ZAMCOM Poverty Vulnerability Mapping: Method, Vulnerability Zones, Hotspots and Typologies

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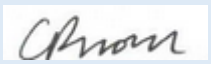
Responsible Person	Task	Date	Signed
Maryna Storie Caroline Brown Kathleen Godfrey	Lead Author(s)	April 2019	
Caroline Brown	CRIDF QC	April 2019	
Andrew Takawira	CRIDF QA		
Charles Reeve	CRIDF Approved		

Disclaimer

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Contents

Preface

This report presents a draft of the vulnerability zones and hotspot analyses informed by available literature and data, through the interpretation of the overlaid metadata and consultations with ZAMCOM's National Steering Committees. The content in this report also informed CRIDF's specific inputs for D5 of the ZSP.

Disclaimers

All spatial data used for analysis or maps created in this report, and all associated data is applied within the context of reasonable use. The data is used either under the principles of Creative Common License, or as free publicly available information. The author of this report does not take responsibility for any unreasonable misuse of the results.

The discussions include the best available and most recent data and information across the units. In some areas where data is not available, elements such as border permeability and natural/topographical features as well as road infrastructure is considered to determine the potential for similarity in selected features across the area, thus supporting extrapolation of unit characteristics in some instances.

The same type of information (for example cellphone coverage/Information and Communication Technology details) is not available for all units – information is therefore presented as best possible via online published reports, books and academic paper, at the time of the narratives being compiled.

1. Review Aim

Poverty vulnerability hotspot mapping assists River Basin Organisations (RBOs) with the identification of 'hotspots', where compounding socio-economic, environmental, political and climatic challenges affect the ability of communities to adapt or respond to shocks (both natural and man-made). In an effort to foster inclusive, sustainable growth in the Zambezi basin, it is critical to understand the predominant (and varying) causes behind these high levels of vulnerability – with a view to ensuring appropriate livelihood infrastructure interventions are identified, designed and implemented in response to specific, localised issues. This Annex therefore presents insight into key identified hotspots in the Zambezi basin using localised spatial data as a basis. The review considers availability of spatial data and presents a method which aims to enable effective localised hotspot characterisation, as well as options for potential intervention based on intervention typologies.

Poverty and socio-economic challenges riddle the Zambezi basin. The only areas that are relatively better off or not severely economically deprived are those in and around the cities of Lusaka, Harare, Lilongwe and Blantyre, and select pockets where large infrastructure investment or economic incentives are present, for example the Copperbelt. The rest of the basin is largely characterised by extreme poverty and high vulnerability to climate related hazards. Thus, the aim of this hotspot mapping analysis was to identify areas that are the worst off/most at risk in terms of extreme poverty.

Given the extensive poverty situation, community reliance on natural resources (such as soil, vegetation, hydrology, weather patterns, climate and rainfall) is high. This typically means where rainfall is low, rivers are seasonal and vegetation sparse, livelihood vulnerability is high and resilience to system shocks such as climate change, is low. The northern part of the basin predominantly displays a wetter (higher rainfall, more lush vegetation) climate, with lower, more variable rainfall to the south. The northern areas are therefore exposed to higher pervasiveness of deforestation, whilst the southern parts display higher prevalence of food insecurity. The typologies identified to address hotspots take these differences into consideration.

The geography across the basin (land cover, climate, weather etc), and infrastructure (for example transport, energy and water supply) differs significantly, which complicates the process of identifying hotspots across the basin in a single overview, using the same variables. To overcome this challenge, the basin was sub-divided into seven vulnerability zones that reflect similarities in environmental and socio-economic characteristics. **Annex A** contains detailed narratives on each zone, considering socio-economic, population, settlement, infrastructure and environmental data. This information in this Annex is based off of both referenced literature as well as interpretation of Spatial Metadata in **Annex B**.

Although total standardisation with regard to characteristics is not possible, and in some areas there may still be significant differences between local community physiognomies, the units reflect similarities in terms of the type of interventions that may be suitable to reduce livelihood vulnerabilities. Within each of these zones (numbered A to G in the Figure below), hotspots are indicated as areas where interventions are critically needed (from both a socio-economic and ecological sustainability perspective) and where interventions could have significant impact, given the location characteristics and typology of intervention(s) proposed.

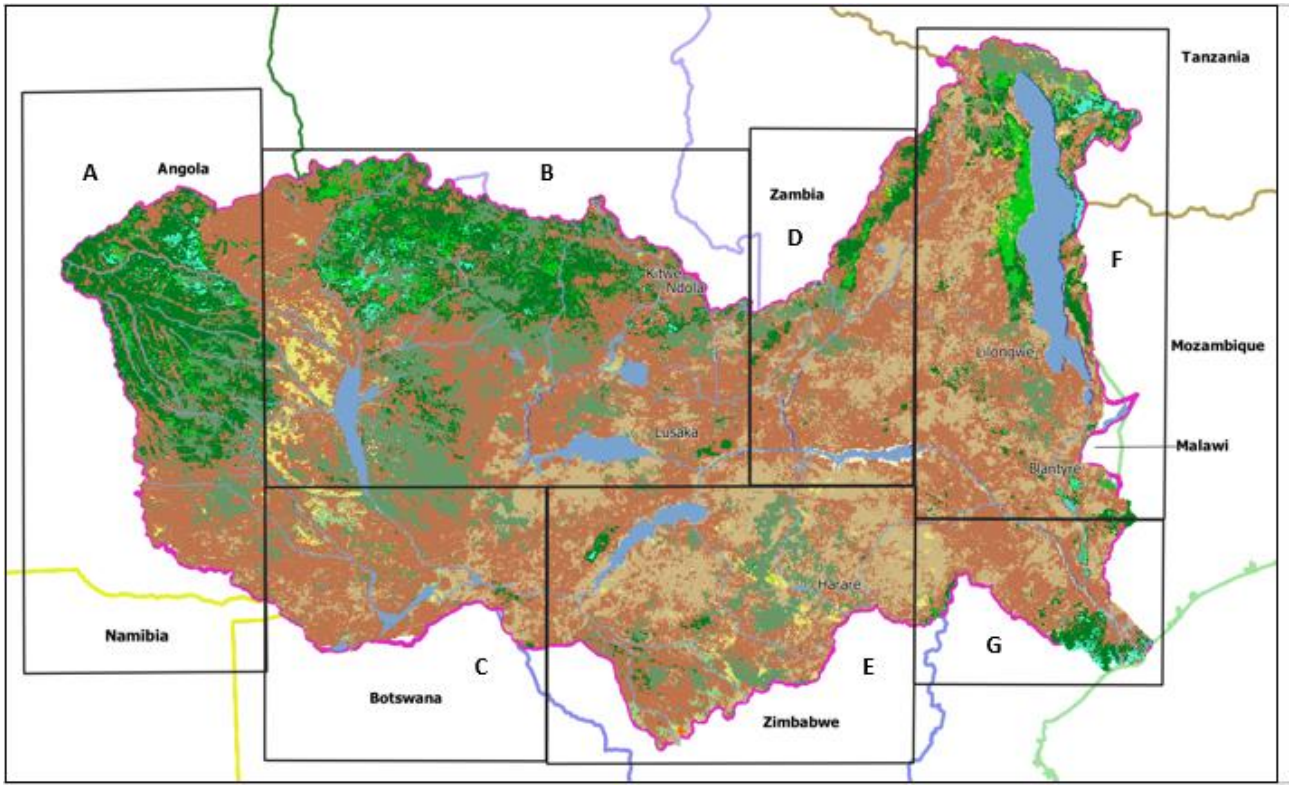


Figure 1: Zambezi basin sub-divided into zones of vulnerability, indicating land cover data as backdrop

Legend:

- Urban and Built-Up Land
- Dryland Cropland and Pasture
- Cropland/Grassland Mosaic
- Cropland/Woodland Mosaic
- Grassland
- Shrubland
- Savanna
- Deciduous Broadleaf Forest
- Evergreen Broadleaf Forest
- Mixed Forest
- Water Bodies
- Herbaceous Woodland
- Barren or Sparsely Vegetated

2. Method

The hotspot identification process included the following activities:

1) Data layer identification and download/collation in a GIS.
2) Vulnerability zone analysis: The identification of hotspots emanated from first achieving a regional overview of the Zambezi basin pertaining to livelihood vulnerabilities (as presented in the above Figure). It enabled the development of large-scale vulnerability zonation and the description of associated narratives across the basin, based on recent and accessible publicly reported data which is available for each member state in the basin.

3) Data layer selection: Including overlay testing based on criteria such as availability, usability, applicability and recency (based on the discussion of Data layer selection in Section 3 hereafter).
4) Hotspot mapping overlay (using the final selected layers).
5) Qualitatively describing the characteristics of identified hotspots, noting that the drivers of poverty may differ between vulnerability zones.
6) Characterisation of livelihood typologies, including a matrix of hotspots vs options for intervention.

The details hereafter present the outcomes of the method followed above, excluding activities 1 and 2 which were preparatory to activities 3 to 6.

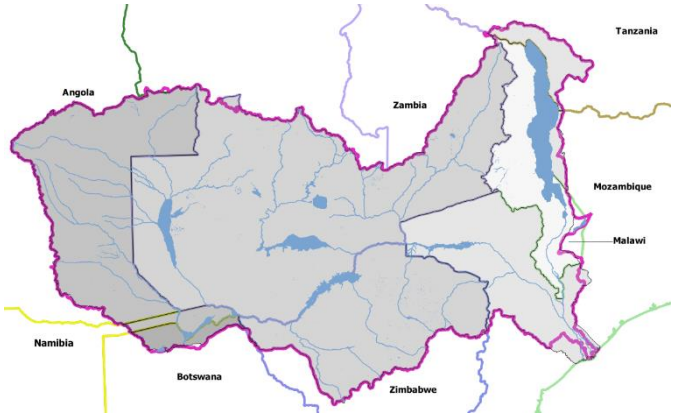
3. Spatial data layer selection

Hotspot mapping (also referred to as 'site selection') is a commonly applied approach to development intervention strategies worldwide and can be done in a number of ways – there is no single approach or standardised method nor international or standardised agreement on which data sets or spatial data layers should be used to develop the layer overlays. Much of the non-standard approaches that are applied relate to the differences in raw data, which enables (or in some cases hampers) the hotspot identification. In essence, the hotspot mapping process relies on spatial data factors in order to be accurate and reflective of real life and when these items are easily accessible, and the resultant data are of high quality, a suitable and effective hotspot mapping method results:

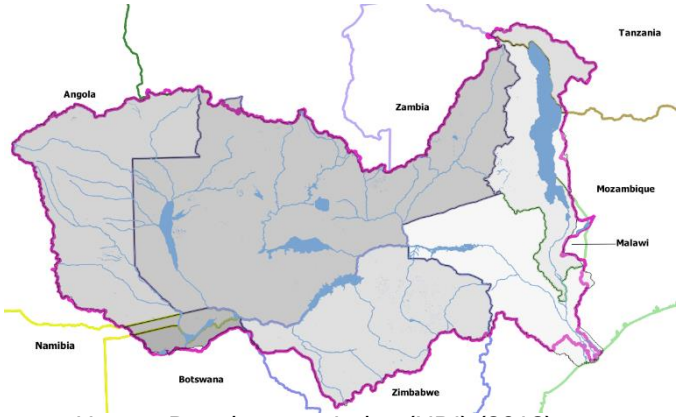
- Data completeness over the study area: Over large geographic areas and especially when considering cross-boundary spatial data, there may be gaps in data sets, where some areas or countries' data is not collected or not available. For example, there is detailed spatial data available for poverty in Malawi and Tanzania, but not for other member states. Thus, this detailed data has to be considered separately for the areas where it is available and cannot be used as a basin-wide layer.
- Data recency/age and timeliness or frequency of update: Although geological and topographical data does not alter significantly over time, other data sets such as demographics, health statistics and environmental baseline information may change reasonably often over the course of five to ten years. There is then a decision to be made as to whether to include or exclude a particular spatial data layer when developing hotspots – usually based on the perceived change that may have taken place over time since the data was captured.
- Aggregation/averaging of data over geographic areas: Some data sets, such as GDP, Total Population, or Human Development Index, are excellent to identify large-scale regional differences between member states. However, these data sets do not lend themselves to small-scale hotspot mapping or identification.
- Representativeness that enables the use of data that may be locally applicable, as proxy data for non-available or non-usable data layers. An example is where data related to health or schools may be used as proxy for non-locally available human development index data.
- Cross-boundary alignment: Often, good and small-scale data may be available at local level, however when working across country borders, the collection parameters for data may not be the same. This brings misalignment of data sets at borders of countries or regions even when data is available across the entire basin area – an example being malaria incidence, which differs in collection method and accuracy between countries, thus creating artificial 'lines' in the data viewed in maps. In this instance, the inclusion or exclusion of the data layer may be decided based on the severity of the difference, or the ability to 'rubbersheet' or generalise the data so that it is applicable to the purpose of the study.
- Format and physical size: Formatting of data has become easier as cross-software/cross-platform integration has improved. However, the time it takes to download data from original sources, reformat or transform the data to make it usable needs to be considered. For example: Bare soils data is known to be available for the Zambezi basin, however with the raw data consisting of over 74 individual satellite image base files that have to be downloaded, merged and interpolated, the time it requires reduces the opportunity to include the data in the hotspot analysis.

- Projection and datums: When working across RBOs, especially when it spans multiple latitudes (time zones), a decision has to be made as to which projection to use. The projection that is used has impacts on for example area (size of measured polygons) and length, since different projections distort area and length in different manners. In this study for example, geographic data is presented (i.e. no projection applies), however that tends to impact the boundaries of areas that may be delineated on in the GIS as 'boxes' with 90 degree corners, to display a 'uneven' boxed areas in map representations.

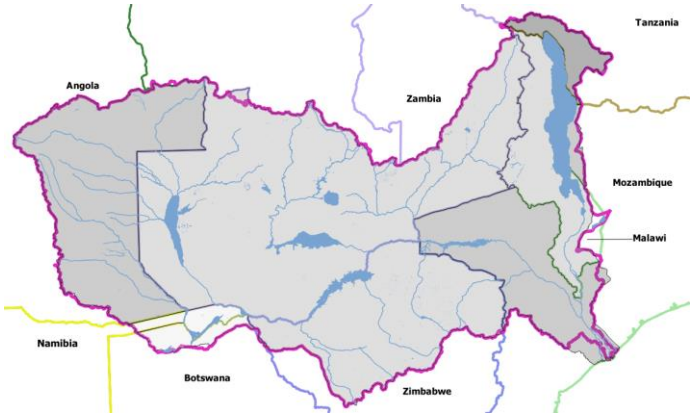
Examples of data available, not applicable and applicable to use for this project purpose are provided below:



Gross Development Product (GDP) (2013)



Human Development Index (HDI) (2013)



Total Population (2013)

Figure 2: GDP (2013), HDI (2013) and Total Population (2013): examples of national averaged data sets that are not suitable to use in localised hotspot identification

This study uses global 2005, population estimates for the hotspot identification process. More recent data is not yet available for use in the analysis, at a localised level.

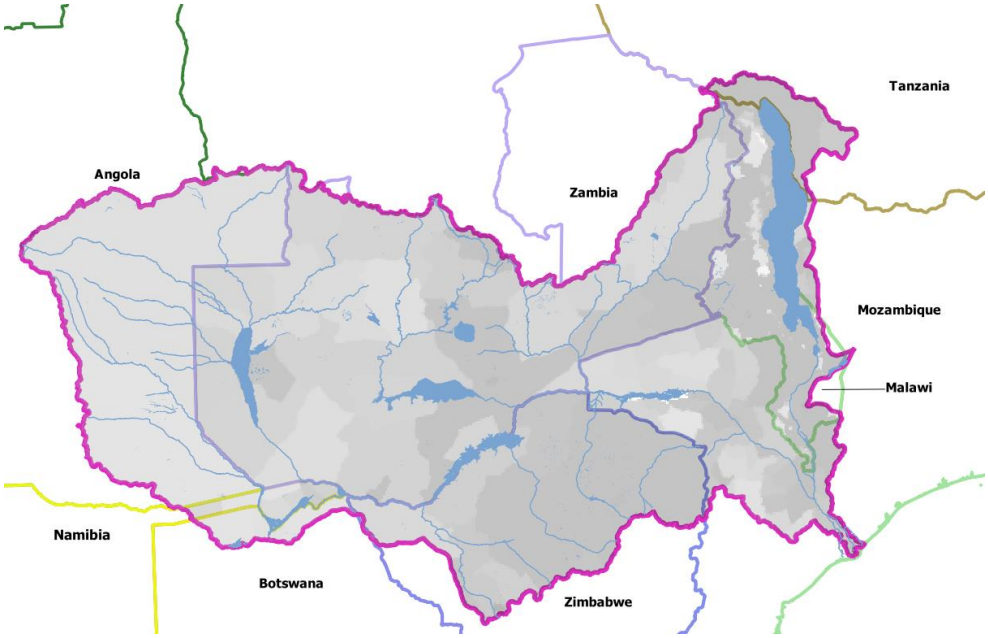


Figure 3: Population density (2005)

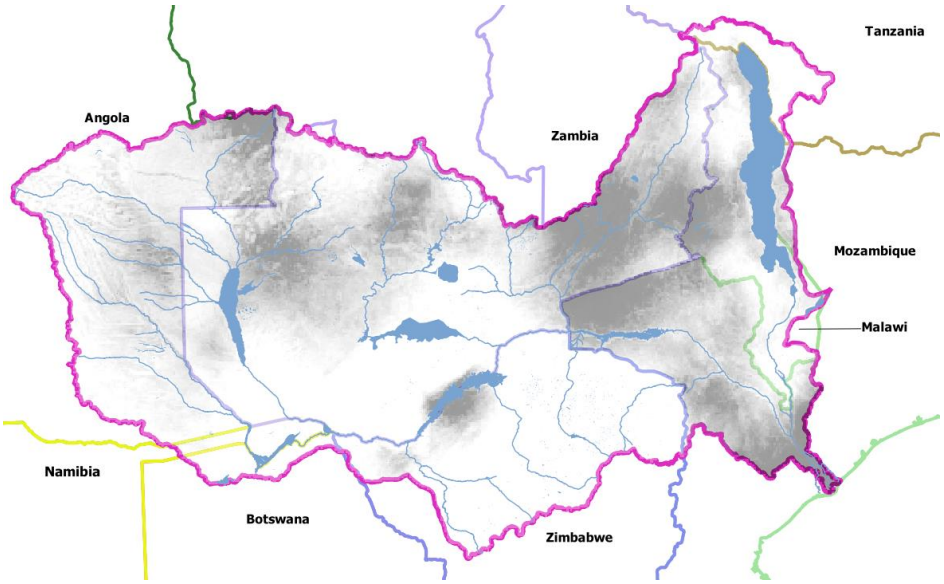


Figure 4: Malaria incidence (2015), showing differences in data collection and resultant views between member states

Source: The Malaria Atlas project (2015)

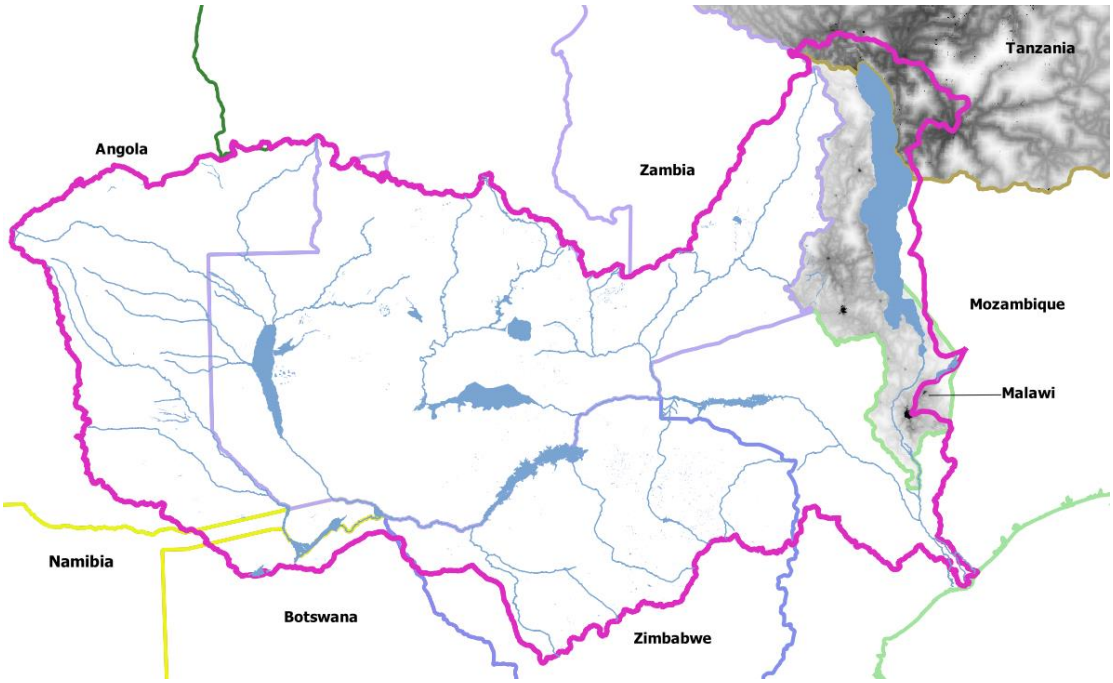


Figure 5: 1km scale Poverty data – only available for Malawi and Tanzania

Source: http://www.afripop.org (2013)

