- Rehabilitation of the existing small dams and irrigation schemes and putting in place management and finances for continued maintenance;
- Identifying and developing diversified livelihood options offering better security and a more resilient future;
- Tapping into the potential for greater sustainable use of groundwater for humans, livestock and crops, within the context of climate change;
- Establishing strong and just governance of access to, and use of, productive natural resources; and,
- Building the resilience of communities to flooding through a combination of early-warning systems and better catchment management practices.

Rainfall is projected to decrease in the Limpopo basin

As a common adaptation measure, the basin countries facilitate the movement of people out of areas where their livelihoods are at risk as well as putting in place social protection schemes to assist people vulnerable to climate change. For example, Botswana and South Africa have national level social protection schemes, including cash transfers to assist in risks related to climate variability (Davis 2011).

At SADC level a regional response team has been established (see box below).

Adaptation To Climate Change in Mozambique

As a downstream country of the Limpopo River Basin, Mozambique faces challenges of intensive upstream water development. This has resulted in significantly reduced dry season flows into Mozambique. The Limpopo River sometimes remains dry for a period of up to 8 months in a year. The lower reaches of the river are also prone to highly devastating floods that damage infrastructure and undermine the livelihood of the riverine populations.

Faced with these challenges, the Government of Mozambique has paid ample attention to the construction of the Mapai Dam on the main stem of the Limpopo River to strengthen the resilience of the Lower Limpopo population against climate change and hydrological extremes.

The proposed dam is located about 80 km from the Pafuri border between Mozambique and South Africa and about 240 km north of Chokwé, Gaza province. It has potential to provide irrigation to over 150,000 ha of productive area in the province hard hit by periodic droughts, thus enhancing food security of more than 200,000 people. The dam is set to protect the cities of Chokwé and the provincial capital, Xai-Xai, from floods which are also frequent in the province. It is also to be used for generation of power.

Source: AfDB 2014

Climate Outlook

Climate change is projected to drastically impact southern Africa during the 21st century under low mitigation futures (Niang and others 2014). Africa's temperatures are projected to rise rapidly, at 1.5 to 2 times the global rate of temperature increase (James and others 2013; Engelbrecht and others 2015). Moreover, the southern African region is projected to become generally drier under enhanced anthropogenic forces (Christensen and others 2007; Engelbrecht and others 2009; James and others 2013; Niang and others 2014). These changes in the annual and seasonal rainfall patterns will have a range of impacts on the Limpopo River Basin, including impacts on energy demand, agriculture (e.g. reductions of yield in the maize crop under higher temperatures and reduced soil moisture), livestock production (e.g. higher cattle mortality as a result of unsuitable temperatures) and water security (through reduced rainfall and increased evapotranspiration) (Engelbrecht and others 2015).

Many factors are taken into account when predicting how future global warming will contribute to climate change. These include amount of future greenhouse gas emissions, developments in technology, changes in energy generation and land use, global and regional economic circumstances and population growth.

The Intergovernmental Panel on Climate Change (IPCC) adopted four greenhouse gas concentration trajectories for its fifth Assessment Report (AR5) (Weyant and others 2009). Known as Representative Concentration Pathways (RCPs), the trajectories describe possible climate futures, all of which are considered possible depending on how much greenhouse gases are emitted in the years to come. These are RCP2.6, RCP4.5, RCP6, and RCP8.5. RCP2.6 assumes that global annual GHG emissions (measured in CO_2-equivalents) peak between 2010-2020, with emissions declining substantially thereafter. Emissions in RCP4.5 peak around 2040, then decline. In RCP6, emissions peak around 2080, then decline. In RCP8.5, emissions continue to rise throughout the 21st century (Meinshausen and others 2011).

Mwenezi river in the dry season

Average Temperature

The model-simulated annual average temperatures (°C) are displayed in Figure 3.9 for the baseline period 1971-2000. The coolest conditions occur over the south and northern central parts of the Limpopo Basin and warming is simulated by CCAM to have occurred over the western and eastern parts.

Rapid rises in the annual-average near-surface temperatures are projected to occur over southern Africa during the 21st century – temperatures over the Limpopo interior are projected to rise at about 1.5 to 2 times the global rate of temperature increase (Engelbrecht and others 2015).

- For the period 2021-2050 relative to the period 1971–2000, temperature increases of 0.7 to 1.7 °C are projected to occur over Limpopo River Basin under high mitigation.
- Under low mitigation, temperature increases over the Limpopo River Basin will be less, but may still reach 3.5 °C over the western part of the basin.
- Temperature increases of 1.2 to 2.7 °C for the high mitigation case under the RCP8.5 scenario by the end of the century. Such drastic temperature increases would have significant impacts on numerous sectors, including agriculture, water and energy.

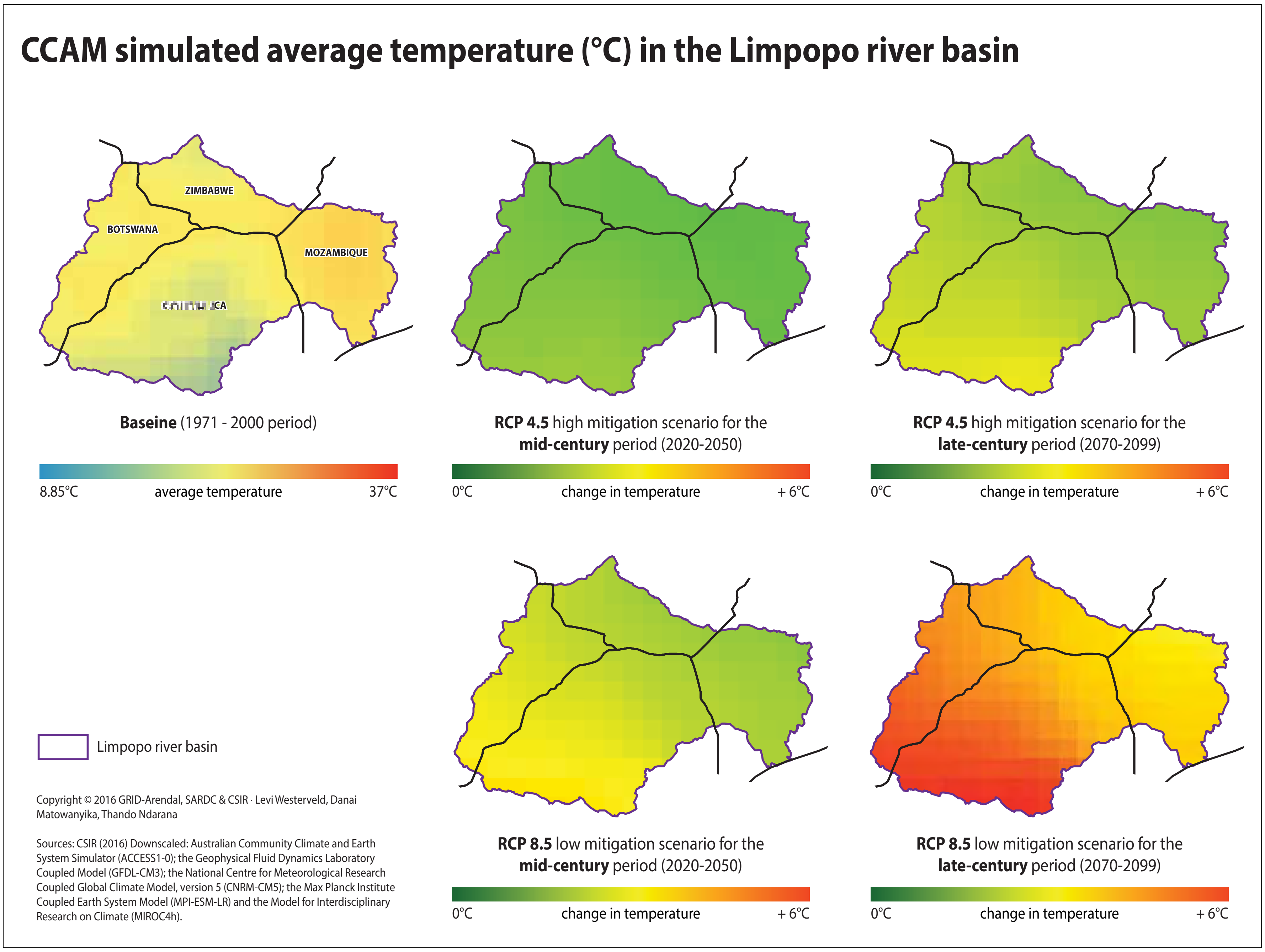


Figure 3.9 CCAM Simulated Average Temperature over the Limpopo River Basin

Maximum Temperature

The model-simulated and bias-corrected annual average maximum temperatures (°C) are displayed in Figure 3.10 for the baseline period 1971–2000. The lowest maximum temperatures occur over the south eastern parts of the basin. The hotter regions are the central interior of the basin and the north western parts are the hottest.

Rapid rises in the annual average maximum temperature are projected to occur over the basin during the 21st century.

- For the period 2021-2050 relative to the period 1971–2000, maximum temperature increases of 0.3 to 1.7 °C are projected to occur over the Limpopo Basin under high mitigation.
- Under low mitigation, maximum temperature increases over the South African part of the basin will be less, although it may still reach 3.6 °C over the south-western part.
- Under both low and high mitigation, maximum temperatures are projected to rise faster than minimum temperatures.
- The projected drastic temperature increases under particularly low mitigation may have significant impacts on many sectors, including agriculture (e.g. crop yield and livestock mortality rates), energy demand (an increased need for cooling to achieve human comfort is plausible, particularly in summer) and possibly also on water security (through increased evaporation rates).
- By the end of the century, maximum temperature increases of 2.98 °C under high mitigation and 5.9 °C under the low mitigation are projected to occur over western parts of the basin.

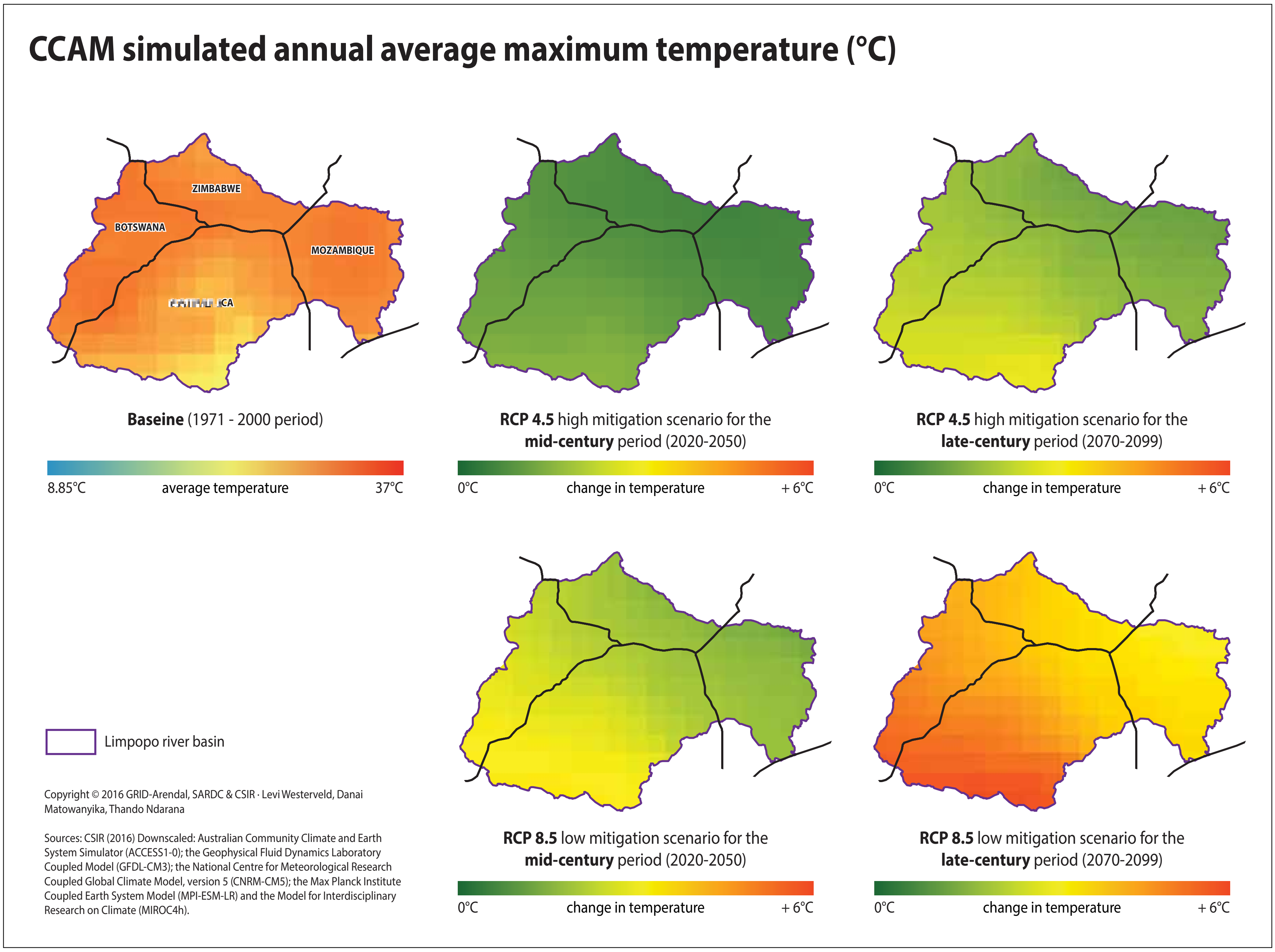


Figure 3.10 CCAM Simulated Annual Average Maximum Temperature over the Limpopo River

The median of simulations is shown for the ensemble downscalings of six GCM simulations.

Minimum Temperatures

The model-simulated and bias-corrected annual average minimum temperatures (°C) are displayed in Figure 3.11 for the baseline period 1971–2000. The coolest conditions occur over central and southern parts of the Limpopo River Basin. The regions with the highest minimum temperatures are the east coast.

Rapid rises in the annual average minimum temperature are projected to occur over southern Africa during the 21st century.

- For the period 2021-2050 relative to the period 1971–2000, minimum temperature increases of 0.96 to 1.76 °C are projected to occur under the high mitigation, with the highest increase over the western parts of the basin.
- Under low mitigation, minimum temperature increases over the region will be less, although it may still reach 3.5 °C over the western part of the basin.
- The projected minimum temperature increases may have significant impacts on energy demand – that is, the household demand for energy during winter (warming needs) may be expected to decrease. Rising minimum temperatures are also associated with a decrease in the number of days with frost, with implications for agriculture and bush encroachment.
- By the end of the century, minimum temperature increases of 5.9 °C are projected to occur over the western regions of the basin under the RCP8.5.

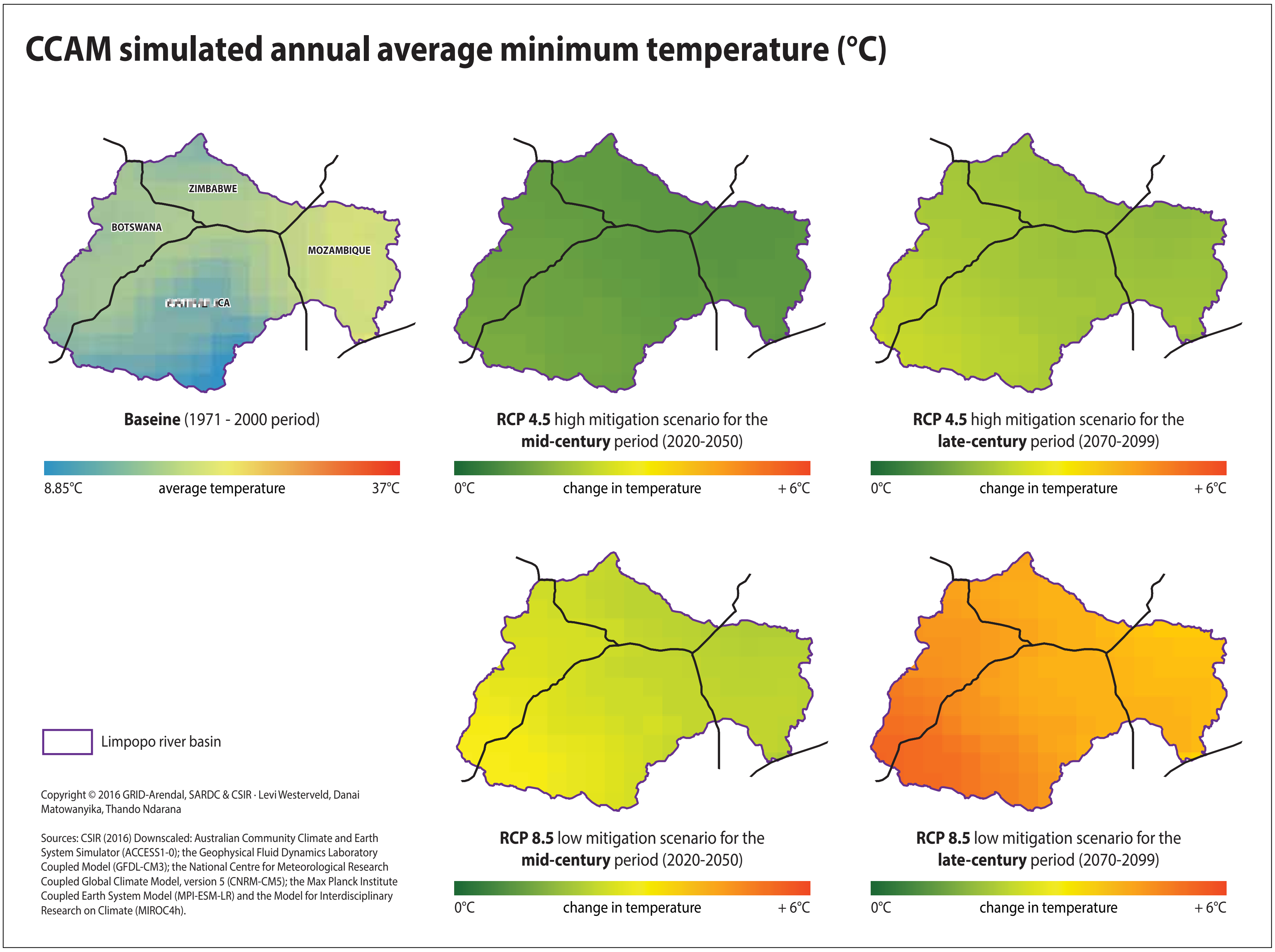


Figure 3.11 CCAM Simulated Annual Average Minimum Temperature over the Limpopo River Basin

The median of simulations is shown for the ensemble downscalings of six GCM simulations.

Very Hot Days

The model-simulated and bias-corrected annual average number of very hot days (days when the maximum temperature exceeds 35 °C, units are number of days per model grid point) are displayed in Figure 3.12. In the Limpopo River Basin, 109–154 very hot days occur on the average annually.

- In association with drastically rising maximum temperatures, the frequency of occurrence of very hot days is also projected to increase drastically under climate change.
- For the period 2021–2050 relative to 1971–2000, under high mitigation, very hot days are projected to increase with as many as 27–35 (and to 35 to 45 in the western parts of the basin) days per year in the Limpopo River Basin. More modest increases are projected for the southern, interior and eastern regions.
- Even under low mitigation, the increase in the number of very hot days may be as high as 70–88 over the Limpopo River Basin.
- Increases in the occurrence of very hot days occur in association with projected changes in the frequency of occurrence of heat-wave days and high fire-danger days. These changes may impact on human and animal health through increased heat stress, are likely to impact negatively on crop yield and are conducive to the occurrence of veld and forest fires.
- The number of very hot days increases by very large margin for the later time slab with the low mitigation scenario exhibiting increases by as high as 113–140.

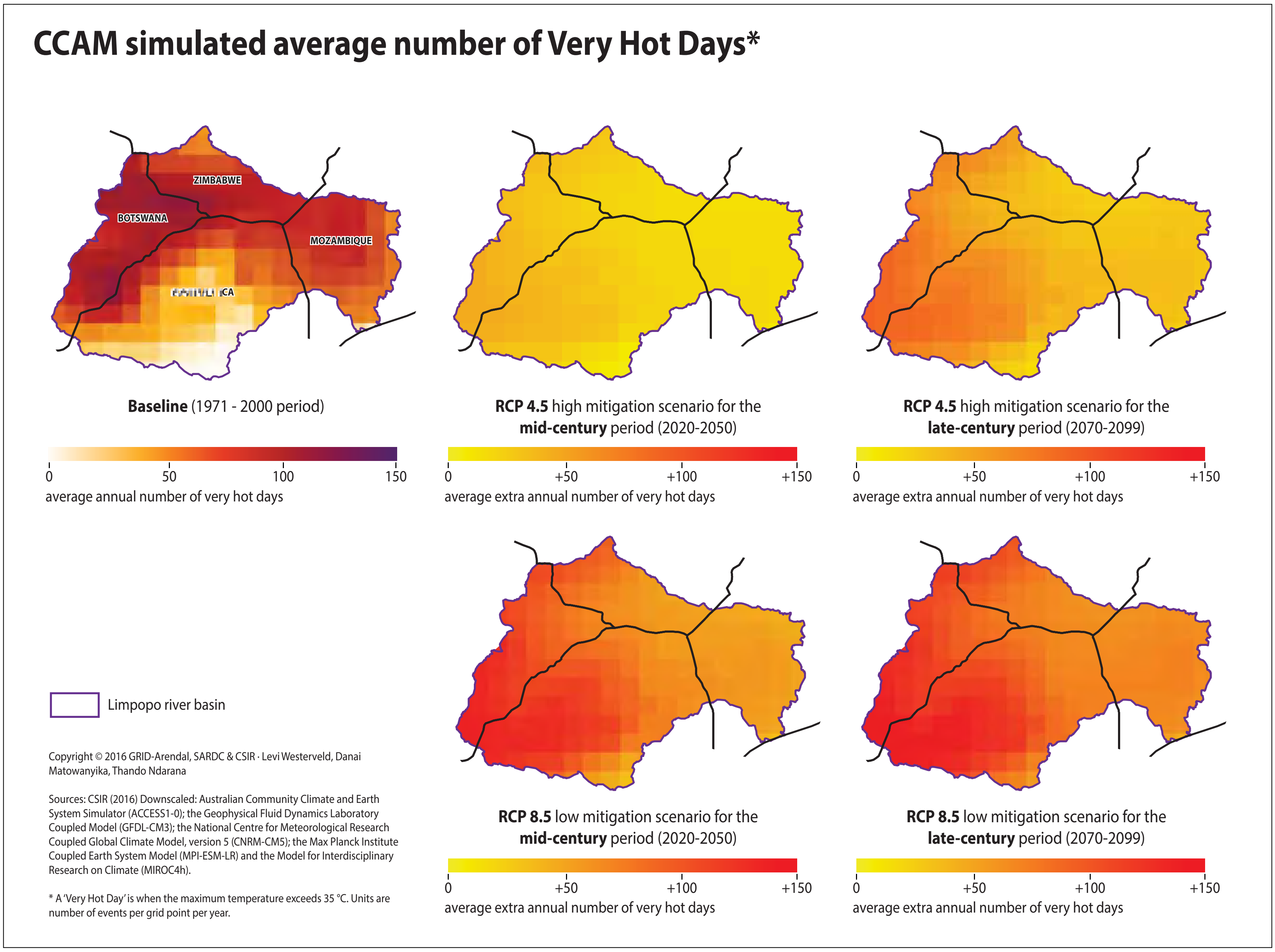


Figure 3.12 CCAM Simulated Annual Average Number of Very Hot Days

Units are number of days per grid point per year. The median of simulations is shown for the ensemble downscalings of six GCM simulations.

Heat-Wave Days

The model-simulated annual-average numbers of heat-wave days (units are number of days per model grid point) are displayed in Figure 3.13. A heat-wave is defined as an event when the maximum temperature at a specific location exceeds the average maximum temperature of the warmest month of the year at that location by 5 °C, for a period of at least three days. The total number of days occurring within a heat-wave is referred to as "heat-wave days". Heat-waves are rare events in terms of southern Africa's present-day climate, but some parts of the Limpopo River Basin have experienced as many as 10–15 heat wave days per annum.

- In association with drastically rising maximum temperatures, the frequency of occurrence of heat-wave days are also projected to increase drastically under climate change.
- For the period 2021–2050 relative to 1971–2000, under high mitigation, heat-wave days are projected to increase with more than 8 days per year over large parts of the basin. More modest increases are projected for the coastal regions.
- Increases in the occurrence of heat-wave days occur in association with projected changes in the frequency of very hot days and high fire danger days. Since heat-wave days are associated with prolonged periods of oppressive temperatures, these changes may impact on human and animal health through increased heat stress, are likely to impact negatively on crop yield, and are conducive to the occurrence of veld and forest fires.
- The number of heat wave days are predicted to increase towards the end of the century. With the low mitigation scenario, the Limpopo River Basin is expected to experience as many as 84 more heatwave days particularly over the south western parts.

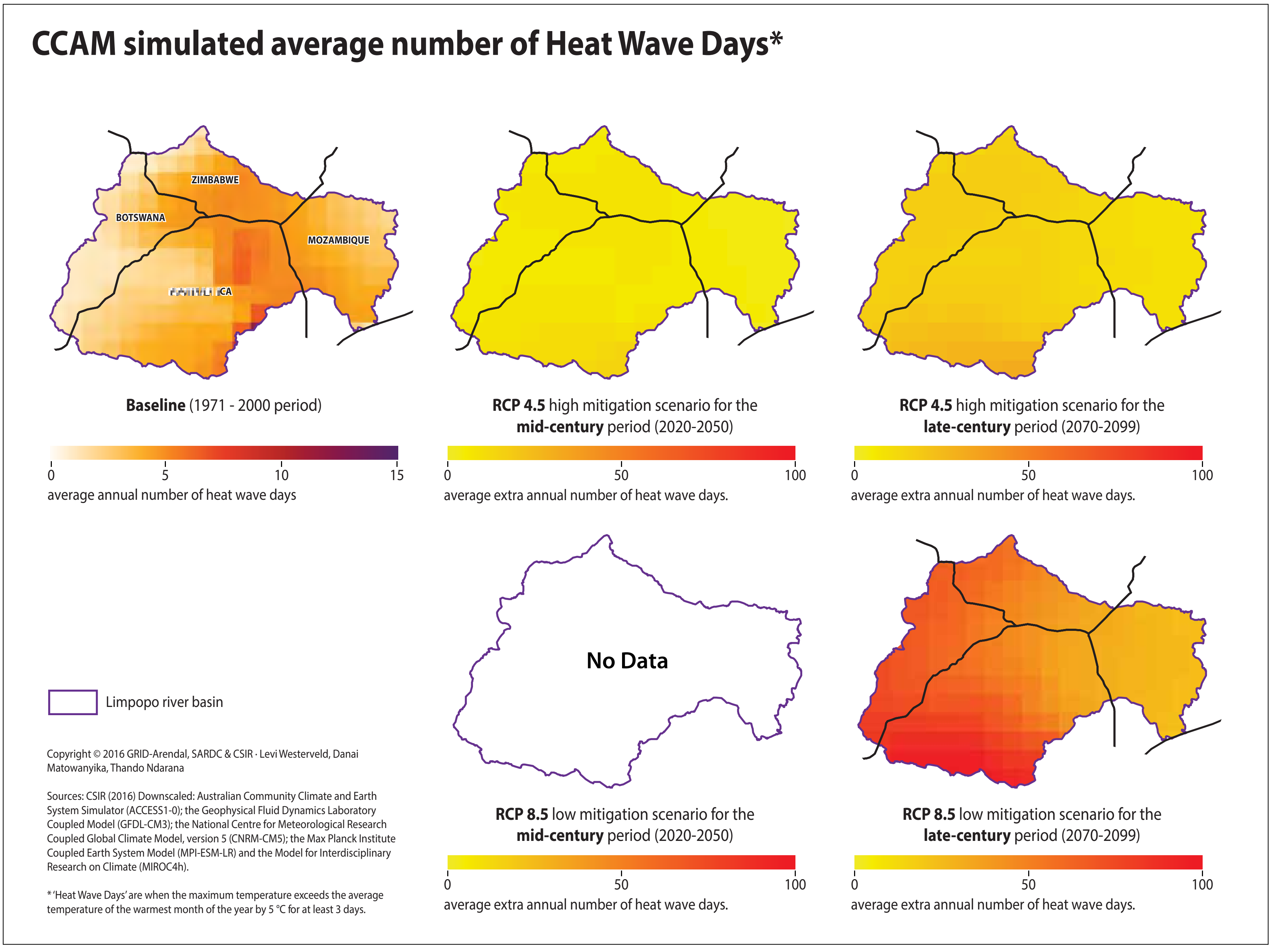


Figure 3.13 CCAM Simulated Annual Average Number of Heat-wave Days over the Limpopo River Basin

Units are number of days per grid point per year. The median of simulations is shown for the ensemble downscalings of six GCM simulations.

