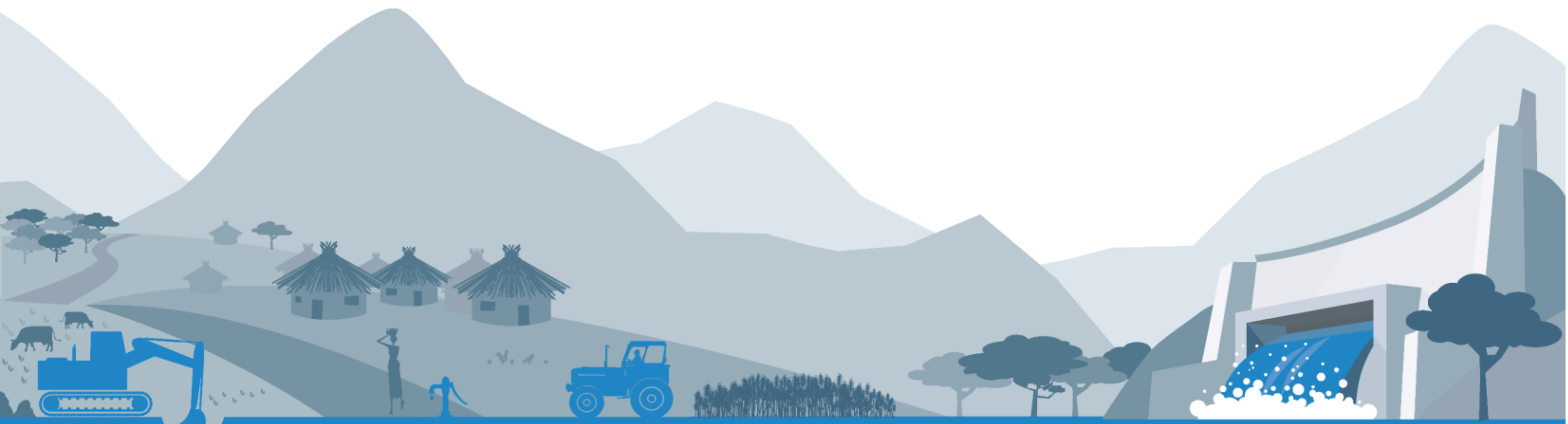
OKACOM Livelihood Vulnerability Hotspot Mapping: Methodology

August 2018

Final



Contents

1. Brief overview of the aim and approach towards Livelihoods Vulnerability Hotspot identification, characterisation and intervention typology consideration in the Cubango Okavango River Basin

Livelihood vulnerability hotspot mapping assists River Basin Organisations (RBO's) with the identification of hotspots where livelihood vulnerability in the basin is significant, considering both the current and potential future impacts of climate change, as a significant component of global change. This report presents the methodology that was followed from inception of the livelihoods vulnerability mapping concept, through to identification of hotspots and appropriate livelihood responses (i.e. livelihood intervention typologies).

Broadly stated, the work activities included:

- A **literature review (Sections 2-5 of this document)**, which consisted of an overview of contemporary (project-based) and academic research in terms of quantitative and qualitative approaches that have been applied worldwide over the past decade, to produce hotspot maps using digital spatial data layers as a basis.
- The work then progressed to the **identification, collection and collation (Sections 6 and 7)** of freely available spatial data layers for the Cubango Okavango River Basin (CORB), relying on freely available online spatial data sources and through collection of data from data holders and data custodians in and related to the basin.
- Thereafter, during a preliminary investigation, the spatial layers were overlaid in a variety of **scenarios (Section 8)** to quantitatively evaluate the relevance and impact that a) individual layers, b) combination of layers, and c) different weighting of layers, may have on resultant hotspot overlay maps.
- Based on the outcomes of the above process, which was to a large degree dependent of the wide variety of characteristics related to livelihood variables that exist across the basin, it was determined that a standard quantitative overlay process - a common approach in hotspot mapping – is not suitable for CORB. The basin was thus divided into five '**homogenous zones**' **(Section 9)** where land cover and related elements of natural and socio-economic variables presented similarities. These five zones correlate with similar studies that have been done earlier and independently for the basin (TNC, 2018).
- Of the five homogenous zones, three are representative of the active hydrological part of the basin. Within these three 'hydrologically active' homogenous zones of the basin, **six hotspots were identified and characterised** (detailed in a separate report) that represent areas where livelihood vulnerability in relation to climate change and the future ecological integrity of the basin exist. At this time, a more qualitative approach was followed to characterise the hotspots, based on the literature review contents and spatial data layer information from the preliminary activities, as well as through interaction with various specialists who were able to provide validation and additional information. The

hotspots correlate with similar study outcomes that have been developed across the basin, which included significant ground-truthing at the time (through the SAREP and MSIOA projects), as well as with more recent investigations in relation to the Endowment Fund (CRIDF, 2018). A separate draft report is available with these narratives and preliminary findings.

- The next activity in the livelihood vulnerability hotspot mapping and characterisation process will be to **identify typologies** that relate to livelihood vulnerability reduction as it pertains global change, of which climate change is a key element.

The overall anticipated project workflow is presented below:

	Objective	Activities
1	Establish & discuss current and future hazards and vulnerabilities collaboratively	Facilitate consultative Inception Workshop on proposed process & interactive session on hazards and vulnerabilities
		Desktop analysis on types of vulnerabilities & hazards *[literature review to inform sourcing of raw data from reports; CRDP development scenarios; SAREP 2013, etc.]*
2	Develop fit-for-purpose methodology for the assessment with OKACOM and collaborating partners	Review of existing methodologies
		Engagement with stakeholders from previous studies
		Define scope & limitations & assumptions to guide methodology • Including stakeholder analysis/mapping
		Draft fit-for-purpose methodology • Capable of incremental / modular changes, feeding into a DSS
		Disseminate to OBSC – incl. continuous interaction & updating OBSC on progress
3	Determine and collate critical datasets through stakeholder engagement, past research and other related studies	Share metadata list for review and input
		Workshop data options
		Source and clip raw data
		Identify existing interventions (locations & basic information)
4	Identify 'hotspots' and define key current and future vulnerabilities and risks by mapping and overlaying datasets	Convert GIS into polygons
		GIS overlay
		Develop basin-wide and country maps
5	Corroborate results by reengaging stakeholders through in-country validation meetings	Facilitate in-country validation focus group discussions with thematic technical experts & CBOs/NGOs operating in the basin
6	Define appropriate livelihoods responses to address each 'hotspot'	Identify livelihood proxy projects / typologies / responses that address hotspot issues *[aligned to Endowment Fund proxy project typologies]*
		Identify linkages between hotspots to develop transboundary narrative
		Relate proxy projects to hotspots & SAP Objectives
7	Identify livelihood projects from existing regional, national, sub-national, and development agency lists – and overlay these on the 'hotspot' map	Identify national and regional lists (NAPs, Plan Generale, national/provincial development plans (Agri & water sector))
		Overlay projects
		Relate projects to hotspots & response types
8	Regional OKACOM stakeholder engagement [*OBSC, WRTC, member state representatives, NDAs, development agencies, national direct access entities for GCF, etc.]*	Synthesise regional report and basin-wide map
		Present and discuss output
		Post-workshop reporting
9	Develop concept notes – designed to attract funders' interest and mobilise finance for implementation of livelihoods interventions	Develop concept note template & 'how-to' guide
		Facilitate capacity building sessions with OKACOM & relevant partners on concept note development, incl. useful tools to support concept note development: • Vulnerability Assessment Tool • Gender tools • Funder screening tool • Climate Change Risk Assessment tool • Local job creation tool (?) – incl. youth

	Objective	Activities
		Collaboratively develop concept notes for several projects (focussing on several different project typologies)
		Provide for capture: selected spatial data & maps, tools, reports, concept notes etc. in OKACOM DSS

2. Literature review: considering spatial data for livelihood vulnerability hotspot mapping

'Everything happens somewhere'. Thus, spatial location is the key to addressing developmental interventions, especially when related to climate change. A vulnerability map gives the locations where people, communities, the environment or infrastructure are at risk (Jaiteh *et al.*, 2015). These are most often created using GIS, but can also be done manually, to form the design of responses and target development, adaptation and risk reduction (*ibid*).