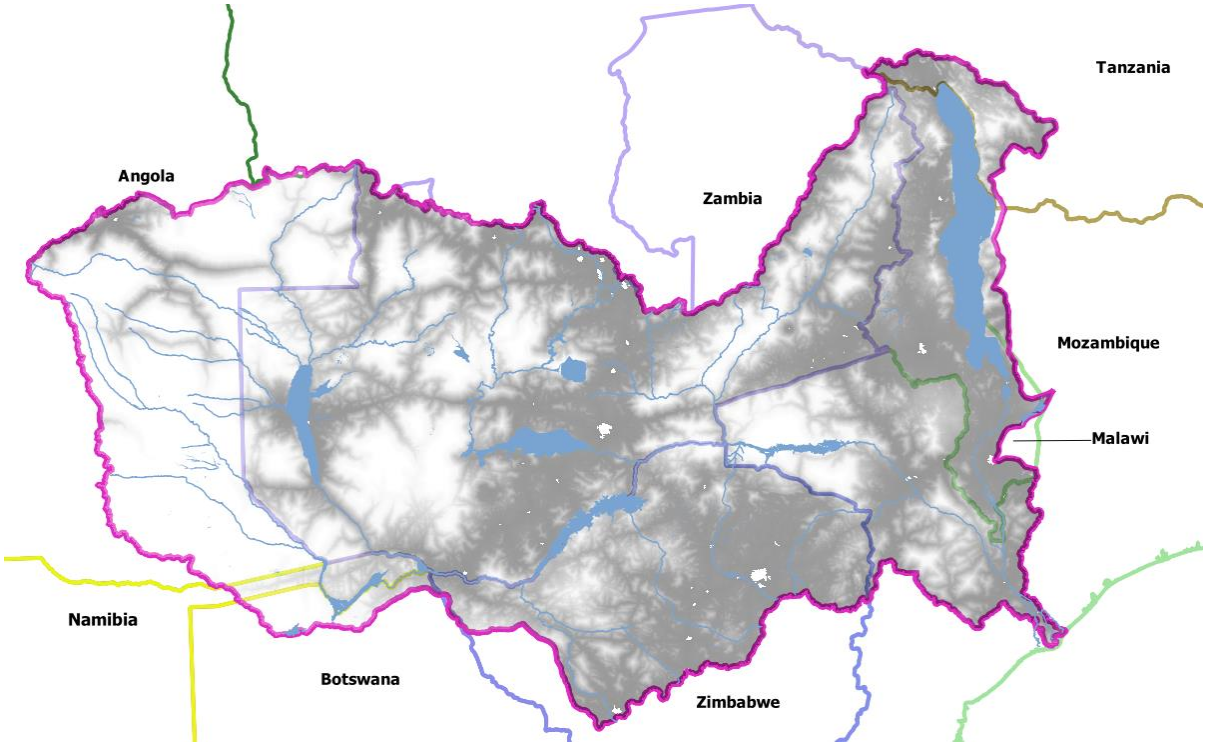


Figure 6: An indication of poverty (by lack of other available data): Market access (low access to markets meaning these areas are hotspots)

Source: The Malaria Atlas project (2015)

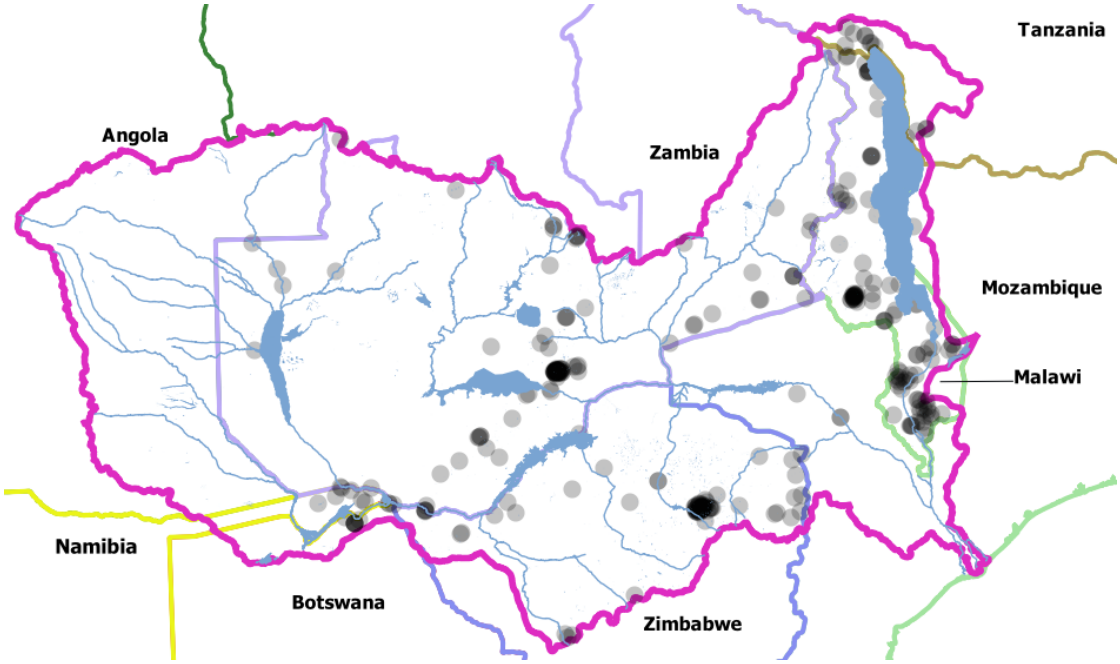


Figure 7: An indication of poverty (by lack of other available data): Clinic and Hospital locations (areas far away from these locations are hotspots)

4. Hotspot mapping overlay

The Hotspot identification was done based on integration of the following available, applicable and usable spatial data layers:

- Population density (2005)
- Proxy for Human Development Index (HDI): Health (malaria prevalence areas as hotspots)
- Proxy for Poverty and HDI: access to clinics (where there are no hospitals or clinics, the areas can be considered hotspots)
- Proxy for Poverty: Market access (low access meaning these areas are hotspots)
- Proxy for HDI: Public violence (areas of high violence incidences are hotspots)
- For Malawi and Tanzania: Poverty (with high poverty/low income as hotspots)
- Forest loss (2000 – 2016)

5. Hotspot characteristics

Hotspots were initially identified solely through the above-described mapping overlay and desk-based analysis. Thereafter, an extensive country consultation process was conducted with representatives from key sectors from each Riparian State. Through this in-country stakeholder engagement and interactive groupwork mapping exercises, feedback and additional insights regarding the vulnerability zones and hotspots was collected. This process not only validated CRIDF's desk-based findings - where broad consensus of the hotspots was reached in each country - but importantly, provided more detailed information on localised issues that could not be identified through CRIDF's prior desk-based analysis and mapping. The hotpots are indicated in Figure 8.

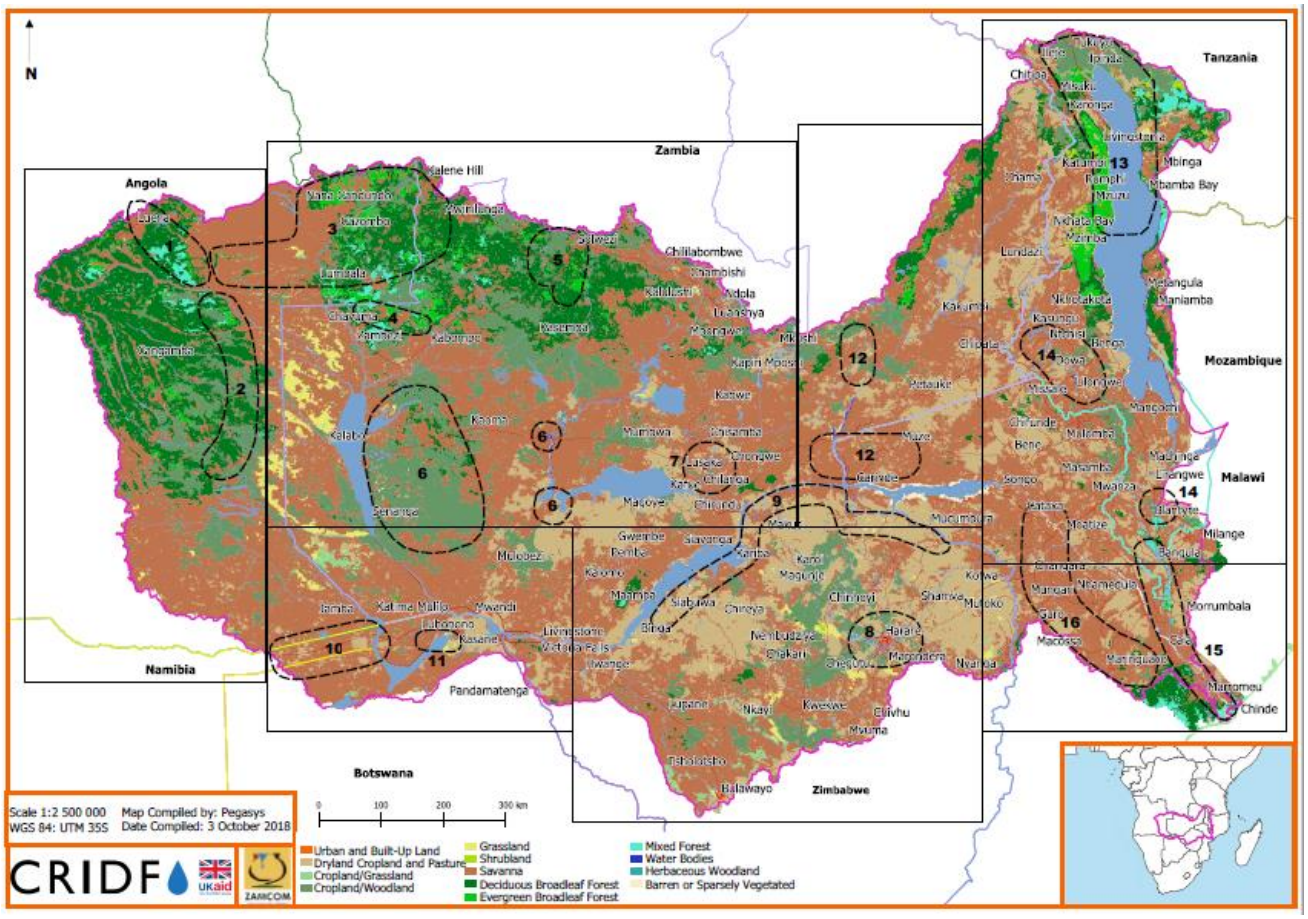


Figure 8: Vulnerability Zone Delineations, with Hotspots Indicated (landcover background)

It should be noted that these hotspot boundaries are porous and have been delineated based on CRIDF's interpretation of the national stakeholder's feedback. The following sub-sections present an explanation of characteristics that define the drivers that prioritise a given location or area as a hotspot:

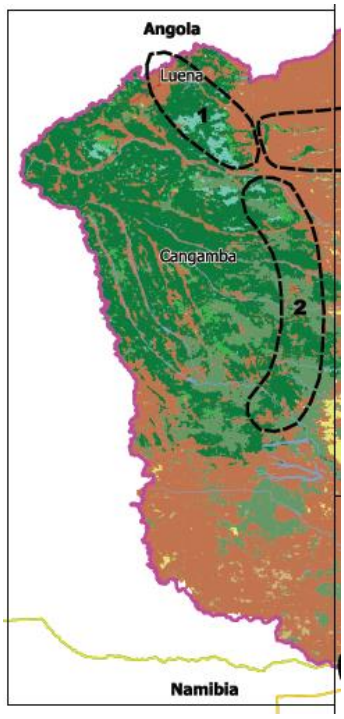


Figure 9: Hotspots 1 and 2

Hotspot 1:

The hotspot runs from the settlement of Luena south along the main road, where most villages and populations are located. The region presents a high level of social, economic and environmental vulnerability. Specifically, this hotspot area is subject to destructive flooding, which further exacerbates the levels of isolation of villages; there is no infrastructure (such as bridges) to connect villages to services/market access. Natural ravines present another hazard to the population.

The hotspot includes forested areas where the sustainability of the deciduous broad leaf, evergreen and mixed tree species is of key concern. Deforestation, practiced to supply wood as cooking fuel, is a significant concern. The loss of vegetation also increases sedimentation downstream. The relatively steep slopes in the area indicate potential increase in erosion along with the deforestation trend. In addition, in the northeast part of the hotspot (east of Luena), poaching presents a challenge to biodiversity. This impacts tourism potential and tourism-related economic activities. Rainfed agriculture is a livelihood activity in the region. In order to protect natural resources, there is a need to balance forested areas with agricultural land and soil-preserving low till, low-fertilisation agriculture.

Hotspot 2:

Hotspot 2 is another relatively isolated area of Angola. The environmental characteristics of this hotspot are similar to that of Hotspot 1, with the forest edge rapidly retracting towards the West, and rivers overflowing regularly. As with Hotspot 1, the area follows the linear road infrastructure. In this hotspot, water-related health concerns are more prevalent than in Hotspot 1; currently, malaria prevalence rates are relatively low, but future risk of cholera and malaria prevalence is likely to be high (especially where standing water is present). It would therefore be opportune to consider interventions that tackle/manage waterborne disease issues, to avoid the severity of outbreaks experienced towards the eastern area of the basin.

Any intervention in this hotspot must consider the safety risks associated with operating in the southern (specifically southwest) area of the hotspot, where landmines are a significant concern, reducing access and infrastructure development.

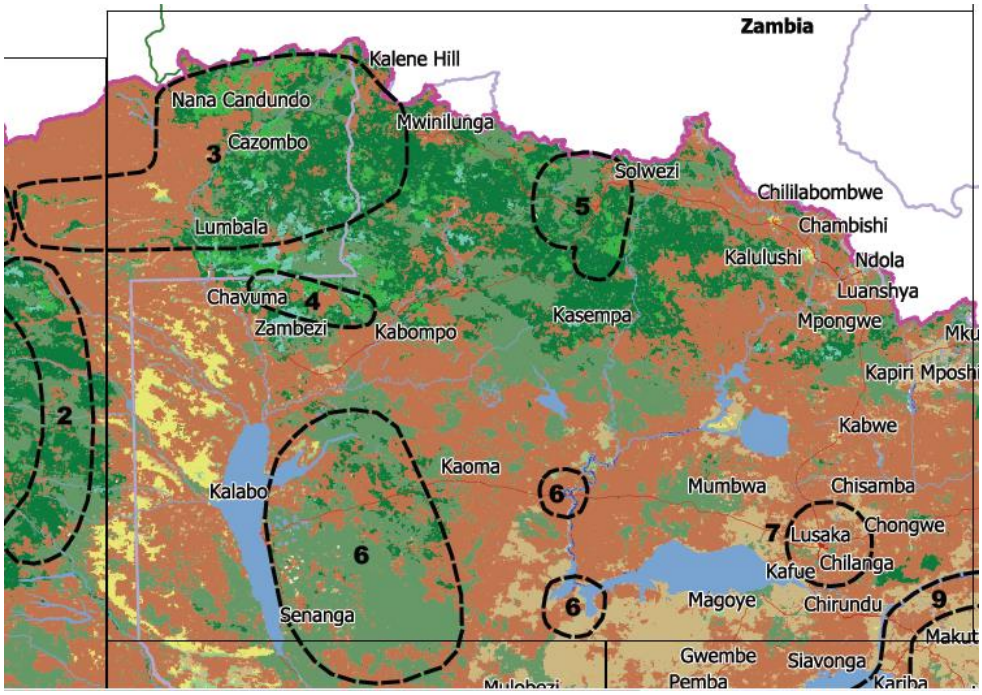


Figure 10: Hotspots 3, 4, 5, 6 and 7

Hotspot 3:

This area, situated between the cross-border settlements of Cazombu and Mwinilunga, is difficult to access with relatively poor electricity and transport infrastructure, leading to long travel times to markets. Just to its north, is a prominent hydropower facility. While the facility creates limited employment opportunities, the energy produced does not reach the hotspot area – meaning the local communities do not benefit from the infrastructure.

Waterborne health challenges are prevalent in the region, mainly due to poor water supply infrastructure and traditional means of sanitation (despite the relatively proximity to bulk water supply infrastructure). As a result, communities are reliant on the natural resources. With relatively higher rainfall (compared to southern areas of the vulnerability zone), improved rainfed agricultural activities (along with improved market access) stand to improve communities' adaptive capacity and also strengthen the natural resource base – provided climate smart practices are employed to maintain the integrity of the soils.

These challenges extend into the North-East of Angola's Zambezi region, where local communities' vulnerability to frequent flooding is heightened by man-made impact on natural ecosystems, through deforestation and poaching. The region also lacks infrastructure and is difficult of access.

Hotspot 4:

This hotspot is a cross-border area between Cavuma and Manyinga; the primary reason for its identification being poor sanitation infrastructure and a high prevalence of waterborne disease, which is related to the low levels of water and electricity supply, and poor, if any, health care services. Improved fresh produce availability could support the general health and wellbeing of the subsistence communities and would support food security in the area.

Hotspot 5:

Deforestation in this hotspot is becoming a critical issue. This hotspot is an emerging hotspot requiring preventative action to mitigate increased risk of vulnerability. There is significant opportunity for reforestation and restoration of forest around the settlement of Solwezi, through agricultural and wood harvesting practices

that promote sustainable forest management. This needs to be coordinated with pollution control measures from the mines to minimise contamination of water sources and the environment. The area is relatively close to the Copperbelt, making it attractive for households to migrate to; however, the natural resource base may not be able to sustain the growing communities unless forest management practices and improved agricultural production are promoted.

Hotspot 6:

The hotspot south of Kaoma is characterised by particularly poor services availability in rural villages (including particularly vulnerable road infrastructure) – with virtually no electrical power, poor water and sanitation, and no formalised health care services. Communities are almost entirely reliant on subsistence farming and significantly exposed to changes in rainfall regime given this area receives on average less rainfall than the northern part of the zone. There is also poaching within the hotspot especially around the Sioma, Liuwa and Ngwezi areas. This hotspot has two additional 'satellite' hotspots to the east – which were identified by stakeholders are specific areas experiencing similar vulnerability characteristics as the larger primary hotspot.

Hotspot 7:

Groundwater contamination leading to waterborne diseases such as cholera, is noted as a significant issue in Lusaka and surrounding peri-urban settlements. The area is characterised by very poor services (especially in peri-urban areas) whose supply is largely dependent on groundwater, which has led to the mushrooming of boreholes which are often poorly equipped and maintained. The challenges here are similar to those indicated and identified in the hotspots covering Harare, Lilongwe and Blantyre (below) where urban flooding, water contamination, and waste discharge (owing to untreated sewer intrusion and other contaminants from industries) are prevalent. This is further compounded by poor service delivery in water supply and sanitation.

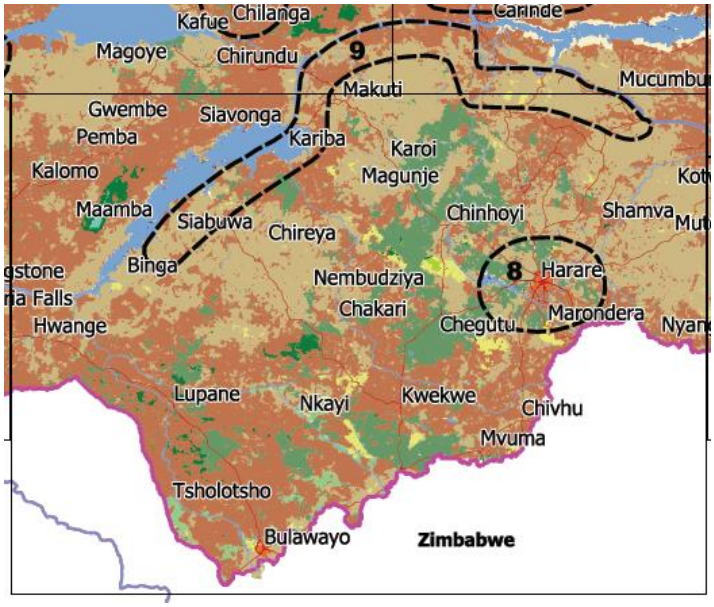


Figure 11: Hotspots 8 and 9

Hotspot 8:

Harare's polluted water sources are due to poor waste water management disposal and mines as well as illegal gold panners. The water pollution from Harare is traced along one of the major rivers through Chinhoyi town all the way to the Zambezi Valley rural areas (see hotspot 9) and finally into the Zambezi River. Along the way, the water has been so polluted that it is no longer suitable for irrigating tobacco and other crops, leading to investments in groundwater by the farmers. Similar to hotspot 7, this hotspot suffers from

substandard water supply and sanitation service delivery and infrastructure, which has resulted in urban flooding and waterborne disease outbreak.

Hotspot 9:

This hotspot is a large band stretching from east to west, widely spaced between the nature reserves and interspaced rural areas towards Zimbabwe's northern border.

Settlements in the hotspot experience high levels of poverty and food insecurity, which is further exacerbated by the polluted water sources from Harare. The water has been so polluted that it is no longer suitable for irrigating tobacco and other crops, leading to investments in groundwater by the farmers.