High Fire-Danger Days

High fire-danger days are days when the McArthur Fire Danger Index exceeds a value of 24, and units are number of days per model grid point. These are displayed in Figure 3.14. These should be used in conjunction with information about forested regions in the Limpopo River basin.

- In association with drastically rising maximum temperatures (Figure 3.10), the frequency of occurrence of high fire-danger days are also projected to increase drastically under climate change.
- For the period 2021–2050 relative to 1971–2000, under low mitigation, high fire-danger days are projected to increase with as many as 10–30 days per year in the forested regions of southern parts of the basin. Smaller increases are projected for the coastal regions, with relatively larger increases also plausible over the western parts.
- Even under high mitigation, the increase in the number of high fire-danger days may be as many as 10-30 over eastern interior, with larger increases possible over the western parts.
- Increases in the occurrence of high fire-danger days occur in association with projected changes in the frequency of occurrence of heat-wave days and high fire danger days.

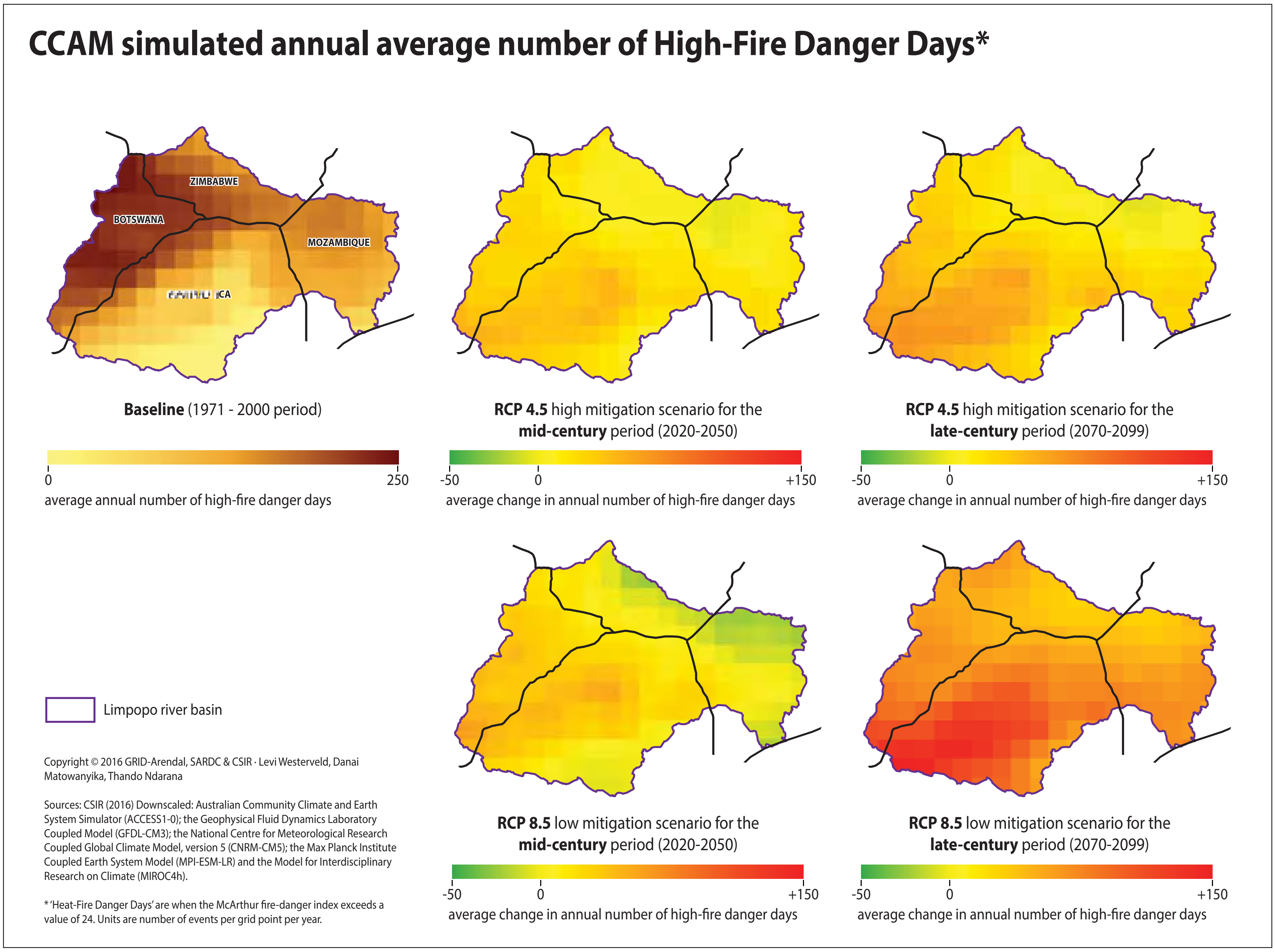


Figure 3.14 CCAM Simulated Annual Average Number of High-fire Danger Days over the Limpopo River Basin

Units are number of days per grid point per year. The median of simulations is shown for the ensemble down-scalings of six GCM simulations.

Rainfall

The model-simulated annual average rainfall totals (mm) are displayed in Figure 3.15. There is a pronounced north-south rainfall gradient over the basin. This gradient is mostly informed by the dominance of the upper level high pressure system that causes subsidence over the basin and transports tropical moisture along its periphery, thus bringing rainfall to the south of the basin through weather systems referred to as tropical temperate troughs.

- A general decrease in rainfall is projected over the Limpopo River Basin as a result of human activities (Christensen and others 2007; Engelbrecht and others 2009).
- For the period 2021–2050 relative to the period 1971–2000, under high mitigation, rainfall is projected to decrease over southern and western parts of the basin. There is a projected increase in rainfall over the central interior and the north eastern parts.
- The projected changes in rainfall patterns under low mitigation are very similar to the patterns projected under high mitigation.
- The projected changes in rainfall patterns display more uncertainty than in the case of projected changes in temperature. This implies that adaptation policy makers need to take into account a range of different rainfall futures, often of different signal (i.e. drier and wetter) during the decision making process.

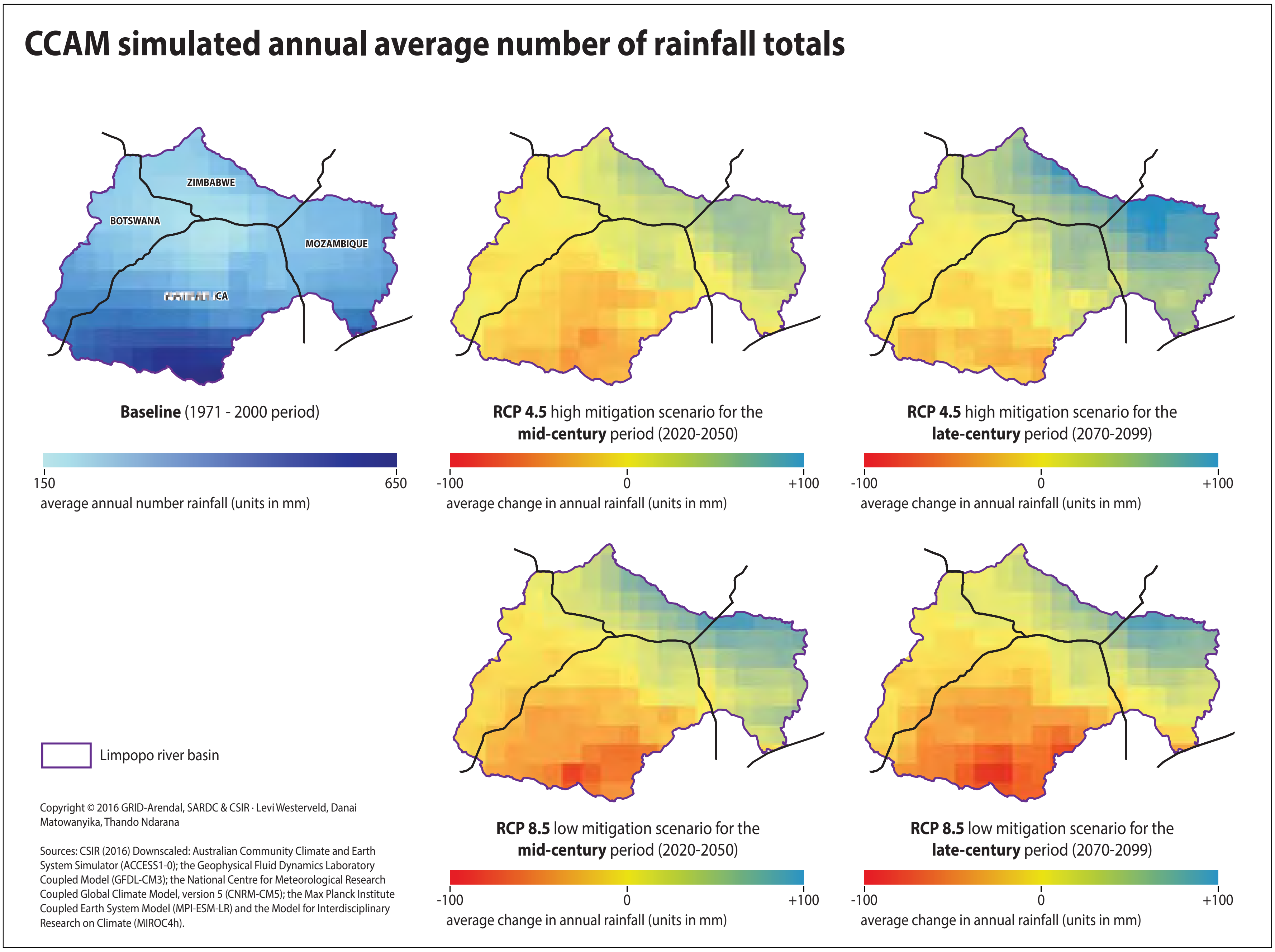


Figure 3.15 CCAM Simulated Annual Average Number of Rainfall Totals over the Limpopo River Basin

4

CHANGING LIVELIHOODS IN A CHANGING ENVIRONMENT

This chapter analyses trends and impacts of the changing environment on human livelihoods. It assesses demographic changes, cultural dynamics, urbanization, industrial development, as well as infrastructure development in the basin. The chapter discusses how these affect agriculture and livelihoods, energy demand, tourism, transport and communications, as well as human health.

Livelihoods are secure and sustainable when households have ownership of, and access to resources and income-earning activities to cope with and recover from stresses and shocks, while not undermining the future natural resource base (Magombeyi and others 2013). In the Limpopo Basin, water is not only vital for economic growth but is also key in promoting healthy livelihoods for the people of the basin. Water is mainly used to support domestic needs, industry, mining, agriculture (livestock and irrigation), and power generation.

Cultural Dynamics

In the Limpopo Basin, as in much of Africa, there are traditional checks and balances on the human use of the natural environment guided by cultures existing in those specific areas (SADC and SARDC 2002). Historically, large rivers have been suited for navigational uses, allowing for the movement of people and goods, as well as encouraging access to resources and trade.

Co-existence of groups on opposing banks of the river is accompanied by frequent economic interaction such as trade, or social interaction such as religious ceremonies, weddings or funerals (Earle and others 2006). All of these activities influence use of natural environment and shape livelihoods throughout the basin.

Marula oil production

Economic Development

In the Limpopo Basin, mining contributes 65.6 percent of the basin's contribution to the countries' GDP, followed by industry at 17.9 percent. Mining therefore is a major employment contributor (see Table 4.1). In all four basin countries, large deposits of different minerals occur and the probability of expansion is high (see Figure 4.1). Mining of copper, nickel and diamonds is an important contributor to the economy (LIMCOM undated).

In South Africa, 70 percent of the world platinum reserves occur in the basin and this would outlast at least the 40 year horizon at current production levels (LIMCOM 2013). There are also large coal deposits in Waterberg region in South Africa, while in the Mozambique portion of the basin, large coal deposits are also found with plans underway to start mining operations. In the Zimbabwe part of the basin, there are platinum and coal deposits, but these are yet to be mined (LIMCOM 2013).

Mine dump

Table 4.1 Contribution of Water Based Economic Sectors to Gross Domestic Product in 2013

	GDP (US$ million)				Employment Created (Numbers)				Household Income (US$ million)		
Sector	Direct	Indirect and Induced	Total contri-bution to GDP	% of GDP	Direct	Indirect and Induced	Total	% of employ-ment	Total	Medium	Low
Irrigation	1 742.8	2 120.5	3 863.4	5.9	251 194	153 423	406 618	20.9	2 291.7	1 197.5	1 094.2
Forestry	56.8	49.1	106.0	0.15	6 866	3 921	10 787	0.6	44.7	13.5	31.2
Mining	22 440.3	20 520.3	42 960.5	65.6	359 806	882 573	1 242 379	63.7	18 443.5	2 800.4	15 643.2
Power	3 979.6	2 542.8	6 522.4	10	9 955	151 825	161 780	8.3	2 451.8	536.8	1 915.0
Industry	4 557.8	7 196.2	11 754.0	17.9	25 245	85 800	111 045	5.7	6 425.5	1 571.7	4 853.8
Eco-tourism	158.1	139.2	297.3	0.45	9 137	9 187	18 325	0.1	122.8	36.8	86.0
Total	32 935.4	32 568.1	65 503.6	100	662 204	1 286 730	1 948 934	100	29 780.0	6 156.7	23 623.4

Source: Adapted from LIMCOM 2013

Venetia Mine panorama – a deep hole caused by open cast mining leaving land degraded

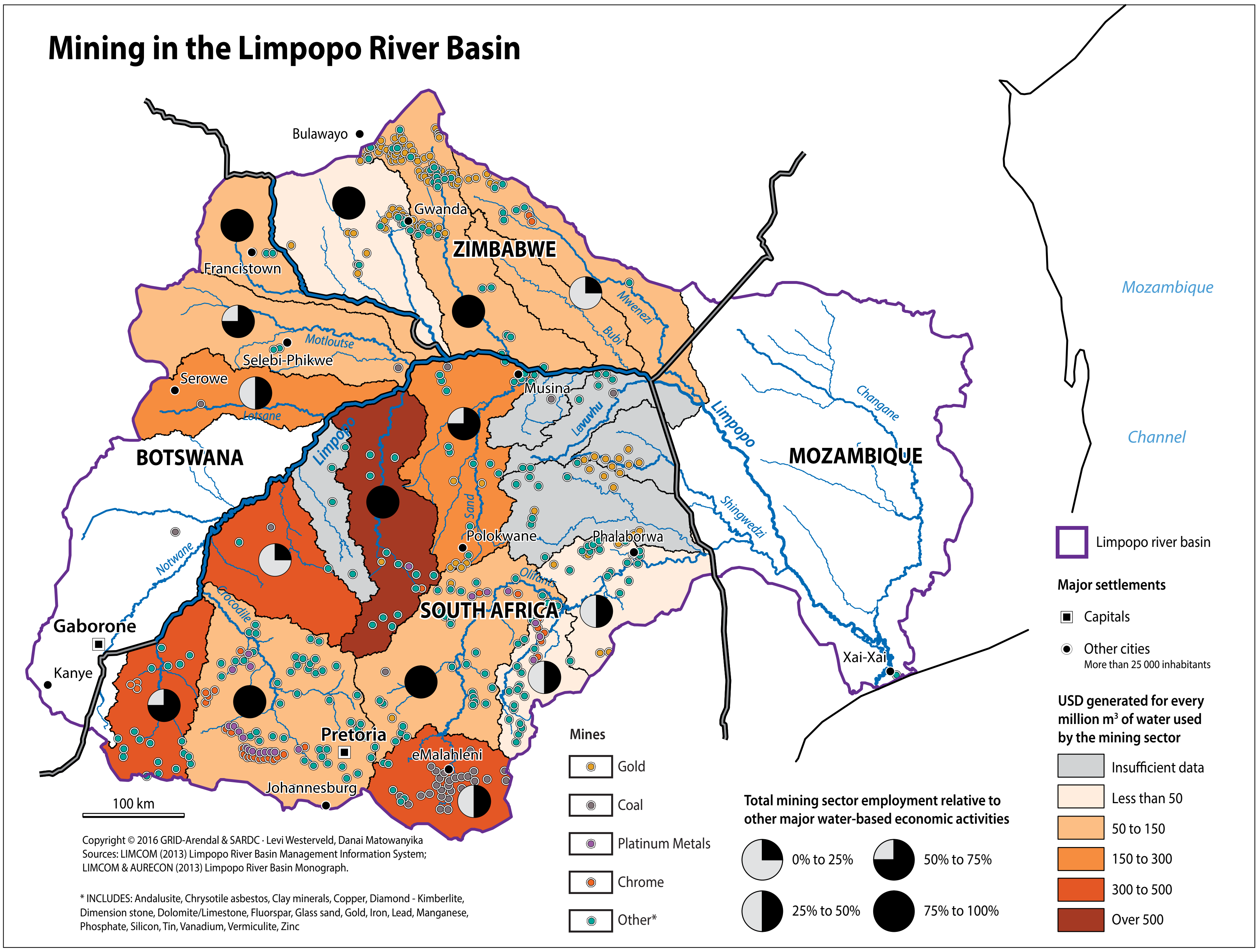


Figure 4.1 Mining in the Limpopo River Basin

Source: LIMCOM 2013

Economic development in Central District of Botswana has seen growth of Selebi Phikwe mine and surrounding urban areas as well as the construction of Letsibogo Dam

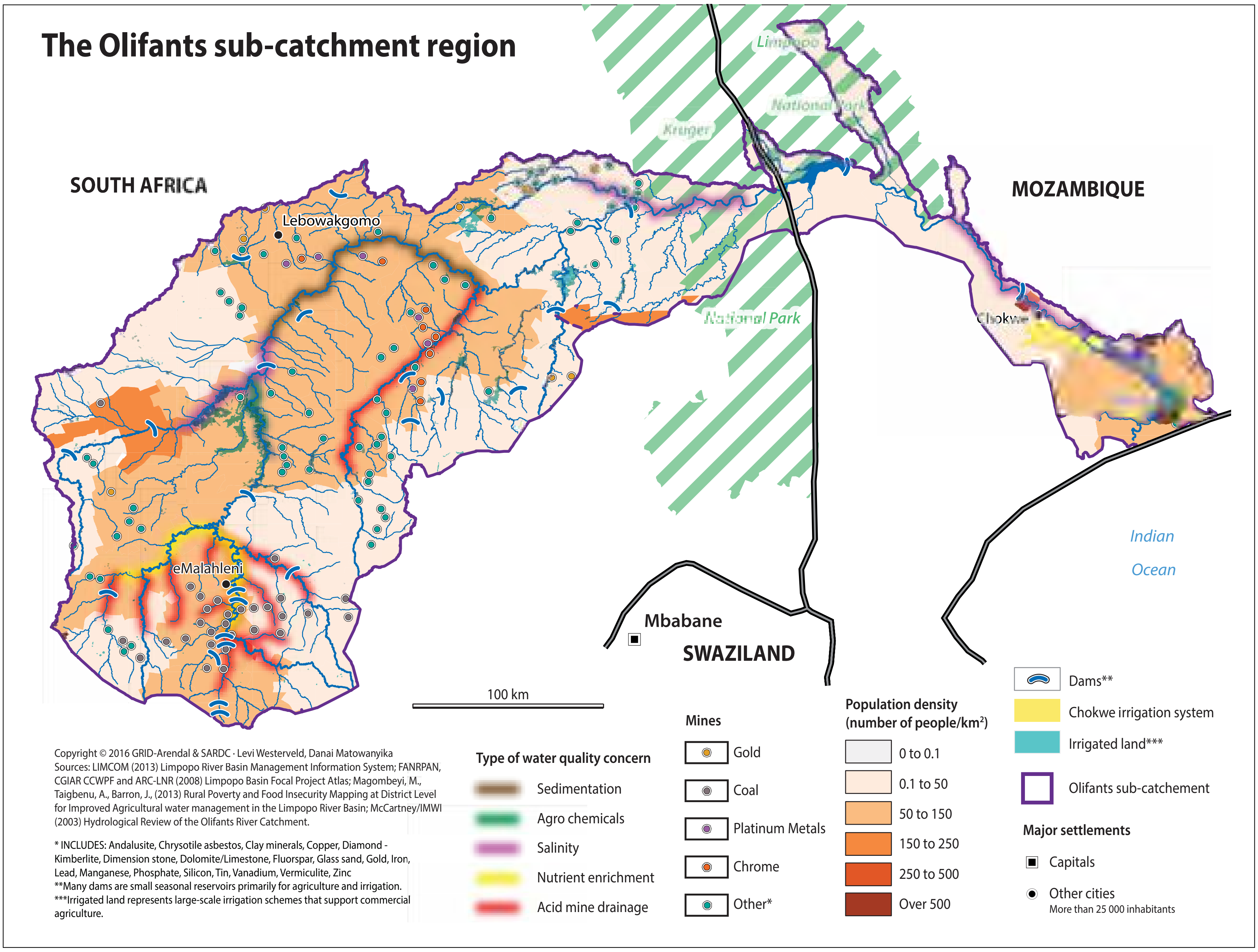


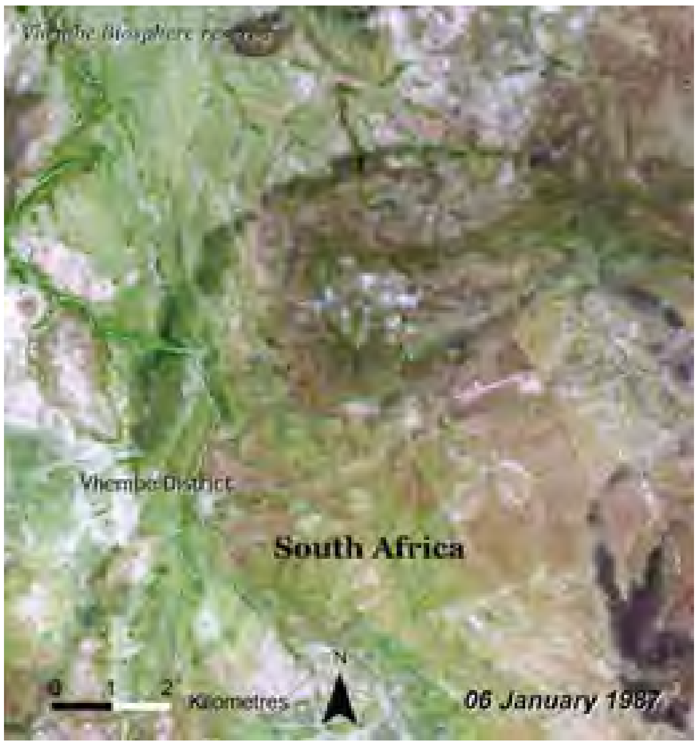
Figure 4.2 The Olifants Sub-basin

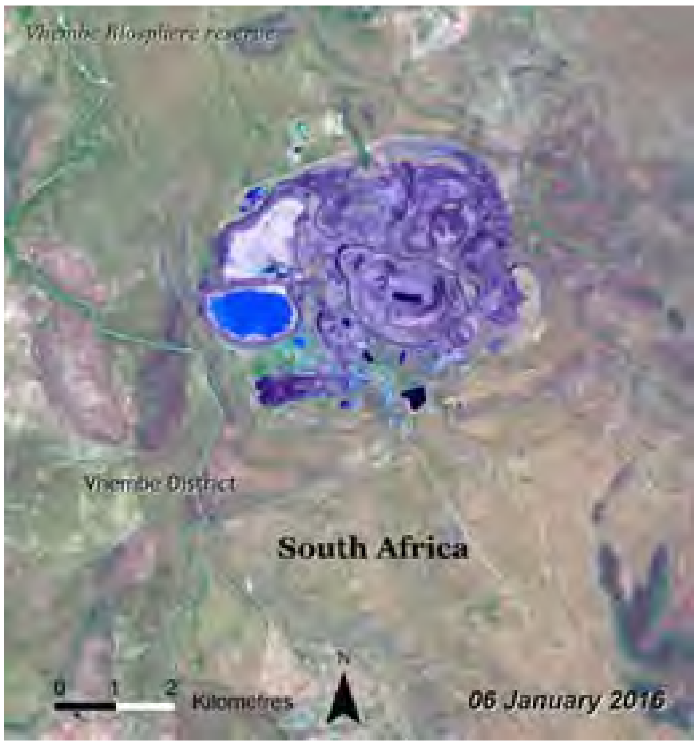
The Olifants River has high sediment-loading as a result of intensive agricultural and industrial activities in the basin (Figure 4.2). The river also has high levels of water pollution, with sodium and chlorides dominating. The presence of sulphates is an indicator of the residual effect of the mining activities in the upper reaches of the catchment.


Groblersdal to origin of Olifants near Hendrina

Mining of gold, coal, diamonds, iron ore, platinum and nickel, both formal and informal, has significantly impacted on the water quality draining from the mined areas (Ashton and others 2001). Contamination of water and fish by heavy metals at sites located at proximities to the border with upstream countries (Botswana, South Africa and Zimbabwe) is notable, with worse cases of pollution incidents resulting in fish and crocodile deaths in the Mozambique and South Africa parts of the basin.

The most extensive open cast coal mining areas situated in South Africa, particularly in the Olifants sub-basin have increased the amount of highly acidic water, pH as low as 2 recorded in groundwater and impacting aquatic life of the rivers draining these areas (Environmentek, CSIR 2003). Future plans to prospect for and mine the minerals in the dunes of Mozambique and in other basin countries will aggravate the water contamination.





Mining activities at Venetia Mine in South Africa have increased since 1972. The image taken in 2016 provides evidence of significant change in the mining activity. Venetia consists of both open pit and underground operations and was officially opened in August 1992. The open pit operations are expected to cease between 2020 and 2023, and mining will continue underground (Environmental Resources Management 2015). The development of the underground mine, which is set to begin producing diamonds in 2021 dovetailing with the winding down of the open pit operation, will in itself create new opportunities for the local communities. Since the commissioning of the mine 23 years ago, about 100 million carats have been mined and current production averages three to four million carats a year (De Beers Group 2014). Despite challenging conditions and strict statutory and self-imposed restrictions to water abstraction, the Mine has not exceeded water abstraction permit volumes (Brown and Erasmus 2004).


Mining equipment

Rural Livelihoods

Livelihood options and opportunities vary significantly across the basin. An extensive study on livelihoods in rural Limpopo has shown that although the number of people living below respective minimal standards of living is high, there has been a slight decrease in poverty incidences. The proportion of persons living below poverty lines have decreased in the Limpopo parts of Botswana (2003–2009/10), Mozambique (2003–2008/2009) and Zimbabwe (2003-2011), while South Africa has experienced a slight increase from 2007–2010 (see Figure 4.3) (Magombeyi and others 2013).

The varied land issues in the basin reflects differential access to natural resource and livelihoods options and opportunities for the basin's population. Some communities have insecure ownership of and access to land-based natural resources and concomitant income-generating activities. Poor access to quality land resources (implying fertile and well-watered areas) is a major source of poor livelihoods as agricultural production and productivity are heavily compromised.


Livelihood diversification in the Limpopo

Activities such as mining provide employment in the basin. Most of the mines are private owned especially in the gold and platinum mines in Gauteng and North-West Provinces of South Africa, the diamond mines in western Botswana and southern Zimbabwe.