Overlay analysis is used to combine the characteristics of a number of datasets into one map. This can be done using vector (lines, points and area-based) overlays or raster (gridded or cell-based) overlays, or a combination of the two. This overlay process yields a single data layer or map with locations that have specific attributes or characteristics, depending on the combined features, and in some instances, weighting or ranking of layers (ESRI, no date). This method can be used to find locations susceptible to, for instance, a particular land-use, that adheres to specific requirements for the objectives of the analysis, or suitable for a particular function or intervention toward livelihood resilience.

Hotspot mapping takes many shapes and forms and is usually approached from a quantitative position – from point-density mapping (which may include spatial interpolation by means of spatial data interpolation methods such as Kriging[1] (SANAC, 2016)), or kernel density estimation (Anderson, 2006) to raster (cell-based) overlays (Strydom, 2004) and vector (polygon-based) assessments. There are also many approaches based on summation or multiplication (with or without weighting or ranking) of spatial data layers that correspond with quantitative analytical process assessments. There are also a range of qualitative approaches that have been used effectively in hotspot identification studies, based on stakeholder engagements where the informed perceptions of knowledgeable specialists and/or indigenous knowledge of communities is harnessed to determine areas of interest depending on study requirements. Regardless of which quantitative, qualitative or combined approach is adopted, hotspot modelling does not aim to provide an indication of trends over time or changes in trends or risks, but rather an indication of a particular moment in time for which the spatial data is

[1] Used in geostatistics to optimally interpolate (predict) the value of a random point-based variable over a spatial region. Given a set of locations, Kriging creates an area-cover spatial layer of the predicted covariance value throughout the region (Bohling, 2005).

assessed or modelled (SANAC, 2016), or where stakeholder involvement is engaged in. Thus, hotspot 'identification and characterisation' is ideally an evolving process where initial hotspot areas and characteristics may be adjusted and adapted over time, to reflect changing situations or programmatic requirements.

Hotspots are geographical areas or locations with *evidence* of high prevalence of spatially represented indicators or behaviours that identify people or communities at risk (UNAIDS/WHO Working Group on Global HIV/AIDS and STI Surveillance 2013). Hotspots are sometimes also referred to as 'high burden zones' (Beyrer *et al*. 2014) – thus, areas where resilience to cope with external impacts and stressors are lower than in other areas.

Hotspot mapping (also commonly referred to as 'site selection' depending on the purpose that it is done for) is often adopted to determine areas where development intervention strategies can/should be implemented. Worldwide and across sectors, there is no single approach or standardised method that can be adopted to identify hotspots. In essence, most hotspot mapping process rely on the following factors to base its success - that is, when these items are of high quality, the hotspot mapping can be considered a 'best practice approach':

- Data completeness and quality (SANAC, 2016), based on scale in relation to study area and purpose: The availability of spatial data (especially in Africa) differ in scale and accuracy depending on what the purpose/aim of the original data capture process was identified as. In many cases available data has not been captured for e.g. livelihood mapping purposes. Thus, data has to be 'massaged' or derived from available useful data sets to enable variables that can be used as proxies – in this case towards livelihoods hotspot mapping.
- Data recency/age (also referred to as 'vintage') (*ibid*) and timeliness or frequency of update: Although geological and topographical data does not alter significantly over time, other data sets such as demographics and health statistic information may change often. There is often a difficult decision to be made as to whether to include or exclude a particular dataset when it is both considered to be a critical variable towards the spatial assessment, versus its age if it is dated.
- Representativeness (*ibid*) and availability of homogenous data sets across an entire study area: this element is important to support cross-country and RBO-wide assessments. There are two elements of concern here: homogeneity of capture and collection (which also relate to scale) and consistency in terms of area-coverage. Often, very good and well-scaled data may be available at country- or regional level, however when data is available in one area and not in another, there is a question as to how to integrate the non-availability of spatial layers – do the non-homogenous data get eliminated from the mapping process, or does it get integrated with a certain weighting, or does it get a place 'down the line of processing' towards a more local assessment of hotspots?
- Format: Recently, formatting of data has become easier as cross-platform integration has become easier. However, the time it takes to reformat or transform data needs to be taken into account (see Big Data below).
- 'Big Data': Although the situation in the current age of Information and Communication Technology (ICT) advancement is less strenuous, there is still a large resource capacity need to download and

process data – especially at the scale that RBO's operate at. Thus, the time it takes to manage and process data and do overlays (as well as revisions to overlays) remains a consideration when developing hotspot models.

- 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 chosen impacts on area and length measurements (since different projections distort area and length in diverse manners).

3. Literature review: quantitative and qualitative approaches to integrate and overlay spatial data layers for hotspot identification

Data that is applied in quantitative hotspot identification studies can be subdivided into Social Capital, Human Capital, Financial Capital and Physical (which include environmental) Capital (Thornton *et al.*, 2008; Rahman and Rana, 2015). Together, these categories can be considered as determinants of 'Livelihoods Capital'. An example of one particular such study, with variables applied shown in Figure 1, indicate a quantitative characterisation where multiple data layers, each relating to different variables are involved:

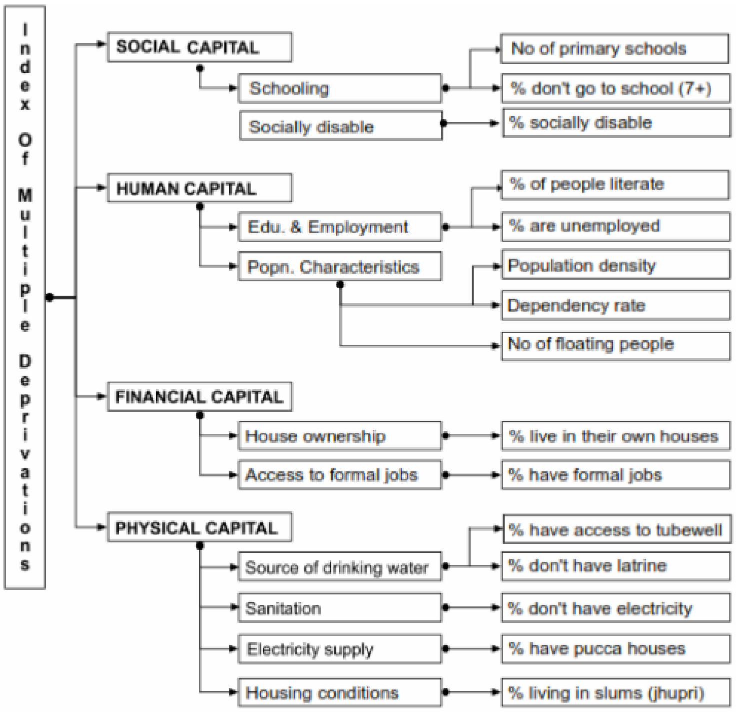


Figure 1: Example of data divided into Social, Human, Financial and Physical Capital (Rahman and Rana, 2015)

