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Rapid Assessment for the Cuvelai River Basin Draft

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Gaborone, Botswana



implemented by:
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CUVECOM

RAPID ASSESSMENT REPORT

DRAFT

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LIST OF ACRONYMS

AfDB	African Development Bank
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
BMA	Basin Management Approach
CBD	Convention on Biological Diversity
CEDAW	Convention on the Elimination of all Forms of Discrimination against Women
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CPTC	Comissao Permanente da Bacia do Rio Cunene
CREST	Coupled Routing and Excess Storage hydrological model
CRU	Climatic Research Unit
DEM	Digital elevation model
DRFN	Desert Research Foundation of Namibia
DRWS	Directorate of Rural Water Supply
DWA	Department of Water Affairs (Namibia)
ECCAS	Economic Community of Central African States
EDF	European Development Fund
EIA	Environmental Impact Assessment
EO-1	Earth Observing-1
ESA	European Space Agency
ET	Evapotranspiration
FRM	flood risk management
GABHIC	Gabinete para a Administracao da Bacia Hidrográfica do Rio Cunene
GCM	Global Climate Model
GDACS	Global Disaster Alert and Coordination System
GDEM	Global Digital Elevation Model V2
GEF	Global Environment Facility
GFDS	Global Flood Detection System
GFMS	Global Flood Monitoring System
GHCN	Global Historical Climatology Network
GHG	Greenhouse gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
GPCC	Global Precipitation Climatology Centre
GWP	Global Water Partnership
HDI	Human Development Index
HYCOS	Hydrological Cycle Observation System
ICT	Information and Communications Technologies
INRH	National Institute for Water Resources (Angola)
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ITCZ	Intertropical Convergence Zone
IWRM	Integrated Water Resources Management

JICA	Japan International Cooperation Agency
JRC	Joint Research Centre (European Commission)
KNMI	Koninklijk Nederlands Meteorologisch Instituut
MAP	Mean annual precipitation
masl	Metres above sea level
MAWF	Ministry of Agriculture, Water and Forestry
MINAMB	Ministry of Environment (Angola)
MODIS	Moderate Resolution Imaging Spectroradiometer
NamWater	Namibian Water Corporation
NASA	National Aeronautics and Space Administration
NBI	Nile Basin Initiative
NCEP/NCAR	National Centers for Environmental Prediction/National Center for Atmospheric Research
NHS	Namibia Hydrological Services
NMS	Namibia Meteorological Service
NOAA	National Oceanic and Atmospheric Administration
NORAD	Norwegian Agency for Development Cooperation
NRT	Near-real-time
NWC	Namibia Water Corporation
PET	Potential Evapotranspiration
PPP	Purchasing power parity
QAQC	Quality Assurance / Quality Control
RBMP	River Basin Management Plan
RBO	River Basin Organisation
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RMF	Regional Maximum Flood
RSAP	Regional Strategic Action Plan
RWP	Regional Water Policy
SADC	Southern Africa Development Community
SAP	Strategic Action Plan
SASSCAL	Southern Africa Science Service Centre for Climate Change and Adaptive Land-Use
SPEI	Standardised Precipitation-Evapotranspiration Index
SRES	Special Report Emissions Scenarios
SRTM	Shuttle Radar Topography Mission
TDA	Transboundary Diagnostic Analysis
TRMM	Tropical Rainfall Measuring Mission
UNCAC	United Nations Convention against Corruption
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNITAR	United Nations Institute for Training and Research
UNOSAT	United Nations Operational Satellite Applications Programme

WB The World Bank
WMO World Meteorological Organisation
WOIS Water Observation Information System

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EXECUTIVE SUMMARY

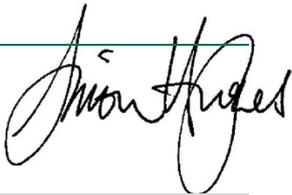
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AMENDMENT RECORD

This report has been issued and amended as follows:

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			Grant Bruce Project Director
			Simon Hughes Project Manager

1.0 INTRODUCTION

The Cuvelai River Basin is a transboundary river basin, shared between the countries of Angola and Namibia. The Cuvelai River is endorheic – draining inland, rather than to the ocean – and on its journey from its source in the Angolan Highlands, it exhibits unique drainage patterns seen nowhere else on Earth. Except for the drainage channels in the Cuvelai and Mui sub-basins in Angola, the Cuvelai River is ephemeral – flowing only in response to rainfall events – and the western portion of the basin is characterised by a broad landscape of interconnected channels known as iishana (singular – oshana). This broad, almost level landscape is also prone to extensive flooding, following high intensity or prolonged rainfall events. These rainfall events are contrasted with long periods of low or absent rainfall, resulting in drought conditions. Northern Namibia and Southern Angola are home to large populations, with settlements spread across the entire region, concentrated in the iishana region, and in villages around the border region. Significant formal and informal cross-border trade in goods and services contribute to livelihoods of many basin dwellers, and transboundary grazing by livestock and other migratory practices are widespread as cultural and social ties across the political boundary are strong. The national business languages are English (Namibia) and Portuguese (Angola), but most basin dwellers share dialects of a common language – Oshikwanyama.

To ease water scarcity and improve water supply in the Cuvelai River Basin, the governments of Angola and Namibia have cooperated on the development of the Kunene Transboundary Water Supply Project, which sees abstraction of water from the Cunene River in Angola at Calueque Dam, which is then transferred over the border into Namibia via a canal, and into the Cuvelai River Basin, and on to Oshakati, where it is treated to augment existing supplies, and redistributed across the region to various towns and villages. Water from this system is also transferred back over the border to Ondjiva in Southern Angola. This project supplements vulnerable water supplies in both countries, and is the basis for an already cooperative environment between the countries of Angola and Namibia.

The agreement to establish the Cuvelai Watercourse Commission (CUVECOM) was signed by the Government of the Republic of Angola and the Government of the Republic of Namibia, in Windhoek, Namibia, in September 2014 (see Appendix A1 of this report), hereafter referred to as the Agreement. The Agreement establishes, among other things, the definitions, the scope of the agreement, and the objectives and functions, structure and powers of the Commission. Following the signing of the agreement, small steps have been taken to move forward, but the current project is intended to catalyse action, and support concrete, tangible steps toward the development and implementation of the Commission.

This Rapid Basin Assessment is part of the ‘CUVECOM Consultancy’ project  funded by GIZ and UKAid on behalf of the CUVECOM. It is intended as a scoping-level assessment of data and information availability for the Cuvelai River Basin. It also summarises a parallel stakeholder engagement process that aimed to inform interested and affected parties about the project and CUVECOM itself, and identify priorities from the stakeholder-level, which, together with information gaps from the rapid assessment, would inform a series of recommendations for technical and institutional programmes for CUVECOM moving forward.

The report includes the following sections:

- A Rapid Assessment of the Cuvelai River Basin, including the following aspects:
 - Physiographic;

- Hydro-climatic;
 - Climate change considerations;
 - Water utilisation and demand;
 - Disaster risk management;
 - Social and economic;
 - Governance and institutional;
 - Cross-cutting themes;
 - Institutional arrangements;
 - Sustainable financing; and
 - Data and information gaps.
- A summary of the Stakeholder Consultations;
 - Recommendations; and
 - Literature cited and data sources.

This report is intended to lay the groundwork for the future growth of CUVECOM, providing direction and inspiration for the nascent Commission.

1.1 PROJECT OVERVIEW

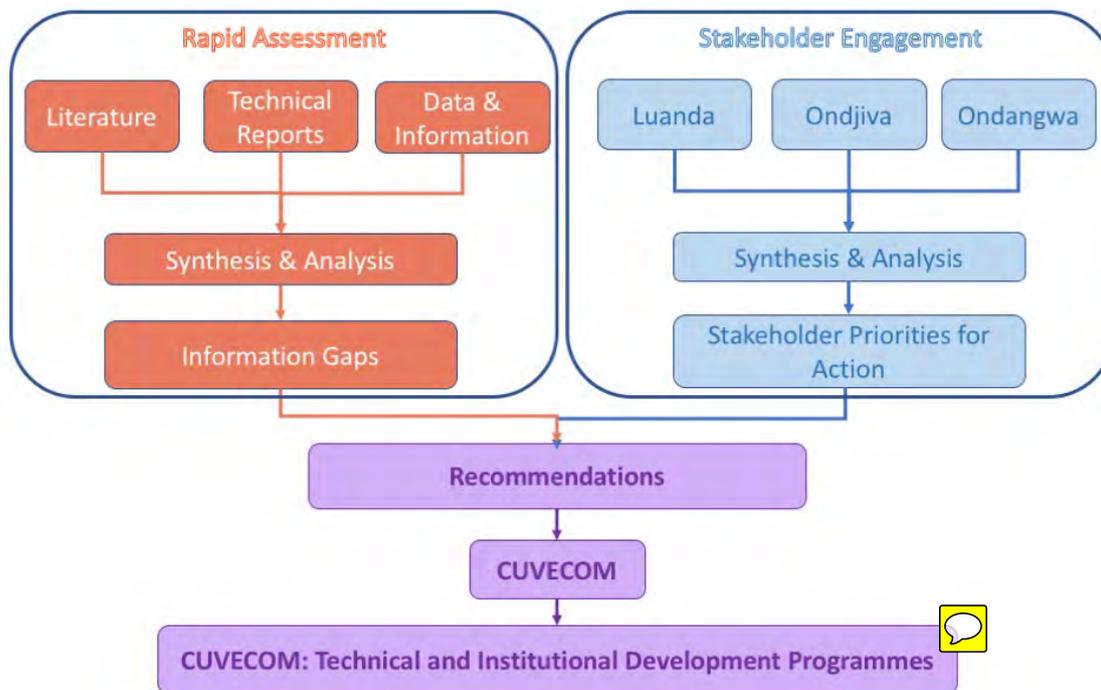
The CUVECOM Consultancy Project was initiated to provide strategic inputs to the development of the Commission, through an evaluation of available information on the basin and its inhabitants, and priorities identified by stakeholders.

The project was implemented through the following the steps:

- Inception meeting with the Angolan and Namibian delegations;
- A literature and data/information availability review;
- Development of a Rapid Assessment of the Cuvelai River Basin ;
- Stakeholder consultations in Angola and Namibia;
- Integration of the Rapid Assessment, the findings of the Stakeholder Consultations and Recommendations into a single report;
- Translation of the report into Portuguese;
- Feedback to the co-chairs;
- Implement updates based on the review by both delegations; and
- Project finalisation.

The project overview is illustrated in Figure 1.

Figure 1 Project Overview.



1.2 METHODOLOGY

A Rapid Assessment provides an inexpensive approach for quickly setting priorities, which can provide direction for future development. From the outset, the purpose of this process was to identify requirements for establishing and continued development of an effective river basin organisation (RBO). Recommendations included as a part of this assessment are preliminary only, and meant to be adapted as ecological conditions, water utilisation patterns, and needs identified by stakeholder groups change.

1.2.1 Rapid Assessment

The Rapid Assessment that forms a central part of this report was guided by available literature, sourced from the consultant’s collection, GIZ, internet sources, and the delegations from Angola and Namibia. It should be noted that much of the reviewed literature focused on outputs from completed projects, which generally addressed one portion of the basin, either Angolan or Namibian.

The primary focus of this Rapid Assessment was the identification of information gaps, which was integrated with stakeholder meeting outputs. Together these inputs are carried forward into a series of the recommendations for formalisation and future development of CUVECOM.

It is not the intention of the Rapid Assessment to rewrite, replicate or compete with the substantial body of work that has been completed by authors including Development Workshop in Angola, John Mendelsohn and Jaro Consulting in Namibia. These publications are extremely detailed and were developed over many years, building upon a growing pool of data, information, knowledge and understanding of the basin and its people. The current consultancy was apportioned a limited time to develop this report, and the consultant believes that while presentation of a profile of the Cuvelai River Basin is useful, more value can be gained from developing the institutional configuration of CUVECOM,

and elaborating the results of the stakeholder workshop. Each section of the Rapid Assessment also includes a brief assessment of information and data gaps, summarised at the end of the chapter. A full list of literature and data used in the development of the Profile of the Cuvelai River Basin is provided in Section 5.0.

1.2.2 Stakeholder Consultations

During March 2017, a series of stakeholder consultations were undertaken:

- **Angola**
 - 2017-03-27, Hotel Tropico, Luanda, including 16 participants; and
 - 2017-03-29, Villa Okapale, Ondjiva, including 16 participants.
- **Namibia**
 - 2017-03-30, Ondangwa Country Lodge, including 44 participants.

The programme of each consultation followed a similar format, with minor variations in response to the stakeholder preferences:

- Welcome from the host agency;
- Round-table introductions;
- Introductory remarks from GIZ Transboundary Water Management in SADC;
- Project overview presentation from the consultant;
- Stakeholder presentations, introducing their mandates, the nature of their involvement in the Cuvelai River Basin, and any challenges and opportunities they foresee for the CUVECOM;
- A participatory process to determine a series of priorities for CUVECOM to consider moving forward; and
- Concluding remarks from the host agency and GIZ.

Detailed participant lists are provided in Appendix A1, listing the agencies represented, their contact details, and the gender of each participant.

The primary intention of the workshops was to allow stakeholders to establish and elaborate their roles in the basin, and put forward their contributions for consideration in future technical and institutional programmes. The processes were not guided by the consultant, and the priorities are transcribed as stated during the workshops.

1.2.3 Formulation of recommendations

The recommendations included in Section 4.0 are a qualitative synthesis of the outcomes from the Rapid Assessment Process, the Lessons Learned from other RBOs from SADC Water Division (Section 2.8.6) and the Priorities identified by stakeholders. They are intended to provide practical direction to CUVECOM, and guide next steps towards activation of CUVECOM as an operational RBO.

1.3 ASSUMPTIONS

All assumptions made in this assessment are based only on available information. Conclusions are limited due to a lack of information and data in both countries  however, in general sufficient data and information sources were accessed to conclude the study. It is the opinion of the consultant that the limitations of documentation, data and information is a combination of **existence** – whether data exists at all – and **access/availability** – whether it is possible to obtain the required sources. Therefore, it is assumed that all documentation, data and information identified and accessed is everything that is available, considering clear requests were issued to both delegations for all relevant sources to be provided to the consultant.

This situation points directly to the urgent need for the establishment of a multi-lingual knowledge sharing platform, which is discussed in more detail in Section 5.1 and a need for consistency in data collection methods and efforts across administrative boundaries.

Please note that the river basin adjacent to the Cuvelai River Basin to the west is spelled ‘Cunene’ in Angola and ‘Kunene’ in Namibia. Throughout this document, attempts are made to use the correct reference when referring to the river in different countries. When referring to the basin it is referred to as **Cunene**.

2.0 RAPID ASSESSMENT OF THE CUVELAI RIVER BASIN

To date, several studies and profiles have been developed for the Cuvelai River Basin, but primarily on a country-basins basis - with maps, data, analysis and commentary ceasing at the border of the studied country.

It is important to note that this profile of the Cuvelai River Basin **is not** intended to replicate earlier studies or literature on the basin; and is also not intended to be a new study, collecting and analysing new data; but rather to provide a rapid desktop overview of the basin, setting the scene for the rapid assessment.

The profile includes the following components:

- Physiographic;
- Hydro-climate;
- Climate Change;
- Water supply and utilisation;
- Disaster risk management;
- Social and economic;
- Governance and institutional aspects;
- Cross-cutting issues;
- Institutional arrangements;
- Sustainable financing; and
- Information and data gaps:

Each section includes a summary of key available data sources, and data and information gaps.

2.1 BIOPHYSICAL PROFILE

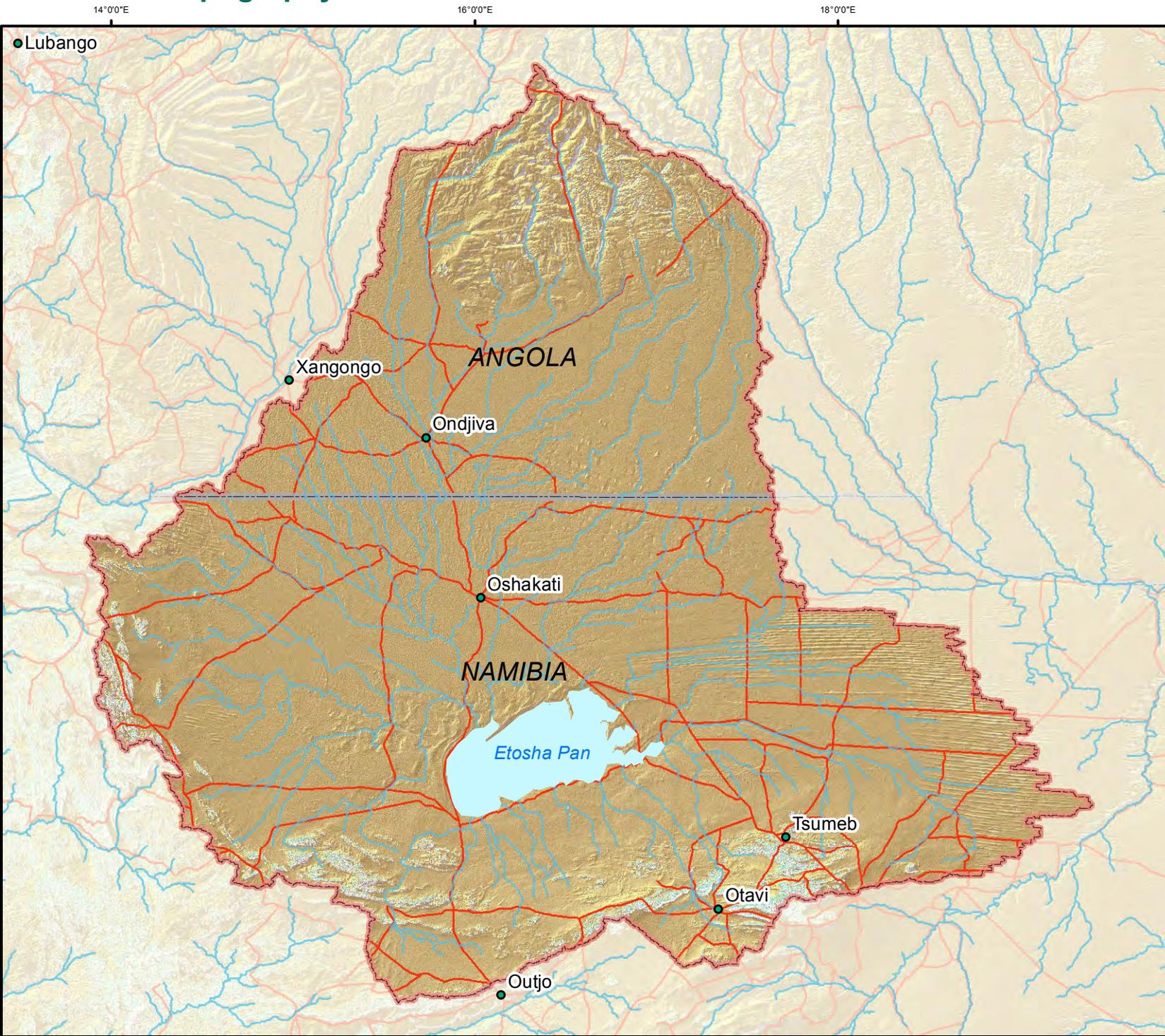
The physiographic profile includes topography, the Cuvelai River Basin extent, a description of the sub-basins, the soils, flora and fauna, geology, geomorphology and land cover.

2.1.1 Topography

There is an approximately 450 m elevation difference between the source of the Cuvelai River in the highlands of southern Angola, and Etosha Pan in northern Namibia, a distance of over 380 km (Mendelsohn, Jarvis, & Robertson, 2013). This is considered to be an extremely flat river basin, especially when compared to other rivers in the region:

- Limpopo – 2,238 m;
- Cunene – 2,000 m; and
- Orange-Senqu - 3,482 m

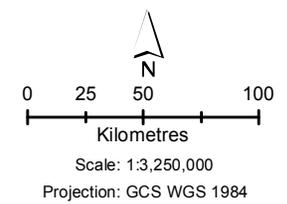
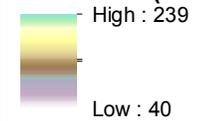
FIGURE 2 - Topography of the Cuvelai River Basin.



Legend

- Settlement
- Major Roads
- Watercourse
- ▭ Political Boundaries

Elevation (masl)



2.1.2 Cuvelai River Basin extent

The source of the Cuvelai River is in the eastern highlands of Angola; the source for other southward flowing rivers, including the Cunene/Kunene and Cubango/Okavango rivers – as shown in Figure 3.

During literature searches, it became clear that there are several accepted basin boundaries in-use. An urgent item for a basin-wide assessment will be to establish an agreed basin boundary, which can be ratified and accepted by CUVECOM. Much of the difficulty in delineating an agreed basin boundary is associated with the extremely flat, and in some cases shifting, topography of the southern half of the basin. Furthermore, it is also noted that there are some channels in the far south west that used to flow to the Cuvelai that now flow to the Kunene (Mendelsohn J. , Pers comms, 2017).

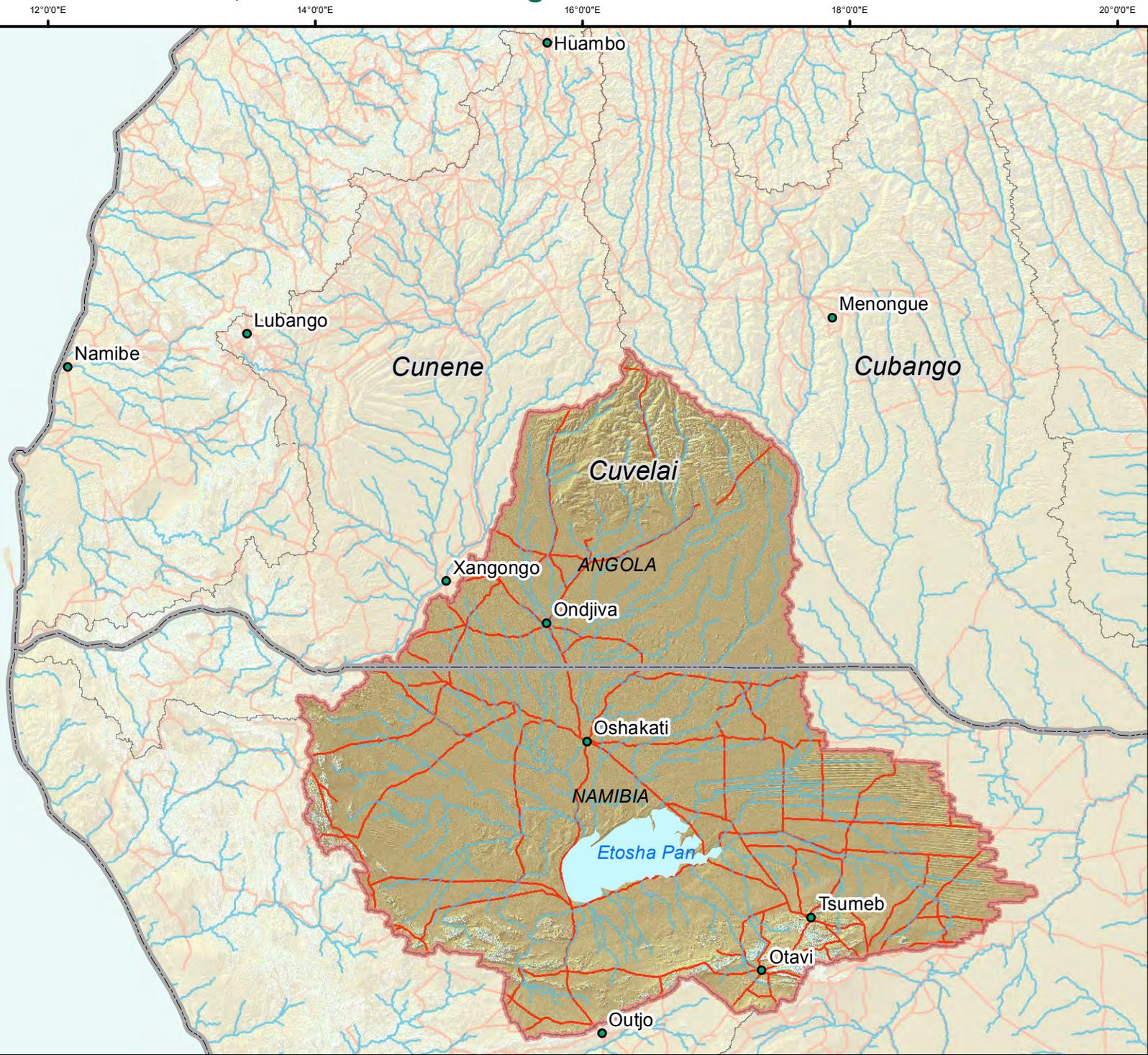
For the purposes of this study, the United States Geological Survey (USGS) HydroSHEDS basin boundary is used, until an official boundary is accepted by CUVECOM. This boundary is applicable at a regional scale, as it was developed using consistent elevation data, captured during from Space Shuttle flight for NASA's Shuttle Radar Topography Mission (SRTM), and developed as part of a suite of geo-referenced vector and raster data sets at a range of scales, including river networks, watershed boundaries, drainage directions, and flow accumulations (USGS, 2010).

Topographic data sources include:

- Shapefiles from the Directorate of Environmental Affairs (2002). Coverage is for the Namibian portion of the Study Area;
- Very high resolution LiDAR datasets (Persendt and Gomez 2016);
- A global 30 m resolution digital elevation model (DEM) from National Aeronautics and Space Administration's (NASA) Shuttle Radar Topography Mission (SRTM)(JPL 2017); and
- A global 20 m resolution DEM from ASTER Global Digital Elevation Model V2 (GDEM) (Gesch et al. 2012).

The last two data sets listed here cover the entire basin; however, in both cases, require validation in the Cuvelai River Basin, and due to their resolution, may not be detailed enough for determining hydrological regimes, and river basin and sub-basin boundaries.

FIGURE 3 - Cunene, Cuvelai and Cubango River Basins.



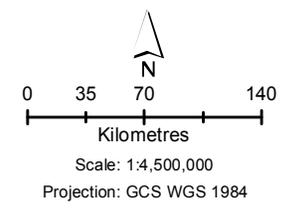
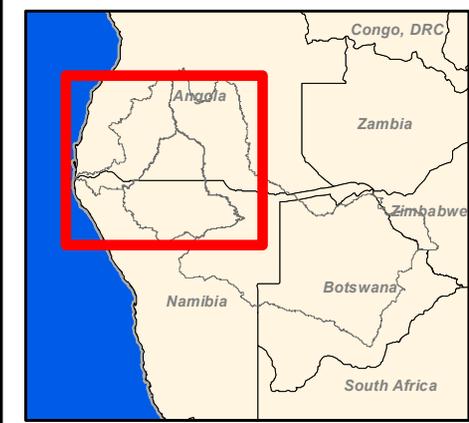
Legend

- Settlement
- Major Roads
- Watercourse
- River Basins
- Political Boundaries

Elevation (masl)

High : 244

Low : 36



2.1.3 Sub-basins

Drainage sub-basins have been mapped and described by Mendelsohn and Weber 2011. From north to south, zones include:

- Cuvelai River sub-basin. Water in this zone tends to be fresh;
- Mui River sub-basin. Water in this zone tends to be flow regularly, and is fresh;
- Calemo-Caundo sub-basin;
- Cuvelai Delta. Water in this zone tends to be flow regularly, and is fresh;
- Shana Zone. Water in this zone tends to be flow regularly, and is fresh;
- Central Drainage sub-basin. Water in this zone tends to be fresh;
- Central Plains sub-basin;
- Eastern Sand sub-basin; and
- Saline Pans sub-basin. There are typically no channels in this sub-basin, water is sourced from precipitation.

These sub-basins are illustrated in Figure 4, and briefly described below.

2.1.3.1 Cuvelai River Sub-Basin Zone

The Cuvelai River Sub-Basin is one of the only perennial sources of the Cuvelai Basin. The Sub-Basin zone receives annual precipitation of approximately 900 mm per year which is much greater than the other sub-basins, aside from the Mui River Sub-Basin.

The water of the Cuvelai Sub-Basin is largely fresh as the channels are narrow and thus the flow of the river is comparatively rapid. North of the Cuvelai Delta, the Cuvelai River fans out at the town of Evale and is a myriad of narrow interconnected channels rather than one primary channel. This fanning out, is similar to river deltas around the world that fan out before they reach the sea or inland delta.

2.1.3.2 Mui River Sub-Basin Zone

The Mui River is one of the only perennial sources of the Cuvelai Basin. The Sub-Basin zone receives annual precipitation of approximately 900 mm per year which is much greater than the other sub-basins, in Cuvelai Basin (apart from the Cuvelai sub-basin as described above).

The water of the Mui River Sub-Basin is largely fresh as the channels are narrow and thus the flow of the river is moving comparatively rapid. The Mui River fans to the west of the Cuvelai Delta, into multiple braided channels that are inter-connected and generally narrow.

2.1.3.3 Calemo-Caundo River Sub-Basin Zone

Though the Calemo-Caundo River Sub-Basins generally receive relatively high annual precipitation, the rivers are ephemeral as they overlay extremely permeable Kalahari Sand. This sandy substrate impacts the drainage of these river sub-basins as water seeps into the ground. The further east, the more this factor impacts the flow of the Sub-Basins. Even during years of extreme rainfall, water travels further through the basin, but ultimately sinks into the permeable sand substrates.

Figure 4 Sub-basins of the Cuvelai River Basin.

Map of sub-basins to follow in next draft. Seeking data.

2.1.3.4 Cuvelai Delta Zone

The Cuvelai Delta zone includes hundreds of interwoven channels from the Cuvelai River, Mui River and parts of the Shana that fan out across the landscape. In years of heavy rain, the Caundo River may flow and combine with channels within the Delta. The Delta has formed over previously laid river-borne sediments and due to the build-up of silt and other materials, the Delta's Apex has likely shifted southward from Mupa to Evale over thousands of years.

These braided channels converge in the Delta and form unified distinct water columns. These larger channels have narrow beds causing the flow of the water to be comparatively rapid and thus the water is fresh. This network of braided channels converge again in the southern area of the Delta, which converge with flows from the Shana Zone to the north-west.

2.1.3.5 Shana Zone

The Shana zone is formed by hundreds of interconnected large broad channels that are braided across the landscape. The channels in the northern end of the Shana zone are generally broader than those found in the southern part of the zone. The Shana flows from north-west to south-east, with the Northern most iishana merging with the Central drainage, while the remainder of the Shana flows south-east into the Omadhiya Lakes.

The southern-most iishana, the Etaka shana, resembles a confined river channel as it has been impounded by the Olushandja Dam, forming a reservoir. The Etaka iishana is thought to have once been part of the Kunene River Basin, however, the Kunene has migrated to flow to the Atlantic Ocean through the Foz du Kunene. As the Etaka iishana has been cut off from its previous source, the system depends entirely on annual rainfall, which ranges between 450 mm to 600 mm per annum. Thus, the flow of the Shana zone is erratic as the system is totally dependent on variable annual precipitation.

The channels can spread across hundreds of meters in width and are mostly shallow, measuring a maximum of 10 m in depth. Soils in the Shana Sub-Basin are generally very saline, which indicates comparatively high rates of evaporation compared to the other sub-basins. This high rate of evaporation is due to the broad, shallow waterways that are found throughout the Shana Sub-Basin. Once flows from in the Shana drop and eventually stop, as occurs annually, the remaining water pools in standing channels and eventually disappear through evaporation and seepage. This process causes previously dissolved salts to be left in the substrate and build up annually as the water is evaporated.

2.1.3.6 Central Drainage Zone

The larger channels, which comprise the Central Drainage Sub-Basin, originated in the Cuvelai Delta, where the northern alluvial fans of the Cuvelai and Mui Rivers converged to form these channels. The water of the Central Drainage Sub-Basin is largely fresh as the channels are deep and narrow and thus the flow of the river is moving more rapidly than the shallow channels of the Shana. The water flows south through the Central Drainage and eventually fills the Omadhiya Lakes. In years of high precipitation, the Central Drainage zone is prone to flood as it is a zone of high convergence and can cause significant damage in the areas between Lake Ondjiva and the Omadhiya Lakes.

2.1.3.7 Central Pans Zone

The Central Pans zone is formed by tens of thousands of small pans which fill with water during localised precipitation events. The pans are mostly isolated from adjacent pans and flooding in this area is not significant, as water is contained in the pans and evaporates or seeps into the subsurface during dry periods.

2.1.3.8 Eastern Sand Zone

The Eastern Sand Sub-Basin is underlain by Kalahari Sand which directly affects the drainage of the zone due to the permeable sands. The few remaining drainage channels are found within wide swaths of grasslands which serve as grazing zones for cattle in the zone. Numerous pans that spread throughout the zone were formed during wetter periods, that sometimes fill with water during periods of heavy local rain. However, these pans usually dry up within the following weeks or months. These pans form the only viable agricultural land in the zone and many people cultivate crops along the edges.

2.1.3.9 Saline Pans Zone

The Saline Pans Zone has formed as salts have been transported over millions of years, from the upper basin to the South through repeated evaporations. This build-up of saline materials has been transported from the southern reaches of the Shana and deposited through both alluvial and Aeolian processes in these pans. Agriculture in this area is limited to cattle farming due to the saline soils and thus few people live in this Zone. The water that fills these pans during localised rain events, is mostly evaporated because the pans are mostly impermeable due to the sands build up. During the annual dry season, wind scours the surface of the pans and removes fine materials, which maintains the depression features of the pans.

2.1.4 Soils

Maps and shapefiles of soil and soil suitability for cultivation in Namibia, are presented in Directorate of Environmental Affairs (2002). Soils in the Cuvelai are described in Mendelsohn and Weber 2011 and Ministry of Agriculture, Water and Forestry (MAWF) 2006.

Overall, soils are relatively fertile in the Cuvelai (Mendelsohn and Weber 2011). Soils are primarily weathered, leached, and sandy arenosols, especially in the east and north of the basin. Weakly defined cambisols are found in the west of the catchment, especially the saline Shana Zone. Lime-rich calcisols are in the Central Zone, Cuvelai Delta zones (Mendelsohn and Weber 2011).

The distribution of soils within the basin largely determines the distribution of the population in the basin, as the productivity of soils have, to a large extent, determine where people have settled across the region (Mendelsohn, Jarvis, & Robertson, 2013).

2.1.5 Ecology

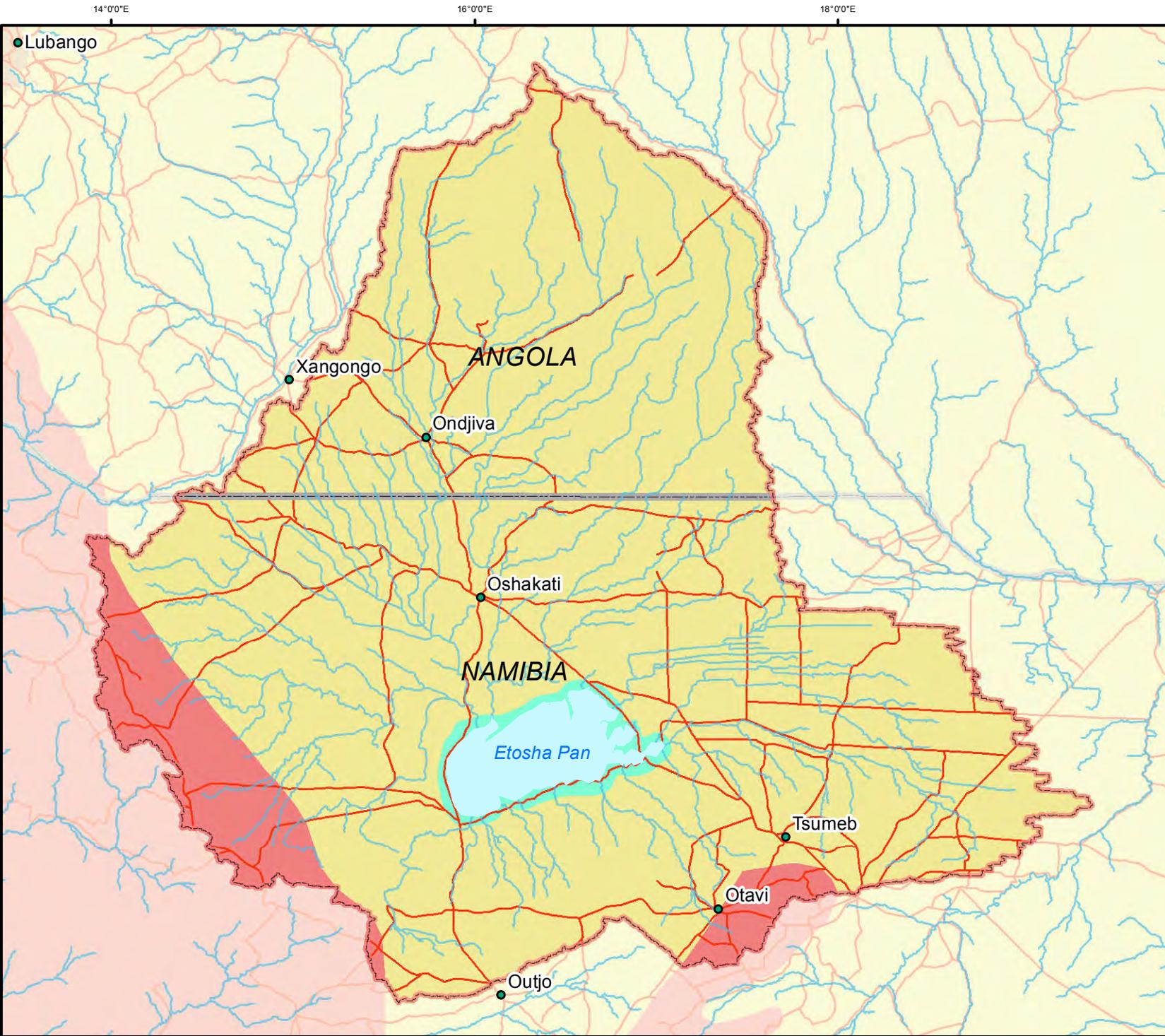
Biomes are globally similar bio-climatic areas, defining major habitat types, like ecological communities of plants and animals, soil organisms and climatic conditions (PJTC Kunene, 2011), and are a useful guide for characterising a landscape and its intrinsic biodiversity in general terms. Biomes are characterised by plant spacing (forest, woodlands, savanna) or plant types (trees, shrubs, and grasses), and the climatic factors that influence the distribution of biomes are latitude and humidity (PJTC Kunene, 2011). The terrestrial biomes present in the Cuvelai River Basin, as defined by the WWF are as follows:

- Deserts and Xeric Shrublands;
- Tropical and sub-tropical grasslands, savannas and shrublands; and
- Flooded grasslands and savannas.

The distribution of these biomes across the basin is illustrated in Figure 5¹. Most the basin is covered by tropical and subtropical grasslands, savannas, and shrublands., with desert and xeric shrublands present in the south, and flooded grasslands and savannas cover the Etosha Pan area.

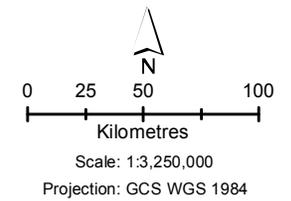
¹ Full descriptions of these biomes can be found on the WWF website: <https://www.worldwildlife.org/biomes>

FIGURE 6 - Terrestrial Biomes.



Legend

- Settlement
 - Major Roads
 - Watercourse
 - ▭ Political Boundaries
- ### Terrestrial Biomes
- Tropical and subtropical grasslands, savannas, and shrublands
 - Flooded Grasslands and Savannas
 - Montane Grasslands and Shrublands
 - Deserts and Xeric Shrublands



2.1.5.1 Terrestrial eco-regions

Terrestrial eco-regions are region and ecosystem-specific characterisations of defined by WWF (2017) as “*large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions*”. The eco-regions intersecting with the Cuvelai River Basin are listed in Table 1, and illustrated in Figure 6.

Table 1 Terrestrial eco-regions of the Cuvelai River Basin (adapted from WWF 2017).

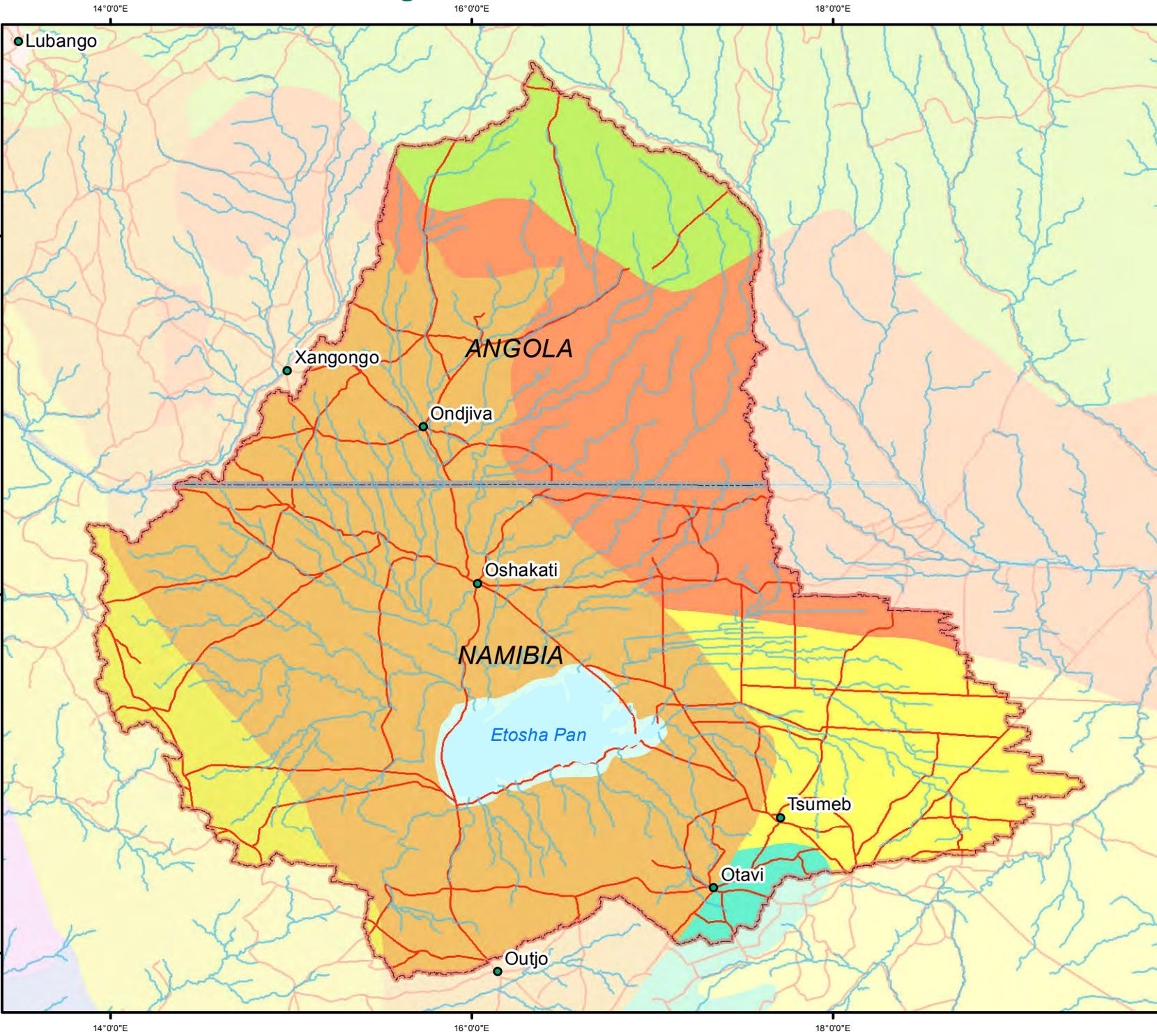
Eco-region	Description
Namibian Savanna Woodland	The Namibian Savanna Woodland ecoregion covers the Great Escarpment that delimits the interior of southern Africa from the Kaokoveld and Namib Deserts. This broken and deeply dissected escarpment is an area of high endemism for plants, invertebrates, amphibians, reptiles, mammals and birds. The northern area of the escarpment, the Kaoko escarpment, is an endemism "hotspot" (an area of extremely high species richness and endemism). This northern area is poorly protected and is under threat from poaching, off-road driving, and to a lesser extent from farming. The formal conservation status of the southern portion of the ecoregion is poor. Other forms of protection, such as conservancies, private nature reserves and game farms do, however, promote conservation of the area. If these areas can be effectively managed through collaboration with local communities, they may solve the conservation crisis in the area.
Etosha Pan Halophytes	The Etosha Pan Halophytics ecoregion is the remnant of a large, inland Pliocene lake. Today, the Etosha Pan is a dry, saline desert. Normally, the cracked, whitish clay is split into hexagonal salt-encrusted fragments, and wildlife is sustained only by surrounding freshwater springs. These springs attract a diverse array of large mammals, especially during the dry season, making it a popular tourist destination. In wet years, when the Ekuma, Oshigambo and Omuramba Ovambo rivers receive sufficient rainfall, the pan is transformed into a shallow lake.
Angolan Mopane Woodland	The Angolan Mopane Woodlands are located in Namibia and Angola, completely surrounding the Etosha Pan, which is considered a separate ecoregion. Mopane trees (<i>Colophospermum mopane</i>) dominate the vegetation, and are an essential resource for both the people and wildlife of the region. Elephants (<i>Loxodonta africana</i>) utilize almost every part of the mopane tree, and the region supports other large herbivores, including the critically endangered black rhino (<i>Diceros bicornis</i>). Species richness in this ecoregion is high, especially in comparison with the arid deserts to the west. Conservation potential is high in Namibia, due to the well-established Etosha National Park, and increasing community involvement and ownership of natural resources. Conservation in Angola has been severely compromised by the lengthy civil war, and many large mammal populations are near local extinction.
Kalahari Xeric Savanna	The Kalahari Xeric Savanna is characterised by a harsh climate, where temperatures may increase by 45°C from night to day, and rainfall is infrequent. Rain only falls on the reddish-brown Kalahari sands during the summer, pelting the savanna with violent, localised storms. Although this area is semi-arid, there is an impressive diversity of migratory birds and large mammals, both herbivorous and carnivorous. A considerable amount (approximately 18 percent) of this ecoregion is protected. Where it is not protected, heavy grazing has degraded the habitat. Fences are a serious problem because they obstruct the migratory routes of ungulates, and they pose significant threats to biodiversity in unprotected areas.

Table 1 (Cont'd.)