The rural area of the hotspot band has high levels of poverty and food insecurity resulting in unregulated harvesting of natural wildlife resources, thus threatening the fragile tourism income base. Subsistence agriculture in this hotspot is insufficient in amount and efficiency to feed communities year-round especially along the valley areas of Muzarabani, Mbire, Chitsungo and Kanyemba, resulting in a high reliance on (often expensive) food imports from other areas. The border stretches from Mukumbura in the East, Mbire in the North, Makuti, and Siyabuwa along the Zambezi Valley and the border with Mozambique; it is characterised by vulnerable, degraded ecosystems exposed to tsetsefly and malaria as well as flooding and drought. The cost of this imported food reduces the affordable nutritional value (food with low nutritional value is often purchased) and adds additional seasonal expenses to households already burdened with limited (and in some cases, no) income. Their highly vulnerable situation causes a downward spiral that reduces their ability to purchase seeds in following seasons, which in turn reduces their ability to harvest local produce. With rainfall being variable, droughts frequent, water pollution along the Manyame and Mazoe rivers endemic, soils leached, erosion levels and evapotranspiration high, the potential for land being agriculturally viable is already low and further reducing rapidly. Critical interventions in this hotspot include land restoration and re-vegetation as well as agricultural interventions that not only maintain but improve the degraded nature of both the land and water bodies.

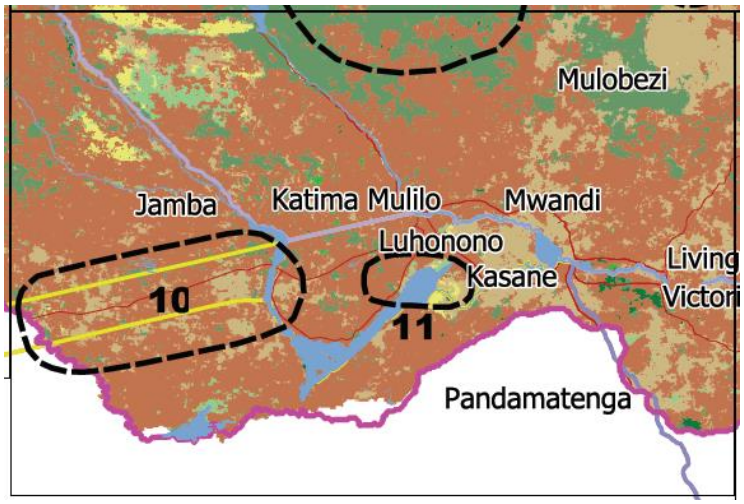


Figure 12: Hotspots 10 and 11

Hotspot 10:

The Caprivi strip has notoriously low service delivery levels, being a somewhat 'disregarded area' far away from Namibia and Botswana's primary service delivery areas. Given the relative remoteness of these communities, they largely subsist off the natural resources in the area - typically following the availability of water resources (i.e. with permanent settlements situated away from wildlife dispersal zones during the wet season, and seasonal homes near the river during the dry season).

Using wood for cooking and heating, the bush for sanitation, and natural water sources for water supply makes them highly vulnerable to external shocks. Droughts and veld fires across all areas (close to as well as away from rivers) and flooding along the river courses – especially downstream and towards hotspot 11), is a major concern for human and livestock safety.

There is also very little formal schooling and healthcare available: severe poverty and in some cases illiteracy within entire villages is of great concern. Malaria is also reported as a major cause of illness (and thus reduced productivity) and death in the area.

A dual economy exists in the hotspot that presents opportunities to improve livelihoods and support localised development. Currently, thriving tourism hubs operate alongside these vulnerable communities, where benefits are largely limited to employment opportunities and conservancy concessions. Opportunities for local communities to intercept the tourism value chain through more impactful, formal mechanisms should be explored. Previously this was readily covered through the participation of community trusts under the rubric of CBNRM, where they shared income from proceeds of trophy hunting. The dilemma is that trophy hunting was banned in Botswana, especially elephant trophies which were the main source of income for the local communities. Although Namibia's hunting regulations differ, the challenge should be considered a shared one across international borders between Botswana and Namibia.

Tourism in the hotspot has taken a step backwards, with many facilities (other than internationally-supported/run concessions) being unable to maintain a high standard of service to its customers. That is, locally run investments have seen declining numbers and a decline in service delivery, with quality of especially restaurant/food services potentially contributing to a large extent to the situation. Such decline has an overall negative effect in returning customers and may cause ever-escalating localised economic downturn. Localised interventions focussed on improved quality and quantity of local produce for the tourism industry, as well as the provision of hospitality training for local communities, would contribute to improved socio-economic growth in the hotspot.

Hotspot 11:

This hotspot around Kasane is characterised by intense and frequent flooding. It is expected that the flood risk for communities in this area will increase as climate variations in the basin increase. Although the population density is relatively low, the close proximity of villages to each other and high numbers of child-headed households enables the potential for interventions to have high and potentially long-lasting impacts. Kasane is also a key regional tourism hub, with a substantial wildlife population (including functioning elephant corridors in the hotspot). The banning of ivory trade has largely impacted on community trusts that relied on proceeds from safari hunting. This has led to the increase in poaching in both hotspots 10 and 11 and is a clear need for interventions that address high levels of poverty in this region. The communities in this area therefore face similar challenges to those in Hotspot 10, and opportunities to support local communities enter into, and benefit from, formal markets must be explored. As a primary and niche tourism hub for Botswana where poverty and human wildlife conflict persist, the whole Kasane and Chobe enclave is dotted with inter-connected vulnerable areas requiring intervention.

The construction of a new major bridge near Kasane to link Zambia with the region south of the border, holds potential for hotspots 10 and 11 to achieve improved road/transport connection which will enable accessibility to share regional improvements in economic opportunities.

Interventions for hotspot 10 and 11 must be of a cross-border nature given the land-use and human-wildlife-conflict (HWC) issues concentrated along and across the Chobe River affect both countries.

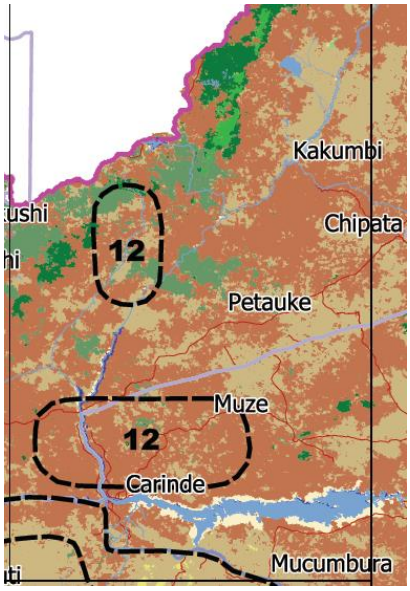


Figure 13: Hotspot 12

Hotspot 12:

This cross-boundary hotspot, although indicated in two separate areas (to the north in Zambia, and towards the south in Mozambique), have the same characteristics. In many ways, the hotspot has similar characteristics in terms of community and subsistence agriculture vulnerability as hotspot 9 (Zimbabwe), although with a lesser water resources contamination character. There two distinct areas within the hotspot houses significantly vulnerable communities who have little or no water supply and sanitation, and very poor transport routing, in addition to the same low-income levels, land degradation and related challenges as discussed in hotspot 9. As in hotspot 9, communities rely to some degree on harvesting of natural wildlife resources that migrate in the area.

The hotspot reflects a much drier savannah landscape than towards the west of the region, where higher levels of vegetation cover and lower levels of evapotranspiration that provide a buffer against systemic shocks which villages face. The hotspot is characterised by higher than average potential for crop failure in drought years or when excessive heat days are experienced. The high dependence of communities on natural resources and a lack of access to basic services are what identified this hotspot as one of the priority areas for intervention.

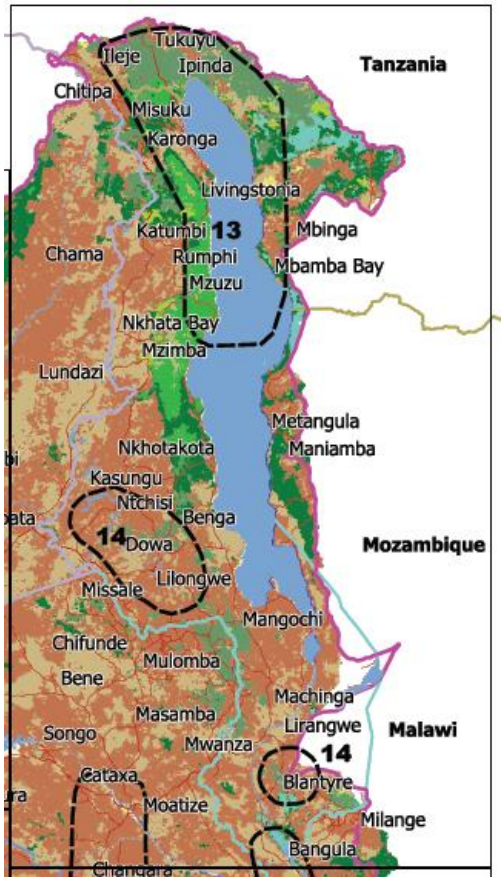


Figure 14: Hotspots 13 and 14

Hotspot 13:

The area indicated by the hotspot runs along the banks of the lake (the name and boundary/ownership of which is contested between Tanzania and Malawi). This hotspot is indicated as only slightly lower population density than that of Hotspot 14, but settlements are of a more rural, remote nature. The density of population alone asks for critical intervention, given the associated levels of poverty and high prevalence of waterborne disease outbreak that communities in this hotspot face.

With poor road accessibility and a lack of reliable energy sources, communities have limited adaptive capacity to respond to the impacts of hazards such as floods and earthquakes. At a household level, reliance on poor farming practices outside large commercial crop planting areas puts significant strain on communities to be self-reliant. Improved agriculture, even hydroponics, as well as a focus on sustainable fisheries would enhance the ability of the natural resources in the hotspot to support the livelihood needs of communities. Capacity building around improved community-based natural resource management and monitoring should accompany these interventions to avoid catchment degradation and preserve the integrity of soils.

Given the transboundary nature of this hotspot, similar interventions in both Malawi and Tanzania will be required to ensure socio-economic development occurs equitably – avoiding cross-border conflict or illegal migration. However, the uncertainty about rights to the Lake's water resources is contentious and the area may benefit if clarity can be found at a governance level, especially with regard to investment in aquaculture.

Hotspot 14:

The cities of Lilongwe and Blantyre draw significant numbers of migrants, creating almost seamless urban edges from north to south along the hotspot. These urban/peri-urban hotspots have the highest population densities in the basin, and with urban capacities and poverty rates growing rapidly (especially in the peri-urban

areas surrounding the cities), existing infrastructure and services are unable to support the population as they face issues of urban flooding, increasingly strong winds, and waterborne disease outbreak. Interventions in this area could focus on improved, climate resilient water and sanitation services (a lack of which puts pressure on the health care services), sustainable urban drainage systems, and urban agriculture (including vertical agriculture), to support food security. If the identified issues in these vulnerable areas are not addressed, there is a high risk of secondary impacts (linked to poverty and disease outbreak) spreading more widely both within Malawi and across the Mozambican border.

The proposed interventions are also applicable to other regional hubs in the Zambezi, where similar socio-economic and physical issues persist. The proposed approaches to improved sanitation, waterworks and food security in these dense (peri-)urban hotspots will therefore serve as demonstration pilots, with the aim of motivating for wider investment and replication elsewhere in the basin.

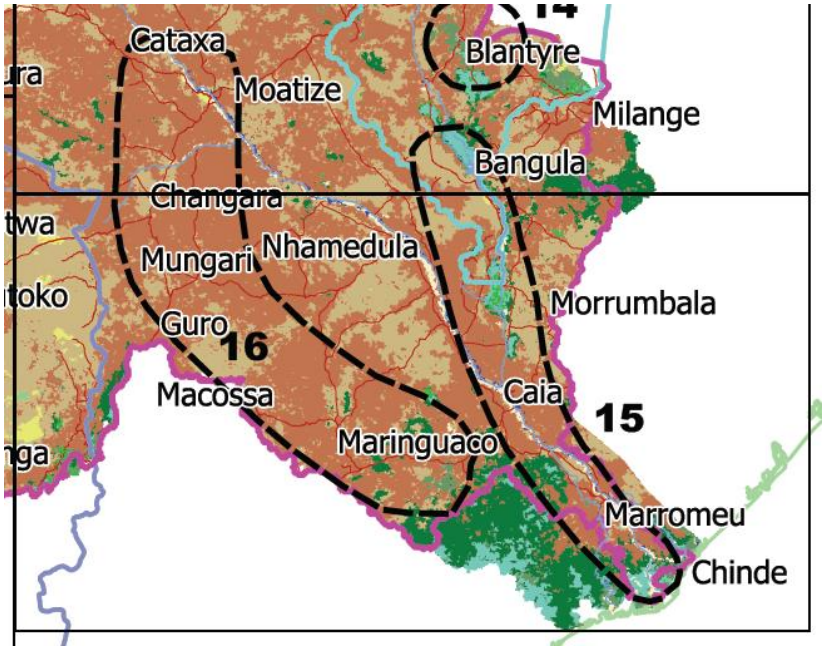


Figure 15: Hotspots 15 and 16

Hotspot 15:

Settlements[1] located along the Shire River in Malawi and Mozambique are exposed to severe, and increasingly prevalent, floods – requiring significant support from the governments' disaster response ministries. People have died, fields damaged, property lost, and in some cases, infrastructure has been destroyed. Siltation issues (resulting from severe deforestation and erosion in hotspot 16) have further affected ecosystem services (including flood mitigation) and increased the region's environmental vulnerability to flooding. The region is also affected by strong winds, and at times storms. With accessibility to some of these areas also posing a major challenge, services and links to markets are limited – which exacerbates widespread poverty and risk of disease outbreak.

Given groundwater in many parts of this area is saline, communities remain reliant on the river as source for domestic and livelihood needs. However, they currently lack the infrastructure to pump and reticulate water to areas of land above the flood line. Priority interventions in the area should therefore focus on improved, climate resilient run-off-river supply schemes – including suitable water storage facilities to account for extended / unexpected drought period.

[1] Such as Murraca and Caia (Mozambique) and Bangula (Malawi)

Given the intrinsic links between challenges in hotspots 15 and 16, it must be noted that the issues in these hotspots cannot be tackled in isolation; that is, interventions to address deforestation and restore the integrity of soils and catchments in hotspot 16 are a critical starting point toward addressing risk of flooding in hotspot 15.

Hotspot 16:

This hotspot covers dry lands, where local communities are affected by droughts. Without proper irrigation facilities, this vulnerability to droughts makes agriculture an unreliable practice, affecting food security. Further, there is a lack of economic opportunities in the region. An important livelihood activity is wood cutting, wood being used for fuel and as construction material. As a result, deforestation and erosion in the hotspot is at a critical level. This increases the prevalence and intensity of floods in downstream areas. In a vicious cycle, food insecurity and poverty trigger migration flow towards riverbeds where the population is vulnerable to floods (*see Hotspot 15*).

6. Typologies

These narratives present a high-level overview of the severity and breadth of challenges faced by vulnerable communities throughout the Zambezi Basin. Given the differing contexts, characteristics and climate change projections of each hotspot, tailored and targeted responses are required to adequately address the localised socio-economic and environmental issues. Potential livelihood responses/types are therefore differentially important to different areas in the basin.

Identifying and defining resilient, appropriate interventions within each hotspot requires significant ground-truthing and stakeholder engagement; however, the following generic livelihood project typologies can be used as a starting point to guide the process.

It is also important to recognise that livelihood projects should not sit in isolation of the larger-scale projects within the ZSP's programmatic structure. Opportunities to expand the wider socio-economic benefits of these larger developments through related livelihoods interventions should be considered both by the Member States and potential funders. The typologies have therefore been linked to the four programmes. In addition, as this livelihoods piece is unpacked through more detailed analysis and engagement, it will be important to remain cognisant of how livelihood interventions link with other programmes of intervention that sit outside the immediate ambit of water resources – but which still contribute to poverty reduction, sanitation, improved human health, food security, etc.

PROGRAMME	TYPOLOGY
Hydropower	• **Off-grid small-scale hydropower generation**, for household and productive use in remote locations –negating the need for (and reliance on) grid energy and reducing extensive fuelwood and charcoal production (thus reducing biomass, increase soil erosion, sedimentation and evapotranspiration). • **Solar power generation** for household and productive use. Whilst not directly linked to the hydropower programme, expanding alternative sources of off-grid power increases the capacity of the power pool, and ultimately reduces the dependency on water for power generation.
Irrigation	• **Sustainable rainfed agriculture**, through the provision of accessible and sufficient storage and localised distribution facilities to bridge variations and mitigate risks during periods of low rainfall.

	• **Small-scale irrigation,** using technology suited to local water availability and climate (e.g. channels, drip irrigation, tunnels, hydroponics, etc.) – with the intention of improving quality, quantity, diversity and consistency of produce to allow farmers to move beyond subsistence horticulture. • **Climate smart agriculture practices,** adopting appropriate cropping schedules/rotations and modern agronomy techniques to optimize water usage and maintain the integrity of the soils. e.g. low/no- till.
Water Supply	**Assured water supply for domestic and small-scale productive use**, noting different sources (ground vs. surface water), infrastructure, governance and tariffing/payment mechanisms will be required for urban, peri-urban and rural areas.

Catchment and riparian asset management	• **Flood management,** through:
	  ○ **Early warning flood systems** that can be managed, interpreted and communicated by local communities.
	  ○ **Dyke construction** and related flood protection infrastructure, as appropriate[2]
	• **Aquatic ecosystem management/enhancement**, promoting fisheries and related aquaculture activities (including harvesting reeds and herbs for medicinal purposes).
	• **Woodland management and forestry restoration,** protecting, and promoting sustainable use of, woodland resources and forests through the provision of assured, alternative energy sources.
	• **Maintaining and/or recovering wildlife corridors and dispersal areas**, by identifying opportunities for local communities to accrue direct benefits from wildlife and surrounding protected/conservation areas through increased participation in formal tourism value chains. Critical to this is improved land use planning (i.e. ensuring irrigation schemes do not encroach on wildlife corridors), which will reduce human wildlife conflicts and maintain the integrity of the ecosystem.
	• **Catchment restoration and management,** through interventions such as agroforestry, erosion control, terracing and buffer strips.
	• **Green infrastructure,** such as wetland health restoration, increased green and blue space in urban areas, riparian buffers, etc.
	• **Urban food security interventions,** through low-water use vertical food gardening in urban areas

These typologies have been matched to the 16 hotspots, with a view to initiating further in-country assessments to both validate the hotspot mapping analysis and inform the conceptualisation, identification and development of specific projects.

The matrix below uses a traffic light system to differentiate between relevant typologies, as follows:

- **GREEN**: Prioritised project typology (targeting key hotspot issues)
- **YELLOW:** Appropriate typology (targeting issues in the hotspot, but not critical to maintaining the system/mitigating a major risk – be it climate, health (human and nature), ecosystem, etc.)
- *Blank*: Not applicable

[2] noting risk of maladaptation responses must be avoided – i.e. providing infrastructure to communities residing in flood zones, which would essentially encourage them to remain in high-risk areas, which will always require emergency/disaster response.