Social Capital variables refers to elements of the socio-cultural nature of people's interactions with their living environment, and networks that enable society to function effectively. **Human Capital** relate to the situation which determines people's ability to work, gain income, and their skills and education which determine their labour return (Rahman and Rana, 2015). The data sets that support the determination of these variables are often difficult to obtain in detailed local scale and in the same manner across country boundaries in Africa – especially when coverage is as far and wide as an entire river basin. **Financial Capital** refers to financial resources (e.g. access to banking services and markets) – something that is often even more difficult to determine than social and human capital - without significant time and resources available to access detailed market-related and financial institutional data that would be required to support this set of variables in quantitative analysis. **Physical Capital** are often the easiest data sets to obtain in a wide coverage and useful fashion in most river basins in Africa. Examples of such latter data include land cover data that may be gained from satellite imagery, or government-based data sets related to especially bulk infrastructure that is needed for people to pursue their livelihoods (*ibid*). Bulk water supply, high voltage electricity grids, roads and railway information is generally easily available, however finer detailed, local grid and reticulation information is not always readily available, and data custodians are in the latter cases often elusive.

Livelihoods studies which do not specifically utilise these four categories, tend to use data which can be classified into similar categories, and in studies that have strong ecological and environmental baseline requirements, the physical capital is often expanded to include a wide variety of topographical, environmental or biodiversity related variables (Westley *et al.*, 2002; Strydom, 2004, Thornton *et al.*, 2008). The overlay and interpolation of such data layers in a digital spatial manner supports quantitative outcomes to hotspot assessments. However, due to the lack of detailed spatial data in many instances across the developing world, and across the Capital categories, qualitative assessment processes are very often applied to verify the lack of adequate detailed data.

It is possible for individuals (sectoral or local specialists, or community members themselves) who are familiar with the specific requirements of projects to identify livelihood vulnerability hotspot locations in a more qualitative manner, or 'manually' (for example using hard copy maps) without scientific or digital spatial data overlays (Westley *et al.*, 2002). In addition, qualitative interpolation can be effectively done through verification of research and literature that may not be spatially represented. Such a 'manual' approach could be somewhat subjective to the individual and stakeholder process that enables the hotspot identification input. Therefore, care has to be taken that the results of qualitative assessments can be independently verified since entirely subjective assessments may lead to uneven hotspot site selection and/or the elimination of areas that may be inaccessible or unknown to the assessor or team of assessors. Once hotspots for a particular study or purpose are identified, and before interventions toward livelihood vulnerability reduction is implemented, it is necessary to engage in community-based interviews to support the detailed intervention programme and approach for livelihoods projects (Malmborg *et al.*, 2018).

4. Literature review: selecting variables

The selection of variables for hotspot analysis is dependent on the availability of adequate data in the selected study area in question. Examples of studies that were reviewed during the literature survey included determination of selection of sites for food economy zones, rural/urban coverage for infrastructure investment, and using ethnic representation as determinants of socio-cultural and gender-based interventions (Westley *et al.*, 2002).

In yet another study, Malmborg *et al.* (2018) used variables including nutritional diversity, income, insurance/saving, material assets and energy and crops for consumption to determine livelihood benefit hotspots. Thereafter they identified socio-ecological patches through participatory mapping and assigned livelihood benefit values to each identified patch in the given area, which was dependent on location and spatial extent (*ibid*). Malmborg *et al*. found that benefits tend to decrease the further a patch is located from a homestead, so assigned a weight based on buffer zones around a house.

Another example of spatial overlays being used to determine hotspots is presented in the RESLIM report (Petrie *et al*, 2014). Studies such as these give insight into managing data and applying layer weightings for specific study purposes. However, studies have vastly different objectives and the CRIDF/UNDP/OKACOM livelihoods vulnerability mapping process is no different. Existing study overlay method and weightings can thus only be used in an indicative manner as to the development of the best applicable method.

A number of studies consider area accessibility as one of the most important variables to consider, due to the impact of transport on access to market, schools, employment, judicial and police services, and infrastructure, amongst other things (Thornton *et al.*, 2008; Graw, 2013; Jaiteh *et al.*, 2015; Malmborg *et al.*, 2018). Thus, this element is also considered as an element in the OKACOM livelihoods mapping from a best practice perspective.

The UK Department of International Development (1999) advises that livelihood issues are subject to larger trends (such as those in population or conflicts), shocks (such as health or natural shocks) and seasonality (such as price and production seasonality). They further state that in terms of livelihoods analysis, the following information should be considered (if available):

- How do the livelihoods ‘portfolios’ of different groups look (percentage of income from various sources, time devoted to various activities by different household members)?
- How and why this change over time?
- How long-term is the outlook (are people saving for the future and what do they prioritise)?
- Are people making positive choices?
- Which combinations of activities yield the best outlook? and
- Which livelihood objectives are not achievable through current livelihoods strategies?

While many of the questions posed above are applicable in particular to smaller scale hotspot mapping or site selection, for example analysis of livelihoods within a specific location or even within a village, they should still be considered in the identification of hotspots in larger scale studies, particularly when it comes to the phenomena that influence questions, such as agricultural potential, health related data and access to transport (which determines access to e.g. markets, clinics, cities and services).

5. Literature review: weighing spatial data layers

Projects that have multiple spatial layer interpolation, may require differentiation in the importance between some of the variables. The weighting process has two purposes: a) to accommodate and account for data challenges (as listed in Section 2 of this document) and b) to support a priority focus or outcomes that may be required by the unique project objectives.