Eco-region	Description
Kalahari Acacia Baikiaea Woodland	Semi-arid Kalahari Acacia-Baikiaea Woodland stretches across the center of southern Africa, from northern Namibia through Botswana and just into the Tuli Block of South Africa. Surface water is scarce here and droughts occur roughly once every seven years. As a result, the human population is fairly low, especially on the sandveld that covers most of the ecoregion. The area supports a rich and diverse fauna, including a variety of ungulates and a number of threatened large animals such as white (<i>Ceratotherium simum</i>) and black rhinoceroses (<i>Diceros bicornis</i>), wild dogs (<i>Lycaon pictus</i>), and elephants (<i>Loxodonta africana</i>). However, human populations are increasing and the growing cattle industry has far-reaching effects on the environment and wildlife. The migrations of large herbivores which used to occur in the ecoregion are now hindered by veterinary control fences, resulting in mass die-offs in times of drought.
Zambezi Baikiaea woodlands	Deep Kalahari sands occur in a wide belt along the Angolan-Namibian border across to Zimbabwe, supporting dry deciduous forest dominated by <i>Baikiaea plurijuga</i> . The hot, semi-arid climate and nutrient-poor soils mean that this region is not suitable for farming, and thus it has retained some of its natural vegetation. Over 160 mammal species are found here, including ungulates and large predators. However, settlements occur along rivers, and the valuable <i>Baikiaea plurijuga</i> is sought after for the timber trade. The civil war in Angola and hostilities between Angola and Namibia in the Caprivi Strip further threaten the future of this ecoregion.
Angolan Miombo Woodlands	Covering all of central Angola and extending into the Democratic Republic of Congo, the extensive Angolan Miombo Woodlands are part of an even larger miombo ecosystem that covers much of eastern and southern Africa. The miombo is characterised by several unique ecological factors, including its propensity to burn, the importance of termites, and the unusual browsing conditions found here. While only poor-quality browsing is available, this ecoregion hosts a rich assortment of large mammals, some bulk feeders like the African elephant (<i>Loxodonta africana</i>), some specialised feeders such as the sable antelope (<i>Hippotragus niger</i>), and some, such as the tsessebe (<i>Damaliscus lunatus</i>), that utilize the wetlands scattered throughout this ecoregion. However, large mammal populations and all conservation activities have been severely affected by the decades-long civil war in Angola since 1974.

Source: (WWF, 2017)

FIGURE 7 - Terrestrial Ecoregions

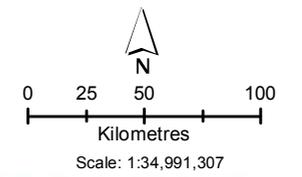
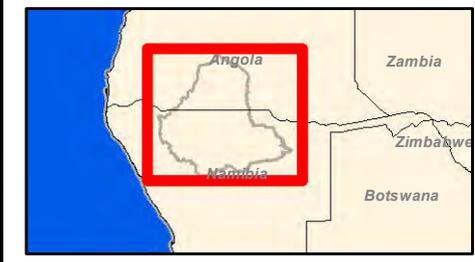


Legend

- Settlement
- Major Roads
- Watercourse
- ▭ Political Boundaries

Terrestrial Ecoregions

- Angolan Miombo woodlands
- Angolan Mopane woodlands
- Angolan montane forest-grassland mosaic
- Etosha Pan halophytics
- Kalahari Acacia-Baikiaea woodlands
- Kalahari xeric savanna
- Kaokoveld desert
- Namib desert
- Namibian savanna woodlands
- Zambeian Baikiaea woodlands



This map illustrates a landscape dominated by Angolan Mopane Woodlands, and Zambezian Baikiaea Woodlands, with small portions of Angolan Miombo Woodlands, Kalahari Acacia-Baikiaea Woodlands, Namibian savanna woodlands, and Etosha Pan Halophytes.

2.1.5.2 Fauna

During periods of good rain, the iishana and pans fill with water and the area is abundant in various species of birds, fish, frogs, and many other small animals. Large mammals and other species are mostly limited to fenced boundaries of Ethosha National Park. The Omadhiya lakes, the Cuvelai iishana and Ethosha Pan are regarded as wetlands of national and global importance and these areas were designated as a Ramsar site in 1995.

2.1.5.3 Avifauna

The Cuvelai Basin is an especially important bird nesting location with over 400 species recorded in Etosha National Park. The largest number of birds are found in the summer period (October to April) as the Etosha Pan is full of water and many nesting birds migrate to hatch their young, adding to the already significant number of birds that inhabit the Pan throughout the year. Birds such as the pelicans and flamingos (Greater and Lessor) migrate from all over Southern Africa to the pan to feed and breed.

The Pan is home to the only breeding site of the Blue crane outside of South Africa, the numbers of which have plummeted over the last 40 years. In 1976, 138 individual Blue cranes were identified, whereas counts in 2012 only yielded 18 adults and 2 chicks. This decline is not limited to Blue cranes, as nesting flamingo counts have also declined from one million individuals recorded in the past, to recent years where only 20,000 individuals could be accounted for (A Profile and Atlas of the Cuvelai-Etosha Basin).

Like the pans, the iishana system sees its highest levels of bird life during high flows periods, which can be separated by months or years. Thus, extended high flow periods result in the highest and greatest concentration of avifauna activity.

The northern areas of the Cuvelai Basin are considered degraded of bird species, as human encroachment has drastically affected habitat.

2.1.5.4 Invertebrates

When flooded the Etosha Pan, and other pans in the area, represent lakes or ponds that feed on invertebrates that have evolved to survive long dormant periods and spawn during wet periods. These invertebrates have adapted to long periods of heat through shorten lifespans and laying eggs that can withstand extended dry periods. Many of these species hatch, mature and lay eggs within a few hours of the wet season. Additionally, adults of some species of invertebrates slow their metabolism to become dormant and hibernate during dry periods, emerging from this hibernation as soon as the wet season begins.

There are sixteen endemic invertebrate species to Namibia which are vital in the food chain of birds, fish, and frogs.

2.1.5.5 Frogs

There are fifteen separate species of frogs found in the Cuvelai Basin though none of these species are endemic. Frogs serves as an important link in the local food chain, as birds, fish, small mammals

and other predators include frogs in their diets. Some species of these frogs have evolved to complete a reproductive lifecycle in as short as 22 days, allowing for these species to take advantage of high flow periods.

2.1.5.6 Mammals

The Cuvelai Basin serves as important habitat for species including carnivores, bats, antelope and rodents. In the past, the Cuvelai provided rich habitats for buffalo, reedbuck and other wetland mammals, but these species no longer occur there. Migratory routes have been blocked by fencing all around the basin and the Etosha National Park, and as a result, most large mammals can only be found within the Park.

Within Etosha National Park, there are over 50,000 large herbivores including zebras, blue wildebeest, and springbok. Elephants, giraffe, black rhinoceros, gemsbok, eland, kudu, steenbok, dik-dik and black faced impala are also common in the Park boundaries. Predators are also found within the Park include leopards, cheetah, hyena, jackals, fox and lions. The Park includes 86 watering-holes, which are become hives of activity during dry periods, while during the wet season populations tend to dissipate as water is less scarce.

2.1.5.7 Reptiles

There are approximately 50 species of reptile in the northern sections of the Cuvelai Basin with approximately 70 species found in the southern areas of the Basin. This difference is based on more diverse habitat for reptiles in the southern area of the basin compared to the north. One small lizard species, the Etosha Agama is endemic to the Basin.

2.1.5.8 Fish

The Cuvelai Basin is also home to many different species of fish with 12 species known to inhabit the iishana, and another 35 species that have entered the system through linkages between the Cuvelai and Kunene river systems. Many of these species only move into the Basins channels during periods of flooding, while some species remain dormant in the substrate only emerging when the iishana or pans are inundated. Species found in the southern reaches of the Basin also tend to be more resilient to higher saline concentrations than species found outside this region.

2.1.6 Geology

The Cuvelai Basin is located in a sedimentary basin known as the Owambo Basin, part of the much larger Kalahari Basin. The Owambo is over 8,000 meters thick and consists of three main super groups overlying a crystalline basement. It is bordered to the east and south by the Damara Belt to the east and to the west by a rift complex. A brief description of the units is provided below.

- **Kalahari** – consolidated and unconsolidated sediments including silt, sand, gravel, sandstone, limestone and mudstone. The sediments within this unit were deposited by continental processes that primarily include Aeolian and fluvial deposition processes. This unit is composed of Quaternary, Tertiary and Cretaceous sediments and is up to 600 meters thick;
- **Karoo** – basalt, siltstone, sandstone, shale, coal, and tillite. This unit is composed of Jurassic to lower Permian sediments and is up to 360 meters thick. This unit includes volcanics (basalt)

and intrusions, Aeolian deposits (sandstone), and glaciofluvial ice sheet deposits (tillite) that form the lower most units of the Karoo;

- **Damara** – Sandstone, siltstone, dolomite, limestone, shale, and phyllite. This sequence contains four known unconformities, is up to 8,000 meters thick, and is composed of Neoproterozoic sediments. This unit contains karstified carbonates that are generally located near faults. The unit has been folded and uplifted and is located in the southern and western edges of the Owambo basin; and
- **Congo Craton** – Meso Proterozoic to Paleo Proterozoic rocks consisting of granite, gneiss, schist, and gabbro.

Except for the Congo Craton, the above sequences each contain between six and 13 formations. Notable formations that will be referred to in the aquifer section of this report include:

- Kalahari formations - Andoni, Lower Andoni, Olukonda, Beiseb, Ombalantu;
- Karoo formations – Etjo; and
- Damara formations – Otavi Group including the Huttenberg, Elandshoek and upper Maieberg

Historic drilling and subsurface investigations have taken place near the Study Area as part of mineral exploration activities and the Tsumeb mine. Data from exploration activities assists in understanding the regional geology of the area.

The Study Area has recently been investigated to define its potential hydrocarbon reserves, with attention to the Damara supergroup. The Kalahari super-group has been studied for its groundwater supply potential particularly within and near the Cubango Megafan.

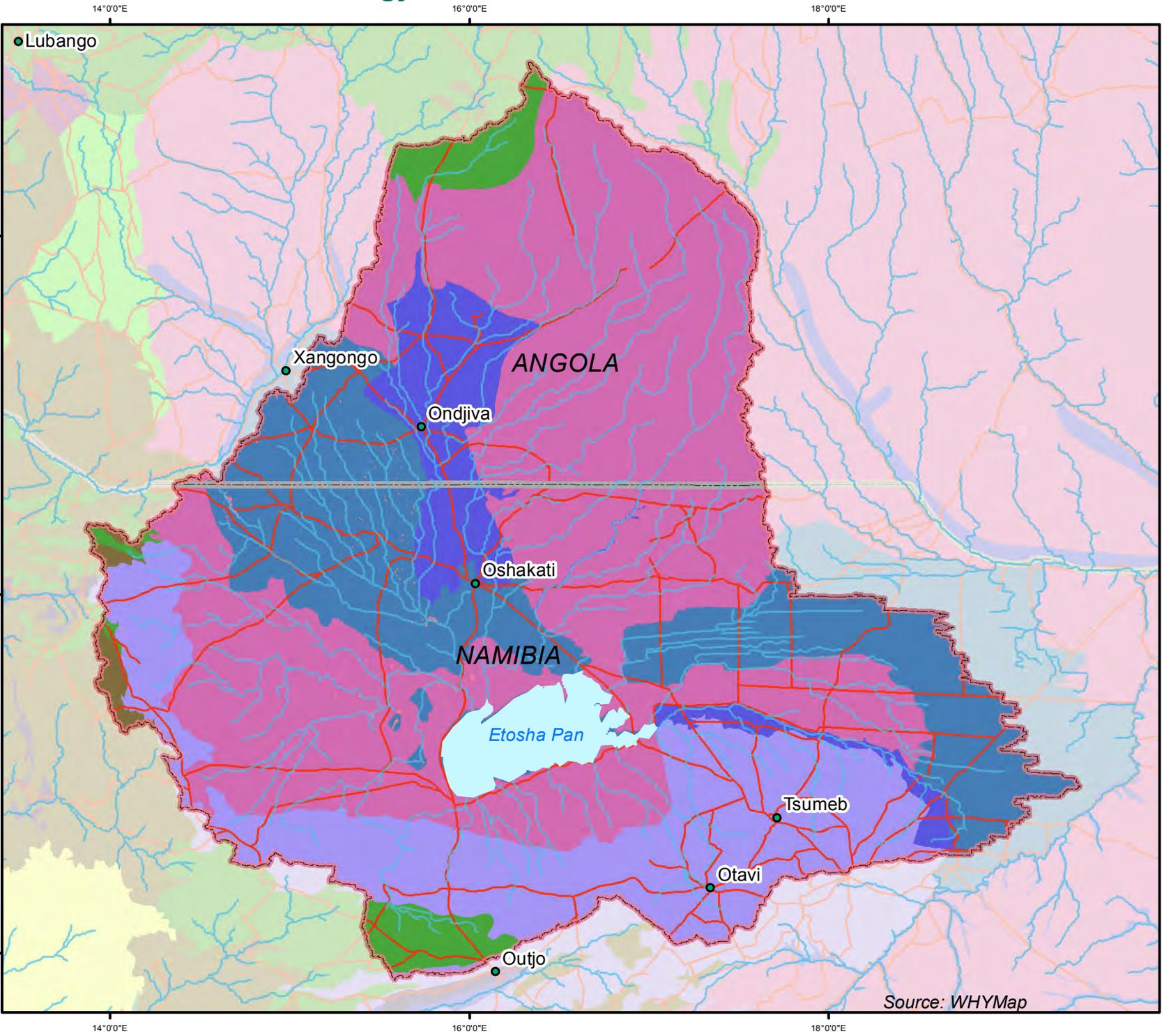
2.1.7 Geomorphology

The Cuvelai basin headwaters are in the Angolan highlands ('planalto'). Water flows from north to south, and forms a network of 'iishana': mostly ephemeral and anastomosing river channels. The iishana network extends from the northwest of the catchment near the Cunene River to the Etosha Pan, and is about 270 km long, and about 150 km wide at its widest point (Mendelsohn and Weber 2011). The basin is endoreic: a closed basin with no outflow.

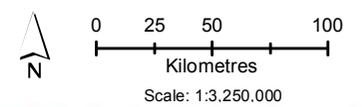
Ephemeral flow during floods ('efundjas') quickly evaporates and leaves salt deposits. The largest salt deposit is the Etosha pan, which is about 110 km by 45 km. The pan was once a lake, and salts have been accumulating there for millions of years. The Etosha is the largest and lowest pan in the basin, but many smaller pans exist. Evaporation of flood water creates saline soils throughout the southern portion of the basin (Section 2.1.4), which hinders plant growth (Mendelsohn and Weber 2011).

Unconsolidated sediments are mostly fluvial, and are hundreds of metres deep. Aeolian sediments are present in the eastern catchment; these sediments are particularly porous, and promote infiltration of rain and flood water (Mendelsohn and Weber 2011).

FIGURE 8 - Surface Lithology of the Cuvelai River Basin.



- Legend**
- Settlement
 - Watercourse
 - ▭ Political Boundaries
 - Major Roads
- Lithology**
- ▨ Aeolian Sediments
 - ▨ Alkaline Intrusive Volcanic
 - ▨ Alluvium - Beach, Strand, Coastal Dune
 - ▨ Alluvium - Fan Deposits
 - ▨ Alluvium - Fluvial
 - ▨ Alluvium - Gpsum
 - ▨ Alluvium - Other
 - ▨ Alluvium - Saline
 - ▨ Carbonate
 - ▨ Colluvium
 - ▨ Extrusive Volcanic
 - ▨ Hydrice - Organic
 - ▨ Inland Water
 - ▨ Kast
 - ▨ Metagenous
 - ▨ Metasedimentary
 - ▨ Non-Carbonate
 - ▨ Silicic
 - ▨ Ultramafic
 - ▨ Volcanic - Ash, Mudflow, Tuff



Source: WHYMap



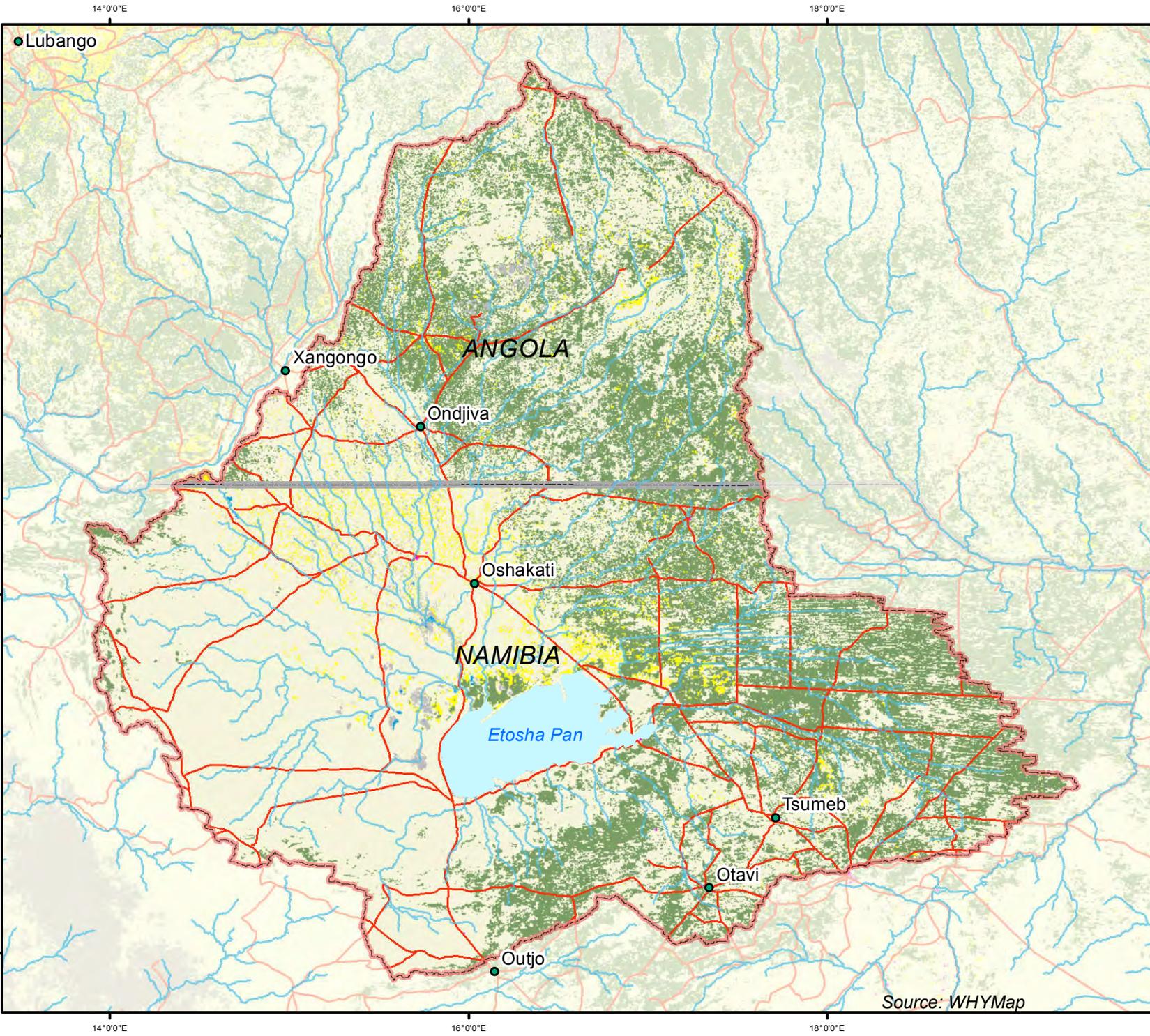
2.1.8 Land Cover

The land-cover of the Cuvelai River Basin closely matches the topography and eco-regions, but with marked changes in land use and land cover south of the border. Figure 8 is a generalised, continental-scale landcover map, showing broad land cover classes for the basin. The map shows sparse forest and woodland cover across the eastern portion of the basin, with some agriculture and barren land across most the western basin. A detailed landcover map, is needed for the Cuvelai River Basin.

2.1.9 Biophysical data and information gaps

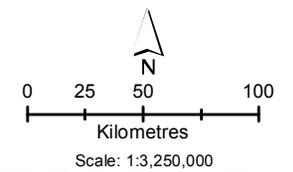
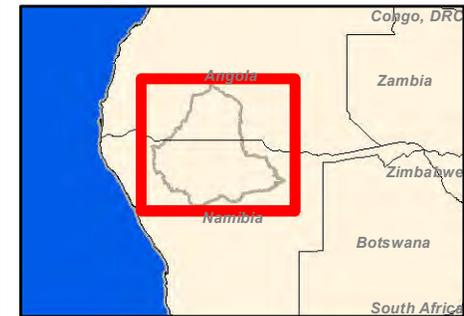
Overall, there is a general lack of consistent biophysical data available for the entire Cuvelai River Basin; a situation that needs to be improved to support future studies. While an effort has been made to collect as much publicly available data as possible for this project, a dedicated inventory project would yield a helpful mix of regional, national, and basin-specific data. Prior to the initiation of a basin assessment, such a preliminary database could be developed through collaborative technical work between government departments, academic research institutions, and activities of NGOs.

FIGURE 9 - Landcover in the Cuvelai River Basin.



Legend

- Settlement
- Watercourse
- Major Roads
- ▭ Political Boundaries
- ▨ Agriculture
- ▨ Shrub / Grass Land
- ▨ Barren Land
- ▨ Forest Cover
- ▨ Urban Areas
- ▨ Water bodies



Source: WHYMap

2.2 HYDROCLIMATIC PROFILE

This section of the Rapid Assessment provides a hydrological and climatological (hydro-climate) profile of the Cuvelai River Basin, based up on available data, information and literature.

2.2.1 Climate

In the section below, the hydrology, climate, and hydrogeology of the Cuvelai Basin are described. The emphasis is on identifying data sources, describing data availability, and assessing gaps.

2.2.1.1 Data Sources

Climatic data are available as station data, gridded data, and published climatic summaries.

Station data

Station data were evaluated from three sources:

- The Global Historical Climatology Network (GHCN v.3.3.0). The GHCN is a global database of monthly and daily air temperature and precipitation time series. Data are tagged by level of Quality Assurance / Quality Control (QA/QC). The dataset is maintained by NOAA (US National Oceanic and Atmospheric Administration), is peer-reviewed, high-quality, and is widely used (Klein Tank et al. 2002; Menne et al. 2012);
- Koninklijk Nederlands Meteorologisch Instituut (KNMI, the Royal Netherlands Meteorological Institute) Climate Explorer (KNMI 2017). The KNMI tool contains global daily, monthly, and annual climate-related time series. It also contains paleoclimatic data and climate change projections. It is peer-reviewed and widely used (Trouet and Van Oldenborgh 2013);
- The Southern Africa Science Service Centre for Climate Change and Adaptive Land-Use (SASSCAL) (Kaspar et al. 2015). SASSCAL provides near-real-time (NRT) data from a large network of weather stations in Namibia and Angola. Data are freely available, and datasets have been well documented. The NRT 'WeatherNet' network is relatively new, and datasets begin as early as 2010. SASSCAL also provides archived hydroclimatic data for stations throughout Namibia and Angola, which begin as early as 1960. Some datasets contain large gaps, and data quality appears to be variable. SASSCAL contains a large repository of weather data from Angola.

Gridded data

Evaluated global gridded data include:

- The Climatic Research Unit, University of East Anglia dataset (Jones and Harris 2008; Harris et al. 2014);
- The Global Precipitation Climatology Centre's (GPCC) "full data reanalysis" (Schneider et al 2015); and
- The Standardised Precipitation Evapotranspiration Index (SPEI; Section 2.2.1.5).

These datasets are freely available, peer-reviewed, have been used in the Study Area, and have high spatial and temporal resolutions. Dataset characteristics are summarised in Table 2.

Table 2 Summary of evaluated gridded data.

Data Product	Time step	Spatial resolution	Available datasets	Examples of use near the Study Area
CRU TS v.3.24.01	Daily for air temperature, monthly for other variables	0.5°*	Air temperature, precipitation, wet-day frequency, potential evapotranspiration, cloud cover, and vapour pressure	Hulme et al. 2001; Small et al. 2003; Persendt et al. 2015, República de Angola. 2016a
GPCC full data reanalysis V7	Monthly	0.5°, 1.0°, 2.5°*	Precipitation	República de Angola. 2016a
SPEI	Monthly	0.5°*	Drought index using CRU TS time series	AFDM 2017

Note: Over the Cuvelai Basin, a 0.5 degree grid cell is about 50 km x 50 km

All gridded data products described above contain data interpolated from nearby monitoring stations. Data are potentially inaccurate when and where instrumental data are sparse. However, the performance of both CRU TS and GPCC datasets has been systematically evaluated in Angola using station data (República de Angola 2016a). Results indicate generally good fits between station data and gridded data. Overall, it was concluded that for precipitation, “GPCC data is rather superior to CRU data as compared with Station data” (República de Angola 2016a).

Other potential disadvantages of gridded datasets in general include:

- Data are averaged over a grid cell, rather than representative of a point. Where climate changes over short distances or elevations, data may need to be downscaled;
- Specialised tools are required to extract, manipulate, and analyse gridded data (e.g., Brown et al. 2012; <https://www.r-project.org/>); and
- The gridded datasets assessed here are not useful for near-real-time applications.

Many other gridded climatic data products are available. For example, the University of Carolina’s Climate Data Guide provides a summary table of air temperature datasets², and a precipitation comparison data table³.

Published hydroclimatic summaries

Published hydroclimatic summaries of the Cuvelai basin are available from several sources (e.g., NWRMR 2000; Amakali 2003; IWRM Plan Join Venture Namibia 2010; Jaro Consultancy 2011; Mendelsohn and Weber 2011 República de Angola 2016a, b, c). Little to no analysis is required to use published hydroclimate data; however, the data may be old, spatial and temporal boundaries of analyses may be static, and methods may not be specified.

² <https://climatedataguide.ucar.edu/climate-data/global-temperature-data-sets-overview-comparison-table>

³ <https://climatedataguide.ucar.edu/climate-data/precipitation-data-sets-overview-comparison-table>.

2.2.1.2 Air Temperature

The emphasis here is on identifying data sources and gaps, and describing examples of available data, rather than providing an exhaustive description of air temperature in the Study Area. Station records of air temperature tend to be relatively short-term, and contain data gaps. Gridded datasets do not have these shortcomings, but their accuracy should first be assessed relative to station data. The CRU TS time series was evaluated in Angola in República de Angola (2016a), and the authors found good agreement.

As an example, air temperature data were extracted from the CRU TS time series for the grid cell over Ondangwa, NM. Results show that air temperatures are highest from October to February, averaging 25°C in the central Cuvelai catchment (Figure 9A). The lowest air temperatures occur in June and July, with average air temperatures of 17°C. Air temperatures have been warmer than normal since the early 1980's (Figure 9B). Prior to this time, multi-decadal periods of relatively warm and cool periods occurred. Total range between warm and dry years since 1900 has been about 1.2°C.

Average annual air temperature is coolest in the higher elevation headwaters (~21°C), and warmest in the lower-elevation south (~23°C). Winter air temperatures are similar, but summer air temperatures are up to 3.7°C warmer in the south. Isoleth maps of air temperature in Namibia, Angola, and the Cuvelai Basin are available from several sources (República de Angola 2016a, Mendelsohn et al 2013).

Air temperature records from climate stations are summarised in Table 2 and Figure 10. Records tend to be shorter, spatially discontinuous (especially in Angola), and contain data gaps (Figure 9C).

Table 1 Summary of air temperature and precipitation records within and near the Cuvelai basin.

Station Name	Country	Latitude	Longitude	Elevation (masl)	Data Source	GHCN ID	WMO Station ID	GHCN Daily Average Air		GHCN Daily Precipitation		KNMI Monthly Average Air		KNMI Monthly Precipitation		SASSCAL Air Temperature		SASSCAL Precipitation	
								From	To	From	To	From	To	From	To	From	To	From	To
CAFU	AO	-16.30	15.30	1,160	KNMI	-	-	-	-	-	-	-	-	1942	1969	-	-	-	-
MULONDO	AO	-15.40	15.10	-	KNMI	-	-	-	-	-	-	-	-	1954	1975	-	-	-	-
MUPA	AO	-16.10	15.80	1,170	KNMI	-	-	-	-	-	-	-	-	1932	1975	-	-	-	-
PEREIRA D,ECA (Ondjiva)	AO	-17.10	15.70	1,150	KNMI	-	66460	-	-	-	-	1941	1960	1928	1975	-	-	-	-
CAFIMA	AO	-16.38	16.02	1,130	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1961	1970	1961	1970
CAFU	AO	-16.32	15.30	1,112	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
CLIMATE CÁIFU (POSTO ZOOT. DO CUNENE)	AO	-16.30	15.20	1,110	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1961	1972	1961	1972
MUPA	AO	-16.12	15.88	1,234	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
MUPA (MISS. CATÁLICA)	AO	-16.08	15.42	-	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1961	1974	1961	1974
PEREIRA D,ECA -DAILY	AO	-17.70	15.73	1,088	SASSCAL Info. System	-	664600	-	-	-	-	-	-	-	-	1974	2013	1974	2013
PEREIRA D,ECA -MONTHLY	AO	-17.70	15.73	1,088	SASSCAL Info. System	-	664600	-	-	-	-	-	-	-	-	-	-	1960	1973
ROCADES	AO	-16.72	15.00	1,099	SASSCAL Info. System	-	664850	-	-	-	-	-	-	-	-	1961	1974	1961	1974
VILA PEREIRA DE ECA	AO	-17.04	15.44	1,110	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1965	1971	1965	1971
VILA PEREIRA DE ECA (S.G.M.)	AO	-17.04	15.43	1,150	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1961	1974	1961	1974
NAMACUNDE	AO	-17.31	15.85	1,112	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2015	2017	2015	2017
ONDJIVA	AO	-16.98	15.62	1,119	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2015	2017	2015	2017
GAUB	NM	-19.45	17.75	1,400	GHCN	WA010554470	-	-	-	1968	1985	-	-	-	-	-	-	-	-
HALALI	NM	-19.18	16.37	1,050	GHCN	WA010526410	-	-	-	1967	1986	-	-	-	-	-	-	-	-
HUTTENHOF	NM	-19.48	17.18	1,300	GHCN	WA010543290	-	-	-	1968	1986	-	-	-	-	-	-	-	-
MAHANENE NAVORSINGSTAS	NM	-17.45	14.78	1,105	GHCN	WA012505070	-	-	-	1971	1986	-	-	-	-	-	-	-	-
NAMUTONI	NM	-18.80	16.97	1,100	GHCN	WA011018280	-	-	-	1968	1986	-	-	-	-	-	-	-	-
OKATANA	NM	-17.75	15.72	1,050	GHCN	WA012003750	-	-	-	1968	1986	-	-	-	-	-	-	-	-
OKAUKUEJO	NM	-19.15	15.91	1,100	GHCN	WA010517310	68010	1975	2017	1968	2017	-	-	1900	2000	-	-	-	-
OMBALANTU	NM	-17.52	15.02	1,000	GHCN	WA011990010	-	-	-	1968	1986	-	-	-	-	-	-	-	-
OMBIKA	NM	-19.33	15.95	1,050	GHCN	WA010518000	-	-	-	1968	1986	-	-	-	-	-	-	-	-
ONDANGWA	NM	-17.93	15.98	1,100	GHCN	WAM00068006	68006	1973	2014	1977	2014	-	-	1902	1988	-	-	-	-
ONGUMA	NM	-18.68	17.10	1,100	GHCN	WA011021610	-	-	-	1968	1985	-	-	-	-	-	-	-	-
ONIIPA	NM	-17.95	16.08	1,100	GHCN	WA012011470	-	-	-	1968	1986	-	-	-	-	-	-	-	-
OSHIKUKU	NM	-17.67	15.47	1,050	GHCN	WA011998200	-	-	-	1968	1986	-	-	-	-	-	-	-	-
REHOBOTH	NM	-17.88	15.08	1,030	GHCN	WA011991430	-	-	-	1968	1986	-	-	-	-	-	-	-	-
SISSEKAB	NM	-19.33	17.20	1,250	GHCN	WA010543500	-	-	-	1968	1986	-	-	-	-	-	-	-	-
SOAVIS	NM	-19.35	17.13	1,200	GHCN	WA010542310	-	-	-	1968	1986	-	-	-	-	-	-	-	-
TOGGENBURG	NM	-19.48	17.95	1,450	GHCN	WA010558090	-	-	-	1968	1986	-	-	-	-	-	-	-	-
TSHANDI	NM	-17.75	14.88	1,000	GHCN	WA011986750	-	-	-	1968	1982	-	-	-	-	-	-	-	-
TSINTSABIS	NM	-18.78	17.95	1,100	GHCN	WA011037970	-	-	-	1968	1985	-	-	-	-	-	-	-	-
TSUMEB - POL	NM	-19.23	17.72	1,311	GHCN	WA010553740	-	-	-	1913	1985	-	-	-	-	-	-	-	-
GROOTFONTEIN	NM	-19.60	18.12	1,400	GHCN	WA010101860	68014	1974	2017	1917	2003	1974	2017	1917	2003	-	-	-	-
ELIM	NM	-17.70	15.40	1,030	KNMI	-	-	-	-	-	-	-	-	1913	1983	-	-	-	-
ENGELA	NM	-17.30	15.50	-	KNMI	-	-	-	-	-	-	-	-	1952	1981	-	-	-	-
ERMO	NM	-19.30	14.60	1,600	KNMI	-	-	-	-	-	-	-	-	1954	1984	-	-	-	-
KAMANJAB	NM	-19.40	14.50	-	KNMI	-	-	-	-	-	-	-	-	1940	1976	-	-	-	-
NAMUTONI	NM	-18.80	17.00	1,100	KNMI	-	-	-	-	-	-	-	-	1902	1996	-	-	-	-
ODIMBO	NM	-17.40	15.90	1,130	KNMI	-	-	-	-	-	-	-	-	1927	1973	-	-	-	-
OLUKONDA	NM	-17.90	16.00	1,110	KNMI	-	-	-	-	-	-	-	-	1886	1964	-	-	-	-
OMBALANTU	NM	-17.50	15.00	1,100	KNMI	-	-	-	-	-	-	-	-	1933	1996	-	-	-	-

Table 1 Summary of air temperature and precipitation records within and near the Cuvelai basin.

Station Name	Country	Latitude	Longitude	Elevation (masl)	Data Source	GHCN ID	WMO Station ID	GHCN Daily Average Air		GHCN Daily Precipitation		KNMI Monthly Average Air		KNMI Monthly Precipitation		SASSCAL Air Temperature		SASSCAL Precipitation	
								From	To	From	To	From	To	From	To	From	To	From	To
REHOBOTH	NM	-17.90	15.10	1,030	KNMI	-	-	-	-	-	-	-	-	1922	1991	-	-	-	-
SOAVIS	NM	-19.20	17.10	-	KNMI	-	-	-	-	-	-	-	-	1940	1976	-	-	-	-
STREBEN	NM	-19.40	16.90	1,200	KNMI	-	-	-	-	-	-	-	-	1950	1969	-	-	-	-
TSHANDI	NM	-17.80	14.90	1,000	KNMI	-	-	-	-	-	-	-	-	1921	1982	-	-	-	-
TSUMEB	NM	-19.20	17.70	1,311	KNMI	-	-	-	-	-	-	-	-	1907	1996	-	-	-	-
CLIMATE OKAUKUEJO	NM	-19.18	15.92	1,103	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1975	2013	1975	2013
ELIM	NM	-17.72	15.48	1,092	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
ERMO	NM	-19.28	14.57	1,245	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
NAMUTONI	NM	-18.80	16.97	1,076	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
ODIMBO	NM	-17.40	15.93	1,097	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
OKONGO	NM	-17.57	17.22	1,152	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	2008	2012	2008	2012
OLUKONDA	NM	-17.98	16.20	1,077	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
OMBALANTU	NM	-17.52	15.20	1,094	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
ONDANGWA	NM	-17.93	15.98	1,081	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
ONDANGWA 1	NM	-17.93	15.98	1,100	SASSCAL Info. System	-	680060	-	-	-	-	-	-	-	-	1973	2013	1973	2013
ONDANGWA 2	NM	-17.88	15.95	1,097	SASSCAL Info. System	-	680130	-	-	-	-	-	-	-	-	n/d	n/d	n/d	n/d
PRECIPITATION OKUAKUEJO	NM	-19.18	15.92	1,103	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
REHOBOTH 1	NM	-17.88	15.80	1,073	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
SITRUSDAL	NM	-19.33	16.38	1,341	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	1993	2012	1993	2012
TSHANDI	NM	-17.75	14.88	1,109	SASSCAL Info. System	-	-	-	-	-	-	-	-	-	-	-	-	1960	1973
ALEX MURANDA LIVESTOCK DEVELOPLEMTN CENTRE	NM	-18.36	19.26	1,166	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2010	2017	2010	2017
KAKO OTAVI	NM	-18.30	13.66	1,427	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2016	2017	-	-
OGONGO	NM	-17.68	15.29	1,111	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2012	2017	2012	2017
OKAPYA	NM	-18.47	17.34	1,138	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2012	2016	2012	2016
OKASHANA	NM	-18.41	16.64	1,106	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2012	2017	2012	2017
OSHAAMBELO	NM	-17.84	14.77	1,114	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2012	2017	2012	2017
XANGONGO	NM	-16.72	14.98	1,123	SASSCAL WeatherNet	-	-	-	-	-	-	-	-	-	-	2015	2016	2015	2016

Note: the same data may be available from multiple sources. i.e. multiple rows may exist for the same locations.

Figure 9 Selected air temperature records in the Cuvelai Basin.

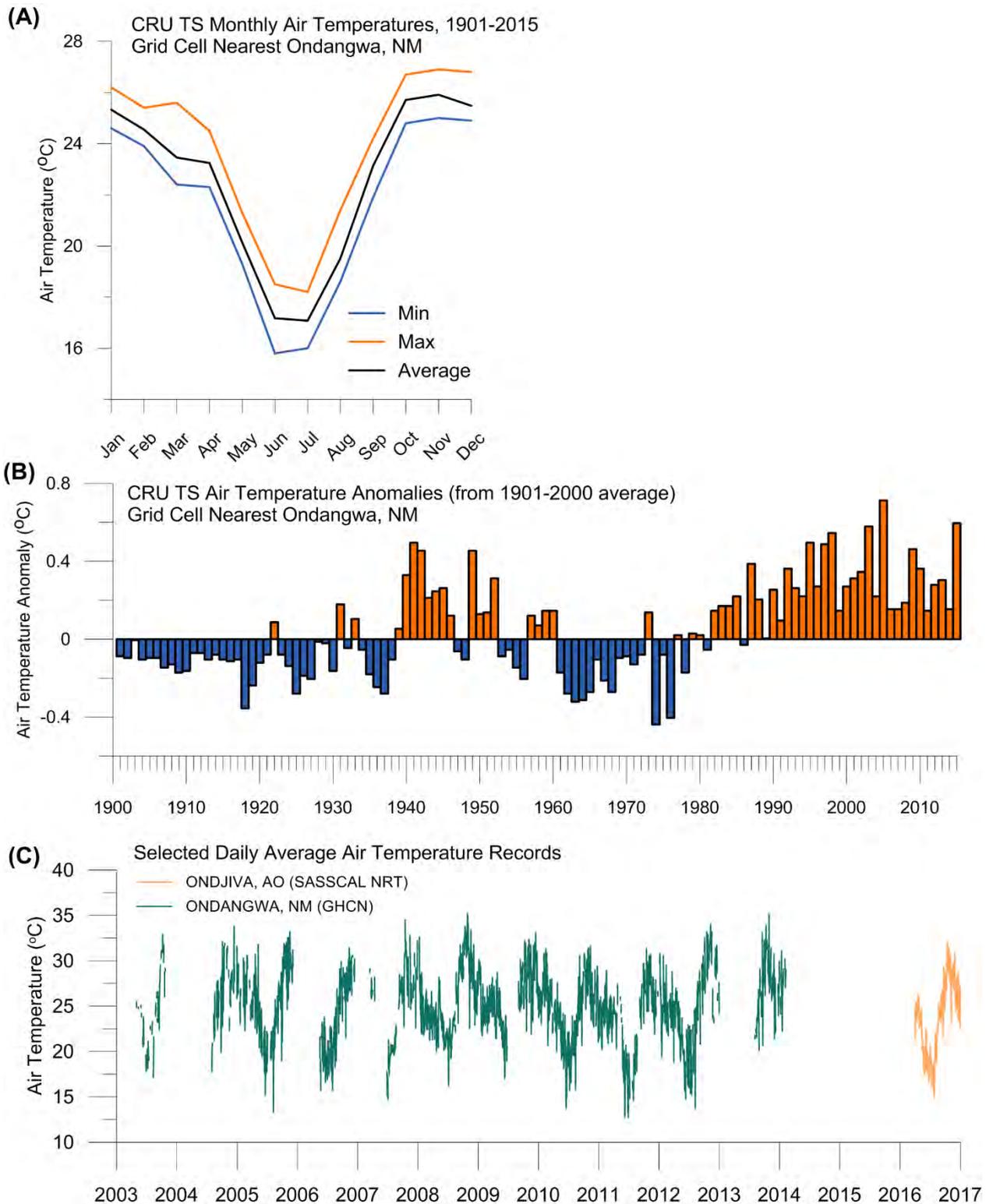
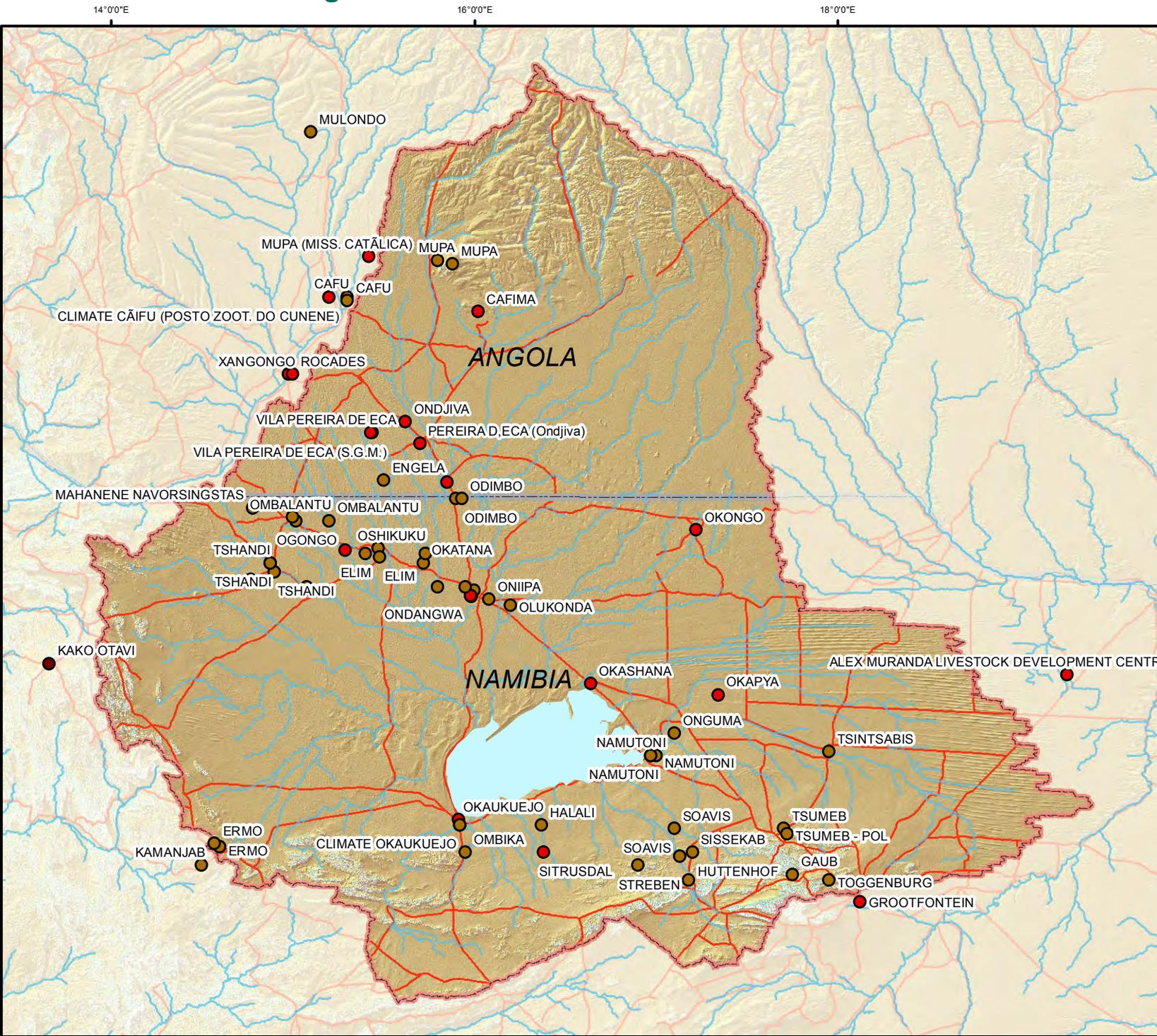


FIGURE 11 - Meteorological stations within and near the Cuvélai River Basin.



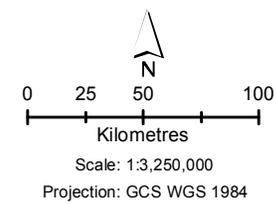
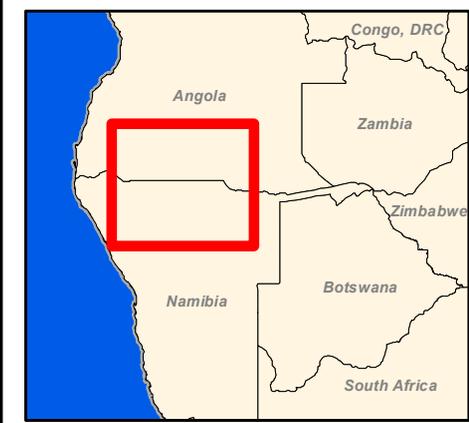
Legend

Meteorologic Station

- Air Temperature
- Precipitation
- Temperature & Precipitation

— Watercourse

▭ Political Boundaries



2.2.1.3 Precipitation

Rainfall distribution, intensity, and duration are finely balanced in the Cuvelai Basin; too little rainfall can easily lead to drought conditions (Section 2.5.1), and too much can lead to flooding (Section 2.5.2). The severity of floods is determined by the location, intensity, and duration of rainfall. Most flood waters cross the border as surface water discharge in the iishana region, spreading south through the shallow oshana channels, and main Cuvelai channel. The following sections briefly describe atmospheric controls on precipitation in the Study Area, spatial and temporal changes in precipitation totals, spatial variability, temporal variability, and intensity. The emphasis is on identifying data sources and gaps, and describing examples of available data, rather than providing an exhaustive description of precipitation in the Study Area.

Atmospheric controls on precipitation

Precipitation in the Cuvelai Basin is controlled by the Intertropical Convergence Zone (ITCZ), and its migration throughout the year. The ITCZ is a band of low pressure circling the globe near the equator caused by solar heating. It brings moisture to the Study Area by drawing moisture from the Indian Ocean, and upwelling air releases moisture as it cools. In the wet season, the ITCZ is located over the Study Area, but in the dry season, the ITCZ migrates northward out of the Study Area. Precipitation events in Southern Africa are also controlled by the occurrence of mid-tropospheric low pressure systems ('closed lows', Engelbrecht et al 2012).

Intra-annual precipitation characteristics

The wet season lasts from roughly December to March, when about 38% of the annual precipitation falls, and the dry season lasts from roughly April to October, when only 9% of the annual precipitation falls (Figure 13A). While the wet and dry seasons do follow the above approximate seasonal distributions, significant variability in duration, intensity, and distribution occurs (note the standard deviation bars on Figure 13A). Figure 11 and Figure 12 show flood waters receding in late March, following the flooding events of earlier in the month.