HOTSPOT NO.	ENERGY	AGRICULTURE	WATER SUPPLY	CATCHMENT AND RIPARIAN ASSET MANAGEMENT
1	Off-grid small-scale hydropower generation	Rainfed agriculture (low-till, low-fertilisation practices)		Woodland management and forestry restoration
2	Off-grid small-scale hydropower generation		Assured water supply for domestic use	Woodland management and forestry restoration
3		Sustainable rainfed agriculture	Assured water supply for domestic use	Aquatic ecosystem management/enhancement Flood management
4		Climate smart agriculture practices	Assured water supply for domestic use	
5	Off-grid small-scale hydropower generation			Sustainable forest management practices
6	Solar power	Sustainable rainfed agriculture Climate smart agriculture practices	Assured water supply for domestic use	Maintaining wildlife corridors and dispersal areas
7			Sustainable urban drainage systems Improved water supply for domestic use	Green infrastructure
8			Sustainable urban drainage systems Improved wastewater management for domestic and industry Improved water supply for domestic use	
9	Solar power	Small-scale irrigation: tunnels (drip/hydroponics)		Catchment restoration & management Recovering wildlife corridors and dispersal areas
10	Solar power	Climate smart agriculture practices Small-scale irrigation: tunnels	Assured water supply for domestic use	Aquatic ecosystem management/enhancement Maintaining wildlife corridors and dispersal areas

HOTSPOT NO.	ENERGY	AGRICULTURE	WATER SUPPLY	CATCHMENT AND RIPARIAN ASSET MANAGEMENT
11		Climate smart agriculture practices		Flood management
		Small-scale irrigation: tunnels		Aquatic ecosystem management/enhancement
				Maintaining wildlife corridors and dispersal areas
12		Small-scale irrigation: water storage facilities for reliable supply	Assured water supply for domestic use	Catchment restoration & management
		Climate smart agriculture practices		
13		Small-scale irrigation: tunnels (drip/hydroponics)		Aquatic ecosystem management/enhancement
				Catchment restoration & management
14			Assured water supply for domestic use, and assured water supply for small-scale productive (in peri-urban areas around urban centres)	Green infrastructure
			Sustainable urban drainage systems	
15		Small-scale irrigation: run-off river / pump & storage schemes outside flood lines		Flood management
16	Solar Power			Woodland management and forestry restoration

Annex A – Vulnerability Zone Narratives

Vulnerability Zone A: Far north-west (Angola)

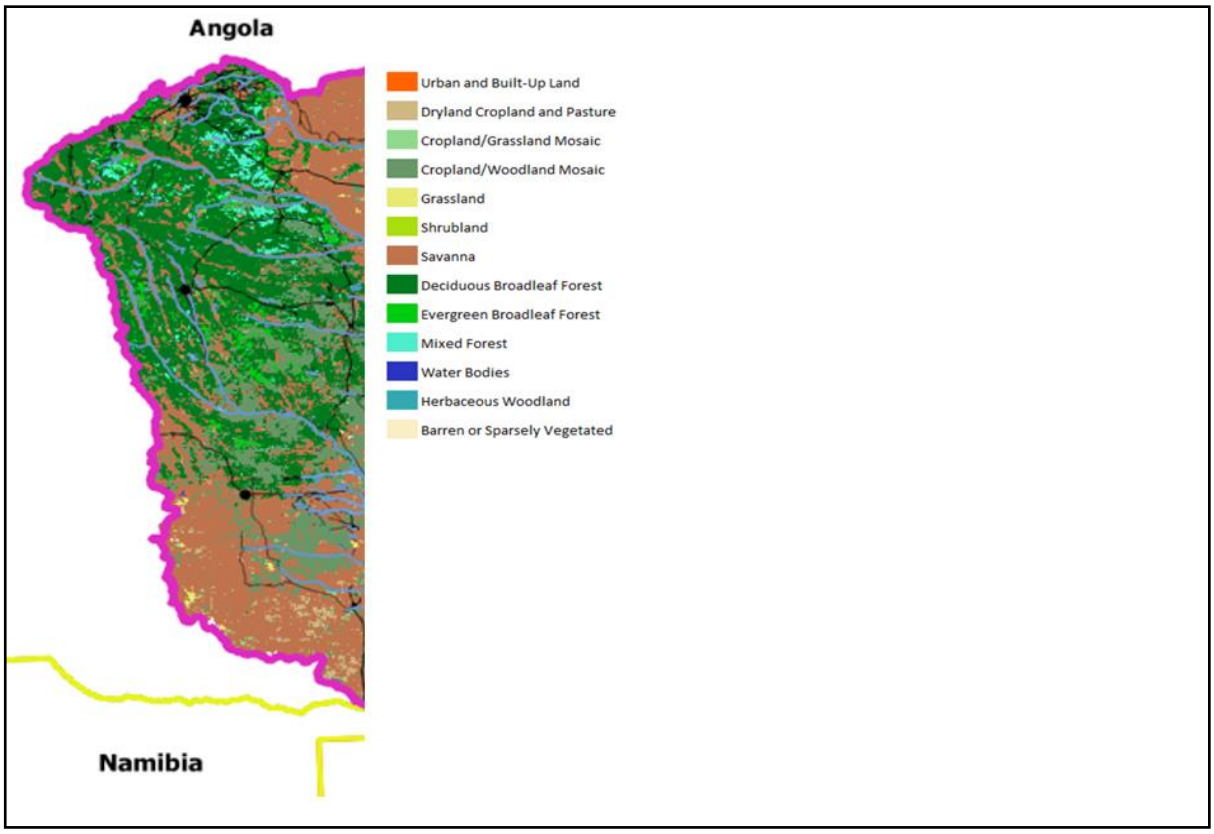


Figure 16: Vulnerability zone A, showing land cover background

Socio-economic

This unit falls entirely in Angola. The area has very low to almost zero economic productivity and a small population. The 2016 Human Development index ranks Angola 149 out of 186 countries on the poverty scale since poverty permeates the entire nation (Kraus, 2016). Local incidence of poverty is not known, however with Angola having an overall poverty incidence of between 40-70%, it is understood that this area is within the higher ranges of this grouping. With two thirds of people in Angola living with less than $2 a day, and an estimate 75% of the country's population living at 'livelihood level', this area is one of the worst affected – expected to have up to 90% of communities at this level (Kraus, 2016). This unit is characterised by severe poverty – not only when compared to the rest of Angola but in comparison to the entire basin.

Corruption is a major concern across Angola. With this unit being in the far east of the country, challenges of lack of available funds and economic benefits (of e.g. forestry, mining and oil) is limited and does not permeate to community-level. However, corruption undoubtedly hinders funders from supporting interventions in the country, including in this zone, due to the array of challenges and risks associated with procurement processes, visas, taxes, etc.

Population (including education and health)

The median age of people in Angola (male and female) is around 18, with life expectancy around the age of 60. High infant mortality is present (the mortality rate for children under five is around 17%). The severity of the population pyramid is illustrated in the graph below, indicating no significant difference between gender gaps. This population pyramid lends itself to a population where child-headed households are prevalent.

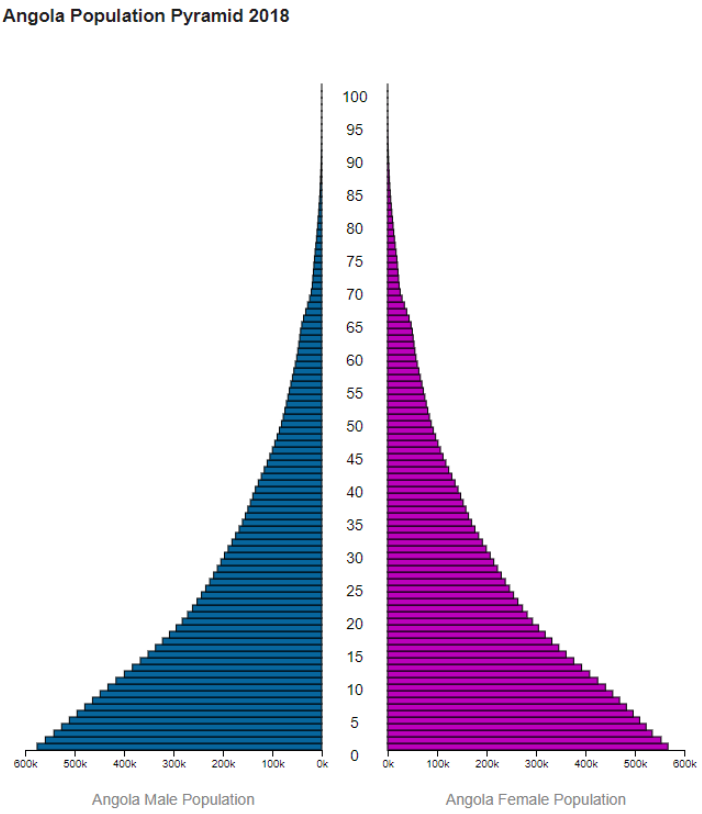


Figure 17: Socio-economic and infrastructure baseline hotspots across the basin (World Population Review, 2018)

The situation reflected in the population pyramid becomes clear when considering the low 40% access to health facilities in the country (CRIDF, 2017). The situation is supported by spatial data searches, which provide no indication of effective and formalised services. Malaria is not a major concern in the unit (around 5% prevalence), although there is some malaria concern concentrated around villages and roads – meaning the primary reason for the overall prevalence being low is because the area is more sparsely populated outside of villages or away from roads. With there being almost no formalised medical services in the unit, diseases such as malaria, cholera etc. are reflected in the high mortality rates. HIV/AIDS rates are relatively low – notably the lowest in SADC.

The population growth rate in the unit is extremely high, with fertility rates among the highest in the world – at least 5.5 children per woman; with a childbearing age of around 28 years of age (World Population Review, 2018). The unit has an extremely low migration rate (practically zero). Economic and infrastructure interventions that support improvements in community-based health, clean water and improved sanitation, could lead to further increases in population rates (as a result of reduced mortality rates) – and it is therefore important that government and development partners recognise this demographic consideration and focus on supporting sustainable solutions for inclusive growth of a growing population in the unit.

Many children do not have access to education causing a high illiteracy rate, making future employment difficult, adding to the child labour situation and supporting the almost zero migration figures (i.e. an inability to escape poverty). Across Angola, 34.6% people have unequal access to education, with 28.9% having an unequal income – with the characteristics of this unit reflecting the poorest and least serviced, these figures are expected to be significantly higher in reality (Kraus, 2016).

Settlement

The unit is predominantly populated by rural communities who reside adjacent to roads, which are often also close to perennial water courses. Poverty is greater in remote rural areas (compared to along roads where

settlements are present). This is a sparsely populated area, and with poverty levels being extremely high throughout, it is clear that all of these communities are vulnerable. With the high reported birth rates, these vulnerable communities also consist of many youths, with insufficient adult capacity to support local livelihoods.

Most settlements are also located along the road infrastructure, which supports linear access and service provision along larger roads. It is important to note that while there is little presence of remaining land mines across the unit, landmines have been located relatively close to main roads in the south, which poses a concern from a safety perspective.

Infrastructure

Houses in the rural parts of the basin are predominantly made of wood, mud and grass, and communities are more dependent on wood and charcoal for fuel. Majority of the population is unlikely to have access to electricity, except in towns (Angola as a whole has a very low electrification rate in rural areas, with only 6% of rural households having access to electricity) (African Development Bank, 2017).

The unit has very poor access to clean water and sanitation. Access to improved sanitation in Angola is on average around 24% (OKACOM, 2011), however considering the remoteness of this unit, it is expected to be significantly worse in this area. Household access to improved water supplies is between 38% and 50% across Angola, with only 17% having adequate access to water in the Moxico province of Angola (in which much of this unit falls). Reliance on rivers as a water source as well as wells and boreholes is high (African Development Bank, 2017). More urban households (i.e. in small towns and villages) tend to use water holes or wells, rather than the river as a water source.

The unit has poor access to markets, urban areas and services and the only access is via the limited road network. Large areas away from roads remain difficult to access, and even then – roads are often in a significantly poor state and very muddy/sandy with travel times away from main roads being extremely slow. The presence of landmines towards the south of the unit, as mentioned earlier, reduce access in the area.

With no running water or proper infrastructure for sanitation and hygiene, disease runs rampant (contributing to the high death rates noted earlier). Diarrheal diseases, cholera, measles and diphtheria are just a few of such illnesses. According to the World Health Organization, there were over 2,000 cholera outbreaks in 2009 (World Health Organisation, 2013). Yet, there was only 1 doctor available for every 10,000 people. As a result, countless communities lack access to vaccines or clinics to treat these diseases. This unit is worse off than the rest of Angola, and potentially one of the worse-affected in terms of poor medical services across the Zambezi basin.

In recent years, there have been successful reconstruction programs, including roads, airports, bridges, electrification, hospitals and schools in Angola – but this support has been largely centralised, meaning the unit has not benefitted much.

This area also faces a severe lack of adequate rural agricultural infrastructure (e.g. feeder roads, irrigation systems, and unreliable, if any electricity supply), low use of yield enhancing inputs and technologies, lack of skills, limited access to credit, weak research and extension services for support to farmers and inefficient land management systems, which drive low agricultural productivity. Natural resource reliance (and subsequent destruction thereof) is a concern.

Environmental

Deforestation is prevalent at village level for cooking and heating fuel purposes, as well as through illegal large-scale logging (although the latter is not as high a risk as the illegal logging that is taking place in northern areas in Angola). This severely impacts this area of the basin as well as downstream areas in terms of moisture loss (due to moisture retention and infiltration being reduced) and change in the local climate due to increased evapotranspiration. Deforestation also contributes to ecological losses, increased flood risk downstream, increased climate change (reduced carbon sequestration) and sedimentation (i.e. resultant loss of capacity for

water storage in dams downstream). In addition, the change in vegetation increases the trend towards savannah landscape creation where an increase in fire prevalence is prominent – thus further speeding up the process of woodland and forest loss. Significant land degradation is of concern in part related to tree cover and vegetation loss, but also related to land use practices. Erosion risks are also relatively high due to relatively steeper slopes in this area, compared to other lower-lying regions.

Fire risk is high mainly in the winter season, and runaway wildfires contribute both to the aforementioned land cover change, but also increased vegetation loss, with resultant potential for increased erosion and even greater downstream sedimentation.

There are some formal reserves/protected areas in this unit, and these, along with the presence of land mines tend to maintain pockets of natural resource stability.

Relatively higher rainfall in the northern area of the unit compared with the southern areas supports slightly increased agricultural activity in the north; however, as a result, this practice is vulnerable to land cover changes and climate change impacts.

Transboundary impacts

The unit has no direct country boundary overlap; however, the unit's hydrological behaviour has a downstream impact on the rest of the basin. The compounding challenges of poverty and population dynamics (including the health and education situation), ineffective/inappropriate land use management, low levels of land use planning from a governance perspective, no control over deforestation/slash-and-burn regimes and use of wood for cooking fuel is a concern that will have a downstream impact across the border. Significant deforestation could increase the vulnerability of the entire area to drought, temperature increases and increased fire risk.

Vulnerability Zone B: Mid-northern (Angola/Zambia), including the Copperbelt

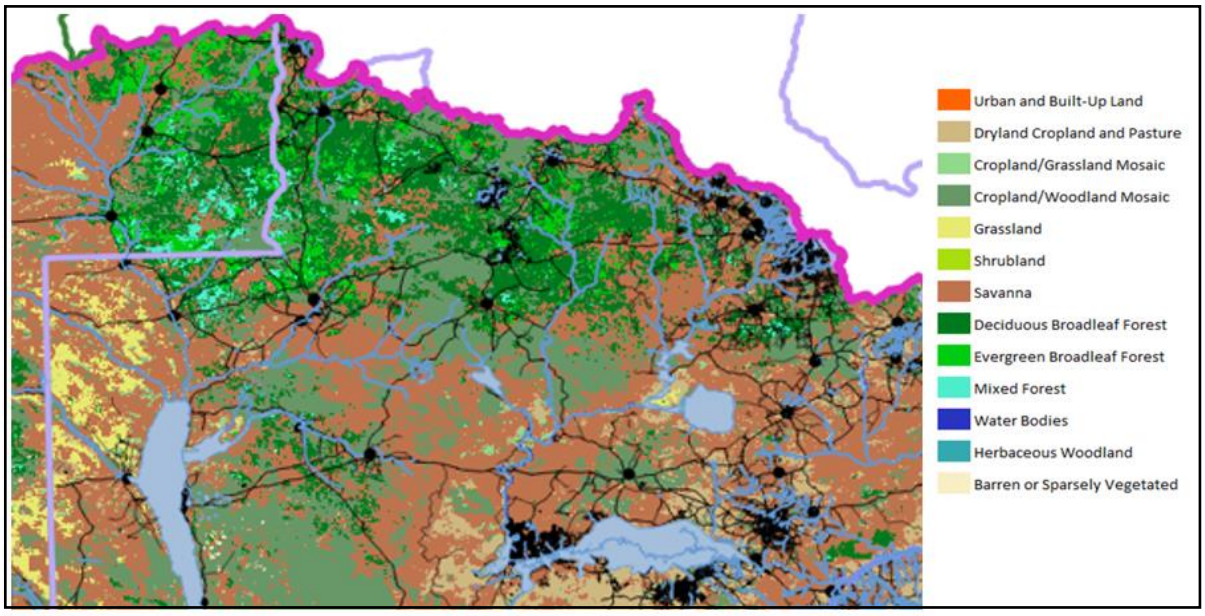


Figure 18: Vulnerability zone B, showing land cover background

Socio-Economic

Most of this unit falls in Zambia, and mainly in the North Western, Central and Copperbelt regions of the country. The border between Angola and Zambia is fairly permeable, and apart for somewhat improved conditions around cities (Lusaka, Ndola, Kitwe), socio-economic conditions across the unit are fairly similar -

reflecting income-stressed communities, although somewhat less so than in other units in the basin. The Angolan part of this unit's narrative reflects the same information as is presented for unit A, where extreme poverty exist along low levels of accessibility to services and a high reliance on natural resources.

Agriculture reliance for livelihoods is high and presents up to 70% of incomes, except in mining areas and large urban areas.

Hydroelectrical power generation in the north-west corner of the Zambia area in the unit provide job opportunities, as do the mines and related urbanised areas in the Copperbelt (Ndola and Kitwe) and in the southern area around Lusaka. This means the area is more favourable in terms of average income and livelihood opportunities. Forestry and agricultural activities provide livelihood income opportunities and a relatively higher rainfall than in the southern area of the basin support rainfed farming practices, with little seeming need for irrigation-supported agriculture.

Population (including education and health)

The narrative applicable to unit A is applicable to this unit as far as it pertains to the north-western area in the unit (i.e. bordering Vulnerability Zone (VZ) A). The population density in the north-east part of this unit is very high and may be the highest in the basin (by far, for example, higher than Lusaka) – a situation that is likely related to mining activity and subsequent migration into the region.

Although there are numerous schools (especially in the southern part of the unit and in Zambia in particular), significantly high numbers of school-going girls leave schooling due to pregnancy (and typically do not return after the pregnancy). The occurrence is no different across this zone. As a result, females are more affected by poor education (not completing their schooling) and thus employment opportunities for females is reduced.

Population density is relatively low compared to the rest of the basin, except for the eastern and south-east area in the unit where populations are clustered around large towns and cities (Ndola, Kitwe, and especially Lusaka). These populations are expected to continue growing in the future, with increased urban-rural migration.

Malaria is a concern; although it is of lower intensity than in zones towards the east of the basin due to the relatively lower population densities. However, access to medical services is particularly poor, thus giving rise to higher death rates and potentially high future risk of fast-spreading water-borne diseases.

Settlement

The Copperbelt and Central region are highly populated and urbanised relative to the rest of the unit, with more formalised building structures and services. Rural areas predominantly reflect traditional dwelling and building styles.

Infrastructure

There is a major infrastructure gap in the unit. Transportation access is similar to unit A, with roads 'criss-crossing' the area only at a high-scale grid pattern. Significant investment is anticipated to be channelled for improved road infrastructure, which is in turn expected to support exports (minerals and agricultural in particular). However, benefits of this are yet to be realised. The speed of road and rail transport is slow, and the rail service is inconsistent. A roads-infrastructure vulnerability project is currently underway for Zambia, which aims to identify areas where improvements can support the challenges that the area faces (Nordic Development Fund, 2018). The road vulnerability map below shows the roads in the Zambian portion of this unit being less than that around the country's borders:

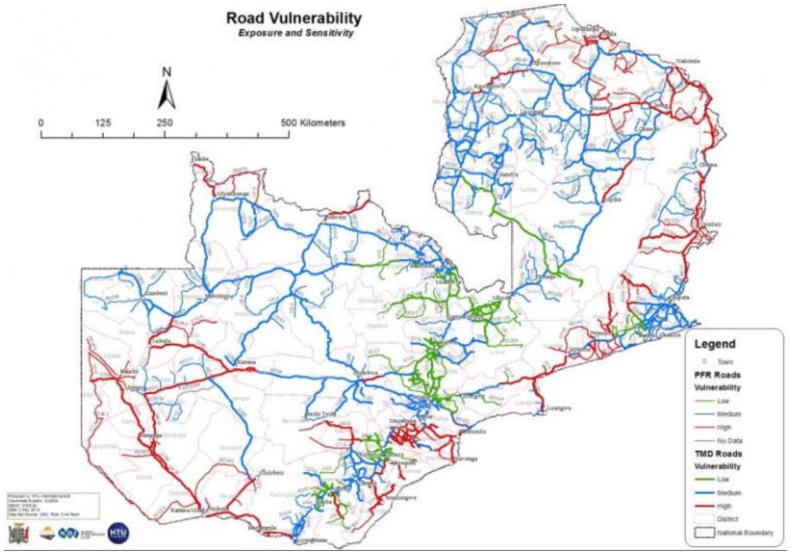


Figure 19: Zambia's road vulnerability in terms of climate impacts (Zambia Invest, 2017)

The electrical grid follows a similar pattern as population density and road infrastructure. Improved electricity access is especially prevalent in the Copperbelt and Central regions of the unit (i.e. in the east of the unit, close to more heavily urbanised areas). In rural areas where forest and woodland land cover is present, there is some reliance on trees to provide heat for cooking. Power outages unfortunately reduce the effectiveness of the grid. The unit's high electricity generation capacity and relatively high consumption are accompanied by fewer power outages than other units in the basin. However, most of the power sector output remains oriented toward the mining industry (i.e. Copperbelt), while household electrification is catching up slowly. Zambia's power tariffs remain among the lowest in Africa and were until recently at less than half the level needed to accelerate electrification and meet mining sector demands.

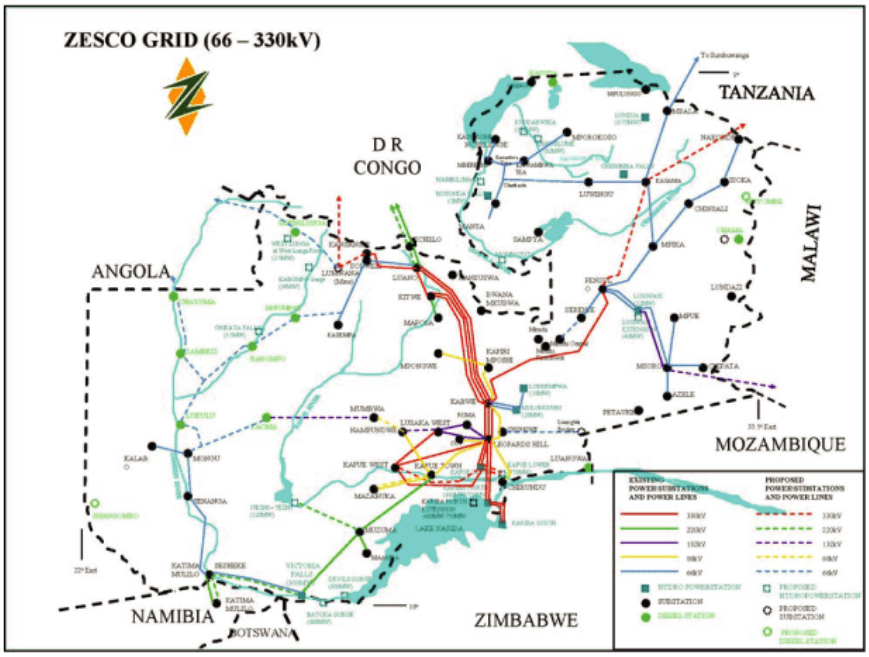


Figure 20: Zambia's electrification grid (ZESCO, nd.)