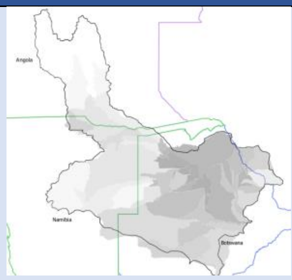
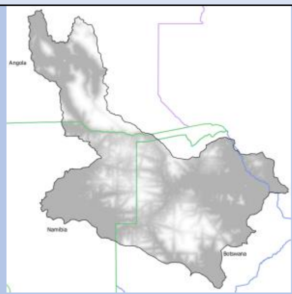
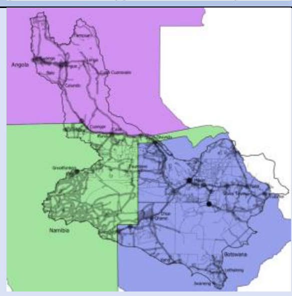
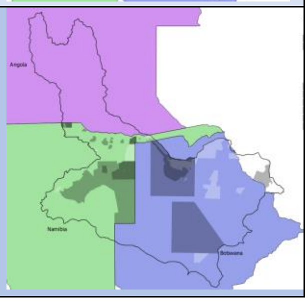
As with the overlay methods that differ significantly worldwide, the weighing and ranking process also varies considerably, with no single approach or standard method to determine the level of weighting or ranking of any given variable or set of variables. A common approach to variable weighting is to consider the ultimate goal of the hotspot analysis, given the purpose of the particular study. The application of such a *weighted overlay method* to analyse an area in question has become widely accepted as a means of differentiating variables that are considered more or less important to another (Westley *et al.*, 2002; Thornton *et al.*, 2008; Graw, 2013; Jaiteh *et al.*, 2015; Rahman and Rana, 2015). This can be done through the application of multiple criteria analyses (MCA) – of which a number of options for ranking and weighting selection is feasible (Saaty, 1970 to 2013; Wedley, 1990; Grimble and Chan, 1995; Triantaphyllou and Mann, 1995; Drake, 1998; Forman and Gass, 1999; Ramanathan, 2001; Triantaphyllou, 2001; Kasperczyk and Knickel, 2005; Vaidya and Kumar, 2006; Dalalah, Al-Oqla and Hayajneh, 2010; Ali, 2012; Haas and Meixner, n.d.). The result considers each variable that is used in a given study, assigning it a *relative weight* based on its contribution to the livelihood and community vulnerability. Even when done via an MCA approach, the relative weighting is selected in a qualitative manner and usually by group consensus of specialists involved in the assessment process. The variables are then overlaid using the weighted approach, to create one final layer showing hotspots of vulnerability. The resultant outcome requires calibration since there may be unexpected outcomes to the overlaid maps.

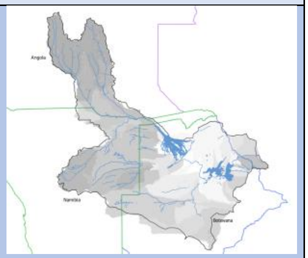
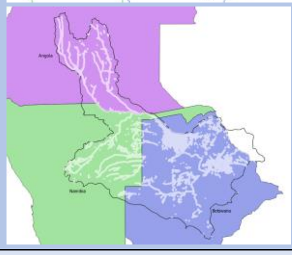
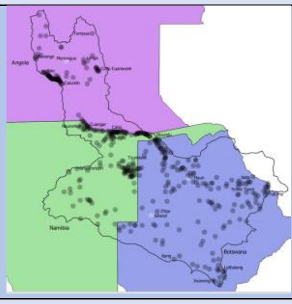
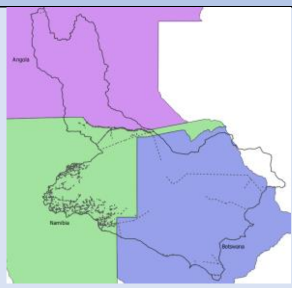
6. Identification, collection and collation: spatial data sets to support envisaged outcomes

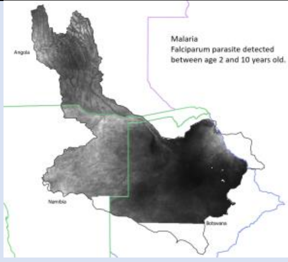
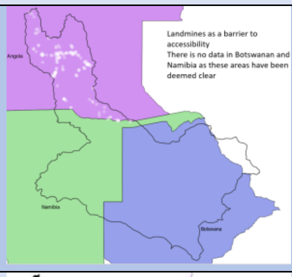
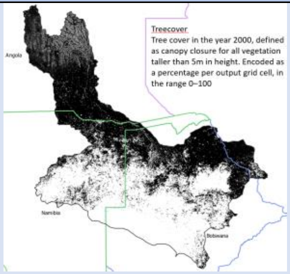
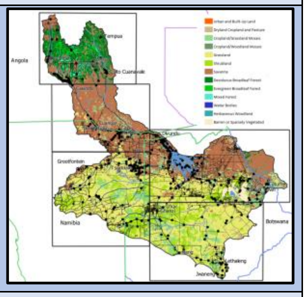
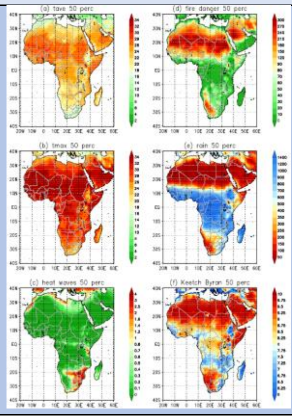
Across studies reviewed, there is a clear distinction between ability to obtain ideal data sets for chosen variables, and actual data availability. Often, compromises have to be made in terms of available spatial data layers that are used in hotspot mapping, and the spatial delineation of areas where hotspots are selected. Research articles seldom provide lists of the data that was used to reflect variables, and even less to the metadata related to how each data set was handled to generate a proxy layer for each variable.

Data sets that have been identified for potential use and which may support the assessment of livelihood variables in CORB include a range of large-scale data (with related metadata available in the accompanying Hotspot Narrative Report):

Table 1: Preliminary Data sets identified for potential use in OKACOM hotspot mapping

Feature	Form / type of data	
Topography	DEM (3D) to provide slope gradients within sub-basins.	
Market access	International study. Free online data.	
Transport	Road, rail, as lines (routes/networks) and points (stations)_ (indicating different types/classes).	
Protected zones/Nature areas	Nature reserves, conservation areas, world heritage sites, private conservancies, protected areas, buffer zones, ecological, wetlands, tourism related areas and the like.	

Water bodies	Wetlands, dams, pans.	See below - merged
Rivers and streams	Perennial rivers, and Delta area (top image shows linear features; bottom image shows buffered and merged layer).	 
Catchments/Basins	Primary, tertiary, quaternary catchments based on topography	(see topography image)
Villages/town/cities	Locations (point-based)	
Schools	Location, type/level: inconsistent across the three Member States.	
Clinics and Hospitals	Location, type/level: as above.	
Energy/electricity grid	Bulk electrification grid data (HV, TM) is available, however solar installations / roll-out / community projects information and minor reticulation is not available.	
Base soils	The data is available online, however the data set is significantly large in size and downloading off the internet has not been successful to date.	Not available yet
Erosion-prone areas	The data can be derived from an overlay of land cover, bare soils and slope, once the Base soils (see above) have been successfully downloaded.	Not available yet
Demographics, population, poverty, socio-economics	Gender, age, level of education, GDP, human development index etc. is available at provincial/regional scale only, and generally not in a format to overlay.	

Health data	HIV/AIDS and Malaria prevalence spatial data is available. HIV/AIDS is however significantly aggregated to small areas and thus not possible to use for overlays.	
Landmines ('Zones of Conflict')	The name of this file is based on an international study, however it will have to be changed for purposes of this project given the potential ambiguity of the term 'conflict'. The data include point-based details related to Political unrest, social violence and the presence of landmines. Only landmine locations are used for the hotspot overlay.	
Tree cover and forest loss	Satellite image analysis have been done worldwide showing 2015 tree cover, and forest loss between 2010-2016.	
Land cover	Satellite image based land cover.	
Human Wildlife Conflict	This data is assumed to exist in some form, however to date not yet obtained.	
Climate future**[2]	Existing model outputs and discussions are available, but primarily in .pdf format – thus not able to be overlaid in hotspot maps. Crude proxy data is available however the scale is so large that it is not deemed particularly suitable) Text-based narratives explore the climate future.	