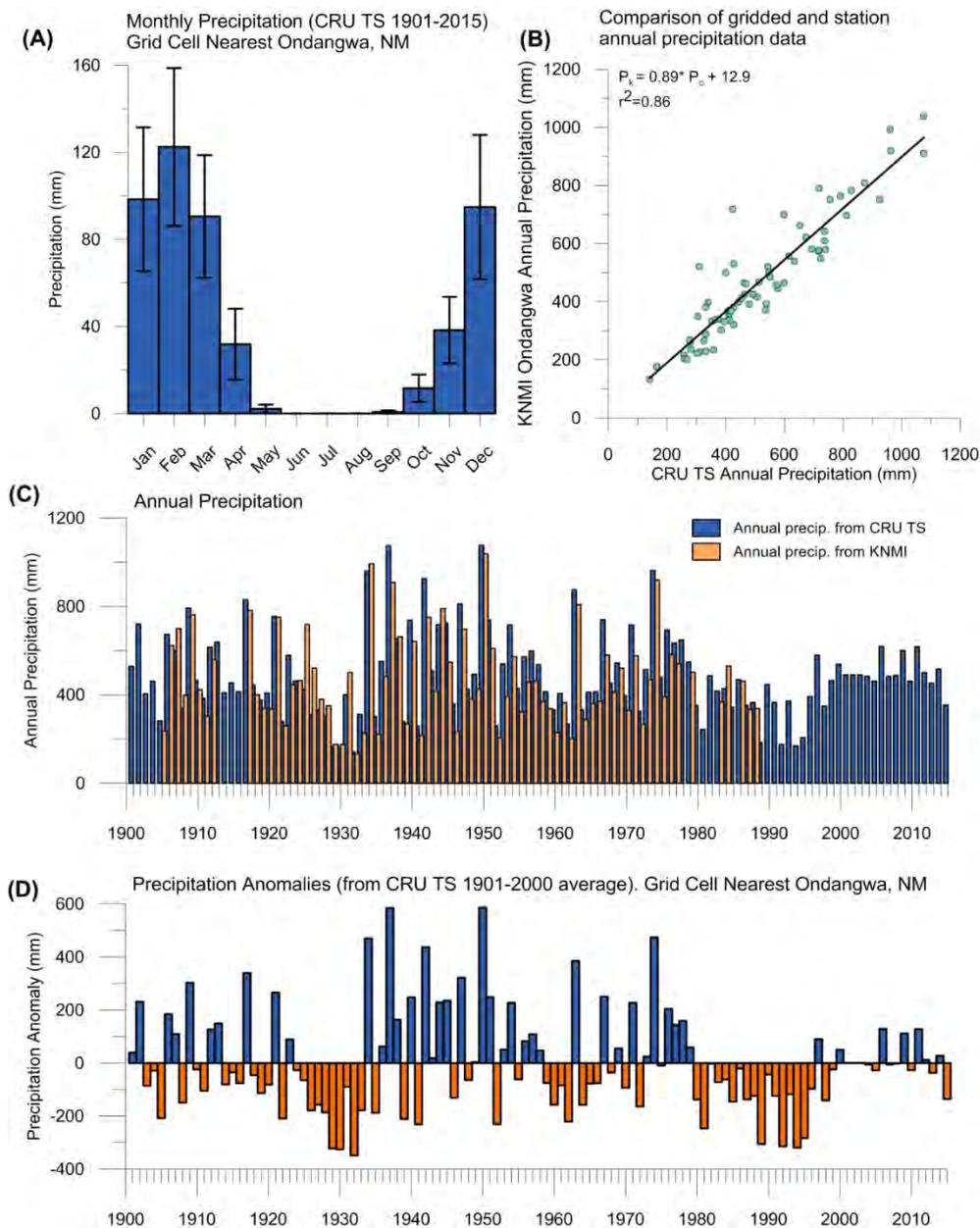
Figure 11 Receding flood waters, southern Angola on 2017-03-29.



Figure 12 Receding flood waters close to Oshakati in Namibia on 2017-03-31.



Figure 13 Selected precipitation records in the Cuvelai River Basin.



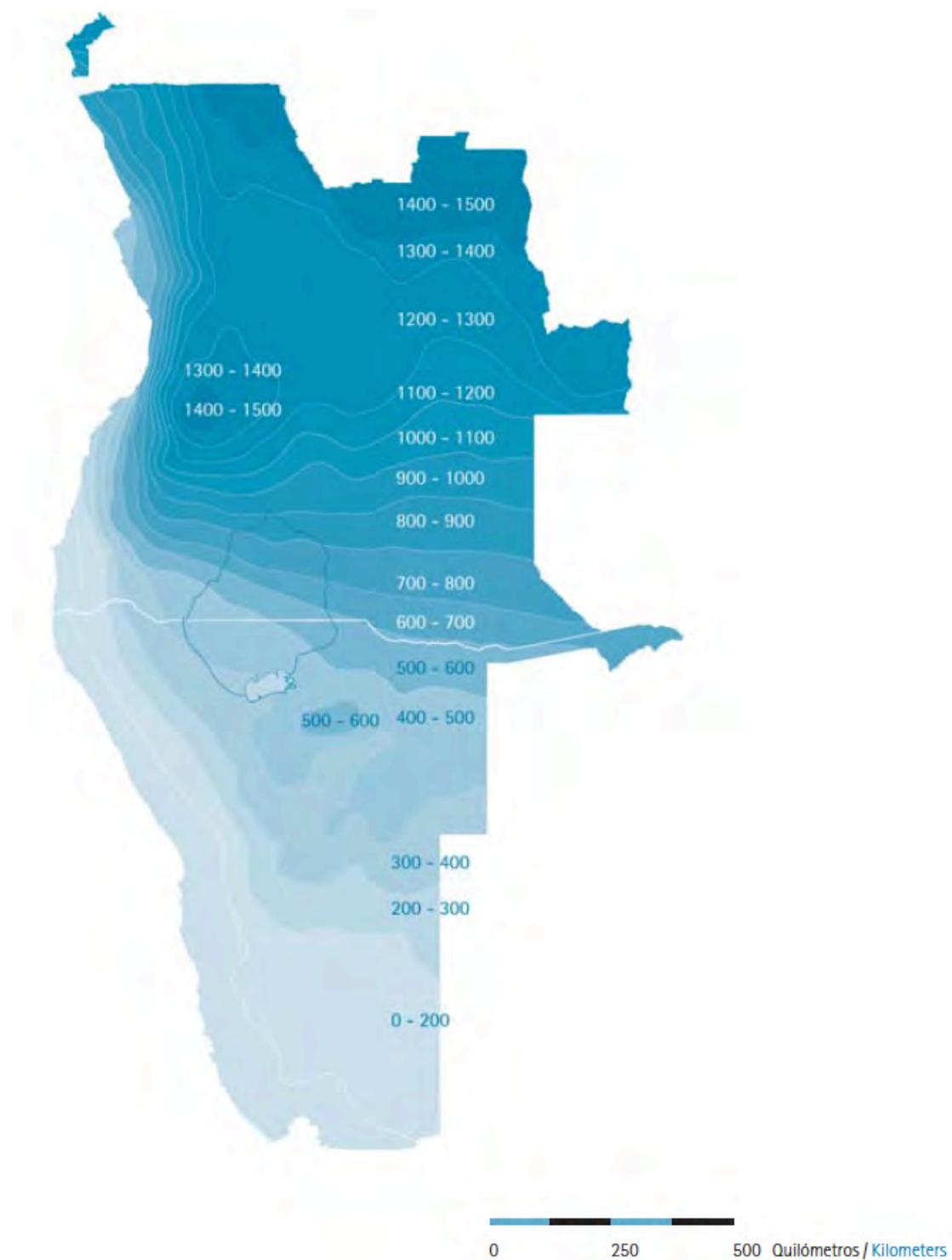
Note: Station data sometimes had months of missing precipitation data. In panels 'B' and 'C', years were excluded if the missing months would account for 10% or more of the annual precipitation in an average year.

Spatial changes in precipitation

Annual precipitation increases from south to north in the Cuvelai catchment. Mean annual precipitation (MAP) is 300 to 400 mm in the south, and 800-900 mm in the north (Mendelsohn and Weber 2011; Harris et al. 2014; Persendt et al. 2015; República de Angola 2016a-c). Mendelsohn et al 2013 further elaborate on rainfall patterns from a spatial perspective, with average annual rainfall highest in the north east of the basin, and lowest in the south west, as illustrated in Figure 14. This figure also shows the variability of rainfall across the basin, illustrated by the coefficient of variation, which is lowest in the north east and highest in the south west. These rainfall patterns significantly contribute to moisture availability for rain-fed agricultural practices in the basin, and also discharge in the river channels and

iishana. Isohyet maps of the Cuvelai basin are available from several sources including Mendelsohn and Weber 2011, Mendelsohn et al (2013), Governo Provincial do Cunene. (2014), Persendt et al (2015), and República de Angola. (2016a and 2016b). The Persendt et al (2015) map is constructed using the CRU TS dataset, and Mendelsohn and Weber's (2011) map is constructed using station data. Note that for a given latitude, eastern portions of the catchment receive more rain than western portions, especially in the south (Mendelsohn and Weber 2011; Figure 14).

Figure 14 Rainfall distribution.



Source: (Mendelsohn & Weber, 2011)

Comparison of gridded precipitation data to station data

As an example, gridded precipitation data were extracted from the CRU TS time series for the grid cell closest to Ondangwa, in the central portion of the catchment. Monthly precipitation data are available from KNMI from 1905 to 1988. Gridded annual precipitation over Ondangwa, agrees well with station data, in terms of trends and magnitude (Figure 11B). A linear regression between KNMI and CRU TS data have an r^2 of 0.86. The linear regression equation suggests that the CRU TS slightly underestimates annual precipitation at Ondangwa. It has been noted that in Angola, the GPCC gridded dataset produces less biased results compared to station data, with higher correlation coefficients (República de Angola 2016a).

Inter-annual precipitation

At Ondangwa, annual average precipitation is 491 mm according to the CRU TS data set (Figure 9C). Inter-annual precipitation variability is high (Figure 11D). Standard deviation of annual precipitation is 192 mm, the 10th percentile is 279 mm, and the 25th percentile is 362 mm. Distinct decadal and multi-decadal periods of relative wetness and drought also occur (Figure 11D). Notable periods of drought include the period from about 1925 to 1935 (average annual precipitation anomaly = -142 mm), and 1980 to 1999 (average annual precipitation anomaly = -131 mm; c.f. Section 2.2.1.6). Given their magnitudes relative to MAP, these anomalies likely had very significant effects on the water balance and human water needs. Also note that the period from about 2000-2015 was a period of neither sustained wetness nor dryness when compared to the overall record; multi-annual to decadal periods of sustained meteorological drought and flood are characteristic of the area, but have not been experienced recently (Figure 11D).

Precipitation trends and extremes

Precipitation indices relating to trends, and wet and dry extremes, were analysed using the 1917-2003 record of precipitation from Grootfontein, Namibia (Table 3) and the 1901 to 2013 CRU TS time series (Persendt et al. 2015). Grootfontein is just outside of the Cuvelai-Etoshia basin, near its southeast boundary (Figure 10). No significant trends in extremes were found (annual maximum 1-day precipitation, annual maximum consecutive 5-day precipitation, and heavy precipitation days). An increase in average dry spell length, and decrease in annual precipitation and number of wet days was found in the Grootfontein record. One notable feature of the record presented in Figure 11C is the lack of very wet years since the late 1960s (greater than about 600 mm/yr).

Precipitation extremes on the Angolan side of the Cuvelai have been calculated and mapped (República de Angola 2016a). For example, the 10-year, 24-hour precipitation event is about 60-90 mm, and the 50-year 24-hour event is about 90-130 mm. Lower values would be expected on the Namibian side.

2.2.1.4 Evapotranspiration

Evapotranspiration (ET) is the combination of evaporation from land surfaces and transpiration from plants, and can be measured, calculated, and expressed in several ways. Pan evaporation is directly measured at a weather station, and represents evaporation from a pan of water. Reference crop ET is the evaporation from a 'reference crop' with unlimited soil moisture; reference crop ET can be calculated using meteorological parameters (FAO 2017). Potential evapotranspiration (PET) is the amount of ET that would occur if sufficient water were available; one approach to the calculation of PET is the Penman-Monteith equation (Dingman 2015). PET and reference ET provide estimates of ET from crops

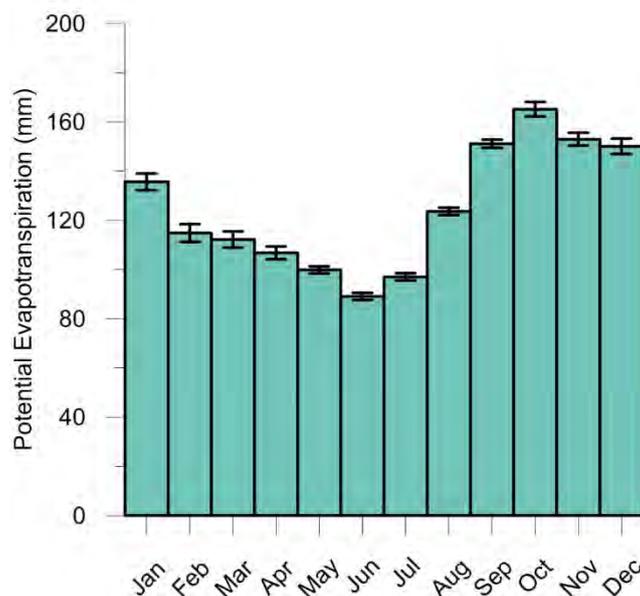
and other land uses; pan evaporation provides an estimate of evaporation from an open body of water, such as the reservoir of a dam (after applying a reduction coefficient and correcting for precipitation; IWRM Plan Joint Venture Namibia 2010). PET and reference ET are useful for water balance studies and estimates of water availability.

Several types of ET data are available in the Study Area, including:

- Gridded CRU TS PET, available at 0.5° resolution globally. PET is calculated using the Penman-Montieth approach, using air temperature, vapour pressure, and cloudiness;
- Gridded National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) PET, available at 2° resolution. These are modelled data;
- Pan evaporation at weather stations. In Namibia, these are water-tight pans with an area of about one metre squared, where changes in pan level are measured. Evaporation measured with an evaporimeter is higher than open water evaporation, PET, and crop reference ET, because open water is freely available for evaporation, no infiltration occurs, and the evaporimeter is heated by solar radiation during the day; and
- PET data from Angola. Seventeen stations with monthly PET data in Angola are presented in República de Angola (2016a). Most data are historic, and available from about 1955 to the early 1980's

As expected, station ET consistently exceeded PET. PET from for Ondanwa, NM using CRU TS averages 1,500 mm per year (Figure 15). Annual variability in PET is low, with a standard deviation of 12 mm. At 1,500 mm/year, PET is more than three times annual average precipitation. PET is highest in the warmest months (about 160 mm/month in September and October), and lowest in the coolest months (about 90-100 mm/month in May to July).

Figure 15 Monthly Potential Evapotranspiration (PET) for the grid cell nearest Ondangwa, NM (CRU TS 1901-2015).



Annual evaporation in northern Namibia is about 2,400 to 2,800 mm per year (Directorate of Environmental Affairs 2002; IWRM Plan Joint Venture Namibia 2010). Evaporative loss from reservoirs is cited as being the largest component of the water balance at dams (IWRM Plan Joint Venture Namibia 2010).

Evaporation is noted as being higher in the southern Cuvelai basin compared to the north (Mendelsohn and Weber 2011).

2.2.1.5 Drought

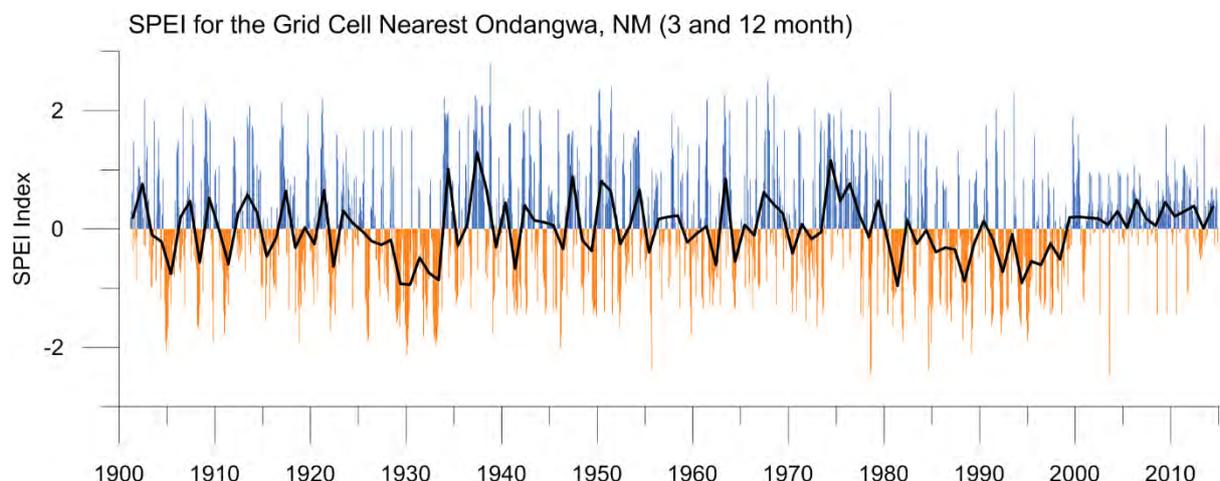
The timing and magnitude of drought affects vegetation, human health and livelihood, wildlife, and wildfires. Droughts in the study area are partially controlled by large-scale ocean-atmosphere teleconnections, especially El Niño (Chishakwe 2010).

Several drought indicators are available, including:

- The Standardised Precipitation-Evapotranspiration Index (SPEI), a standardised drought index using air temperature, precipitation, and evapotranspiration from CRU TS v.3.24 (Beguería et al. 2010; Vicente-Serrano, Beguería, and López-Moreno 2010; Vicente-Serrano, Beguería, López-Moreno, et al. 2010) At the time of writing, SPEI data were available from 1901 to 2014;
- The African Flood and Drought Monitor, which provides time series, point data, monitoring data, and forecasts of drought, including hydrometeorological indicators, other drought indices, and remotely sensed vegetation data (AFDM 2017); and
- The Blended Drought Index, a gridded drought index that has been applied to the Cuvelai Basin (Stein, Luetkemeier, Liehr, & Drees 2015; please refer to Section 2.6.3 for additional information).

SPEI was extracted for the grid cell nearest Ondangwa, and results are presented in Figure 12. The average SPEI is zero, and the standard deviation is one. Periods of drought are identified for the periods roughly between 1925 and 1935, and 1980 to 2000. Very similar periods of low precipitation were identified in the precipitation anomaly graph presented in Figure 11C.

Figure 16 The Standardised Precipitation-Evapotranspiration Index of drought for the grid cell nearest Ondangwa, NM.



2.2.1.6 Climate Data Availability and Gaps

Assessed climatic datasets are summarised in Table 4. The suitability of a dataset depends on its use. For assessments of near-real-time or recent weather conditions, the network of weather stations is generally adequate in Namibia; however, there are only two near-real time weather stations on the Angolan side of the Cuvelai Basin: Ondjiva and Namacunde (Table 3 and Table 10). Both stations are within 50 km of the Namibian border. Therefore, datasets from the catchment headwaters in the Angolan highlands are sparse. This is important since this is where precipitation is highest, where the only perennially flowing rivers are found, and where floodwaters originate. Over time, it will become increasingly important to establish a more holistic climatic monitoring network, accompanied by time-series data available to all parties.

Table 4 Summary of assessed weather and climate data.

Dataset	Custodian	Components	Time series?	Gridded?	Geographic coverage	QA/QC Level	Completeness	Assessment	Comments	URL
CRU TS	Climatic Research Unit, University of East Anglia	Mean, maximum, minimum air temperatures, precipitation, wet-day frequency, vapour pressure, cloud cover, frost day frequency, and potential evapotranspiration.	✓	✓	Global	High	Complete	Excellent	0.5° grid resolution. Daily and monthly data from 1901 to 2015. Accuracy of gridded datasets should be assessed relative to monitoring stations before using. Vetted and frequently used by climatologists, and history of use in Africa and Cuvelai. For precipitation, GPCC data may better match station data.	https://crudata.uea.ac.uk/cru/data/hrg/
GHCN	Global Historical Climatology Network; National Centers for Environmental Information	A full suite of climate data; availability varies by station	✓	x	Global	High	Variable data gaps where monitoring data are not available.	Excellent	Monthly and daily dataset from meteorologic stations worldwide. Air temperature and precipitation data available in the Cuvelai.	https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn
GPCC	Global Precipitation Climatology Centre	Precipitation	✓	✓	Global	High	Complete	Excellent	Lowest resolution is 0.5°. Monthly data from 1901 to 2013. Accuracy of gridded datasets should be assessed relative to monitoring stations before using. Vetted and frequently used by climatologists, and history of use in Africa and Cuvelai.	http://www.dwd.de/EN/ourservices/gpcc/gpcc.html
KNMI	Koninklijk Nederlands Meteorologisch Instituut (KNMI, the Royal Netherlands Meteorological Institute)	A full suite of climate data; availability varies by station	✓	x	Global	High	Variable data gaps where monitoring data are not available.	Excellent	Monthly and daily dataset from meteorologic stations worldwide. Air temperature and precipitation data available in the Cuvelai.	https://climexp.knmi.nl/selectdailyseries.cgi?id=someone@somewhere
SASSCAL Information System	Southern Africa Science Service Centre for Climate Change and Adaptive Land-Use	Air temperature and precipitation	✓	x	Southern Africa	Low	Variable data gaps where monitoring data are not available.	Good	Data from a large network of meteorologic stations in the Cuvelai, both in NM and AO. Well documented station data, and data are readily downloadable. Discharge and level data are available in Southern Africa, but not in Cuvelai.	http://leutra.geogr.uni-jena.de/sasscalRBIS/metadata/overview.php?view=ts_timeseries
SASSCAL WeatherNet	Southern Africa Science Service Centre for Climate Change and Adaptive Land-Use	Air temperature and precipitation	✓	x	Southern Africa	Low	Relatively short records. Variable data gaps where monitoring data are not available.	Good	Near-real-time data from a large network of meteorologic stations in the Cuvelai, both in NM and AO. Well documented station data, and data are readily downloadable.	http://www.sasscalweathernet.org/index.php
SPEI	Standardised Precipitation-Evapotranspiration Index	Drought index	✓	✓	Global	High	Complete	Excellent	SPEIbase provides drought conditions at the global scale, with a 0.5 degrees spatial resolution and a monthly time resolution. SPEI time-scales between 1 and 48 months. 1901 to 2014.	http://spei.csic.es/database.html

For assessments of weather and climate after about 1950, the available dataset is larger, both in Namibia and Angola (Table 3). In Angola, the number of operating weather stations declined in the 1970's, and has remained low. A total of 16 Angolan station records are available from KNMI and SASSCAL in the Cuvelai Basin; however, some of these may be redundant, and large data gaps exist in some records. The spatial network of stations that monitor precipitation is more extensive than stations that measure air temperature (Table 3). GHCN data appear to have undergone careful QA/QC.

Where spatially and temporally continuous weather and climate records are required, the CRU TS and GPCP time series are useful, accurate, and have been vetted for use in Africa and the Cuvelai. Given the performance of the GPCP time series, they appear to best represent precipitation, at least on the Angolan side of the Cuvelai Basin (República de Angola 2016a). Gridded data are useful for examining spatial and temporal changes in the Cuvelai catchment. The catchment is sufficiently large, and the grid resolution is sufficiently high, that spatial changes in climate are well represented. Data should be examined carefully before use, to ensure they are representative of monitored weather. Downscaling may be required to fit monitored data to data from gridded data products. The gridded data products described here are generally not useful for near-real-time assessments.

2.2.2 Hydrology

2.2.2.1 Hydrologic Regime

The Cuvelai Basin covers an area of about 159,620 km² (Mendelsohn and Weber 2011), of which 67% is in Namibia, and 33% is in Angola (Filali-Meknassi et al. 2014). The basin is quite flat, with a nominal drop in elevation - 1,500 masl in the north to 1,050 metres above sea level (masl) in the south, over approximately 400 km (Mendelsohn and Weber 2011). The level nature of the basin landscape, and the seasonality of precipitation (Section 2.2.1.3) promote flooding. The Cuvelai is an 'iishana' system: a collection of ephemeral rivers, shallow pans, and wetlands. During floods, water flows for hundreds of kilometres from the north in Angola into the Etosha Pan, where it evaporates. Iishana are dry most of the time, especially in the east of the basin. Flow is more regular over the northern and western portions of the catchment, especially the Mui and Cuvelai rivers, and the Shana zone (Mendelsohn and Weber 2011). The Shana is particularly saline, since the channels are broad, and evaporation occurs efficiently. Water in the northern Cuvelai and Mui tends to be fresher, since precipitation is greatest in the northern portion of the catchment, and runoff occurs rapidly. The natural hydrologic regime has been highly modified by large-scale water diversions, extensive land use, and small-scale collection and storage of flood water.

The hydrologic regime of the Cuvelai Basin is highly variable within and between years because of varying precipitation patterns, geology, and soil. Active flow is limited to the north and west of the catchment (Shana Zone, Cuvelai River, Mui, Cuvelai Delta, and Central Drainage Zones) (Mendelsohn and Weber 2011). Elsewhere, flow rapidly infiltrates or evaporates.

2.2.2.2 Estimates of runoff

Runoff data should be interpreted with caution because the monitoring network is extremely sparse, drainage and drainage patterns are highly influenced by human activity, spatial and temporal flow variability are high, and available runoff estimates are insufficient to characterise this variability (Section 2.2.2.4). For example, in a system where rivers are typically ephemeral, annual average runoff may be a misleading statistic. Some studies that have quantified runoff in Namibia have declined to estimate

runoff in the Cuvelai basin, likely due to the low magnitude of runoff, and the lack of data (IWRM Plan Joint Venture Namibia 2010).

Estimates of runoff come from:

- Estimates of annual volumetric outflow in the Cuvelai (Amakali 2003; IWRM Plan Joint Venture Namibia 2010; DRFN and Heyns Consultancy 2013). Estimates place outflow between 100×10^6 to 150×10^6 m³/year. With a catchment area of 159,620 km² (Mendelsohn and Weber 2011), this equates to between 0.6 and 0.9 mm/year of runoff;
- Estimates of runoff from hydrologic models. These are discussed in more detail in Section 2.2.2.4; model results most pertinent to estimates of runoff include:
 - Gridded global runoff data available from the Global Runoff Data Centre (GRDC; 0.5° grid resolution; Fekete et al. 1999, Fekete et al. 2002). GRDC data predict annual runoff is <1 mm per year in most of the catchment, and about 50-150 mm Angolan highlands.
 - Estimates of runoff in Angola produced using gridded precipitation, evapotranspiration, and the Turc-Pike equation (República de Angola 2016a). This dataset predicts near-zero runoff on the Angolan side of the Cuvelai Basin. Runoff in the northern Cuvelai Basin in the Angolan Highlands appears to be broadly similar to GRDC estimates provided above.

2.2.2.3 Dams, Diversions, and Transfers

Water from the Kunene River is pumped from Calueque Dam in Angola into the Olushandja Dam in Namibia, and into the Cuvelai catchment. The Olushandja Dam has a reservoir volume of 42.3×10^6 m³ (IWRM Plan Joint Venture Namibia 2010). Records of water abstraction from 2013 to 2016 at the Calueque Dam are presented in Figure 17. Annual abstractions have ranged from 56×10^6 m³ per year to 84.7×10^6 m³ per year, and have generally increased over time. Monthly abstraction volumes tend to be highest in the dry season. The Kunene Transboundary Water Supply Project allows for 180×10^6 m³ of withdrawal into Namibia per year. These annual volumes are large fractions of the annual Cuvelai water balance (see ‘Estimates of Runoff’ above). The purpose of the Olushandja Dam is for “*Urban water supply, fishing, balancing dam and, emergency water supply to Oshakati*”. From the dam, water is distributed through Namibia and then back into Angola through the Etaka and Ogongo-Oshakati Canals (Figure 18). The history and evolution of this transboundary Project is described in Varis et al (2008), and project infrastructure is described in República de Angola (2016b).

Figure 17 Records of water abstraction at the Calueque Dam.

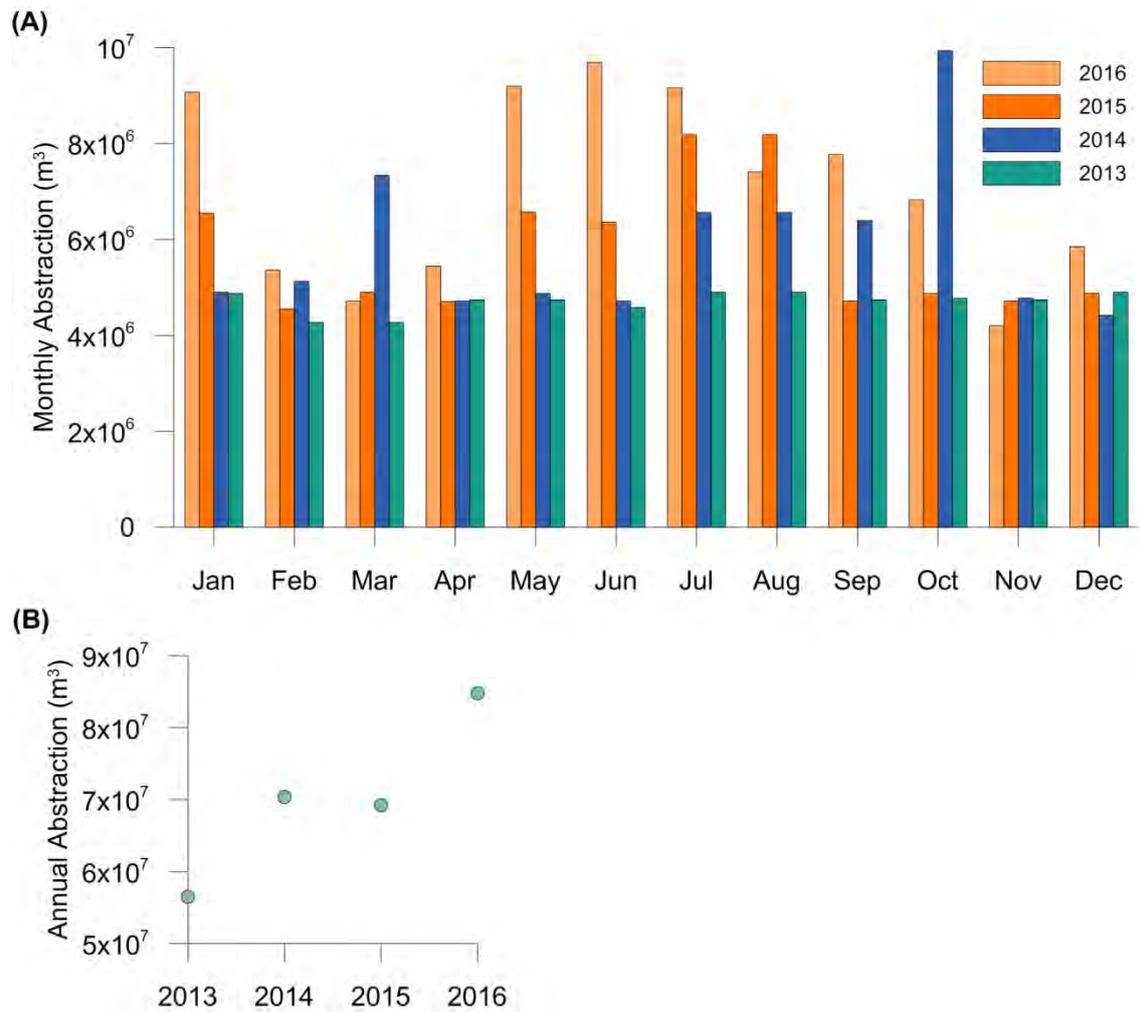
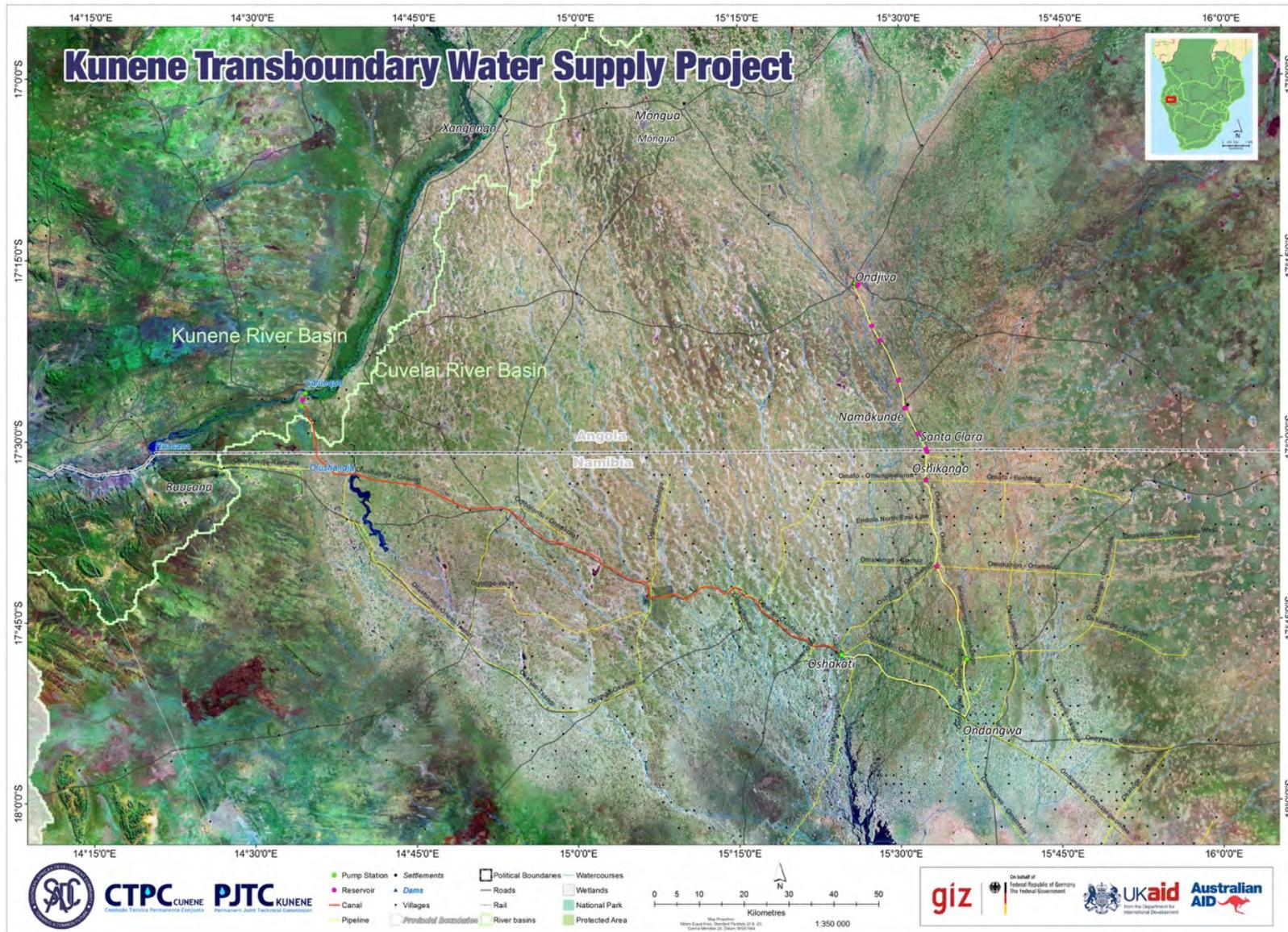


Figure 18 The Kunene Transboundary Water Supply Project.



The history and evolution of this transboundary project is described in detail in Varis et al (2008).

While McDonald and Ruiters 2005 identify approximately 40 dams present in the Cuvelai River Basin, in Angola and Namibia, it is assumed that most of these are very small.

2.2.2.4 Hydrologic Data Availability and Gaps

Monitoring

The hydrometric monitoring network in the Cuvelai is sparse for several reasons. First, the purpose of much of the hydrometric monitoring in Namibia is to assess water availability and the potential for dams. Since the potential for dams in the Cuvelai basin is low, the monitoring network is sparse (IWRM Plan Joint Venture Namibia 2010). Second, river flow in the Cuvelai is typically ephemeral, and flow is distributed over through numerous *iishana*. Therefore, the relationship between water level and flow is not consistent, and flow is extremely difficult to calculate. Finally, access to rivers during times of flood is difficult.

Hydrometric monitoring data were found for the following:

- **Near-real-time (NRT) water levels** in *iishana* at Shakambebe, and Shanelago, Namibia. These stations are equipped with telemetry capability and were installed by the Department of Water Affairs and Namibian Water Corporation (NamWater) immediately before the 2008 flood season (IWRM 2008). Data from the 2011 flood event are presented in Mendelsohn et al. (2013). Near-real-time data do not appear to be available online;
- **Manually-measured water level measurements** at numerous stations, conducted during flooding (e.g., Hydrological Services Namibia 2016). Monitoring locations include Engela, Shanalumono, Shahaingu, Shakambebe, Shakamwa, Shanaheke, Okalongo, Shanaimbwengendje, Shanelago, Onembaba, Shapoko, Ogongo, Oshikuku, Otamanzi, Shashuuli, Ombwana, Endola, Okatana, and Ompundja. Water level data are provided in flood bulletins, but long delays between measurements and online data presentation are apparent;
- **Hydrological Cycle Observation System (HYCOS)** Station 68007 for Oshakati is cited in the SADC Baseline Discovery Portal. However, no data from this site could be found;
- **A transect of discharge measurements** that spans at least 100 km and follows the D3608 road in northern Namibia during the 2008 flood event (IWRM 2008). These data are supplemented with data from the 2008 flood event from water level monitoring stations, and extensive remotely-sensed imagery during flooding. This is a highly valuable record of discharge during an exceptional flood event;
- **Qualitative records of water levels** during flooding in 2010 at Evale, Ondjiba (Angola), and Engela and Oshakati (Namibia) (Mendelsohn and Weber 2011); and
- **Discharge at Oshakai, Namibia** (Amakali 2003). Records exist from 1941 and 1967, and are based partly on diaries from missionaries. These data have been summarised to an annual time step. Monthly records also exist from 1975 to 1979. The record is likely useful an indicator of flooding frequency and magnitude, rather than water availability. In addition, the period of record may not be representative of typical conditions in the catchment (Amakali 2003).

Assessments of the hydrologic monitoring network in the Cuvelai have concluded that the current monitoring network is inadequate, and more gauging stations are needed, especially during times of

flood (IWRM Plan Joint Venture Namibia 2010; Filali-Meknassi et al. 2014). Hydrometric stations have less than five years of data, and the current condition of the stations is ‘under question’, and ‘all measurements have gaps in the time series’ (Filali-Meknassi et al. 2014). It is recommended that real-time data and staff gauge measurements be disseminated quickly to the public, the scientific community, and to decision makers.

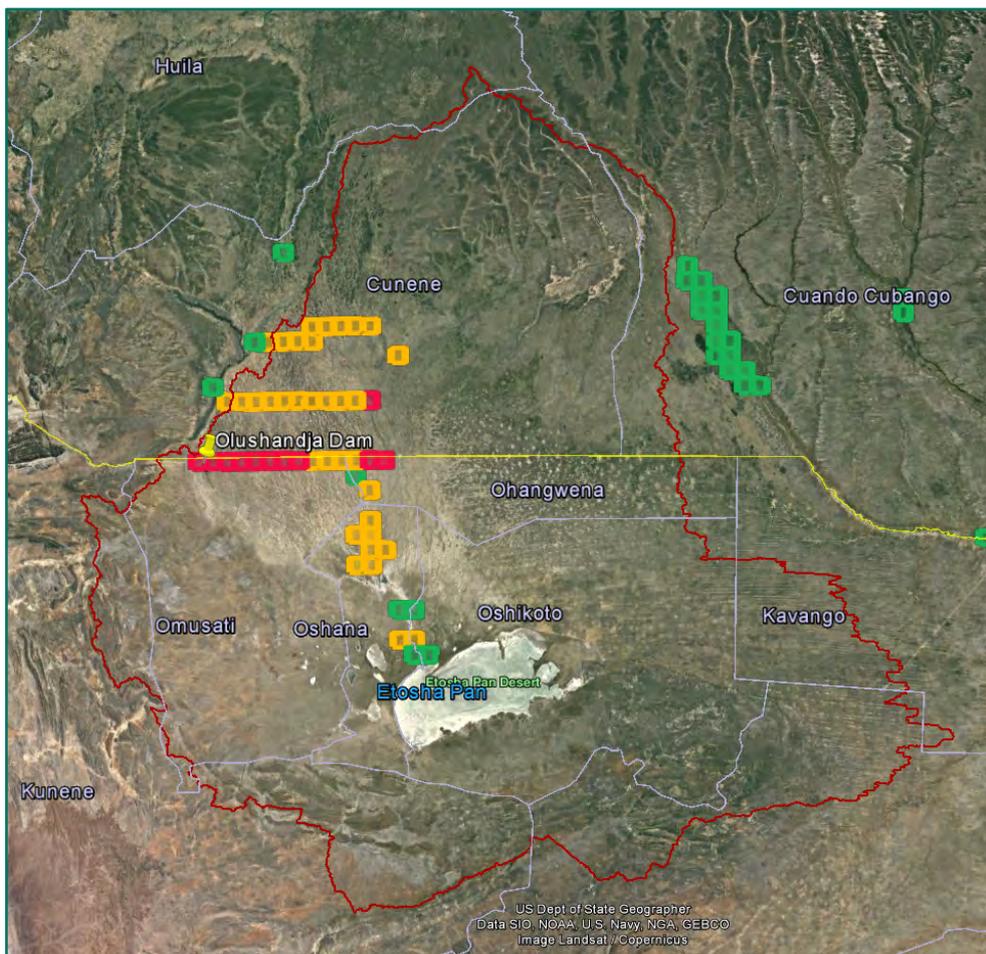
Remote Sensing

Remote sensing data sources are reviewed here where they supply hydrometric data. Flood forecasting in the Cuvelai Basin is reviewed in Section 2.5.3.

The Global Flood Detection System (GDACS) provides remotely sensed estimates of water surface area and flood magnitude at key flood-prone areas in the Cuvelai (GDACS 2017). Methodologies are based on analysis of passive microwave remote sensing imagery (De Groeve et al. 2006; Brakenridge et al. 2007; Kugler and De Groeve 2007; De Groeve and Riva 2009a; De Groeve and Riva 2009b).

A snapshot of the near-real-time flood assessment for the Cuvelai Basin was retrieved on March 22, 2017 (Figure 19). Data were retrieved during a period of ‘the worst flood in memory’ in Northern Namibia (Al Jazeera 2017 Mar 17).

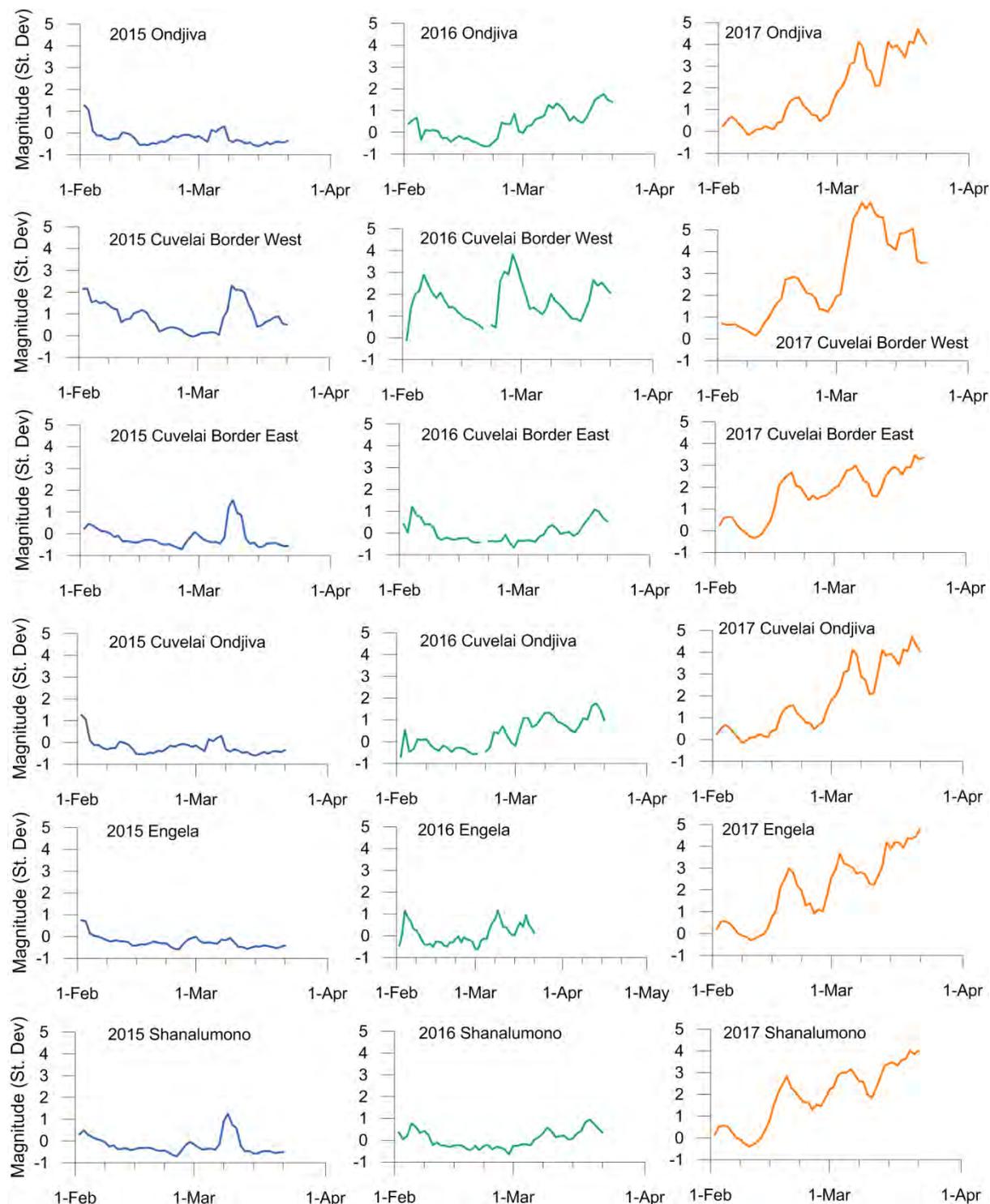
Figure 19 Near-real-time GDACS flood assessment for the Cuvelai Basin, March 22, 2017.



Note: green = no flood, orange = magnitude > 2 (small potential flood), red = magnitude > 4 (potential flood with high return period)

Remotely sensed flood assessments have also been archived for six regions in the Cuvelai since 2015. Data are presented in Figure 20, and clearly show flood waters at all locations exceeding recorded variability beginning in early March 2017.

Figure 20 Archived assessment of flood magnitude for the Cuvelai Basin, 2015 to 2017.



Remotely sensed data provide continuous, near-real-time data, and are available in remote, ungauged regions. However, it is recommended that data quality be assessed, and calibrated using field

measurements where possible, especially if these data are to be used operationally. An opportunity exists to compare remotely sensed data with measurements of near-real-time water level from Shakambebe and Shanelago, and manual staff gauge measurements. This may already have been completed; however, no results were found.

Modelling

Hydrologic modelling of the Cuvelai is difficult for several reasons. First, as described above, the monitoring network is sparse and inadequate, making model calibration problematic. Second, the hydrologic response to rainfall is variable within the catchment, difficult to predict, and depends on land management practices. Rainfall following long dry periods can produce more runoff than rainfall following a wet period, so knowledge of antecedent conditions is essential. During periods of drought, vegetation growth is low and overgrazing occurs, leading to compaction, low infiltration, and high runoff ratios when overland flow occurs. Sediment particles and sediment grain size may also play a role partitioning surface runoff and recharge. Silt particles are thought to fill pores in river beds, increasing surface runoff (Mabande 2011).