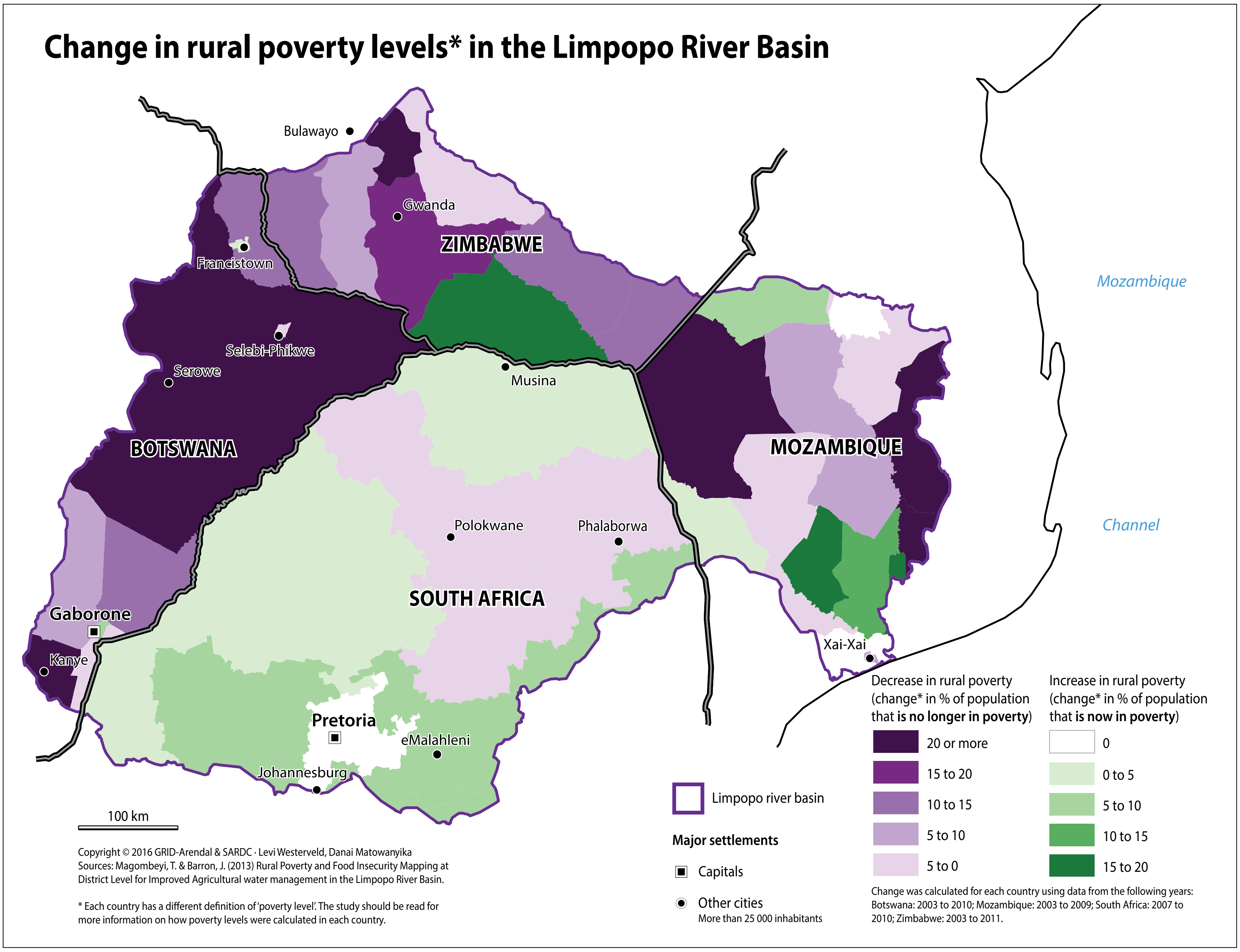


Figure 4.3 Change in Rural Poverty Levels

Source: Magombeyi and others 2013

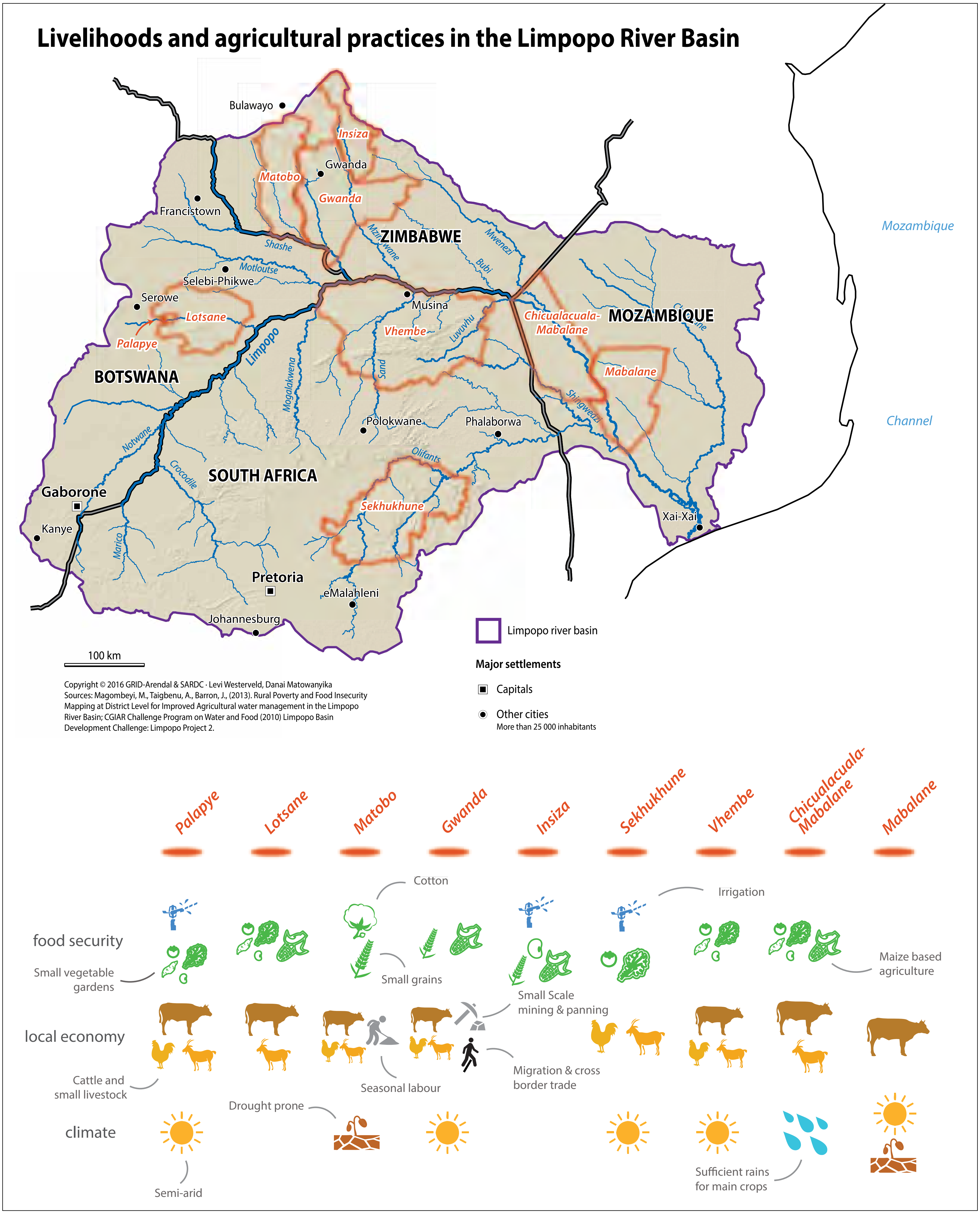


Figure 4.4 Livelihoods and Agricultural Practices

Source: Adapted from Magombeyi and others 2013

Agriculture and Livelihoods

The value that agriculture provides in terms of food security, income generation, poverty alleviation and employment is essential to the well-being of many in the basin. In Botswana for example, although the sector only accounts for around 4 percent of the country's GDP, 65 percent of the population living within the Limpopo River Basin rely on agriculture and derive their livelihoods from agricultural activities, which largely include livestock rearing (FAO 2004). Most agricultural operations in the basin are at the subsistence level with an average farm size of 1–3 ha of land (LBPTC 2010). In Mozambique, subsistence agriculture is practiced by almost all of the families living in the basin and average farm size ranges from 1.1 to 1.4 ha (LBPTC 2010). Small and large scale irrigation schemes are also dominant in Chokwé.

Irrigation, concentrated largely in South Africa and Zimbabwe tends to rely on stored water. The majority of the rural population relies on rain-fed agriculture for their livelihoods (Earle and others 2006).

Significance of Livestock in the Limpopo Basin

In the Limpopo River Basin, livestock production is both socially and financially important to smallholder farmers. Owning livestock is an indicator of wealth. Cattle are used to pay bride prices and school fees, to acquire and store wealth, to spread the risk in mixed farming systems, and for meat and milk. Livestock are a crucial financial buffer and act as a form of savings account for farmers, who can liquidate their assets – by selling off livestock – when needed. The biggest challenge to this system is to ensure that livestock have enough feed to make it through the dry season and the frequent droughts, when livestock mortality is generally high.

Source: CPWF 2014

Mixed crops/livestock farming systems occupy the largest proportion of land in rural areas in the Limpopo River Basin. Cattle are managed in communal lands and are kept for draught power, milk, meat, as well as social value. Local breeds prevail in the production system as they are well adapted to the harsh climatic and environmental conditions. However, the breeds are less productive, with low calving rates and small average weight.

The low rainfall in the Limpopo River Basin, particularly in Botswana and Zimbabwe makes livestock production a more viable option than crop production. As such, livestock contributes significantly to national economies in these countries. Goats, sheep and poultry are other common livestock in the basin and are valued as a source of meat and cash. Donkeys are mostly reserved as draught animals.


Rearing of goats is part of livestock production in the Limpopo Basin

Herd numbers are higher in Botswana and Zimbabwe compared to other basin countries. In South Africa, output of livestock commodities (milk, eggs, meat, skins etc.) account for 25 percent of the national agricultural domestic product and animal products contribute 45 percent (LIMCOM undated). The contributions of livestock to the national economy of Mozambique are small relative to its potential, accounting for only five percent at its peak livestock numbers in 1980/81. The national cattle herd declined dramatically during the civil war and has been recovering ever since.

Livestock production is both socially and financially important to smallholder farmers in the Limpopo River basin, and play an important role in smallholder farming systems. They provide draught power and are an asset to household income security.

An analysis of cattle distribution in the basin indicates that the highest concentrations of cattle density are in the southern districts of Botswana within the Basin (see Figure 4.5). The Northern parts of the basin in Zimbabwe tends to have relatively lower cattle density as compared to the rest of the basin. Commercial cattle rearing occurs mainly the central and eastern parts of the basin. Cattle density across the basin is subject to many environmental factors such as recurring droughts and the spread of diseases such as Foot-and-Mouth, especially in those areas that overlap with wildlife.

Most farmers keep goats, sheep and chickens mainly used for own consumption and as a source of household income. The distribution of these livestock is skewed towards the south western part of the basin which is in Botswana (see Figure 4.6). The area is dry and only suitable for livestock rearing.

In smallholder rural settings, there is little purchased supplementary feeding to augment the veld grazing. In times of drought, overstocking abounds and there is more pressure on the usually water-deficient grazing areas. Movement of stock as a drought avoidance strategy is hampered by fixed land tenure structures and the fact that severe droughts generally affect large areas. A case study on access of land illustrates the restrictions in the land tenure system experienced in the basin.

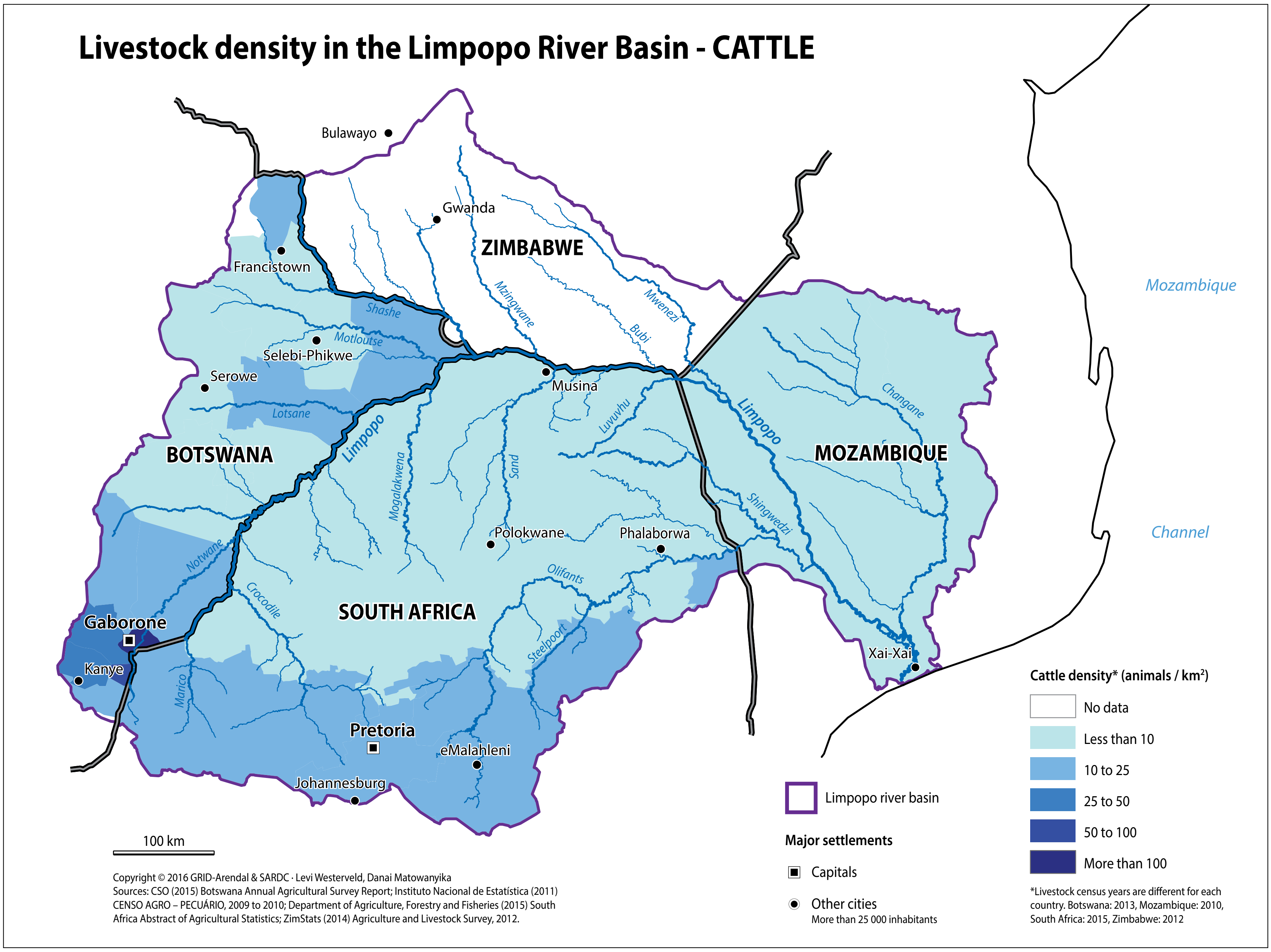


Figure 4.5 Cattle Density in the Limpopo River Basin

Latest count: Botswana is 2013, Mozambique is 2010, South Africa is 2015, Zimbabwe is 2012

Communal farmers using cattle draught power

Livestock water demand was about 25-30 million cubic metres per annum for an estimated 2.2 million animals in the whole basin area in 2008, of which 70 percent were cattle. Gaza Province, which occupies most of the Limpopo Basin within Mozambique, required about 7 million cubic metres per annum to satisfy its 400,000 herd of cattle as at 2007 (LBPTC 2010). In 2012 the livestock water requirements increased to 100 million cubic metres per annum (LIMCOM 2013), and these water requirements ranged from 20 million cubic metres for Botswana, 21 million cubic metres per annum for Mozambique, 45 million cubic metres for South Africa, to 14 million cubic metres per annum for Zimbabwe.

Land Tenure and Access

Much of the Limpopo River Basin is characterized by a dual system of land tenure. These are large commercial, intensively managed crop or grazing land; and small-scale/subsistence, tribal or communal lands, usually not intensively managed and characterised by low productivity. This duality implies large differences in productivity and socio-economic costs. A further problem is the lack of purchasing power for acquiring critical farm inputs such as feed, fertilizers and seed, particularly among resource-poor small-holders. Establishment of communal schemes to pool resources as a solution is usually fraught with problems such as management disagreements and waste of resources. Therefore, land tenure security issues are an important, but politically sensitive, facet of community empowerment and poverty eradication in these settings.

Source: Murwira and Yachan 2007

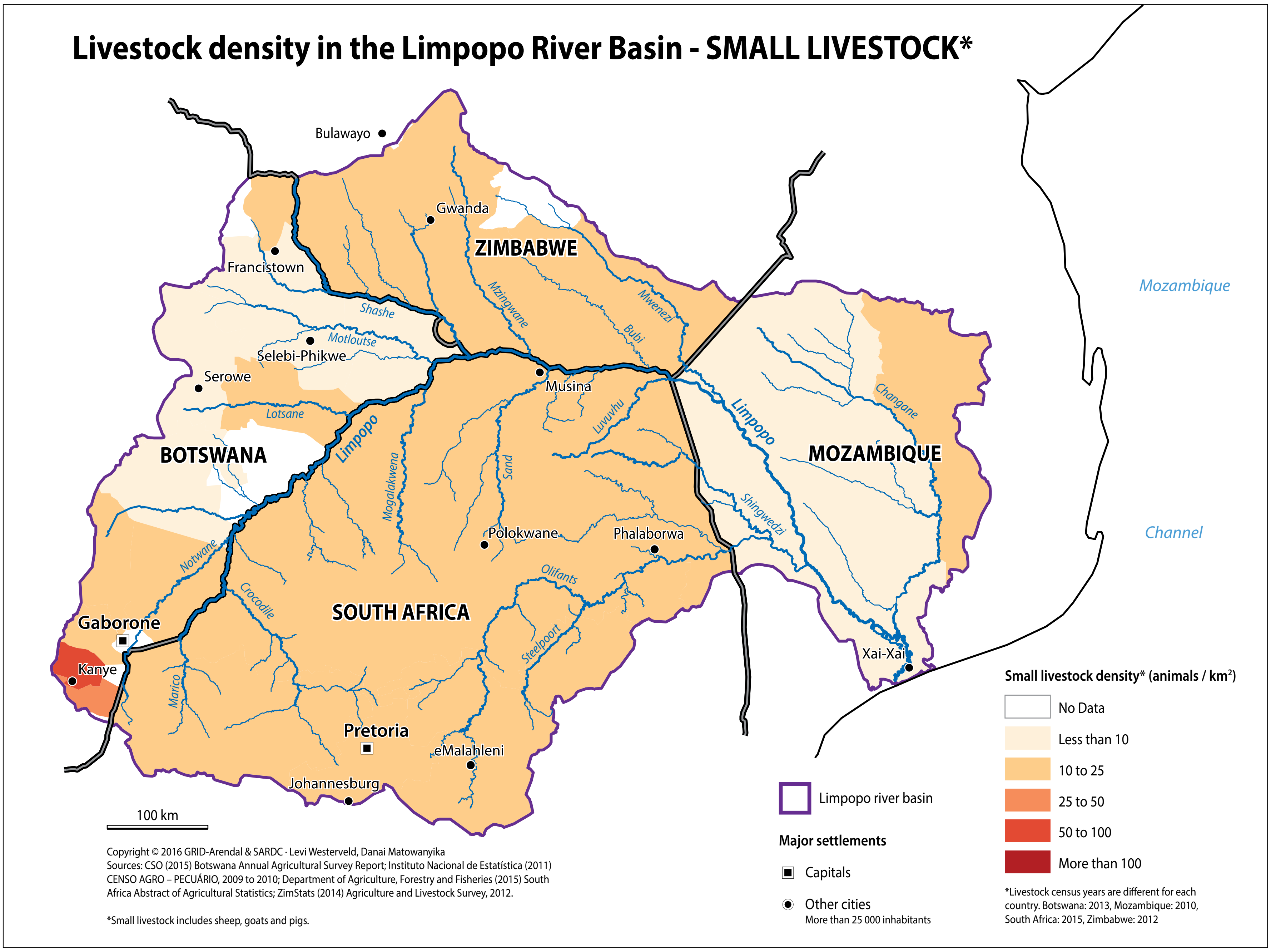


Figure 4.6 Small Livestock Density in the Limpopo River Basin

Energy Demand

The Limpopo River Basin mainly relies on coal-fired thermal power stations and on hydroelectricity generated from a few major reservoirs outside the basin for its energy (SADC and SARDC 2002).

It is estimated that over 95 percent of the electricity in the Limpopo River Basin is generated in South Africa (LIMCOM 2013). Botswana and South Africa are heavily dependent on coal for their electricity needs; Mozambique is solely reliant on hydropower and Zimbabwe is equally split between coal and hydropower on a country-wide basis (see Figure 4.7) (LIMCOM undated). South Africa has made significant progress in transitioning to reliable, clean and efficient fuels and energy services as shown in Figure 4.8.

The Limpopo Basin has low potential for hydropower, and much of the electricity available to the basin is generated outside the basin, and made available to the basin via the Southern Africa Power Pool.

Hydropower potential however exists at Massingir Dam in Mozambique (28 MW) and Manyuchi Dam (5 MW) in Zimbabwe. The availability of electricity has positive benefits on human health and the environment. The primary benefits from access to electricity include improved education, human health, communication and entertainment, comfort, protection, convenience and productivity.

There has been a notable change in access to electricity in almost all the four riparian countries in the Limpopo Basin at national level. For example in 2012, urban access to electricity in South Africa and Botswana stood at 85 and 75 percent while in Mozambique and Zimbabwe, it stood at 66 and 80 percent (REN21 2015) (also Figure 4.9). However rural access to electricity for Mozambique and Zimbabwe is still very low at 27 percent and 14 percent, respectively (REN21 2015), implying that the majority of rural communities in these countries still rely on firewood for energy supplies.

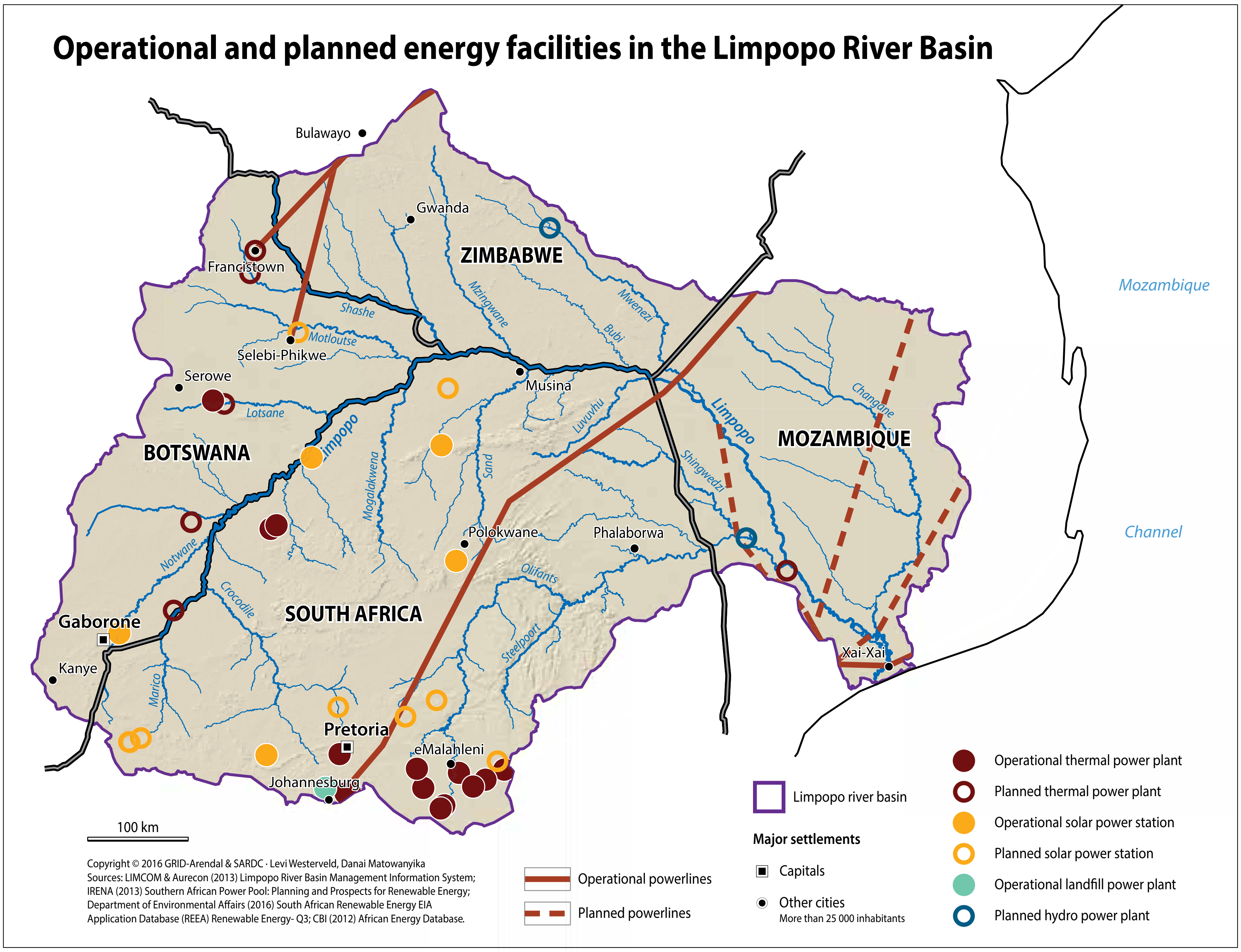


Figure 4.7 Limpopo Basin Energy Infrastructure

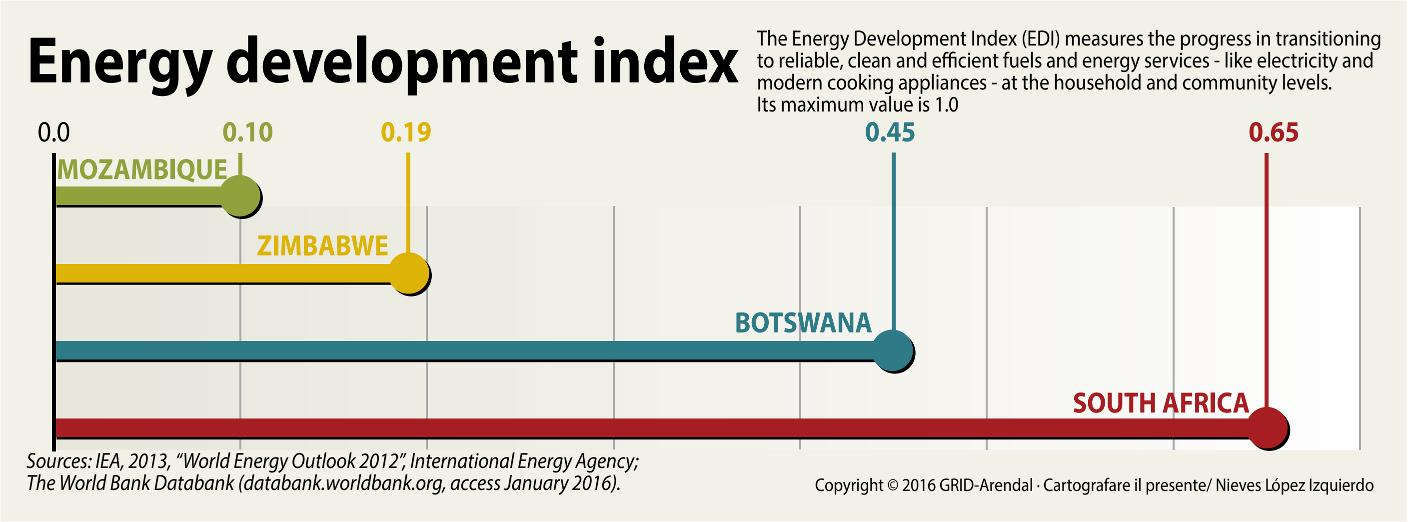


Figure 4.8 Energy Development Index

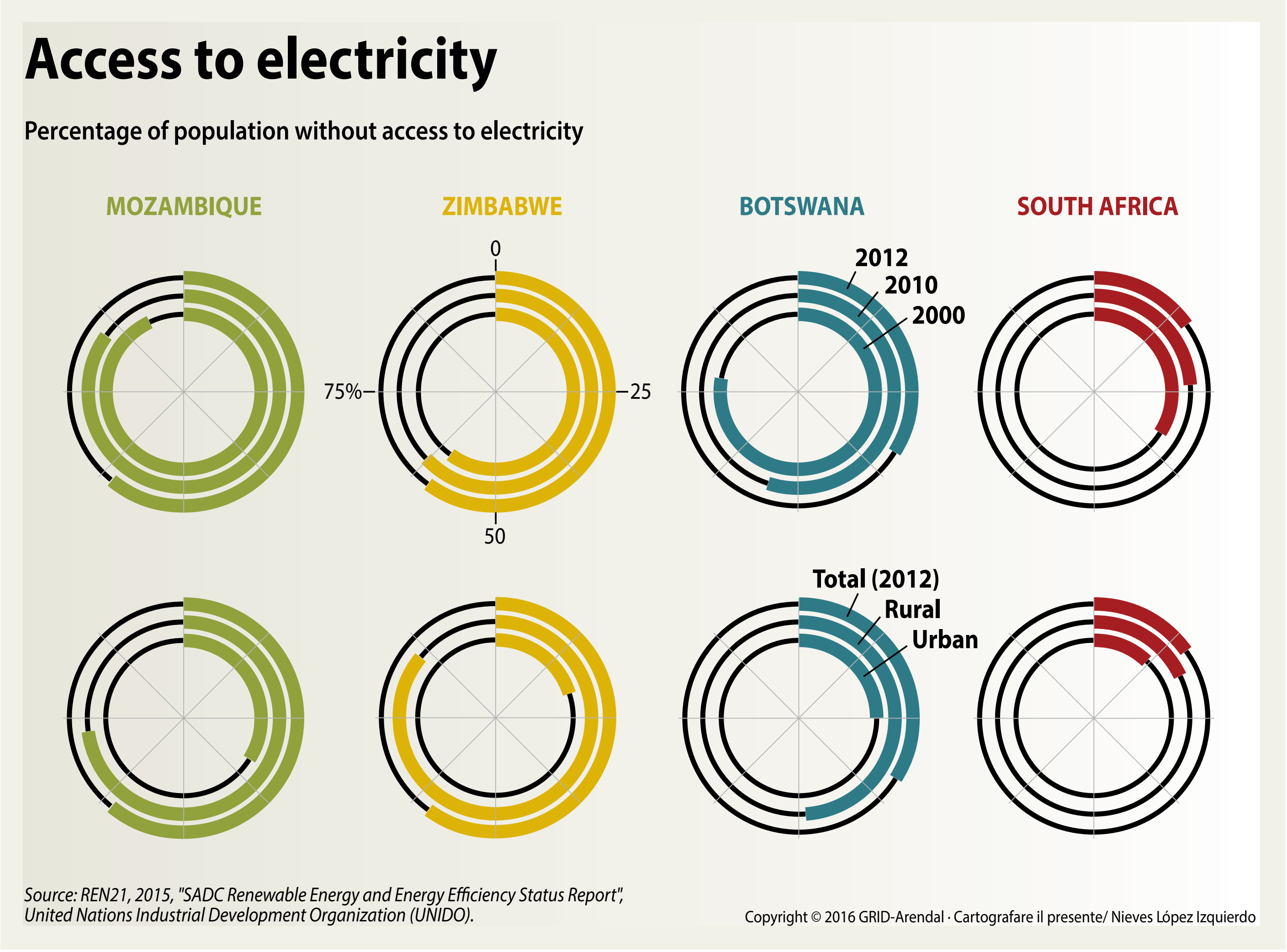


Figure 4.9 Access to Electricity

In most areas of the Mozambique portion of the Limpopo River Basin, firewood is the only form of energy, and is extensively harvested for local use and for sale. Fuelwood cutters and charcoal producers have set up numerous camps along the major roads, and the railway line where Mopane woodlands are being cut down and sold to dealers. Elsewhere in Gaza province, wood such as "simbiri" (*Androstachys johnsonni*) is used locally for house building, and this building material is also traded in the main centres (SADC and SARDC 2002).