[2] Spatial data in a format suitable to use for hotspot mapping purposes is not easily accessible. Global and Regional climate model discussions are available primarily in text format, with associated image-based maps, which cannot be overlayed in digital format without considerable time and effort. A feasible option may be to digitise the results presented in e.g. a recent CRIDF report (Figure 2), showing the Angola highlands as a key area of influence (top left rectangular area marking a portion of CORB). The area marked with a rectangle below would be secondary in importance, and the rest of the basin (unmarked on the figure) would have low importance in

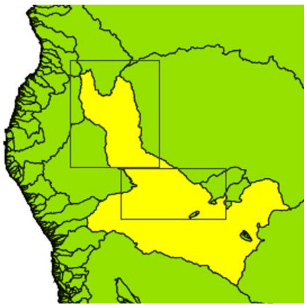


Figure 2: Climate Change Assessment for the Okavango Delta, Botswana, based on Self-Organising Maps (CRIDF, 2017)

The hotspot assessment assumes (with reasonable quality checking per data set) that the data obtained and analysed as per the aforementioned table is fit for purpose – except where comments in the table indicate otherwise. The following assumptions were furthermore made during the decision-making process of inclusion and exclusion of data used in the hotspot identification:

- Data is fairly recent (ideally 2013 or more recent);
- Data quality control rules were applied by data custodians/originators uniformly and consistently as far as possible across the basin (there is concern that this is not always the case, based on spatial disparities that are visible when viewing the data);
- The data was obtained from free sources, under open data licenses;
- Similar data collection behaviours and patterns occurred basin-wide for the selected data layers;
- The model does not consider spatial patterns (i.e. no spatial interpolation is done), and behavioural elements such as preferences for service utilisation, demographics, traveling and transportation patterns is not considered; and
- All populations have equal baseline vulnerability (i.e. no predetermined hotspot identification of overlay of existing or historical intervention data at this time).

terms of this variable. However, this option would not enable much effective climate future narratives for localised units within the basin. The proposed approach is therefore to use the best to-date available model narrative from the CSIR, as presented in a published article, to developed localised unit-based narratives in terms of climate futures, across the basin (Engelbrecht, 2015).

7. Identification, collection and collation: processing data towards enabling overlays

Figure 3 shows the framework of spatial data layer inclusion that were investigated for potential use during the hotspot analysis process[3]. As noted in Table 1, not all the data sets were available at sufficient scale and over the basin geographic area to create the livelihoods vulnerability hotspot output[4]. The figures indicated in this report are a static view of the spatial data layers that were used during the assessment. All the spatial data layers are available in digital spatial format, and have been compiled in a .pdf map for use by non-geographic information systems professionals, to enable basic viewing of available spatial data layers.

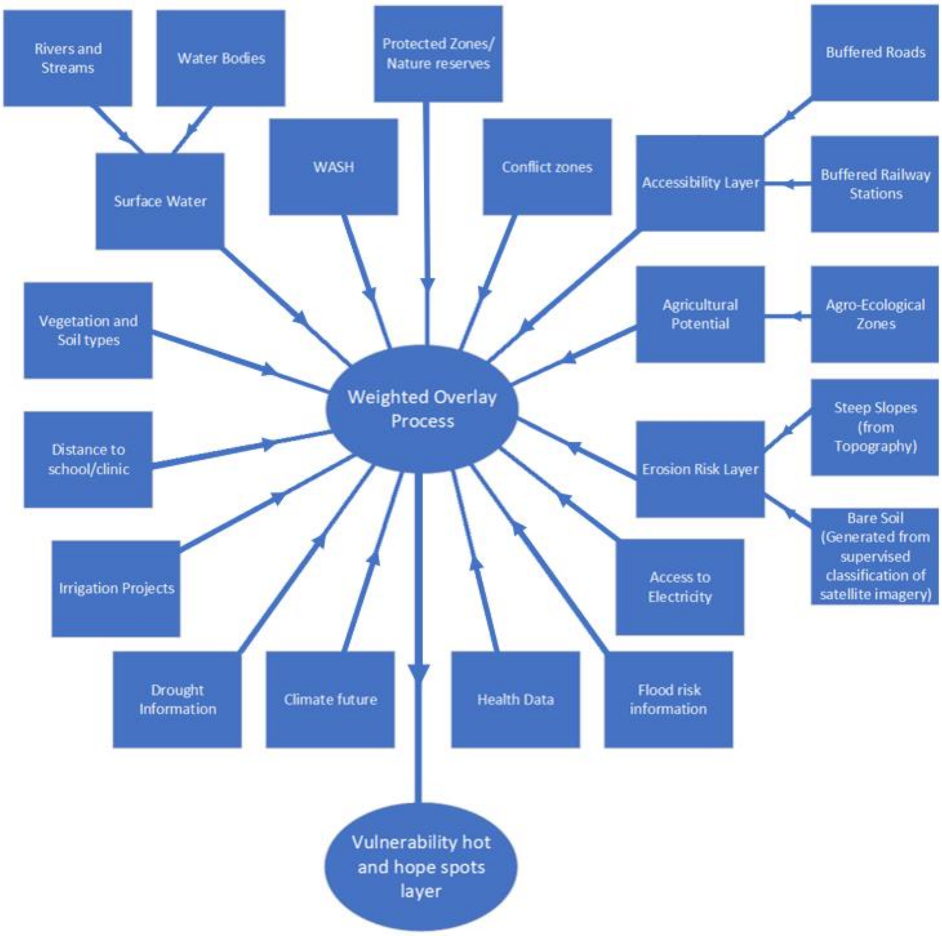


Figure 3: Layer compilation diagram: OKACOM livelihoods hotspot vulnerability mapping

[3] Noting graphic is still to be updated reflect tree cover & forest loss, human-wildlife conflict, and renaming of 'conflict zones' to avoid ambiguity.

[4] Noting not all data may be available, e.g. bare soils are not yet available due to the size of data set to be downloaded

The phases and activities related to spatial data assessment are detailed below:

Phase 1: Data preparation:

The following activities were performed:

1. **Projection standardisation:** Data layers were re-projected to WGS84 / UTM34S.
2. **Area delineation:** Clipped to the boundary of the basin.
3. **Clean-up:** Duplicate place names were removed from the *Place names* dataset.
4. **Merging and simplification:**
    i. Transportation layers: The different countries' road layers were merged into a single layer, and then subdivided according to road type ('fclass'). The transport data is considered important in relation to this study as it is related to the level of access available to settlements in the area.
    ii. Surface water layers (rivers and streams and water bodies) were combined into a single surface water layer.
5. **Buffering:** Overlays for hotspot mapping needs to be done using buffer distances to ensure that at a given scale (in this instance basin-wide) the features are visible and able to add their value in the overlaid mapping output. Buffer distances were applied as presented in Table 2.
    i. The transport data was processed by separating the roads into tar roads, dirt roads and tracks/footpaths and buffering these at variable distances (as shown below to account for how far people are willing to travel to access each type of road). These values are based on the time that persons are generally willing to spend to travel these distances. The same process applies to railway stations. Airports are excluded from the study since at the scale that these features are present in CORB, it does not have a significant influence on community-based livelihood vulnerability.