Information and communication (ICT) services in the unit are relatively well established, with relatively good cellphone connectivity across the unit.

Environmental

There are a number of disaggregated reserves and protected areas of various types across the unit (although less so in the Angolan side of the unit).

The north-east corner of the unit receives on average a higher rainfall than the rest of the unit, with the southern part being susceptible to drought. In general, the rainfall across the unit is higher than that of the areas in the south of the Zambezi basin, supporting improved surface water access for the many communities that do not have access to piped water, and also supporting rainfed agriculture as part of the unit's subsistence livelihoods (i.e. away from towns). Thus, the community vulnerability from a water availability point of view is less than in other areas in the basin. However, while there is potential for rainfed agriculture to support livelihoods in the unit, deforestation and slash-and-burn practices that enable agricultural expansion counters the long-term sustainability of water resources (and the role of the unit as a climate change regulator (i.e. losing its ability to provide a carbon sink)).

Environmental monitoring stations in the county are relatively few– this unit in particular has significantly fewer SASSCAL meteorological stations and thus historical weather trend monitoring is not always reliable.

Fire prevalence in the unit is high, especially in winter months. Along with deforestation, fires pose a high threat to climate change mitigation.

Transboundary impacts

Being in the upper sub-catchments of the Zambezi basin, the unit plays an important role in terms downstream catchment hydrological control; it is important to note that erosion and sediment loss in this part of the catchment, as well as forest loss, will have sedimentation and flooding impacts downstream.

Vulnerability Zone C: Namibia/Botswana/Zambia/ Angola/Zimbabwe (mid-southern)

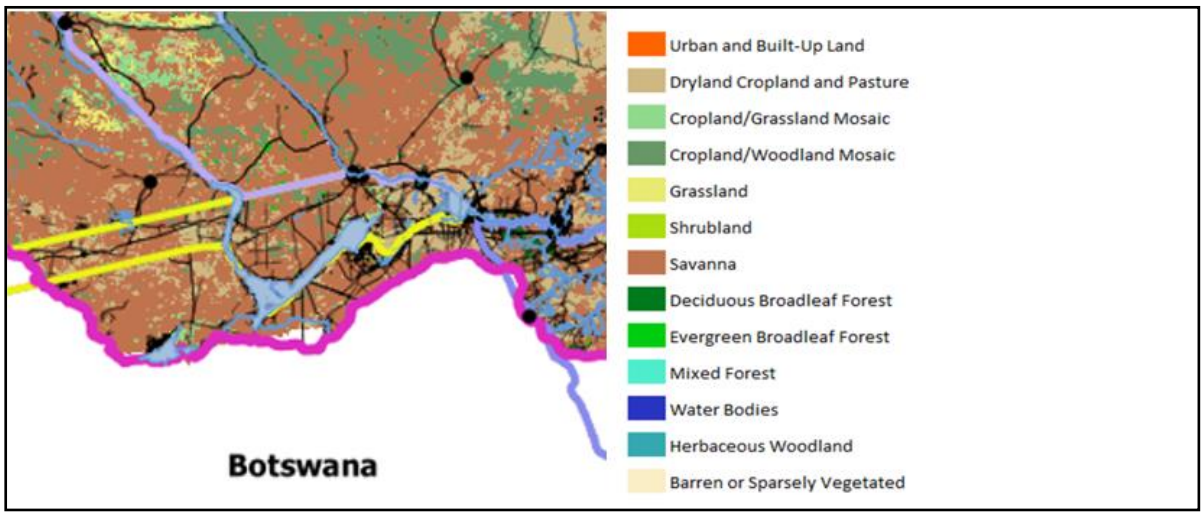


Figure 21: Vulnerability zone C, showing land cover background

Socio-Economic

Although the unit covers areas in five countries, the socio-economic situation across the unit is very similar given the permeability of the borders, and the remoteness of the areas in terms of all the countries' extremities. The unit houses very poor populations, with significant food insecurity and high levels of current (and anticipated future) vulnerability. An element that currently supports positive resilience potential is road access, which is the only thing that makes the unit slightly less vulnerable than unit A (which displays similar poverty levels). At least 60% of people in the unit live at 'livelihood level' – although given the remoteness of the area in terms of the five country's borders, this percentage is likely to be higher in reality.

The Namibian stretch (Caprivi province) reflects some of the highest headcount rate for poverty in the country (between 28 – 53%), and more than 50% unemployment (Republic of Namibia - National Planning Commission, 2015). The highest poverty pockets in Botswana are also found in this area – given its remoteness and it being almost entirely rural. Botswana's rural North-West province consistently has the highest share of poor and vulnerable where 30.1% of the region's population is considered poor whilst 26.5% is deemed vulnerable. Within this province, acute levels of poverty are found in the more remote areas, most prominently in Ngamiland around the Okavango and Chobe. The same detailed recent information is not available for the Zimbabwe area in the unit; however, the situation is understood to be similar. The description of Zambia's characteristics is similar to that provided for unit B, however vulnerability is likely to be higher given the remoteness of the area as well as lower rainfall and relatively reduced biodiversity.

Poverty rates in the area have improved since the early 2000's (ibid) – to some extent related to relatively smaller household sizes; and unemployment rates have dropped by just over 5% in the same period. The poverty reduction can be attributed mainly to a combination of increasing agricultural incomes, including subsidies (especially in the Botswana area in the unit), tourism, and demographic changes. A micro-simulation exercise projects that poverty across Botswana continue to reduce, however, inequality across geographic space reduces the potential for this to be achieved in this zone, due to its remoteness. The remoteness of this unit in terms of all five countries is the primary issue hampering improved resilience in this area.

Issues of poverty, vulnerability and inequality remain a challenge. Female employment rates remain much lower than that of males – by around 20% in the Botswana area, and even worse in the Zimbabwe area. Poverty is also largely a youth challenge. Poverty and vulnerability seem to be on a declining trend in terms of share of the total population, as well as in actual numbers. However, while the gaps between rural and urban areas declined, the risk of this unit falling back into abject poverty is higher especially due to the high

dependence on small scale and subsistence farming – with little or no irrigation, and high reliance on highly varying rainfall.

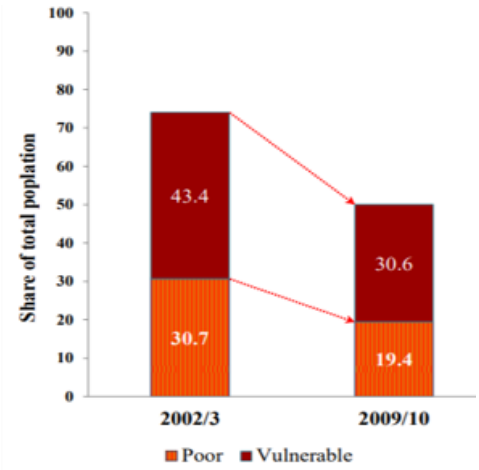


Figure 22: Botswana poverty and vulnerability trends (World Bank, 2015)

Livelihoods across the unit are largely agro-pastoral, which implies high reliance on relatively low rainfall and reliance on perennial surface water from upstream catchments. The mean expenditure per person per year is reported for the Namibian portion of the unit, to be no more than 145U$. This reflects poor economic productivity and significant reliance on subsistence-farming (especially livestock) across the unit.

The western half of the unit remains riddled with landmines, especially in bush areas away from border posts and along roads. Thus, there are not many settlements located away from the road infrastructure. As reflected in unit A, this poses a challenge from a safety perspective when implementing infrastructure projects.

Population (including education and health)

Detailed population challenges in the unit are not defined, and thus some national and regional statistics have to act as an indication of population and demographics in the unit. Due to the remoteness (towards the west of the unit) and widespread economic challenges in the unit, figures are expected to be worse than discussed hereafter.

Malnutrition in children under age five remains a significant problem; there is a 30% stunting incidence amongst children under five (in households usually headed by someone unemployed or less educated). HIV/AIDS rates are around the highest globally as well as in the Zambezi basin, at around 20%, with high infant mortality (33/1000 live births). Most deaths of children under age five are a result of preventable diseases, with an upward trend in the infant mortality (World Bank, 2015). Conversely, malaria rates are among the lowest in the basin.

Fertility rates are fairly low compared to the rest of the basin (falling from around 6+ children per woman to just over 3 in the mid 2000's) and population growth slowed down (the growth is for example dramatically lower than for example seen in unit A). Average life expectancy is around 25 years.

Since the unit has permeable borders and with Botswana having one of the world's highest HIV/AIDS rates, resulting in large numbers of deaths (leading to single parent households and AIDS orphans), there is a sizeable number of incomplete families in the unit, which are more likely to be poor. This increases the food insecurity challenge that the unit's inhabitants face.

The literacy rate nationally in Botswana's rural areas is 75%, and although this is not expected to be reflected across the entire unit, the overall literacy rate is somewhat better than that of other areas in the Zambezi basin.

The establishment of numerous schools in Zimbabwe, from a historical baseline, also supports the higher literacy figures in the unit. The unit is thus fairly well-represented by schools, although there is a high Standard One dropout rate compared to global averages. Compared to unit A, the literacy rate in the unit is improved. However, the unit displays significantly low improvement in education levels after primary school, with less than 20% having education higher than primary school.

Settlements

Settlements are small – extended household and villages are commonly found; and building materials are predominantly traditional.

Infrastructure

There is some access to safe drinking water in the Namibian portion of this unit – with at most 30% of the population in this area having such access. Elsewhere in the unit – especially in rural areas - access is worse and most water is sourced from surface or ground water sources, which is highly dependent on rainfall and upstream flows.

Improved sanitation services are almost non-existent in this unit.

Although electrification across the unit exists, instability of the grid as well as high poverty levels result in a high usage of wood for cooking and heating fuel – leading to deforestation.

Road infrastructure is present and provides linkages between the five countries; however, the roads are in poor condition and accessibility to markets is among the lowest in the entire basin. It is expected that formalised border crossings are not always present. The presence of a large number of landmines in the west of the unit, as mentioned earlier, reduce ease of access to certain areas.

Due to the Namibian portion of the unit being virtually ‘cut off’ from the rest of Namibia due to the existence of protected areas between it and the rest of country, the Namibian portion function largely as an extension of its bordering countries.

Environmental

The unit has a relatively higher green biomass level than unit E, to the east, supported by some stability in surface water run-off. Flooding is a concern along the far eastern border of Namibia, where it joins the other country boundaries. The areas is however, highly susceptible to drought conditions, making communities highly vulnerable to current as well as future climate variability.

Protected areas in the unit are fairly numerous and serve to maintain the ecological integrity in the area, although deforestation poses a risk for the continued maintenance of the biomass levels. Rainfall figures are expected to reduce drastically in future climate regimes, placing the agro-pastoral livelihoods and reliance on surface water resources under pressure.

Human-wildlife conflict exists and is of most concern in this unit within the Zambezi basin. Environmental degradation is exceptionally high – which again fuels a decline in soil fertility, as well as soil loss and associated downstream sedimentation risk for dam infrastructure.

Transboundary impacts

The unit has direct multiple transboundary links. Due to the remoteness of the area in terms of being on the border zones of each country, country-specific interventions seldom range to these areas, thus maintaining poverty levels.

Future food security due to drought impact is expected to be severe (based on estimated lower rainfall as well as increased heat waves). The unit’s high reliance on agricultural subsistence pose a higher risk of crop failure and herd reduction.

Investments in human capital and efficient safety-net targeting are key areas that could speed up poverty reduction and reduce inequality in the unit. Eradicating poverty will likely depend on increased linkages to more urbanised areas and improved transport, while improved access to water services will support improved health.

Vulnerability Zone D: Zambia/Zimbabwe (mid north-west)

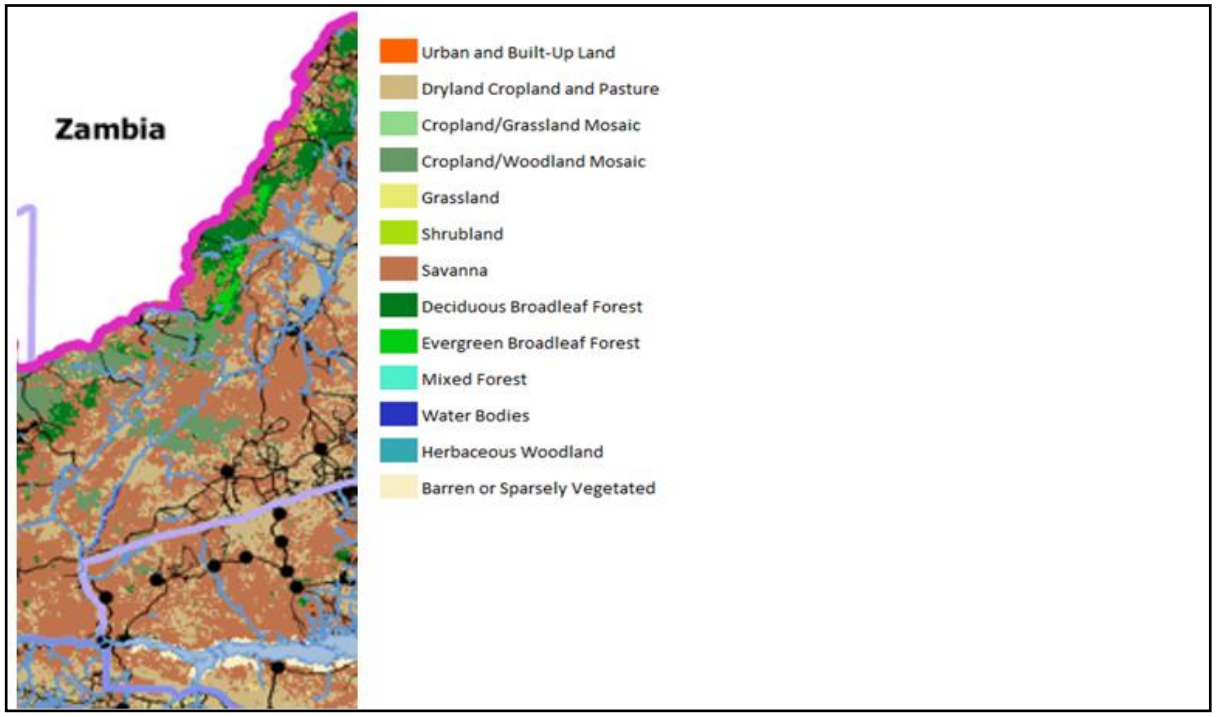


Figure 23: Vulnerability zone D, showing land cover background

Socio-Economic

The unit falls across Zambia (discussed in more detail as part of unit B) and Zimbabwe (discussed in more detail in unit E), thus displaying characteristics of both countries – although with the areas being fairly remote towards both countries' borders, the situation is potentially slightly worse in all regards, than what national averages portray. The border is fairly permeable, making conditions across the unit similar.

Agriculture reliance for livelihoods is very high. With relatively higher rainfall in this northern part of the basin compared with the southern areas, this unit supports rainfed farming practices with only limited irrigation-supported agriculture.

The unit houses poor populations, where food insecurity is a concern. However, the higher rainfall and fairly constant availability of surface water supports resilience in terms of year-round rainfed subsistence farming, provided the necessary storage and agriculture inputs are available.

Poverty rates have remained relatively stable over the past decade, with not much change in relative income levels. Education and employment similarly remain largely unchanged.

Population (including education and health)

The population narrative for these two areas are the same as that of Zimbabwe and Zambia – discussed in more detail in units B and E. Population density in the unit is among the lowest in the basin (Moise et al, 2011).

The unit is very poorly serviced by hospitals and clinics, causing the population death rates (especially that of children) to be significantly worse than the national averages. Malaria challenges in this unit are among the highest in the basin, and other diseases such as cholera and HIV/AIDS is also significantly high – in part related to the wetter and warmer climate that supports disease vector breeding, but also due to the poor health service status (Moise et al, 2011).

Settlement

Settlements in this unit are largely traditional, and small villages are predominantly located along road infrastructure.

Infrastructure

All infrastructure related service delivery is very poor; the resultant high reliance on natural water sources increases the health-related challenges in the unit.

Road conditions in the unit are particularly bad (Zambia Invest, 2017). Similarly, electricity supply is lacking and there is a very high reliance on natural tree supply for wood and charcoal (Africa Energy Atlas, 2014). The charcoal also gets sold – mainly gained from the northern areas of the basin where tree cover is still present, towards the villages and towns along the border.

Environmental

Relatively high levels of surface water availability and generally good run-off supports fairly suitable surface water quality – however, significant ponding of water, especially after rains, increases the risk of malaria, cholera and related waterborne-diseases (Future Climate for Africa, 2016).

As noted in the infrastructure narrative above, deforestation is a significant concern. Even though there are supposedly protected areas in large sections across the unit, these seem to function as a natural resource as opposed to serving as biodiversity maintenance/support areas.

Transboundary impacts

The impacts on this unit in terms of transboundary water management largely relate to downstream impacts on the drier southern area in the basin – a reduction in flow in this unit would impact downstream communities negatively, who are already water-stressed and highly susceptible to changes in the hydrological regime.

A key consideration in this unit is that the situation that communities face here seems to have stagnated. There is no evidence of planned improvements / interventions, and notably high disease rates are an on-going concern. This could have an impact on sustained livelihoods, given the ability of the population to engage in livelihood activities will deteriorate as a result of increased deaths and chronic illnesses. The only element of resilience that supports the unit is its natural capital – i.e. land cover and surface water sources – if these are compromised (e.g. through human intervention such as deforestation; or through climate change when a drier climate ensues) the unit stands the risk of becoming severely unstable.

Vulnerability Zone E: northern Zimbabwe (basin south-east)

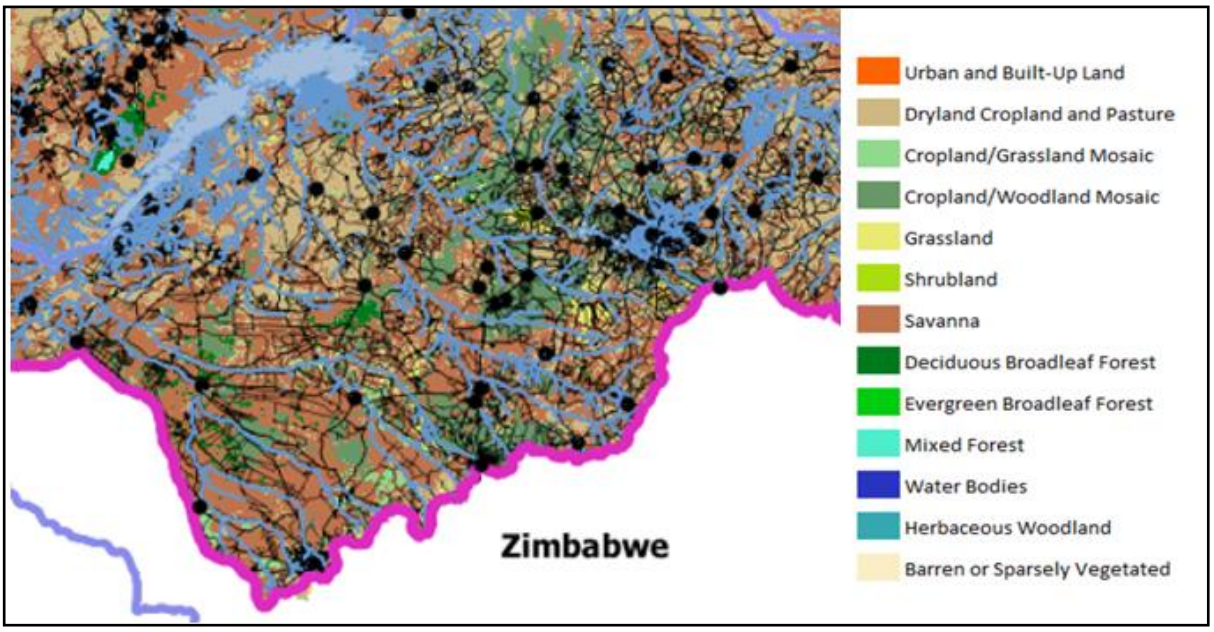


Figure 24: Vulnerability zone E, showing land cover background

Socio-Economic

The socio-economic situation in the unit is dire. Most households are poverty stricken with little food security, and high child-headed household levels are prevalent (at least two thirds of the population are below 25 of age, with a median age of 19). The situation is almost as dire as it is in unit A, with the exception that in this unit, some benefits from Harare are accrued (e.g. food can be sourced/sold) (SARUA, 2014).