The renewable energy database (IRENA 2016) shows that hydropower is the major renewable energy in the basin with South Africa dominating in all the four renewable sources which include solar, wind and bioenergy (Figure 4.10). This record seems to exclude the off-grid sources of energy in other countries, such as the home solar and bioenergy. There is no significant renewable energy installation in Botswana.

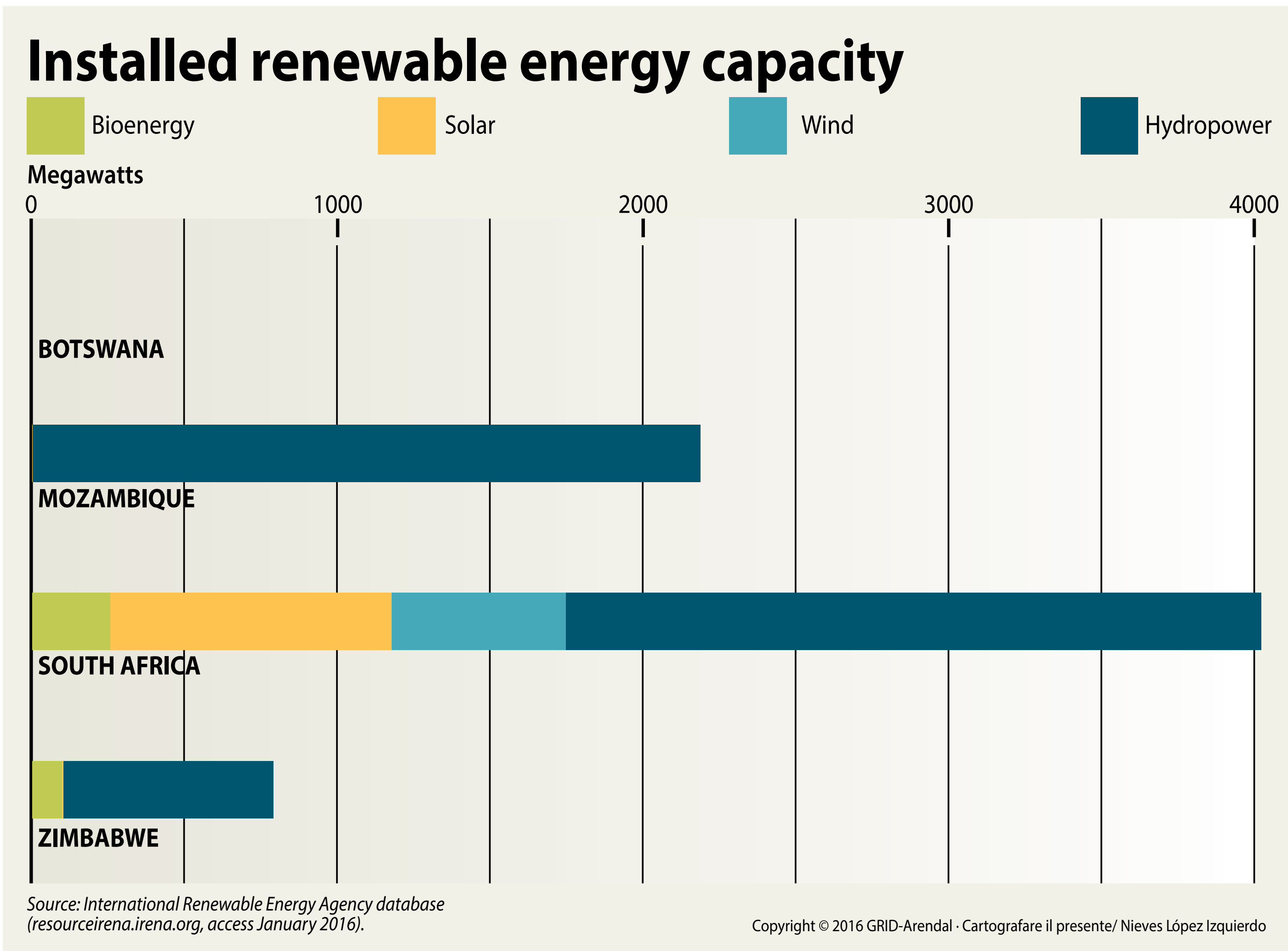


Figure 4.10 Installed Renewable Capacity

Infrastructure Development

Water infrastructure consists of human-made structures and facilities used to abstract, retain, treat, convey and deliver water to users, and to collect, transport, treat and dispose of wastewater. Typical infrastructure includes groundwater well-fields, water supply schemes, sewage treatment facilities, dams, river water abstraction works, inter-basin transfers (bulk transfers), and canals (LIMCOM undated).

There are a number of large dams in the north-eastern parts of Botswana, all in the Limpopo River Basin, and these are Gaborone, Shashe, Letsibogo and Bokaa dams, with total storage capacity of about 355 million cubic metres. Other reservoirs are Dikgatlhong, Lotsane and Thune dams.

Mega-infrastructure projects in South Africa includes the De Hoop dam on the Steelpoort River and the construction of bulk raw water distribution infrastructure, delivering water to more than three million people in the Greater Sekhukhune, Waterberg and Capricorn District Municipalities (Lebowa – Middle Olifants) as reported by Petrie and others (2014). The Crocodile River (West) water augmentation project supplies the new Medupi power station in the Waterberg coal fields, as well as the Lephalale local municipality and industry. The Groot Letaba water resource development project, the Matoks regional bulk scheme, Magalies Water (a water services entity), and the Waterberg regional bulk scheme (including increased exploitation of groundwater) are other water infrastructure projects in the basin (Petrie and others 2014).

Blyde dam in South Africa has a capacity of 54 million cubic metres

The limited irrigation practices, despite the huge potential of the Limpopo Basin as illustrated in Figure 4.11, is also due to lack of infrastructural support, and so is the flooding which is due to the poor warning and regulation of flow of water in the basin.

There is expansion of irrigated area in the lower Limpopo through the Baixo Limpopo Irrigation Scheme. With a total area of 70,000 ha, the Baixo Limpopo Irrigation has the potential to boost agricultural production and improve livelihoods, with direct benefits to many smallholder farmers in the area.

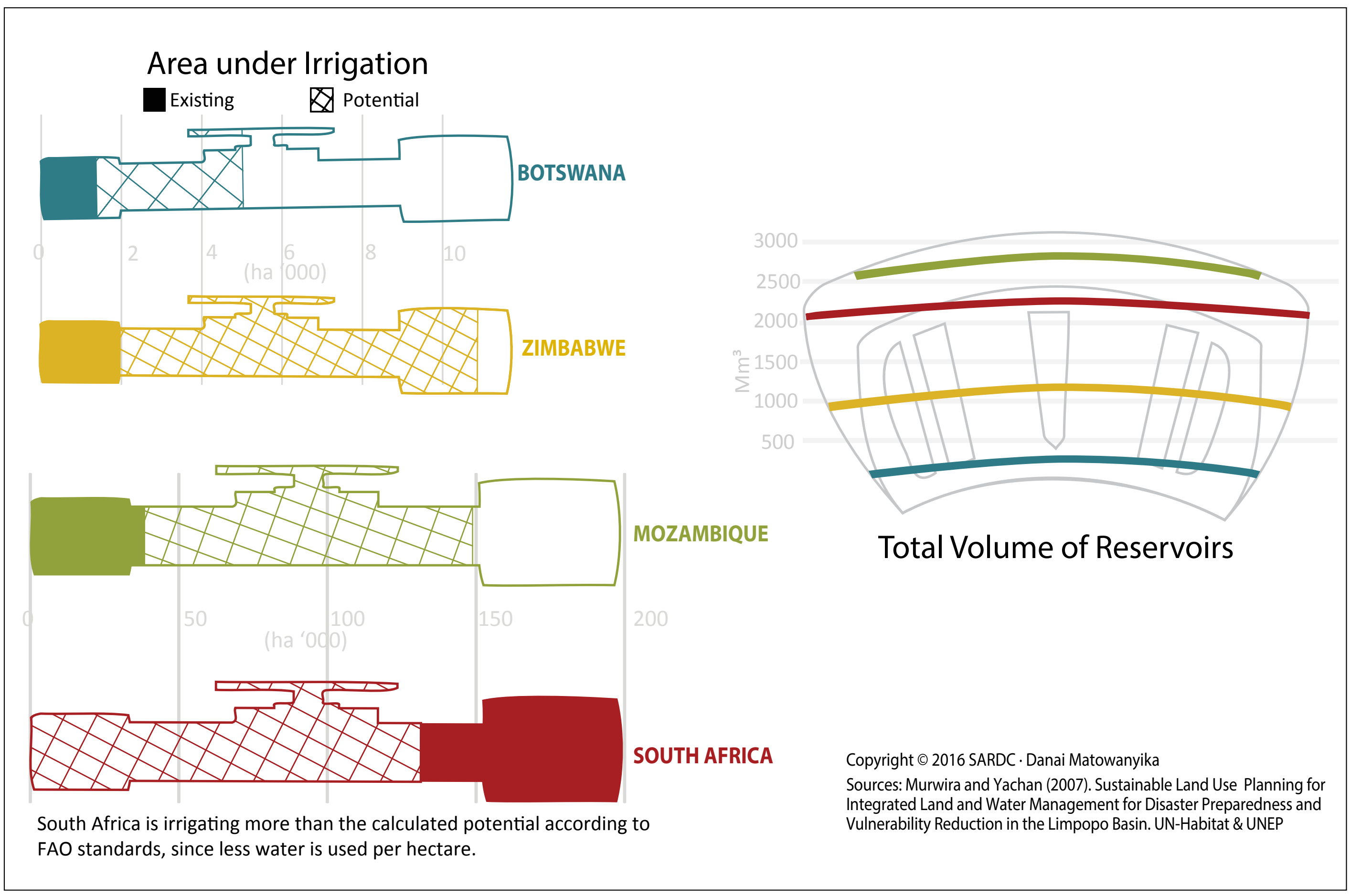
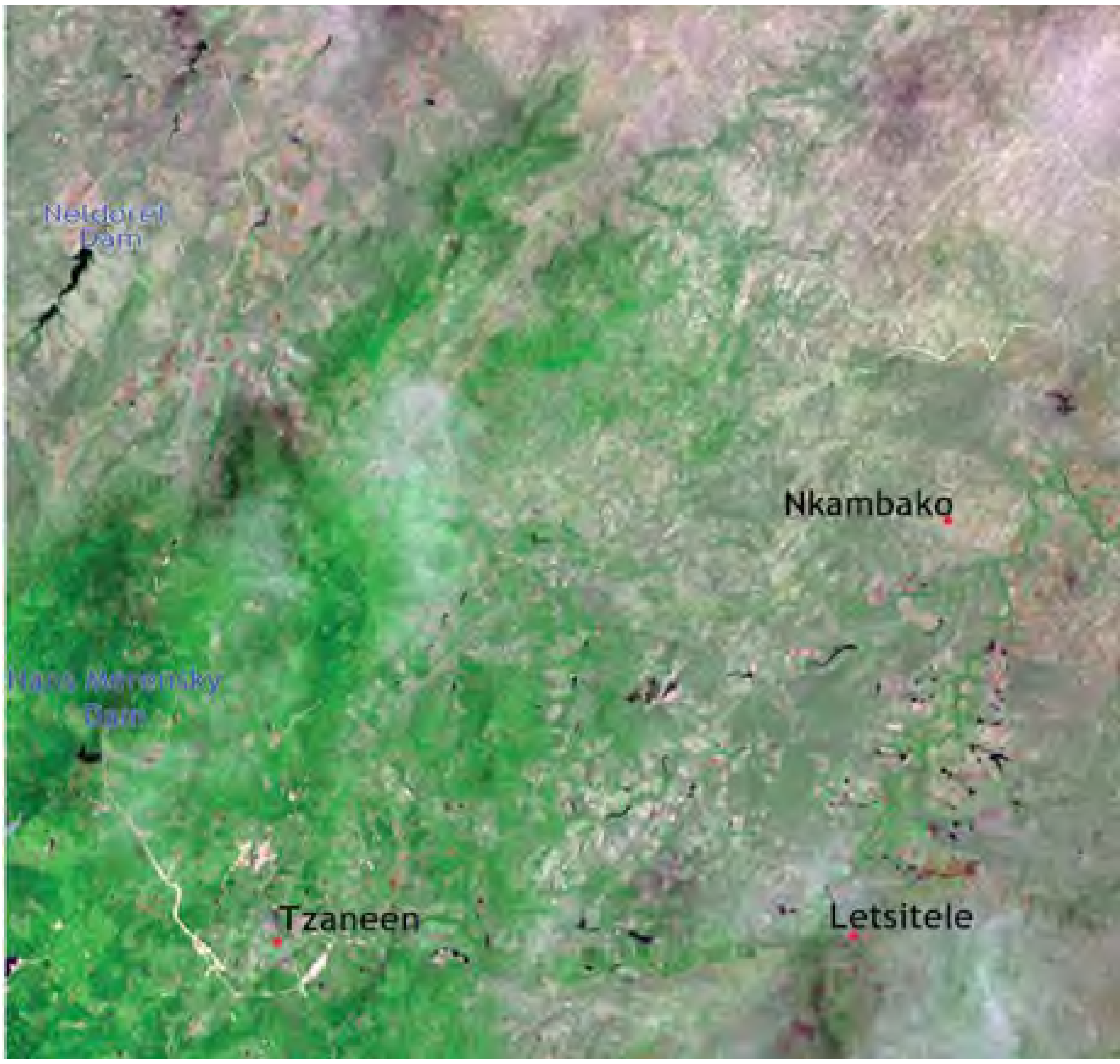
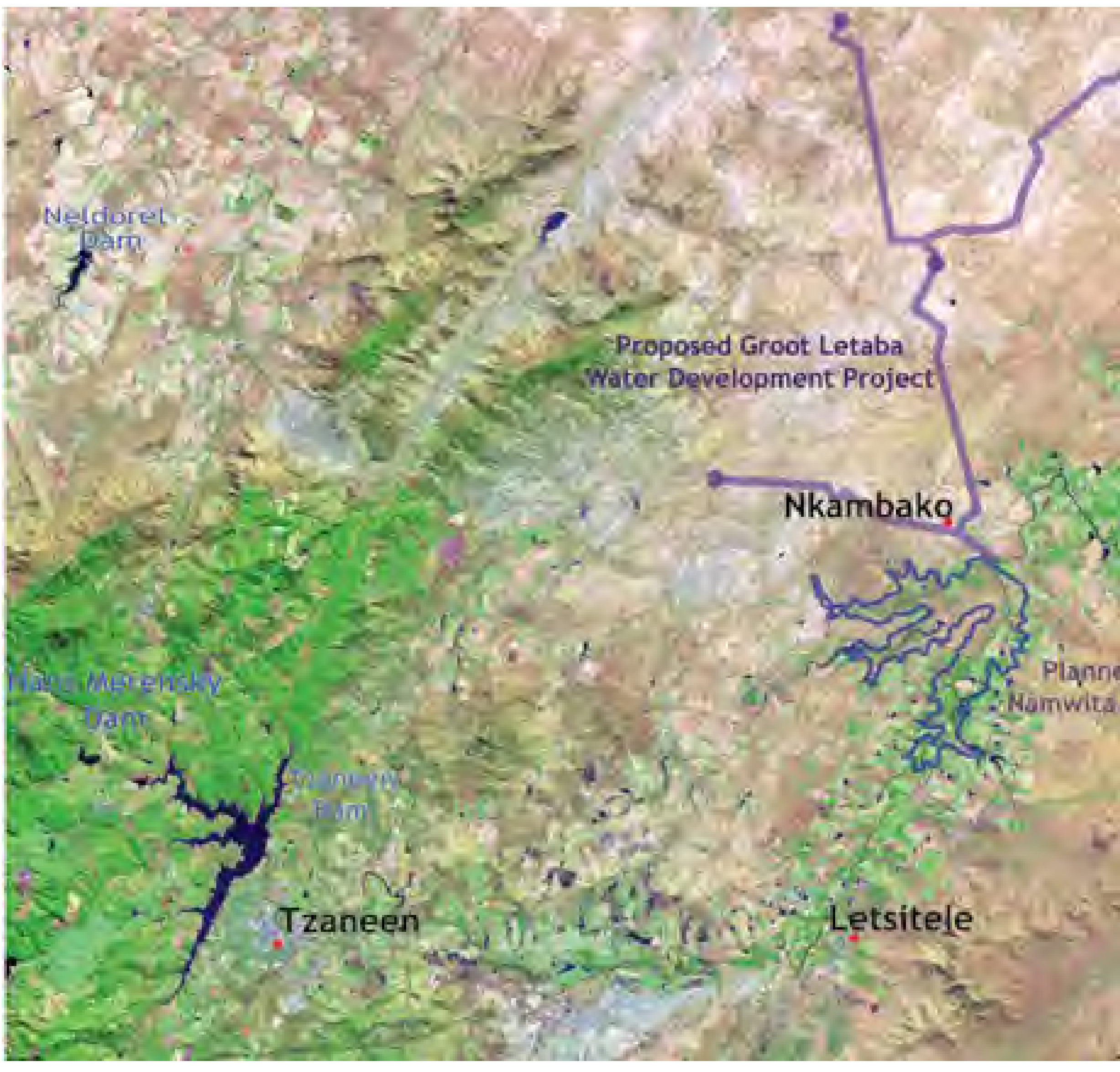


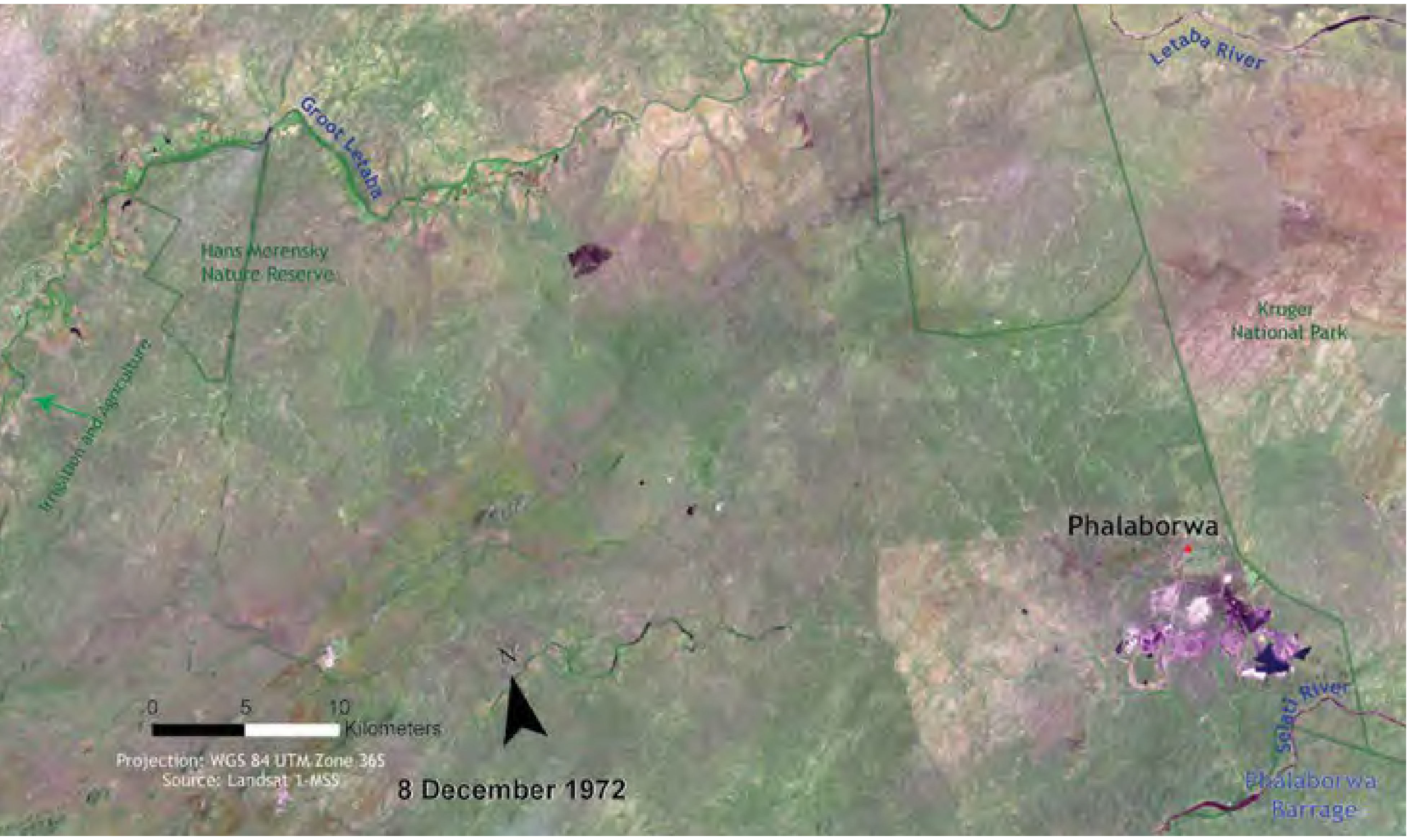
Figure 4.11 Current and Potential Irrigation in the basin

The total volume of reservoirs in basin is about 65 000 million cubic metres. Source: Murwira and Yachan 2007





The Groot Letaba water resource development project is a mega-infrastructure project in Letaba sub-basin to increase water storage and supply for irrigation, mining and growing urban areas (DWA 2010).


Letaba River
Groot Letaba
Hans Merensky
Nature Reserve
Kruger
National Park
Irrigation and Agriculture
Phalaborwa
Selati River
Phalaborwa
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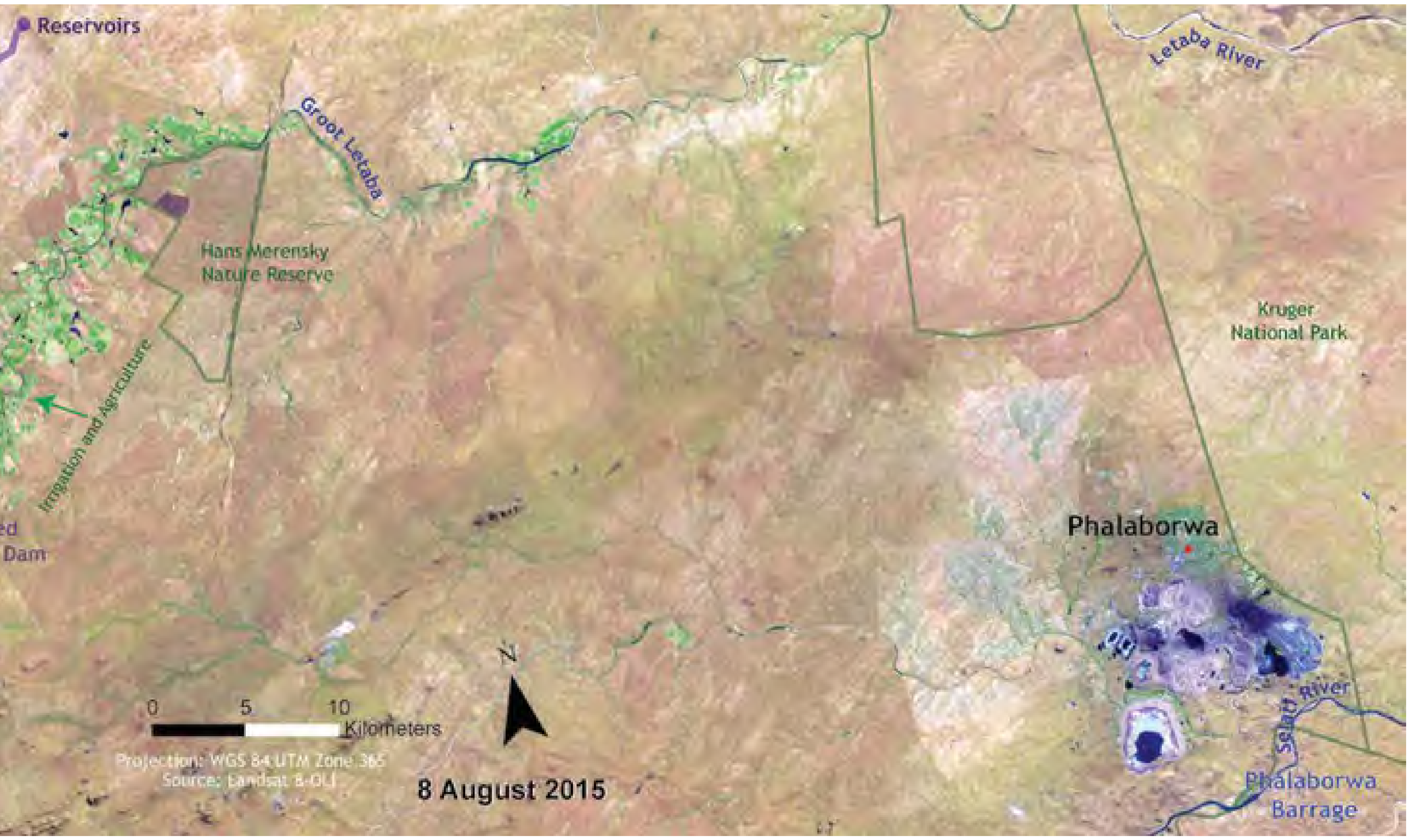
Projection: WGS 84 UTM Zone 36S
Source: Landsat 1-MSS
8 December 1972


Reservoirs
Letaba River
Groot Letaba
Hans Merensky
Nature Reserve
Kruger
National Park
Irrigation and Agriculture
Phalaborwa
Selati River
Phalaborwa
Barrage
N
0 5 10
Kilometers
Projection: WGS 84 UTM Zone 36S
Source: Landsat 8-OLI
8 August 2015

Chokwé Irrigation Scheme

Chokwé is about 220 km northwest of the Mozambican capital Maputo, and is accessible by road. Its irrigation area is 23,000 ha and before the civil war (1977–1992) more than 100,000 tonnes of rice were produced. The scheme's function was stagnated and rice production in the scheme dropped to one tenth of its peak as a result of civil war, changing economic system after independence, and the 2000 floods. Due to the impacts of floods, salinization, and lack of rehabilitation and maintenance, the usable irrigation area has dropped to just 7,000 ha.

A total of 176,564 inhabitants live in these villages (about 29,000 families), and are linked to the irrigation scheme by owning irrigated farms or as a source of labour for the commercial farmers and companies operating in the area.