       The surface water layer was buffered to reflect access to water resource (how far persons need to travel to access freshwater resources, as well as whether those resources are perennial or non-perennial).

Table 2: OKACOM Livelihood hotspot mapping buffer distances

Type of transport	Narrative and proxy development	fclass	Buffer distance
Trunk	The most important roads in a country's system that aren't motorways	Class 1	5km
Primary	The next most important roads in a country's system. (Often link larger towns.	Class 1	5km
Secondary	The next most important roads in a country's system. (Often link towns.)	Class 1	5km
Tertiary	The next most important roads in a country's system. (Often link smaller towns and villages)	Class 1	5km

Unclassified	The least most important through roads in a country's system – i.e. minor roads of a lower classification than tertiary, but which serve a purpose other than access to properties. Often link villages and hamlets.	Class 2	3km
Residential	Roads which serve as an access to housing, without function of connecting settlements. Often lined with housing.	Class 2	3km
Service	For access roads to, or within an industrial estate, camp site, business park, car park etc.	Class 2	3km
Unknown	A road/way/street/motorway/etc. of unknown type. It can stand for anything ranging from a footpath to a motorway.	Class 2	3km
Track	Roads for mostly agricultural or forestry uses.	Class 3	1km
Footway / footpath	For designated footpaths; i.e., mainly/exclusively for pedestrians. This includes walking tracks and gravel paths.	Class 3	1km
Path	A non-specific path.	Class 3	1km
Railway Stations	All types/no distinction	n/a	40km
Class 1-3 airports	Excluded from model, although it is available	n/a	n/a

6. **Reverse indication:** Resultant data layers can be used in two ways: to indicate areas that have a positive reflection on project implementation or where the feature is intended to highlight challenges. For example: focussing on hotspots as being areas that have relatively easy access to roads: when selecting areas that are relatively easy to access when projects are implemented; versus focussing on areas that are remote i.e. where projects may be chosen to be implemented due to the significant remoteness of the location. Another example is closeness to water bodies or watercourses: where hotspots might either be areas that are close to water due to risk of disease when water quality is poor, or hotspots might be areas far away from watercourses, where communities have challenges to access water supply. In the case of this overlay analysis it should be noted that boreholes and well locations are not available as a data set, and thus the in-field reality of access to water may not be as exact or real as is presented by the spatial data overlay.
7. **Weighting:** As discussed earlier in this document, spatial layers may be assigned weights relative to their relative importance in terms of livelihoods. Calibration and pilot testing of weighted overlays were done in a variety of forms: Initially at this time, layers that are deemed key to water resource related livelihoods interventions are available to weigh 'double' than other layers. The layer process is possible for other layers if it should be required in future.

8. Scenarios

A number of potentially different overlay scenarios were created to explore the importance and impact that selected 'mixing' of spatial data overlays, and selected weightings may have on the resultant outcome, at a basin-wide level. The figures below indicate some of the scenario-overlays that were done:

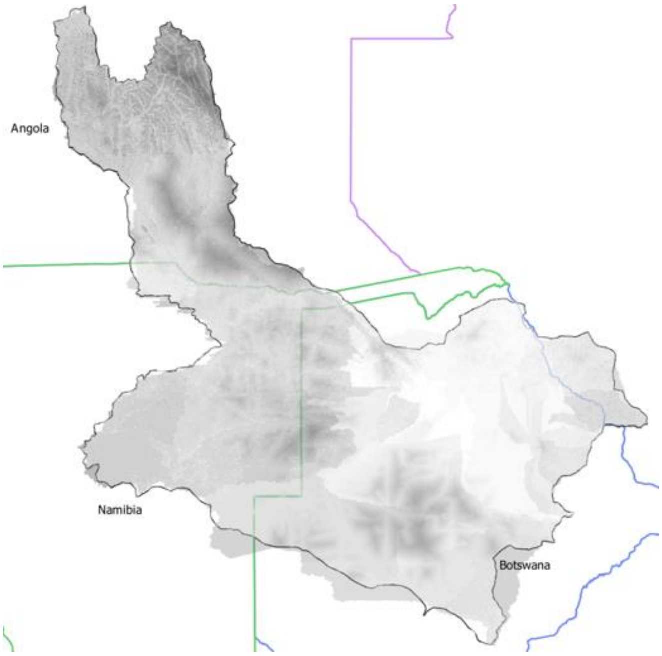


Figure 4: Example of combination of water resources related spatial layers, singular weighting

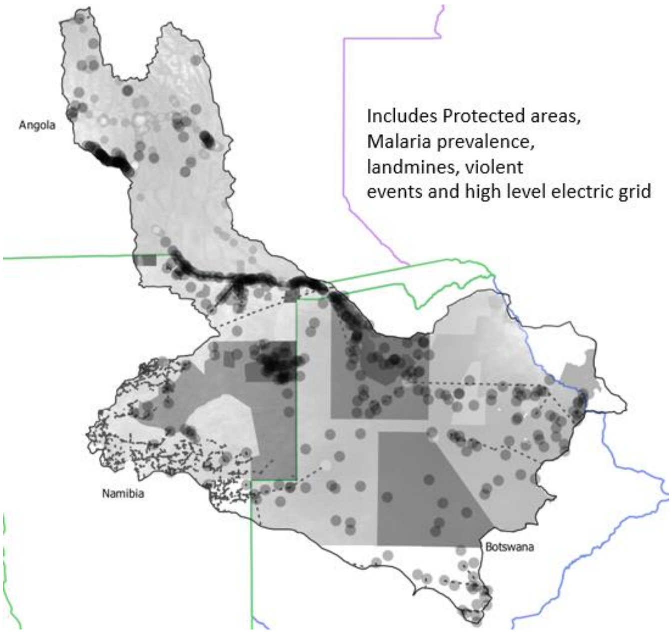


Figure 5: Example of combination of social and economic related spatial layers, singular weighting