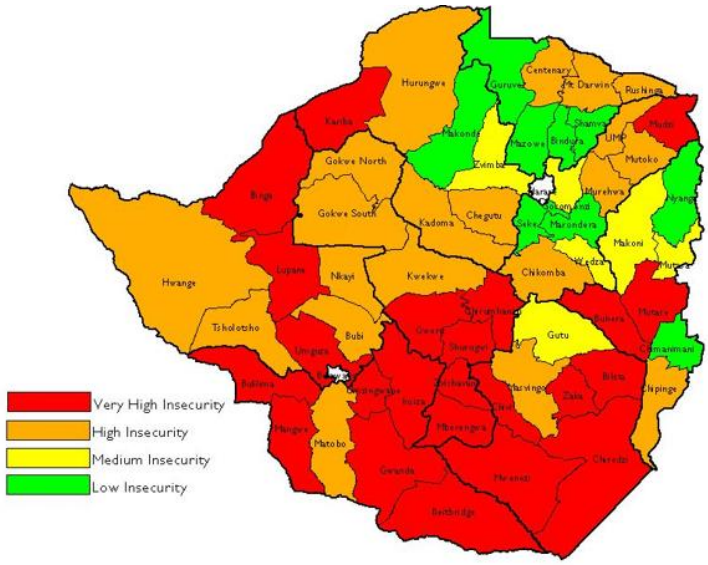


Figure 25: Zimbabwe severity of food insecurity by district (2008 being the latest for which these particular mapped statistics are available (ZimStat, 2012)

Cropland intensity has drastically decreased in the past decade, indicated in the figure below.

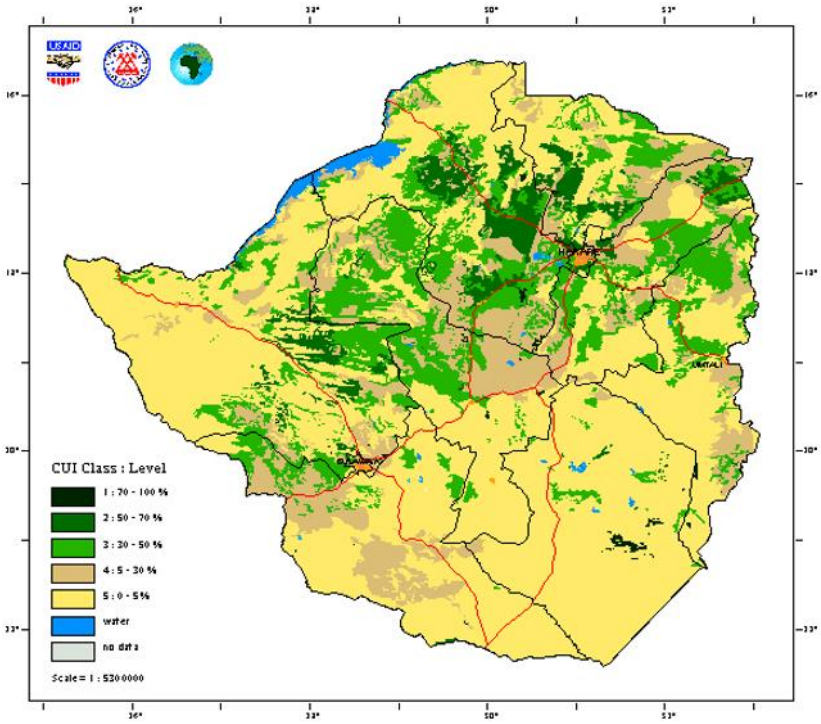


Figure 26: Cropland use intensity across Zimbabwe (ZimStat, 2012)

Most people rely on food imports and subsistence farming for food sources. Although the percentage of farmers in the population has increased, the change that Figure 27 does not note is a change in type of agriculture: a radical change from commercial to subsistence farming. Thus, while the number of farmers may have increased, food production output has decreased to well below where it can sustain consumption. Infrastructure supporting the delivery of seeds and fertilizer has become unstable, adding to the result in worse maize production figures in particular, year on year.

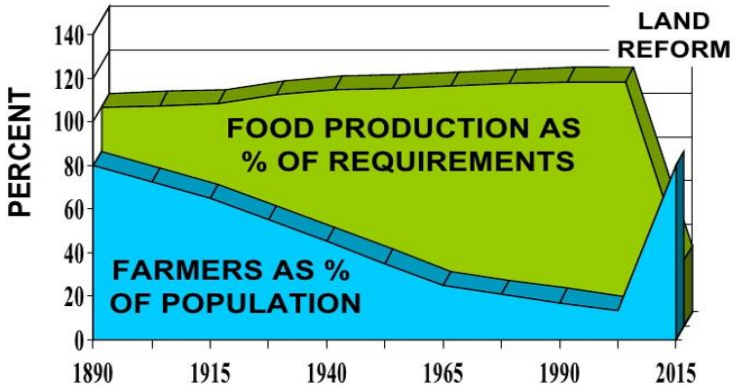


Figure 27: Historical agricultural production trends in Zimbabwe (United Nations, 2014)

Estimates show that approximately 2 million people are food insecure during growing seasons; this figure rises to at least 5 million during the 'hungry season' each year.

The presence of Lake Kariba enables subsistence farmers along the shores of the lake to rely on (relatively limited) tourism income as well as fish resources to augment their diet. The only exception is in and around Harare where the situation is improved. The situation is thus slightly improved from an average per-capita perspective due to improved formal employment figures in the city. However, the high influx of poor people into the urban area results in a wide disparity between the migrating poor and employed population in the urban area.

Zimbabwe's economy experienced severe challenges over the past two decades, reaching crisis proportions. Gross Domestic Product (GDP) is estimated to have contracted by at least 50% from historical estimates and official inflation rose above and beyond estimates of between 231 000 and 355 000 percent in 2008 (figures across reported sources differ significantly due to lack of reliable input data).

The economy is largely informal, thus reducing tax returns accordingly. Severe food and foreign currency shortages are still being experienced, even though the situation seems to have improved in the past year, relative to earlier this decade.

The context shows stabilisation and turnaround following the adoption of a multicurrency payments system in 2009. Other significant macroeconomic contributors to the stabilisation and resuscitation include price liberalisation, removal of surrender requirements on export proceeds, removal of exchange restrictions, the end of Grain Marketing Board (GMB) monopoly, imposition of budget constraints on Parastatals, and the reform of monetary and fiscal policy frameworks and institutions such as the Reserve Bank of Zimbabwe (RBZ). The 2013-3018 Zimbabwe Agenda for Sustainable Socio-economic Transformation (Zim Asset) was also set as the economic development blueprint and turnaround plan for Zimbabwe's development priorities. Despite these changes, the population is not benefitting in terms of livelihoods sustainability. It might take decades for the turn-around described above to have a real impact on community and household level.

Real GDP growth (2013)	4.5%
GNI per capita, Atlas method (current US$) (2013)	$820
Population, total (2012)	13,061,239
Population by sex (2012)	Females - 6,780,700 (51.9%) Males - 6,280,539 (48.1%)
Poverty headcount ratio at national poverty line (% of population) (2013)	72.3%
Life expectancy at birth, total (years) (2012)	58
Literacy rate, adult total (% of people ages 15 and above) (2013)	91.3%
External debt US$ (2013)	$8.934 Billion

Figure 28: Country analysis report for Zimbabwe (UN, 2014)

The foreign debt indicated in the table above soared in 2014 again – at least doubling, and it remains critically high. The socio-economic challenges in the unit are significant and diverse: including long-term economic stagnation, unemployment, inflation, food insecurity, poverty, HIV/AIDS prevalence, limited provision of basic services, power outages, droughts, lack of clean water, etc.

Population (including education and health)

The 2018 population is estimated at 16.91 million – an increase from the 2013 estimate of 14.09 million (UN, 2018). Population growth especially towards the north of Harare is high. The population density in the same area (Mashonaland Central) is also the highest in the unit. Approximately 30% of the country's population is urbanised. The female population in the unit is approximately 10 to 15% more than males.

Health services are poor, following the exodus of medical staff from the region, over time.

Although there are educational establishments in the unit, especially in and around Harare, the reality of this service being consistent and of high quality is doubtful. Nevertheless, literacy rates are reportedly some of the highest across the basin.

Zimbabwe's economic crisis during the past two decades have precipitated an exodus of university students and professionals from the country. Areas of expertise affected include medicine, engineering, surveying, architecture, audiology, veterinary medicine, and forensic science, among others. The exodus leaves this zone with particularly low human capital, skills and experience to support engineering-related infrastructure upgrades, food security and agricultural expertise. As a result, expertise and skills above certain levels are largely 'imported', which does not improve the outlook for local communities or households in terms of income generation.

Settlement

The unit is virtually 'dotted' in a grid-fashion, with villages and towns, linked via road access across the entire unit. Away from cities and towns, building materials remain traditional. Roads are not in a good state but remain travelable. Harare is the only larger city in the area, where formal housing and development is in place. However, the city's road and building infrastructure is (except for a few exceptions) in poor condition, with little maintenance and even fewer upgrades planned. Recent investment outlooks for the country creates the expectation of improved future settlement and infrastructure conditions which fuels urban migration; however, this is not yet visible (interpreted from various GIS layers).

Infrastructure

Primary road infrastructure in the unit is limited – with basically one highway crossing the area (the line in green, from Harare to the north-west in Figure 29). Road access (although it may not be of good quality) and access to small markets is relatively high compared to other units.

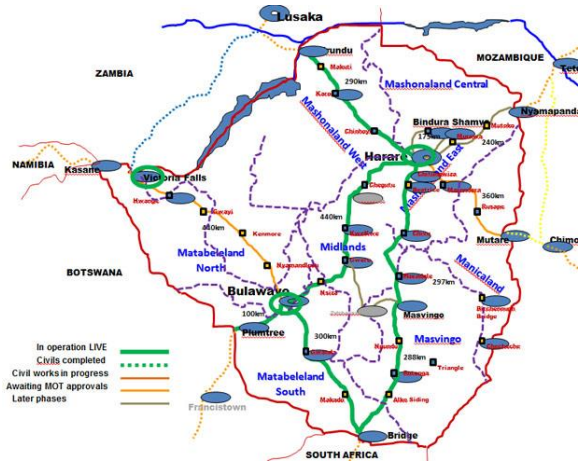


Figure 29: Road Infrastructure and growth in Zimbabwe as per AfDB, 2011-2020

There are seemingly high levels of access to electrical grid as well as water and sanitation services, based on historical infrastructure interventions. However, maintenance of this infrastructure remains almost non-existent, causing rapid deterioration of the networks, as well as return in reliance by communities on natural areas/traditional methods to support their water, sanitation, heat and cooking requirements.

Internet and cellphone coverage across the region is poor, as indicated below.

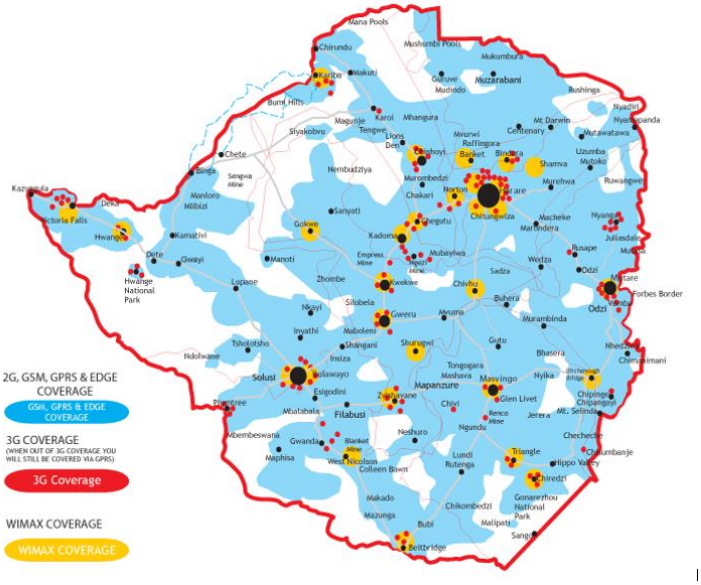


Figure 30: Cellphone/internet coverage in Zimbabwe as per AfDB, 2011-2020 (2018);

Environmental

The unit has a largely humid, subtropical climate, however recent droughts and low rainfall have reduced the ecological productivity of the area. The unit also represents significant ecological degradation, with associated erosion and loss in soil fertility driving the ever downward spiralling trends in farming outputs. Historical presence of game has virtually disappeared, reducing the ability of the region to regenerate its prior potential for tourism income (USAID, 2019).

In line with the settlement narrative above, as well as severe food insecurity, historically formally protected areas (e.g. near Urungwe, Charara, Mana pools and Umfurudzi) have lost their integrity. Poaching to augment food supplies as well as wood collection and bush-cutting have reduced the natural capital almost to negligent proportions. There is thus virtually no ecological baseline for the region to recover from, considering its existing level of degradation.

Sustained population growth and poverty levels along with this very low natural capital baseline presents a dire outlook for future livelihood sustainability across the unit. Extreme food insecurity is expected to increase, especially considering the high possibility of a drier, hotter climate, with increased droughts and heat waves (USAID, 2019).

Transboundary impacts

A primary transboundary concern relates to downstream catchments (in, as well as outside of, the unit) due to high levels of sedimentation, which relate to high levels of erosion and soil loss, and in turn relate to land degradation and unsustainable subsistence farming practices. Another key concern that could have transboundary implications is political instability, with the impacts of historical challenges having lasting repercussions.

Vulnerability Zone F: North-east (Zambia, Tanzania, Mozambique, Zimbabwe, Malawi)

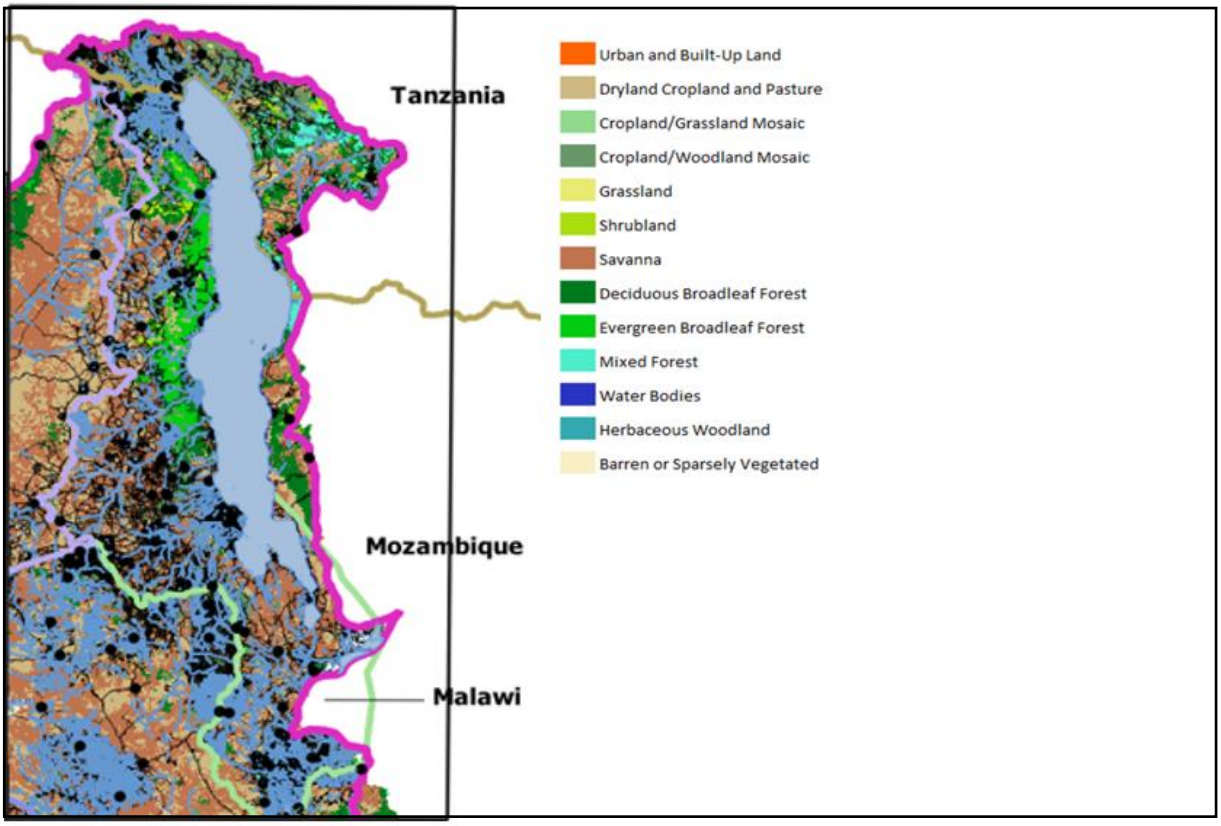


Figure 31: Vulnerability zone F, showing land cover background

Socio-Economic

Poverty in this unit is extreme (reflected by the expenditure figure below).

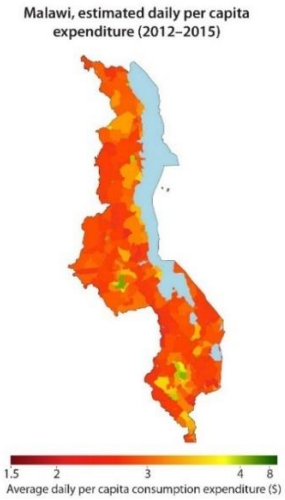


Figure 32: Estimated daily per capita expenditure (The solutions journal, n.d.)

The difference in this unit compared to others in the Zambezi basin is that the population density is also significantly high – virtually the highest across the region. Thus, positive interventions in this unit will have a multiplying effect since high impacts could be gained through very localised interventions.

There are some positive economic production figures, especially towards areas bordering the lake and permanent watercourse areas (illustrated in Figure 33 – noting that the far east of the map below is actually covered with water – and that the border 'on/in/along' the Lake edge is contested). However, it does not negate the acute levels of food insecurity in the area (see Figure 34).

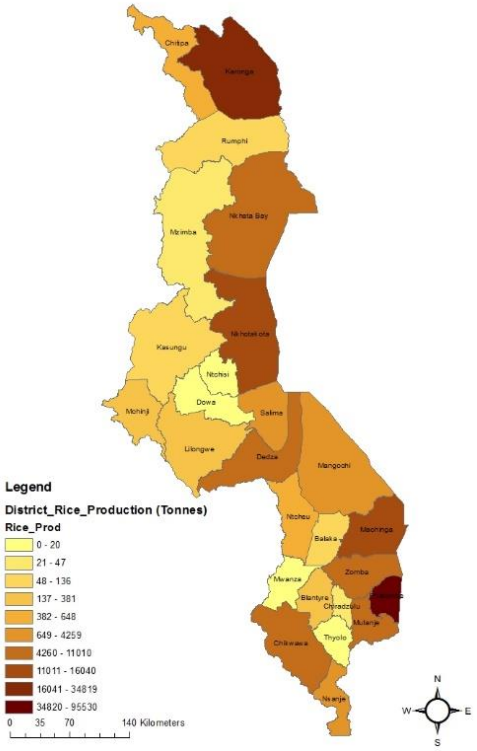


Figure 33: Rice Production as an indicator of income and food security (DFID, no date)

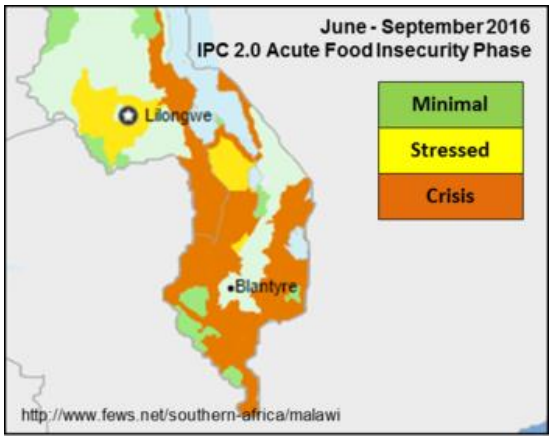


Figure 34: Food insecurity in the southern part of Malawi (FEWS, 2016)

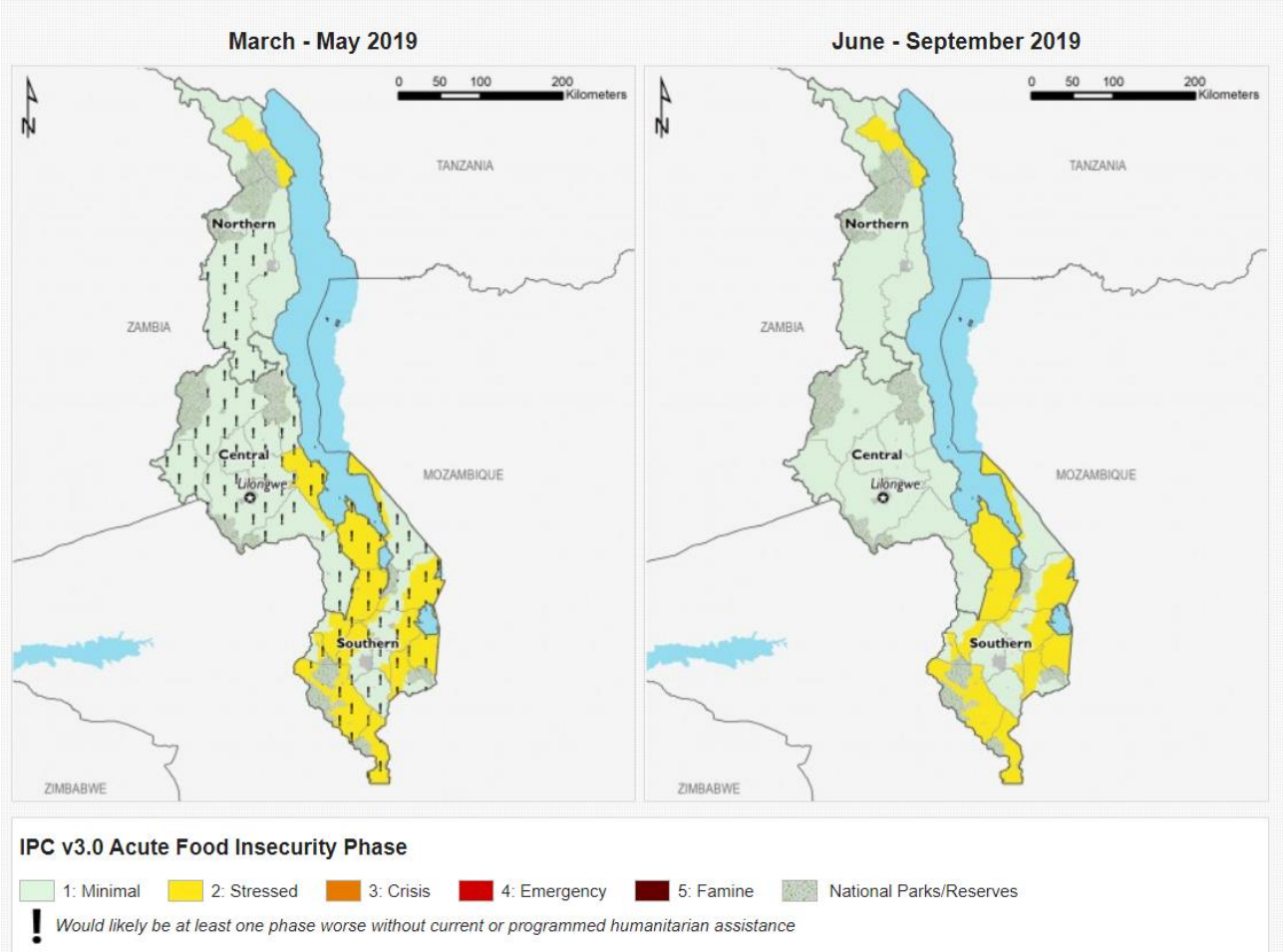


Figure 35: Food insecurity in the southern part of Malawi (FEWS, 2019)