Despite these difficulties, several hydrologic models have been applied to the Cuvelai basin, including:

- A model to simulate and predict flooding, using remotely sensed flood maps from 2009 for calibration (Mabande 2011; Mufeti et al. 2013). The authors conclude that modelling of extreme events in the Cuvelai using remotely sensed data is possible;
- Runoff data from a global water balance model published by the GRDC, with a 0.5 degree grid resolution (Fekete et al. 1999; Fekete et al. 2002; Section 2.2.2.2). Data from the model generally agree with spatial patterns of precipitation and observations of perennial and ephemeral rivers in the catchment (Mendelsohn and Weber 2011). It is assumed that the runoff model is driven entirely by climate data and a water balance model; therefore, results should be interpreted with caution;
- Estimates of runoff in Angola produced using gridded precipitation, evapotranspiration, and the Turc-Pike equation (República de Angola 2016a; Section 2.2.2.2). Again, the unique physiography of the Cuvelai may not have been fully incorporated, so within-watershed runoff variability may not be well characterised;
- A hydrologic and hydraulic model constructed to assess hydrologic responses and impacts from the potential construction of a flood diversion channel to protect the town of Oshakai (Muir 2012). The local nature of this model limits its applicability; and
- The flood forecasting section of this document describes other modelling efforts aimed at flood forecasting that have been used, or are being developed, for the Cuvelai Basin (Section 2.5.3).

Given the unique and variable hydrology of the Cuvelai, these modelling datasets should only be used if they are thoroughly assessed. Unfortunately, few flow records are available to validate different models.

Summary

Compiled hydrometric datasets are summarised in Table 5.

Table 5 Summary of assessed hydrologic data.

Custodian	Theme	Components	Time series?	Gridded?	Geographic coverage	QA/QC Level	Completeness	Assessment	Comments	URL
Global Flood Detection System (GFDS) - Version 2	Hydrology	Remotely sensed water level in iisahana	✓	✓	Key flood-prone locations in Cuvelai Basin	Unknown	High	Excellent	Continuous daily time series available since 2015	http://www.gdacs.org/flooddetection/overview.aspx
Global Runoff Data Centre	Hydrology	Discharge, runoff, watersheds	✓	✓	Global; however, no stations within the Cuvelai catchment	High	High	Good	Long-term runoff and discharge.	http://www.bafg.de/GRDC/EN/Home/homepage_node.html
Hydrological Services Namibia	Hydrology	Manually measured water level in iisahana in Namibia	x	x	Key flood-prone locations in Namibian portion of Cuvelai Basin	Unknown	Low	Adequate	Data appear to be sporadically measured and made available.	http://www.mesasadc.org/namibia-hydrological-services
n/a	Hydrology	Long-term record of flood events	✓	x	Oshakia, NM	Unknown	Moderate	Adequate	Flow measurement methodology is unknown. Data are not time series per se. Rather, flood events are binned by size.	n/a. Data available in Amakali 2003.
Southern Africa Science Service Centre for Climate Change and Adaptive Land-Use	Hydrology	Air temperature and precipitation	✓	x	Southern Africa; however, no stations within the Cuvelai catchment	Low		Good	Data from a large network of meteorologic stations in the Cuvelai, both in NM and AO. Variable data gaps where monitoring data are not available. Well documented station data, and data are readily downloadable. Discharge and level data are available in Southern Africa, but not in Cuvelai.	http://leutra.geogr.uni-jena.de/sasscalRBIS/metadata/overview.php?view=ts_timeseries
University of New Hampshire and Global Runoff Data Centre	Hydrology	Runoff	✓	x	Global; however, no stations within the Cuvelai catchment	High	High	Adequate	Global database of runoff data from stations.	http://www.grdc.sr.unh.edu/

Back of table.

2.2.3 Groundwater

There are six main aquifers defined within the Study Area. Five of the aquifers are located within the Kalahari sequence, and one is located within the Damara sequence. The Karoo sequence is mostly inferred to act as an aquitard between the Damara and Kalahari units; however, in isolated areas groundwater can be extracted from this unit. Many of the aquifers are multi-layered including the Otavi Dolomite Aquifer located in the Damara sequences and the six main aquifers are known as:

- Otavi Dolomite Aquifer;
- Etosha Limestone Aquifer;
- Oshivelo multi-layered aquifer;
- Ohangwena multi layered aquifer;
- Oshana multi layered aquifer; and
- Omusati multi layered aquifer.

A recently introduced aquifer naming/abbreviation system has been utilised in recent studies and publications. The naming system consists of three letters and a number. The first letter represents the sequence (ie. 'K' for Kalahari) and the second and third layer represent the aquifer name and a number represents formations can be distinguished within the larger aquifer group. Table 6 provides a summary of the aquifers, associated geological units, water quality, and water yield.

Table 6 Summary of Aquifers within the Cuvelai River Basin (after Bittner 2006 and República de Angola. 2016b).

Name of Aquifer	Abbreviated Term	Sequence	Group	Formation	Rock Type	Depth (m)	Water Quality	Yield (m ³ /h)
Discontinuous Perched Aquifer	KDP			Recent	n/d	n/d	n/d	n/d
Etosha Limestone Aquifer	KEL			Andoni (Etosha Limestone)	Dolocrete, calcrete, sand	10-100	Fresh, locally high nitrates	3-100
Oshivelo Multi-layered Aquifer (undifferentiated)	KOV			Ombalantu, Beiseb, Olukonda, Andoni	Conglomerate, sandstone, sand, dolocrete, calcrete	30-150	Fresh to brackish	25-200
	KOV1			Andoni				
	KOV2			Andoni, Olukonda				
Oshana Multi-layered Aquifer (undifferentiated)	KOS	Kalahari	n/a	Ombalantu, Beiseb, Olukonda, Andoni	Sand, calcrete/ limestone	60-180	Saline to hypersaline	1-30
	KOS1							
Ohangwena Multi-layered Aquifer (undifferentiated)	KOH			Andoni, Olukonda	Sand, sandstone	60-180	Fresh to brackish	25-200
	KOH1			Andoni, Olukonda				
	KOH2			Olukonda				

Table 6 Cont'd.)

Name of Aquifer	Abbreviated Term	Sequence	Group	Formation	Rock Type	Depth (m)	Water Quality	Yield (m ³ /h)
Omusati Multi-zoned Aquifer (undifferentiated)	KOM	Kalahari	n/a	Ombalantu, Beiseb, Olukonda, Andoni	Sand, clay and calcrete, dolocrete	20-100	Brackish, fresh in places	1-30
Karoo Sequence Aquifer/Aquitard (undifferentiated)	KR	Karoo	Ecca	Dwyka, Omingonde, Prince Albert, Kalkrand, Etjo	n/d	n/d	n/d	n/d
Mulden Group Aquifer/Aquitard (undifferentiated)	DM		Mulden	Owambo, Kombat, Tschudi	n/d	n/d	n/d	n/d
Otavi Dolomite Aquifer (undifferentiated)	DO		Otavi	Huettenberg, Elandshoek, Maieberg, Ghaub, Auros, Gauss, Berg Aukas, Varianto, Nabis	n/d	n/d	n/d	n/d
	DOT			Tsumeb Subgroup				
	DOT1		Otavi	Huettenberg				
	DOT2	Damara	(Tsumeb)	Elandshoek				
	DOT3			Maieberg				
Otavi Dolomite Aquifer	DOT4			Ghaub	Dolomite	20-150	Fresh	>50
	DOA		Otavi	Abenab Subgroup				
	DOA1		(Abenab)	Auros,				
	DOA2			Gauss				
	DOA3			Berg Aukas				
Nosib Group Aquifer/Aquitard (undifferentiated)	DN		Nosib	Varianto, Nabis	n/d	n/d	n/d	n/d

n/d=no data; n/a=not applicable

The Kalahari sequence sediments include several complex and interconnected groundwater systems (Christelis et al 2001; MAWF 2006). This sequence is primarily unconsolidated sands and clays, with occurrences of limestone lenses, calcrete, and semi-consolidated sandstone and sandstone fragments. A brief description of the sediments in the Kalahari aquifer formations is provided below:

- Andoni – Light green to white sand, calcrete and clayey sand to sandy clay;
- Olukanda – Red clay and sand, clayey sand to sandy clay;
- Beiseb – Light green to white sand, red semi-consolidated sand, locally clayey; and
- Ombalantu Formation – Red shale and conglomerate with sand and clay and local sandstone and limestone lenses.

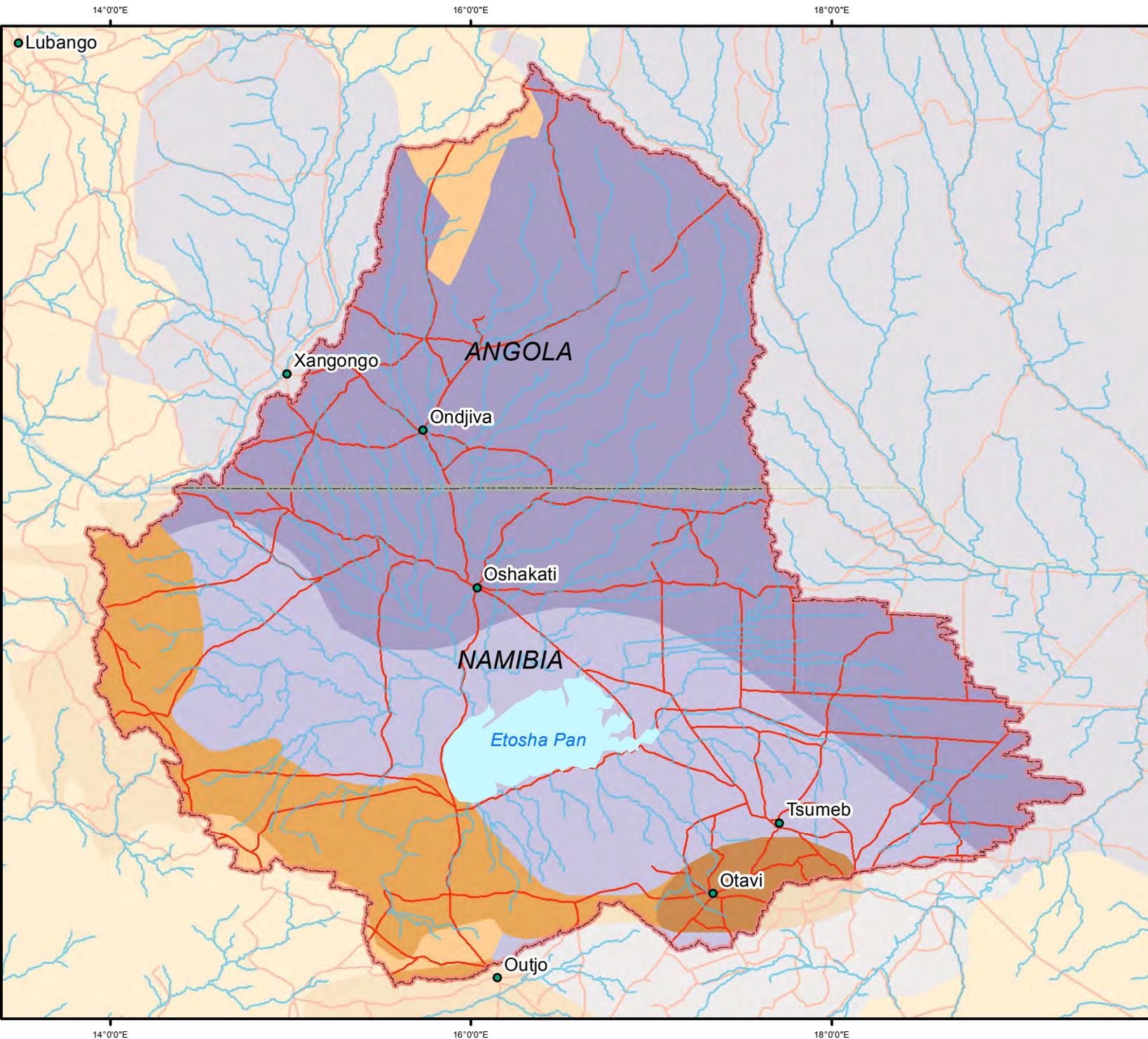
The Damara sequence contains the Otavi Dolomite Aquifer that consists of nine aquifer formations within two subgroups. Five aquifer formations have been identified in the Tsumeb group, and four are located within the Abenab group. The Otavi group is primarily consolidated carbonates (dolomite and

limestone), with varying degrees of karstification. A summary of the available hydraulic conductivities within the Kalahari formation is provided in Lindenmaier *et al*, 2014.

The continental Groundwater Resources of Africa Map (Struckmeier & Richts, 2008) identifies the following main categories of groundwater resources for the Cuvelai River Basin, which are then illustrated in Figure 21:

- Major groundwater basin, 20 to 100 mm per annum recharge;
- Major groundwater basin, 100 to 300 mm per annum recharge; and
- Area with complex hydrogeological structure, with less than 20 mm per annum recharge.

FIGURE 22 - Groundwater Resources of the Cuvelai River Basin.

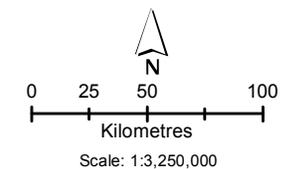
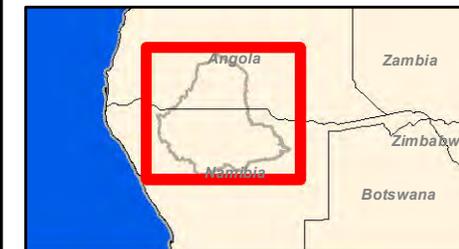


Legend

- Settlement
- Major Roads
- Watercourse
- ▭ Political Boundaries

Groundwater Resources

- area with complex hydrogeological structure, 100 - <300 mm/a recharge
- area with complex hydrogeological structure, 20 - <100 mm/a recharge
- area with complex hydrogeological structure, < 20 mm/a recharge
- area with local and shallow aquifers, < 100 mm/a recharge
- area with local and shallow aquifers, >= 100 mm/a recharge
- major groundwater basin, 100 - <300 mm/a recharge
- major groundwater basin, 2 - <20 mm/a recharge
- major groundwater basin, 20 - <100 mm/a recharge
- major groundwater basin, < 2 mm/a recharge
- major groundwater basin, >= 300 mm/a recharge



2.2.3.1 Wells

Numerous boreholes for water extraction are located throughout the Study Area, and a map of these locations is provided by Mendelson et al., 2013 (p.144). Water well records and borehole logs are not available for most the wells. A national groundwater database is in the process of being developed for Namibia that will include information related to borehole lithology, water levels and chemistry data (Greenwood and Bolliger 2016).

2.2.3.2 Groundwater Flow

The Cuvelai River Basin exhibits an elevation difference of approximately 450 meters from the north to the south axis, and 100 to 200 meters in the east-west axis. The groundwater flow mimics the topography, and flows towards the centre of this basin towards the Etosha Pan. The Damara sequence sub-crops and outcrops along the southern and western edges of the Study Area, and gently dips towards downward towards the north. The sub-cropping and outcropping Damara sequences provide areas of potential groundwater recharge that are noted by MAWF 2006.

A summary of the regional groundwater flow systems is provided in MAWF 2006. Two main groundwater flow systems are identified with the Study Area, and a summary of these two flow systems is provided below:

1. Groundwater recharge from the southern and western edges of the basin flows north and east through the Damara Sequence dolomites, and recharges the overlying Karoo and Kalahari sequences, much of this water discharges as springs and is evaporated; and
2. The deep multi-layered Kalahari Aquifer is recharged from the north in Angola and flows south toward the Etosha Pan and the Okavango River.

2.2.3.3 Groundwater Data Availability and Gaps

Groundwater Monitoring

Groundwater monitoring data is sparse, and a centralised source of groundwater information for the region or country is not available. Limited continuous time series data are available from five monitoring wells (Bittner 2006). Manual water level data are sparse and are available from a limited number of wells, and an extensive regional groundwater monitoring network has not yet been established in the region.

Groundwater Flow Systems

The groundwater flow regime and aquifer interconnectivity in the Study Area is not well understood, and pertinent data could not be found during the data collection exercise. Data pertaining to the following areas of interest would provide a more thorough understanding of the groundwater flow regime:

- Groundwater recharge from both meteoric and surface water sources and the relative contributions of each were not well defined in the reviewed reports, and only very basic conceptual models could be found;
- Aquifer mapping is limited and conceptual cross sections or groundwater models displaying the hydrographic sequences within the Study Area could not be found;

- Data pertaining to the hydraulic properties (e.g., transmissivity, storativity, and permeability) were available for a few select aquifers; however, the data are spatially and temporally limited; and
- Groundwater/Surface water interaction potential or data pertaining to the local processes related to the interactions were not available. This includes vertical gradients.

Recent published geological and hydrogeological data pertaining to the Cubango Megefan and the associated Ohangwena II aquifer (KOH-2) contains some of the relevant data required to fill the data gaps identified above and provides an adequate model for future investigations in the region (Lindenmaier et al. 2014).

2.3 CLIMATE CHANGE CONSIDERATIONS

Climate change will have direct effects on climatic variables such as air temperature, precipitation, evapotranspiration, and soil moisture. Average conditions will change, but extremes will also change. For example, it is possible for mean annual precipitation to decrease, but for extreme precipitation events to increase, resulting in increased runoff. Climate change will also have a series of secondary effects, for example on water availability, human health (e.g., climatic suitability water-borne diseases, food and water availability, temperature-related health impacts), economic activity (e.g., agriculture and tourism), and ecosystem activity (e.g., suitable range for animals) (Republic of Namibia Ministry of Environment and Tourism 2011).

The Cuvelai River basin is extremely dry, prone to floods and drought, and supports a large rural population dependant on agriculture and water availability. These characteristics make the basin sensitive and vulnerable to climate change, making the assessment of likely changes and uncertainties essential for mitigation and planning (Zeidler et al. 2010). Climate change adaptation and mitigation strategies are described in Chisakwe (2010) and SADC (2011).

2.3.1 Climate Change Models and Scenarios

Climate change projections are derived from computer models fed with varying greenhouse gas (GHG) scenarios. Model extent is either global (Global Climate Models, GCM) or regional (Regional Climate Models, RCM). Uncertainty in model output stems from unrealistic simulation of climatic processes, and uncertainty due to the timing and magnitude of future GHG forcing. Uncertainty is assessed by inter-comparing results from a suite of models, and by running models with a suite of GHG forcing. It is generally not useful to use results from a single model without an assessment of how that model fits into results from a community of models.

Results from multiple GCMs and GHG forcing scenarios have recently been inter-compared and thoroughly reviewed by the Intergovernmental Panel on Climate Change (IPCC) (Pachauri et al. 2014; Stocker et al. 2014). Results are summarised in the sections below, along with an assessment of uncertainty and inter-model variability.

GCMs typically have relevantly coarse grid cells (about 1.25-2.5°), and may not accurately simulate climate in the relatively small Study Area. GCMs can be used to feed into RCMs, to increase model resolution and improve the accuracy of the simulation of climatic processes. Results from RCM that cover the Study Area are summarised below, where available.

Scenarios are defined by the IPCC as 'representative concentration pathways' (RCP). RCP vary by GHG emissions and land use (e.g., deforestation vs. reforestation). RCP range from '2.6', where global warming is kept at less than 2°C above pre-industrial temperatures by 2100, to '8.5' where global warming is about 3.7°C above pre-industrial temperatures by 2100. RCP replace emissions scenarios used in previous IPCC reports known as 'Special Report Emissions Scenarios' (SRES).

2.3.2 Air Temperature

For a given GHG scenario, inter-model variability in air temperature in the Study Area is low, and confidence in results is high (Pachauri et al. 2014; Stocker et al. 2014). By the last two decades of the 21st Century, annual air temperatures are expected to increase by 1-1.5°C (RCP2.6) to 5-7°C (RCP8.5). The largest uncertainty for future air temperatures is therefore the GHG emissions that occur, rather than between-model uncertainty. Warm temperature extremes are expected to increase by similar magnitudes. Air temperatures in southern Africa are expected to increase more in summer months compared to winter months (Tadross et al. 2005).

2.3.3 Precipitation

Annual precipitation is expected to decrease in the Study Area by 2100 by up to about 10% for RCP8.5, and between-model confidence is high. For RCP with lower GHG emissions, lower annual precipitation is also expected, but between-model variability is higher.

Predicted changes in precipitation vary seasonally, and there is more between-model variability in results. Some studies predict that the dry season will become increasingly dry, and the wet season will become increasingly wet (Solomon et al. 2009). Other studies predict significant decreases in rainfall in the wet season (Tadross et al. 2005).

Globally, precipitation and drought extremes are expected to increase, and this is also the case in the Study Area (Pachauri et al. 2014; Stocker et al. 2014). Both the maximum 5-day precipitation total, and consecutive dry days are expected to increase, and between-model confidence in these changes is high. Return periods for extreme precipitation events are expected to decrease.

Grid size plays a role in the accuracy and precision of modelled precipitation, particularly at lower than annual timescales. By coupling RCM with GCM, climatic processes can be more accurately simulated. For example, a coupled RCM-GCM for southern Africa showed a decrease in low pressure systems that bring moisture and most floods to the Study Area (Engelbrecht et al. 2013). However, an increase in extreme rainfall events was found by the same study, which was attributed to an increase in convective rainfall events. In a review of GCM and RCM covering the Cuvelai, it was concluded that the Study Area is expected to become drier in the future (Zeidler et al. 2010).

2.3.4 Evapotranspiration

Under RCP that predict relatively small increases in GHG, models disagree on the sign and magnitude of changes in evapotranspiration. Under more aggressive RCP, evaporation is expected to decrease by about 0 to 0.4 mm per day in the Study Area. This decrease corresponds to a decrease in precipitation and water availability for evapotranspiration (Pachauri et al. 2014; Stocker et al. 2014). Some uncertainty in estimates of evapotranspiration stem from feedbacks between air temperature, precipitation, and transpiration from vegetation, the latter of which is poorly modelled and uncertain.

2.3.5 Runoff, Droughts, and Floods

The Study Area is vulnerable to changes in runoff, drought, and floods (Chishakwe 2010). GCM predict slightly decreased runoff by 2100 in the Study Area; however, between-model variability is large, and confidence in the direction and magnitude of change is low (Pachauri et al. 2014; Stocker et al. 2014). Some hydrologic models incorporating climate change in Africa have generally predicted increases in runoff (Faramarzi et al. 2013). An examination of different methodologies of running climate change hydrologic models in southern Africa revealed large differences in results depending on the model, model initialisation, and model forcings (Arnell 2003). This is not surprising given the between-model differences in precipitation and evapotranspiration described above.

Overall, there is little quantitative information on the future frequency and magnitude of hydrometeorological extremes in the Cuvelai; however, the consensus is that both will increase (Zeidler et al. 2010).

It has been recommended that the hydrometeorological monitoring system be improved in the SADC region, since monitoring can detect, and warn of extreme hydrometeorological conditions (SADC 2011). Flood protection structures are being constructed and considered to reduce climate change-related risks from flooding (SADC 2011; Muir 2012).

2.3.6 Groundwater

Groundwater is not directly modelled by GCM or RCM. Given that knowledge of modern and future runoff and recharge is low in the Study Area, predictions of future groundwater conditions are also uncertain. However, a very useful management support tool called GRIMMS has recently been developed in the SADC region (Villholth et al. 2013). GRIMMS is a GIS-based tool that incorporates layers relating to human and physical influences on groundwater. Its outputs include groundwater drought risk under current conditions, and under climate change scenarios. Current groundwater drought risk in the Study Area is 'low' to 'moderate'. Under the SRES A1B scenario, groundwater drought risk is 'moderate' to 'high'. The A1B scenario is a 'middle of the road' scenario that predicts GHG emissions will begin dropping by mid-century. Overall, a 30-70% reduction in groundwater can be expected in the 21st Century in Namibia (Republic of Namibia Ministry of Environment and Tourism 2011). Groundwater is viewed as a key resource for providing a water supply in the Study Area in the future (SADC 2011).

2.3.7 Agriculture and Livestock

Since models disagree over the magnitude and intra-annual timing of precipitation changes, the effects on agriculture and livestock are also uncertain. Crops that are particularly sensitive to climate change include grains and dryland crops. Livestock will be influenced by changes in rangeland capacity. Climate change will directly influence agriculture and livestock through changes in rainfall temperature, and evapotranspiration, but also indirectly through changes in soil quality, pests, and pathogens (Zeidler et al. 2010).

2.3.8 Climate Change Data Availability and Gaps

Major data sources, data quality, and gaps are summarised in Table 7.

Table 7 Summary of assessed climate change data.

Variable	Prediction	Uncertainty	Data Availability	Assessed Data Sources
Air Temperature				
Global	●	●	●	Pachauri et al. 2014; Stocker et al. 2014
Namibia	●	●	●	
Angola	●	●	●	
Annual Precipitation Totals				
Global	●	●	●	Pachauri et al. 2014; Stocker et al. 2014
Namibia	●	●	●	
Angola	●	●	●	
Evapotranspiration				
Global	●	●	●	Pachauri et al. 2014; Stocker et al. 2014
Namibia	●	●	●	Solomon et al. 2009, Engelbrecht et al. 2013, Zeidler et al. 2010
Angola	●	●	●	
Runoff				
Global	●	●	●	Pachauri et al. 2014; Stocker et al. 2014
Namibia	●	●	●	Chishakwe 2010, Faramarzi et al. 2013, Amell 2003
Angola	●	●	●	
Drought				
Global	●	●	●	Pachauri et al. 2014; Stocker et al. 2014
Namibia	●	●	●	Zeidler et al. 2010
Angola	●	●	●	
Floods				
Global	●	●	●	Pachauri et al. 2014; Stocker et al. 2014
Namibia	●	●	●	Zeidler et al. 2010
Angola	●	●	●	
Groundwater Vulnerability				
Global	●	●	●	n/a
Namibia	●	●	●	Villholth et al. 2013
Angola	●	●	●	
Agriculture and Livestock Vulnerability				
Global	●	●	●	n/a
Namibia	●	●	●	Zeidler et al. 2010
Angola	●	●	●	

Legend

- Predicted increases, low uncertainty, or high data availability ●
- Predictions variable, uncertainty moderate, data availability moderate ●
- Predicted decreases, high uncertainty, or low data availability ●

Overall, in the Study Area, air temperatures are expected to increase, annual precipitation totals are expected to decrease, and evapotranspiration is expected to decrease. Confidence in these directions of change is high. Runoff is expected to decrease, and droughts and floods are expected to increase. Uncertainty is moderate for these responses in the Study Area. Groundwater vulnerability is expected to increase, and confidence is high based on the GRiMMS study (Villholth et al. 2013). Agriculture and livestock are expected to be negatively impacted by climate change, but no quantitative studies were found.

Regional climate change data are more complete in Namibia compared to Angola. In 2010, it was assessed that GCM models from IPCC are “the most robust available” (Zeidler et al. 2010). However data from the Angolan side of the Cuvelai has improved since 2010, with the introduction of several new high-resolution regional datasets (Tadross et al. 2005; Solomon et al. 2009; Zeidler et al. 2010; Engelbrecht et al. 2013; Villholth et al. 2013). Regional assessments of mitigation and adaptation strategies have also been completed (e.g., SADC 2011).

2.4 WATER UTILISATION AND DEMAND

Water collection is mainly achieved through two methods: by a network of NamWater and Directorate of Rural Water Supply (DRWS) pipelines from the Angolan Kunene River Reservoirs; and by boreholes to retrieve water from aquifers (Dragnich, Dungca, Pendleton, & Tracy 2007). Water from the Calueque Dam reservoir is transported using canals and pipelines through northern Namibia and back into some of Angola. Rainwater collection and floodwater collection are also important sources of water (IWRM Joint Venture Consultants n.d.). Small-scale excavations and earthen dams are used locally for harvesting flood waters from oshanas.

2.4.1 Domestic

Domestic water sources in the Cuvelai Basin include wells that withdraw water from shallow aquifers that require rainwater to recharge (Mendelsohn J. 2015a). In large areas of the Namibian portion of the basin and Ondjiva in Angola, water supply is highly dependent upon NamWater pipeline system that collects water from the Calueque reservoir, particularly during dry periods (Dragnich, Dungca, Pendleton, & Tracy 2007). The Xangongo Dam on the Kunene River, 75 km upstream from the Calueque dam is an important source of water for much of the Angolan portion of the basin (Marley Pipesystems 2017).

A survey conducted in the Angolan portion of the Basin reported that traditional wells were the most utilised source of water, followed by rainwater, earth dams, rivers, ponds and chanas, lakes and seasonal channels, hand pumps and taps (Calunga 2015). Most people reported using multiple sources of water. Only 28% of respondents reported treating water, despite 98% using open sources of water (considered unsafe due to the potential for contamination) (Calunga 2015). Roughly 53% of households were found to be within 2 km of a water source.

2.4.2 Sanitation

Effective sanitation can help to prevent disease and infection. It is unknown how much water in the Cuvelai Basin is utilised for sanitation purposes. It is also unknown if other options for effective sanitation (e.g., composting) can, or are, being used in the Basin. The level of collaboration between line agencies that deal with water supply, health, sanitation (which are all linked in this case) is also unknown. CuveWaters reports approximately 40% of the Namibian portion of the Basin's urban population lacks access to improved sanitation facilities and less access in rural areas (2015). Earth dams in the oshanas are mainly used to harvest water for livestock (IWRM Joint Venture Consultants n.d.).

2.4.3 Agriculture

Over 100,000 cattle withdraw water as they overwinter in the Oshimolo floodplain grassland areas north of the Angola-Namibia border (Mendelsohn J. 2015b). Pearl millet is heavily relied upon in the region due to its ability to be grown in dry and sandy soils (Mendelsohn J. 2015a). 

2.4.4 Fisheries and Aquaculture

Based upon information gathered during the stakeholder consultation process for this, and publicly available literature sources, aquaculture is viewed as an important contributing sector for food security in Namibia, which also applies to the Cuvelai River Basin. The Ministry of Fisheries and Marine Resources is committed to maintaining a position as a leading fishing nation, with a well-developed

aquaculture industry, and has implemented several pilot aquaculture projects across Namibia (FAO, 2017), including those listed in Table 8. Critical to note are the projects in the Omusati and Oshana regions – understood to be community-based fish farming facilities - both of which are in the Cuvelai River Basin (MFMR, 2017).

Table 8 Aquaculture projects across Namibia.

No.	Name	Type of Facility	Location
1	Mpungu Fish Farm	Community based fish production farm	Nkurenkuru, Kavango Region
2	Karovo Fish Farm	Community based fish production farm	Rundu, Kavango Region
3	Kamutjonga Inland Fisheries Institute (KIFI)	Fingerling & fish production, Research, Training; Information center	Divundu, Kavango Region
4	Likunganelo Fish Farm	Community based fish production farm	Lisikili, Caprivi Region
5	Kalimbeza Fish Farm	Community based fish production farm	Kalimbeza, Caprivi Region
6	Epalela Fish Farm	Government fish grow out farm	Omusati Region
7	Onavivi Inland Aquaculture Center	Fingerling & fish production, Research, Training;	Omusati Region
8	Onavivi Fish Feed plant	Fish feed production facility	Omusati Region
9	Ongwediva IAC	Fingerling and fish production facility	Oshana Region
10	Hardap IAC	Fingerling & fish production, Research, Training;	Hardap Region
11	Fonteintjie FF Project	Community based grow out project	Karas Region
12	Leonardville IAC (NEW)	Under construction: Fingerling & fish production, training	Omaheke Region
13	Noordoewer IAC (New)	Feasibility study stage	Karas Region

Source: (MFMR, 2017)

If these aquaculture projects prove to be sustainable – financially, and logistically – the could contribute significantly to the food security equation in the north of Namibia, and by extension, into southern Angola through trade, as fish provide a good source of protein.

Limited remarks, on fish biota in the Cuvelai River Basin are presented in Section 2.1.5.8. 

2.4.5 Environmental Water Demand

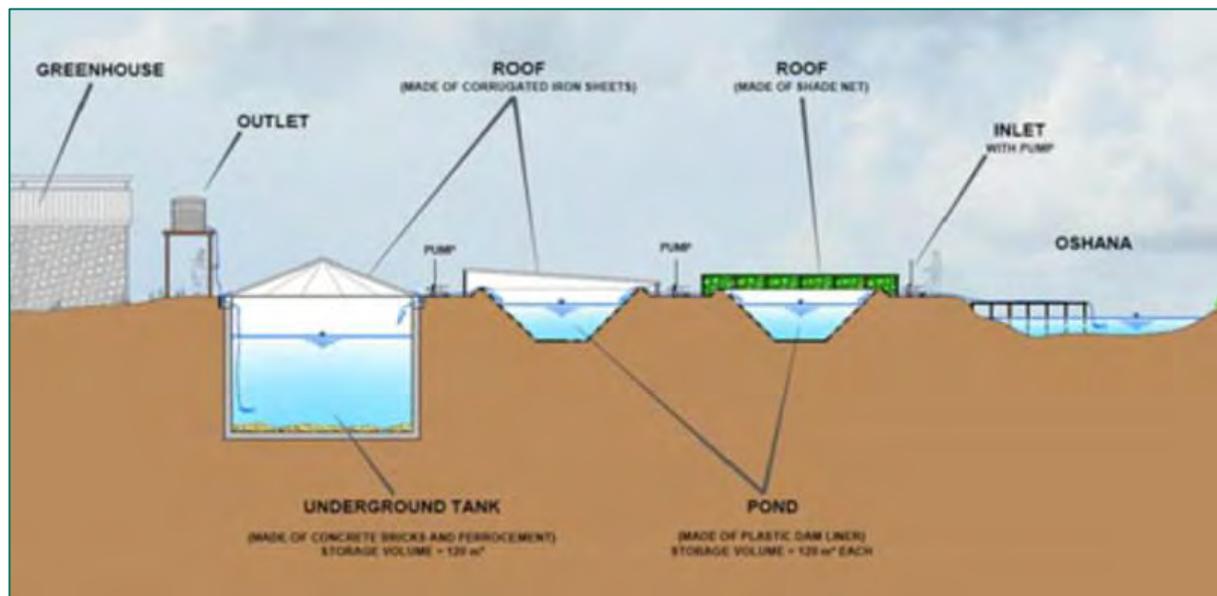
Environmental flows are the amount of water flow, the timing of water flow and the quality of water required for environmental purposes (including the support of ecosystems, species and livelihoods). No data or information was found on the water requirements for environmental purposes. Environmental Flow Assessments for various ecosystems and livelihood systems will help to inform minimal flows required.

2.4.6 Flood and Rainwater Harvesting

Among its other achievements, the CuveWaters project, which ended in 2015, implemented a series of innovative pilot water reuse, harvesting and desalination facilities across northern Namibia. One critical element of this project was the development and implementation of flood and rainwater harvesting facilities. In 2011 and 2012, the pilot plant was established in Lipopo, a remote village in the southern Oshana region of northern Namibia. Water is pumped from flooded Oshana, and stored in underground storage tanks, and covered ponds.

These facilities were intended to provide water for irrigation of gardens for subsistence agriculture and market production, using stored water gathered from rainfall events and flooded Oshana. One pond has a shade-net roof and one is covered with corrugated iron, with a total storage capacity of 400 m³. These storage facilities are located next to greenhouses, providing facilities for growing market-ready vegetables protected from direct sunlight, wind, and pests; and open gardens that use drip-irrigation. Figure 22 shows a cross-section of the facilities, and Figure 23 shows the plant next to a flooded Oshana during the floods of 2011.

Figure 22 Example rainwater harvesting facility.



Source: CUVEWaters

Figure 23 The Oshana in lipopo during the flood of 2011, in the background the floodwater harvesting plant.



Constructed over 5 years ago, the facilities are still operational, as are rainwater harvesting facilities at this and other locations. Following is a summary of lessons learned provided by the CuveWaters team (Jokisch, pers comms, 2017):

- Good quality floodwater was collected in two out of three seasons during the project, and the facilities are still in operation.
- It was concluded that construction and operation of floodwater harvesting facilities in Namibia is a viable option.
- Income generation from the first growing season was N\$ 4,700 from selling market produce from the greenhouse, over and above subsistence crop production.
- The diet and health status of families involved with the project improved throughout the project lifetime, and ten permanent jobs were created.
- The floodwaters of the Cuvelai River Basin vary greatly from year to year in volume and spatial distribution. These variations present challenges for consistent water supply, even though substantial quantities are stored.

- The team recommended that only locations north of the Oshakati to Okahao road should be considered to maximise potential for harvesting flood waters. The secondary benefit of this zone is that soils are better in this area, meaning that facilities would be more productive.
- Floodwater harvesting should also be combined with rainwater harvesting, to maximise rainwater capture and storage, especially in lower flood years.
- Facilities should be located no more than 20 km from markets within urban centres, such as Okahao, Outapi, Oshakati or Oshikuku.
- All rainwater and flood-water harvesting and gardening facilities development should be supported by capacity development initiatives, to increase the understanding of construction, management and farming techniques, making the projects more sustainable.
- Based on experiences, the CuveWaters team recommended that groups developing and utilising these facilities should be small private businesses or maximum 5 families working together as a cooperative venture. 

2.4.7 Desalinisation

While groundwater across the southern portion of the basin is relatively shallow (10 to 100 m; Mendelsohn, et al 2013) salinity is frequently high (Mendelsohn et al. 2000), meaning that if communities wish to utilise readily available groundwater resources for livestock watering, irrigation or consumption, it needs to be desalinated. Desalinisation is widely known to be an energy intensive process, often pushing the costs up to the point that the solution is unsustainable. However, the CuveWaters Project piloted four facilities – in the villages of Amarika and AKutsima - to determine the feasibility of developing and implementing desalinisation as an option for providing clean drinking water. Each facility managed to create 5 m³ of clean drinking water per day from highly saline groundwater sources, using a mixture of desalinisation technologies, most successful of which were heat exchange and reverse osmosis (CuveWaters, 2015).

Figure 24 Solar powered desalination facility in Akutsima.



Source: ISOE Wikom 2014

2.4.8 Water Utilisation and Demand Data Availability and Gaps

The general uses of water in the Cuvelai Basin are understood; however, detailed data on water extraction and the amount of water used per purpose were not readily available. A basin-wide assessment of water demand would help to inform management of water balance decision making. Such a study would also help to inform where water conservation efforts are required and where conservation efforts might be most efficient. One significant gap in knowledge with respect to groundwater is the extent and sustainable yield potential of the Ohangwena II Aquifer.

2.5 DISASTER RISK MANAGEMENT

While the Cuvelai River Basin is prone to many types of typical disasters, such as fire, earthquakes, floods and droughts, the two main priorities, especially from a transboundary water management perspective, are **drought and floods**. These two issues are discussed briefly below, followed by an assessment of the SADC Flood Atlas, and its application in the Cuvelai River Basin as a Flood Forecasting and Management tool.

2.5.1 Drought

The timing and magnitude of drought affects vegetation, human health and livelihood, wildlife, and wildfires. Droughts in the study area are partially controlled by large-scale ocean-atmosphere teleconnections, especially El Niño (Chishakwe 2010).

Several drought indicators are available, including:

- **The Standardised Precipitation-Evapotranspiration Index (SPEI)**, a standardised drought index using air temperature, precipitation, and evapotranspiration from CRU TS v.3.24 (Beguería et al. 2010; Vicente-Serrano, Beguería, and López-Moreno 2010; Vicente-Serrano, Beguería, López-Moreno, et al. 2010) At the time of writing, SPEI data were available from 1901 to 2014;

- **The African Flood and Drought Monitor**, which provides time series, point data, monitoring data, and forecasts of drought, including hydrometeorological indicators, other drought indices, and remotely sensed vegetation data (AFDM 2017); and
- **The Blended Drought Index**, a gridded drought index that has been applied to the Cuvelai Basin (Stein, Luetkemeier, Liehr, & Drees 2015; please refer to Figure 25).

SPEI was extracted for the grid cell nearest Ondangwa, and results are presented in Figure 16. The average SPEI is zero, and the standard deviation is one. Periods of drought are identified for the periods roughly between 1925 and 1935, and 1980 to 2000. Very similar periods of low precipitation were identified in the precipitation anomaly graph presented in Figure 16.

Floods are often thought of as causing the greatest impacts to the landscape, infrastructure and livelihoods, because of the rapid nature of their onset, and immediately observable physical destruction; however, droughts can have greater impacts, with longer term effects on households, due to prolonged food insecurity, and water scarcity (Mendelsohn J. , Pers Comms, 2017).

The people of the Cuvelai Basin are no stranger to drought. In 2013 for example, the government of Namibia declared a state of emergency due to drought. About one third of the population in Namibia and another 1.5 million people in Angola were classified as food insecure as a result of drought (United Nations Office for the Coordination of Humanitarian Affairs 2013). With an annual PET of 1,500 mm and a mean annual precipitation of between 300 to 400 in the south and 800 to 900 in the north (Mendelsohn & Weber 2011), PET is greater than three times the precipitation. Using remote sensing and data for three parameters (precipitation, soil moisture and potential evapotranspiration) Stein *et al.* showed that drought exposure is highest in eastern and central areas of the Cuvelai (see Figure 25; Stein, Luetkemeier, Liehr, & Drees 2015).

A temperature increase of between 1 and 7°C is projected as is an increase in temperature extremes, which can be expected to contribute further to an increase in evapotranspiration. This would influence crop survival, in a region of high dependence on agriculture. Temperature change is expected to be more drastic the further inland from the coast.

2.5.2 Floods

Exceptionally high flows are known as 'efundjas', since 1941, floods have occurred in 1950, 1954, 1957, 1971, 1976, 1977, 1995, 2004, and 2008-2011 (Mendelsohn and Weber 2011; DRFN and Heyns Consultancy 2013); with substantial flood waters experienced across the central basin in March 2017. (Al Jazeera 2017 Mar 17). Receding flood waters from the March 2017 floods can be seen in Figure 26.

Figure 25 Mean annual Blended Drought Index (BDI) – drought exposure map (Stein, Luetkemeier, Liehr, & Drees 2015).

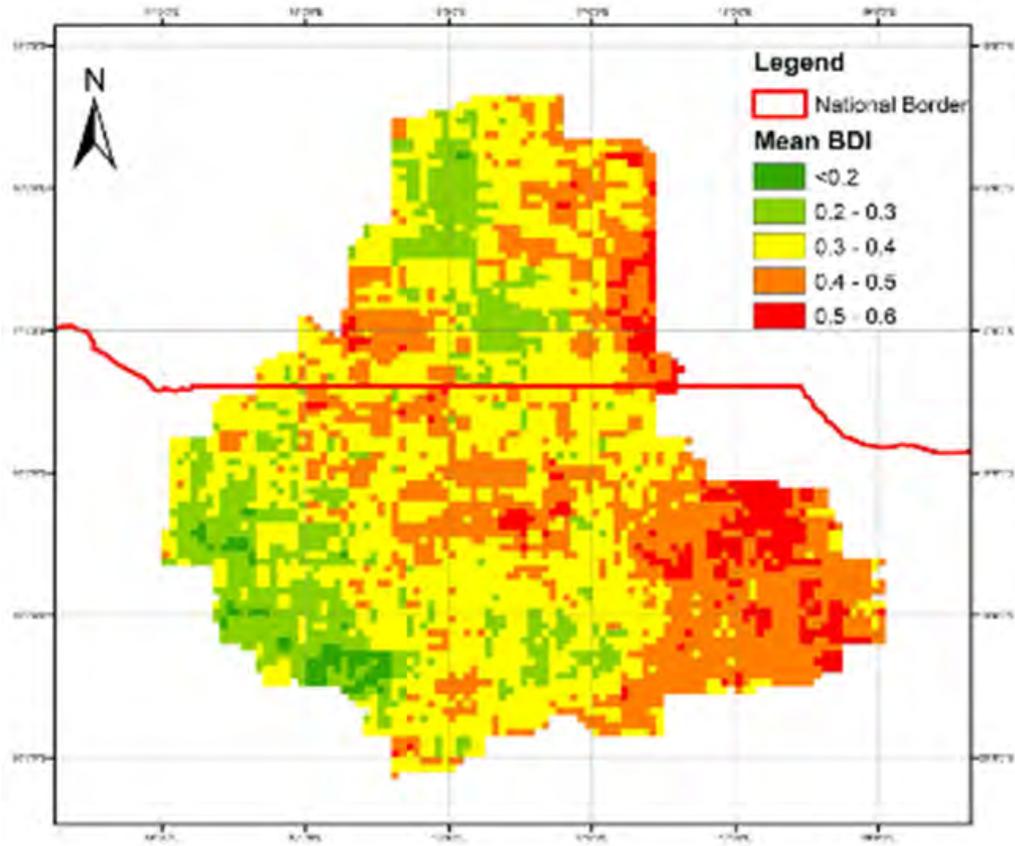
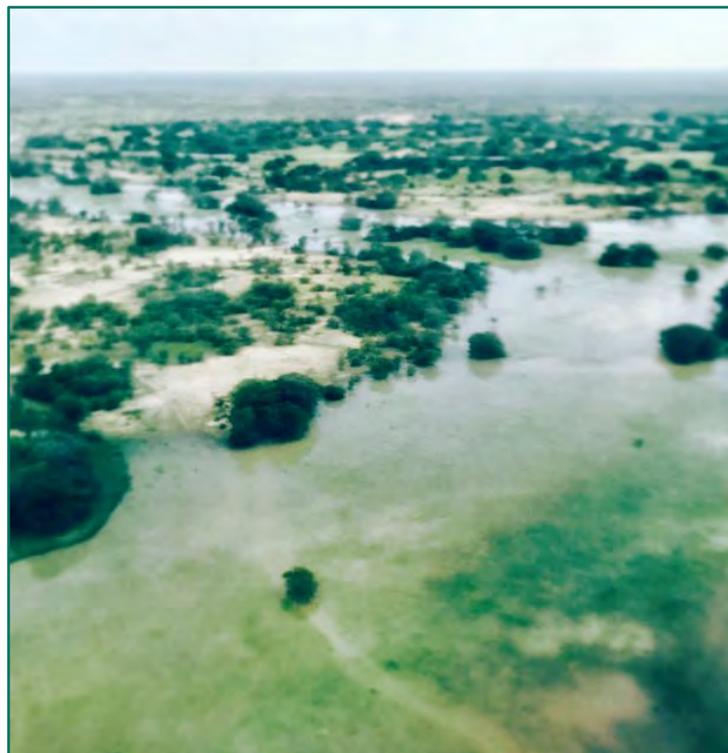


Figure 26 Remnants of flooding, late March 2017.



Source: Hughes 2017

Flood waters can take weeks or months to pass, owing to the level nature of the landscape and limited variability in topography in the catchment. Flooding is particularly difficult to predict, since flood waters take different paths through iishana at different times, in response to rainfall distribution and intensity (Section 2.5.3).

Flood waters in at least one example, take approximately 19 days to travel from Evale in the northern portion of the basin to Oshakati, south of the border (RAISON 2013).

Figure 27 Evale town adjacent to the Cuvelai River, in flood.



2.5.2.1 Impacts of Floods

The Cuvelai River basin has recorded several significant seasonal floods since 2008, causing numerous impacts on rural livelihoods, some positive, most negative; with the greatest impact being felt by vulnerable communities with limited means to prepare for, respond to, and survive these events (Shifidi, 2016). Apart from the security risks posed by the actual floods to the basin inhabitants, their livelihoods are threatened in the following ways:

- **Property** – damage to assets such as homes and property lead to reduced livelihood capacities as do any damage to infrastructure such as roads (e.g., reduced access to markets);
- **Human health** – increased incidences of illness and fatalities due to drowning, disease and parasites, and potentially exacerbated by reduced access to healthcare when roads are blocks;
- **Plant and crop communities** – damage to crops through reduction of soil oxygen levels, clogging of soil pores, change in soil pH balance, etc; and
- **Livestock** – reduction in productivity due to food shortages and fatalities and illness brought on by drowning, disease and parasite outbreaks.