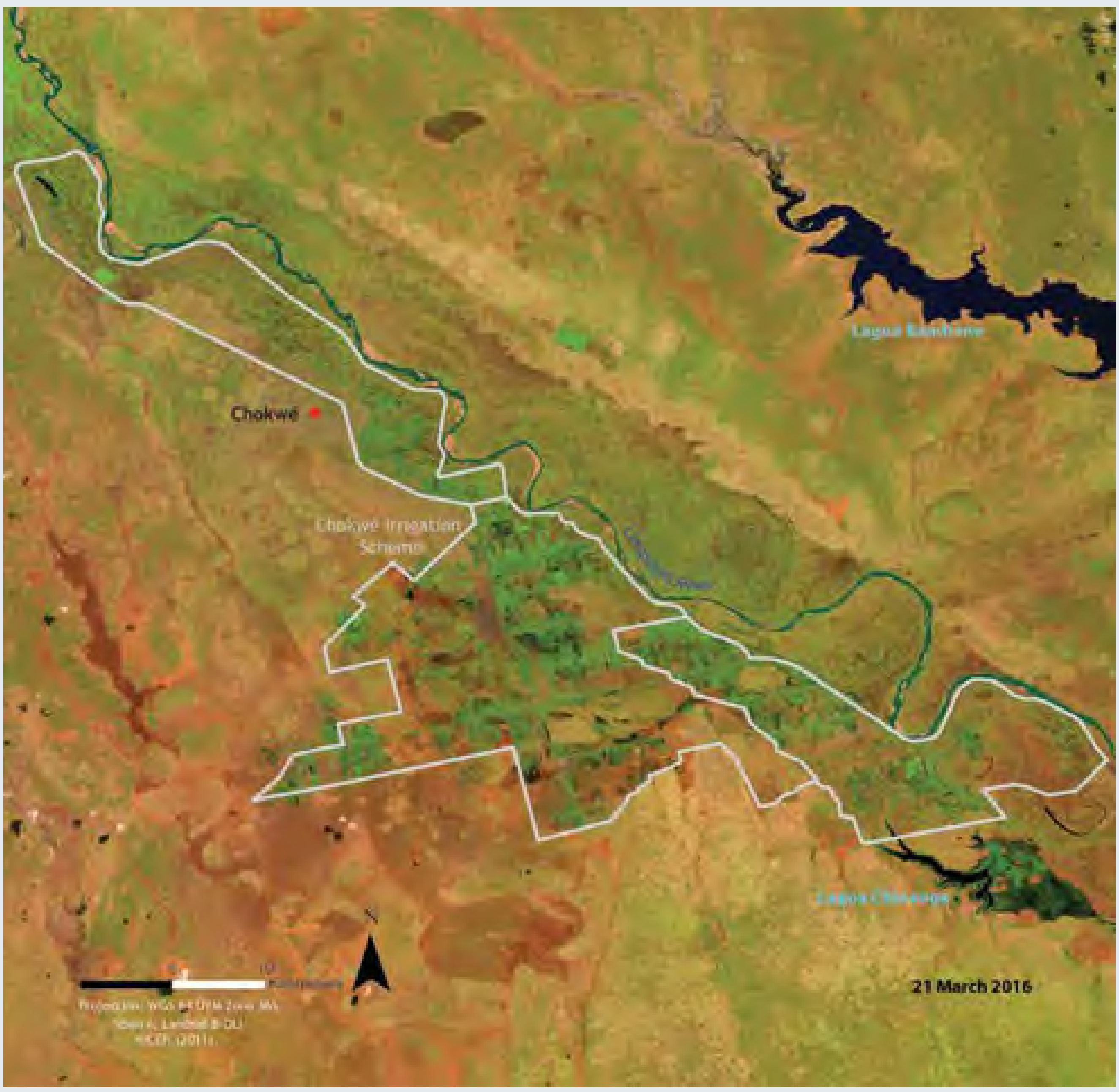
In 2010, the government announced plans to rehabilitate the country's largest irrigation scheme in a bid to guarantee the full exploitation of its potential.

Since then small portions of the irrigation scheme have undergone sporadic rehabilitation, but this has come nowhere near full recovery. The scheme still remains crucial for the government's plans to reduce the country's dependence on imported rice.

In 2010, the government reported that it had negotiated funding from the Islamic Development Bank to rehabilitate 7,000 ha of land in the irrigation scheme. Some of the key challenges cited by farmers include the degradation of access roads throughout the irrigated area, lack of involvement of the private sector in producing seeds, the high cost of agricultural inputs, and the low producer prices for their crops.

Large scale irrigation expansion on the Lower Limppo has downstream impacts that will create tensions with upstream water users, as the Limpopo River does not carry sufficient water for all planned initiatives.

Sources: SADC and SARDC 2002, HICEP 2011 van der Zaag and others 2010



Transport and Communications

Transport and communications play a pivotal role in the basin as it touches almost all the important sectors of the economy. The peace and stability in the region, particularly among the basin states saw increased demand for cross border trade and movement of people, resulting in increased demand for transport systems, services and facilities (SADC and SARDC 2008). At national level, the number of people travelling by air significantly increased across all the four countries since 2000. Zimbabwe for example, had 89,000 passengers travelling by air in 2000 and this number increased to 127,297 in 2012 (SADC 2013).

The key challenge affecting the region is poor allocation of resources and lack of financial resources for maintenance and rehabilitation causing existing infrastructure to deteriorate. This situation has prompted governments to implement policy reforms that promote market based and private sector led infrastructure and service provision, thus accelerating the pace of privatisation in the sector (SADC and SARDC 2008).

In terms of railways, the networks in the southern tier of SADC nations are in fairly good condition, with the exception of Mozambique due to the long period of civil strife. The Limpopo Line was also heavily damaged by the February 2000 floods (SADC and SARDC 2008).

At national level, rapid changes are taking place in information and communications systems. For example, internet access is expanding rapidly and the growth of mobile phones is spectacular (SADC and SARDC 2008) (also see tables 4.2 and 4.3).

Growth in number of people using mobile phones enhances access to vital information on markets, health services as well as general awareness, particularly in rural areas of the basin. Mobile phones are increasingly being used to transfer and receive money, thereby enhancing resilience and livelihoods of people in these areas.

Thanks to the increasing level of internet access and mobile phones, early warning messages reach affected areas quicker in case of a flood disaster.


Road networks enable easy movement of people in the basin

Table 4.2 Number of Mobile Cellular Subscribers in Basin States

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Botswana	106 029	222 190	332 264	444 978	522 840	571 437	825 076	1 153 768	1 559 102	2 390 868	2 644 982	2 900 263	3 081 726	3 274 542
Mozambique	51 065	152 652	254 759	435 757	708 000	1 503 943	2 339 317	3 079 783	4 405 006	5 970 781	7 224 176	7 855 345	8 108 480	15 583 820
South Africa	8 339 000	10 787 000	13 702 000	16 860 000	20 839 000	33 959 958	39 662 000	42 300 000	45 000 000	46 436 000	50 372 000	64 000 000	68 394 000	76 865 278
Zimbabwe	266 441	314 002	338 779	363 651	425 745	647 110	849 146	1 225 654	1 654 721	3 991 000	7 700 000	9 200 000	12 613 935	13 518 887

Source: SADC 2013

Table 4.3 Internet Users per 100 Inhabitants in Basin States

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Botswana	2.90	3.43	3.39	3.35	3.30	3.26	4.29	5.28	6.25	6.15	7.70
Mozambique	0.11	0.16	0.26	0.42	0.68	0.85	0.84	0.91	1.56	2.68	4.17
South Africa	5.35	6.35	6.71	7.01	8.43	7.49	7.61	8.07	8.43	10.00	12.30
Zimbabwe	0.40	0.80	3.99	6.39	6.56	8.02	9.79	10.85	11.40	11.36	11.50

Source: SADC 2013

Tourism

Tourism remains a significant contributor to the regional economy and plays a critical role in the alleviation of poverty (SADC 2015a). Looking at the Limpopo Basin, the tourism sector is crucial in providing an additional avenue for economic diversification and poverty reduction by empowering communities through the Community-based Natural Resources Management (CBNRM) programme (LIMCOM 2013). Conservation measures in the Limpopo basin comprise of reserves, parks, and wildlife management areas for nature and game preservation. A significant portion of the Limpopo River Basin is utilized for eco-tourism and conservation (FAO 2004).

In Botswana, tourism within the basin consists of game reserves due to wildlife populations residing along the east side of the Limpopo River, in the Tati farms, Mashatu and Gaborone Game Reserves, Khama Rhino Sanctuary, and in seven private game farms (LBPTC 2010). There are also historical sites such as Lepokole, Tswapong, Shoshong Hills, and the Moremi and Domboshaba ruins. There are two tourism sites that are not yet operational within the basin (Lepokole/Mapananda Community Project and Moremi Manonnye Conservation Trust) (LBPTC 2010).

In Mozambique, the coastal zone districts of Bilene, Mandlakazi, Massinga, and Xai-Xai are classified as high potential for beach tourism (LBPTC 2010). For South Africa, the northern half of Kruger National Park falls within the Limpopo River Basin (FAO 2004), and it also has a number of nature reserves such as Blyde River Canyon Nature Reserve. Gonarezhou National Park in Zimbabwe is part of the newly formed Greater Limpopo Transfrontier Park.

Table 4.4 shows trends in tourist arrivals in the four countries of the Limpopo Basin. South Africa is leading in tourist arrivals since 2000 followed by Zimbabwe. From 2010 there is a declining trend for Zimbabwe, while trends for Mozambique are improving. The declining trends for Zimbabwe could be attributed to the economic crisis experienced during that period.

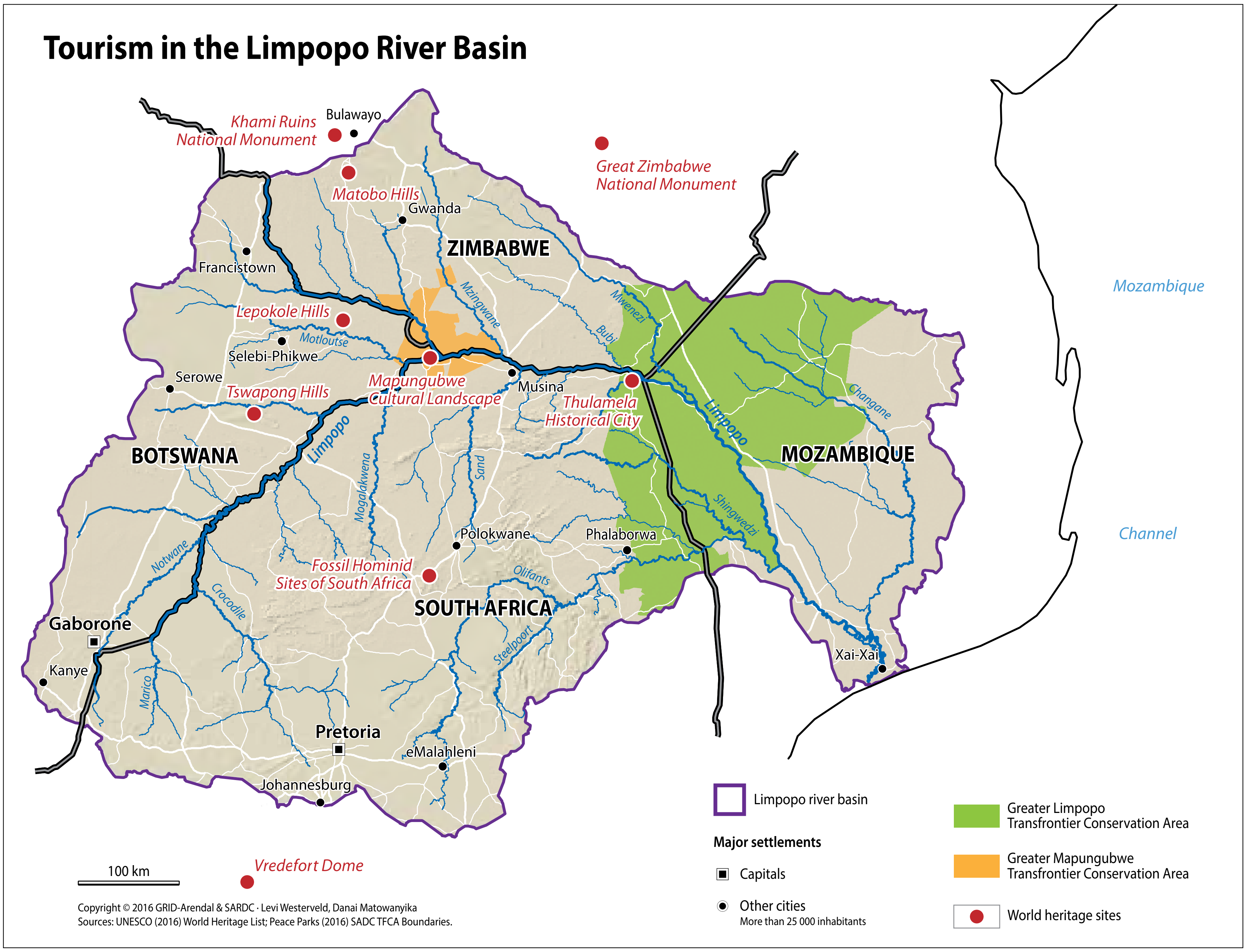


Figure 4.12 Tourism in the Limpopo Basin

Source: LIMCOM 2013

Among the very important, accessible and attractive historical sites in the basin are the great stone structures, built without mortar and now several hundred years old, such as Khami and other sites in Zimbabwe; sites in South Africa including Tulamela, near the Zimbabwe-Mozambique border; and Mapungubwe in Mozambique (see Figure 4.12). Historical tourism, as well as cultural tourism which is well promoted in South Africa, would seem to be a very important area for strengthening tourism receipts and economic development in the basin states (SADC and SARDC 2002).

Selling of curios to tourists provide incomes to communities

Table 4.4 Arrivals of Non-resident Tourists in Limpopo Basin states (thousands)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Botswana	1 104	1 193	1 274	1 406	1 523	1 474	1 426	1 455	1 500	1 594	n.a.	n.a.	n.a.	n.a.
Mozambique	n.a.	323	541	441	470	578	664	771	1 439	1 711	1 836	2 012	2 205	1 970
South Africa	5 872	5 787	6 430	6 505	6 678	7 369	8 396	9 091	9 592	16 544	19 377	20 436	22 257	23 855
Zimbabwe	2 420	2 763	2 990	4 479	5 488	4 320	6 538	3 179	2 513	2 756	3 308	1 552	1 745	1 945

Source: SADC 2013

FIFA World Cup 2010 South Africa – The first in Africa

South Africa recorded a remarkable 15% increase in tourist arrivals to the country in 2010 – outperforming the global average by 8%. While the FIFA World Cup in June and July played a role in the increase, tourist arrivals were buoyant all year round. Figures from the UN World Tourism Organization showed that global tourism arrivals were estimated to have grown by 6.7% in 2010. This meant that South Africa outperformed the global market by 8%. The Department of Tourism said 90% of the tourists who came for the World Cup had indicated that they would want to come to South Africa again, as the tournament had created a better image of the country.

Minister of Tourism in South Africa, van Schalkwyk, said in addition to more than 309,000 tourists arriving in South Africa for the primary purpose of attending the World Cup and a R3.6 billion boost to our economy, the survey shows that tourists were extremely satisfied with their experience in the country and would highly recommend the destination to friends and family. Tourist arrivals from January to September 2010 increased by 16.8% compared to the same nine months in 2009. From January to September 2010 saw more than 5.9 million tourist arrivals, compared to about 5 million last year.

Growth for the month of September 2010 was 12.9% compared to September 2009, with a total of more than 650,000 tourist arrivals. The overall average spent per tourist was R11,800, which is notably higher than the annual average spend in South Africa in 2008 (R8,400) and 2009 (R9,500). More than 30% of the money spent was on shopping, followed by 20% on accommodation, 19% on food and drink, 16% on leisure and 11% on transport.

Source: South African Tourism 2011, Minister launches results of survey on tourism impact of the World Cup. 8 November 2011.

An Emerging Society

Human Health

The level of access to social services is generally skewed across the basin states, due to various historical factors such as apartheid and its impact on both South Africa and Mozambique, in backing the post-independence war that ravaged the countries. In Zimbabwe social services were first affected by the structural adjustment programmes in the early 90s (SADC and SARDC 2002) and then by the economic challenges faced by the country in the decade 2000–2010.

HIV and AIDS takes a toll on the social services in the basin states, impacting various social, human and economic activities (SADC and SARDC 2002). Its impacts include increase in child, women and elderly-headed households. Child, women and elderly-headed households are highly impacted by climate related hazards such as floods. As such, the HIV and AIDS burden puts additional challenge for such households, and limits their ability to cope.

HIV and AIDS rates have however remained relatively consistent with the exception of Zimbabwe which has experienced huge drop in infections although it still remains a challenge in some of the Limpopo portions of the country (LIMCOM 2013).

Throughout Limpopo states, the relative HIV infection rate has decreased since 1999 due to increases in awareness, education and treatment and use of condoms (LIMCOM 2013). New HIV infections are also dropping in the riparian states due to implementation of robust HIV programmes. The impacts of climate change and environmental change are often felt more by those living with HIV and AIDS, as they are less able to deal with climate shocks and need to focus their resources on health care (Ziervogel and Drimie 2008). In all the four countries, it is important to note that women carry the greatest burden of the HIV pandemic, with HIV prevalence higher than that of men. The high HIV prevalence in women is believed to be a result of the physiology of women (LIMCOM 2013).

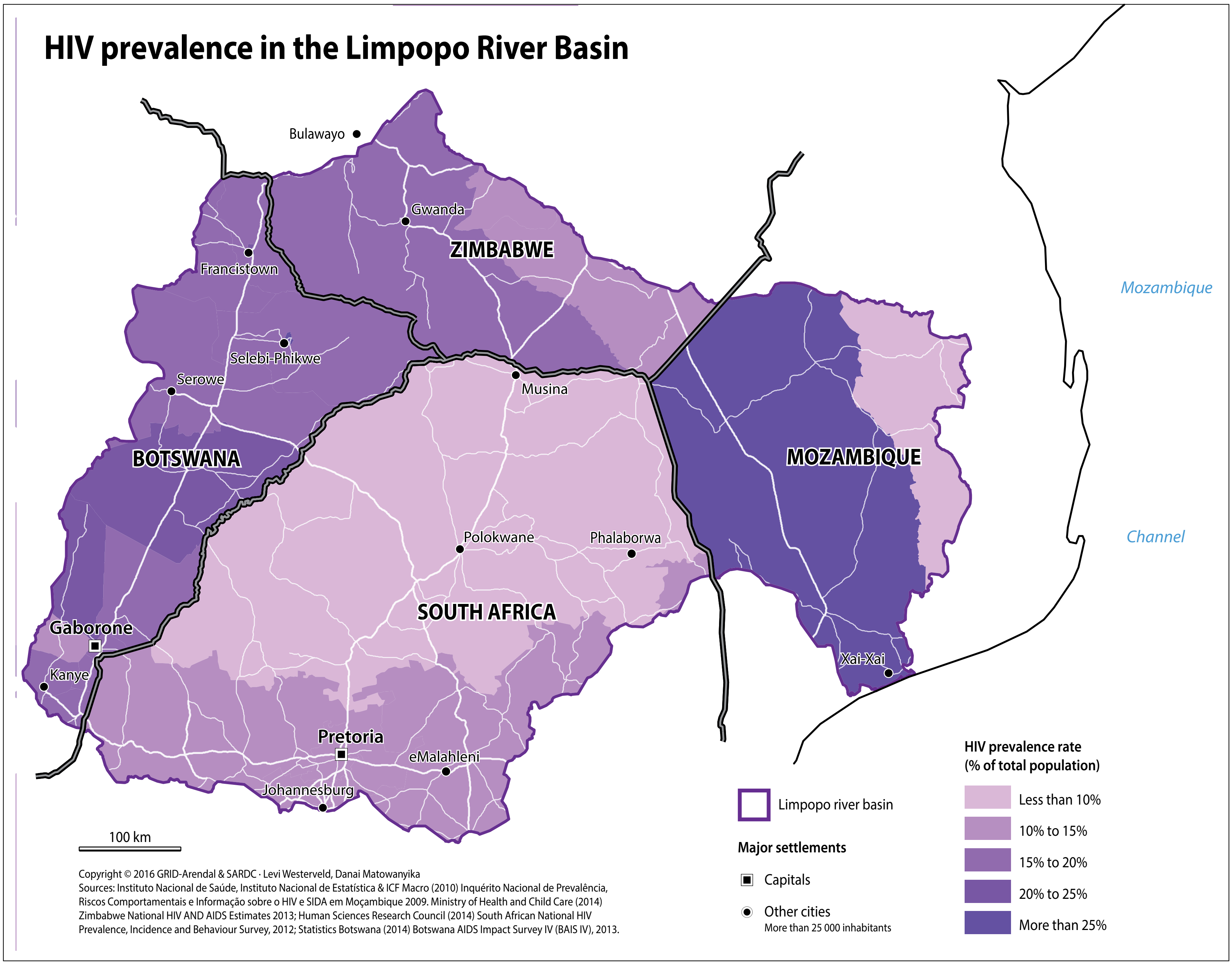


Figure 4.13 HIV Prevalence in the Limpopo River Basin

Response to HIV and AIDS in Zimbabwe

As part of the nation's attempts to raise funds for the control and management of HIV and AIDS the Government of Zimbabwe introduced the National AIDS Trust Fund (also called AIDS Levy) which entails collection of 3% of all taxable individuals and corporates incomes to fund HIV and AIDS programmes.

There has been introduction and integration of family planning with HIV/STI and maternal health services voluntary counselling and testing (VCT), prevention of mother-to-child transmission (PMTCT) including primary care to identify the infected individuals with the intention of preventing both horizontal and vertical transmissions. Widowhood plays an important role in the transmission and has been associated with 8–17% of all HIV cases.

The epidemic in Zimbabwe is believed to be declining as a result of programmes such as male circumcision. Since 2009, Zimbabwe has provided circumcision to adult and adolescent men through a collaborative effort between the government and technical agencies with the aim to reach 1.2 million 15–29 year-olds by 2015. Decline could also be due to the early adoption of a home-based care policy by the Zimbabwean government which also inadvertently accelerated the process of behaviour change. It has been hypothesized that when AIDS patients die at home, an experience that offers an opportunity among close family members and friends to have direct confrontation with AIDS morbidity and mortality, is more likely to instil fear of acquiring HIV and AIDS compared to a situation when they are primarily cared for in health institutions.

Source: Duri and others 2013

Other health risks are also a concern under changing climate conditions. There is a particular concern about the increased occurrence of vector-borne diseases. In Botswana, there is likely to be a significant increase in the proportion of the population living in malaria prone areas by 2021 (Urquhart and Lotz-Sisitka 2014).

Limited cases of water-borne diseases have been recorded at basin level. Cholera however has been reported at SADC regional level resulting in increased morbidity and mortality (UN OCHA 2013). The worst outbreak of the past decade in southern Africa occurred outside the basin in Harare, Zimbabwe between August 2008 and February 2009 when 83,265 cases and 3,877 deaths were recorded, with a case fatality rate of 4.7 percent (see table 4.5).

For countries in southern Africa, the social-cultural dimension of cholera is extremely important, as communities often hold ideas and beliefs about the spread and treatment of cholera that often perpetuate the spread of the disease and must be taken into account in planning prevention and control programmes (UN OCHA 2013).

Table 4.5 Cholera Outbreaks/Acute Watery Diarrhoea in Selected Countries (August 2008–February 2009)

Country	Cases	Deaths	Case Fatality Rate (CFR)
Botswana	8	1	12,5%
Mozambique	6,124	66	1,1%
South Africa	11,461	58	0,5%
Zimbabwe	83,265	3,877	4,7%

All figures given are for national and not specific to areas within the Limpopo Basin
Source: UN OCHA 2013


Women play an important role in families, including water collection and family health


Water treatment works help in provision of clean water

Education

Access to education and literacy rates improved considerably in the post-independence period. Primary and secondary education are readily available in the Limpopo Basin. With the exception of Botswana and South Africa, residents of the basin have to go outside the basin for specialised tertiary level training.

The accession to democracy and independence of the four basin states spans a period from 1966 to 1994, and the educational systems, skills and literacy reflect that divide, as well as the impact of the apartheid system in South Africa and the extended conflict in Mozambique. The educational levels and technical skills available in each country affect their capacity to develop and protect the Limpopo River Basin (SADC and SARDC 2002).

In Mozambique, literacy levels improved from 43 percent in 2000 to 49.9 percent in 2014 while in Botswana, it improved from 81.2 percent in 2003 to 88.6 percent in 2014. In South Africa literacy levels increased from 92.9 in 2009 to 94.1 percent in 2014. Zimbabwe's literacy level continues to rise standing at 98 percent in 2014 up from 88.7 in 2000 (SADC 2014).

The occurrence of floods and droughts in the basin negatively affects attendance of children in schools as they are sometimes forced to stay home mainly as a result of floods. A study undertaken in Xai-Xai Mozambique in 2001 indicated that 23 percent of the children interviewed indicated that they were, at times, not studying as a result of floods (UNDP 2002).


Education is vital for development.


The majority of the basin's population is of school-going age groups.

Transboundary Economic Opportunities

The Limpopo River Basin is an important intersection of the intra-regional trade network, particularly through the Beitbridge border post (see Figure 4.14). One of the key expectations from the private sector about the SADC Trade Protocol is that border posts should operate 24 hours a day to facilitate speedy flow of goods and services and reduce transit costs. Beitbridge is currently the busiest border post in the basin (SADC and SARDC 2002). The well-developed road and rail transport network of the basin, however, facilitates easy links between the north and the south of the Limpopo (especially South Africa, Botswana and Zimbabwe), while the network linking the east to the west is long and winding. However, the basin's road and rail networks are in different conditions, with the road network linking Botswana, South Africa and Zimbabwe being generally good and tarred all round. As the road system accounts for the vast majority of surface transport in the region, SADC aims to sustain its current successes in this sector and improve upon them as the region develops in the future (SADC 2012).

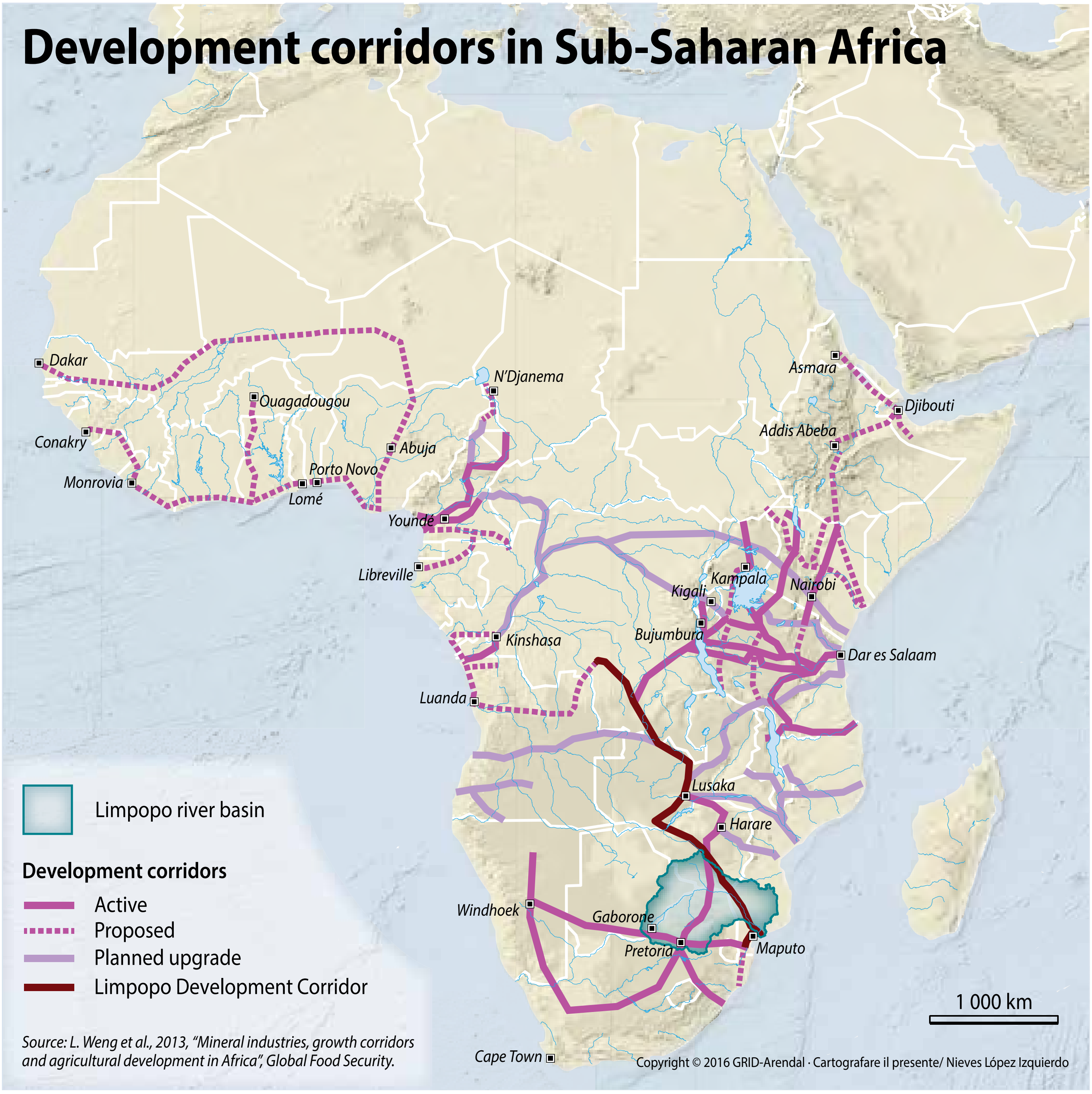


Figure 4.14 Development Corridors in Sub-Saharan Africa

5

TRANSBOUNDARY WATER MANAGEMENT IN THE LIMPOPO – OPPORTUNITIES FOR SUSTAINABILITY

Water resources shared by countries pose complex political and management challenges. While it is widely acknowledged that international waters have created some opportunities for fostering regional economic cooperation and political integration through cooperative development, the added complexity can lead to tension and undermine the development of common resources (World Bank Group 2015). These challenges can be accentuated by increasing competition between different sectors within riparian states and the prospects of climate related risks. It is against this background that cooperative river basin planning and management can overcome some of these challenges. However, when water management institutions needed to address these tensions are weak and fragmented, successful cooperation will take longer than envisaged.