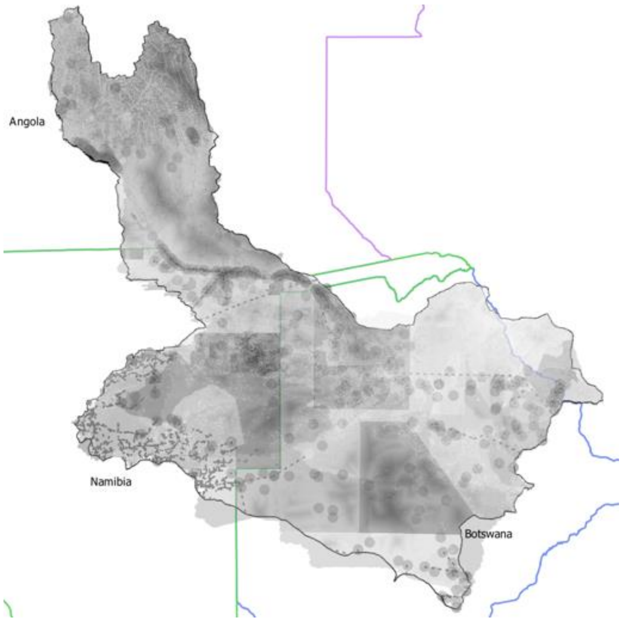


Figure 6: Example of combined overlay across the basin – singular weighting

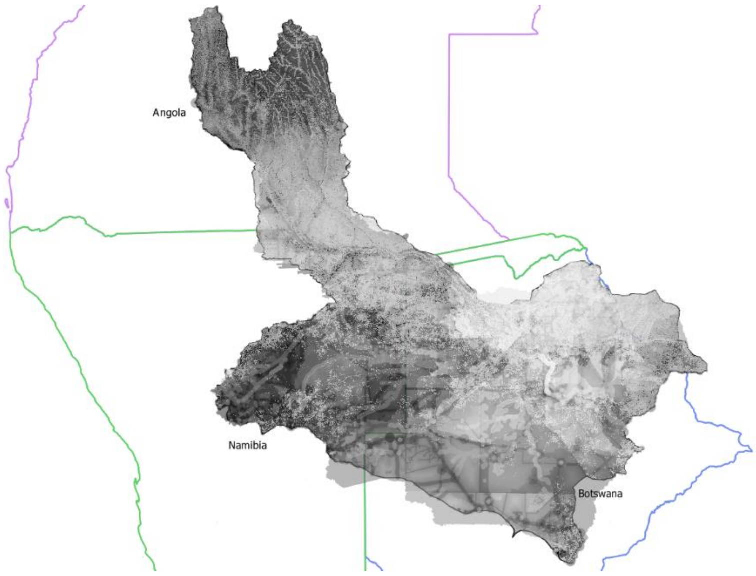


Figure 7: Example of combined overlay across the basin – duplicate weighting for water resources layers

9. Homogenous zones

The scenarios noted in Section 8 brought an important consideration to the assessment – that the overlay of spatial layers in the manner presented above (with examples presented in Figures 4 to 7) have *some* relevance to hotspot identification. However, there are 'outliers' and irrelevant locations or areas that emerge as hotspots, where in fact the project focus should not be allocated a hotspot. Reasons for these 'false' hotspots emerging largely relate to two underlying factors: a) the raw data differs in quality and detail/scale between countries, and b) the focus of the project is largely constrained to the hydrologically active part of the basin.

The basin is thus recognised to consist of a wide variety of different characteristics in terms of socio-economics, population, settlements, infrastructure and natural environmental elements. Based on these differences, the basin was divided into five 'homogenous zones', that are largely based on spatial data layers that present similarity in characteristics across a given unit. This zonal delineation enables more effective hotspot identification at zonal scale. The Figure hereafter shows the zone delineations. Land cover satellite image data is provided as back-drop to the map:

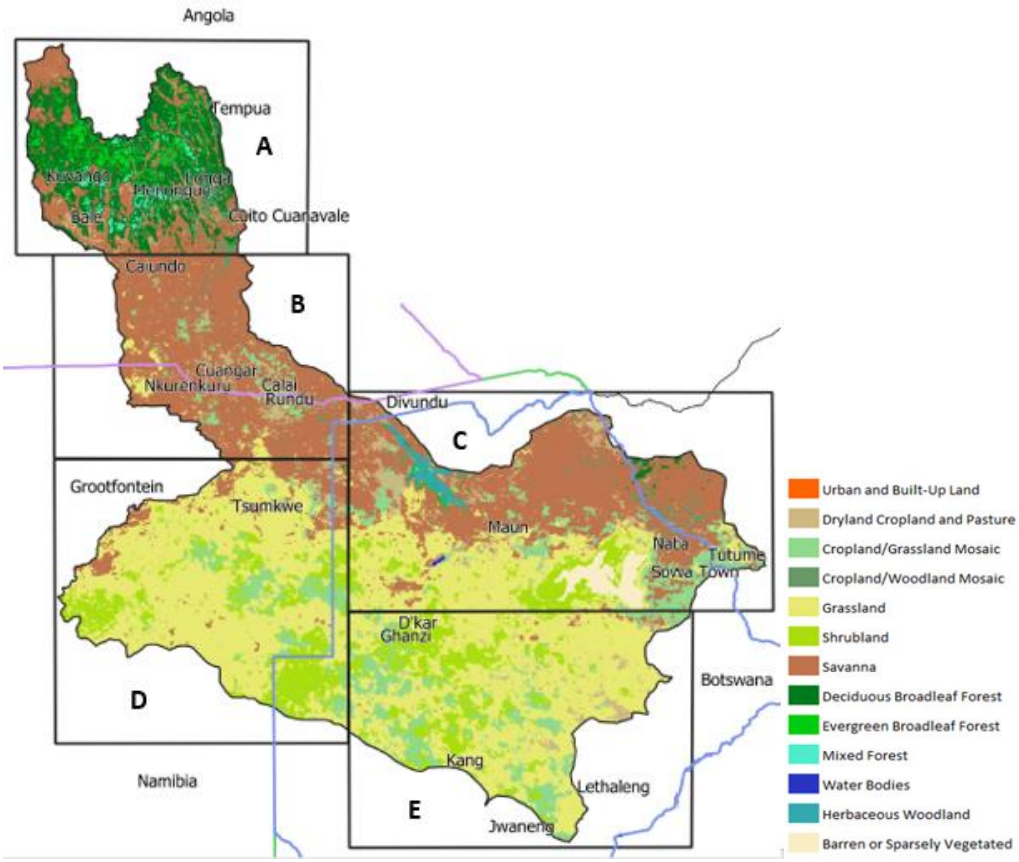


Figure 8: CORB divided into five homogenous zones

The approach towards implementing homogenous zones also reflects the findings from the stakeholder Inception Workshop on 13th April, where distinct, differing hazards and vulnerabilities were identified in specific areas by Member State representatives: example of the Hazards indicated, in the figure hereafter:

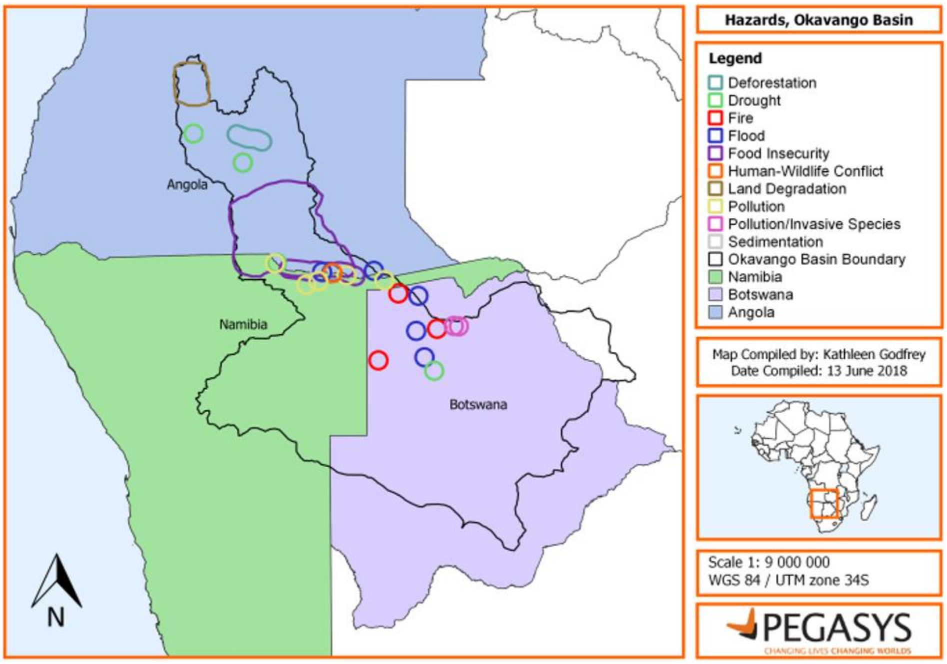


Figure 9: Hazard identification for CORB as based on stakeholder inputs on 13 April 2018