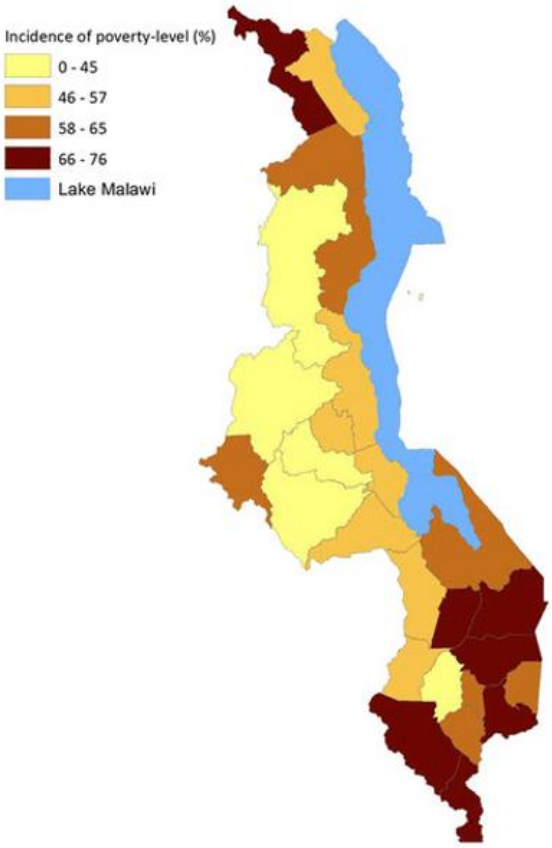


Figure 36: Malawi incidence of poverty in 2010 (Manda et al, 2015)

Population (including education and health)

Although only Malawi's graph is presented below, the demographics have the same shape as that of unit A populations. The difference is that in this unit, the population is slightly more aged than that of unit A.

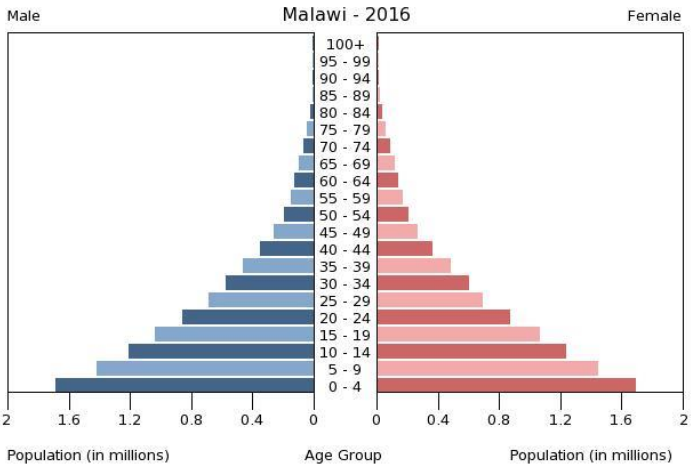


Figure 37: Malawi demographics (CIA, 2017)

This unit has a significantly high population and village density – as high or in some cases higher than any of the other units (Figure 38).

The population density is particularly high towards the south, in the Malawi portion of the unit, with Lilongwe and Blantyre having large urbanised populations. The poverty gap index is almost 'reversed (Figure 39), showing rural areas to be more affected by a larger income gap – which is to be expected considering the impact that urban areas have on income in general. The challenge it brings, however, is high urbanisation rates which place undue pressure on urban services to supply the needed support to the growing population. Similar data is not available across the entire unit; however, it is expected that the rural component of this picture is reflected in the rest of the unit, across borders with neighbouring countries.

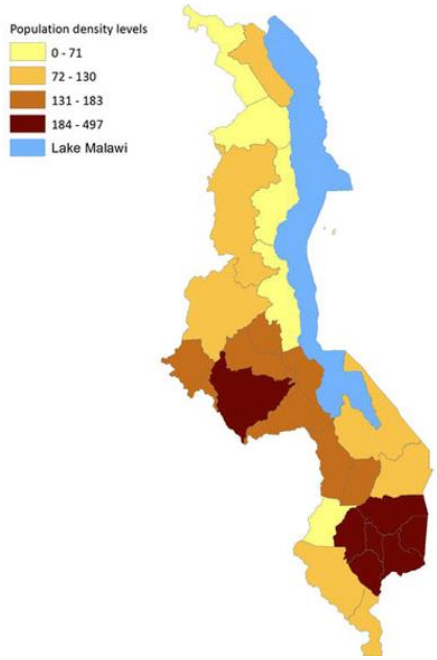


Figure 38: Malawi population density levels (2008) – by lack of more recent data (Manda et al, 2015)

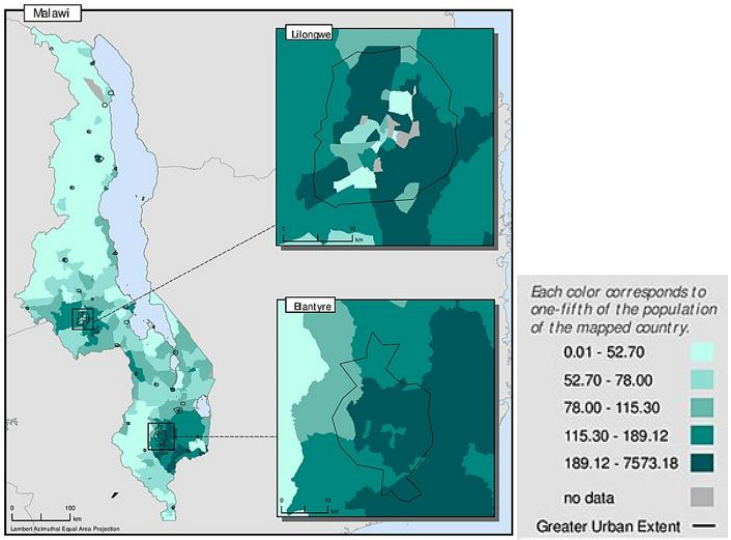


Figure 39: Malawi poverty density focussing on urban areas (CIESIN, 2005)

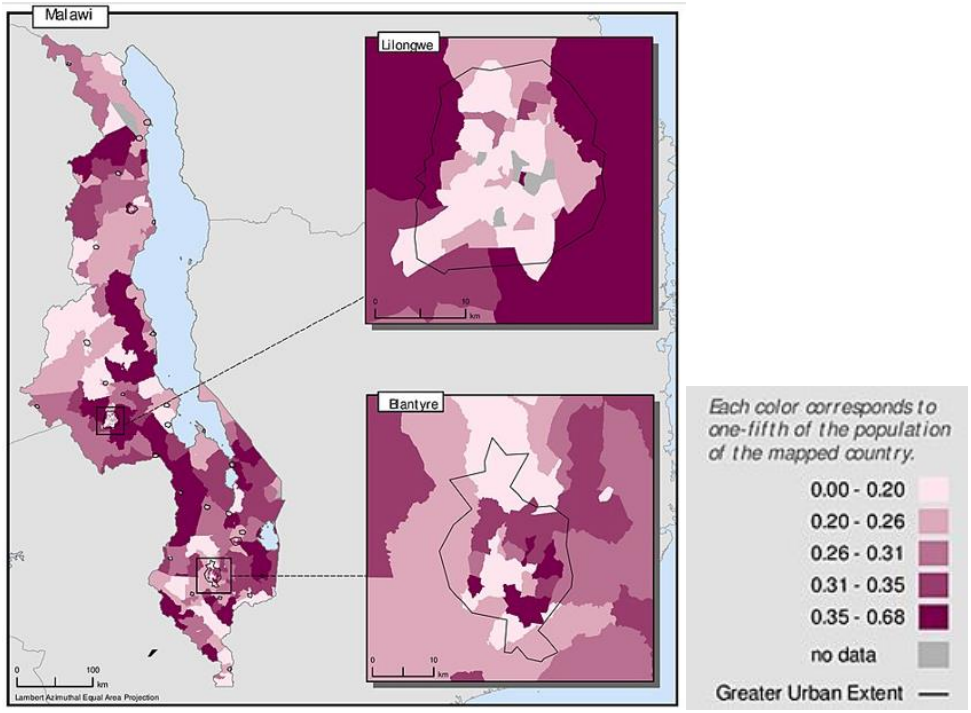


Figure 40: Malawi Poverty Gap Index [FGT(1)] focussing on urban areas (CIESIN, 2005)

There is a high incidence of violence in the unit – relatively higher than in the other units in the basin. The violence potentially reflects the population dynamics and the intensity of many people living (and migrating into) the area.

As is the case in unit D, malaria is of major concern – however, it is even greater: unit F and unit G have the highest malaria rates worldwide.

Settlements

Villages and homesteads are located across the unit, with often little distinction of where one entity starts and another ends. Building materials remain largely traditional. Cities have more formalised structures, although maintenance and upgrades are generally lacking.

Towards the Lower Shire valley (far south of the unit) and along the shores of Lake Malawi, (Lake Shore and upper Shire valley), as well as inland from the Lake, population densities are relatively lower, and the areas have poor market access. The only areas that can be considered as having good market access are the areas around Lilongwe and Blantyre.

Infrastructure

The electricity network in the Malawi area of the unit is fairly connected: however, consistency of supply is not secure. Road infrastructure is 'average' compared to that of the rest of the basin, with similar conditions existing in terms of road conditions reported across this document (i.e. poorer access and quality of roads as areas become more remote relative to urban hubs).

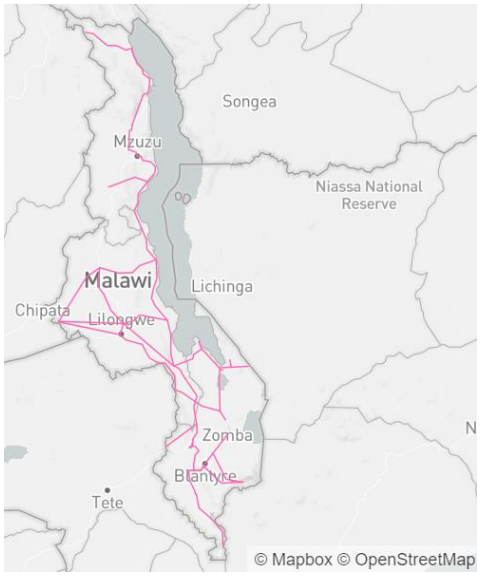


Figure 41: Malawi electricity network (International Renewable Energy Agency, 2015)

Similar electricity data for Tanzania and Mozambique has not been sourced, however the situation in those areas are deemed to be worse off than what is shown above. Railway coverage is also very poor.

Figure 42: Malawi rail network (Global Logistics Cluster, 2010)

Environmental

There is a low presence of protected natural areas in the unit (small areas in green indicated in Figure 43), with most of the unit being inhabited. The Malawi composite vulnerability to climate change (based on socio economic components) shows climate vulnerability is highest in areas where population density is highest – around the outskirts of urban areas and in the southern area of the unit. Although the same data is not available for the rest of the unit, the situation in terms of climate vulnerability is expected to reflect the same increased vulnerability towards the south.

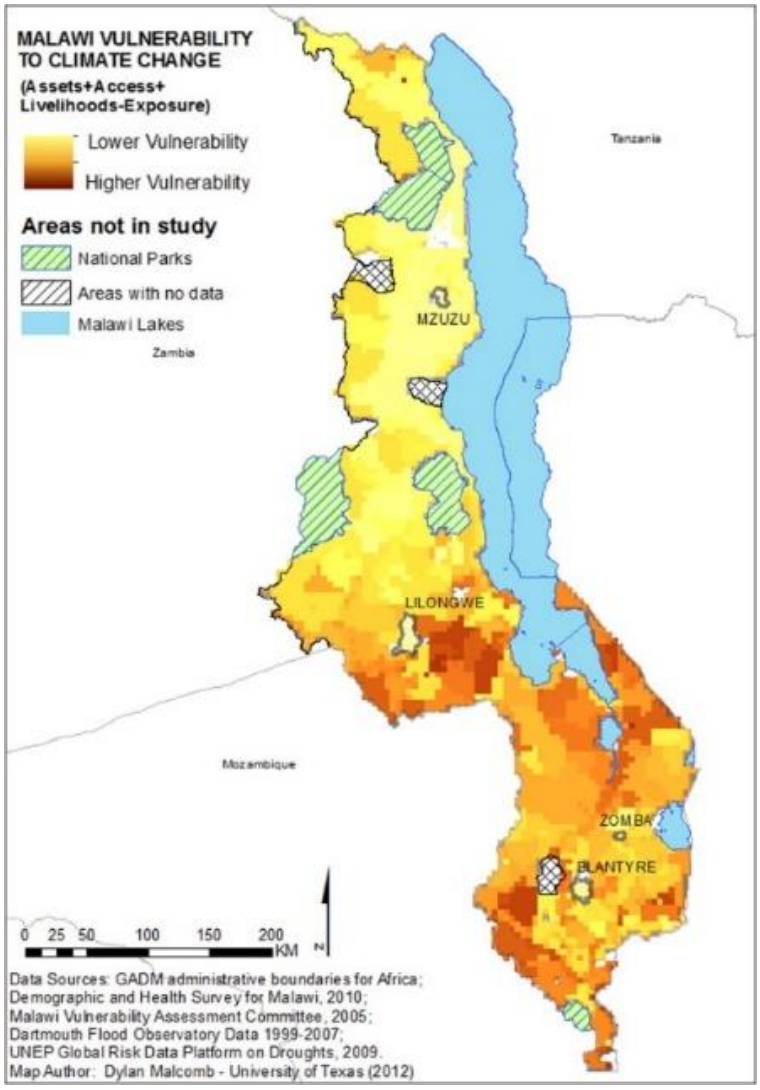


Figure 43: Malawi vulnerability to climate change (Malcolm, 2012)

Although dated (2002), a study that reflect on the incidence of forest vegetation occurrence and poverty rates (Figure 44) indicates a close correlation between forested areas (in this instance 'closed' forest) and poverty in Malawi. This association of natural capital and economic wellbeing points to major challenges when addressing poverty (i.e. opening areas for subsistence crop farming, for example) in comparison to the need to maintain forests for purposes of soil stability, climate balancing and localised air moisture content maintenance, as well as carbon sequestration. Care should thus be taken when interventions are designed in forested areas, to secure/maintain the forested areas.

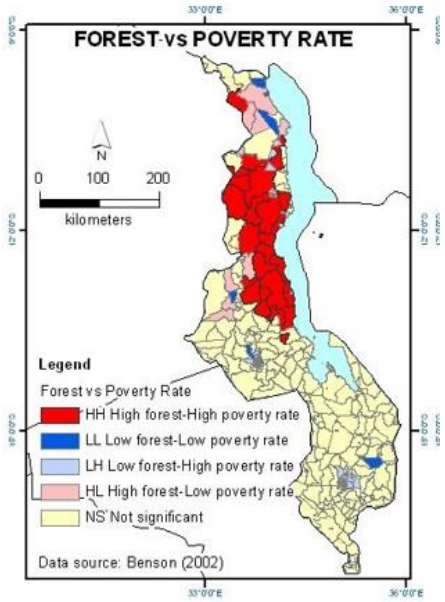


Figure 44: Malawi forest vs poverty rate correlation (Benson et al, 2002)

Transboundary impacts

Along with unit C, this unit has the largest number of transboundary considerations. The difference between this one and unit C is that here, population densities are notably higher. Thus, the pressures that communities face in terms of livelihoods is multiplied.

With the country borders crossing the Lake being contended, there is often unclear direction about how this surface water resource is to be managed effectively.

Figure 45: Malawi/Tanzania border dispute areas (Tanzanian Affairs, 2012)

Vulnerability Zone G: South-east (Primarily Mozambique)

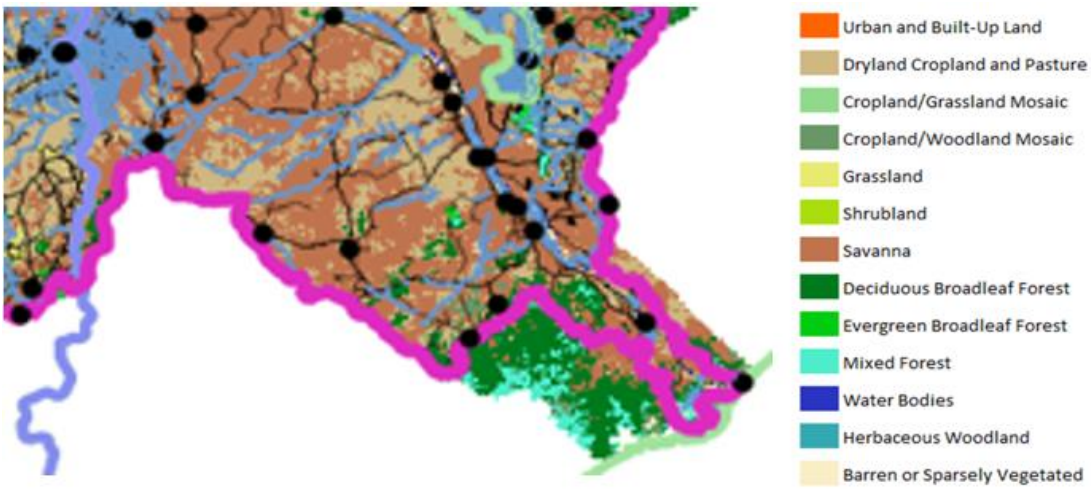


Figure 46: Vulnerability zone G, showing land cover background

Socio-economic

Populations in this unit reflect the same poverty levels as unit F. From a food security perspective, they are considered less vulnerable having a more varied food source basket than other more inland units (Figure 47).

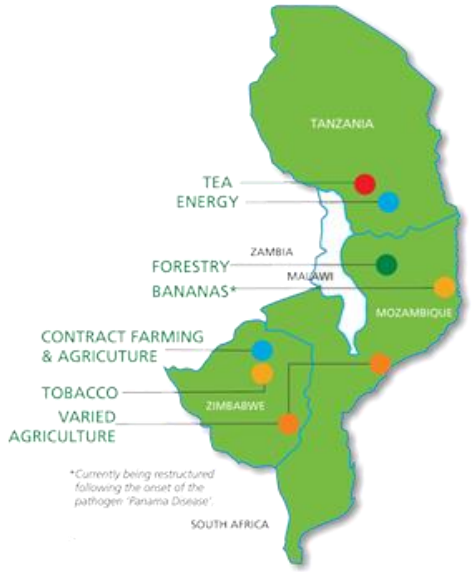


Figure 47: Agriculture variation across countries in eastern southern Africa (Rift Valley, 2016)

Staple foods in the unit include cassava and fruits harvested from non-commercial growth (interspaced in many instances in open forest areas). Sugar cane and Sisal farming is also present, in the form of commercial farming ventures.

Population (including education and health)

Population density in the unit is average (in relation to the rest of Mozambique) – around 30 to 50 persons per square kilometre (Figure 48, 2017 estimates). This shows a significant increase from the year 2000, when the same area sported on average 6 to 25 persons per square kilometre.