These, and other, negative impacts accumulated over the years preceding 2016 created damage estimated to cost USD 136.4 million in direct losses, and USD 78.2 million in indirect losses (Shifidi, 2016).

While floods are, often for good reason, viewed as purely negative events, communities across the region, although negatively impacted, largely believe the short-term negative impacts of floods are greatly outweighed by long-term benefits (Shifidi, 2016). Benefits of floods include increased harvest and livestock productivity in drier areas, and recharge of riparian and other aquifers, as well as the replenishment of fish stocks.

2.5.3 Flood Forecasting System Assessment

The following section presents an assessment of the approaches to flood forecasting that are currently in use in the Cuvelai Basin and the surrounding region. The intent of this assessment is to provide a high-level overview; as such, it is limited to a desktop-based review of existing documentation and resources for flood forecasting in the Cuvelai Basin. It is not intended to be a comprehensive evaluation or detailed gap analysis.

2.5.3.1 Background

The Cuvelai Basin has a high degree of hydrological and climatic variability (Section 2.2.1). Climate change and climate variability have exacerbated both dry and wet conditions in the region in recent years, with the past decade containing historically severe droughts and floods (particularly the floods in 2008, 2009, 2011; (Mendelsohn and Weber 2011). Flood forecasting in the basin is particularly challenging due to the complexity of its topography and drainage networks (Filali-Meknassi et al. 2014).

In response to the most recent flooding, national and international partners initiated broad-scale re-evaluation of the flood management system in the region. Two projects are of high relevance to the Cuvelai Basin, and were used as the primary information sources for the development of this assessment:

- A review project, with the objectives of evaluating the flood forecasting system for Namibia (including an assessment of existing data) and making recommendations for flood forecasting and disaster response methods, was initiated by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) in 2011. The final report for this project, titled “Data Access, Availability and Quality Assessment for the Development of a Flood Forecasting Model for Namibia” was published in 2014 (Filali-Meknassi et al. 2014).
- A flood risk management (FRM) program led by the SADC HYCOS, referred to as the SADC HYCOS FRM, began in early 2014 and continued through 2015. The four-volume final report, “Integrating SADC HYCOS into Flood Risk Management Strategies that Support Regional Disaster Risk Reduction” was published in November 2015 (Atkins 2015). A major component of this program was the development of a Regional Flood Atlas consisting of maps showing flood-prone areas and the relative severity of the flood hazard.

2.5.3.2 Evaluation Criteria

The flood forecasting system was evaluated based on the following three criteria:

1. Is the existing flood forecasting methodology appropriate for application in the Cuvelai Basin, given the basin’s unique hydroclimate and topography?
2. Are available data sufficient to support a robust flood forecasting system in the Cuvelai Basin using the current methodology (i.e., period of record, data quality, and spatial coverage)?

3. Are collaboration, data sharing, and communication systems sufficient to support the flood forecasting system in the Cuvelai Basin?

2.5.3.3 Evaluation Results

The current activities related to flood forecasting in the Cuvelai Basin fall into three broad categories, summarised in Table 9, and described in greater detail below.

Table 9 Summary of flood forecasting-related activities and products in the Cuvelai Basin.

Activity or Product	Key Agencies	Description
Data		
Hydrometric monitoring (HYCOS)	SADC, Namibia Hydrological Services (NHS)	Approximately 24 telemetric level gauges on the Namibian side of the Cuvelai Basin; however, little long-term (>5 years) data available for these gauges, and their condition is uncertain. No known functional hydrometric gauges on the Angolan side of the basin.
Meteorological monitoring	NMS	Possibly one staffed meteorological station and at least seven automatic meteorological stations on the Namibian side of the Cuvelai Basin; no known meteorological stations on the Angolan side of the basin
Remote sensing data (rainfall, water levels, topography)	e.g., NASA (TRMM, SRTM), UNITAR/UNOSAT Flood Portal, GDACS	Remote sensing data are available from various sources for studies of the Cuvelai Basin (e.g., Atkins 2015; Awadallah and Tabet 2015)
OpenStreetMap	NHS	Open-source, collaborative map used by the NHS to store water level data obtained from public contributors (e.g., locations of water recorded by handheld GPS), which are used in conjunction with historical satellite data to relate modelled streamflows and/or satellite rainfall data to the spatial extent of floods.
Data analysis and modelling tools		
TIGER-NET	ESA, NHS	Open-source software that provides flood forecasting capabilities using water level data and satellite RADAR imaging
HEC-RAS	NHS	Open-source hydraulic modelling software that has been used by the NHS in flood studies
CREST	NHS	Grid-based hydrological modelling program used by the NHS to predict flood magnitude and timing using satellite-derived digital elevation data, rainfall data, evapotranspiration data, and information about soil properties, land use, and land cover
Data synthesis and dissemination		
Namibia Flood Dashboard and Flood Early Warning Project	NASA	River flow records, basin maps, infrastructure maps, TRMM rainfall forecasts, and other satellite overlays combined in an interactive, user-driven format
HYCOS Flood Atlas	SADC	Maps of flood hazards and flood-prone areas in 14 major transboundary river basins in the SADC region including the Cuvelai
Daily flood bulletins	NHS	Bulletins containing flood gauge data, rain gauge data, satellite maps of potential rainfall, and observations from flood zones

CREST: Coupled Routing and Excess Storage; ESA: European Space Agency; GDACS: Global Flood Detection System; HYCOS: Hydrological Cycle Observation System; NASA: National Aeronautics and Space Administration (United States); NHS: Namibia Hydrological Services; NMS: Namibia Meteorological Service; SADC: Southern Africa Development Community; SRTM: Shuttle Radar Topography Mission; TRMM: Tropical Rainfall Measuring Mission; UNITAR/UNOSAT: United Nations Institute for Training and Research/UNITAR's Operational Satellite Applications Programme.

Data

- As of 2013, Namibia Hydrological Services (NHS) operated approximately 24 telemetric level gauges on the Namibian side of the Cuvelai Basin, but no long-term data (>5 years) were available for these gauges and the condition of the stations was uncertain (Filali-Meknassi et al. 2014). As of 2013, no known functional hydrometric gauges existed on the Angolan side of the basin (GEF 2013; Filali-Meknassi et al. 2014), and at the time of this report, no documentation could be found indicating that any Angolan gauges exist in the basin.
- As of 2013, one staffed meteorological station (daily rainfall measurements) and at least seven automatic meteorological stations (hourly rainfall measurements) exist on the Namibian side of the Cuvelai Basin. Several additional stations existed in the past, but are now decommissioned (Filali-Meknassi et al. 2014). Recent documentation suggests that there are no meteorological stations on the Angolan side of the Cuvelai Basin (GEF 2013).
- Remote sensing data (topography, rainfall, water levels) are available from various sources, most notably NASA (e.g., TRMM and SRTM data), the United Nations (e.g., UNITAR/UNOSAT Flood Portal), and the European Commission Joint Research Centre (JRC) Global Flood Detection System (GDACS) for studies of the Cuvelai Basin (e.g., Atkins 2015; Awadallah and Tabet 2015).
- NHS uses OpenStreetMap (2017e), an open-source, collaborative project to create a free editable map of the world, to store and organize water level data obtained from public contributors (e.g., locations of water recorded by handheld GPS). These data are used in conjunction with historical satellite data (MODIS, Radarsat, and EO-1) to relate modelled streamflows and/or satellite rainfall data to the spatial extent of floods and calibrate hydrological models (Filali-Meknassi et al. 2014; Mandl).

Data analysis and modelling tools

- TIGER-NET (2017g), an open-source software program, is part of the European Space Agency (ESA)'s TIGER initiative to improve Integrated Water Resources Management (IWRM) in Africa (2017a). It is used by the NHS for streamflow forecasting, flood monitoring, and flood vulnerability assessment (Filali-Meknassi et al. 2014). The TIGER-NET Water Observation Information System (WOIS) provides forecasting capabilities seven days in advance using recorded water level data and satellite radar imaging.
- HEC-RAS, a widely used open-source hydraulic modelling software program developed by the United States Corps of Engineers, has been used by the NHS in flood studies (Filali-Meknassi et al. 2014). It was also a key tool in developing the maps for the SADC HYCOS Regional Flood Atlas (Atkins 2015), discussed in more detail below.
- CREST, the Coupled Routing and Excess Storage hydrological model (2017c), is a collaborative project between Oklahoma University and NASA (Wang et al. 2011) that is used by the NHS (Filali-Meknassi et al. 2014). CREST is raster-based (i.e., grid-based) and can be used to predict flood magnitude and timing using satellite-derived digital elevation data, rainfall data, evapotranspiration data, and information about soil properties, land use, and land cover.

Data synthesis and dissemination

- The Namibia Flood Dashboard and Flood Early Warning Project (2017d) combines river flow records, basin maps, infrastructure maps, TRMM rainfall forecasts, and other satellite overlays in an interactive format that allows the user to select different layers. According to the Flood Dashboard website, its flood potential maps are based on a meso-scale hydrological model, which is assumed to be the University of Maryland Global Flood Monitoring System (GFMS), described on the TRMM Global Flood and Landslide Monitoring website (Wu et al. 2014; 2017b). The GFMS is a NASA-funded experimental system that uses TRMM data as input to a hydrological runoff and routing model. Streamflow, surface water storage, and inundation are calculated at 1 km resolution.
- The SADC HYCOS FRM project produced a Regional Flood Atlas for Southern Africa, showing flood hazards and flood-prone areas in 14 major transboundary river basins in the SADC region, including the Cuvelai Basin (Atkins 2015). The atlas is intended to be used as a tool for high level planning.
- To develop the Flood Atlas, the Regional Maximum Flood (RMF) approach (Kovacs 1988) was first used to estimate the upper limit of flood peak flows for a given upstream watershed area (estimated by Kovacs to be a >200 year recurrence interval). The Kovacs method is based on an earlier approach developed by Francou and Rodier (Francou and Rodier 1967) who plotted global maximum flood peaks against corresponding upstream watershed areas to derive envelope curves for maximum flows, described by the equation:

$$Q = 10^6 \times \left(\frac{A}{10^8}\right)^{1-0.1k}$$

where Q is the maximum flow (m^3/s), A is the corresponding upstream watershed area (km^2), and k is a regional dimensionless factor which accounts for variations in rainfall, geology, topography, and vegetation. Kovacs refined the k -values for Southern Africa by back-calculating k -values for locations where flood peaks and upstream watershed areas were known, and then grouping regions of Southern Africa into RMF envelopes, or “zones”. Using the Kovacs approach, RMF can be calculated using the following equation:

$$Q = c \times A^x$$

where c and x are regional constants defined by (Kovacs 1988). The Flood Atlas uses approximate RMF return periods of >200 years and 50 years (using scaling factors), and incorporates a climate change allowance into both return period scenarios (Atkins 2015).

Floodplain delineations for the Flood Atlas were derived using HEC-RAS 1D hydraulic modelling. For most of the basins in the study area, the HEC-RAS models used 30 m resolution SRTM data for topographic inputs and streamflow data derived from the RMF approach. However, the 30 m resolution of the SRTM data is insufficient to define watercourses in the predominantly flat topography of the Cuvelai Basin. Therefore, flood outlines obtained from NASA Near Real Time Global Flood Mapping (“NASA NRT Global Flood Mapping,” 2015), the Dartmouth Flood Observatory (2017f), and UNITAR/UNOSAT (2017h) were used in conjunction with SRTM data to define the flood event outlines for the Cuvelai.

The Flood Atlas is a relatively new product, and it is unclear to what extent it is currently being implemented.

- Daily flood bulletins are posted on the Namibia Flood Dashboard and the NHS website, and are disseminated via email by request (Filali-Meknassi et al. 2014). The bulletins contain flood gauge data, rain gauge data, satellite maps of potential rainfall, and observations from flood zones.

The results of the flood forecasting system assessment are discussed below with respect to each of the evaluation criteria (Section 2.5.3.2).

1. Is the existing flood forecasting methodology appropriate for application in the Cuvelai Basin, given the basin's unique hydroclimate and topography?

The Namibian Flood Dashboard appears to be the primary resource for flood forecasting in the Cuvelai Basin. The TIGER-NET, HEC-RAS, and CREST models are currently in use by the NHS (Filali-Meknassi et al. 2014), but the *extent* of their use is unclear, as is the degree to which their results are integrated with the Namibian Flood Dashboard.

The use of remote sensing information to characterise flooding events is an extensively used approach, and can be particularly important in areas with limited data from sensors on the ground (e.g., Hossain et al. 2014; Awadallah and Tabet, 2015). Numerous sources of satellite data are available for the Cuvelai Basin area.

However, a key uncertainty in the application of satellite data-based models to the Cuvelai Basin is the topographic definition of the basin (Filali-Meknassi et al. 2014; Atkins 2015). The accuracy of the models is limited by the relatively coarse resolution of the available topographic data. This uncertainty has not been explicitly quantified across the basin, but it is noted by (Filali-Meknassi et al. 2014) that a vertical difference of less than half a meter may determine whether an area will be submerged in floodwaters or not.

Although the extent of its current use is unclear, the Flood Atlas is a promising approach for assessment of flood risk. It is however a static tool, intended to be used for planning rather than near-real-time forecasting. Its purpose is therefore different from that of the Flood Dashboard.

The Flood Atlas, like the Flood Dashboard, has uncertainty related to satellite data resolution. Its methodology was adjusted to account for the flat topography of the Cuvelai Basin, but (Atkins 2015) notes that this adjustment may result in lower confidence in the Flood Atlas for the basin.

The Kovacs regional method used by (Atkins 2015) for the Flood Atlas is supported by a detailed review (Pegram and Parak 2004) and a recent Namibia-specific study (Cloete et al. 2014). It has the advantage of providing a consistent and readily applied methodology across a broad geographical area, which makes well-suited for application in large-scale regional mapping. However, there are several limitations to the Kovacs approach with implications for interpretation and use of the Flood Atlas results.

The Kovacs approach assumes the same rainfall and catchment characteristics for large regions. This is a disadvantage of generalised equations. Although RMF results derived from Kovacs can provide useful coarse-scale estimates, the Flood Atlas should be used with the caveat that there may be substantial, unaccounted local variability. An additional limitation is that the Kovacs approach does not account for antecedent conditions, which are often an important influence on the runoff response to rain

events. Finally, while the basis of the Flood Atlas in the Kovacs approach makes it useful for long-term planning for high-magnitude, low-frequency flood events, it was not designed (and cannot be used) as a tool for predicting flood potential in response to a given precipitation event.

In summary, for both the Flood Dashboard and the Flood Atlas, the existing methodologies are generally suitable for the region; however, the quality and availability of data inputs may be a major limitation, as discussed below.

2. Are available data sufficient to support a robust flood forecasting system in the Cuvelai Basin using the current methodology (i.e., period of record, data quality, and spatial coverage)?

Lack of historical ground-based hydrological and meteorological data in the Cuvelai Basin is a major impediment to modelling and calibration (Filali-Meknassi et al. 2014). The Kovacs regional values for Namibia are tentative due to the relatively small database (Kovacs 1988). Quality of available current data is also a major limitation in near-real-time forecasting in the region (Atkins 2015).

The density and configuration of the monitoring network are additional obstacles for accurate flood forecasting for the Cuvelai Basin. Most rain falls in the Angolan (northern) portion of the basin, where there are no hydrological or meteorological stations (the hydro-meteorological monitoring network is sparse across Angola in general, as noted above). However, the flooding risk in Angola is relatively minor (Mendelsohn and Weber 2011), with little incentive or capacity to invest in a monitoring network or forecasting efforts. In Namibia the risk of flooding is greater, but hydro-climatic monitoring is limited or absent in the Angolan headwaters (Hossain et al. 2014).

Overall, limitations in the quantity and quality of available ground-based data (both historical and current) are a substantial source of uncertainty in Cuvelai Basin flood forecasts (Filali-Meknassi et al. 2014; Atkins 2015). However, satellite data (e.g., TRMM, GDACS) are readily available from numerous providers, often as free products, and are already frequently used by the NHS.

3. Are collaboration, data sharing, and communication systems sufficient to support the flood forecasting system in the Cuvelai Basin?

Data management and data sharing were noted by (Filali-Meknassi et al. 2014) as a key issue in flood forecasting in Namibia. The lack of a unified approach to data management among different agencies has generated problems in data use. Similar issues exist in Angola (GEF 2013), and cross-border data sharing presents additional difficulties. As noted above, as a “downstream” country Namibia often does not receive adequate notice of floodwaters originating in Angola (Hossain et al. 2014). The establishment of effective cross-border data sharing protocols would require substantial investment in terms of both time and cost (Filali-Meknassi et al. 2014).

Data dissemination to the public is limited. Although the Flood Dashboard provides a simple, easily accessible platform for data dissemination, the website does not appear to be regularly updated. At the time of this assessment (March 2017), the most recent daily bulletin on the dashboard was dated April 17, 2015, and the most recent daily flood report for Cuvelai was dated April 19, 2011, although a more recent flood bulletin was obtained by request via email.

Organisational capacity in both Namibia and Angola is another limitation. Multiple agencies have identified the need for proper training of staff in both field and data analysis/modelling techniques (Filali-Meknassi et al. 2014; Atkins 2015).

Collaboration, data sharing, and communication are lacking in the Cuvelai Basin region, which in turn creates an impediment to effective flood forecasting.

2.5.3.4 Recommendations

The following recommendations are proposed, based on the flood forecasting system assessment described above:

- Move towards a more unified, collaborative approach to flood forecasting by improving data management and data sharing. The Namibia Flood Dashboard is a useful tool that could be substantially expanded and/or linked to other data portals to include more information related to hydrology and flood forecasting. The use of OpenStreetMap could also be expanded to integrate more local knowledge into flood modelling efforts. Consideration should be given to improving management and dissemination of near-real-time data.
- Continue and expand the current emphasis on satellite-based information sources. There are substantial information gaps in measured data for the Cuvelai Basin, limiting the usefulness of ground-based data in model calibration. Focusing on satellite-based sources would be a relatively low-cost, efficient approach to improving the data used in flood forecasting. Higher resolution topographic data is needed for the Cuvelai Basin region. TIGER-NET has been identified as a promising current initiative (Filali-Meknassi et al. 2014).
- Increase human capacity through training programs and enhancement of partnerships between government agencies and academic institutions. These training programs should cover both field protocols and data analysis/modelling methods.

2.6 SOCIAL AND ECONOMIC PROFILE

Namibia and Angola share the Cuvelai Basin. Any attempt to sustainably manage a resource must acknowledge the system's interlinkages with the socio-political context and varied perceptions and processes.

The Cuvelai Basin is characterised by ephemeral rivers, high rates of evaporation, densely populated rural communities, a growing population, limited water resources and high demand for water. Subsistence livelihoods are prevalent, with heavy reliance on cattle, a limited number of crop species, and food gathering to some degree. There is a high level of reliance on groundwater aquifers for domestic water supply and for agriculture.

2.6.1 Population

Accurate population statistics that are basin-specific are difficult to obtain. Population statistics sourced from census bureaus from 2011 (Namibia) and from 2014 (Angola) indicate that there are between 1.35 million and 2.4 million people living in, and/or near to, the Cuvelai Basin. A population of 1.35 million assumes that the boundaries of the basin include the Namibian regions of Omusati, Oshana, Oshikoto, and Ohangwena as well as the Angolan province of Cunene. A population of 2.4 million assumes that the boundaries include portions of the Namibian regions of Kunene and Otjozondjupa, and the Angolan province of Cuando Cubango. High resolution satellite imagery was used to identify a total of 14,234 urban homes and 43,865 rural homes in the Basin (Calunga P, Haludilu T, Mendelsohn J, Soares N, and Weber B 2015).

Population densities in both countries are relatively high when compared with similar regions of southern Africa, and are rising. Density is concentrated in the centre of the basin and roughly correlates with higher soil fertility (RAISON 2013). Access to water is likely a key limiting factor to population growth. There are 45 towns and villages in the basin, 25 in Namibia and 20 in Angola (RAISON 2013). The population of urban areas in Northern Namibia (still within the Cuvelai Basin) increases by as much as 300% during public holidays (Zimmermann 2013) which has implications for water management. Ethnicity in the basin, at least historically, is almost entirely Owambo (RAISON 2013).

Namibia

Namibia ranks 125 on the Human Development Index (HDI) (United Nations Development Programme 2016). The country has an infant mortality rate of 32.8 per 1,000 births and a life expectancy of 65.1 years. Namibia receives a medium score on the inequality-adjusted HDI (based on life expectancy, education and income gaps) at 0.415. Finally, Namibia obtains medium score of 0.986 on the gender development index.

Table 10 Demographics of the Cuvelai regions in Namibia (Namibia Statistics Agency, 2011).

Region	Population			Density	Growth Rate	Age Distribution (%)				Rural
	Female	Male	Total	People per km ²	%	Under 5	5-14	15-59	60+	%
Omusati	133,621	109,545	243,166	9.1	0.6	14	26	49	11	94
Oshana	96,559	80,115	176,674	20.4	0.9	12	21	59	8	54
Oshikoto	94,907	87,066	181,973	4.7	1.2	14	26	52	9	87
Ohangwena	133,316	112,130	245,446	23.0	0.7	15	29	47	9	90
TOTAL	458,403	388,856	847,259							

Numbers presented as they appear in the Namibia 2011 Population and Housing Census. 2011. Retrieved from <http://cms.my.na/assets/documents/p19dmn58guram30ttun89rdp1.pdf> on February 24, 2017

Note that although a small portion of the Regions of Kunene and Otjozondjupa are inside the far south of the Cuvelai River basin, population statistics for the two Regions are excluded from the table above, as they would skew the overall population statistic for the Namibian portion of the basin

There is some indication that population estimates require updates. In official census statistics for 2011 for example, the city of Oshakati has a population of 35,600 but the mayor estimates it has grown to approximately 45,000 (Zimmermann 2013). There is a trend towards urbanisation reported by census data in all of Namibia's Cuvelai regions however over 77% of the population continue to live in rural areas. Of note, there are more than 65,000 fewer males than females in the Namibian portion of the basin. In some administrative regions, there are more women head-of-households than men, which can at least partially be attributed to migrant labour (Cecilski, Makhabane, Ndevashiya, & Hasheela 2001).

Table 11 Head of households by gender (Namibia Statistics Agency, 2011).

Region	Head of Household (%)	
	Female	Male
Omusati	55	45

Oshana	54	46
Oshikoto	49	51
Ohangwena	57	44

There are reported to be at least 127 health facilities in the Namibian portion of the basin, and 85% of the population have access to (or are within 10km of) one of these facilities (RAISON 2013).

Angola

Angola ranks 150 on the Human Development Index (HDI) (United Nations Development Programme 2016). The country has the highest infant mortality rate in the world (96 of every 1,000 births) and one of the world's shortest life expectancies (at 52.7 years). Angola scores low on the inequality-adjusted HDI, based on life expectancy, education and income gaps, at 0.336. Finally, no HDI data exists for the gender development index.

Table 12 Demographics of the Cuvelai regions in Angola (Instituto Nacional de Estatística, 2016).

Province	Municipalities	Population			Density	Rural
		Female	Male	Total	People per km ²	%
Cunene	All	514,474	450,814	965,288	12.5	79
Cuando Cubango	Cuchi	22,665	20,234	42,899	3.6	43
	Monongue	157,792	148,830	306,622	13.0	
	Cuangular	13,919	13,416	27,335	1.4	
TOTAL		708,850	633,294	1,342,144		

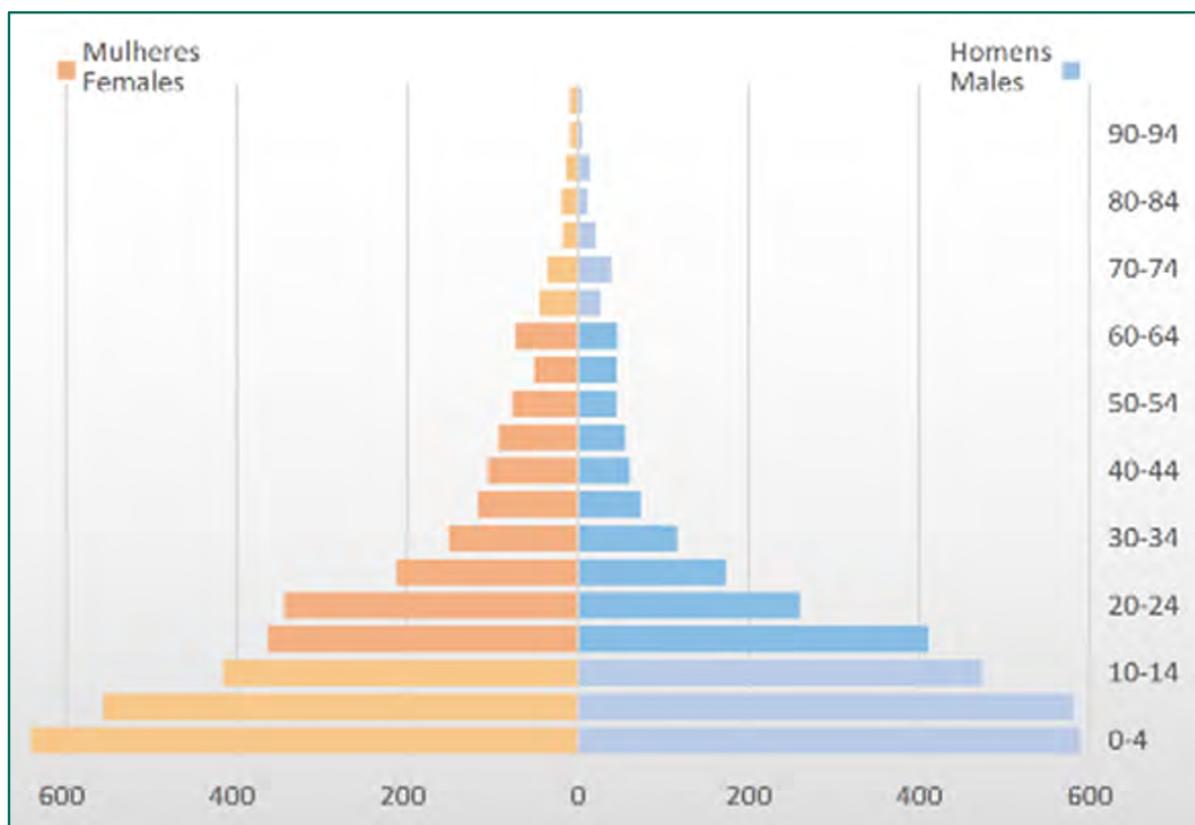
Numbers presented as they appear in Angola's 2014 Census.

Note that although a small portion of Huila Province is inside the far north of the Cuvelai River basin, population statistics for Huila Province are excluded from the table above, as they would skew the overall population statistic for the Angolan portion of the basin.

Most of the northern half of the basin is in Cunene Province, with a small area of the upper basin reaching into Cuando Cubango. and Huila Provinces.

Calunga P. et al. found that only 33% of people in interviewed households in rural areas were between the ages of 20 and 64 (2015). This leaves the population with a very high rate of dependency. They also found only 86 males to every 100 females in rural households and 92 males per 100 females in urban households. The care of dependents is therefore most often entrusted to working age women.

Figure 28 Age pyramid of rural homes in the Angolan portion of the Cuvelai Basin.



Source: (Calunga et al. 2015).

Population Data and Information Gaps

The Cuvelai Basin crosses administrative boundaries in both Angola and Namibia. Basin-specific and current population and demographic data is lacking from each country’s statistics. Statistics could also benefit from more refined delineation of age groups.

Information on population and density from different sources sometimes conflict. The methodologies for collecting population and demographics data may need to be standardised and quality assurance, or validation mechanisms reviewed. Additional information needed to better understand the social context of the Basin include: access to health care, distance from water sources and from sewage, level of education, and literacy. Gender disaggregated data is needed on all population indicators.

2.6.2 Economy

Angola

Angola has a gross national income of 6,211 per capita (2011 PPP\$). The percentage of Angola’s working aged population (15 years or older) that is employed is 68.4 (UNDP 2016). Data on the workforce in different sectors are unknown however; unemployment is reported at 7.6%. The country has a high reliance on oil followed by services. Agriculture, energy and public service sectors are experiencing growth (Fews.net 2012). The country plans to mitigate potential declines in oil with agriculture, investments in infrastructure, gradual reduction of imports, financial reform, skills development and improvement of business environment (Gallardo & Muzima 2016). Rural livelihoods rely heavily on agriculture, including livestock, and on fishing and hunting. Nomadic pastoralism is

prevalent (Few.net 2012). Results of a household survey indicated income earners in urban areas had jobs in public service, in informal businesses and as labourers in urban households; and in rural areas, very little to no income is generated aside from selling homemade liquor (Calunga et al. 2015).

Namibia

Namibia is classified as an upper middle income country; however, it is also one of the world's most unequal in income distribution. Namibia has a gross national income of 9,770 per capita (2011 purchasing power parity [PPP]). The percentage of Namibia's working age population (15 years or older) that is employed is 59.4 (UNDP 2016). The percentage of the workforce working in agriculture is 31.4% and in services is 54.2%. Unemployment rates in the Namibian portion of the basin are reported to range between 13 and 20% (Namibia Statistics Agency 2011) and 25.5% by the United Nations Development Programme (UNDP) HDI data (2016).

In rural areas subsistence economy is prevalent (Zimmermann 2013). Other economic activities include agriculture and mining (diamonds, uranium, zinc and other minerals) (CIA 2017). Tourism is increasing, particularly in the Etosha National Park, but also to the south and east of the park (RAISON 2013). Locally sourced products are traded and sold in Namibian shops and in some cases exported. Marula fruits for example are used in skin and haircare products (RAISON 2013).

Table 13 Income sources in Namibia (Namibia Statistics Agency 2011).

	Population	Farming	Wages	Remittance	Business	Pension
Omusati	228,842	46	16	6	8	22
Oshana	161,916	36	32	5	13	12
Oshikoto	161,007	56	20	3	6	11
Ohangwena	228,384	52	13	5	8	20

Numbers presented as they appear in the Namibia 2001 Population and Housing Census. 2001. Retrieved from <https://web.archive.org/web/20120111224420/http://www.npc.gov.na/census/index.htm> on February 24, 2017

Economy Data and Information Gaps

It is unknown the extent of private sector's interest or investment into socially responsible water management in either Angola or Namibia. Information like this can help to inform the planning and implementation of effective awareness raising campaigns for corporate water extractors.

Data collected on many economic indicators are required. Examples can be found on the World Bank website (The World Bank 2016). Data on the economic activities that require water withdrawal is largely unknown. This type of information might include crop zones, livestock density, mine locations, etc.

2.6.3 Water Vulnerabilities

Vulnerability can be understood by understanding the likelihood of exposure to a potentially harmful change, the severity of potential harm, and the capacity to respond to changes. Potentially harmful changes can include flood, drought, crop failures and crop disease, pollution, disease, decreased access to safe water, decreased access to health care, to economic participation, among others. The ability to respond to changes is influenced by factors that include socio-economic position, education, assets, capacities for alternative livelihoods, governance capacities and disaster risk reduction systems. Vulnerabilities can be exacerbated for certain groups (e.g., women, elderly, youth, disabled) over others

due to social, economic, institutional or regulatory limitations (e.g., laws that restrict women from owning property), that limit their ability to cope with change.

Using downscaled regional climate models, the Desert Research Foundation of Namibia (DRFN) projects an increase in precipitation due to climate change, a later start to the rainy season and an earlier cessation of the rainy season (Dirkx, Hager, Tadross, Bethune, & Curtis 2008). More intense rain events may therefore be expected. The shallow topography of the basin, combined with concentrated periods of precipitation (up to 96% of rainfall occurs between October and April) can mean severe floods (Zimmermann 2013), particularly in the central drainage zone (RAISON 2013). The road network connects communities, facilitates market participation and social interaction, allows for access to health care and is essential to disaster risk reduction efforts. It is largely unusable during flood situations.

Poorer households are often situated in areas more susceptible to flooding and constructed from materials less resistant to flooding (RAISON 2013), which can contribute to a higher likelihood for loss of assets. In March 2017, potentially record breaking floods occurred, triggering disaster relief mechanisms, In Namibia 1,092 people were moved to relocation camps (International Federation of Red Cross and Red Crescent Societies 2017) and 255 families in Cunene Province, Angola were displaced (DW 2017). Several sections of roads were washed away, impacting access to basic services and interconnectivity between communities (NewEra 2017).

Post-disaster assessment of damage and losses due to the 2009 floods, in six of Namibia's regions (including the four Regions in the Cuvelai Basin) are summarised in Table 14.

Table 14 Summary of damage and losses from 2009 floods in northern Namibia (Government of the Republic of Namibia 2009)

Sector	Damage (US\$ million)	Losses (US\$ million)
Infrastructure	34.3	4.9
Water Supply Sanitation	5.9	3.4
Transport	27.4	0.4
Energy	1.1	0.2
Production	49.7	71.7
Agriculture	4.7	14.8
Industry	17.6	19.9
Commerce	25.7	35.5
Tourism	1.6	1.4
Social	51.1	2.4
Housing	47.3	1.7
Health	0.1	0.7
Education	3.7	0.0
Cross-sectoral	1.2	0.1
Environment	1.2	0.1
TOTAL	136.4	78.2

Groundwater quality is influenced by chloride, sodium, fluoride and sulphate (Bittner Water Consult 2006). Salinity, fluoride and sulphate concentration increases towards the basin centre and elevated levels of nitrates are found in the southeast portion of the basin (RAISON 2013). Salinity of groundwater

has been measured above 5,000 milligrams per litre, leading to deeper drilling to reach cleaner water (Mendelsohn, El Obeid, & Roberts 2000). Groundwater is discussed in more detail in Section 2.2.3. Research at four boreholes indicate that groundwater use between 1990 and 2010 exceeded replenishment (RAISON 2013). Demand can be expected to increase with an increasing population.

Other water related issues can include increases in vector-borne and water-borne diseases and an increase of crop infestations and disease during or after flooding. Calunga et al. for example, found that over 72% of households in the Angolan portion of the Basin reported a loss of livestock due to drought within the previous two years (2015). The same survey showed that the impacts of drought were reported to be less severe (e.g., fewer deaths of people and livestock and fewer people moving away) in the northern region of the Basin.

Resource conflicts over water in the basin include: South Africa troops occupying the Ruacana hydropower complex in 1975; and Angolans attacking the Calueque Dam in 1988 (Pacific Institute 2016). Namibia and Angola have experienced six other water-related conflicts (in other basins) between 1904 and 2000. Protests unrelated to water in late 2015 resulted in the destruction of water meters in Oshakati (Armed Conflict Location & Event Data Project 2016). Household surveys, conducted in the Angolan portion of the Cuvelai Basin assessed the vulnerabilities of livelihoods (Calunga P et al. 2015).

SADC reports that 40% of the Namibian population in the Cuvelai Basin are food insecure (SADC 2016). The locations of fish refugia (where small populations of fish survive through dry periods) are unknown, making conservation of these areas difficult. During wet years, fish are an important source of food, and in some cases fisheries support local economic activities (Mendelsohn J. 2015d). Marula (*Sclerocarya birrea*), bird plum (*Berchemia discolor*) and jackal berry (*Diospyros mespiliformis*) are culturally important food-source trees (Mendelsohn J. 2015c). Although not a proven linkage, increasing mortality in recent years of these trees may be an indicator of increasing water vulnerability that would be of interest to water managers. Vast areas that were traditionally used for cattle grazing are increasingly fenced in for farming, and cattle excluded (Mendelsohn J. 2015e). Lands rights are customary at best for most of the rural population in the Namibian portion of the basin (RAISON 2013). Soil fertility is in decline due to population pressure, land management practices, deforestation and unsustainable land use by individuals who lack land rights (Dahlberg & Wingqvist 2008). In Angola, remnant land mines may still be of concern in agricultural areas (República de Angola 2009). Access to safe drinking water continues to be widely accepted as a critical issue. Only 25% of households in Cunene Province, Angola, have access to potable water (Fews.net 2012). Solar powered desalination is practiced in at least two locations (RAISON 2013).

In Angola, the population living below the poverty line, defined as \$1.90 per day (PPP) is 30.1% and in Namibia, it is 22.6% (United Nations Development Programme 2016). Poverty is associated with inadequate access to: transportation, communication, health services, education, food and clean water – all of which contribute to a lowered capacity for managing risks associated with water supply or water-related disasters. Informal settlements, for example, required evacuation during flooding in 2008, 2009 and 2011 (RAISON 2013), and other communities evacuated in 2017 (Al Jazeera 2017).

The level of education completed by adults in the Angolan portion of the Basin is low. Nearly half (49%) of the rural population aged 20 or more have never attended school (Calunga 2015). In the Namibian portion of the Basin, between 8 and 23% of the population over the age of 15 have never attended school (National Planning Commission 2011). A low level of education is a limiting factor for participating in economic activities and for alternative livelihoods in times of scarcity.

Another potential issue impacting the ability to respond to climate shocks may include crop disease. In March 2017 for example, African army-worm was reported to have been impacting maize crops in Omusati for months. The worm thrives in humid weather. Maize is often milled into flour, sold to the Office of the Prime Minister and distributed as drought relief (The Namibian 2017).

Community level participation in water governance in Namibia, despite decentralisation having been mandated, remains minimal. Dragnich et al. found that perceptions at the community level are a factor in slow uptake of participatory processes, indicating a need for improved awareness and capacity (2007).

Other factors contributing to capacity gaps include limited access to health care (particularly for populations experiencing high rates of disease such as malaria or HIV/AIDS), few options for income/livelihood diversification, limited access to schooling in some rural areas, low household income, limited access to adaptable agricultural technologies and practices, among others. Calunga et al. found that only 16% of survey respondents had at least some secondary school education and attribute this to factors such as a lack of schools and teachers and a reluctance to send children to school (2015). They also mapped the locations of health care facilities and found that over 47% of residents in the Angolan portion of the basin are further than 5km from one of these facilities.

Vulnerability Data and Information Gaps

Basin-specific data on the following is required:

- It is widely suggested that increasing siltation due to agriculture (ploughing, over grazing and land clearing for crops) in the already shallow topography may be contributing to more extensive and longer lasting floods (Mendelsohn J. 2015f). However, data is required to prove this and to support management.
- Detailed information about the transportation network (roads, railways, etc.).
- Location and capacity of desalinisation efforts.
- Impacts of industry on water quality (e.g., copper smelter in Tsumeb).
- Information of the impacts from previous climate extremes (floods and drought) on loss of livelihoods, loss of life, loss of assets, etc.
- A household survey conducted in the Angolan Basin collected data on household assets (Calunga 2015). Generally, though, food insecurity and climate change vulnerability data is needed for the entire basin (e.g., assets, livelihood alternatives, etc.).
- Traditional knowledge of ecological systems can help to improve adaptive capacity (e.g., Niipele et al. 2015). The extent of involving or understanding of traditional knowledge is incorporated into decision-making processes.
- Distance at which water is available for households.
- Cost of water to households.
- Distance between sanitation and users' houses.

- Numbers of people trained in the development and maintenance of water supply systems and sanitation systems. Information is also needed about the number of people in governance structures with training and responsibility for investigating sources of vulnerability.
- Wherever possible, all data requires gender disaggregation.
- Location of fish refugia (and other resources important for subsistence).
- Land ownership vs. informal settlements.
- Budget allocations to water sectors and to addressing climate change.
- High resolution remote sensing data can be used to identify locations (homes, communities, roads, sewage, and other infrastructure) at risk of flooding during efundjas.
- With the ever-present potential for transboundary water conflicts, it is important to understand the systems in place for negotiations, for managing conflict, the utilisation of those systems and effectiveness/amount of training provided to those who would be required to administer such systems.

2.6.4 Land Use

Subsistence economy is prevalent in the region. Most of the region is rural and is used for subsistence agriculture (livestock and some crops). There is an increasing trend towards private land ownership, which excludes the use of the land for traditional subsistence purposes (Mendelsohn J. 2015e). There are two parks in the Basin: Mupa in Angola and Etosha in Namibia. Over time, a decrease in woodland extent is observed, followed by an expansion of arable land, driven by subsistence agriculture and urban infrastructure expansion (Wingate VR, Phinn R., Kuhn N, Bloemertz L, and Dhanjal-Adams KL 2016). Changes in land use were noted to be most prominent nearer to towns, villages, rivers and roads.

2.7 GOVERNANCE AND INSTITUTIONAL PROFILE

This section of the basin profile includes the following aspects:

- Southern African Development Community (SADC);
- SADC guidance on gender mainstreaming;
- The regulatory framework in both countries;
- Institutional framework; and
- Civil society.

2.7.1 Southern African Development Community (SADC)

SADC was established as the Southern African Development Coordinating Conference (SADCC) in 1980 and became SADC in 1992. The 15 member countries include Namibia and Angola. The institutional framework is determined by Article 9.

Figure 29 Summary of SADC governance units and functions.

Summit of Heads of State or Government	Policy-Making institution of SADC
Summit Troika of the Organ	Promotes peace and security in the SADC region
SADC Tribunal	Ensures proper interpretation and adherence
SADC Council of Ministers	Oversees functioning, development and proper implementation
Sectoral and Cluster Ministerial Committees	Advises, oversees activities, monitoring of the core areas of integration
Standing Committee of Senior Officials	Technical advisory committee to the Council of Ministers
SADC Secretariat	Principal executive institution
SADC National Committees	Policy and strategy at national level and oversee national implementation
SADC Committee of Ambassadors and High Commissioners	Advise National Committees and facilitate linkages throughout SADC
SADC Parliamentary Forum	Improve regional integration (incl. best practices) through parliamentary processes

Source: (SADC, 2017)

SADC's objectives include development, peace and security, economic growth, alleviation of poverty, enhanced standards and quality of life, support for the socially disadvantaged through regional integration, to build on democratic principles and equality, and sustainable development.

2.7.1.1 SADC Protocol on Shared Watercourses

The SADC Protocol on Shared Watercourses states the following objects for RBOs:

- To develop a **monitoring policy** for shared watercourse systems;
- To **promote the equitable utilisation** of shared watercourse systems;
- To formulate **strategies for the development** of shared water course systems; and

- To **monitor the execution** of integrated water resource development plans in shared watercourse systems.

The Protocol states that the purpose and function of RBOs shall be as follows:

- *With regard to National Water Resources Policies and Legislation:*
 - *Harmonisation of national water resources policies and legislation; and*
 - *Monitoring compliance with water resource legislation and, where necessary, recommending amendments thereto and the introduction of new legislation.*
- *With regard to Research, Information and Data Handling:*
 - *Collecting, analysing, storing, retrieving, disseminating, exchanging and utilising data relevant to the integrated development of the resources within shared watercourse systems and assisting member States in the collection and analysis of data in their respective States;*
 - *Reviewing the provisions of National Development Plans relating to the water course systems;*
 - *Designing and conducting studies, research and surveys relating to the environmentally sound development and management plans for shared watercourse systems;*
 - *Stimulating public awareness and participation in the sound management and development of the environment including human resources development; and*
 - *Promoting in accordance with the national development plans of the Basin States, the formulation of integrated master plans for shared watercourse systems.*
- *With regard to Water Control and Utilisation in shared watercourse systems:*
 - *Recommending regulation of the flow and drainage;*
 - *Promoting measures aimed at flood and drought mitigation;*
 - *Recommending and promoting measures to control desertification, soil Erosion and sedimentation;*
 - *Monitoring the utilisation of water for agriculture, domestic, industrial and navigational purposes;*
 - *Monitoring the establishment of hydro-electric power installations;*
 - *Monitoring the generation of hydro-electric power; and*
 - *With regard to Environmental Protection.*
- *Promoting measures for the protection of the environment and the prevention of all forms of environmental degradation arising from the utilisation of the resources of the shared watercourse systems:*

- *Assisting in the establishment of a list of substances whose introduction into the waters of a shared watercourse system is to be banned or controlled;*
- *Promoting environmental impact assessments of development projects within the shared water-course systems; and*
- *Monitoring the effects on the environment and on water quality arising from navigational activities.*
- *With regard to Hydro-meteorological Monitoring Programme:*
 - *Promoting a hydro-meteorological monitoring programme in consultation with other SADC sectors.*

Essentially, the SADC Protocol on Shared Water Courses guides Member States to equitably share transboundary water resources through the application of IWRM principles, supported by the establishment of RBOs and sharing of information.

2.7.1.2 SADC Regional Water Policy

The Southern African Development Community (SADC) Regional Strategic Action Plan (RSAP) is a framework to support sustainable water resource development and management. The fourth iteration of the plan (2016-2020) seeks to address various issues that include; human rights to water; water quality; research for development; gender mainstreaming and youth engagement; UN Groundwater Articles; climate change; and indigenous knowledge and citizen science (Global Water Partnership 2013).

2.7.1.3 Implementation of the SADC Regional Water Policy

In 2015, the Global Water Partnership (GWP) assessed SADC member countries on their progress towards implementing the SADC Regional Water Policy (RWP). The RWP for the SADC region is aimed at providing a framework for sustainable, integrated and coordinated development, utilisation, protection and control of national and transboundary water resources.

Following is a summary of the GWP assessment for both Angola and Namibia.

Angola

The Water Sector Development Strategy in Angola provides the main legislative framework for integrating the RWP. Numerous instruments are in place and facilitate the implementation of the Regional Water Policy. Challenges that remain include: updating baseline data on water resources; improving inter-sectoral cooperation and coordination; an infrastructure maintenance backlog; updating and implementing up to date legislation and regulations; and financial constraints.

Key water-related issues in Angola include the following:

- Climate change;
- Water scarcity;
- Desertification;
- Deforestation of tropical rain forest;

- Soil erosion; and
- Pollution.

Improved capacity is required in the areas of: data collection infrastructure; sanitation infrastructure; Integrated Water Resources Management; implementation of policies and regulations; cross-sectoral harmonisation; and climate adaptation and mitigation, disaster risk reduction and gender mainstreaming.

Namibia

In Namibia, the Water Resources Management Act, the National Water Policy and the Water Supply and Sanitation Policy provide the main legislative framework for integrating the GWP. The Department of Water Affairs and Forestry within the Ministry of Agriculture, Water and Forestry is responsible for all water and sanitation management. The Environmental Management Act requires Environmental Impact Assessments for projects which may have a significant effect on the environment or the use of natural resources. The legislative and institutional framework for Strategic Environmental Assessment (SEA) is currently under review.

Key water-related issues in Namibia include the following:

- Water scarcity and erratic precipitation patterns;
- Insufficient sanitation;
- A dedicated water law is yet to be finalised; and
- Insufficient implementation of policy and plans.

Improved capacity in the areas of policy analysis, planning and management, pollution control, sanitation and related element and basin management committees is required.

2.7.2 SADC Guidance on Gender Mainstreaming

The SADC Declaration on Gender and Development (1997) reaffirms SADC's commitment to eliminating gender discrimination and mainstreaming gender issues. Guidance on gender mainstreaming in the SADC water sector (SADC n.d) recognise the different roles men and women play in water utilisation and water management. It also recognises that men and women are impacted differently when changes occur to social, environment, political, cultural and water availability contexts. Participatory processes are recognised as a way to strengthen sustainable water management efforts. To support the State-level efforts for mainstreaming gender in the water sector, SADC has identified four strategic interventions:

- **Supporting the creation of an enabling regulatory environment:** States are advised to improve political will and reflect gender mainstreaming in appropriate legal, institutional and administrative frameworks and budgets (all that account for continental, international, SADC, and country-specific regulations and policy);
- **Capacity building and awareness raising:** States and organisations are advised to improve awareness and commitment of staff to remove gender inequality (including vertical and horizontal learning exchanges, providing a foundational knowledge with respect to gender

concepts and definitions, benefits of gender mainstreaming, tools/systems for gender mainstreaming, etc.);

- **Providing conducive institutional arrangements:** States are advised to improve systems that guide, plan, monitor and evaluate gender mainstreaming (including disaggregated data collection and analysis, gender responsive budgeting, dedicated staff, and systems for transparency); and
- **Gender sensitive management instruments for all stages of the policy cycle:** States are advised to improve the implementation of gender policy.