Groundwater is the major source of safe drinking water for rural communities.

When institutions and policies are weak, agencies with authority over a particular economic sector can make uncoordinated decisions about water allocation and use, which lead to inefficiency and degradation of the resource. Therefore, the cost of noncooperation becomes high, including the economic cost of negative environmental impacts, suboptimal water resource development, political tensions over shared resources, and the forgone benefits of joint water resource development (World Bank Group 2015).

As such, a multi-purpose, integrated and cooperative approach has the clear potential not only to help riparian countries build economic resilience to climate change, but more importantly, to diversify their economies. Multi-purpose cooperative water resource development has the potential to offer significant benefits to such countries, provided that appropriate water governance institutions manage the complex dynamics of multi-country development backed by enabling policies.

Water resources of the Limpopo Basin remain imperative for development and environmental management within the region. The shared water and other natural resources present an opportunity for both cooperation and conflict. Differing socio-economic contexts and the different levels of development among the Limpopo countries has resulted in uneven distribution and use of water resources as shown by the different environmental water requirements needed for each country (LIMCOM 2013). A coordinated effort for sustainable utilization is important to boost cooperation and avert conflict. Various transboundary management arrangements exist at the regional, basin and national levels that can be used to foster effective transboundary management. These arrangements range from bilateral to multi-lateral as reflected in the changing political, social, economic, policy and institutional landscape within the region.

Noting that land and water resources within the Limpopo River Basin are heavily utilized by all four riparian states (LIMCOM 2013), access to and use of these resources are of critical strategic significance to development in the basin. Arguably, the basin is strategically important to each of the four riparian countries for varied reasons.

In Botswana for example, these resources support the bulk of the human population that live in a belt wedged between the Kalahari Desert and the narrow belt of better-watered land adjacent to the South African border (LIMCOM 2013).

For South Africa, water resources in the basin sustain mining and agriculture, as well as a large human population, and substantially contributes to the ecological resource for the Kruger National Park.

In Zimbabwe, water resources in the basin are the only reliable and significant source of water other than the Zambezi, the latter for political reasons at present being difficult to develop for irrigated agriculture (LIMCOM 2013).

For Mozambique, the Limpopo is the only reliable water in a very arid portion of the country with a moderate population density and significantly contributes to irrigated agriculture in the Chokwé belt. It is important to note that though the greatest user of water by sector in the four Limpopo River riparian states is irrigation, which takes approximately 50 percent of the total water demand, large urban centres such as Gaborone, Pretoria, Johannesburg and Bulawayo are major users of water resources within the basin (CPWF 2014; LIMCOM 2013; LBPTC 2010).

Key drivers/pre-conditions for regional cooperation, policy and institutional changes in the basin

- Net benefits of cooperation are percieved to be greater than net benefits on non-cooperation, and the distribution of these net benefits is percieved to be fair
- Riparian state-driven transboundary programmes and projects effectively generate socio-economic benefits and gender-inclusive poverty reduction
- Shared knowledge, data and analytical tools contribute to trust and confidence among riparian states, and form the basis of effective transboundary coordination around institutions and investments

Figure 5.1 Key Drivers of Cooperation, Policy and Institutional Changes in the Limpopo River Basin

Institutional and Policy Arrangements

SADC Regional Water Policy

The SADC Regional Water Policy (RWP) and Regional Water Strategy (RWS) lay down regionally agreed policy guidelines concerning water resources management, covering a wide range of areas from infrastructure development, information exchange, capacity building to gender aspects and stakeholder involvement. They are important guides for the ongoing harmonisation of national water policies of the SADC Member States, and also inform the implementation of the SADC Regional Indicative Strategic Development Plan (RISDP), SADC Regional Strategic Action Plans (RSAP) and related development plans of the SADC (LIMCOM 2013).

The RWP and RWS are based on the concept of Integrated Water Resource Management (IWRM) and furthermore recognise the importance of regional cooperation over water resources and the need to manage water resources in an integrated manner (Malzbender and Earle 2007), specifically highlighting the need for regional integration as well as cooperation between all affected (water use) sectors (SADC 2005).

The RWP promotes the establishment and development of transparent institutions and the involvement of stakeholders in water management decision-making.

Principles of Revised SADC Water Protocol

The Revised SADC Protocol on Shared Watercourses (SADC 2000) is a framework agreement, which contains the generic rules for the management of shared rivers within the SADC region, but does not contain basin-specific rules. The Revised SADC Protocol on Shared Watercourses establishes a legally binding framework for transboundary water management in the region. It provides the general direction and principles for

SADC Regional Water Policy (RWP) and River Basins

In line with the provisions of the Revised SADC Protocol, the RWP calls for the establishment of Shared Watercourse Institutions (SWCI) on each shared watercourse (Policy 9.2.2), which shall promote stakeholder participation in decision-making (Policy 9.2.8) (Malzbender and Earle 2007; Earle and others 2006). The policy speaks on stakeholder participation and capacity building, stating that water resources management and development at all levels shall be based on a participatory approach (Policy 10.1) and that stakeholders need to be empowered to effectively participate in such decision-making (10.1.2) (Malzbender and Earle 2007).

Revised SADC Protocol on Shared Watercourses and Limpopo Basin

The link between the Revised SADC Protocol and the basin-specific rules is made in Article 6 (3) of the Protocol, stating that "watercourse states may enter into agreements, which apply the provisions of this Protocol to the characteristics and uses of a particular shared watercourse or part thereof" LBPTC 2010).

Main points of the Revised SADC Protocol on Shared Watercourses

- Ensuring that utilisation of shared watercourses is open to each riparian state without prejudice to its sovereign rights;
- Observing the objectives of regional integration;
- Ensuring that all interventions are consistent with sustainable development;
- Respecting the existing rules of customary and general international law;
- Recognising the unity and coherence of each shared watercourse system;
- Maintaining a balance between water resources development and conservation;
- Pursuing close cooperation in the study and execution of all projects on shared watercourses, exchange of information and data;
- Utilising a shared watercourse in an equitable and reasonable manner;
- Maximising the benefits from a shared watercourse through optimal and sustainable development;
- Participating and cooperating in the use, development and protection of a shared watercourse;
- Taking all appropriate and reasonable measures when utilising a shared watercourse to prevent significant harm to other states;
- Eliminating or mitigating such harm and where appropriate, discussing and negotiating the possibility of compensation; and
- No state shall deny anyone the right to claim compensation or other relief in respect of significant harm caused by activity carried out in a shared watercourse.

Source: SADC 2000

Transboundary Water Management in the Limpopo Basin (South Africa and Mozambique)

With the focus on regional and international policies to adapt to water scarcity and other related impacts, transboundary water security is placed high on the agenda and involves regional scale policy measures, based on political agreements and research development, which tackles climate change impacts through ensuring water needs are met and can continue to provide a sustainable water supply in the future. Water scarcity in the Limpopo Basin between South Africa and Mozambique not only pertains to seasonal variability but also to increasing climatic changes, and as a result existing agreements on the use and distribution of water need to be re-examined to assess their rigidity in order for the agreements to account for climate change variability as well (Davis 2011). Furthermore, a 'benefit sharing' approach of the basin between South Africa and Mozambique provides an alternative focus from water sharing to water sharing benefits – that is the rewards that come from the basin are distributed between the two countries based on the broader context of uses derived from the basin (Davis 2011). As a result, more use can be made from the benefits of the basin than simply as a source of water, which shows a shift in views from that of rigidity to that of growing adaptation given the impacts of climate change in the region and the need to fuel alternative strategies.

Source: FARNPAN 2011

any future watercourse agreements concluded in the SADC region, while at the same time allowing for the consideration of certain characteristics that may be specific to the watercourse in question (LIMCOM 2013).

The Revised SADC Protocol on Shared Watercourses contains the key rules of international water law, i.e. "equitable and reasonable utilisation" (Article 3 (7)) and the "duty to take reasonable measures to prevent significant harm" (Article 3 (8)). It furthermore, among others, contains provisions dealing with notification and consultation requirements regarding planned measures and rules on pollution prevention, reduction and control (LIMCOM 2013).

Furthermore, the Revised SADC Protocol on Shared Watercourses establishes an institutional framework at the regional level for the implementation of the instrument. In Article 5 it establishes the SADC Water Sector Organs and mandates them as well as Shared Watercourse Institutions with the implementation of the Protocol. In practice, the SADC institutions are currently mandated primarily with monitoring functions concerning the application of the Revised SADC Protocol on Shared Watercourses as well as with facilitating the harmonisation of water law and policy between SADC member states (LIMCOM 2013:172). SADC institutions are not mandated with the implementation and enforcement of basin-wide agreements. Where those have been concluded this is done by Shared Watercourse Institutions as well as the domestic institutions in the countries that are party to the basin-wide agreement.

Table 5.1 Transboundary Institutions Established Within the Limpopo River Basin

Institution	Responsibility
Limpopo Basin Permanent Technical Committee (LBPTC)	Established in 1986 by Botswana, Mozambique, South Africa and Zimbabwe to advise the parties on transboundary issues related to the management and utilisation of the Limpopo.
Joint Permanent Technical Commission (JPTC)	Formalised in 1987 between Botswana and South Africa on the management of Limpopo, Molopo and Nossob Rivers. One of the key outputs of the JPTC was the Joint Upper Limpopo Basin Study (JULBS), which was made to investigate a range of issues including the evaluation of the most successful and cost effective way of jointly exploiting and regulating the main stem river.
Joint Water Commission (JWC)	Formalised in 1996 to provide a technical forum to advise the two Governments of Mozambique and South Africa on technical matters relating to the development and utilisation of water resources of common interest.
Joint Permanent Commission for Co-operation (JPCC)	Established in 1997 between Botswana and South Africa with the aim of dealing with a variety of operational issues, including the transfer of water from the Molatedi Dam on the Marico River.
Limpopo Watercourse Commission (LIMCOM)	Established in 2003 to advise the Contracting Parties and provide recommendations on the uses of the Limpopo, its tributaries and its waters for purposes and measures of protection, preservation and management of the Limpopo.

Source: LIMCOM 2013

LIMCOM Agreement

The Agreement on the Limpopo Basin Permanent Technical Committee was signed by representatives from Botswana, Mozambique, South Africa and Zimbabwe in 1986. Whilst it appears that the LBPTC was relatively inactive for a period during the mid-1990s, the LBPTC was important in that it provided a platform to ensure that dialogue and negotiation occurred between the riparian countries leading to the establishment of the Limpopo Watercourse Commission (LIMCOM). In 2003 representatives from Botswana, Mozambique, South Africa and Zimbabwe signed the Agreement on the establishment of the Limpopo Watercourse Commission. The agreement was then ratified by Member States in 2011 (LIMCOM 2013). Table 5.1 shows the evolution of transboundary institutional arrangements over time.

The Revised SADC Protocol mandates (in Art. 6 (3)) watercourse states to enter into basin-specific agreements in line with the legal principles of the Revised SADC Protocol (LIMCOM 2013). In 2003 the Limpopo River Basin states concluded an agreement on the establishment of the Limpopo Watercourse Commission (hereafter LIMCOM Agreement), which entered into force in 2011 after the ratification requirements were met. The LIMCOM Agreement is only the second (after the 1986 Agreement establishing the Limpopo Basin Permanent Technical Committee - LBPTC) basin-specific agreement to which all four basin states are Parties (see Table 5.1). While there is a long-standing history of cooperation on the Limpopo, all agreements except the LBPTC Agreement and the LIMCOM Agreement, are bilateral agreements (LIMCOM 2013). In terms of Art. 12 (3) of the LIMCOM Agreement, the LBPTC Agreement lapses with the entry into force of the former, with LIMCOM replacing the LBPTC as the basin-wide cooperative mechanism. The purpose of the LIMCOM Agreement is to establish LIMCOM and define the Commission's objective, functions and powers as well as the institutional arrangements and operational rules (LBPTC 2010; LIMCOM 2011; LIMCOM 2013). The LIMCOM Agreement establishes the LIMCOM as a technical advisor to the Parties (Art. 3 (1) & 7 (1)) on matters relating to the development, utilisation and conservation of the water resources of the Limpopo. The LIMCOM comprises of the Council, as the principal organ of the commission, as well as a secretariat and a number of task teams (see Figure 5.2). There is a proposal for establishment of Council of Ministers above commissioners.

Members of the LIMCOM Technical Task Teams

Interim Secretary of LIMCOM speaking with a stakeholder

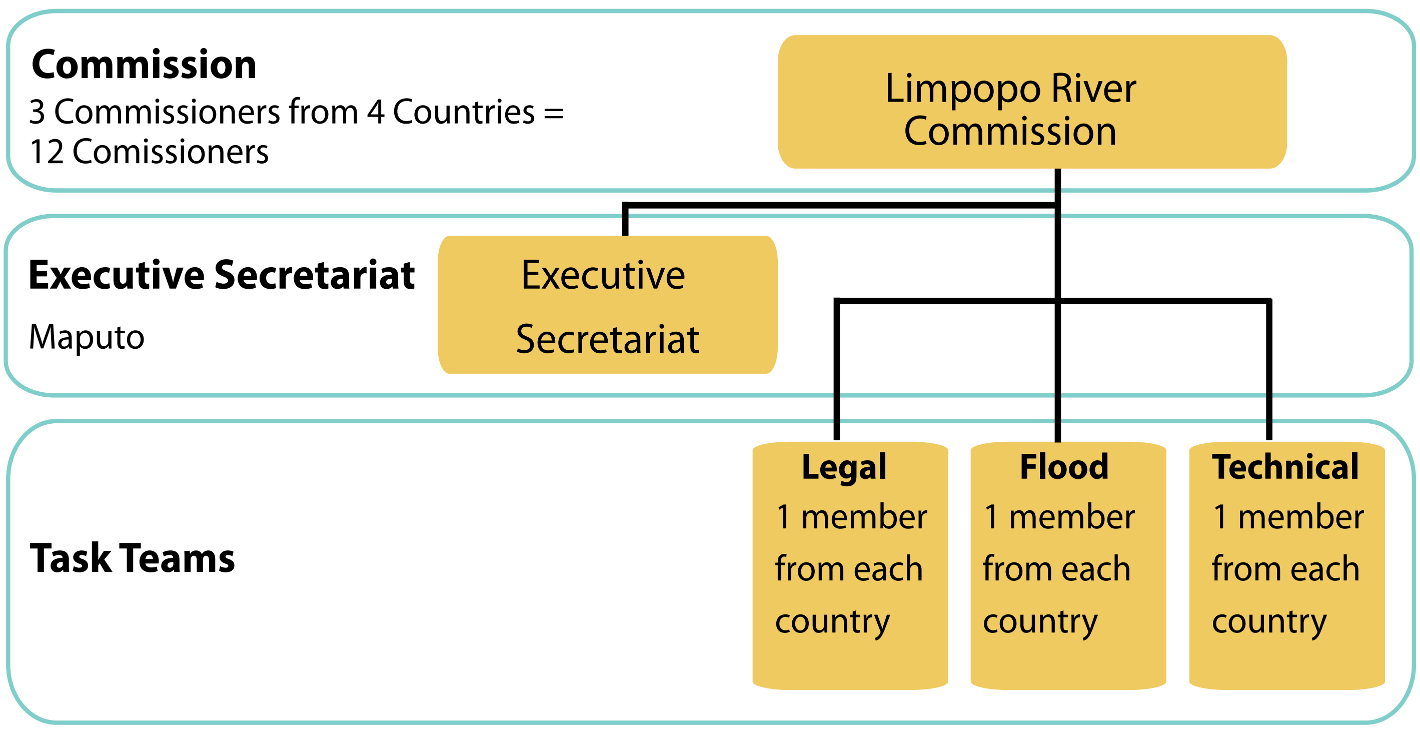


Figure 5.2 Structure of the Limpopo Watercourse Commission

Source: LIMCOM undated

Agreement on the Establishment of LIMCOM

Article 3: Objectives of the Commission and General Principles of the Agreement

3.1 The objectives of the Commission shall be to advise the Contracting Parties and provide recommendations on the uses of the Limpopo, its tributaries and its waters for the purposes and measures of protection, preservation and management of the Limpopo.

3.2 For the purposes of this Agreement the general principles of the Revised Protocol on Shared Watercourses (Protocol) shall apply to, in particular:

a) Sustainable Development;
b) Inter-generation equity principle;
c) Prevention principle;
d) Transboundary impact assessment principle

Article 7: Functions of the Council

7.1 The Council shall serve as technical advisor to the Contracting Parties on the matters relating to the development, utilisation and conservation of the water resources of the Limpopo. The Council shall perform such other functions pertaining to the development, and utilisation of water resources as the Contracting Parties may agree to assign the Council.

7.2 The Council shall advise the Contracting Parties on the following:

a) Measures and arrangements to determine the long term safe yield of the water available from the Limpopo;
b) The equitable and reasonable utilisation of the Limpopo to support sustainable development in the territory of each Contracting Party and the harmonisation of their policies related thereto;
c) The extent to which the inhabitants in the territory of each of the Contracting Parties concerned shall participate in the planning, utilisation, sustainable development, protection and conservation of the Limpopo and the possible impact on social and cultural heritage matters;
d) All aspects related to collection, processing and dissemination of data and information with regard to the Limpopo;
e) Contingency plans and measures for the preventing and responding to harmful conditions whether resulting from natural causes such as drought or human conduct as well as emergency situations that result suddenly from natural causes such as floods or human conduct such as industrial accidents;
f) The investigations and studies, separately or jointly by the Contracting Parties with regard to the development of the Limpopo including the construction, operation or maintenance of and water works;
g) Measures with a view to arriving at settlement of a dispute; and
h) Any other matters affecting the implementation of the Protocol

7.3 In making any recommendations or giving any advice in terms of the Article, the Council shall consider the provisions of the Protocol

Limpopo River Basin IWRM Plan (2011–2015)

The first IWRM Plan (2011-2015) provided a framework for the implementation of the LIMCOM agreement with the main goal being;
"To develop the capacities (individual, organisational and institutional) in the riparian states for the sustainable management and development of the Limpopo River Basin"

The IWRM plan defines three strategic areas; Water Governance, Water Management and Water Resources Development. Through this IWRM plan, important studies such as the Limpopo Basin Monograph and development of the Limpopo River Awareness Kit were carried out. The plan also guided LBPTC activities and set groundwork for future developments to improve transboundary management in the basin.

Indigenous and Community Institutions

Earle and others (2006) studied and analysed the evolution of indigenous governance structures and their interface with statutory frameworks in terms of the socio-political history that is specific to each of the riparian states, given their unique experiences. But local-level studies demonstrate that basin communities have their own traditions, values, priorities and institutional mechanisms for solving natural resources management problems, and these may have little in common with those imposed from elsewhere (often top-down as well as transnational in nature). This disconnect between local-level perspectives and the principles underlying budding transnational institutions may be an additional impediment to achieving effective cooperation on river basin management (Merrey 2009).

The relationship between the current state and traditional/indigenous regimes is a crucial area of inquiry for basin management, particularly because of the uneven success of state interventions. While the state has managed to claim the legal and administrative domain, there is still opportunity available for indigenous water management systems to prosper. Given that the Limpopo Basin is predominantly inhabited by people speaking languages of the Bantu linguistic family, an analysis of the language and population groups in the four basin countries shows that some groups were found across nation-state boundaries and that different ethnic groups were also found to be living in the same locality (Merrey 2009).

There were also similarities across the basin countries in the way that institutions associated with rain-making ceremonies were structured. Despite the similarities, it should be noted that social interactions between different ethnic groups within the same geographical locality shaped water management practices and traditional governance structures. It is further argued that what is currently perceived as 'indigenous' is a construction of political and social interactions of various groups of people within defined but fluid historical periods (Earle and others 2006; Merrey 2009).

A few case examples exist to illustrate this versatility and dynamism of indigenous institutions. Makamuri (1995) noted that water resources among the Kalanga were guarded by animal water guardians, e.g., mermaids, particular fish types and snakes. This ordering of the universe is different from rainmaking amongst other Bantu speaking cultures in southern Africa. For example, the Nguni see rainmakers as special "herbalists," not chiefs, a tradition of sacred leadership reiterated amongst the rain-queens. Thus, a noble leader's power was based, in part, on the claim that his or her ancestors would intervene to ensure the fertility of the land and its people.

Rainmaking ceremonies would usually take place on steep-sided hills that were inaccessible to commoners. The ability of a leader to induce a deity to provide rain determined how powerful the leader was. Periods of climatic perturbation, such as drought would lead to changes in the political powerbase, with evidence emerging of population shifts from one site to another corresponding to changes in the climatic regime (Huffman 2000), Boege (2009) suggests one example drawn from a custom in Botswana he refers to as kgotla. Kgotla (literally meeting place within a kraal: see Manzungu and others 2008:19) is a culturally sanctioned part of life in rural communities in Botswana, a process of consultation between local chiefs and community members as a basis for decision-making. Said to be resisted by some modern officials, it nevertheless gives legitimacy to decisions and ensures full community support. It seems likely that stakeholder consultations implemented using kgotla principles will prove more effective and legitimate in the long run than decisions based on majority voting, for example. Such culturally sanctioned consultation is common throughout southern African rural communities (Merrey 2009).

Manzungu and others (2008) document local indigenous water management arrangements in several villages in each of two areas in the Limpopo basin portion of Botswana and Zimbabwe. In Sibasa communal lands, a dam, multiple boreholes and a government-constructed canal providing water to an irrigation scheme are all managed through local customary institutions. The researchers document a "water security system" based on local customary principles balancing multiple sources of water for complementary uses to accommodate seasonal variations in supply and demand. The authors note that there is an unfortunate disconnection between these effective local management arrangements and the formal state-sponsored local institutions. Pereira and Ricardo's 2008 study in Mozambique cited in Merry 2009, notes that informal local management arrangements are legal in nature and are in principle supported by higher-level statutory institutions (at sub-district level and above). They found cases where statutory institutions have supported and assisted local associations, but also note that the information flows are often weak and achieving full community buy-in is commonly problematic. In contrast, Goldin and Thabethe (2008) paint a bleak picture based on the South Africa case studies, of confusion, conflicts and contradictions among traditional authority, water management committees in some communities, ward councillors, municipalities and national departments. This has resulted in significant problems in terms of extending or even maintaining water infrastructure and access to water by poor people (see Merrey 2009).


Crop growing under drip irrigation to save water

Sectoral Policies

Water and Land Use Management

Irrigated agriculture is a major user of water in the basin. The food security policies and strategies that the basin states have adopted are aligned with the national development programmes and poverty reduction strategies of the countries in order to allow for a coordinated approach to poverty reduction (Sullivan 2010; LIMCOM 2013). It is also noted that though the agricultural and irrigation policies recognise the need for water efficiency, they also promote agricultural expansion for ensuring food security leading to additional demand on the Limpopo system.

Some of the national policies and strategies are included in the Table 5.2 below.

The riparian states are in different stages, historical and currently, in terms of addressing the challenges of siltation, erosion and tilling practices in order to stem the negative effects on the Limpopo River.

SADC recognises that education in the formal sector needs to take place at all points on the education timeline, from the early years through to higher learning. In order to develop capacity to deal with climate change, one of the region's climate adaptation strategy objective is to 'Develop the ability of students and professionals to make informed judgements and choices in adapting to climate change' (SADC, 2011:17). SADC organised training and positioning workshops for negotiators and developed the network of climate change negotiators during COP17. Moreover, SADC (2012) recognises the need for developing capacity in economic, policy and social sciences related to climate change, because such knowledge is a crucial support for policy. To this end, the region is developing scientific

Man doing his work manually on a wetland

Table 5.2 National Policies and Strategies in the Limpopo Basin

Riparian State	Food security policies and strategies
Botswana	• The National Development Plan 10 of 2009 target has been set to raise the agricultural production to meet 50% of the country's cereal demand (NDP 10 2009); • Integrated Support Programme for Arable Agriculture Development ISPAAD (2008 to 2015); • National Strategy for Poverty Reduction (NSPR) in 2003, to allow for a coordinated approach to poverty reduction. Given the high incidence of poverty in rural areas, agriculture has a role to play in contributing to the achievement of poverty reduction targets; • The draft Water Conservation (WC) policy (2004) prioritises different water uses as follows. Water for human consumption, urban and domestic use has top priority followed by water for production, environment, agriculture and livestock; and • National Policy on Agricultural Development in 1991. The policy aims to improve food security at the household level; diversify the agricultural production base; increase employment opportunities; provide a secure and productive environment for agricultural producers and conserve scarce agricultural land resources for future generations and to enhance rangeland management.
Mozambique	• The National Irrigation Policy and its Implementation Strategy (NIPIS) were formulated in 2002 and recognised the great strategic importance vested in irrigation, and established a set of guiding policy principles; • The Food and Nutritional Security Strategy (ESAN) was developed in 1998 and is the base for the overall government strategies related to rural development and food security.
South Africa	• The Integrated Food Security Strategy (IFSS) of 2002, designed in response to address food insecurity; • The Agricultural Drought Management Plan (ADMP), which outlines a vision and strategic objectives pertaining to drought risk management, the implementation guidelines of the plan as well as the challenges faced within the new dispensation and new approach to drought risk management.
Zimbabwe	• The Zimbabwe National Agricultural Policy Framework (1995-2020) aims at facilitating and supporting the development of a sustainable and competitive agricultural sector that assures food security at national and household level and maximizes the sector's contribution to GDP.

Source: Adopted from LIMCOM 2013

When policies and institutions are weak … RESILIENCE to livelihoods and ecosystems becomes challenging

and technical capacities to understand the problem and its effects at the national and sub-national level, model its long-term impacts, and elaborate responses and adaptive strategies to the level of implementation .

Essentially, water resource management within the basin is implemented at national levels through the various institutions and structures in-country. The states face similar dilemmas, albeit at varying scales, on a shared resource and recognise that the broad principles of IWRM are critical. It is of value to note that with the harmonisation of policy and law that has evolved over recent years, clearly with the SADC Revised Protocol on Shared Watercourses supporting and guiding this, that the institutional arrangements within the member states are showing similar nuances (LIMCOM 2013). Table 5.3 below shows the key national institutions for water management in all the riparian states within the basin.

Assessment of how different policies and institutions evolved in the basin illustrating three phases including establishment, operations and sustainability.