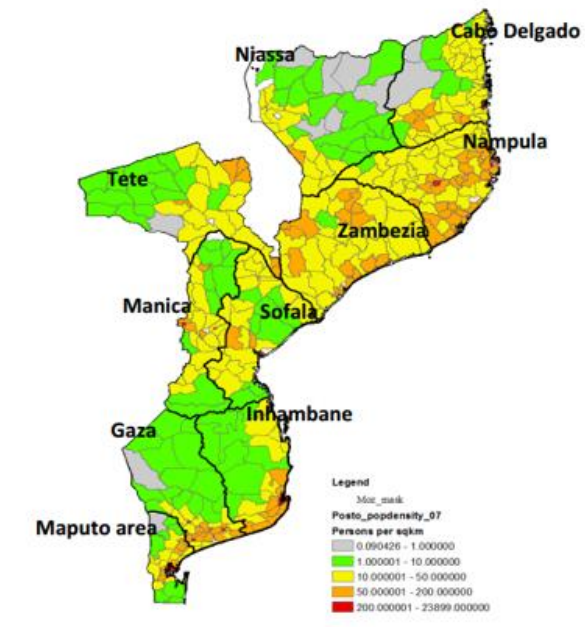


Figure 48: Mozambique population density by region and district (Alfani et al, 2012)

Malaria is a significant concern – along with units D and F, this unit has some of the highest rates in the basin. HIV/AIDS is very high.

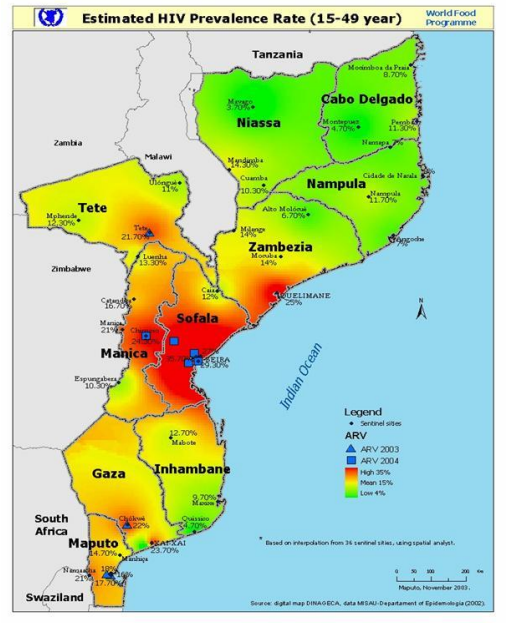


Figure 49: Estimated HIV/AIDS Prevalence rates in Mozambique (FAO, 2005)

There have been a significant number of vector-related disease interventions in the unit, with reported outcomes in terms of vector control rated as being very low to having almost no impact (orange and link colours in the Figure 50).

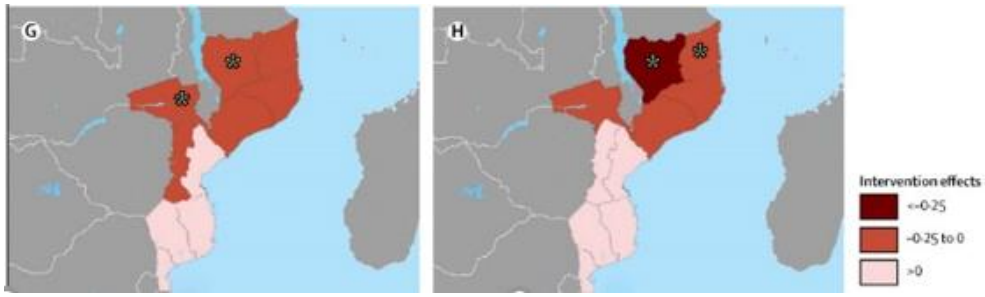


Figure 50: Vector intervention effects in Mozambique (Giardina et al, 2014)

Settlements

Settlements are largely in the form of dispersed villages and expanded households, with building materials largely traditional and non-durable.

Infrastructure

Although most of the major infrastructure in Mozambique initiates (starts) from Tete, the rural areas in the unit have relatively poor access (Figure 51). Where energy generation as well as oil and gas exploration and mining occur (the latter somewhat more to the south, outside of this zone), infrastructure is improved – however the improvements do not permeate to rural communities.

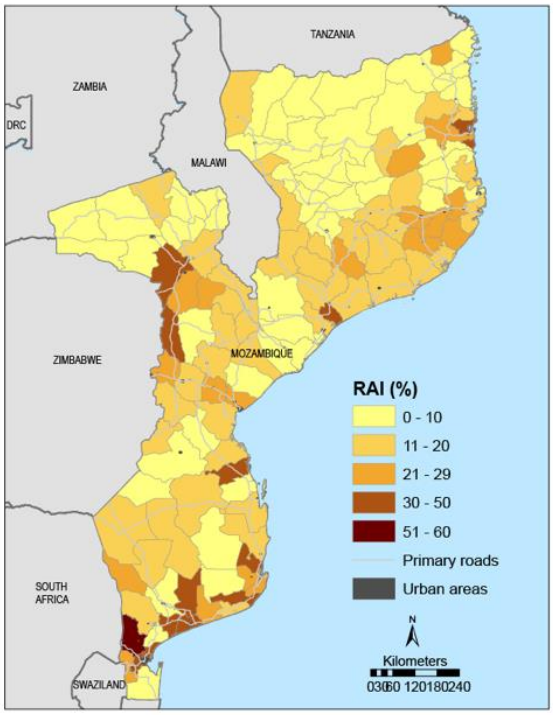


Figure 51: Mozambique rural access index, (Purdie, 2016)

Figure 52: Mozambique infrastructure and mining indications (Cross Border Information, 2013)

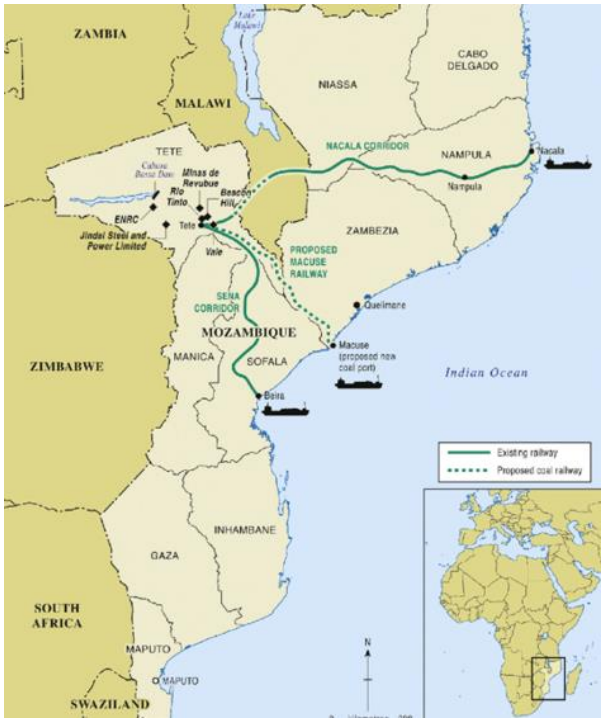


Figure 53: Existing and proposed additional rail (Kirschner et al, 2015)

Apart from a few fairly poorly tarred or gravel road, roads in the rural areas in the unit are mainly sand roads - making access challenging. Although available sources indicate no remaining landmine presence in the area,

local communities are concerned that there are still landmines remaining in the forested areas along some of the rural roads in the unit.

Electrical grid supply across the unit is high (from the Cahora Bassa dam in the north-west, towards South Africa) – however, local supply to rural communities remains limited (Figure 54 and Figure 55 below).

Figure 54: Mozambique power sector infrastructure (Kirschner et al, 2015)

Figure 55: Simplified power infrastructure map (Kirschner et al, 2015)

Water infrastructure services in this unit's rural areas are equally poor, with sanitation mainly existing in non-improved forms.

Environmental

There are almost no protected areas in the unit. Flooding, especially in the area closer to the river mouth/coast, is frequent and often severe. These flood impacts are expected to increase in severity, both due to increased sedimentation (which is related to deforestation and soil loss upstream) as well as flash-flood releases related to upstream catchment management practices (or lack thereof).

The unit has largely a warm humid climate, with tropical savanna, and broadleaf forests towards the inland area, with Mangrove swamps towards the coast.

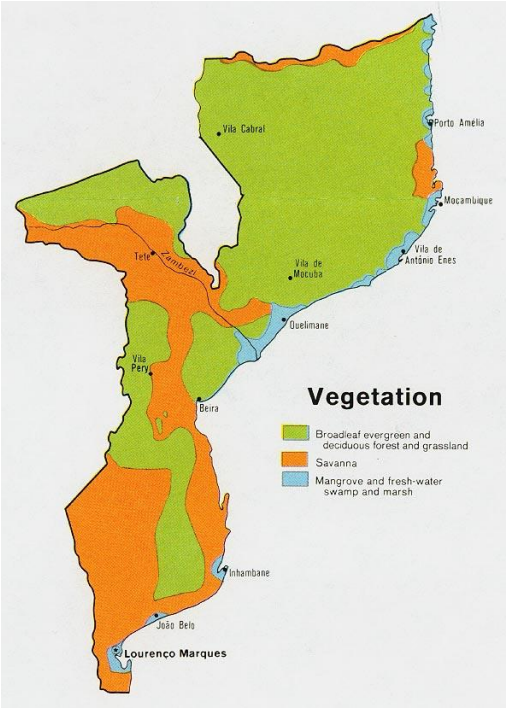


Figure 56: Mozambique simplified vegetation cover (1973, Accessed from Mapcruzin)

The same forestry-poverty correlation exist in much of the unit, as is described for unit F.

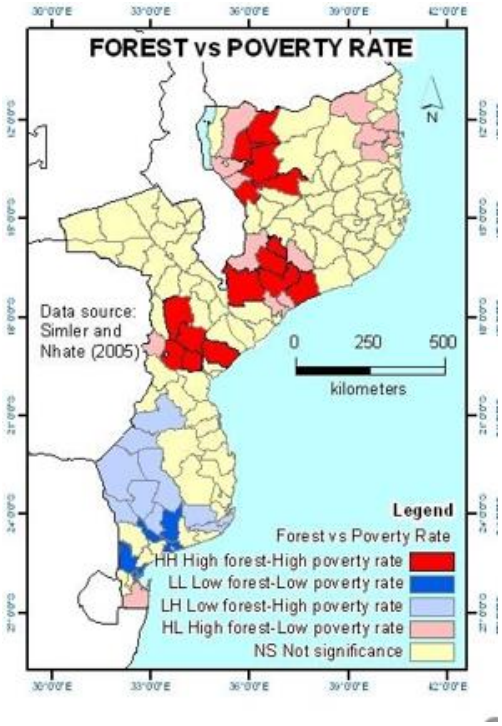


Figure 57: Mozambique forest vs poverty rate correlation (Benson et al, 2002)

Air pollution is a concern in the area, related to the burning of wood for cooking – due to poor rural electrification.

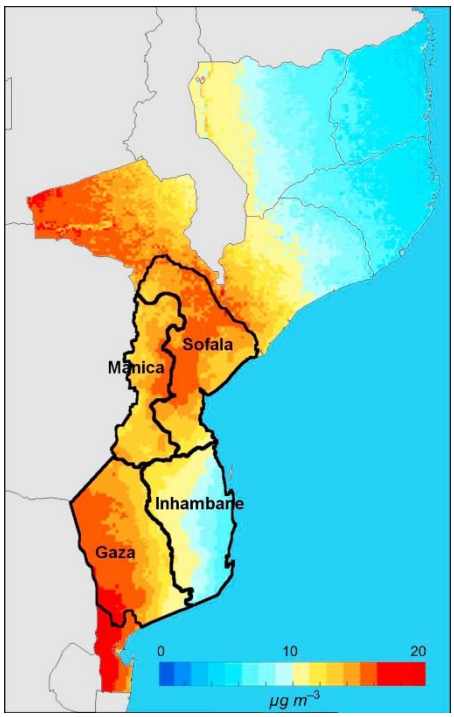


Figure 58: Mozambique air pollution related health and climate risk map (Anenberg et al 2017)

Deforestation in the unit is of *critical* concern: Satellite imagery shows deforestation in Mozambique from 2000 (left) to 2012 (centre) and projections to 2019 (right) if current rates continue.

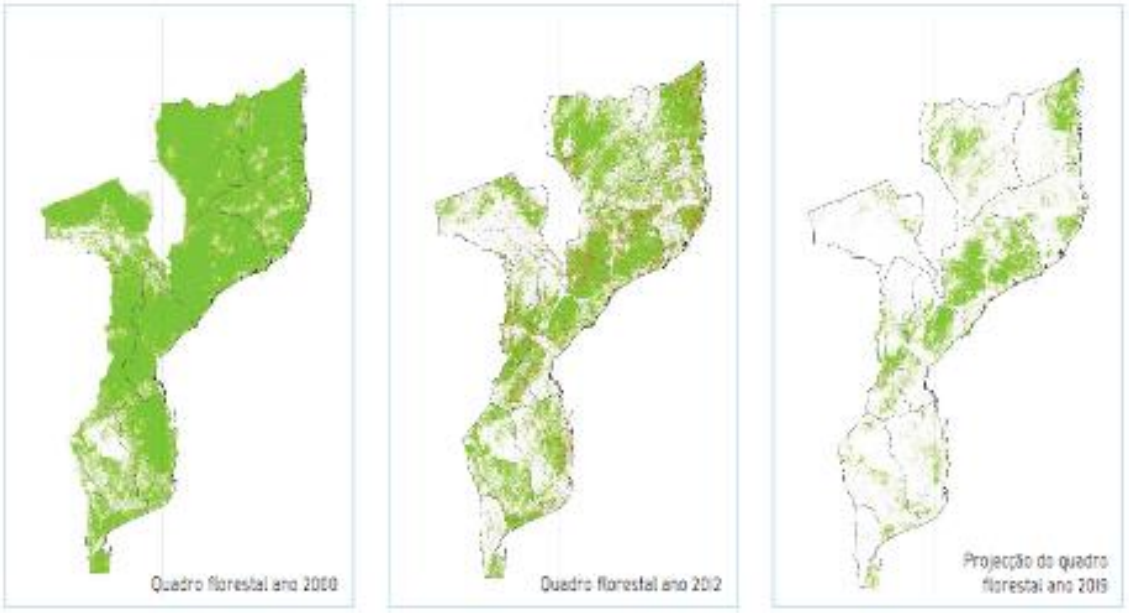


Figure 59: Mozambique air pollution related health and climate risk map (Schwartz, 2016)

Transboundary impacts

Although the unit does not have much border-share with other countries in the basin, it is directly affected by all upstream countries and therefore very vulnerable to upstream changes in environmental, as well as population, economic and political processes.

Annex B - Spatial Data Metadata

Layers indicated in orange are not currently used in the spatial data overlay but are available for desk-based text review.

Layer	Source	Source URL	Original Metadata URL	License	Date Obtained	Date Created	Processing done	Citation
City Accessibility	The Malaria Atlas project	https://map.ox.ac.uk/explorer/#/explorer	http://doi.org/10.1038/nature25181	www.creativecommons.org/licenses/by/3.0 You may use the image in your publications, provided you accredit us.	May 2018	2015	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	D.J. Weiss, A. Nelson, H.S. Gibson, W. Temperley, S. Peedell, A. Lieber, M. Hancher, E. Poyart, S. Belchior, N. Fullman, B. Mappin, U. Dalrymple, J. Rozier, T.C.D. Lucas, R.E. Howes, L.S. Tusting, S.Y. Kang, E. Cameron, D. Bisanzio, K.E. Battle, S. Bhatt, and P.W. Gething. A global map of travel time to cities to assess inequalities in accessibility in 2015. (2018). Nature. doi:10.1038/nature25181.
Malaria (Falciparum incidence between 2 and 10 years old)	The Malaria Atlas project	https://map.ox.ac.uk/explorer/#/explorer	https://dx.doi.org/10.1038/nature15535	www.creativecommons.org/licenses/by/3.0 You may use the image in your publications, provided you accredit us.	May 2018	2015	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	Bhatt S, Weiss DJ, Cameron E, et al. The effect of malaria control on Plasmodium falciparum in Africa between 2000 and 2015. Nature. 2015;526(7572):207-211.
Hansen Tree loss	Hansen/UMD/Google/USGS/NASA	http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.5.html	**Error! Hyperlink reference not valid.** _v1.5.html	Creative Commons Attribution 4.0 International License	May 2018	2017	Merged and Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S. Vectorised and feature ids 1-16 dissolved	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from:http://earthenginepartners.appspot.com/science-2013-global-forest.
Hansen tree cover	Hansen/UMD/Google/USGS/NASA	http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.5.html	http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.5.html	Creative Commons Attribution 4.0 International License	May 2018	2017	Merged and Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S. Vectorised and feature ids 1-16 dissolved	Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. Data available on-line from:http://earthenginepartners.appspot.com/science-2013-global-forest.
Sub basins (mean slopes for each sub basin)	WaterBase	http://www.waterbase.org/download_data.html	email waterbase.contact@waterbase.org	States that may be used freely	April 2018	?	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	
Transport layer	OSM	Direct download through QGIS. Also available with Geofabrik.	Metadata can be found per feature online.	Open Database License	June 2018	version April 2018	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	Our requested attribution is "© OpenStreetMap contributors". You must also make it clear that the data is available under the Open Database Licence. This can be achieved by providing a "License" or "Terms" link which links to www.openstreetmap.org/copyright or www.opendatacommons.org/licenses/odbl.
Water Layer	OSM	Direct download through QGIS. Also available with Geofabrik.	Metadata can be found per feature online.	Open Database License	June 2018	version April 2019	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	Our requested attribution is "© OpenStreetMap contributors". You must also make it clear that the data is available under the Open Database Licence. This can be achieved by providing a "License" or "Terms" link which links to www.openstreetmap.org/copyright or www.opendatacommons.org/licenses/odbl.
Settlements	OSM	Direct download through QGIS. Also available with Geofabrik.	Metadata can be found per feature online.	Open Database License	June 2018	version April 2020	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	Our requested attribution is "© OpenStreetMap contributors". You must also make it clear that the data is available under the Open Database Licence. This can be achieved by providing a "License" or "Terms" link which links to www.openstreetmap.org/copyright or www.opendatacommons.org/licenses/odbl.
Landmines	OBIS/ CNIDAH- Comissão Nacional Intersectorial de Desminagem e Assistência Humanitária	http://leutra.geogr.uni-jena.de/obis/metadata/view.php?view=geodata&id=23463&ident=854941330384463104	**Error! Hyperlink reference not valid.** view.php?view=geodata&id=23463&ident=854941330384463104	Original data source inaccessible	May 2018	#####	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	UNKNOWN
ACLED data	ACLED	https://www.acleddata.com/data/	Metadata contained in excel spreadsheet downloaded or contact admin@acleddata.com	Creative Commons Attribution Share-Alike	May 2018	used March 2013-March 2018 data	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	Raleigh, Clionadh, Andrew Linke, Håvard Hegre and Joakim Karlsen. 2010. Introducing ACLED-Armed Conflict Location and Event Data. Journal of Peace Research 47(5) 651-660.

Protected areas	Protected Planet	https://www.protected planet.net/	Not found in a metadata format	https://www.protectedplanet.net/c/terms-and-conditions	May 2018	Updated monthly. Used version of May 2018	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	UNEP-WCMC and IUCN (year), Protected Planet: [insert name of component database; The World Database on Protected Areas (WDPA)/The Global Database on Protected Areas Management Effectiveness (GD-PAME)] [On-line], [insert month/year of the version downloaded], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.
Landcover esa	ESA	https://www.esa-landcover-cci.org/		Copyright 2015 @ European Space Agency All rights reserved.	May 2018		Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	
Country Administrative boundaries	GADM	https://gadm.org/data .html	https://gadm.org/ metadata.html	The data are freely available for academic use and other non-commercial use. Redistribution, or commercial use is not allowed without prior permission.	March 2018	Often updated. Used version of March 2018	Reprojected from WGS 84 to WGS 84 :UTM 34S	
Zambezi Basin Boundary					May 2018		Reprojected from WGS 84 to WGS 84 :UTM 34S	
Reservoirs and Dams	NASA Socioeconomic Data and Applications Center (SEDAC)	http://sedac.ciesin. columbia.edu/data/set /grand-v1-reservoirs-rev01/data-download#close	http://sedac.ciesin. columbia.edu/data/ set/grand-v1- reservoirs-rev01/ metadata	The Global Water System Project (GWSP) holds the copyright of this data set. The GRanD database is freely available for non-commercial use. Users are prohibited from any commercial resale, or redistribution without explicit written permission from the authors (Lehner et al. 2011) or GWSP. Users should acknowledge the authors (Lehner et al. 2011) and SEDAC as the distributor as the source used in the creation of any reports, publications, new data sets, derived products, or services resulting from the use of this data set. GWSP or CIESIN may also request reprints of any publications. For further details regarding acknowledgements, citation, disclaimers, and restrictions please refer to Section 4 of the Technical Documentation which is provided with the data.	21-06-2018	2011	Clipped to Zambezi Basin and reprojected from WGS 84 to WGS 84 :UTM 34S	Lehner, B., C. Reidy Liermann, C. Revenga, C. Vorosmarty, B. Fekete, P. Crouzet, P. Doll, M. Endejan, K. Frenken, J. Magome, C. Nilsson, J.C. Robertson, R. Rodel, N. Sindorf, and D. Wisser. 2011. Global Reservoir and Dam Database, Version 1 (GRanDv1): Reservoirs, Revision 01. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H4HH6H08. Accessed DAY MONTH YEAR. AND Lehner, B., C. Reidy Liermann, C. Revenga, C. Vörösmarty, B. Fekete, P. Crouzet, P. Döll, M. Endejan, K. Frenken, J. Magome, C. Nilsson, J.C. Robertson, R. Rodel, N. Sindorf, and D. Wisser. 2011. High-Resolution Mapping of the World's Reservoirs and Dams for Sustainable River-Flow Management. Frontiers in Ecology and the Environment 9 (9): 494-502. http://dx.doi.org/10.1890/100125.

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