The entire project cycle (from problem formulation to project implementation and monitoring to project closure evaluations) is to utilise gender mainstreaming tools.

The SADC **Protocol on Gender Development** guides the operations of the Gender Unit and has the following priorities:

- Policy Development and Harmonisation;
- Gender Mainstreaming;
- Institutional Strengthening and Capacity Building;
- Women's Empowerment Programmes;
- Communication, Information Sharing and Networking; and
- Research, Monitoring and Evaluation.

2.7.3 Regulatory Framework

2.7.3.1 International Conventions

The following international conventions contain provisions directly or indirectly relevant to sustainable water management in the Cuvelai Basin (this list is not exhaustive):

- **Convention on Biological Diversity (CBD) 1992,** Contains provisions for the biodiversity associated with inland waters. Both Angola and Namibia are signatory to the CBD.
- **Economic Community of Central African States (ECCAS):** Angola became a signatory to this economic community in 1999. The Protocol on Cooperation in Natural resources between member states of the ECCAS requires that participating countries harmonise natural resource policies and activities, the sharing of research results, and development of joint capacity development programs. Angola is a member of this economic community.
- **Convention on the Conservation of Migratory Species of Wild Animals (CMS):** Angola is party to this convention.
- **Dar-es-Salaam Declaration on Agriculture and Food Security in the SADC Region (2004):** Member states are expected to allocate substantial portions of their agricultural budgets to water management. The declaration contains provisions for trans-basin water transfers and sustainable use of living aquatic resources/ecosystems. Private sector investment is expected

to play a big part in transboundary water resource development and management policies and programs. Angola and Namibia are both member states.

- **Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia (Raptors MOU):** This MOU falls under the CMS and is legally non-binding. Angola is a signatory and Namibia contains species relevant to the MOU.
- **United Nations Convention against Corruption (UNCAC):** This convention requires parties to implement anti-corruption measures focussing on: prevention, law enforcement, international cooperation, asset recover and technical assistance and information exchange. Both Angola and Namibia are signatories to this convention.
- **The Cotonou Agreement (2000):** The agreement is essentially a way to prioritise good governance strategies. It provides for state autonomy in social and economic development, participatory governance (e.g., civil society, local governments, private sector), political dialogue and mutual obligations, and considering country-specific and regional contexts (e.g., least developed countries or vulnerable regions). Both Angola and Namibia have signed the agreement.
- **United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa (UNCCD) (1994):** The convention aims to combat desertification and combat the effects of drought. Both Angola and Namibia are signatories.
- **International Renewable Energy Agency (IRENA) (2009):** The organisation seeks to improve member country regulatory processes and capacities for renewable energies. Both Angola and Namibia are member countries.
- **The Convention on the Elimination of all Forms of Discrimination against Women (CEDAW) (1979):** CEDAW requires participating nations to work towards non-discrimination and women's rights to equal political, economic and social participation.
- **The Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa (Maputo Protocol) (2005):** Signatories of this protocol ensure the rights of women, including the right to participate in political and decision-making processes, the right to sustainable development, and the right to a healthy and sustainable environment, among others. Both Angola and Namibia are party to the charter.
- **The Convention on the Law of Non-Navigational Uses of International Watercourses:** The convention governs the shared use of waterways that cross international boundaries. This convention requires each riparian state to ensure, in an ongoing manner, that its use is equitable and reasonable visà-vis other riparian states. What is equitable and reasonable in any given case may be determined only by considering all relevant factors and circumstances—both natural (e.g., climate, hydrography) and human-related (e.g., social and economic needs of the riparian states, effects of uses in one state on co-riparians, existing and potential uses). States are to take “all appropriate measures” to prevent causing “significant harm” to co-riparian states and “consult” with the other international watercourse states and provide prior, “timely notification” about any new use or change in an existing use of an international watercourse

that could have significant adverse effects on co-riparian states, along with relevant technical information. The convention entered into force in 2014.

- **The Ramsar Convention:** The Etosha Pan, Lake Oponono and Cuvelai drainage in Namibia constitutes a Ramsar wetland (wetland of international importance).
- **World Meteorological Organisation (WMO):** The WMO is an intergovernmental organisation. Angola's implementing institution is the Instituto Nacional de Hidrometeorología e Geofísica. Namibia's implementing institution is the Namibia Meteorological Service in the Ministry of Works and Transport.

In addition to the above, the international community contains many examples of best practices that can help guide effective water resources management, including:

- IFC Performance Standards;
- Millennium Development Goals; and
- The Climate Investment Fund's Phase 2 Gender Action Plan (pillar three focuses on green growth and sustainable livelihood, including water and food security).

Many international agreements contain wording on involvement of women in the management of water and other resources. These include, but are not limited to:

- Dublin Principles (1992);
- Agenda 21 (1992);
- World Water Forums;
- Bonn Conferences on Fresh Water (2001);
- Pan-African Implementation and Partnership Conference on Water (2003);
- African Union Gender Policy (2009);
- AMCOW Policy and Strategy for Mainstreaming Gender in the Water Sector in Africa (2011);
- African Charter on Human and People's Rights of Women in Africa (2011);
- African Water Vision 2025; and
- Rio+20.

2.7.3.2 Laws

The following provides a summary of water governance laws relevant to the Cuvelai River Basin. The summaries are not extensive legal reviews.

Angola

The Constitution of the Republic of Angola (2010) establishes public ownership of inland waters, lakes, lagoons and watercourses (including their beds). Responsibilities for managing water are applied to local authorities.

The National Water Law (2002) forms the core of the legal framework for the water sector. It establishes the water basin as the basic unit for water resources management, recognises water as a social and economic good, and decentralises water management to the Provinces.

The National Environment Law (1998) requires Environmental Impact Assessments (EIAs) and Social Impact Assessments (SIAs) be conducted for all activities that have potential impact to communities or to natural resources. The law also requires public consultation for EIAs and SIAs.

The Law of Local State Administrative Units (2007) and the Decentralisation Law (1999) extend responsibilities for executing sector plans and policies to provincial and municipal governments.

Namibia

In Namibia, water resources are 'owned' by the state (as per the Water Resources Management Act). Namibia has legislated participatory and decentralised resource management both in general terms (Namibian Decentralisation Policy 1998) and more specifically with respect to water resources (Water Resources Management Act No. 24 of 2004). This makes participatory decision-making at a local level a priority in water resource management. It also means that the capacity of regional councils and local authorities to facilitate and participate in decision making relevant to effective management.

The Local Authorities Act (1992) outlines the development and authorities of local government. Parts VI and VII of the Act outlines the authorities of local government to construct water works, supply water to persons other than residents, limit supply of water or use of water during drought or other emergencies, and issue penalties associated with offences. Part VII outlines the authorities of local government to construct, maintain and operate sewage and draining systems. It also describes the duties associated with stoppages or defects of sewage systems, and the issuance of penalties associated with offences.

The Namibia Water Corporation Act of 1997 establishes NamWater as a public company with the State as sole shareholder. The act outlines the objectives and activities of the Corporation and includes a duty to supply water, to conserve and protect water resources and the environment, to maintain records, to maintain and publish service standards and the provision of subsidies. Section 6(c) of the act establishes the legal basis for sharing water across international boundaries subject to Section 7 which prevents the supply of water to customers outside of Namibia without ministerial approval. Notably, Section 6(g) also requires the Corporation to develop and deliver training – an important point for when RBOs are planning capacity development. Cost recovery tariffs, borrowing, selling and renting of assets is provided for in Section 7 of the Act.

The Water Resources Management Act of 2013 incorporates the 2004 version of the Act, which replaced the Water Act of 1956. The objectives of the Act are to “to ensure that the water resources of Namibia are managed, developed, used, conserved and protected in a manner consistent with” fundamental principles which are in line with Integrated Resources Management principles. The Act establishes governing bodies (including responsibilities and authorities) such as water advisor council and Basin Management Committees. It contains the legal framework for: internal watercourses; management of rural water supply; an integrated water resources management plan; water supply, abstraction and use; water service suppliers and licensing; groundwater access and protection; pollution control; water protection areas; water related emergency or pollution threats; management of dams; management of wetlands and water quality; fees for service; land occupancy; and tribunals and appeals.

Rights to gender equality are established by the **Constitution**. The Communal Land reform Bill treats men and women equally in terms of rights to customary land and the treatment of widows/widowers. It is unknown how extensively customary practice (which favors male land ownership) overrides law.

2.7.3.3 Regulations and Plans

Angola

The Strategy for Water Sector Development (2003) and The Water Sector Development Program (2004) allowed for sanitation master planning and assessments of rural water and sanitation sectors. Principles that guide implementation include users and polluters pay, collected wastewater should be treated, and management occurs at the smallest possible scales.

The National Development Plan (2013-2017) recognises gender inequity as an issue for rural development and promotes gender equality (República de Angola, 2012). The ultimate goal of the **Strategic National Programme for Water (2013-2017)** is to guide multi-sectoral water management investments.

The Water for all Program (2007) aimed to install or upgrade 7,000 wells and boreholes with hand pumps, install or rehabilitate 265 piped systems and benefit more than 5 million people in rural areas by 2012. Activities mandated by the program included development of operation and maintenance systems and training for public and private sector professionals and entrepreneurs.

A National Policy on Environmental Sanitation was drafted in 2011 with the help of international donors.

Namibia

The **National Water Policy White Paper (2000)** and the **Water Supply and Sanitation Policy (2008)** establish legislative provisions for implementing agencies.

The Basin Management Approach (BMA) guides implementation of water management and contains provisions to enhance stakeholders' capacity to participate in water management. It also promotes inter-sectoral collaboration on all natural resource management (Dragnich, Dungca, Pendleton, & Tracy 2007). The BMA provides an entry point for establishing an international basin organisation in Namibia.

Namibia's Vision 2030 focuses the country's development policy around five major themes which include sustainable agriculture and gender equality. Poverty reduction activities are also prevalent.

The National Gender Policy (2010-2020) was drafted by the Ministry of Gender Equality and Child Welfare. The Policy provides guidance and mechanisms for the planning, implementation of and monitoring of gender equality strategies

2.7.3.4 Monitoring and Enforcement

National parks within the basin include the Etosha National Park in Namibia and Mupa National Park in Angola. The parks would have some responsibility for enforcement within the boundaries of the parks.

2.7.4 Institutional Framework

The institutional frameworks of Angola and Namibia, with respect to water management, are discussed below; however, a critical aspect of water resources management at a local scale in Angola is the responsibility of provincial governments and Municipios, with input from GABHIC, whereas in Namibia

management of water has been devolved to Sub-basin or catchment level, guided by the Ministry of Agriculture, Water and Forestry and the Department of Water Affairs.

Angola

The Ministry of Energy and Water and the Ministry of Finance are responsible for managing water resources, including setting tariffs. The National Water Directorate is responsible for sector planning. Additional agencies have been created recently that are likely to have relevance to water management. These include: the Ministry of Environment (MINAMB), created in 2008; the position of Secretary of State for Water Affairs, created in 2007; and the National Institute for Water Resources (INRH), established in 2012.

The Office for the Management of the Cunene River Basin (Gabinete para a Administracao da Bacia Hidrografica do Rio Cunene [GABHIC]) is part of the Permanent Commission of the Cunene River Basin (Comissao Permanente da Bacia do Rio Cunene [CPTC]). Initially established specifically to address the management of the Cunene River, the remit of GABHIC was recently expanded to also include the Cubango and Cuvelai rivers.

The World Bank (WB) is working with the Government of Angola (Water Sector Institutional Development Project) to develop new administrative units, including; autonomous provincial water and sanitation utilities, a regulatory agency for urban water supply and sanitation, and a national institute for Water Resources (Water and Sanitation Program - Africa 2011).

The National Gender Commission is mandated to monitor implementation of national gender policy and CEDAW.

The Instituto Nacional de Hidrometeorologia e Geofisica is the implementing agency for WMO.

Namibia

MAWF oversees water management at the national level and is responsible for water-related infrastructure, organises water-related data collection and management. MAWF and the Department of Water Affairs implement water resource management through the BMA - see Section 2.7.3.3 – devolving management of water resources within catchments to Basin Management Committees (BMCs) with direct input from a range of stakeholder groups, as listed in Table 15. NamWater is the corporation responsible for water supply. A Governor is elected to each of the four Regions in the Basin, which are sub-divided into constituencies represented by elected councillors (Bittner Water Consult 2006). Traditional authorities (headmen, kings or queens) govern roughly 8 tribes and the main language is Oshiwambo, with other languages spoken by minority groups (Mendelsohn, El Obeid, & Roberts 2000). Water supply and sanitation are the responsibilities of the Namibian Water Corporation (NamWater), as legislated in the Namibia Water Corporation Act of 1997.

Practically, there are indications that the implementation of decentralised decision making has been challenged, mainly due to a lack of resources and possibly also to resistance to participation. Dragnich et.al (2007) researched perceptions regarding water management held by key stakeholders. The research was interested in the implementation of community participation in decision making processes. They found that due to limited funds, the large distances separating communities and a lack of time available to officers, the structure of water governance in the Namibian portion of the basin varied from the planned structure laid out by the BMA. Water management information was disseminated by DRWS Extension Officers and Chief Extension Officers to local water user committees, but not to the

communities. The Basin Management Committee is meant to promote community participation and monitor sustainable management of water resources. Local Water Associations and Water Point Associations coordinate water supply management at a local level.

Table 15 Community involvement management of water in Namibia.

Institution	Representing	Roles	Reporting to	Supported by
Water Point Users Association (WPA)	Comprised of all households using a water point	Use water efficiently for domestic and livestock needs	Themselves	Rural Water Supply Extension Officers (RWS-EO) & WPC
Water Point Committee (WPC)	Water Point Users Association	Take care of water point, collect fees & pay to LWC	WPA	WPA & RWS-EO
Local Water Committee (LWC)	Water Point Committees on branch line or groundwater area	Manage branchline, ensure payment to bulk water supplier	WPCs	RWS-EO & WPCs
Regional Water Committee (RWC)	Local Water Committees	Contribute to planning of water supply	LWCs and Rural Water Supply	RWS-EO & LWC & RWS- Regional Office
Basin Management Committee	Line ministries, NGOs, regional institutions; all stakeholders	Contribute to management & planning of water supply	All stakeholders	Department of Water Affairs, Division of Hydrology

Source: Zijlma, 2004; Amakali and Shixwameni, 2003; in Seely, Peet and Manning.

Directorate of Disaster Risk Management coordinates disaster response alongside Regional Councils through Regional Emergency Management Units. The National Planning Commission helps to coordinate disaster response with the international community.

The Namibia Meteorological Service in the Ministry of Works and Transport is the implementing agency for WMO. The organisation reports an annual budget of 42 Million N\$ and, out of 52 staff, 14 are women (WMO 2017).

2.7.5 Civil Society

Civil Society Data and Information Needs

Awareness levels among civil society with respect to water management roles, responsibilities, participatory processes, etc. are unknown.

Most Angola's portion of the basin falls within Cunene province, with only a very small portion of the basin reaching into Cuando Cubango and Huila provinces. The southern, Namibian, portion of the basin spreads across four administrative regions of Oshikoto, Omusati, Ohangwena and Oshana, with a small area of the lower basin reaching into Kunene and Otjozondjupa administrative regions (RAISON 2013).

Governance Information and Data Gaps

A better understanding is needed of the roles communities (men and women) hold with regards to barriers to participation in decision-making. Additionally, the percentage of women who are members

of decision-making structures, important for understanding gender equity, is unknown (e.g., local councils, regional councils, parliament, and administrative structures).

Indicators used to measure water management performance are unknown.

Revenue from tariffs are unknown, as is the revenue sharing/allocation structure.

Systems of enforcement are unknown.

Methods used to collect information on and understand social and environmental conditions in the Basin are unknown. Also, unknown if these methods are standardised.

2.8 INSTITUTIONAL ARRANGEMENTS FOR CUVECOM

This section of the Rapid Assessment of the Cuvelai River Basin addresses the key institutional arrangements that should be considered during the current formalisation process, describing what will be required to set-up CUVECOM formally, and considerations for sustainable financing of CUVECOM.

2.8.1 River Basin Organisations

Transboundary river basins are, by definition, river basins that straddle the political boundaries of two or more sovereign nations. If there are mutual institutional, economic or social benefits associated with working together towards common goals related to water management in a basin, this is usually undertaken through a River Basin Organisation (RBO). They are established primarily to facilitate equitable and reasonable utilisation of water resources; prevention of significant harm from water or land management activities upon water resources, and prior notification of planned developments (SADC, 2010).

RBOs are established either as temporary joint technical committees - bodies intended to serve a specific project or programme; interim institutions – established as a precursor to a formalised RBO; permanent joint technical committees – providing a vehicle for long-standing cooperation on a single issue, or set of focused issues; or a transboundary RBO. They are set-up in response to specific political/institutional needs, or in response to demands of stakeholders (Global Water Partnership 2012).

As policies and legal instruments that govern quantification, rights, distribution and allocation of water resources are established at a national level (GWP/INBO 2009), the role of an RBO is to advise the parties on courses of action, and interventions, with respect to transboundary water management (including water resource allocation, water quality, and impoundment), resolution of transboundary resource conflicts, negotiations on inter-basin water transfers, infrastructure developments, and environmental flows. Beyond the multi-country perspective, the status of the RBO is enshrined in the core principles of the SADC Protocol on Shared Watercourses (2001), stating the basin or riparian states of shared watercourse systems shall without prejudicing their sovereignty, equitably share use and access to water resources – surface and sub-surface. This equitable sharing must take into consideration factors and issues including the biophysical and hydro-climatic characteristics, the socio-economic conditions, shared use implications, existing and future uses of water resources, and agreed standards.

Across the SADC region – where all major watercourses are shared by two or more countries (Watkins 2006) - RBOs have been established to cooperate on river basin/watercourse planning to balance water

user needs with resource availability/allocation, and coordinate efforts with respect to water related hazards (floods, droughts, etc.) (Global Water Partnership 2012). While different RBO's are substantially different from one another in terms of biophysical conditions, hydro-climate, socio-economic circumstances, number of member states, mix of surface water and groundwater, and capacity, each basin has had to address the question of financing. Independent of the configuration and size of the basin, and the needs and demands of the member states, sustainable financing is not isolated to the day-to-day administration and operation of the RBO; financing must also cover technical programmes that must inevitably be undertaken to understand and address key issues facing water resource managers in the basin.

2.8.2 RBO Agreements

RBOs are established through agreements that, through a series of articles, and supported by a set of definitions, clearly lays out the purpose, nature and operations of the institution (SADC, 2000).

While based on the same basic principles, as described above from the SADC Protocol on Shared Watercourses, each RBO agreement is different; reflecting the individual institutional, governance, biophysical and hydro-climatic conditions within the basin in question.

2.8.3 Phases of RBO Development

While the focal areas and dynamics of each RBO are defined by the specific institutional and biophysical setting of each basin, there are recognised stages of development for RBOs – a continuum of sorts – (Hooper 2006):

1. **RBO initiation phase** – establishment of dialogue between the parties, resulting in Memoranda of Understanding, identification of interim secretariat, roles and responsibilities and initial contributions from Member States;
2. **RBO establishment and development phase** – where the RBO is formalised, with a permanent secretariat in one of the riparian states, and the preparation of a strategic river basin planning document - Transboundary Diagnostic Analysis (TDA), Strategic Action Plan (SAP) or River Basin Management Plan (RBMP); and
3. **RBO full operation phase** – projects emanating from the planning document are being implemented, and tangible results are available to decision-making.

A fourth stage is possible, which includes the joint development and financing of mutually beneficial water management infrastructure. (Ruthenberg & Arntzen 2016).

CUVECOM is currently with Phase 1 of this continuum, with the agreement signed, but the location of an interim secretariat, roles and responsibilities, and the funding agreement yet to be determined. As there is already significant cooperation on the Kunene Transboundary Water Supply Project, it could be said that elements of additional stages are already being addressed to some extent.

2.8.4 RBO Establishment

The SADC Guidelines for Strengthening River Basin Organisations establishing present the RBO establishment process illustrated in Figure 30, and described below in terms of developmental stages.

These guidelines were designed with the intention of shortening the learning-curve for new RBOs being established in the SADC region.

Figure 30 RBO establishment and development process.



Source: (SADC, 2010)

2.8.4.1 Establishment Process

The establishment process includes the following steps:

- **Conceptualisation** – identification of main issues of mutual concern, defining the need and drivers for cooperation;
- **Negotiation** – Development of a draft agreement, consulting with political structures, and obtaining legal review.
- **Establishment** – signing and ratification; and
- **Operationalisation** – appointing staff, formulation of issues and designing financial sustainability model.

CUVECOM is currently at the Operationalisation stage.

2.8.4.2 Watercourse Agreement

The Watercourse Agreement includes the following elements:

- **Preamble** – stating the purpose and drivers behind the agreement,
- **Establishment** – desire of the parties to establish the joint body, outline the legal status it will assume, and the objectives, functions and powers;
- **Governance** – outline the governance structures;

- **Obligations** – specify the obligations of the parties, in terms of projects, information and data exchange, financing mechanisms and notification mechanisms
- **Legal Arrangements** – identifying mechanisms for dispute resolution, accession withdrawal, dissolution, force majeure, amendment, language, and when it will enter into force.

Except for financing mechanisms, these elements are all covered within the CUVECOM agreement. The parties will need to determine whether an amendment will later be required to the agreement to formalise the financial mechanisms.

2.8.4.3 Organisational Structure:

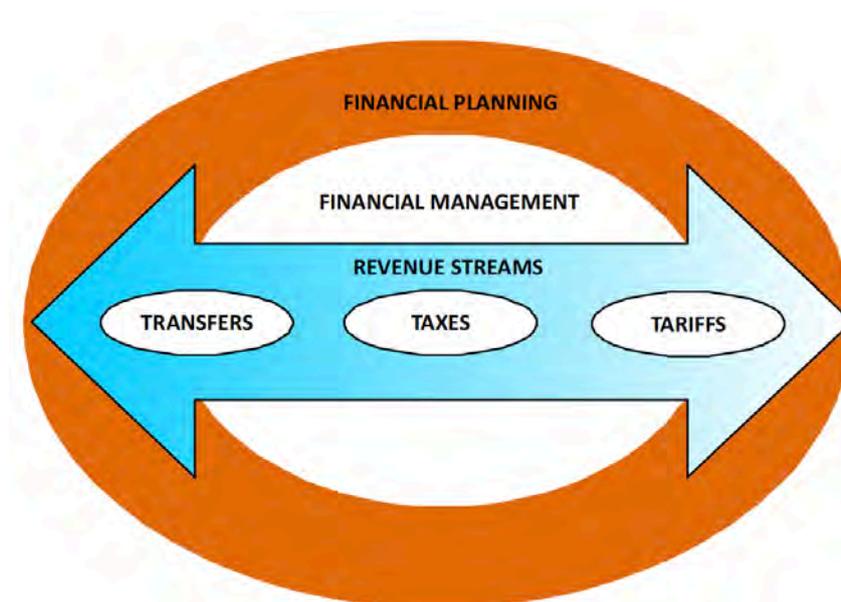
Organisational structure essentially determines whether a River Basin Commission, a Joint Water Commission/Joint Technical Committee, or a Joint Water Authority is needed for the co-management of the water resources of the Cuvelai River Basin.

The parties have essentially already decided that they wish to establish an RBO – CUVECOM.

2.8.5 Financial sustainability

The SADC Guidelines for Strengthening River Basin Organisations: Funding and Financing Guideline document (SADC, 2010) provides guidance for developing RBOs in terms of financial development, planning and sustainability, as illustrated in Figure 31.

Figure 31 Holistic funding concept for RBOs.



Source: (SADC, 2010)

2.8.5.1 Financial Planning

The first step towards establishing a financially sustainable RBO is development of a detailed financial plan for the institution, which outlines the mission and objectives, specifies financial requirements, and explores opportunities for sustainable funding opportunities, which in turn supports the development of a funding strategy.

2.8.5.2 Revenue Streams

As an RBO is being established, the relevant revenue streams identified by in the Guidelines for Strengthening River Basin Organisations: Funding and Financing Guideline (SADC, 2010) are as listed in Table 16.

Table 16 Applicable revenue streams for sustainable financing.

Funding Option	Type
Grants	Transfer
Funds	Transfer
Member state contributions	Taxes
Payments for services	Tariffs
Public Private Partnerships	Tariffs

Source: (SADC, 2010).

2.8.5.3 Financial Management

The SADC Guidelines for Strengthening River Basin Organisations: Funding and Financing (SADC, 2010) identifies a series of interventions for RBOs for financial management:

- Establishment of a financial management and governance system;
- Preparation of annual budgets;
- Establishment of formal accounting systems;
- Formulate and implement control and accountability procedures; and
- Adopt standardised and formal financial reporting mechanisms.

The proposed steps provide the parties and all involved in the operational management of the RBO with transparency, and clear roles and responsibilities with respect to financial management. Such regulations and operational guidelines will build and support confidence between the parties and the RBO, and any business partners – donors, private sector business, etc, which in turn will support further investment.

2.8.6 Lessons Learned

While often de-emphasised in favour of technical and institutional requirements, identification of sustainable financing frameworks for RBOs from the outset is a critical element that must be addressed during the establishment of RBOs. This fact is reinforced by lessons learned from across the region and around the world, and underpinned by set of guidelines for RBO development.

Categories of lessons learned focus on the following aspects:

- Institutional establishment; and
- Financial sustainability.

While all adhering to the Dublin Principles of Integrated Water Resources Management (IWRM), and guided by the SADC Protocol on Shared Watercourses (as Revised; SADC 2000) each RBO established in the SADC region has been founded at different times, with varying mandates, priorities, and operational models. Agreements have been amended as time has passed, responding to internal lessons learned, and the changing needs of the parties. For example, ORASECOM was established with the apex body below ministerial level, which may have allowed technical and institutional advancement, has meant that the responsible ministers have requested the amendment of the agreement to elevate the upper-most decision-making platform to be at ministerial level (Ramoeli, 2017).

Several RBOs in the SADC region have potential to generate revenue through the application of levees to water uses. For example, tariffs can be applied to hydropower utilities, producing power on large rivers within shared river basins to contribute to operational and technical programmes of RBOs. The Zambezi River Authority applies such levees to support the running of the Authority. Equally, ecosystem services and tourism levees can be applied to tourism operators in the Okavango Delta, to support OKACOM; and other large users of water, such as bottling facilities, breweries, power stations, and other large water-using industrial facilities can provide revenues to support other RBOs.

The challenge for CUVECOM is identifying a probable source of sustainable income that is not so sensitive to small levees being applied that the revenue generation renders the business unsustainable.

2.8.7 CUVECOM

This portion of the report reviews the CUVECOM Agreement (2014), and utilises the wording of the agreement to layout the structure of CUVECOM, priorities identified during the stakeholder consultation process to propose Technical Task Teams to support the Commission, and oversee and steer technical programmes; and the CUVECOM calendar. Finally, it presents a proposal to form a Basin-wide Stakeholder Consultation Forum.

2.8.7.1 CUVECOM Agreement

The CUVECOM Agreement of 2014, included as Appendix A1 in this report, establishes the following key elements:

- **The purpose of the Commission** – advise the parties on equitable and reasonable utilisation, sustainable development and the efficient integrated management of the water resources of the Cuvelai watercourse. This shall be attained through the following functions:
 - Collection, evaluation and dissemination of data and information to support the implementation of the agreement;
 - Development of early warning systems against extreme events;
 - Take measures and arrangements to determine the long-term safe yield of water resources in the system;
 - Undertake joint research to support the sustainable development of the water resources, including construction, operation and maintenance of water works and infrastructure;

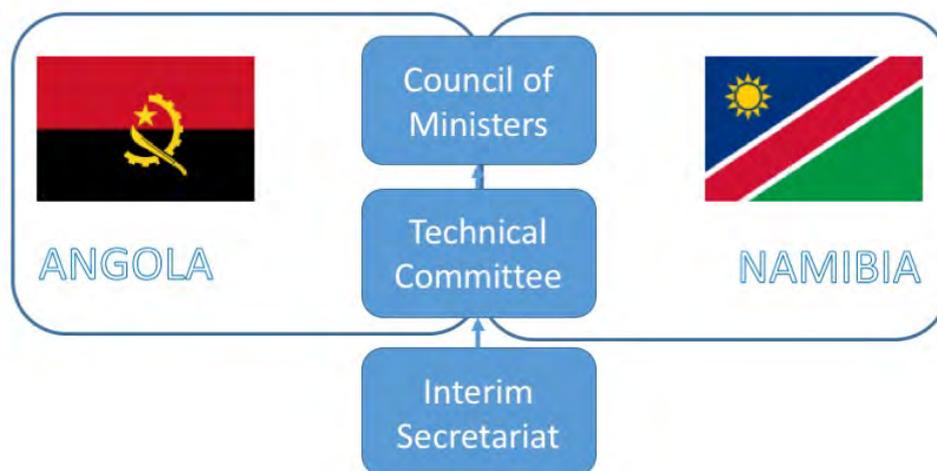
- Promote, support, coordinate and harmonise management of shared water resources;
 - Advise the parties on planning, management, utilisation, development, protection and conservation of the Cuvelai watercourse;
 - Advise the parties on measure to avoid disputes and conflicts over the planning, management, utilisation, development, protection and conservation of the Cuvelai watercourse;
 - Foster awareness among basin inhabitants on the equitable and reasonable utilisation, and efficient management and sustainable development of the water resources of the Cuvelai watercourse;
 - Cooperate with SADC and other national and international institutions, as necessary;
 - Promote and assist in the harmonisation of national water policies and legislative matters; and
 - Undertake other functions and duties as assigned by the parties at their discretion.
- The institutional **configuration, functions, responsibilities and powers of the Commission** - Council of Ministers, Technical Committee, and Secretariat;
 - The **obligations of the parties in terms of cooperation** and support, avoidance of significant harm (as specified in the SADC Protocol), exchange technical data and information, provision of notice to the other party if planning of projects, programmes or activities that may cause significant adverse effects upon the other party;
 - Obligations in terms of **preservation of the headwaters** environment, management and control pollution sources and hazards to human safety, prevention and management of alien species;
 - Provides preliminary introduction of how **emergency situations** should be addressed;
 - Frameworks for **resolution of disputes**, including obligations for notification, mediation, appointment, powers, authority and nature of dispute resolution tribunals;
 - Recognition of **existing agreements** between Angola and Namibia;
 - **Financing of the Commission** activities, including official meetings, budgetary compositions, and the nature of contributions;
 - **The languages of operation** – namely English and Portuguese;
 - **Mechanisms for amendments**; and
 - **Mechanisms for dissolution** – should such a situation arise.

2.8.7.2 Configuration of the CUVECOM

Following are recommendations for the configuration of CUVECOM, based on the contents of the CUVECOM Agreement (2014), lessons learned from other river basins, and technical requirements in response to the priorities identified by stakeholders throughout the basin.

Figure 32 provides an overview of the proposed configuration of the CUVECOM, with the Council of Ministers supported by a Technical Committee, who in turn is supported by an Interim Secretariat (as discussed in the following section).

Figure 32 CUVECOM Configuration.

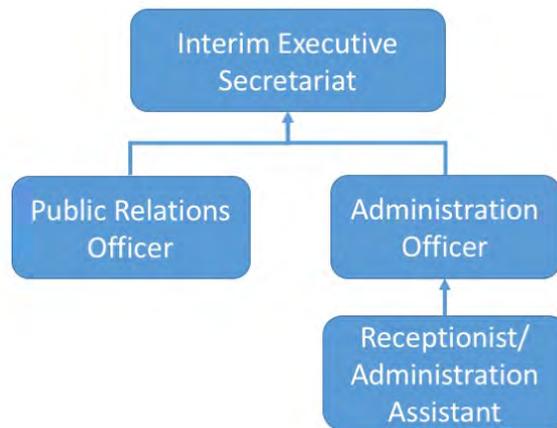


2.8.7.3 Interim Secretariat

To keep costs manageable, not creating an unsustainable financial burden from the outset, and avoid strain on already limited human resources within ministries in Angola and Namibia, it is proposed that an Interim Secretariat is established with a minimal staff (and not second staff from Ministries):

1. Interim Executive Secretary;
2. Receptionist/administration assistant;
3. Administration officer; and
4. Public relations and communication specialist.

Figure 33 Proposed structure for the CUVECOM Interim Secretariat.



It must be noted that this is an **Interim Secretariat**, wherein the parties will establish the location, need, direction and requirements for a **Permanent Secretariat**. It is recommended that the location of the Interim Secretariat should not be rotated.

It is also recommended that the Interim Secretariat is established in one of the main towns in northern Namibia, such as Oshakati or Ondangwa. This will provide access to reliable energy and telecommunications technologies, access to air and road links, as well as accommodation and conferencing facilities. This arrangement could be reviewed should the Interim Secretariat be replaced by a Permanent Secretariat.

The interim secretary would need a full command of English, Portuguese, and Oshikwanyama.

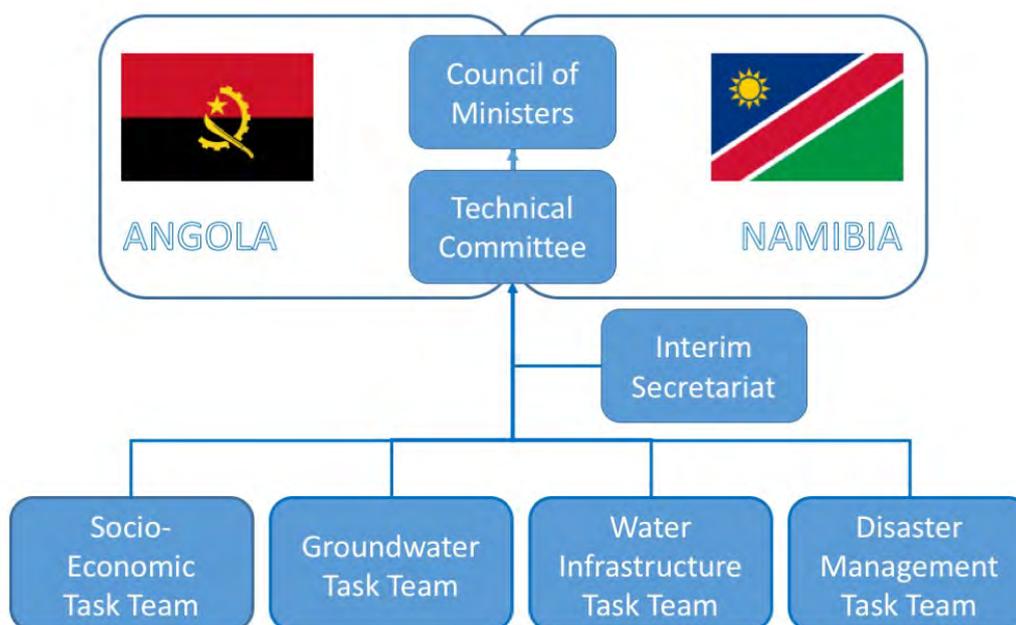
2.8.7.4 Technical Task Teams

Based upon the priorities identified during the stakeholder consultations, it is proposed that the following technical task teams are established:

- **Socio-Economic Task Team** – addressing stakeholder coordination and socio-economic studies (including gender and poverty);
- **Groundwater Task Team** – coordinating groundwater projects and initiatives within the basin, between the parties;
- **Water Infrastructure and Supply Task Team** – addressing design, implementation and co-management of water management and supply infrastructure within the basin, and discussing impacts of inter and intra-basin transfers;
- **Disaster Management Task Team** – addressing early warning and DRM.

The TTTs will comprise representatives from the Ministry of Energy and Water in Angola, and the Ministry of Agriculture, Water and Forestry in Namibia, and sub-ordinate departments, depending upon the focal area. The TTT will include a minimum of three members from each country, and a maximum of five. The TTTs will meet independently of the Technical Commission and prior to ordinary session meetings, to undertake steering and review of technical projects, and prepare feedback for the Technical Commission and Council of Ministers.

Figure 34 Proposed Technical Task Team Configuration.



2.8.7.5 Delegation representation to CUVECOM

The above proposed structure of CUVECOM will require the commitments summarised in Table 17 in terms of the Council of Ministers, Technical Committee, Interim Secretariat and Task Teams.

Table 17 CUVECOM Institutional Requirements.

	Members			Status
	Angola	Namibia	Total	
Council of Ministers	1	1	2	Council
Technical Committee	3	3	6	Committee
Interim Secretariat		1	1	Interim
Interim Secretariat Support Staff		3	3	Contract
Socio-Economic Task Team	2	2	4	Task Team
Groundwater Task Team	2	2	4	Task Team
Water Infrastructure and Supply Task Team	2	2	4	Task Team
Disaster Management Task Team	2	2	4	Task Team

2.8.7.6 CUVECOM Calendar

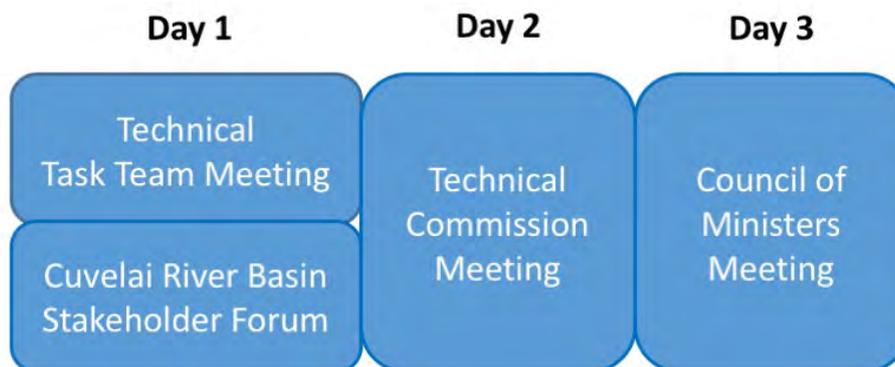
Using other RBOs as a reference, it is proposed that CUVECOM hold two Ordinary (scheduled) sessions per year, one in Angola and one in Namibia. Extraordinary sessions would be held in response to specific issues. The schedule for the meetings would be as illustrated in

Figure 35 Proposed schedule for CUVECOM ordinary session meetings.



Should the Cuvelai River Basin Stakeholder Forum be established as proposed (see following section), perhaps as an annual event to reduce the financing burden, the stakeholder forum would be held in parallel to the Technical Task Team Meeting (Day 1) and the outcomes would be presented to the Technical Commission on Day-2 to discuss and then carry forward to the Council of Ministers on Day-3.

Figure 36 Proposed schedule for CUVECOM ordinary session meetings, with the Cuvelai River Basin Stakeholder Forum.



2.8.7.7 Cuvelai River Basin Stakeholder Forum

A stakeholder forum or advisory group can provide an independent, third-party perspective on water management issues (Global Water Partnership, 2012), carrying forward issues from grassroots level to the Commission, from the Commission to the communities, and provide a platform for dialogue for all levels of engagement.

Based on the active response during the stakeholder consultation process of this project, and requests during these sessions to be included in the process, it is strongly recommended that CUVECOM consider establishing a Basin-Wide Stakeholder Forum (BWSF), following models established by other river basin organisations, such as OKACOM during the ‘*Every River Has It’s People*’ project.

The Basin Wide Forum for the Cubango-Okavango River Basin was established in 2001 under the *Every River Has It’s People* project, creating a platform for representation by stakeholders at the basin-level. The Country Forum Members, who represented ten communities in each of the three basin states – Angola, Botswana, and Namibia - met twice a year at a national level, and once a year at a basin-level, sharing experiences to obtain and retain a synoptic view of the basin from hydro-climatic and socio-economic perspectives. This mechanism provided the necessary information and understanding to help formulate knowledge-based community livelihoods and environmental action plans (OKACOM, 2017).

This forum would provide a mechanism for a wide range of stakeholders to interact with CUVECOM, through a formalised and constructive process and interaction mechanism, enabling the following key success factors for community participation in transboundary river basin management:

- Enable transparent representation of all levels of stakeholders at the basin-scale;
- Help distinguish between information, consultation, participation and empowerment;
- Gain a balance of involvement – not involving all, and not involving only a few;
- Support and foster ownership of basin action plans through community participation;
- Provide supporting coordination mechanisms for all levels of action plan implementation; and
- Provide an opportunity for capacity development in all stakeholder groups.

(Global Water Partnership, 2012)

Such a forum would require a Terms of Reference, which would include the following components:

- **Purpose** – the general purpose of the Forum;
- **Duties** – what the Forum exists to achieve;
- **Accountability** – who the Forum is accountable to, and who they report to;
- **Forum leadership** – who would chair the Forum, and the leadership, including mechanisms for election, tenure, arrangements for deputisation, etc;
- **Membership** – who the members of the Forum are, and their roles within the basin and the Forum;
- **Declaration of interests** – determination of the types of interest groups within the Forum;
- **Meeting frequency** – how frequently the Forum will meet;
- **Meeting organisation** –the process for organising
- **Reporting** – how the Forum will report on its outcomes and the process for interfacing with the Commission, and out to the wider stakeholder groups;
- **Standing agenda items** – generic agenda items to be discussed at each meeting; and
- **Regular review of ToR** – the process and frequency with which the ToR of the Forum are reviewed.

A draft outline of a ToR is provided in Appendix A2, as an example.

2.9 SUSTAINABLE FINANCING

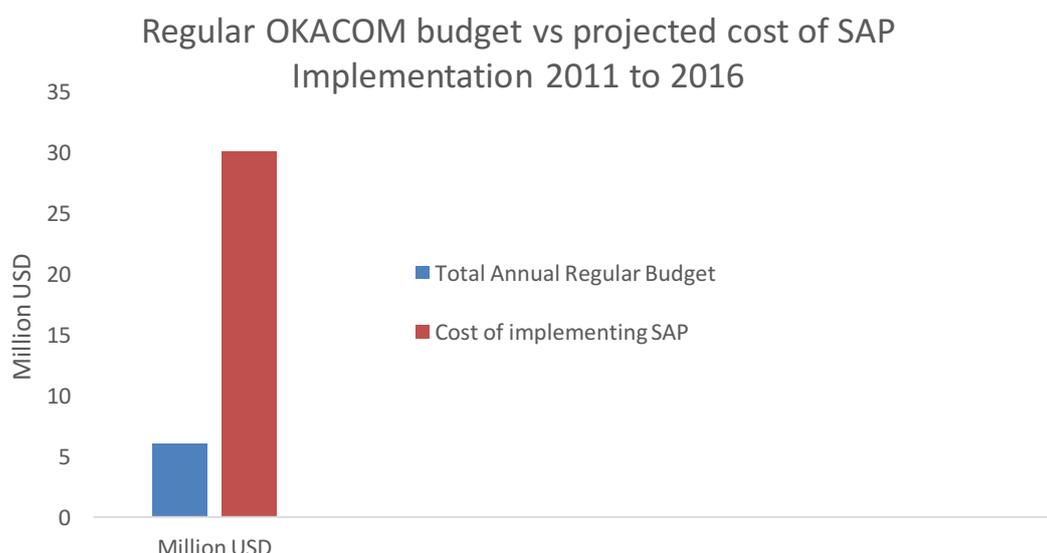
Despite the importance of the technical and institutional cooperation that will be realised through CUVECOM, development of a sustainable financing framework for the Commission will be the single most important aspect of the early stages of work. Henkel, et al. (2016) propose four dimensions of financing that provide essential perspectives on RBO sustainability:

- **Sufficiency** of funding;
- Degree of **self-financing**;
- **Reliability** of financing; and
- **Resilience** of the organisation from a financial perspective.

Each of these dimensions add clear perspective to the importance of addressing financial models as early in the process as possible. Sufficiency is a clear first step – does the budget available match the operation costs, and programme of work for the period in question? Degree of self-financing refers to the portion of the budget that is continuous; coming directly from government coffers, or from fees; rather than temporary or transient sources, such as donor funding. Reliability of funding means the level to which the RBO can depend upon contributions being paid, whatever the source. And, finally, resilience refers to ability of the institution to weather fluctuations or unreliability in funding flows. This is usually addressed through financial reserves (Henkel, Schüler, Carius, & Wolf 2016).

It is also important to differentiate between operational or regular budget, and programmatic or implementation budget. The operational budget covers the day to day running costs for the RBO – rent, salaries, Information and Communications Technologies (ICT) requirements, travel, allowances, etc. – allowing the body to function effectively. The programmatic budget provides financial support to technical programmes that further the cause of the RBO (Henkel, Schüler, Carius, & Wolf 2016). The difference between regular budget and programmatic budget is brought into stark relief when examining the example of OKACOM’s regular budget from 2011 to 2016 in comparison to the cost of implementing the Strategic Action Plan over the same period, as illustrated in Figure 37.

Figure 37 OKACOM regular budget vs budget to implement the SAP over a five-year period.



Source: (Henkel, Schüler, Carius, & Wolf 2016)

For finances to be sustainable, there is a need for accountability and transparency, which ultimately begins with effective budgeting and accounting, and is carried forward supported by monitoring and evaluation frameworks. These functions are critical to the sustainability of the institution.

Without accepted fiduciary standard and measures and regular reporting, member state contributions, levees and donor funding will be compromised, as all sources will require accountability.

2.9.1 Sources of Financing

Financing for operational and programmatic budgets of RBOs include two main sources:

- Donor funds;
- Revenues.