Narrative compilation: The layers may be assigned weights relative to their relative importance in terms of livelihoods. At this time, layers that are deemed key to water resource related livelihoods interventions are available to weigh 'double'. A narrative for each of the homogenous zones were developed, covering each of the following areas:

- Socio-economic;
- Population (including settlement characteristics);
- Infrastructure (road, water and sanitation, health, rail, electricity etc.);
- Environment;
- Climate future; and
- Transboundary considerations.

Three pieces of key livelihood models, which are closely linked to poverty mapping are essentially informed by these narratives:

- Creation of jobs;
- Wealth, through e.g. smallholder ownership; and
- Local economies improvement and provision of services to poor communities.

The resultant hotspot map present potential areas that are pro-poor, and where interventions will have a clear positive economic impact and increase resilience. Figure 10 indicates the preliminary hotspot map, where darker areas on the map indicate areas of compounding vulnerability.

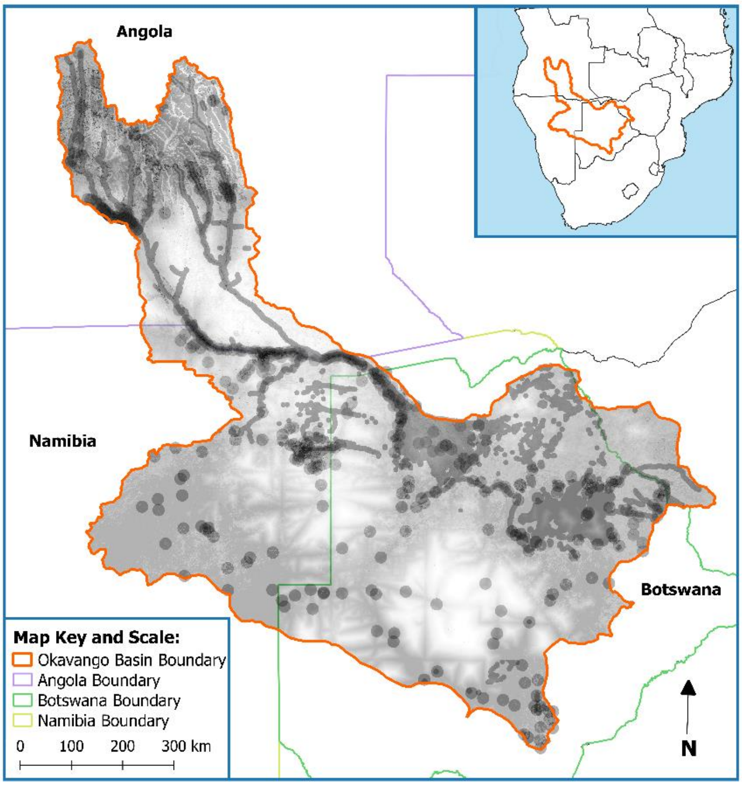


Figure 10: Preliminary CORB Vulnerability Hotspot Map

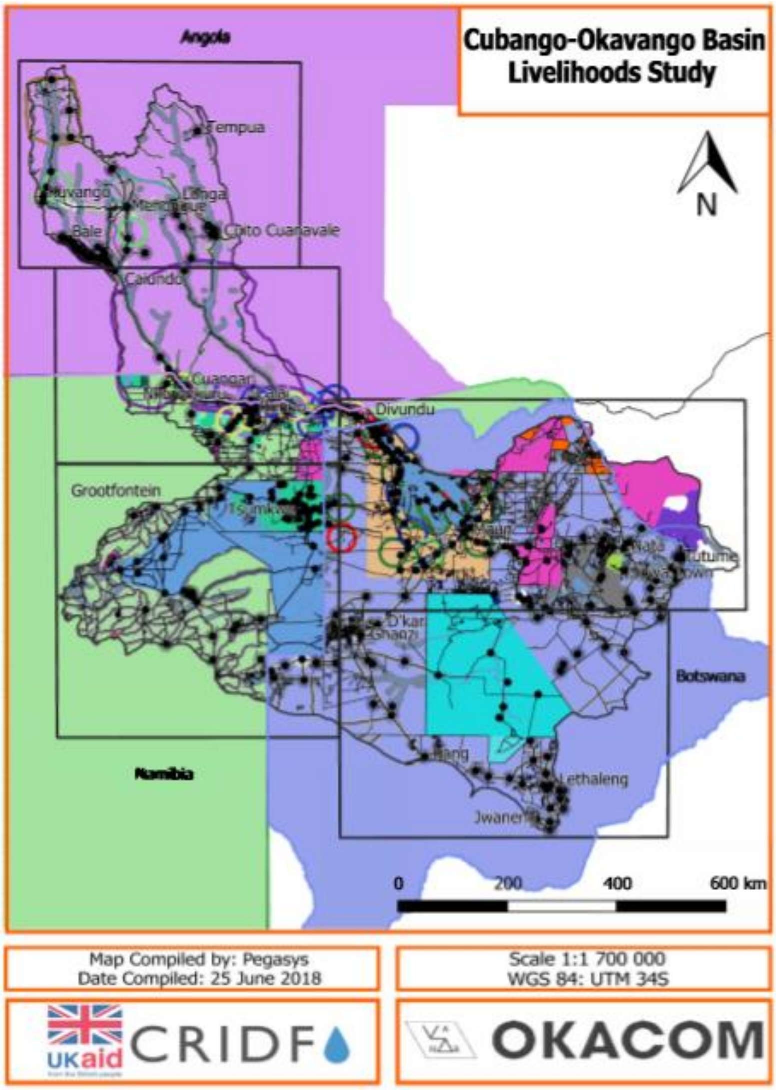


Figure 11: .pdf based overlay file, enabling non-GIS specialists to view some the key spatial data layers that were used in determining the hotspot locations and characteristics

10. Next steps: localised assessments to strengthen the analysis

The next activity in the livelihood vulnerability hotspot mapping and characterisation process will be to identify appropriate typologies that relate to livelihood vulnerability reduction as it pertains global change, of which climate change is a key element. This process will require further analysis of key issues at a localised scale through in-country engagements. That is – the nuanced, and differing, nature of vulnerabilities within hotspots requires engagement with local stakeholders, specifically concerning the impacts of changes in climate and related hazards at a community scale.

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