Table 5.3 Key National Institutions for Water Management for Each Riparian Country

Riparian State	National policies and strategies
Botswana	In Botswana, the Ministry of Minerals, Energy and Water Resources (MMEWR) has overall responsibility for water policy, assisted by the Department of Water Affairs (DWA), Department of Geological Surveys (DGS), Water Utilities Corporation (WUC) and the Ministry of Local Government (MLG) through District Councils (DCs) (Kgomotso 2005; DWA 2010; Commonwealth Local Government Forum 2011; LIMCOM 2013). The Water Apportionment Board in Botswana is a quasi-judicial body charged with the responsibility of administering conditional rights to abstract and use both surface and ground water (Kgomotso 2005; Earle and others 2006). The planning, construction, operating, treating, maintaining and distribution of water resources in Botswana's urban centres and other areas mandated by the government is undertaken by the WUC (LIMCOM 2013; DWA 2010).
Mozambique	Mozambique is in the process of transforming the water sector to a model of decentralised management. The National Water Policy aims to decentralise water resources management to autonomous entities at the basin and provincial levels. The National Water Council is the body that defines water policy whilst the National Institute of Meteorology (INAM) and National Directorate of Water and Resource Management (DNGRH), as part of the Department of Public Works and Housing, are responsible for planning, regulatory and monitoring functions regarding water resources as well as for the provision of water supply and sanitation. Five Regional Water Authorities (ARAs) in Mozambique are responsible for the management of water resources and each ARA manages several basins being simultaneously close enough to expedite management and coordination with political authorities (LBPTC 2010). ARA-SUL is operational within the Limpopo basin and is responsible for a suite of water resource management and related functions including operation and maintenance of dams, monitoring, flood management, and water use licensing. River basin management institutions (UGBs) are to be established to manage water resources at a catchment scale. In order to create a more participative environment River basin management committees (RBCs) are being established as consultative bodies to work with the UGBs.
South Africa	The Department of Water and Sanitation (DWS) in South Africa has nine DWA regional offices. Within the Limpopo basin two regional offices, namely the Mpumalanga Regional Office and the Limpopo Regional Office are present with the former taking responsibility for the Olifants water management area and the latter taking responsibility for the Limpopo water management area (Sithole 2011). The DWA makes provision for the establishment of Catchment Management Agencies (CMAs) and Water User Associations (WUAs). The CMA will eventually have powers and delegated functions to enable the CMA to issue water use authorisations and to issue compliance monitoring and enforcement directives. Only one CMA has so far been established which concerns the LRB namely the Inkomati CMA insofar that water is transferred from the Komati catchment to the LRB. WUAs are an important element of the framework in that they manage local resources and operate localised infrastructure in this regard. Various WUAs have been established in the LRB (LIMCOM 2013; Sithole 2011). Water services provision is guided by the Water Services Act (Act 108 of 1997) which provides for Water Services Authorities (WSA) that have the responsibility to plan and oversee the provision of water services that are undertaken via a Water Services Provider (WSP).
Zimbabwe	The Department of Water in the Ministry of Environment, Water and Climate in Zimbabwe maintains responsibility and oversight for the water sector. The Zimbabwe National Water Authority (ZINWA), is a parastatal, which acts as an operator and a regulator and is responsible for the following functions at the national level: water planning and implementation; management of public dams; supply of bulk water to the agriculture, industrial and mining sectors; supply of bulk water to urban centres, and coordination and supervision of the five catchment councils (Chagutah 2010; Sithole 2011; Manzungu 2014). Catchment Councils (CCs) are established by the Minister of Water Resources Management and Development, in consultation with the ZINWA.

Women fetching water for household uses

Key National Institutions for Water Management for each Riparian Country

The slow shift in institutional frameworks means that with states all at different stages, there is a mismatch in the institutional discourse across the larger basin. For example, in some instances one must communicate with the national department, in other instances the decentralised institution (Catchment Council or ARA) must be contacted. This complexity can have an impact upon operational issues and, quite importantly in this basin, can result in poor levels of regulation across the basin. This is important in a basin where allocation and water quality challenges are increasing. However, the evolution and changes in both policies and institutions within the basin has seen remarkable progress towards cooperation between and among riparian states. Although it has taken relatively long for the establishment and ratification of the LIMCOM, what is undeniable is the trickling of benefits as evidenced by among others, the Southern African Power Pool; the GLTP; and the planned developments in both energy and agriculture.

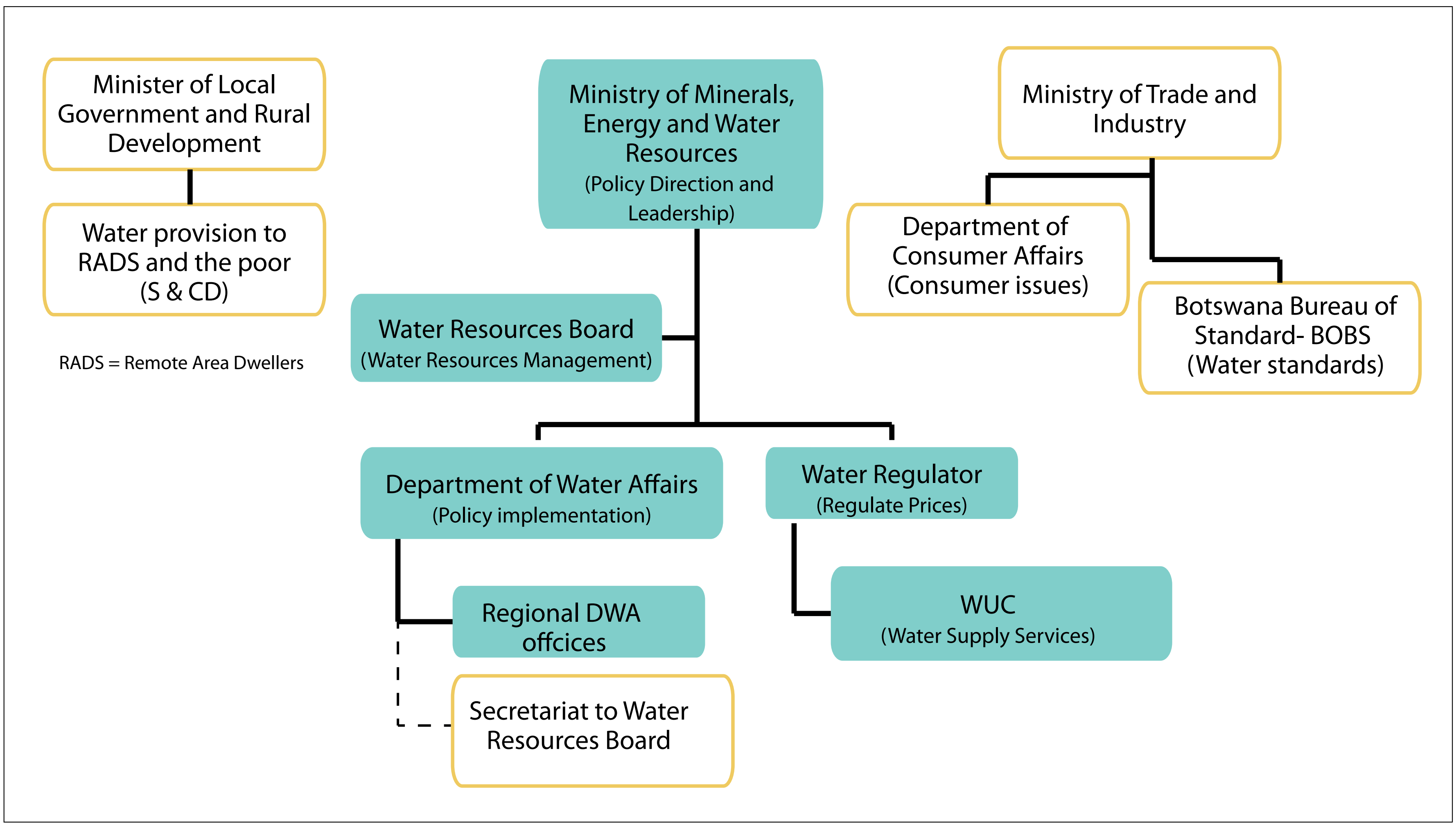


Figure 5.3 Future Water Sector Framework for Botswana after completion of Water Sector Reform

Source: LIMCOM 2013

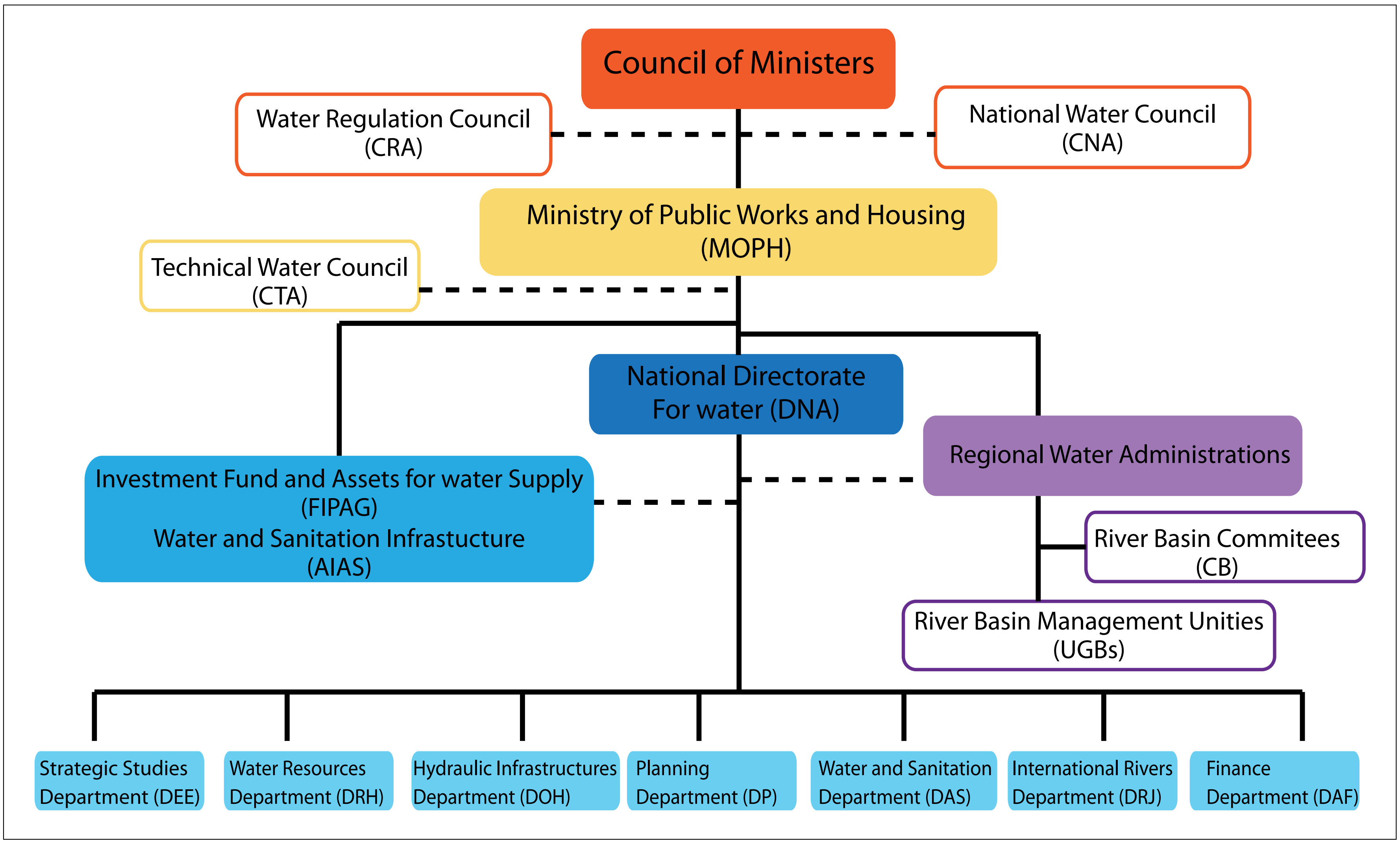


Figure 5.4 Water Sector Framework for Mozambique

Source: LIMCOM 2013

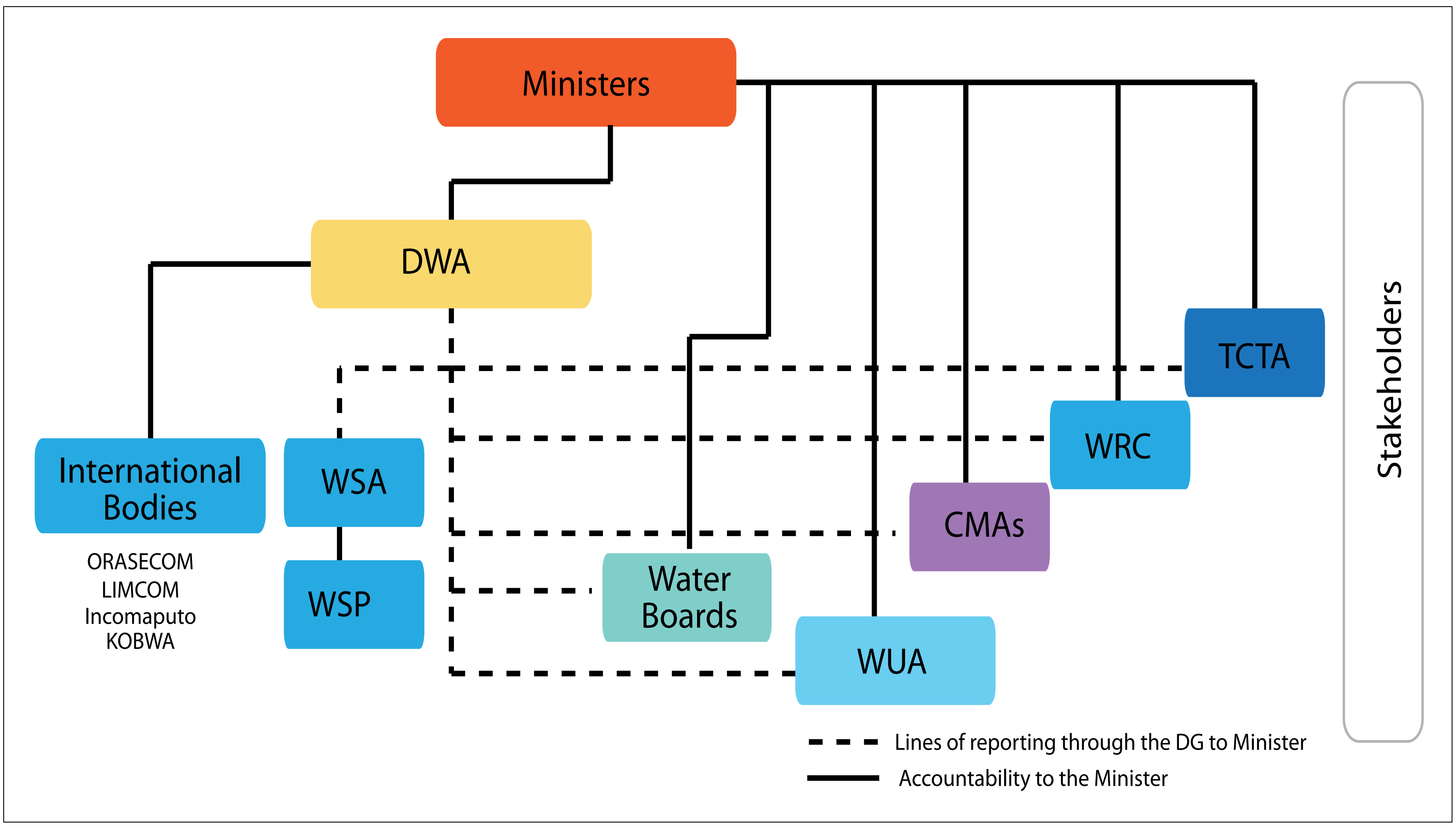


Figure 5.5 Institutional Arrangements for Water Resource Management in South Africa

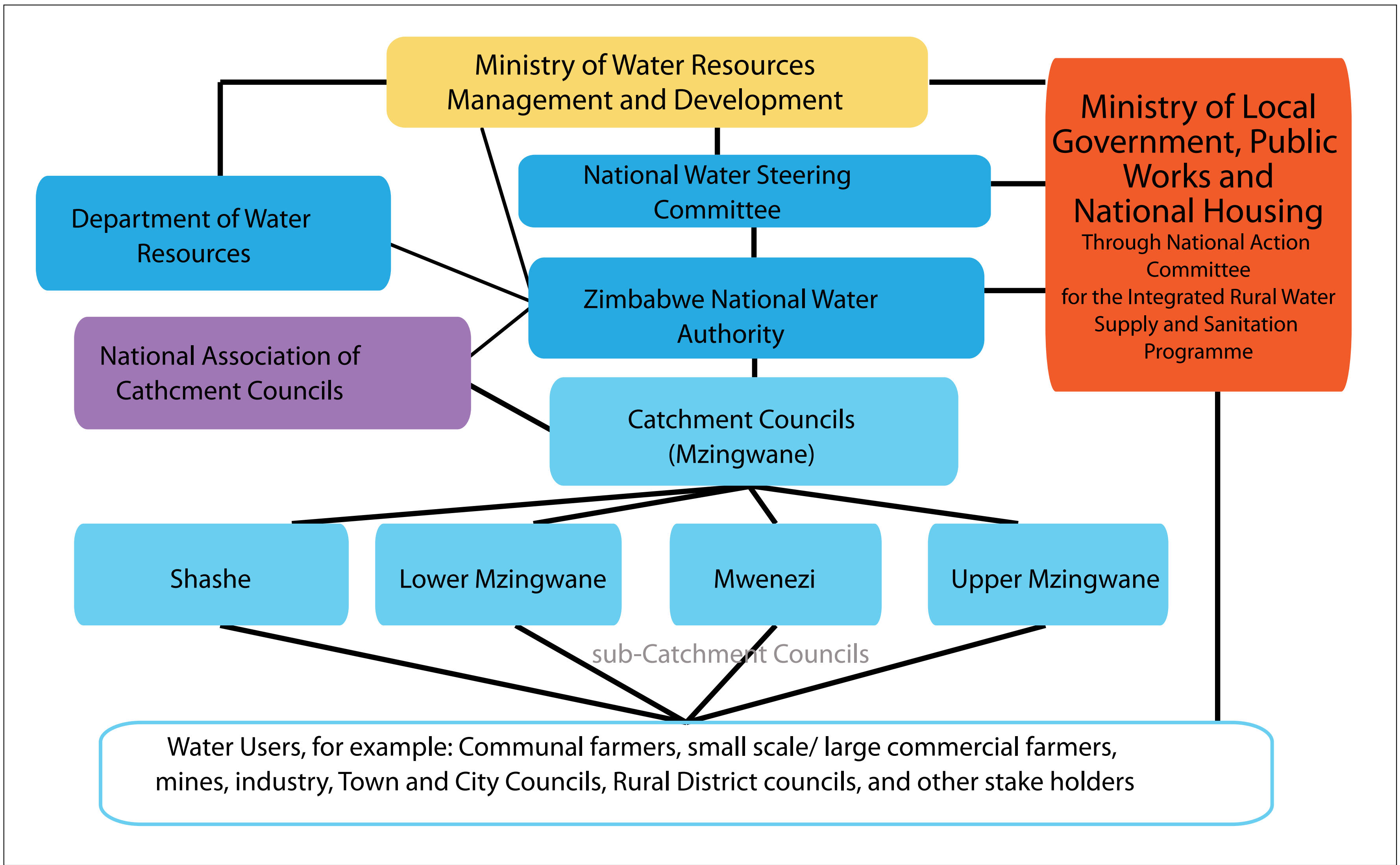


Figure 5.6 Institutional Arrangements for the Water Sector in Zimbabwe

Source: LIMCOM 2013

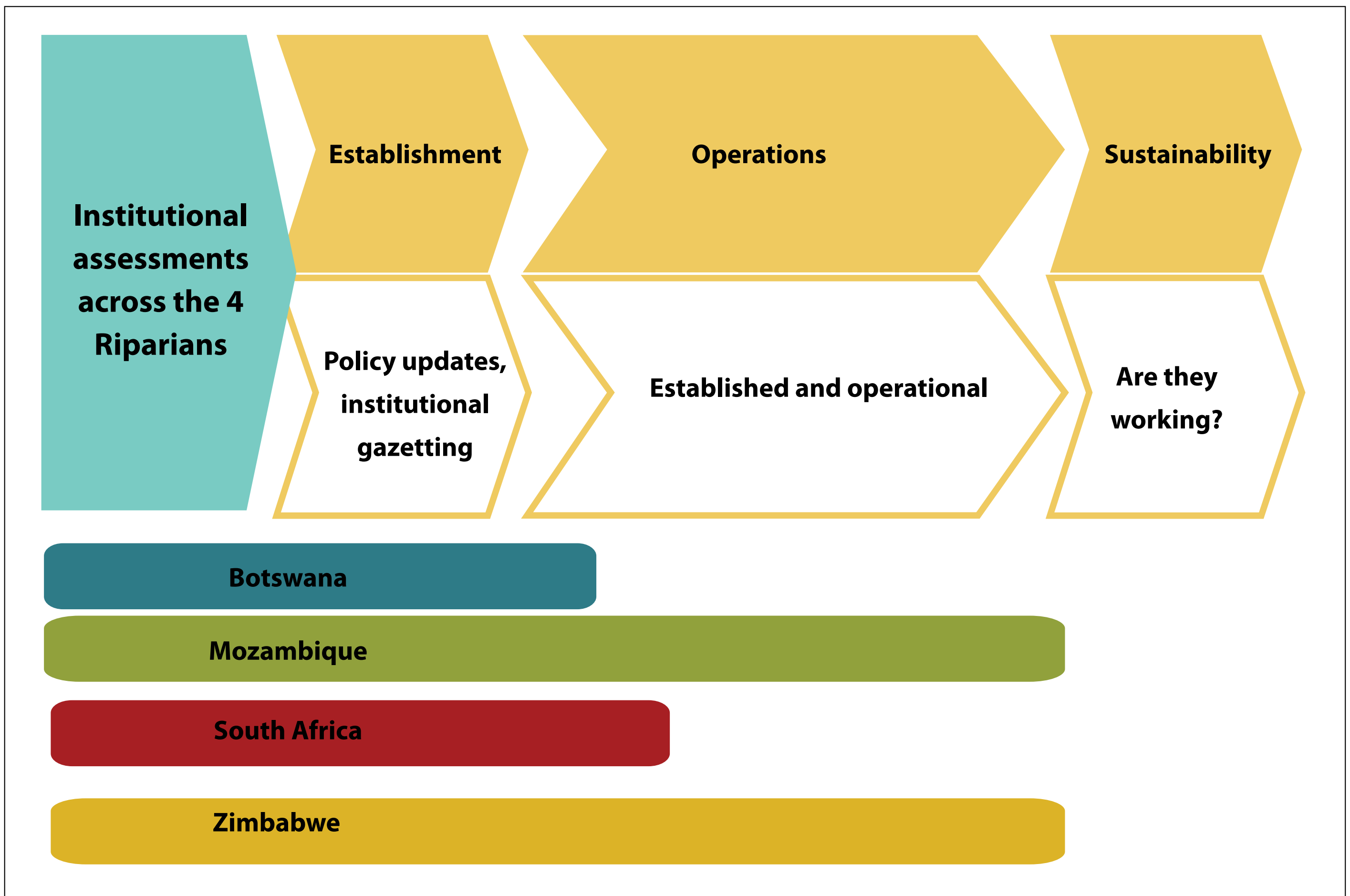


Figure 5.7 High-level Catchment Institutional Lifecycle Phases and Changes in the Limpopo Basin

Conserving Biodiversity

The Revised SADC Protocol on Wildlife promotes conservation and the sustainable use of biodiversity on a regional level. The protocol promotes both community involvement in wildlife management and transfrontier cooperation. The preamble recognises that "the survival of wildlife depends upon the perceptions and development needs of people living with wildlife and recognises the importance of regional management of wildlife and wildlife products (Jones 2009). Importantly the protocol also refers to the harmonization of legislation for wildlife management. One of the objectives of the Protocol is to facilitate the exchange of information concerning wildlife management, utilisation and the enforcement of wildlife laws (LIMCOM 2013).

In the Limpopo Basin there are a total of 10 eco-regions associated with diversity in ecosystem services, which is critically important for the diversity of livelihoods among the Limpopo basin communities (Buzzard 2001; LIMCOM 2013). The high levels of biological diversity drive a vibrant ecosystem-based tourism economy, which supports both the local population via community-based natural resources management programmes, and the national and regional economies via protected areas. The latter is evidenced by the creation of the Great Limpopo Transfrontier Park, which was formed to realise the economies of scale involving the amalgamation of the Gonarezhou National Park in Zimbabwe, the Kruger National Park in South Africa, as well as the Limpopo National Park in Mozambique (Jones 2009). In order to allow for tourism to increase requires preserving an acceptable balance within the Limpopo watercourse, it is necessary to ensure that an adequate ecological reserve in both the quantity and quality of water in the river are maintained. Thus, the basin countries need to agree on which levels for ecological reserve of water that ensures the ecological integrity of the estuaries, wetlands, and surface and groundwater resources.

According to LIMCOM (2013:34), the governments of three Basin States – Mozambique, South Africa and Zimbabwe signed the treaty establishing the Great Limpopo Transfrontier Park (GLTP) in November 2002. The treaty defines two areas:

- The Transfrontier Park (TFP), comprising Kruger, Limpopo and Gonarezhou National Parks, and the linking areas of Malipati Safari Area (Zimbabwe), the Makuleke Contractual Park (South Africa) and the Sengwe-Tshipise Wilderness Area (Zimbabwe-South Africa).
- The Transfrontier Conservation Area, comprising a far larger surrounding mosaic of land in the three countries that also seeks to include Banhine and Zinave National Parks in Mozambique, several private conservancies and the intervening matrix of community or communal land (Jones 2009).

Despite this development, there are on-going tensions and conflicts regarding both land tenure issues between respective states and the affected communities on the one hand, and the accrual of benefits from the GLTFCA where communities have contested and challenged the authorities on the allocation of benefits from the park. However, the legalities and rights to both the GLTFCA and communities remain problematic for the parties.

Remarkably, most national policies and legislation do not specifically mention transboundary issues. However, individually, they deal with the same collective natural resources issues, as each country seeks to govern, control and regulate activities and actions related to those resources. It is also noted that in some basin countries such as South Africa, different spheres of government such as provinces have their own biodiversity policies and legislation, which may differ not only from national policy, but also from that of neighbouring provinces (DPLG 2007; DWA 2009). This is to say that, under such circumstances it may be important to consider both provincial and national policies in the harmonisation processes.

Collecting samples to measure the status of water quality

Developments and Infrastructure

Through the SADC Energy Protocol, Member States are required to work towards regional integration and cooperation in energy development. The four Limpopo Basin States are members of the Southern African Power Pool (SAPP), which is made up of the different power utilities in Southern Africa. The National Energy Policies for the basin states all strive to facilitate the provision of energy supplies at the least cost to the economy as well as improve service delivery to meet customer needs while at the same time managing energy related environmental and health impacts for sustainable development. The regional power trade under SAPP is a benefit sharing option that can increase water allocation options in the Southern African River Basins including Limpopo.

The energy supply base in the Limpopo basin is dominated by coal with hydroelectricity generation taking the second place. As a result, it may be concluded that the energy supply base in the basin may have detrimental effects to the environment. Basin countries have embarked on either diversifying energy supply base and reduce reliance on the coal-fired power plants, or using technologies that save water in the cooling systems. The Medupi Coal fired Plant in Lephalale, South Africa has employed the dry cooling technologies that require minimal use of water resources. On the other hand, Mozambique has realized its high hydropower potential and has plans to install more hydropower plants on Mphanda Nkuwa and Cahora Bassa.

The trade and industrial policies of the basin states generally point toward encouraging increased value-added production on a more labour-absorbing industrialisation path that can catalyse employment creation and diversify the economy away from the current over-reliance on traditional commodities and services with agri-business and food processing as main sectors of priority (LIMCOM 2013). The Revised SADC Protocol on Trade – also known as the Maseru Protocol was adopted in 1996. The aim of the Protocol on Trade is to liberalise 85% of intra-SADC trade, paving the way for the SADC Free Trade Area (FTA). South Africa and Botswana are members of the Southern African Customs Union (SACU), which also involves the non-Limpopo basin states of Lesotho, Namibia and Swaziland - where goods flow free of any tariff duties. The Industrial policies for Mozambique, South Africa and Zimbabwe mention clearly that the success of the policies hinge upon addressing other issues that affect the sector, such as infrastructure and utilities with a particular emphasis on energy and water supplies and also aim at supporting development of such infrastructure programmes (LIMCOM 2013). It is noted that firstly as the countries pursue their industrialization policies, it is expected that there will be increased demand for water to meet the production requirements. Secondly, the economic diversification and growth would likely increase the vulnerability of the resources in terms of the quality of water in the system (LIMCOM 2013). Thirdly, industries are mainly concentrated in the basin's major cities; this may have an impact on the existing urban water supply systems as people migrate from rural to urban centres for job opportunities.