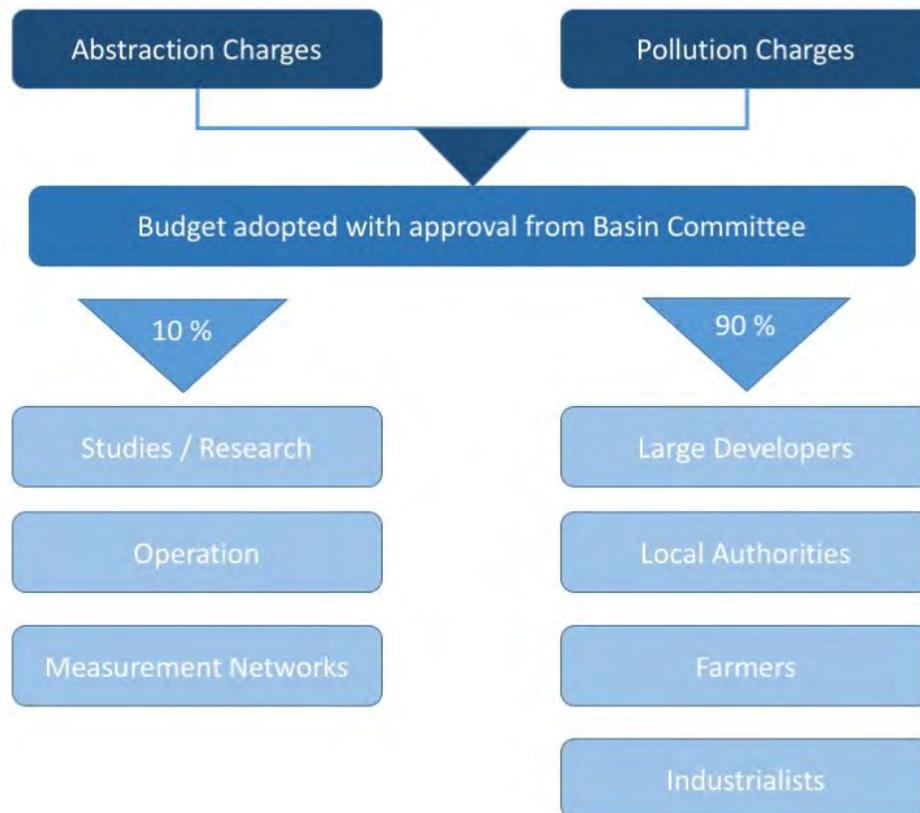
Typically, the majority of RBOs, particularly those in southern Africa, have been donor-supported, through multi-lateral transboundary water management programmes. While this often allows significant progress to be made towards IWRM, it also creates a dependency that once established is difficult to change, unless deliberately programmed to eventually be phased-out from the outset. Hence, donor-only or majority-donor support should be viewed as unsustainable financing, since although relatively consistent in the past, donor spending can be influenced by source-country political and social conditions, or changing development priorities or approaches. Should multilateral funding be withdrawn from large donor-dependent RBOs, the vacuum such a withdrawal would leave behind is often difficult to fill using other sources of funding; meaning that operational and programmatic budgets would both be at risk. Identifying non-donor, sustainable and mixed financing sources from the outset reduces the risk to the institution. Donor support in establishing the RBO should not affect the long term financial sustainability of an RBO, as long as the support is short-term, and focused on developing capacity and strategic planning activities. Hence, sustainable financing should focus primarily on revenue-based sources. GWP/INBO (2009) identifies three key sources of revenue to support support sustainable financing:

- **Taxes** – government contributions from the national tax-base;
- **Tariffs** – levees paid by direct and/or indirect water users, including the polluter-user pays concepts; and
- **Transfers** – fees for water transfers.

The 'three T's' are standard sources of revenue-based financing for RBOs. Government contributions are increasingly common in the SADC region (GWP/INBO, 2009). The Orange-Senqu River Commission (ORASECOM) was government financed at an operational level from the outset, with all countries paying contributions up-front. The Permanent Commission for the Okavango-Cubango River Basin (OKACOM) also migrated to government contributions from the tax-base once donor support was programmed-out, but it quickly became clear that these sources were insufficient. Hence, a mixed revenue-based funding model is being explored – with sources such as tourism or ecosystem service levees being considered.

One financing option, enshrined in French Water Law since 1964, known as the Polluter-User Pays Principle, allows the recovery of levies or water charges by water agencies – river authorities, water utilities, or RBOs - on abstractions (volumetric use), or discharges that impact water quality (pollution); either on modifying the water regime that must then be managed by the agency.

Figure 38 The Polluter-User Pays Principle.



Source: Adapted from (GWP/INBO 2009).

Options for levies in the Cuvelai include the following options:

- Abstractions - water users;
- Ecosystem Services;
- Tourism Levies;
- Polluter-pays from polluting industries; and
- Establishment of a trust-fund.

Migration away from donor dependence has become a priority for many larger RBOs, in response to shifting geographic and thematic priorities within large multilateral donor agencies, and increasing limitations in international development spending from many nations following economic recession. In 2013, the Nile Basin Initiative (NBI) initiated a programme to increase member state contributions and the reduce dependency of NBI and its regional centres on donor funding, as a percentage of core budget (USD \$3.8M). This migration from only 48 %-member state funding to over 100 % by 2018 is illustrated in Table 18.

It must also be noted that levies and charges must be developed and implemented in a collaborative and sensitive manner, so as not to jeopardise relations with business, and deter investment in the region.

Table 18 Increase in member state contributions to NBI from 2013 to 2017 and percent core cost coverage.

	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018
Nile-SEC	90,000	90,000	145,000	145,000	200,000
NELSAP-CU	47,037	47,037	79,074	79,074	111,111
ENTRO	114,000	148,000	182,000	216,000	150,000
Total (in USD)	1,826,370	1,962,370	2,968,740	3,104,740	4,111,110
Core cost coverage	48 %	52 %	78 %	82 %	108 %

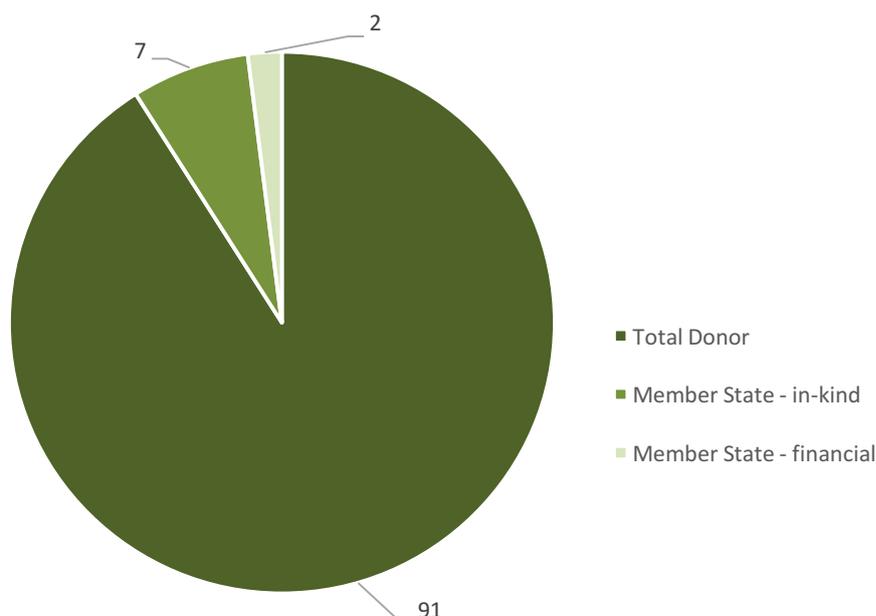
Source: (Henkel, Schüler, Carius, & Wolf 2016)

2.9.2 In-kind Contributions

An often-over-looked element of financing is in-kind contribution. While sometimes difficult to track, and account for, in-kind contributions play a role in RBO support, particularly in early stages of development, when delegation costs and time are covered by member states: salaries are paid by member states, but instead of attending to regular duties, the officers are assign to RBO/technical committees, etc. A cost that is also rarely considered is that the officer in question, when engaged in RBO activities, is not undertaking their regular duties.

Exploring the financing of the NBI and its component institutions using data from 2011, Henkel, et al. (2016) identified that seven percent of financing came from member state in-kind contributions, compared to 91 % from donor funding, and two percent member state financial contributions – Figure 39.

Figure 39 In-kind and financial contributions of NBI members (percentage; 1999–2011).



Source: (Henkel, Schüler, Carius, & Wolf 2016)

2.9.3 Indicators for financial sustainability

With the intention of assessing financial sustainability of a range of RBOs from around the world, with specific focus on Africa and international bench-marks, Henkel, et al. (2016) developed a series of indicators against which the RBOs could be measured:

- Total expenditure;
- Regular budget (adopted);
- Development funds;
- Ratio of regular budget to development funds;
- Share of staff cost in adopted regular budget;
- Country contributions:
 - Total contributions;
 - Regular budget; and
 - Commitment to regular budget.
- Coverage rate (% of committed contributions);
- In-kind contributions;
- Other sources of funding; and
- Cost sharing arrangement.

2.10 CROSS-CUTTING ISSUES

2.10.1 Gender

Gender inequity can exacerbate vulnerabilities and can hinder economic development. Water-related inequities can arise from unequal access to or control over water, or from unequal distribution of benefits from its use. Based on the literature survey conducted with this project, no recent basin-wide or country-specific gender studies have been conducted. According to the OECD however, Angola scores a medium and Namibia scores a low, on the Social Institutions and Gender Index (2014). Three main categories of data are required:

- **Livelihoods:** The roles of women and men in accessing water, and in maintaining households and livelihoods, particularly in rural areas.
- **Benefits:** The distribution of water and benefits from the use of water amongst men and women.
- **Governance:** The roles of women and men in water management, water-related policy and planning, and water-related decision making.

A gender expert can design investigations in a way that is unbiased. A better understanding of gender dynamics and the gendered aspects of water management can help to inform mainstreaming of gender

into decision making, inform capacity development efforts, and improve gender equity. However, such work needs to be informed by detailed gender-disaggregated socio-economic data and information, currently lacking in the Cuvelai River Basin.

2.10.2 Poverty

Limited access to quality water and water services (e.g., sanitation) is often a contributing factor to continued poverty and effective water management plays a critical role in poverty reduction. Similarly, water investments, plans and policies impact the poor in ways that need to be accounted for. Poverty-reducing water strategies would ideally include targeted intervention (e.g., provision of safe water and sanitation to poor communities) and broad interventions (e.g., Basin-wide infrastructure). Water interventions that affect poverty include (WB 2003):

- Broad scale:
 - Resource development and management: Basin-wide water resource interventions that can include major infrastructure, inter-basin transfers, etc.
 - Service delivery: Basin-wide service delivery interventions that might include multi-purpose and multi-sectoral basin management plans or improvements to water supply utilities.
- Poverty targeted:
 - Resource development and management: Targeted water resource interventions to improve local access to safe water and sanitation (e.g. restoration of degraded habitat utilised by poor communities).
 - Service delivery: Targeted water services for poor communities, which can include community water and sanitation supply projects to previously unsupplied areas.

Finally, stakeholder engagement is critical for planning all effective interventions.

Sustainable Financing Information and Data Gaps

Development of realistic budgets will mostly be forward-looking, utilising budget estimations for operational and technical work. However, access to compiled financial information for projects conducted to date would provide a method of cross-checking proposed budgets. The development of operation budgets for CUVECOM could also be supported by compiled financial information for meetings conducted to date, including all in-kind contributions. This will help the parties understand the resources that will be needed for regular session meetings of the Commission; and information on salaries and remuneration packages from across other RBOs would further assist in the assessment of operational requirements.

2.11 SUMMARY OF INFORMATION GAPS IDENTIFIED

Table 19 below provides a full summary of the data and information gaps identified the development of this Rapid Assessment.

Table 19 Summary of data and information gaps.

Thematic area	Data/Information Gap	What is required	Comments
Physiographic	Overall lack of consistent biophysical data outside Etosha	<ul style="list-style-type: none"> Further studies of the complete basin with consistent methodologies and studies. 	A better understanding composition of the Basin is necessary.
Climate Data	Datasets from the catchment headwaters in the Angolan highlands are sparse	<ul style="list-style-type: none"> Climate monitoring infrastructure and data for the catchment headwaters in the Angolan highlands 	This area is where precipitation is highest in the Basin and understanding this data will be important.
Hydrological Data	Hydrometric monitoring network is sparse across the Cuvelai Basin.	<ul style="list-style-type: none"> Establish hydrological monitoring stations throughout the Cuvelai Basin 	This data tends to be collected for dam impoundments but should be collected in the Cuvelai Basin to develop consistent data.
	Flow Data is incomplete.	<ul style="list-style-type: none"> Benchmarking studies of other low flow data collection methodologies. Agreed methodologies for studying flow across the Basin. Regular, consistent data collection. 	Flow data is difficult to assess because of the ephemeral nature of the streams, especially the iishana.
	No centralised source for groundwater data	<ul style="list-style-type: none"> Centralised data collection centre for groundwater data for the Basin. 	CUVECOM can serve this purpose and promote ground water data sharing across the region.
	Groundwater flow system is not well understood.	<ul style="list-style-type: none"> Groundwater recharge studies from both meteoric and surface water sources. Aquifer mapping and cross sections showing the hydrographic sequences Updated and consistent hydraulic property data. Groundwater/surface water interaction studies. 	Understanding the nature of groundwater and regeneration is important to monitor impacts of developments in the Basin.
Climate Change	Runoff Data	<ul style="list-style-type: none"> Stronger runoff data is required as existing data is limited. 	Data availability is limited in Angola and Namibia.
	Drought Data	<ul style="list-style-type: none"> Stronger drought data is required as existing data is limited. 	Data availability is limited in Angola and Namibia.
	Flood Data	<ul style="list-style-type: none"> Stronger flood data is required as existing data is limited. 	Data availability is limited in Angola and Namibia.
	Agriculture, aquaculture, fisheries and Livestock Vulnerability	<ul style="list-style-type: none"> Stronger agriculture, aquaculture, fisheries and livestock vulnerability is required as there is virtually no data available. 	This information will be important for socio-economic data as well as inform climate mitigation programmes and investment.

Table 19 (Cont'd.)

Thematic area	Data/Information Gap	What is required	Comments
Water Utilisation and Demand	Knowledge of groundwater and sustainable yield potential of Ohangwena II aquifer	<ul style="list-style-type: none"> Detailed studies of the Ohangwena II aquifer. 	This information will contribute to understanding the current status of the aquifer and provide a baseline for further studies.
	Knowledge of water demand	<ul style="list-style-type: none"> Detailed study the amount of water used for each purpose (e.g., sanitation, domestic, environmental flows, etc.). 	This information will help to inform an understanding of the water balance for the Basin and water management decision-making.
	Knowledge of the quality of water used for drinking and sanitation	<ul style="list-style-type: none"> Stronger water quality data is required. 	The information is important for informing water-related vulnerabilities.
Disaster Risk Management	Lack of centralised flood forecasting data availability.	<ul style="list-style-type: none"> Establish a unified/collaborative approach to flood forecasting by improving data management/sharing. 	Standardised data collection methodologies are important to provide comparisons geographically and temporally.
	Satellite based-information system	<ul style="list-style-type: none"> Satellite based information gathering rather than ground-based data gathering. 	Satellite information is low-cost, efficient compared to ground-based data.
Socio-economic (all data to be disaggregated by gender)	Lack of Basin-specific current population and demographic data	<ul style="list-style-type: none"> Angola and Namibian governments provide up to data census data for the Basin and refine age group data. 	Up-to-date data is important for any decision making process.
	Conflicting data from different sources	<ul style="list-style-type: none"> Standardised data collection methodologies and analysis. 	Standardised data collection methodologies are important to provide comparisons across groups and time.
	Data gaps include information on access to health care, distance from water sources/sewerage, level of education and literacy rates.	<ul style="list-style-type: none"> More in depth census studies to collect relevant data. 	Expanded census indicators will provide a better understanding of livelihood data for the Basin.

Table 19 (Cont'd.)

Thematic area	Data/Information Gap	What is required	Comments
Socio-economic Cont'd	Economic data is regarding private sector investment in socially responsible water management is lacking.	<ul style="list-style-type: none"> Review programmes being implemented that are being implemented or promote responsible water management 	This information will provide an overview of which programmes, if any are in the Basin and can be supported.
	Data should be collected on expanded economic indicators.	<ul style="list-style-type: none"> Collection of census uniform census data in both countries. 	Expanded indicators can be found on the World Bank website.
	Water withdrawal data for economic activities is unknown.	<ul style="list-style-type: none"> A detailed study looking at water withdrawal in both countries. 	This information will likely include crop zones, livestock densities and mine locations, etc.
	Data on the impact of remittances is widely unknown.	<ul style="list-style-type: none"> Remittances should be included in income categories in census collection. 	Remittances can be a significant income for many households.
	Basin-specific and basin-wide data on food security is unknown.	<ul style="list-style-type: none"> Detailed study of food-security indicators (e.g., food reserves). 	This information will help to understand water-related vulnerabilities.
Institutional considerations (wherever possible, institutional participation in water governance requires gender disaggregated data)	Civil society involvement in water management roles, responsibilities, participatory processes are unknown.	<ul style="list-style-type: none"> Review of organisations operating in the Basin. 	This information will provide an overview of which programmes, if any are in the Basin and can be supported.
	Information on community participation in decision-making is needed, including gender disaggregated data.	<ul style="list-style-type: none"> Review of community structures and social structures that exist in the Basin. 	This information will help understand how to engage with communities and engage with vulnerable community members.
	Indicators for measuring water management performance is unknown.	<ul style="list-style-type: none"> Review national indicators for measuring water management performance. 	Understanding these measures will help compare water management strategies, if they exist and influence further
	Revenue from tariffs are unknown.	<ul style="list-style-type: none"> Review national tariff schemes for water use. 	Understanding these tariff schemes will establish means for accessing funding and mechanisms for funding.

Table 19 (Cont'd.)

Thematic area	Data/Information Gap	What is required	Comments
Institutional considerations Cont'd	Enforcement measures are unknown.	<ul style="list-style-type: none"> Review national enforcement measures. 	This information will contribute to monitoring overdrafts.
	Methods used to collect information on understanding social and environmental conditions in the Basin.	<ul style="list-style-type: none"> Compare data collection methods in both countries and promote standardised data collection methods. 	Standardised data collection methodologies are important to provide comparisons across groups and time.
	The level of cross-sectoral collaboration on water management is unknown.	<ul style="list-style-type: none"> Assess institutional collaboration infrastructure and processes. 	This information will help to inform the development of capacity development activities.
	Information on employment legislation in both countries	<ul style="list-style-type: none"> Analysis of labour law in Angola and Namibia, to ensure future contracts are compliant. 	To be used in the development of Interim Secretariat contracts.
Financial Sustainability	Compiled financial information for projects conducted to date	<ul style="list-style-type: none"> Inventory of all single-state and transboundary projects conducted in the Cuvelai River Basin to date, including project value. 	This information will be used to estimate project values for proposed technical work.
	Compiled financial information for meetings conducted to date, including all in-kind contributions.	<ul style="list-style-type: none"> Financial information for all CUVECOM and Task-Force Calueque meetings in the past five years 	This information will be used in the estimation of costs for running CUVECOM meetings, and overall budgeting
	Information on salaries and remuneration packages from across other RBOs.	<ul style="list-style-type: none"> Survey of salaries and remuneration packages across other RBOs in SADC 	This will be used to determine fair compensation for proposed Executive Secretariat staff.
Cross-Cutting Issues	A gender/water assessment for the Cuvelai River Basin.	<ul style="list-style-type: none"> A detailed socio-economic assessment, designed to include collection of gender-disaggregated water data, based on WWAP guidelines. 	
	A comprehensive poverty and vulnerability assessment for the entire Cuvelai River Basin.	<ul style="list-style-type: none"> A detailed socio-economic assessment, designed to include collection of 	

3.0 STAKEHOLDER CONSULTATIONS SUMMARY

The stakeholder consultation prioritisation participatory process was conducted as follows:

1. Stakeholders selected priority areas – this was conducted in a range of ways:
 - i. **Verbal consensus** – the group discussed it amongst themselves;
 - ii. **Card-sorting** – stakeholders wrote three priorities on three separate cards, which were then collaboratively clustered into priority areas; and
 - iii. **Facilitated discussion** – a facilitator lead a process to select priority themes, using the discussions stakeholder presentations from the morning as a starting point.
2. The Prioritisation process elicited a range of responses from the assembled stakeholders, which were then discussed in smaller groups, guided by a set of ‘framing questions’:
 - i. Title for the theme;
 - ii. What is needed to address this priority?
 - iii. Who are the key stakeholders?
 - iv. What data and information is needed to support progress in this area? and
 - v. Is any work being done in this area in the Cuvelai River Basin at the moment?
3. At the end of each discussion session, the groups nominated a spokesperson, who then reported back to the assembled stakeholder group.

The results of each discussion are summarised in Table 20.

Figure 40 Stakeholders selecting priority areas at the Ondjiva workshop.



Table 20 Stakeholder participatory process results.

Summary of Consultation of Stakeholders on Priorities for CUVECOM, Luanda, Ondjiva, and Ondangwa					
	Title	Necessary to address priority	Stakeholders	Information needed	Work being done
Group 1 Theme 1 Location: Ondjiva Date: 29 March 2017	Information sharing	Interact with the different beneficiaries (communities) and players in different/ various sectors on how to engage with the project	Communities along the basin Min of Agriculture, Energy and Waters, Min of Environment, Hospitality industry and tourism, INAMET (Instituto Nacional de Meteorologia e Geofísica), Administrations, Ministry for Family and Advancement of Women (Ministério da Família e Promoção da Mulher), Institutions of Higher Learning, Civil Protection, IDA (Institute for Agrarian Development [Instituto de Desenvolvimento Agrário]), EDA (Agrarian Development Stations [Estações de Desenvolvimento Agrário]), Traditional Authorities	Areas susceptible to catastrophes Affected populations Affected livestock Affected farm land Availability of water Infrastructures	Xangongo-Ondjiva Water Supply Project Água para Todos (Water for All) Programme Development of Resilience to Climate Project (MINAMB) Angola-Namibia Integrated Resilience Project (PIRAN) – FAO Integrated Programme to Combat Hunger and Poverty – Municipal Administrations
Group 1 Theme 2 Location: Ondjiva Date: 29 March 2017	Use of Water Resources	Create infrastructures for the use of water resources (dams, boreholes, levees, canals) Studies and planning of water systems for the supply and management of said systems Water transfers (Cunene River and Okavango River to Cuvelai River)	Institutions of higher learning Consultancy firms Farmers Beneficiary communities	Target populations Livestock Soils Annual occurrences Seasonal activities	None
Group 2 Theme 1 Location: Ondjiva Date: 29 March 2017	Climate-Smart Seeds	Study of the region's soil-climate characteristics Financial resources Technical and material means	Communities within the areas concerned	Soil and climate characteristics Crop varieties	Crop diversification projects are under way in the Mukolongodjo area
Group 2 Theme 2 Location: Ondjiva Date: 29 March 2017	Construction of Water Management Infrastructure	Preliminary viability study Financial resources Technical and material means	Communities within the areas concerned Ministry of Construction (Public Works)	Information from the local communities Hydrological information Geographical and topographical terms of reference	Construction of levees in the Luvale, Mukolongodjo and Mupa settlements (politically “communes”)
Group 3 Theme 1 Location: Ondjiva Date: 29 March 2017	Infrastructure for the Use of Water Resources along the Basin	Identification of the areas of implementation Dialogue with local authorities and communities That there be financing	Governments of Angola and Namibia Population of the Cunene and Northern Namibia	Number of beneficiaries Technical mapping of the water resources Risk zones	None
Group 4 Theme 1 Location: Ondjiva Date: 29 March 2017	Channelling of water courses	Studies and projects	Energy and Water, Agriculture, Environment, Municipal Administrations, civil society, INAMET (Instituto Nacional de Meteorologia e Geofísica)	Historical hydrological background of the area, knowledge of the water courses of each area of the basin	Study and project for the redirecting or transfer of water flows
Group 4 Theme 2 Location: Ondjiva Date: 29 March 2017	Early Warning System	Installation of a comprehensive information service in the basin	Energy and Water, Agriculture, Environment, Municipal Administrations, civil society, INAMET (Instituto Nacional de Meteorologia e Geofísica)	Survey of settlements, mobilisation of communities to protect equipment, and training of equipment operators	Yes, a number of early warning systems have been put in place by Development Workshop and Civil Protection at a number of settlements in the basin
Group 1 Location: Luanda Date: 26 March 2017	Sectoral Coordination	Information sharing Coordination mechanisms GABHIC to unite government responses and liaise with Gov. Namibia.	All levels of government and stakeholders from national to local, NGOs and CSOs.	Meteorological information Socio-economic data Demographics	NA

Table 20 (Cont'd.)

Summary of Consultation of Stakeholders on Priorities for CUVECOM, Luanda, Ondjiva, and Ondangwa

	Title	Necessary to address priority	Stakeholders	Information needed	Work being done
Group 2 Location: Luanda Date: 26 March 2017	<ul style="list-style-type: none"> Common Framework for Development - As an Entire Basin Including Strategic Planning 	<ul style="list-style-type: none"> Involvement of Stakeholders through national workshops at all levels. Approval at Commission level Transboundary Diagnostic Analysis 	<ul style="list-style-type: none"> Public institutions CSOs NGOs Traditional leadership Research institutions 	<ul style="list-style-type: none"> Institutional data Biophysical data Socio-economic data 	<ul style="list-style-type: none"> CUVECOM dialogue to date, but limited action so far.
Group 3 Location: Luanda Date: 26 March 2017	<ul style="list-style-type: none"> Sustainability of Projects in the Cuvelai River Basin 	<ul style="list-style-type: none"> Centralisation of data Information Sharing Training of local staff Implementation of actions that can be taken when needed Coordination 	<ul style="list-style-type: none"> Communities Local authorities/government National government CSOs Research 	<ul style="list-style-type: none"> Leadership Translation Simple message development Information on solutions applicable to commission Rural upwards, rather than downwards to rural Orgnisation of responses Coordinating body Data on water extractions, transfers to Xangongo, Readings of transfers from Cunene to Cuvelai 	<ul style="list-style-type: none"> Question and Answer: <ul style="list-style-type: none"> Q1. Centralisation of data? Asking because earlier in the day it was not recommended. A1. The term centralisation has negative connotations Q2.Sustainability? General or financial? A2. Multisectoral stakeholder engagement should make decisions on financial sustainability. A2. One other thing to think about would contribute to sustainability is receiving local proposals, not top-down. Grassroots approach can be very effective. A3. (UNICEF) Continuity planning is very important. Need to consider financial sustainability from the outset.
Group 3 Location: Luanda Date: 26 March 2017	<ul style="list-style-type: none"> Financial Sustainability of CUVECOM 	<ul style="list-style-type: none"> Coordination between the governments to ensure no gaps or duplication Need to spend less to do more Institutional memory must not be lost through consultants and project-oriented mentality. Common platform to coordinate projects – through CUVECOM Adequate finances and regulated/coordinated approach Who is defining contracts? Need for coordination entity – CUVECOM? Project and programme coordination must occur through CUVECOM River Basin Management is not linear – there are multiple aspects, which all needed to be adequately financed. 	<ul style="list-style-type: none"> CUVECOM Ministry of Agriculture MINEA Ministry of Environment 	<ul style="list-style-type: none"> Project and programme requirements Institutional requirements 	None
Group 1 Theme 1 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Water Supply 	<ul style="list-style-type: none"> Water harvesting To address the distraction of water infrastructure by flood, and the vandalism of water infrastructure by people and wild animals. 	<ul style="list-style-type: none"> MAWAF, NAM Water, Traditional Authority, Regional Council and Local Authority, Ministry of Environment and Tourism, Community-based organisation 	<ul style="list-style-type: none"> Awareness creation on water supply Training the community Information on water management Water inventory Desalination of underground water Statistics of population (people and animals) with regard accessibility to water 	<ul style="list-style-type: none"> Yes, the basin management committees and water point committees are established. Practical examples of water desalination plants are constructed at Akutsima and Amalika, Omusati region.

Table 20 (Cont'd.)

Summary of Consultation of Stakeholders on Priorities for CUVECOM, Luanda, Ondjiva, and Ondangwa					
	Title	Necessary to address priority	Stakeholders	Information needed	Work being done
Group 1 Theme 6 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Policy Harmonisation 	<ul style="list-style-type: none"> To ensure that the agreed policies between the two countries are implemented and monitored. The responsible ministries should spearhead the implementation of these policies. 	<ul style="list-style-type: none"> Angola Government Namibian Government CUVECOM 	<ul style="list-style-type: none"> Explore the existing laws and regulations in this regard 	<ul style="list-style-type: none"> The establishment of Water resource management Act no. 11 of 2013, 6. Water and sanitation Policy of 2008 National Sanitation Policy
Group 2 Theme 6 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Information Sharing and Knowledge Management 	<ul style="list-style-type: none"> Exchange programme, continuously networking platforms, documentation, publication and dissemination with a clear translation through media and language translation; and Accessibility of information and knowledge resources. 	<ul style="list-style-type: none"> CUVECOM, Basin Management Committees, NGOS, Ministry of Environment, line ministries, Traditional Authorities, Churches, and Regional Councils 	<ul style="list-style-type: none"> Documentation Articles Case studies that are verified 	<ul style="list-style-type: none"> Awareness raising campaigns; Seminars; Reports; and Strategic Plans.
Group 2 Theme 2 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Coordination of Sustainable Development Projects and Programmes 	<ul style="list-style-type: none"> Coordination body to be established, consisting of all stakeholder groups; Finance Willingness of stakeholders through awareness raising; Monitoring and Evaluation 	<ul style="list-style-type: none"> Regional council, line ministries, traditional authorities, NGOs, Community members, churches, local authorities and roads authorities 	<ul style="list-style-type: none"> Policies and regulations, survey data, disaster risk management data, climate data, maps and GIS, institutional profiles. 	<ul style="list-style-type: none"> Establishment of basin support officers; and Disaster Risk Management Committee
Group 3 Theme 8 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Research 	<ul style="list-style-type: none"> Identify research topics and ensure that there are the necessary skills to carry out these research activities. 	<ul style="list-style-type: none"> Educational institutions, line ministries, local authorities, NGOs 	<ul style="list-style-type: none"> Need to review literature already in place and existing research that has been performed to date. 	<ul style="list-style-type: none"> Literature, books and pamphlets about the Cuvelai.
Group 3 Theme 3 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Financial Sustainability of CUVECOM 	<ul style="list-style-type: none"> Two governments under the line ministries should have budgets allocated for the sustainable financing of the commission. 	<ul style="list-style-type: none"> The Namibia Governments through the Ministry of Agriculture, Ministry of Water and Forestry, The Angolan Government through the Ministry of Water & Energy, NGOs, Parastatals and Private Entities. 	<ul style="list-style-type: none"> Need to list authentic activities and associated costs. Background information about the Cuvelai River Basin. 	<ul style="list-style-type: none"> Awareness and information sharing forums were done. Construction of earth dams were also done in certain areas. The NGOs that funded.
Group 4 Theme 1 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Flood Early Warning 	<ul style="list-style-type: none"> Monitoring systems; Experts in hydrology; Communication system; Cooperation between stakeholders 	<ul style="list-style-type: none"> Ministry of Agriculture, Water and Forestry; Ministry of Information and Communication Technologies; Local authorities; Traditional authorities; Ministry of Education; Regional councils 	<ul style="list-style-type: none"> Water level data; Velocity and acceleration of water; and Literature review of flood. 	<ul style="list-style-type: none"> Warning messages are communicated through radios, TV and community meetings by hydrologists.
Group 4 Theme 9 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> Stakeholder Participation 	<ul style="list-style-type: none"> Platform; Finances; Awareness; and Identification of focal persons. 	<ul style="list-style-type: none"> Local authorities; Consistency offices; Traditional authorities; Farmers unions; Ministry of Information and Communication Technologies; Angola Ministry of Education 	<ul style="list-style-type: none"> Water use and management data; and Source of water information. 	<ul style="list-style-type: none"> Annual stakeholder forums are in place and convened; and Stakeholder consultation workshops.

Table 20 (Cont'd.)

Summary of Consultation of Stakeholders on Priorities for CUVECOM, Luanda, Ondjiva, and Ondangwa					
	Title	Necessary to address priority	Stakeholders	Information needed	Work being done
Group 5 Theme 5 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> ▪ Disaster Risk Management 	<ul style="list-style-type: none"> ▪ Data; ▪ Committee; ▪ Technological advancement; ▪ Policy formulation; ▪ Funds. 	<ul style="list-style-type: none"> ▪ Office of the Prime Minister; ▪ Regional Council; ▪ Traditional authorities; ▪ Local authorities; ▪ Media; ▪ Namibian Defence Force; ▪ Namibian Police; and ▪ NGOs. 	<ul style="list-style-type: none"> ▪ Flood data; ▪ Drought data; ▪ Temperature; ▪ Humidity; and ▪ Population density. 	<ul style="list-style-type: none"> ▪ Flood early warning devices have been installed in streams; and ▪ Regional disaster risk management committees have been established.
Group 5 Theme 10 Location: Ondangwa Date: 31 March 2017	<ul style="list-style-type: none"> ▪ Health Education and Awareness 	<ul style="list-style-type: none"> ▪ Data; ▪ Information materials; ▪ Funds; and ▪ Human resources. 	<ul style="list-style-type: none"> ▪ MOHSS; ▪ MIT; ▪ MOE; ▪ Regional Council; ▪ NGOs; ▪ Community Based Organisations; and ▪ Traditional authorities. 	<ul style="list-style-type: none"> ▪ Target populations; ▪ Communications networking; and ▪ Size of area to be covered. 	<ul style="list-style-type: none"> ▪ School visits.

3.1 STAKEHOLDER CONSULTATION SUMMARY

Through the above process, a series of common themes revealed themselves. The list below is presented alphabetically:

- Climate Smart Agriculture;
- Disaster Risk Management;
- Early Warning Systems;
- Floodwater Harvesting;
- Information Sharing and Knowledge Management;
- Stakeholder Participation;
- Technical Programme Coordination;
- Water Management Infrastructure; and
- Water Supply.

Apart from Climate Smart Agriculture and Floodwater Harvesting, these subjects were raised and discussed in all workshops. Climate Smart Agriculture was only discussed in Luanda and Ondjiva, and Floodwater Harvesting was raised in both basin-workshops (Ondjiva and Ondangwa), but it is felt that both are important subjects to cover, especially Floodwater Harvesting. As the workshops followed directly a flood event, this issue was more present than ever in peoples' minds. However, this subject would have been raised at any time, as they witness huge volumes of water during floods, then long periods of drought, wishing they had access to technologies to harness and impound these waters for utilisation later.

Figure 41 Stakeholders discussing the priority areas during the Ondangwa workshop.



3.2 PRIORITIES

The priorities identified by the stakeholders can be grouped into two thematic areas:

Institutional

- **Information Sharing and Knowledge Management** – establishing effective communication protocols and a platform for sharing and developing knowledge products;
- **Stakeholder Participation**- establishing and developing a forum for stakeholder participation and consultation within the basin; and
- **Technical Programme Coordination** – ensure that all technical programmes are coordinated through the commission, ensuring that funding allocated for technical activities is spent effectively, and that no duplication or non-strategic activities are occurring.

Technical

- **Climate Smart Agriculture** – research and implementation of cropping practices and seed varieties that are resilient to climate variations;
- **Disaster Risk Management** – management and mitigation of flood and drought risks;
- **Early Warning Systems** – development and implementation of an effective transboundary flood early warning system;
- **Floodwater Harvesting** – development of infrastructure and processes for collecting, storing and managing floodwaters for re-use later;
- **Water Management Infrastructure** – development of water management structure in the basin, including dams, levees, boreholes/well-fields, canals, etc through coordinated efforts to ensure that decisions take into consideration transboundary water resource management issues – surface and groundwater; and
- **Water Supply** – the design, development and co-management of inter-basin and transboundary water transfer schemes.

Figure 42 Stakeholders discussing the priority areas during the Luanda workshop.



4.0 RECOMMENDATIONS

The recommendations put forward by this consultancy project respond to the information gaps identified in the desktop literature review, and the outcomes of the stakeholder holder process; and are grouped into two broad categories, with a series of sub-categories proposed within each main category:

- **Institutional**
 - CUVECOM structure and physical location;
 - Technical Coordination;
 - Capacity Development;
 - Stakeholder Engagement;
 - Research;
 - Naming conventions; and
 - Knowledge Management and Information Sharing.

- **Technical**
 - Monitoring infrastructure;
 - Physical Infrastructure;
 - Groundwater; and
 - Disaster Risk Management.

4.1 INSTITUTIONAL RECOMMENDATIONS

The institutional recommendations carried forward from the Rapid Assessment and Stakeholder consultations are elaborated below.

4.1.1 CUVECOM Interim Secretariat structure and physical location

To ensure that CUVECOM is financial sustainable, on a day-to-day basis, and does not compete for resources with already constrained national technical departments (Department of Water Affairs and GABHIC), as discussed earlier in this document (Section 2.8.7.3) the Interim Secretariat should be kept to a minimum staffing level, with an Interim Executive Secretary, and basic support staff – as illustrated in Figure 33.

A RBO, like any institution, requires consistent basic services – power, internet, water, etc., to operate on a day-to-day basis. Therefore, it is proposed that the physical location of the CUVECOM Interim Secretariat should be in Oshakati, Namibia. This will provide access to an in-basin location, with sustainable power and telecommunications services, allowing the team located there to focus on the business of the Commission. Location of the Permanent Secretariat in southern Angola should be considered when the Commission reaches that junction, transitioning from an Interim to a Permanent Secretariat.

4.1.2 Technical Coordination

Coordination of technical programmes and activities was identified as a pivotal role for CUVECOM during stakeholder workshops; addressing technical programme strategy and action planning to ensure that work is not duplicated, and gaps are not left. Coordination at this level also ensures that there is integration between projects, facilitating access to data and information, and ensuring that activities are harmonised and complimentary. Furthermore, such coordination would reduce the amount of 'one-country-only' activities taking place, allowing the growth of basin-wide perspectives and understanding.

The foundation for technical coordination in a transboundary river basin is a basin management strategy (Global Water Partnership, 2012), usually covering a ten to twenty-year period, identifying long-term goals and key targets, and direction for the basin, looking forward. This strategy then provides the basis for the development of a detailed three to six-year basin management plans (Global Water Partnership, 2012). Such a strategy allows for the gathering and integration of the following key data and information at a national and basin-wide scale:

- Water management policies and institutional frameworks;
- Context, types, scale and severity of water and land resources management problems;
- General and water-specific development goals and objectives;
- Level of economic development of the basin;
- Understanding and development of capacity of water managers and institutions to manage natural resource issues; and
- An understanding of the financial resources available during the period of the strategy.

(Global Water Partnership, 2012)

A successful basin management strategy should include the factors adapted from (GWP TEC, 2004):

- A clear understanding of water resources in the basin;
- Agreement on goals, objectives and targets;
- Scenarios to be discussed and developed with stakeholders;
- Coordination of priorities and actions for all stakeholders;
- A framework for decision-making and approval;
- Linkage of basin strategy to broader development goals, and national and regional development plans and processes;
- Anticipation of capacity development needs;
- Develop a full understanding of the socio-economic landscape, including aspects of gender and poverty;
- Engage stakeholders through a constructive and accepted platform or mechanism;
- Allocate human and financial resources to the planning process; and
- Establish milestones and a realistic schedule for implementation of key actions;

4.1.3 Stakeholder Engagement

The establishment of a Cuvelai River Basin Stakeholder Forum, through which the Commission could establish and maintain dialogue with basin stakeholders, would be an extremely valuable contribution to transboundary water management in the Cuvelai River Basin. It would enable grassroots issues to be formally and effectively communicated to the Commission for integration into work plans, whilst also providing an essential communication channel to communities, for the Commission for sharing key information on all aspects of water, land and disaster risk management.

As discussed in Section 2.8.7.7, it is recommended that the Forum would meet twice a year at a national level, and basin-wide, holding dialogue with the Commission at the end of their session, annually. The Forum should include community leaders from Sub-basin authorities in Namibia, municipal authorities in Angola, traditional leadership, regional representatives from national departments of water, NGOs, CSOs, and where relevant, private sector representation. Dialogue within the basin (national, and basin-wide) would likely be in the vernacular language, but reporting, including those to the Commission, would be in English and Portuguese.

At their first meeting, the Forum would develop and approve a Terms of Reference, to guide their process, and formalise the platform.

A final critical factor that must be addressed with respect to Stakeholder Engagement is that should a Cuvelai River Basin Stakeholder Forum be established; how will it be funded. While the activities will not incur substantial costs, it must be recognised that meetings do require a venue, and honoraria for travel and accommodation for participants travelling from long distances. While budgets for these meetings could be supported by donors during initial iterations, to establish the forums and their operations, sustainable financing for this initiative will be important to ensure that it can be sustained into the future. Suggestions for financing include the following proposals as individual or co-financing options:

- National contributions from government;
- Private-sector sponsorship;
- International civil society or philanthropic foundations; and
- Trust-funds.

Initial meetings could rely on national government contributions, but a combination of private-sector-sponsorship and international

4.1.4 Capacity Development

A recurring theme during all stakeholder consultations was Capacity Development – amongst stakeholders, and technical agencies. To establish impact in this key priority area, capacity development will need to be integrated into the basin strategy development process, and all strategic action planning. In addition to delivering capacity development through technical programmes, the Commission should aim to utilise the Cuvelai River Basin Stakeholder Forum to implement capacity development throughout the region on key community and household level issues, such as water harvesting and water saving, sanitation and health, and environmental education.

4.1.5 Knowledge Management and Information Sharing

A key issue identified by stakeholders during consultations was sharing of information and access to documentation and information about the basin – Knowledge Management. Knowledge management is often perceived to be an Information and Communication Technologies (ICT) solution, or approach; whereas it is often only really supported by ICT (Subashini, Rita, & Vivek, 2012). Knowledge management, in its purest form, is an institutional cultural activity or paradigm within an organisation or entity. It is driven by a need to have access to knowledge and information, and requires stakeholder institutions to adjust their view of information management from **retention to sharing**.

4.1.5.1 Knowledge Platform

A key next step for CUVECOM will be to establish a temporary knowledge and information repository, providing public access to all key literature and technical resources, in English and Portuguese. This could be achieved through the implementation of a simple website, which could be administered through a Content Management System, supported by an integrated Document Management System. This would be an inexpensive mechanism for sharing information, but would need to be supported by a concerted effort by both delegations to source, and upload all available content. This can be converted into a formalised website or river awareness kit at a later date.

4.1.5.2 Information sharing

Knowledge management has been established a success factor for RBOs, with the effective cataloguing, organising and sharing of data, information and knowledge contributing significantly to the river basin dialogue (Hughes, et al., 2010). Once adopted as an approach or strategy, knowledge management also encompasses an approach to the preparation and dissemination of knowledge. How is knowledge captured, stored, shared and disseminated? This speaks to the need consider preparation of knowledge products that communicate key issues at all stakeholder levels. This will become an important component of information sharing, as identified by stakeholders, as it will enable the Commission to communicate key issues through a formalised, and agreed process.

Moving forward, it will be prudent to explore the establish of a Geographic Information System at the Commission, which will store all relevant spatial data. The GIS can later be supported by Decision Support Tools and Models. However, these activities would be integrated into mid-term objectives and projects, and could be developed and managed by an academic institutions in the interim period.

4.1.6 Naming conventions

As the Cuvelai River Basin encompasses a large geographic area, including two countries, two former colonial languages, and numerous vernacular languages, there is a substantial degree of variation in naming of common or shared resources. As CUVECOM is developed into a full coordinating body for technical and institutional activities in the basin, it will become increasingly important to agree upon and formalise technical and institutional terms, to develop a shared understanding of the basin.

Formalised naming should be recommended for all technical and institutional projects coordinated by or associated with CUVECOM as a standard operating procedure.

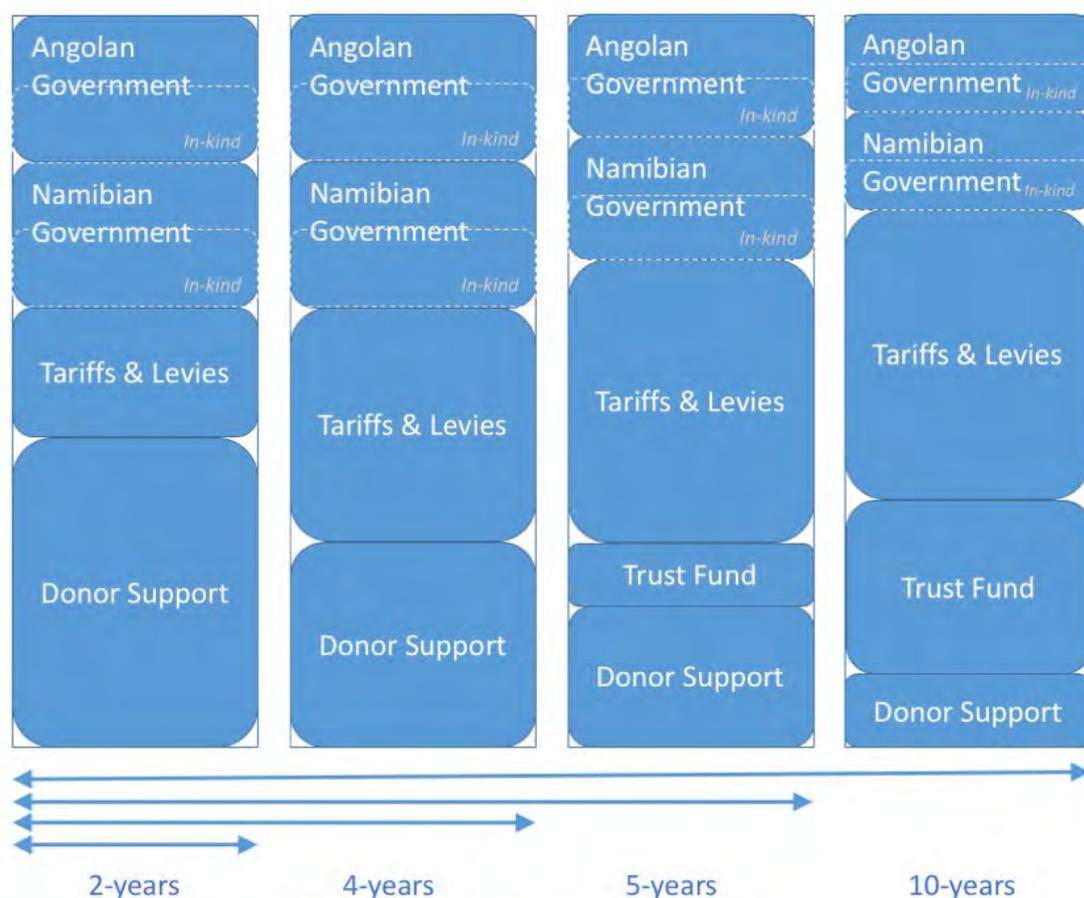
4.1.7 Sustainable Financing

Based upon the need to achieve financial sustainability as early as possible in the formalisation of CUVECOM, whilst also leveraging technical assistance from key donors, and introducing revenue-based contributions as early as possible, the proposed funding model for CUVECOM should integrate the following key principles:

- Access limited donor funding for key institutional support early, quickly phasing-down this support to minimal contributions, or specific projects;
- Introduce revenue-based tariffs from key sectors from the outset, no matter how small to begin with;
- Government (tax-based) revenue contributions should also be introduced from the outset;
- Exploration of innovative financing mechanisms, such as trust fund?

This model is illustrated in graphical form in Figure 43.

Figure 43 Financial model for CUVECOM.



4.1.7.1 Financial Planning for CUVECOM

In terms of financial planning, CUVECOM should establish a series of short and medium term financial plans, to frame and guide financial sustainability, moving forward.

Short-term Plans

- Document detailed operational budgetary requirements;
- Estimate technical programme budgets, based on preliminary assessments associated with the basin strategy;
- Utilise the above inputs to develop a financial plan for the Commission, with financial targets and indicators, including the various financial sustainability contributions identified above;
- Establish financial reporting protocols, based on best practices from other RBOs, and other relevant international financial institutions, to support open and transparent financial management;
- Undertake a feasibility study for the establishment of a Trust Fund, to sustain financing of CUVECOM; and
- Establish a preliminary monitoring and evaluation framework for financial sustainability.

Medium-term Plans

- Develop a detailed financial planning framework, including identification and arrangement of levy charges with various business users;
- Based on rigorous financial management and reporting, CUVECOM should develop annual financial statements, which should be publicly available, on the Commission's website; and
- Establishment of the Cuvelai River Basin Trust Fund.

Examples of financial strategy from OKACOM

To reduce reliance on funding from donors, OKACOM is increasing Member States' contributions to approximately USD 400,000, which in 2010 was thought to be enough to cover annual operational costs (SADC, 2010). This is also being augmented by the establishment of a Trust Fund, to attract philanthropic and other larger funding donations.

4.1.7.2 Sources of revenue:

The most significant challenge facing CUVECOM is the identification of an innovative and sustainable source of tariff-based income that can contribute approximately 40 to 50 % of operational costs moving forward. This does not even include programmatic requirements. As far as the consultant can establish, there are no large water-related businesses, or utilities operating in the Cuvelai River Basin that could be engaged for such payments.

4.1.8 Monitoring and Evaluation

An institutional Monitoring and Evaluation (M&E) framework should be developed for CUVECOM, utilising a set of agreed institutional indicators. Such an M&E Framework would need to be based on a set of collaboratively identified and agreed indicators and targets, reflecting IWRM best practices, progress towards implementation of the SADC Regional Water Policy, and institutional objectives.

4.2 TECHNICAL RECOMMENDATIONS

The technical recommendations carried forward from the Rapid Assessment and Stakeholder consultations are elaborated below.

4.2.1 River Basin Assessment

A critical first stage in the sustainable development and co-management of the Cuvelai River Basin will be the development of a detailed river basin assessment, which will inform provide a unique perspective of the entire river basin, and a strategic basin management or action plan. The nature of the assessment will be entirely determined by funding process, as funding/donor agencies have different requirements and processes. UNDP/GEF follows the Transboundary Diagnostic Analysis (TDA) process, whereas GIZ utilises the Monograph approach. However, in general terms, this process should be undertaken directly after the development of a basin management strategy, to provide the information necessary to development and implement the Basin Management or Action Plan, and guide technical development moving forward. The River Basin Assessment will likely include the following primary components:

- Detailed inventory of all literature and data available for the Cuvelai River Basin to date;
- Detailed assessment of all biophysical, socio-economic, institutional and technical aspects of the basin;
- Development of detailed thematic technical programmes;
- Development of comprehensive capacity development programmes;
- Establishment a knowledge management platform to share results; and
- Provision of recommendations and strategic and national action plans for both member states.

A river basin assessment will be a substantial undertaking, requiring the allocation of significant funds. Table 21 provides a series of examples of basin-wide studies across the SADC region, including the funding agency, cost and duration.

Table 21 Examples of other basin assessments.

Basin	Type of Study	Funding agency	Cost (USD)	Duration	Year
Orange-Senqu	Transboundary Diagnostic Analysis (TDA)	UNDP-GEF	38,365,500*	6 years	2015
Limpopo	Monograph	GIZ, AusAID, UKAid	1,735,000	2 year	2012
Cubango-Okavango	Transboundary Diagnostic Analysis (TDA)	USAID	12,000,000		

* GEF grant USD 6,300,000, remainder was country and other ICP co-financing.

Lessons learned from the development of the ORASECOM TDA process indicate that it is important not only are sufficient funds allocated for the execution of the project, but also the schedule for the project should be clearly established and agreed at the outset. Specifically, the timeline for the

completion of the TDA, such that sufficient time is allocated for the development of the Strategic Action Plan (SAP), and National Action Plans (NAPs). This is critically important to guarantee that political support for the SAP and NAPs is established early enough, ensuring that there are no delays implementing this strategic process (ORASECOM, 2015).

This river basin assessment will include a full assessment of water resources, surface water and groundwater, beginning with a topographic analysis to evaluate existing boundary definitions, and either accept one, or proceed with the delineation of a new boundary.

4.2.2 Strategic and National Action Plans

Once the River Basin Strategy has been developed, and the River Basin Assessment has been conducted, the result will be a Strategic Action Plan, and complementary National Action Plans for both countries. These plans will formalise the plans, objectives and goals of the basin in terms of technical, institutional and capacity development for CUVECOM, moving forward. These plans will be reviewed over time, in terms of adherence to monitoring and evaluation frameworks, and in terms of direction and relevance, as time passes.

4.2.3 Monitoring infrastructure

Through the stakeholder consultations and desktop research for the development of the basin profile, it became clear that one of the most significant current weaknesses that needs to be addressed is the lack of robust monitoring infrastructure, and the management and dissemination of data from such instruments.

To be able to effectively co-manage the basin, the relevant management authorities need to have access to consistent time-series of hydrological (including groundwater) and climatological data. This can only be achieved through cooperative development of monitoring infrastructure and development of shared data management systems. Such a data system would also need to be supported by a formalised data and information sharing policy, agreed by all parties. Such an agreement in turn is supported by agreed clear and unambiguous monitoring and data management standards, which will enable the various parties to effectively utilise the information emanating from the shared monitoring infrastructure.

4.2.4 Physical Infrastructure

The River Basin Assessment (above) will provide the understanding of the entire basin that will enable the parties and Commission to discuss and agree on water management infrastructure needs for sustainable water management, flood defence and drought mitigation. This can only be determined once sufficient information is available to undertake detailed modelling and analysis of topography, flows, discharge, climate and demands.

4.2.4.1 Flood and rainwater harvesting

The lessons learned from the CUVEWaters project (as elaborated in Section 2.4.6) lay practical groundwork for development of a full-scale feasibility study for a regional flood water harvesting initiative, which will build upon this solid foundation. ~~The sustainable capture, storage and usage of flood and rainwaters must be explored in detail to understand if it could contribute to development of a long-term sustainable water management strategy.~~

4.2.5 Groundwater

One of the first technical programmes that should be considered within the technical programme of CUVECOM is a basin-wide geohydrological assessment, which would begin with an integration of all groundwater knowledge and data from across the basin, then undertake a comprehensive groundwater study, including aquifer delineation, identification of key recharge zones, groundwater potential, groundwater vulnerability zones, and modelling. This would likely be conducted as part of the river basin assessment process.

4.2.6 Socio-Economic Assessment

While there is access to census (demographic data) for both countries, and household-level sampling has been undertaken for the Angolan portion of the Cuvelai River Basin, which provides indications of house-hold income and other poverty paradigms, it is still difficult to undertake gender assessments using these data, at a basin scale. Therefore, there is a need to undertake a detailed socio-economic survey and assessment for the Cuvelai River Basin, including the collection of gender-disaggregated water data. This important additional set of parameters will enable a gender expert to undertake gender analysis and poverty analyses, with the following indicator topics included for gender:

- Water Governance;
- Safe drinking water, sanitation and hygiene;
- Decision-making and knowledge production;
- Transboundary water resources management; and
- Water for income generation for industrial and agricultural users, including unaccounted-for labour.

The detailed sub-indicators for these indicator categories are included in Appendix A3.

4.2.7 Disaster Risk Management

Cycles of flood and drought have profound effects on the people, infrastructure and landscape of the Cuvelai River Basin, and Disaster Risk Management (DRM) will be a key focus for the River Basin Assessment, and strategic and national action planning moving forward.

DRM activities will need to include the following aspects:

- Preparedness;
- Management
- Mitigation; and
- Monitoring.

4.2.7.1 Preparedness

Early Warning

One of the most widely referenced issues discussed by stakeholders during consultations was the need for a flood early warning system, so critical information regarding impending extreme weather events and flooding can be shared with in countries and across borders, enabling local authorities and communities prepare for the worst. It is also important that although drought operates on a different timescale to floods, the monitoring and early warning of drought conditions are considered part of early warning activities in the Cuvelai River Basin.

Planning and Capacity Development

It must be noted that preparedness is not only early warning, but also must include planning and capacity development, which will inform how early warning messages are applied, how communities respond, and the level of impact on the communities and their livelihoods.

Planning will enable communities to effectively, and should include, but not be limited to, the following components, as established by the UN-ISDR (2008):

- Observation capabilities – a tower, or other means of high-level viewing;
- Regular meetings to establish drills and access to first-aid, and shelter;
- Access to community radio, and preferably an AM radio, with power back-up;
- Plans to minimise environmental degradation in the communities, removal of trees and vegetation, which increase vulnerability;
- Training of all stakeholders to address gender issues;
- Sharing of skills and knowledge at household-level; and
- Education and awareness raising in schools and other community meetings.

(UN-ISDR, 2008)

A critical component of preparedness is the development and strengthening of capacity at community-level to plan and prepare for disaster conditions (UNISDR, 2013), to minimise loss of life, damage to property and infrastructure. Hence, disaster preparedness should not only comprise early warning systems and plans, but should also be supported by a capacity development programme, to ensure that all levels of stakeholders know how to act once warnings are issued.

4.2.7.2 Management

With a comprehensive DRM plan in place, CUVECOM, and it's parties, will be better placed to manage disaster events, when they occur. With a early warning and planning measures in place, local government, civil protection and communities/households will be better place to respond when warned, and ready to take action. Once early warning announcements have been made, authorities will be able to begin implementing plans, based upon the location and severity of the flood.

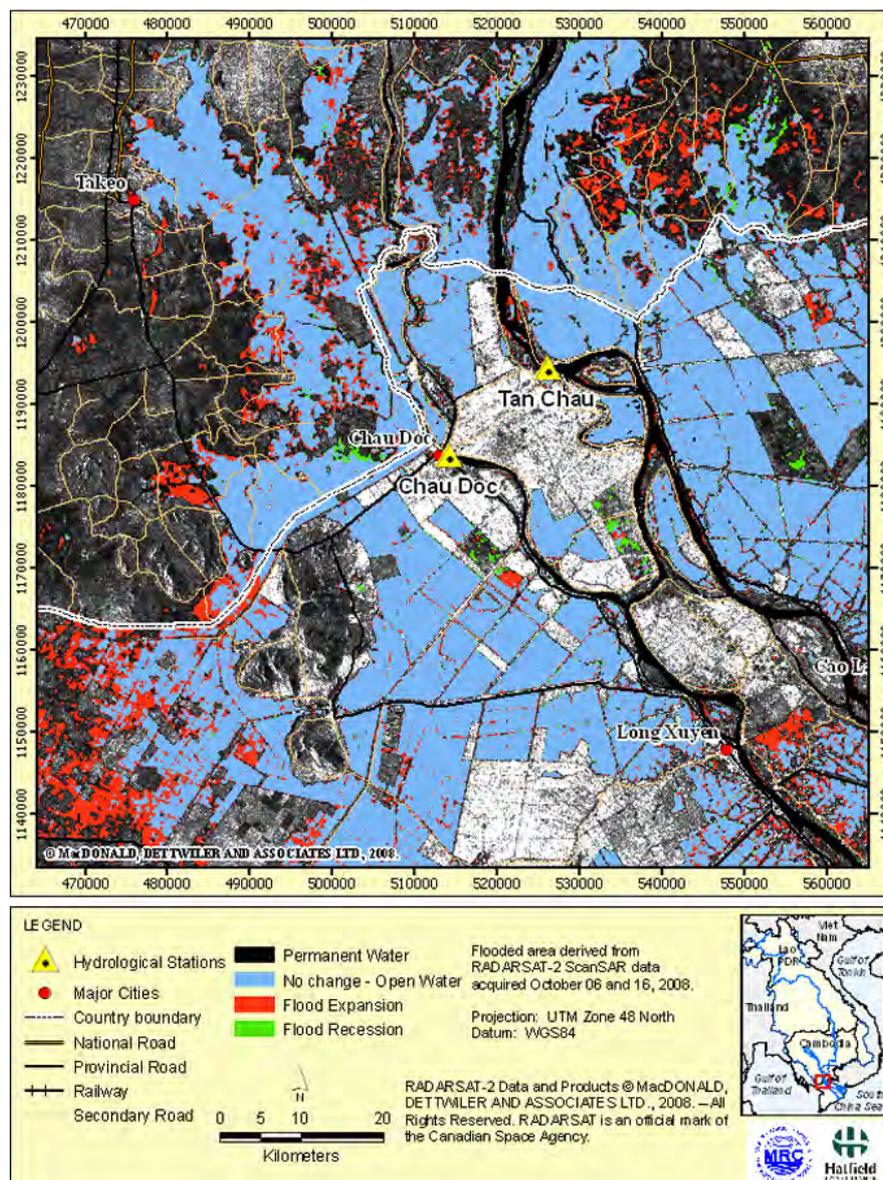
4.2.7.3 Mitigation

In the long-term, once a river basin assessment has been developed, the associated strategic action planning activities that follow should tackle the mitigation of flood and drought conditions; addressing how impacts be minimised, and benefits, such as harvesting of flood waters, and development of flood protection and shelter infrastructure.

4.2.7.4 Monitoring

Preparedness, management and mitigation are the key steps in DRM, but exploring, developing and utilising monitoring tools, such as satellite image analysis, combined with GIS, allows authorities to closely monitor the progress of a specific flooding event. The utilisation of Synthetic Aperture Radar (SAR) remote sensing can provide powerful monitoring tools. Figure 44 shows an example of near-real-time flood monitoring in the Lower Mekong River Basin (LMRB), conducted for the Mekong River Commission (MRC). This application saw two images per week captured over the LMRB being processed, and the map products delivered to MRC within 24 hours.

Figure 44 Flood monitoring in the Lower Mekong River Basin.



5.0 LITERATURE CITED AND DATA SOURCES

5.1 LITERATURE SOURCES

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APPENDICES

Appendix A1

The CUVECOM Agreement

AGREEMENT

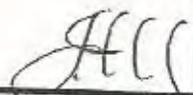
BETWEEN

THE GOVERNMENT OF THE REPUBLIC OF ANGOLA

AND

THE GOVERNMENT OF THE REPUBLIC OF NAMIBIA

ON THE
ESTABLISHMENT OF
CUVELAI WATERCOURSE COMMISSION
(CUVECOM)



PREAMBLE

The Government of the Republic of Angola represented by Ministry of Energy and Water and The Government of the Republic of Namibia represented by Ministry of Agriculture, Water and Forestry. (Jointly hereinafter referred to as the "Parties" and in the singular as a "Party"),

CONSIDERING the relative paucity of the water resources in the Southern African Region

RECOGNISING the importance of the mutually shared and extremely scarce water resources of the Cuvelai Watercourse;

BEARING IN MIND the principles of regional economic integration and cooperation advocated in the Treaty of the Southern African Development Community (SADC);

CONSCIOUS that collaboration between the Parties with regard to the development of water sources of common interests could significantly contribute towards the peace, security, welfare, mutual benefit and prosperity of their people;

RECALLING the modern principles and norms reflected in international and regional water law respectively embodied in the Convention on the Law of the Non-Navigational Uses of International Watercourses adopted by the United Nations General Assembly and the Revised Protocol on Shared Watercourses in the SADC Region;

COMMITTED towards the realisation of the principles of integrated water resource management, sustainable resource utilization and the preservation of the natural environment;

DESIROUS to extent and consolidate the existing tradition of good neighbourliness, friendly relations and close cooperation between the parties by promoting the coordinated and sustainable development of all the resources of the Cuvelai Watercourse;

HEREBY agree as follows:



ARTICLE 1 DEFINITIONS

In this Agreement, unless the context otherwise indicates -

"Budget" means resources, funds of the Commission available at any given time for implementation of programmes, projects and activities of the Commission as provided for by Article 16 of this Agreement;

"Commission" means the Cuvelai Watercourse Commission established in terms of Article 3 of this Agreement (hereinafter called the "Commission" or "CUVECOM");

"Council" means the Council of Ministers established in terms of Article 6 of this Agreement;

"Cuvelai Watercourse" means the system of surface and ground waters of the Cuvelai consisting by virtue of their physical relationship a unitary whole, flowing normally into a common terminus, the Etosha Pan;

"Emergency" means a situation resulting suddenly either from natural causes or from human conduct and causing or posing an imminent threat of causing serious harm to the Cuvelai Watercourse or to a Party

"Equitable and reasonable utilization (ERU)" means equitable and reasonable utilization as provided for under Article 3 (7) (a) and (b), and Article 3 (8)(a) and (b) of the SADC Protocol;

"Executive Secretary" means the Executive Secretary provided for in terms of Article 10 of this Agreement;

"Party/Parties" means the Governments mentioned in the Preamble from which this Agreement has entered into force;

"SADC" means the Southern African Development Community;

"SADC Protocol" means The Revised Protocol on Shared watercourses in the Southern African Development Community, adopted in August 2000;

"Secretariat" means the Secretariat established in terms of Article 10 of this Agreement;



"Technical Committee" means the Technical Committee established in terms of Article 8 of this Agreement;

"Tribunal" means the Tribunal of the SADC established in terms of Article 14 of the Treaty of the Southern African Development Community, adopted in 1992;

"Significant harm" means non-trivial harm capable of being established by objective evidence without necessarily rising to the level of being substantial.

ARTICLE 2 SCOPE OF THE AGREEMENT

This Agreement shall apply to the Cuvelai Watercourse as defined in Article 1 hereunder.

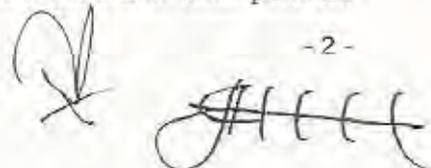
ARTICLE 3 ESTABLISHMENT OF THE CUVELAI WATERCOURSE COMMISSION

- 3.1 The Parties hereby establish and undertake to maintain the Cuvelai Watercourse Commission (hereinafter referred to as the "Commission" or "CUVECOM") in accordance with the provisions of this Agreement.
- 3.2 The Commission shall be an international watercourse organisation, with legal personality, in accordance with the legal systems of each of the Parties. The legal capacity of the Commission is limited to the powers and actions that are strictly necessary for the achievement of the objectives and functions of this Agreement.
- 3.3 In the absence of an agreement to the contrary, nothing in this Agreement shall affect the rights and obligations of a Party arising from other agreements in force prior to the date this Agreement comes into force for such a Party.
- 3.4 The headquarters of the Commission shall be determined by the Council at its first ordinary session.

ARTICLE 4 OBJECTIVE AND FUNCTIONS OF THE COMMISSION

- 4.1 The Commission shall serve as an advisor to the Parties on matters relating to the equitable and reasonable utilization, sustainable development and efficient management of the water resources of the Cuvelai Watercourse and shall perform

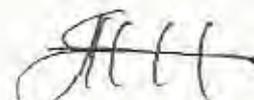
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such other functions pertaining to the integrated water resources management in the Cuvelai Watercourse as the Parties may agree to assign to the Commission.

4.2 To that end the Commission shall have the following functions:

- a) collect, evaluate and disseminate all data and information on the Cuvelai Watercourse as may be necessary for the implementation of this Agreement;
- b) establish joint early warning systems against extreme events (floods, droughts and other disaster situations);
- c) take measures and arrangements to determine the long term safe yield of the water sources in the Cuvelai Watercourse;
- d) carry out jointly or separately research and investigations with regards to the development of the Cuvelai Watercourse, including any project or construction, operation and maintenance of any water works;
- e) promote, support, coordinate and harmonise the management and development of the water resources of the Cuvelai Watercourse;
- f) advise the Parties on the planning, management, utilization, development, protection and conservation of the Cuvelai Watercourse as well as on the role and position of the Public with regard to such activities and the possible impact thereof on social and cultural heritage matters;
- g) advise the Parties on measures necessary for the avoidance of disputes and assist in the resolution of conflicts between the Parties with regard to the planning, management, utilization, development, protection and conservation of the Cuvelai Watercourse;
- h) foster greater awareness among the inhabitants along the Cuvelai Watercourse of the equitable and reasonable utilization and the efficient management and sustainable development of the resources of the Cuvelai Watercourse;
- i) co-operate with the institutions of SADC as well as other relevant international and national organisations where necessary;



- j) promote and assist in the harmonization of national water policies and legislative measures;
- k) carry out such other functions and responsibilities as the Parties may assign from time to time.

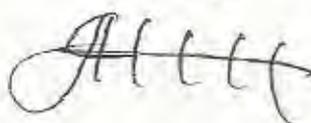
ARTICLE 5
ESTABLISHMENT OF ORGANS OF THE COMMISSION

- 5.1 In order for the Commission to discharge the functions entrusted to it, the following organs are hereby established:
 - a) The Council of Ministers;
 - b) The Technical Committee; and
 - c) The Secretariat.
- 5.2 other organs may be established as necessary

ARTICLE 6
COUNCIL OF MINISTERS

- 6.1 The Council shall comprise of at least one Minister responsible for water resources management and development from each of the Parties, and shall be the policy and decision making organ of the Commission.
- 6.2 The Council shall meet once annually in ordinary session on rotational basis in the territory of one Party and may meet in extraordinary session at the request of any of the Parties. The extraordinary session of the Council shall be held at a venue confirmed by the Executive Secretary of the Commission in consultation with the Chair.
- 6.3 The chair of the Council shall be held in turns by each Party for a period of twelve months. The first hosting country of the first ordinary session shall chair the meeting and remain chairperson until the next ordinary session.
- 6.4 The Chairperson, in consultation with the other Party or as directed by the Council may invite observers to observe the Council meetings whenever deemed necessary.
- 6.5 Decisions of the Council shall be by consensus and shall be recorded in writing.

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6.6 The Council shall adopt its own rules of the procedure.

ARTICLE 7
FUNCTIONS AND POWERS OF THE COUNCIL

7.1 The functions of the Council shall be to:

- a) adopt policies and decisions and provide other necessary guidance on the promotion, support and coordination of the effective management, sustainable development, reasonable and equitable utilisation of the water resources of the Cuvelai Watercourse;
- b) oversee the implementation of the plans, programmes and projects of the Commission;
- c) approve the budgets of the Commission;

7.2 The powers of the Council shall be to:

- a) appoint an Executive Secretary of the Commission;
- b) appoint the members of the Technical Committee;
- c) conclude agreements with the Parties, and / or on behalf of the Parties, enter into agreements or any other arrangements with other States, institutions or international organisations;
- d) allow representatives of non-Parties or international organisations to attend its meetings as observers and determine the terms and conditions for such attendance;
- e) evaluate programmes and projects with regard to the Cuvelai Watercourse and where necessary conduct or commission studies for purposes of evaluating, harmonising or co-ordinating such programmes or projects;
- f) entertain, address and resolve differences or disputes arising in connection with the interpretation or implementation of this Agreement, referred to it by any of the Parties, the Technical Committee, the Secretariat or any Party and

make recommendations to the Parties with a view to arriving at an amicable settlement thereof;

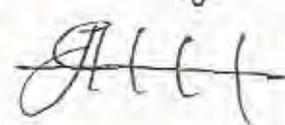
- g) appoint commissions of enquiry where necessary;
- h) decide on the course of action to be taken in the event of non-compliance with the provisions of this Agreement; and,
- i) decide on any other matter referred to it by the Technical Committee or the Secretariat.

ARTICLE 8 THE TECHNICAL COMMITTEE

- 8.1 The Technical Committee shall comprise of no more than three delegations from each Party and /or such number of advisors/experts as each Party may determine.
- 8.2 The Technical Committee shall meet once annually in ordinary session, before the ordinary session of the Council and may meet in extraordinary session at the request of the Secretariat or one of the Parties through the Secretariat.
- 8.3 The Technical Committee shall be chaired by the Parties on the rotational basis and the persons so chairing shall function in such capacities until the next annual ordinary session.
- 8.4 Decisions of the Technical Committee shall be by consensus and shall be recorded in writing.
- 8.5 The quorum for meetings of the Technical Committee shall be four members (two delegates from each Party).

ARTICLE 9 FUNCTIONS AND POWERS OF THE TECHNICAL COMMITTEE

- 9.1 The functions of the Technical Committee shall be to:
 - a) implement policies and decisions of the Council and such other tasks as may be assigned by Council from time to time;

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- d) recommend the plans, programmes and projects to be developed and implemented by the Secretariat to the Council for approval;
- e) propose the appointment of the Executive Secretary to the Council and develop the terms and conditions of his or her service or employment;
- f) recommend the annual budget of the Commission before the beginning of the financial year to the Council for approval;
- g) recommend the annual accounts of the Commission to the Council for approval;
- h) appoint independent external auditors and fix their fees and remuneration at the beginning of each financial year according to terms and conditions defined by the Council;
- i) adopt staff and financial rules, and rules of procedure for the organs of the Commission according to terms and conditions defined by the Council;
- j) determine in accordance with the financial rules, the annual contribution of each Party towards the budget of the Commission according to terms and conditions defined by the Council;
- k) develop the Strategic Plan for the Cuvelai Watercourse and present it to the Council for approval;
- l) develop and propose for consideration and approval by the Council, rules of application to facilitate Equitable and Reasonable Utilisation (ERU) of the Cuvelai Watercourse, including and not limited to:
 - i. establishing strategic hydrometric stations on the Cuvelai Watercourse to capture the relevant hydrological data;
 - ii. developing and establishing early warning systems against extreme events (floods, droughts and other disaster situations) and procedures to sound alarms for such events; and,
 - iii. instituting a monitoring mechanism for water abstractions and intra watercourse transfers;



- m) formulate recommendations on matters for decision by the Council;
- n) appoint the technical personnel of the Secretariat; and,
- o) take action on the recommendations and reports of the Secretariat.

9.2 The powers of the Technical Committee shall be to:

- a) make recommendations to the Council on the implementation by Parties of the Cuvelai Watercourse Agreement;
- b) make recommendations to the Council on the harmonisation of the water laws and policies of Parties;
- c) make recommendations to the Council on the definition by Parties of the role and position of the Public in respect of the planning, utilization, development, protection and conservation of the Cuvelai Watercourse and the possible impact thereof on social and cultural heritage matters;
- d) establish ad hoc or standing working committees, comprising representatives from Parties as may be necessary for the implementation of this Agreement;
- e) make recommendations to the Council on the standardised methodology to be adopted by Parties for collecting, processing and disseminating data and information with regard to all aspects of the Cuvelai Watercourse;
- f) make recommendations to the Council with regard to contingency plans by Parties for responding to emergency situations;
- g) draft rules of the procedure for organs of the Commission for approval by the Council; and,
- h) assign tasks to, and supervise the Secretariat.

ARTICLE 10 THE SECRETARIAT

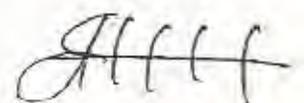
10.1 The Secretariat shall comprise:



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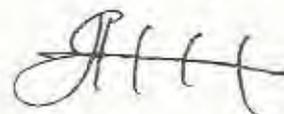
- a) the Executive Secretary;
 - b) such number and categories of technical personnel as may be approved from time to time by the Council; and,
 - c) such number and categories of supporting administrative personnel as may be approved from time to time by the Council.
- 10.2 The Executive Secretary, the technical and administrative personnel shall possess appropriate qualifications and experience.
- 10.3 The appointment of the Executive Secretary, technical and administrative personnel shall satisfy the requirements for equitable representation of the Parties and a fair gender balance.
- 10.4 The Secretariat shall be headed by the Executive Secretary who shall be appointed for period of four years and may be re-appointed for further period not longer than four years each.
- 10.5 The Executive Secretary shall:
- a) appoint the supporting administrative personnel of the Secretariat in accordance with the procedures and the terms and conditions of service determined by the Council;
 - b) prepare and submit the annual budget to the Technical Committee for its consideration and recommendations to the Council;
 - c) prepare and submit a Strategic Plan to the Technical Committee for its consideration and recommendation to the Council;
 - d) prepare and submit annually to the independent external auditors appointed by the Technical Committee the books and accounts of the Commission;
 - e) prepare the ordinary and extraordinary meetings of the Council and the Technical Committee;
 - f) report annually to the Technical Committee on its activities as well as the programmes and projects planned, initiated or executed;



- g) be responsible for the effective and efficient functioning of the Secretariat as administrative head; and,
- h) perform all such other functions as the Council or the Technical Committee may from time to time assign.

10.6 The Secretariat shall:

- a) be responsible for the day-to-day administration of the Commission;
- b) provide technical and administrative services to the Council under the Technical Committee's supervision;
- c) facilitate the development of a Strategic Plan, annual work programme, plans, studies, assessments and other documents required for the implementation of this Agreement for the approval of the Technical Committee;
- d) collect, obtain, collate and evaluate data and information with regard to all relevant aspects of the Cuvelai Watercourse as well as disseminate all such data and information to the Parties;
- e) institute research and training programmes aimed at the sustainable utilization, protection and management of the Cuvelai Watercourse;
- f) advise Parties on the planning, utilization, development, protection and conservation, of the Cuvelai Watercourse as well as the role and position of the Public with regard to such activities and the possible impact thereof on social and cultural heritage matters;
- g) advise the Council and the Technical Committee on the listing and the effects of substances, the introduction of which into the Cuvelai Watercourse shall be prohibited, limited, investigated or monitored by Parties, and provide guidelines for their mitigation;
- h) on the request of one of the Parties and subject to the approval of the Council, plan and implement development programmes or projects with regard to the Cuvelai Watercourse;



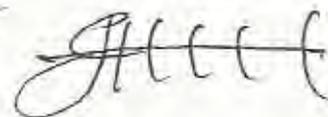
- i) develop and distribute programmes and materials aimed at fostering greater awareness among the inhabitants of the Cuvelai Watercourse on the equitable and reasonable utilization of the Cuvelai Watercourse;
- j) co-operate with the institutions of SADC and others as necessary and provide such data and information as may be reasonably required and be requested by such institutions;
- k) obtain financial and technical support for the implementation of programmes, plans and projects necessary for the achievement of the objective of this Agreement in accordance with the guidelines and directives provided by the Council from time to time;
- l) implement the decisions of the Council and of the Technical Committee;
- m) make recommendations to the Technical Committee on the harmonisation of the national water policies and laws of the Parties; and,
- n) perform all such other functions as the Council or the Technical Committee may from time to time assign.
- o) the Secretariat shall be the depository of all records and decisions of the Commission.

ARTICLE 11 OBLIGATIONS OF THE PARTIES

- 11.1 The Parties shall give their full co-operation and support (including technical, administrative and financial) to the implementation of this Agreement and the Commission established hereunder.
- 11.2 The Parties shall, in their respective territories, utilise the resources of the Cuvelai Watercourse in an equitable and reasonable manner with a view to attaining optimal and sustainable utilisation thereof, and benefits therefrom, consistent with adequate protection of the Cuvelai Watercourse. The term "equitable and reasonable" shall be interpreted in line with the SADC Protocol.
- 11.3 The Parties shall, in utilising the resources of the Cuvelai Watercourse in their territories, take all appropriate measures to prevent the causing of significant harm



- to other Party. The term "significant harm" shall be interpreted in line with the SADC Protocol.
- 11.4 The Parties shall exchange available information and data regarding the hydrological, hydrogeological, water quality, meteorological and environmental condition of the Cuvelai Watercourse.
- 11.5 A Party planning any project, programme or activity with regard to the Cuvelai Watercourse which may have a significant adverse effect upon the other Party, or which may adversely affect such Cuvelai Watercourse, shall forthwith notify the Commission and provide all available data and information with regard thereto.
- 11.6 Unless otherwise agreed, a Party notified as contemplated in Sub-article 11.5 of this Agreement, shall communicate its reply to the notifying Party within six months.
- 11.7 In the event that the implementation or execution of any planned measures is of the utmost urgency in order to save life, or to protect public health and safety, or other equally important interests as a result of an emergency situation, the Party planning the measures may immediately proceed with implementation or execution; provided that in such event a formal declaration of the urgency of the measures shall be communicated to Commission.
- 11.8 If so requested by an affected Party or technical experts or consultants appointed by the Commission, a Party shall provide the other Party, as well as the technical experts and consultants, with data and information that are available or obtainable on any planned project, programme or activity which may have a significant adverse effect upon the affected Party.
- 11.9 For the purposes of this Article, information in respect of a planned project, programme, or activity which may have a significant adverse effect upon another Party, or which may adversely affect the Cuvelai Watercourse, shall include the findings of an environmental impact assessment addressing the effects on the ecosystems of the watercourse as well as the social, cultural, economic and natural environment.
- 11.10 If a Party has reasonable grounds to believe that the other Party is planning a project, programme or activity which may have a significant adverse effect upon it, such Party may request the other Party planning the project, programmes or activity to comply forthwith with the provisions of Sub-article 11.5. The request shall be accompanied by a documented explanation setting forth its grounds.



- 11.11 The Parties shall employ their best efforts to collect and, where appropriate, to process data and information with regard to the Cuvelai Watercourse, in a manner which facilitates its utilisation by the other Parties, technical experts or consultants who may be appointed by the Commission. The Parties shall make every effort to employ a standardised form for collecting, processing and disseminating data and information, as appropriate.
- 11.12 The Parties shall individually and jointly take all measures that are necessary to protect and preserve the Cuvelai Watercourse from its sources and headwaters to its common terminus.
- 11.13 The Parties shall individually and jointly prevent, reduce and control pollution of the Cuvelai Watercourse that may cause significant harm to the Parties, including harm to the environment, or to human health or safety, or to the ecosystem of the Cuvelai Watercourse.
- 11.14 The Parties shall take all measures necessary to prevent the introduction of species, alien or new, into the Cuvelai Watercourse that may have a detrimental effect to the ecosystem of the watercourse.
- 11.15 If the Parties agree to co-operate in the planning of a project, programme or activity with regard to the use of the Cuvelai Watercourse, either jointly or by way of a continuous exchange of available data and information, and communicate timeously their respective evaluations and findings on the data and information, any specific periods of notification and reply with regard to the projects, programmes or activities shall only apply to the extent agreed to by the Parties.

ARTICLE 12 EMERGENCY SITUATIONS

- 12.1 For the purposes hereof, "emergency" means a situation resulting suddenly either from natural causes or from human conduct and causing or posing an imminent threat of causing serious harm to the Cuvelai Watercourse or to a Party or Parties and requires immediate action or attention of a Party or the Parties.
- 12.2 A Party shall, without delay and by the most expeditious means available, notify and promptly supply all the necessary information to the other Parties as well as the Secretariat of any emergency originating within its territory or known by it or effecting it (irrespective of the origin).



- 12.3 A Party within whose territory an emergency originates shall, in co-operation with potentially affected Parties and, where appropriate, the Secretariat, immediately take all practicable measures necessitated by the circumstances to prevent, mitigate and eliminate harmful effects of the emergency.
- 12.4 The Parties shall individually and/or jointly develop contingency plans for responding to emergencies in co-operation, where appropriate, with the Secretariat and competent institutions and international organisations.

ARTICLE 13 SETTLEMENT OF DISPUTES

- 13.1 Any dispute concerning the interpretation or implementation of this Agreement shall be settled amicably through consultation and negotiations between the Parties.
- 13.2 A Party that considers there to be a dispute has an obligation to notify the other Party that it is declaring a dispute.
- 13.3 Where a dispute has not been settled within one year from the date upon which consultations were requested, the Parties shall refer the matter for mediation.
- 13.4 The Mediator shall be appointed by agreement between the Parties within three months after the said year had elapsed.
- 13.5 If no agreement can be reached between the Parties about the appointment of the Mediator, a Tribunal will be appointed
- 13.6 The Tribunal shall comprise three members, namely
- a) One person appointed by each one of the Parties plus one other person, jointly nominated by the two appointed members, to chair the Tribunal.
 - b) Should any one of the Parties fail to appoint a person to the Tribunal within three months, the other Party may request the President of the SADC Tribunal to appoint a person within two months of receiving the request, on behalf of the Party who failed to appoint a person.
 - c) If the two persons appointed to the Tribunal fail to nominate a third person, and after a period of not more than one month has elapsed since their

appointment, the Parties will jointly request the President of the SADC Tribunal to appoint a third person within two months of receiving the request.

- 13.7 The members of the Tribunal shall decide about the rules of procedure to be followed by the Tribunal.
- 13.8 The decision(s) of the Tribunal, both on procedures and substance, shall be taken by a majority vote of its members.
- 13.9 If the Parties do not agree on the subject matter of a dispute, the Tribunal shall determine the subject matter.
- 13.10 The Tribunal may, at the request of any one of the Parties, recommend interim measures of protection.
- 13.11 The Tribunal shall render its decision(s) in accordance with the provisions of this Agreement, and the interpretation of International and Regional Water Law.
- 13.12 The decision(s) of the Mediator or the Tribunal shall be submitted in writing to the Parties and shall be signed by the Mediator or all the members of the Tribunal, as the case may be.
- 13.13 The decision(s) of the Mediator or the Tribunal, as the case may be, shall be final and binding upon the Parties.
- 13.14 The Mediator or the Tribunal, as the case may be, shall determine the distribution of the costs of the arbitration between the Parties. The Parties shall bear the cost on the Mediator or the Tribunal on equal basis.

ARTICLE 14 EXISTING SHARED WATERCOURSE AGREEMENTS

The existing Agreements between Angola and Namibia on water related matters will remain in force as far as they are not in conflict with this Agreement.



ARTICLE 15
FINANCIAL ARRANGEMENTS

- 15.1 Each Party shall in respect of all meetings of the Commission be responsible for all costs incurred in connection with the attendance and participation of its delegation and of any person included in its delegation as an adviser.
- 15.2 The budget of the Commission shall be drawn from annual cash contributions by Parties; donations, grants and loans from bilateral and multilateral organizations; funds raised internally; and other sources of funding agreed to by the Council.
- 15.3 The contributions of the Parties to the ordinary budget of the Commission shall be determined by the Council.
- 15.4 Unless specified by the Council, contributions by the Parties to projects implemented by the Commission could either be in cash or in kind. In kind contributions include: staff time, experts, training facilities, services, office accommodation and equipment or any other contributions as may be agreed by Council from time to time.

ARTICLE 16
ASSETS

- 16.1 Property, both movable and immovable, acquired by or on behalf of the Commission, wherever their location, shall constitute the assets of the Commission.
- 16.2 Property acquired by any of the Parties, under the auspices of the Commission, shall belong to the Party concerned, but shall be accessible to the Commission and the Parties on an equitable basis.

ARTICLE 17
LANGUAGE

The working language of the Commission shall be English and Portuguese.

ARTICLE 18
SIGNATURE

This Agreement shall be signed by duly authorised representative of the Parties.



**ARTICLE 19
RATIFICATION**

This Agreement shall be ratified by the Parties in accordance with their respective constitutional procedures.

**ARTICLE 20
ENTRY INTO FORCE**

This Agreement shall enter into force thirty (30) after the date on which the last Party has notified the other Party through the diplomatic channel of its compliance with the constitutional requirements necessary for the implementation thereof.

**ARTICLE 21
AMENDMENTS**

This Agreement may be amended by mutual agreement between the Parties and the modifications shall become effective on the date of the exchange of the appropriate diplomatic instruments.

**ARTICLE 22
MISCELLANEOUS**

In case of doubts and omissions in the interpretation and implementation of this Agreement, the Parties will refer to the revised SADC Protocol on Shared Watercourses of 2000, as well as the rules of the UN Convention on the Law of Non-Navigational Uses of International Watercourses of 1997.

**ARTICLE 23
DISSOLUTION**

- 23.1 The Council may decide by a resolution supported by the two Parties to dissolve CUVECOM or any of its organs and determine the terms and conditions for dealing with its liabilities and the disposal of its assets.
- 23.2 Notification of a proposal to dissolve CUVECOM shall be given by the Party wishing to make such a proposal at least six (6) months prior to submitting it to the Council. The Council shall not decide on such proposal until a period of at least twelve (12) months has elapsed after the proposal has been submitted to it.

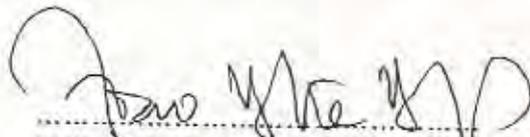


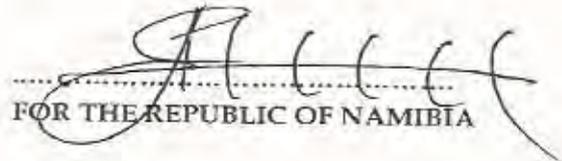
ARTICLE 24
DEPOSITARY

- 24.1 The original of this Agreement and all instruments of ratification and accession shall be deposited with the Secretariat, who shall transmit certified copies to all the Parties.
- 24.2 The Secretariat shall register this Agreement with the Executive Secretary of SADC Secretariat.

IN WITNESS HEREOF the undersigned representatives, being duly authorized by their respective Governments, have signed and sealed this Agreement in four original texts, two text in the English language and two text in the Portuguese language, all texts being equally authentic.

DONE at.....WINDHOEK on this 16th day of SEPTEMBER 2014


.....
FOR THE REPUBLIC OF ANGOLA


.....
FOR THE REPUBLIC OF NAMIBIA

Appendix A2

Example Terms of Reference for the Cuvelai River Basin Stakeholder Forum

A3.0 **STAKEHOLDER FORUM TERMS OF REFERENCE**

- PURPOSE:** The general purpose of the Stakeholder Forum is to ensure that.....
- DUTIES:** The Stakeholder Forum exists to:
-
- The forum will also oversee the operation of a number of specialist groups and their role will include:
-
- ACCOUNTABILITY:** The Stakeholder Forum is accountable to
- LEADERSHIP:** The forum has an elected Chair and Vice Chair to provide leadership to the forum. The Chair and Vice Chair will be elected by the forum members, through a vote, on a bi-annual basis.
- MEMBERSHIP:** The following will comprise membership of the Stakeholder Forum:
-
- Each member organisation will be invited to send a representative, who will articulate the views of their stakeholder community. Representation will be reviewed every 2 years. Deputies can attend though they must be suitably briefed and the XXX notified in advance.
- INVITED TO ATTEND:** In addition to the members of the Stakeholder Forum, it may be appropriate to invite subject matted experts to provide advice, support and information.
- DECLARATION OF INTERESTS:** Everyone in attendance at the Stakeholder Forum must declare any actual or potential conflicts of interest; these shall be recorded in the minutes. Anyone with a relevant or material interest in a matter under consideration must be excluded from the discussion; this shall also be recorded in the minutes.
- MEETING FREQUENCY:** Meetings shall be held
- MEETING ORGANISATION:**
- Meetings of the Stakeholder Forum shall be set before the start of the financial year;
 - Meeting administration and secretariat support will be provided by the
 - The draft agenda shall be compiled by the meeting administrator and the Chairman in advance of the meeting;
 - All final papers/reports must be submitted to the meeting administrator 7 days in advance of the meeting;
 - The agenda and supporting papers shall be forwarded to each member of the Stakeholder Forum and planned attendees or invitees 7 days in advance of the meeting;

- The meeting administrator will prepare an attendance register for each meeting and ensure that the attendance/non-attendance of all individuals is correctly recorded at each meeting.

REPORTING:

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**STANDING AGENDA
ITEMS:**

Welcome remarks
Introductions
Election of a chair
Identification of rapporteur
Review of minutes from previous meeting
Review of Agenda
Technical Reports
Resolutions
Closing
Identification of the next meeting date
Identification of the next meeting host

**REVIEW OF TERMS OF
REFERENCE:**

Every year, the Stakeholder Forum will conduct a review of its purpose and effectiveness, including compliance with its Terms of Reference, and propose any adjustments which may be required.

Appendix A3

Indicators for Gender Disaggregated Water Data Collection

Indicator	Sub-indicator
1. Water governance	
1.a	Number of Male/Female (M/F) paid staff in public water governance agencies, disaggregated by job category/level and decision-making capacity (and salary if available), at: national level; county/province/state level; town/village level (sample)
1.b	Number of M/F in paid and unpaid positions in local water governance formally structured entities (water users associations, etc.) at town/village level (sample); disaggregated by nature of relationship to the entity (e.g. "member", "board", "executive", "leadership", decision-making group, etc.) and types of tasks
1.c	Intensity of M/F in (sample/representative) meetings of public entity bodies sampled at national, sub-national, and local levels, including outcomes such as: ratio of contributions in decision-making meetings by women and men; percentage of decisions adopted from women's contributions in meetings
1.d	M/F perceptions of gender discrimination (or equality) regarding women's participation in decision-making entities
1.e	Number of M/F staff responsible for water issues (disaggregated by job level) in gender ministry/lead agency
1.f	Number of M/F staff responsible for gender issues (disaggregated by job level) in lead and other relevant agencies for the water sector
1.g.	Designated ministerial responsibility for gender in relation to water policies; the extent to which gender-specific agencies are included in water sector decision-making
1.h.	Presence and nature of gender sensitive training within responsible ministries/lead agencies. Participation of M/F staff
1.i.	The extent to which gender outcomes and gender-sensitive accountability indicators are included in Monitoring and Evaluation (M&E)/impact statements/benefits analyses of national-level Water, Sanitation and Hygiene (WASH)-sector projects (project proposals and/or outcomes assessments). Sample projects
1.j.	The presence and nature of gender-specific objectives and commitments (or gender strategy) in national and sector-level water policies.
1.k.	The nature and extent of gender-disaggregated data related to water and sanitation collected by responsible public entities at national and local levels (in relation to the totality of social indicators on water and sanitation collected).
2. Safe drinking water, sanitation and hygiene	
2.a	Percentage of households without water on premises, by sex of main person responsible for collecting drinking water and by type of household (using rural/urban sample)
2.b	Unpaid time spent by individual household members in supplying water, making it safe for use, and managing it (M/F informants)
2.c	M/F perceptions of the adequacy of current water supply/availability in both quality and quantity in the household
2.d	Percent households with access to "improved" sanitation facility, by household structure and by nature of "improved" facility
2.e	Intra-household M/F use of /access to improved sanitation facilities
2.f	M/F prioritisation of gaining access to improved sanitation facilities; willingness to allocate household budgets for such access
2.g	M/F perception of the safety of sanitation facilities that are located outside the house; identified particular safety concerns
3. Decision-making and knowledge production	
3.a	M/F participation in past decade of two major global international water meetings (and nationally significant comparable meetings): World Water week (Stockholm); World Water Forum (World Water Council); (could be topic specific or region specific)

3.b	M/F inclusion on nationally and internationally convened scientific panels and advisory boards
3.c	Gender audit of World Health Organisation/United Nations Children's Fund (WHO/UNICEF) Joint Monitoring Programme (JMP). (could be topic specific or region specific)
3.d	M/F perceptions of/knowledge of current total household use of water, by category of use and by primary use
3.e	Household member primarily responsible for managing the household water: M/F perceptions of the nature of their household decision-making process of water priorities and use M/F perceptions of the primary decision-maker on water issues within the household (if any) M/F perceptions of how intra-household conflicts related to water (if any) are resolved
3.f	M/F expressed priorities for water use within households
3.g	M/F perceptions of household gender equality in water decisions
4. Transboundary water resources management	
4.a	Number of M/F staff on transboundary water commissions (sample for pilot countries), disaggregated by job category/level and decision-making capacity (and salary, if available)
4.b	The extent to which gender outcomes and gender sensitive accountability indicators are included in M&E/impact statements/benefits analysis of transboundary agreement/ activities
4.c	The presence and nature of gender-specific objectives and commitments (or gender strategy) in transboundary agreements
4.d	Intensity of M/F participation in (sample/representative) meetings of transboundary meetings, including outcomes such as: ratio of contributions in decision-making meetings by women and men; percentage of decisions adopted from women's contributions in meetings
5. Water for income generation for industrial and agricultural uses, including unaccounted-for labour	
5.a	% irrigated farms in region under survey; % irrigated farms managed by/owned by M/F
5.b	Average size of irrigated farms run by/owned by women/men
5.c	Gendered division of labour related to irrigated farming: gender-specific tasks related to irrigated crops, by nature of tasks; gender differentiated daily time-use of household members involved in irrigated farming work
5.d	Decision-makers and participants in household-based decision-making process regarding irrigation (M/F informants/perception); decisions regarding allocation of time and financial resources; crops to be irrigated
5.e	Decision-makers and participants in community-based decision-making process (if any) regarding irrigation (M/F informants/perceptions); decisions regarding allocation of time and financial resources; crops to be irrigated
5.f	M/F perceptions of gender discrimination (or equality) regarding women's participation in decision-making in relation to irrigation
5.g	M/F access to support services for irrigation; participation in technical training; M/F access to bank loans/credit; and incentives for the development of irrigated agriculture
5.h	M/F membership in and intensity of participation in community-based irrigation communities
5.i	% of directly water-related industries managed by/owned by M/F
5.j	% M/F employees in water-related industries
5.k	Presence of women's cooperatives in water-related industries