Phalaborwa barrage in Phalaborwa

Opportunities and Outlook

Harmonizing Institutional Efforts

Key regional institutions play a role in water related matters in SADC where the SADC Water Division works together with SADC Member States in supporting, facilitating and coordinating the implementation of regional water related activities. In the Limpopo basin, there has been an increasing realisation by the four basin states, of the importance for joint coordination, management and governance of the basin. A number of bilateral agreements exist and serve to coordinate technical matters between the two states. A Joint Water Commission exists between Mozambique and South Africa, whilst the Joint Permanent Commission for Co-operation facilitates discussion between Botswana and South Africa. South Africa and Zimbabwe are in the process of establishing a Joint Water Commission.

The Agreement on the Limpopo Basin Permanent Technical Committee was signed by representatives from Botswana, Mozambique, South Africa and Zimbabwe in 1986 and in 2003 representatives from Botswana, Mozambique, South Africa and Zimbabwe signed the Agreement on the establishment of the Limpopo Watercourse Commission. The agreement was ratified by member states in 2011 (LBPTC 2010).

The institutional arrangements, in the various Member States, are at differing levels of progress across the Limpopo Basin. Whilst this may not immediately appear to be a challenge, this can introduce a level of complexity in terms of ensuring effective and uniform water resource management across the basin. During processes of institutional change there are typically governance gaps that emerge and operational tasks that may not be undertaken. For example, without Catchment Management Agencies being established in South Africa the development of Catchment Management Strategies is being held back (legally this is the responsibility of the CMA). The current "plans", which are the Internal Strategic Perspective and Water Resources Overview are all close to a decade old, and so the need for up to date planning is being held back (LIMCOM 2013).

Strengthening Institutions

A common observation throughout the LRB countries is that a plethora of institutions exist, and often with overlapping mandates. This calls for an improvement in national and transboundary river basin management, planning and co-ordination (SADC and SARDC 2002).

Table 5.4 Institutional strenghts, weaknesses, opportunities and threats

Strengths	• All countries have water related policies, laws and regulations • Long-term history of transboundary cooperation between the basin states • Guiding principles from SADC Regional Protocols, policies and strategies • Existence of Limpopo Watercourse Commission legal and institutional framework • Existence of mechanisms for information exchange and joint monitoring through LIMCOM • Existence of the framework for communication and outreach through Limpoporak • Existence of national development planning frameworks in each basin state • Existence of natural resources management and economic sectors policies
Weaknesses	• Differing parameters for standard guideline values for the quality for water use • Except for South Africa, at national level the existing biodiversity related legislative pieces do not address transboundary issues • Differing approaches in the shared IWRM principles and ways policy are translated into national legislation and implementation • Absence of clear guidelines for harmonised policy framework • Criteria for water allocation not yet been fully developed • No clear guidelines on allocated water and agreed minimum border flows on development of water-related infrastructure • Limpopo basin agreement is silent on the priority for water use
Opportunities	• Existence of the benefit sharing options in the basin e.g. energy trading arrangements under SAPP • Poverty alleviation forms a key developmental policy objective for all the Limpopo basin states • National Policies on agriculture and irrigation recognise the need for water efficiency, since irrigation is the major water user in the basin • Commitment towards IWRM principles reiterate by SADC regional water frameworks facilitates harmonization process
Threats/Challenges	• Increasing demand for use and vulnerability of available water resources on the Limpopo system • Existence of inconsistencies between sector policies both within as well as between basin countries • Need for a common basin mechanism for carrying out environmental flow assessment • Lack of an effective mechanism for basin wide management of natural disasters and dam safety

Table 5.5 Department/Ministries and their Specific Responsibilities

Country	Department/Ministry	Interest/responsibilities
Botswana	Department of Water Affairs	Policy and implementation on flood monitoring, forecasting and warning
		Water resources management
	Meteorological Services	Policy and implementation of climate and weather data collection and forecasting
Mozambique	National Directorate of Water, DNA	Policy and implementation on flood monitoring, forecasting and warning
		Water resources management
	ARA, Sul	Planning, development and implementation of FFEWS and water resources management
	National Institute of Disaster Management, INGC	Policy and coordination of flood preparedness, mitigation, response and recovery
	National Roads Authority	Safety of roads and bridges from floods
South Africa	Department of Water Affairs	Policy development and implementation on flood monitoring, forecasting and warning; and, Water resources management
	South African Weather Services	Policy and implementation of climate and weather data collection and forecasting
	National Disaster Management Authority	Policy and coordination of flood preparedness, mitigation, response and recovery
Zimbabwe	National Weather Service	Responsible for climate and weather data and information
	Department of Civil Protection	Coordinate flood disaster preparedness, mitigation, response and recovery
	Zimbabwe National Water Authority	Planning, development and implementation of FFEWS and water resources management

Empowering Women and Girls

As society is developing, men and women's roles and responsibilities are shifting to suit household, social and economic needs, but still within the traditional division of labour framework. The post-colonial era has seen more women, for example, now being found in decision-making positions that traditionally have been dominated totally by men. In all the four riparian countries of the Limpopo River Basin, appropriate gender machineries have been put in place, mainly at the government level so as to take into account gender interests of society. At the SADC level, targets have been set to promote the cause of formerly suppressed gender groupings. Gender has been incorporated into various national frameworks and has also been incorporated into the SADC agenda such as the Gender Unit within the SADC Secretariat (SADC and SARDC 2002).

Women returning home after planting mangroves

Providing EWS for Disasters and Risks

The changing climate ensures that extreme climatic events and natural hazards such as floods and droughts remain a reality throughout the Limpopo Basin. Effective early warning systems should be mainstreamed into development and management plans across all major sectors. A key tool for EWS is regular monitoring of the Limpopo River and meteorological trends. The current Flood Forecasting Early Warning System (FFEWS) is an LBPTC initiative that consists of close to 2,700 rainfall stations and some 700 river gauging stations that provide data and information on river flows/floods through a telemetry network throughout the basin (WMO 2012). The FFEWS continues to face several challenges such as lack of real time transmission of data in some areas that hinder its effectiveness. Future LIMCOM plans indicate a dedication to continue improving this system.

Each basin state has systems in place to deal with natural hazards each of which are stakeholder of the Limpopo FFEWS and EWS at the SADC level. This provides an opportunity for LIMCOM to harmonise national efforts to create a robust regional EWS effort. Table 5.4 show the different ministries or departments and their specific interest and responsibilities within the four riparian states.

Improving Valuation of Ecosystem Goods and Services

The evaluation of the ecological infrastructure within the basin and the linkage of this to the various goods and services which this sustains may well argue for greater water allocation rights for particular sites within the basin such as estuaries. For example, subsistence fishing at its current levels within some estuaries represents the greatest threat to the sustainable utilisation of fish, and to a lesser extent the larger crustacean and bird fauna of the Limpopo Estuary (LIMCOM 2013). Fishing techniques observed included: hand lines, seine netting and gill netting. The former takes place in the lower reaches of the system, while seine and gill boats were deployed everyday throughout the length of the estuary. Gill nets remained in the estuary for long periods and at times were strung along the length of the estuary forming a continuous obstacle. These impacts have undoubtedly had a major impact on the structure, fish community and abundance, with the possible exception of the truly benthic species that are not targeted by these techniques.

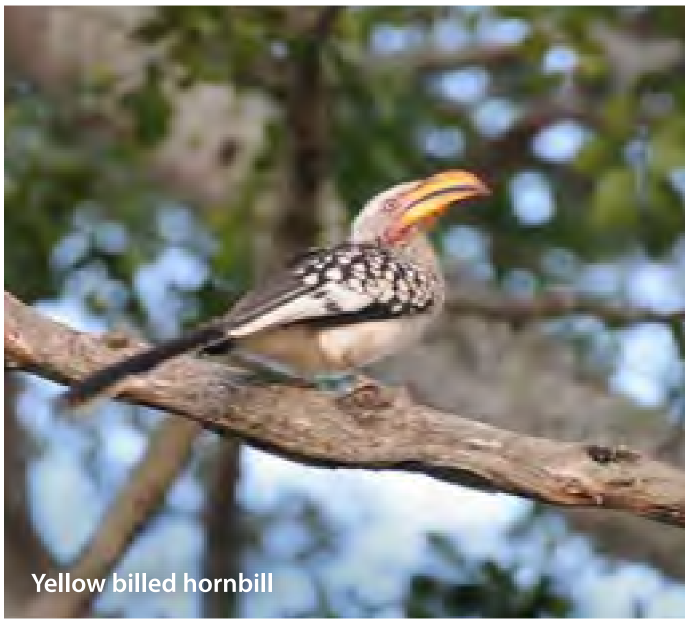
Hope and Hot Spots

Hope Spots:

- Harmonising institutional efforts – great opportunity in the basin (supported by LIMCOM & SADC WD)
- Strengthening Institutions
- Existence of the benefit sharing options in the basin e.g. energy trading arrangements under SAPP

Hot Spots – Challenges:

- Increasing demand for use and vulnerability of available water resources on the Limpopo system
- Existence of inconsistencies between sector policies both within as well as between basin countries
- Lack of an effective mechanism for basin wide management of natural disasters and dam safety



Yellow billed hornbill

Sustainability

Sustainability is an on-going challenge within the basin where financial challenges are hampering institutional development across the region. Institutions are reliant on funds from central government as well as revenue generated from permits and water use. In many instances, these resources are limited meaning that core functions are not being undertaken as desired and the capacity required to take up functions is also not in place.

Looking into the future is needed for sustainable management of resources

Key Findings and Recommendations

Key Findings

The Limpopo River Basin is endowed with numerous natural resources including lakes, wetlands, forest and wildlife, as well as land and minerals.

The basin has experienced significant environmental changes over the years as a result of climate change and human activity. The location, extent and significance of impacts occurring through changes in land use are closely related to human population pressure on the land.

Population is increasing and is expected to reach 20 million in 2040, from 18 million in 201l. Population growth is estimated at around 2.3 percent per year. About 83 percent of the basin's population resides in South Africa, accounting for over 15 million basin inhabitants, largely because of metropolitan areas of Tshwane and part of Johannesburg.

As the population increases there has been an increase in demand for water resources from competing uses. The basin water use increased by seven percent between 2007 and 2012. It is expected that temperature rise is likely to increase evaporation of water resources as well as increase demand for water.

Maximum temperatures in the Basin has increased by between 1°C and 1.4°C in summer months. This trend is expected to continue with a significant increase in the frequency of hot extremes in the basin and a decrease in the number of cold extremes. By the end of the century, projections indicate a maximum temperature increases of 2.97 under the high mitigation scenario and 5.9 °C under the low mitigation scenario over the interior regions of western parts of the Basin.

The number of hot days in the basin are expected to increase. Projections for selected sites in the basin between 1960 and 2100 indicate an increase of 66 hot days at Messina in South Africa and Francistown in Botswana, while in Xai-Xai, Mozambique an increase by 94 hot days is expected. In the Shashe Sub-Basin the number of very hot days is projected to increase by 40 to 60 days per year in the long term, with the highest increases in the northern part of the basin;

In the long-term, average rainfall is expected to decrease by up to 15 percent. In the north-eastern side of the basin, rainfall is projected to reduce by as much as 20 percent in summer by 2100. There has been an increase in rainfall intensity over a short period, accompanied by an increase in the duration of dry spells. General projections indicate a reduction of rainfall in March, April and May by 2100.

Seasonality and timing of future rainfall seasons is expected to shift due to the climate change. Late onset of rains and long dry spells are expected. These patterns differ with the most significant decrease in rainfall expected over the summer and autumn months.

The basin is prone to drought, floods and water-related diseases such as cholera and malaria. Limpopo River often flood its banks inundating, homes, and irrigation schemes, in areas such as Chokwe in Mozambique. The flooding occurs 3-4 times every 10 years;

The largest impact of flooding historically has been in the Mozambican Floodplains Zone because of cyclonic activity. Areas in the lower Limpopo such as Xai-Xai and Chókwé are highly prone to floods. Drought prone areas include the Upper Umzingwane, Pafuri triangle, Shashe–Limpopo confluence and Upper Limpopo. The Lower Limpopo in addition to flooding also undergoes significant periods of drought;

Mozambique is historically most devastated by disasters such as floods and droughts, suffering from 53 natural disasters in the past 45 years, an average of 1.17 disasters per year.

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Rural communities in the basin are dependent on forests and trees for food, timber, fodder, medicine, shelter and construction material. The mopane worm, for example, is an important source of protein around the Gwanda area of Zimbabwe, and in south-east Botswana. Small towns, particularly in lower Limpopo have however grown in size, putting additional pressure on resources such as forests leading to deforestation around these areas.

Veld fires continue to alter ecosystems throughout the region. While natural fires sustain ecosystems by rejuvenating grasses and shrublands to prevent the development of dense woodlands and forests, and they help recycle nutrients contained in dead organic matter, human-induced fires which are frequent destroy the environment. For example in Zimbabwe veld fires affect an average of 900,000 hectares of the country's land surface annually.

A major concern in the Limpopo Basin is transboundary transmission of animal diseases, especially foot-and-mouth disease (FMD) between wildlife and livestock. The emergence of the Great Limpopo Transfrontier Conservation Area has seen growing incidences of FMD cases leading to economic impacts such as restricted exports of beef. FMD is easily transmitted between wildlife, especially buffalo and cattle.

Several species have been introduced in various ecosystems of the basin. The invasive species, include water hyacinth (*Eichhornia crassipes*), red water-fern (*Azolla filiculoides*) and parrot's feather (*Myriophyllum* *aquaticum*), Australian wattles (*Acacia* species), guava (*Psidium guajava*), bugweed (*Solanum mauritianum*), lantana (*Lantana camara*), jacaranda (*Jacaranda mimosaefolia*), and syringa (*Melia azedarach*).

There is increased coordination between Basin countries towards sustainable and conservation of wildlife. The creation and expansion of transfrontier conservation areas allow tourists and wildlife to cross international borders with minimal difficulties, but there are potential threats to contend with, including plant and animal pests and diseases, and relocation of people within tourism zones.

There are mega-infrastructure projects in South Africa to increase water supply for uses such as irrigation, mining and in the expanding urban areas. An example is the Groot Letaba Water Resource Development project. There is considerable potential to boost economic development through additional infrastructural developments and water use efficiency improvements.

Storage dams in the Limpopo River system provide reliable supplies of clean water to people in both rural and urban settings. A total of 97 dams (total storage of 7,528 million cubic metres) of various sizes in the basin.

Although development of storage dams is already substantial in the basin, hydrological data shows additional dam and irrigation development potential on the Mozambique side of the basin.

Agriculture is key for the economies of the Limpopo Basin, supporting the livelihoods of more than 60 percent of the basin's population.

There has been a marked increase in the area under irrigation in the middle and lower Limpopo, for example there has been rehabilitation and increase of national irrigation schemes in Mozambique, e.g. Baxio Limpopo Irrigation Scheme and Chokwé Irrigation scheme. The irrigation potential is however compromised due to the fact that most rivers in the basin are seasonal or have reduced flows during the dry season.

Despite increasing area under irrigation, subsistence crop production is still mostly rain-fed and generates low incomes, with most of the smallholder farmers located in low lying areas that are vulnerable to climate instability.

Over 95 percent of the electricity generated in the Limpopo River Basin takes place in South Africa. There are 12 thermal power stations in the basin, one in Botswana and 11 in South Africa and have a total water use of 223 million cubic metres per year.

Water pollution is an increasing challenge, particularly as a result of growth and expansion of mining activities in South Africa. As a result of increased nutrient load, most of the surface water bodies are affected by eutrophication.

Recommendations

Rapid population and urban growth in Limpopo River Basin must be aligned with improvement in service delivery, particularly in big basin cities like in Johannesburg which have experienced notable expansion in the last two decades.

Basin states need to recognise the importance of indigenous knowledge systems in sustainable development and when considering new climate change adaptation strategies. Incorporating IKS into policies and strategies provides local solutions which come from and are understood by communities, thus giving more opportunity for community ownership and participation in disaster preparedness and response. It empowers local people as well as reducing dependence on outside help.

Use of traditional methods to preserve grain as well as cultivating drought-resistant crops such as finger millet, sorghum and pearl millet helps to reduce vulnerability.

Early Warning Systems can be improved by including men and women at all levels of information dissemination especially within local structures where women are most affected. Information dissemination at local level can be strengthened through tools such as community radio.

There is need to empower communities in the conservation of wildlife based in protected areas. Most of the conservancies are surrounded by communities.

Sustainable fire management practices should be strengthened particularly during the dry season due to the threats posed by wildfires; This could include enforcing deterrent penalties against bushfires.

The spread of diseases for wildlife must be taken into account in planning prevention and control programmes.

There is need to ensure the use of SADC Protocol on Wildlife promotes conservation and the sustainable use of biodiversity as it promotes both community involvement in wildlife management and trans frontier cooperation.

As invasive species are significant cause of biodiversity loss in major water bodies, basin states are encouraged to adopt sound land and water management practices to reduce spread of alien species.

Governments and relief agencies should give equal prominence to prevention as is given to response. Governments and relevant agencies should incorporate disaster risk reduction concepts into their operations and should work across borders to coordinate and align disaster risk reduction policies.

Basin states should deepen their efforts in moving towards sustainable development through green economies and green growth as adaptation and mitigation strategies to address the impacts of climate change, as well as an opportunity to create jobs and livelihoods. Other adaptation measures should include:

- Continuous implementation of proven best soil and water management practices, such as conservation agriculture;
- Implementing measures to control erosion and siltation caused by mining and poor land management;
- Rehabilitation of the existing small dams and irrigation schemes and putting in place management and finances for continued maintenance;
- Identifying and developing diversified livelihood options offering better security and a more resilient future;
- Tapping into the potential for greater sustainable use of groundwater for humans, livestock and crops, within the context of climate change;
- Establishing strong and just governance of access to, and use of, productive natural resources; and,
- Building the resilience of communities to flooding through a combination of early-warning systems and better catchment management practices.

Water, energy and food are inextricably linked. The use and management of one of these resources can impact on the others. With population growth, urbanization and its associated increase in well-being, economic growth, climate change and variability impacts, there is increasing pressure on water, energy and food resources in the Limpopo Basin. As demand increases, the three sectors should not be viewed in isolation. There is need to understand how and where these three systems intersect in the form of a nexus.

Linked to the water, energy and food nexus approach there is need to develop appropriate river simulation models to identify the influence of dam operations on the downstream flow regime, including unregulated tributaries as well as optimize multi-purpose management of existing reservoirs.

To plan and implement projects effectively, pertinent and timely data is needed. Strengthening capacity in data collection and analysis as well as institutional capacity to facilitate data sharing is essential.

Most of the industries in the basin are still concentrated in major cities and this have an impact on the existing urban water supply systems as people migrate from rural to urban centres. There is need for government to decentralise other services and industries to rural areas.

There is need to stimulate the uptake of renewable energy products and technologies and reduce dependence on fossil fuels. This would include identifying and promoting options for small-scale hydropower development.

Riparian States should ensure that their national policies and legislation specifically mention transboundary issues so as to regularise management of transboundary resources in the basin.

There is need to strengthening institutions so as to improve national and transboundary river basin management, planning and co-ordination in the basin.

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Workshop Participants

Regional Experts Workshop on the Conceptualisation of the Limpopo River Basin Atlas
18-19 August, 2014
Bulawayo, Zimbabwe

Lameck Betera – Department of Civil Protection, Zimbabwe
Luxon Nhamo – International Water Management Institute, South Africa
Agostinho Xilanas – National Directorate of Water, Mozambique
Jose Rafael – VEM
Paulo Selemane – National Directorate of Water, Mozambique
Baboloki Autlwetse – Kalahari Conservation Society (KCS)
Mpaphi Casper Bonyongo – Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL)
Manuel Magombeyi – AWARD
Nkobi Moleele – RESILIM
Jean Marie Kileshye Onema – WATERNET
Zvikomborero Manyangadze – Ministry of Environment, Water and Climate, Zimbabwe
Michael Ramaano – GWP SA
Wellington Dzvairo – GWP SA
Chipangura Chirara – Biodiversity Office; Ministry of Environment, Water and Climate
Nick Tandi – Strategic Water Partners Network (SWPN)
Sara Feresu – IES University of Zimbabwe
Edgar Chongo – AMA-SIL
Alycan Mushayabasa – FEWSNET
Egline Tauya – SARDC
Girma Ebrahim - International Water Management Institute, South Africa
Isaac Kusane – MESA-SADC
Obakeng Sethamo – Botswana Red Cross Society (BRCS)
Lara Rall – RESILIM
Phanuel Ncube – Mzingwane Catchment Council
Arafat Zainadine – National Institute of Disaster Management (INGC), Mozambique
Jackson Aliwa – University of Botswana
Amy Sullivan – Private
Bernardas Padegimas – GRID-Arendal
Clever Mafuta – GRID-Arendal
Tommy Rosen – Zimbabwe National Water Authority, Zimbabwe
Evelyn Gope – GWP SA
Chelesani Moyo – GWP SA

Limpopo Atlas Planning Workshop
5 April 2016
Johannesburg, South Africa

Andrew Takawira – GWP SA
Arafat Zainadine – National Institute of Disaster Management (INGC), Mozambique
Danai Matowanyika – SARDC IMERCSA
Egline Tauya – SARDC IMERCSA
Enias Zvokuomba
Gimo Macaringue – ARA-Sul, Mozambique
Henrique Rosa – ARA-Sul, Mozambique
John Isaac Molefe – MESA-SADC
Julienne Yebga – GWP SA
Justino Marrengula – National Directorate of Water Resources Management, Mozambique
Kule Chitepo – RESILIM
Lameck Betera – Department of Civil Protection, Zimbabwe
Masego Pitso – Office of District Commissioner, Tlokweng, Botswana
Michael Ramaano – GWP SA
Nkobi Moleele – RESILIM
Oageng Raletshegwana - DWAB
Patricia Lumba – GWP SA
Paulo Selemane – National Directorate of Water, Mozambique
Ruth Beukman – GWP SA
Sergio Sitoe – LIMCOM
Sibongile Mangena – AGRITEX NEWU
Tommy Rosen – Zimbabwe National Water Authority, Zimbabwe
Webster Gumindoga – University of Zimbabwe
Zvikomborero Manyangadze – Ministry of Environment, Water and Climate, Zimbabwe

Cartography Training Workshop
22-27 May 2016
Harare Zimbabwe

Felicidade Isabel Massingue Jorge – Eduardo Mondlane University, Mozambique
Manuel Magombeyi – AWARD
Chipangura Chirara – Ministry of Environment, Water and Climate, Zimbabwe
Admire Ndhlovu – SARDC IMERCSA
Neto Nengomasha – SARDC IMERCSA
Danai Matowanyika – SARDC IMERCSA
Mercy Chimuzimu – SARDC IMERCSA
Levi Westerveld – GRID-Arendal
Bochengedu Somolekae – Department of Water Affairs, Botswana
Eugene Apindi Ochieng – UNEP
Clever Mafuta – GRID-Arendal

Limpopo Atlas Review Workshop Participants
23-24 June 2016
Johannesburg, South Africa

Joseph Z. Matowanyika – Chinhoyi University of Technology, Zimbabwe
Chipangura Chirara – Consultant, Zimbabwe
Pinimidzai Sithole – Pegasys Strategy and Development, South Africa
Thando Ndarana – Council for Scientific and Industrial Research (CSIR), South Africa
Bochengedu Somolekae – Department of Water Affairs, Botswana
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Sergio Malo – Eduardo Mondlane University, Mozambique
Chipo Mubaya – Chinhoyi University of Technology, Zimbabwe
Leonissah Munjoma – Zambezi Watercourse Commission (ZAMCOM)
Piet Kenabatho – University of Botswana
Cathrine Mutambirwa – IUCN-ESARO, South Africa
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Tendani Nditwani – Department of Water and Sanitation, South Africa
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Julienne Yebga – GWP SA
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Monica Rakhuhu – GWP SA
Tendai Gandanzara – GWP SA
Jeanette Normand – USAID
John Harris – USAID

Partners' Profiles

Resilience in the Limpopo River Basin (RESILIM) Program

The Resilience in the Limpopo River Basin (RESILIM) is a United States Agency for International Development (USAID)'s program that supports the four riparian countries of Botswana, Mozambique, South Africa and Zimbabwe, in their efforts to improve shared management of water resources. The program also addresses the economic, environmental, and social needs of the basin, with a view to enhancing the resilience of people's livelihoods and ecosystems integrity. RESILIM supports equitable access to water that balances urban and rural needs with ecosystem requirements under a changing climate environment, and reduces vulnerabilities across the basin by implementing interventions that improve adaptive and transformative capacities for integrated transboundary water resource management at various levels (basin, national and local/community).

The program also notes the need to bolster participatory processes built on sound science that effectively incorporates ecological, social, and economic aspects of water resource management in the face of climate change, with specific focus on enhancing individual and institutional capacities for better anticipation and response to changes, in ways that ensure equitable and lasting development.

Global Water Partnership Southern Africa (GWP SA)

The Global Water Partnership (GWP) is an international network that was created in 1996 to foster the application of Integrated Water Resources Management (IWRM) – the coordinated development and management of water, land and related resources in order to maximise economic and social welfare without compromising the sustainability of ecosystems and the environment. GWP's vision is for a water secure world, while its mission is to advance governance and management of water resources for sustainable and equitable development. The network is open to all organizations which recognise the principles of IWRM endorsed by the Network. Partners of GWP include states, governments, institutions (national, regional, and local), intergovernmental organisations, international and national non-governmental organisations, academic and research institutions, private sector companies, and service providers in the public sector.

The GWP network has 13 Regional Water Partnerships, 84 Country Water Partnerships and 3,000 partners located in 172 countries. The Global Water Partnership Southern Africa (GWP SA) is one of the 13 Regional Water Partnerships. As an implementing partner of the Southern African Development Community (SADC), GWP SA has helped to establish IWRM processes and procedures as a standard in SADC member states and River Basin Organisations such as the Limpopo Watercourse Commission, Okavango River Basin Commission and Zambezi Watercourse Commission. These processes have tackled various development challenges by effectively advancing the implementation of the IWRM framework. Working with countries at different scales – from transboundary to local, has ensured that water management actions contribute to sustainable development.

GRID-Arendal

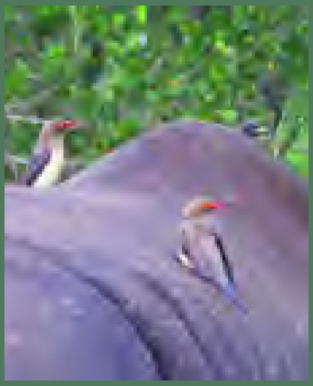
GRID-Arendal is a centre that collaborates with the United Nations Environment Programme in supporting informed decision making and awareness-raising through environmental information management and assessment, capacity building, and the development of outreach and communication tools, methodologies and products. Through a dynamic portfolio of projects, GRID-Arendal partners with various organizations to facilitate free access to and exchange of information in support of decision making and promotion of a sustainable future.

GRID-Arendal was established by the Norwegian government to support the UN in the field of environment, and its mission is to create environmental knowledge that enables positive change. This is achieved by organizing and transforming available environmental data into credible, science-based information products, delivered through innovative communication, including cartographic services. GRID-Arendal's vision is a society that understands and values the environment on which it depends. In pursuing this vision, GRID-Arendal strives to be a creative, sustainable and motivating environmental organization that makes a difference locally and globally.

SARDC IMERCSA

The Southern African Research and Documentation Centre (SARDC) is an independent regional knowledge resource centre that seeks to strengthen key development processes in southern Africa through the collection, production and dissemination of information, and generating access to knowledge. SARDC was established in 1985 with offices in Harare and Maputo. The SARDC institute responsible for environmental reporting and climate change issues is the I Musokotwane Environment Resource Centre for Southern Africa (SARDC IMERCSA), named after the late IUCN Regional Director for Southern Africa, India Musokotwane from Zambia, who inspired IMERCSA and its Vision that "…people at all levels of environmental decision-making in southern Africa are motivated and empowered to take positive actions to counter environmental degradation and move towards sustainable development paths through provision of accurate, accessible and meaningful knowledge and information on the environment."

SARDC IMERCSA initiated the first report on southern African environment in 1994 – *State of the Environment in Southern Africa* – in partnership with SADC and IUCN-The World Conservation Union. The institute has continued to produce thematic and other reports on the southern African environment. SARDC works in partnership with the Southern African Development Community (SADC) through a Memorandum of Understanding, and has regional and national partners throughout southern Africa. SARDC IMERCSA is the regional collaborating centre for southern Africa for UNEP, with notable contributions towards the Africa Environment Outlook and the Global Environment Outlook products.


The Limpopo River Basin is one of the 63 transboundary river basins in Africa and is the fourth largest in southern Africa. The basin is endowed with underground water resources that are important in supplementing surface water resources. The catchment characteristics of the basin are very diverse, covering different climatic and topographic zones, as well as land use types, including protected areas. The basin represents one of the best of what southern Africa has in terms of shared natural capital. The natural capital in the basin defines the economic activities that range from agriculture, mining and manufacturing to conservation and tourism, as well as scientific monitoring and research.