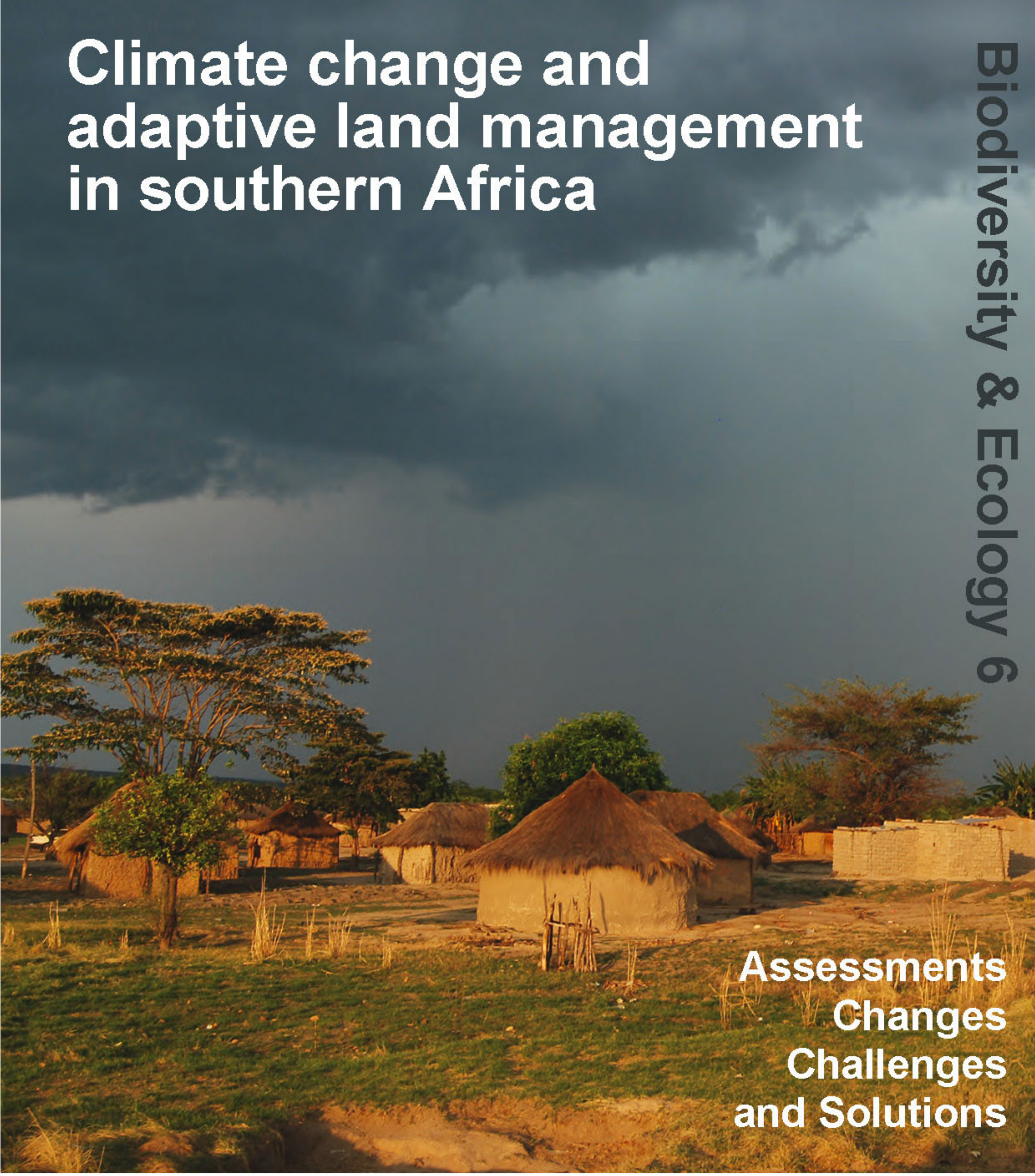
Climate change and adaptive land management in southern Africa

Biodiversity & Ecology 6



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Climate change and adaptive land management in southern Africa

Assessments, changes, challenges, and solutions

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Drought sensitivity in the Cuvelai Basin: empirical analysis of seasonal water and food consumption patterns

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Abstract: The population in Sub-Saharan Africa is regularly affected by droughts, such as those recently triggered by El Niño. Rural smallholders in semi-arid environments such as the transnational Cuvelai Basin in southern Angola and northern Namibia directly depend on local blue and green water availability and are therefore at risk of drought. This study builds on local knowledge of seasonal water and food consumption patterns to estimate household drought sensitivity. An empirical survey was conducted with 461 households to (1) determine the reliability of water and food source types under dry conditions, (2) estimate consumption dependencies, and (3) contribute to drought risk assessments. The consumption patterns reveal differences in the reliability of source types. In particular, traditional types are used extensively during the rainy season but become unavailable during the dry season. Households with a strong dependence on these types are particularly sensitive to drought. This is true for rural areas, notably in Angola, where reliable water and food infrastructures are less available. This methodology can be implemented in conventional surveys to continuously monitor drought sensitivity conditions on the household level.

Resumo: A população da África Subsariana é regularmente afectada pela seca, recentemente desencadeada pelo El-Niño. Os pequenos agricultores rurais em ambientes semiáridos dependem directamente da disponibilidade local de água azul e verde e estão, por isso, em risco de seca, tal como se verifica na bacia transnacional de Cuvelai, no Sul de Angola e Norte da Namíbia. Este estudo baseia-se no conhecimento local da água sazonal e dos padrões de consumo de alimentos, de modo a estimar a sensibilidade domiciliar à seca. Foi realizado um estudo empírico com 461 famílias para (i) determinar a fiabilidade dos tipos de fontes de água e alimentos sob condições de seca, (ii) estimar as dependências de consumo e (iii) contribuir para as avaliações do risco de seca. Os padrões de consumo revelam diferenças na fiabilidade dos tipos de fontes. Em especial, os tipos tradicionais são usados extensivamente durante a época das chuvas, mas ficam indisponíveis na época seca. As famílias com uma forte dependência dos respectivos tipos são particularmente sensíveis à seca. Isto é verdade para áreas rurais, especialmente em Angola, onde há menor disponibilidade de infraestruturas de água e alimentos. Esta metodologia pode ser implementada em estudos convencionais para continuamente monitorizar as condições de sensibilidade à seca ao nível doméstico.

1. Introduction

Droughts are a critical threat throughout Sub-Saharan Africa (UNISDR, 2012). People who inhabit particular semi-arid environments adapted to the conditions centuries ago (Ehret, 2001). They developed adequate strategies to utilize the limited blue and green water resources (Falkenmark & Rockström, 2006; Freire-González et al., 2017) in an efficient way to meet their needs for domestic water and food consumption (Diao et al., 2010; Collier & Dercon, 2014). However, enhanced population growth, economic development, and urbanization in conjunction with a changing climate and limited coping capacities (Thornton & Herrero, 2015) alter the way societies interact with their environment and create challenges not experienced in the past. Consequently, severe and prolonged droughts, such as those recently aggravated by El Niño in large parts of Sub-Saharan Africa (Baudoin et al., 2017; Smith & Ubilava, 2017), are occurring more frequently and have a stronger impact.

Droughts play a major role in the transnational Cuvelai Basin in southern Angola and northern Namibia (Luetkemeier et al., 2017). The majority of the population is strongly connected to the hydroclimatic conditions to sustain their livelihoods, since subsistence agriculture and traditional water supply systems remain dominant (Luetkemeier & Liehr, 2015).

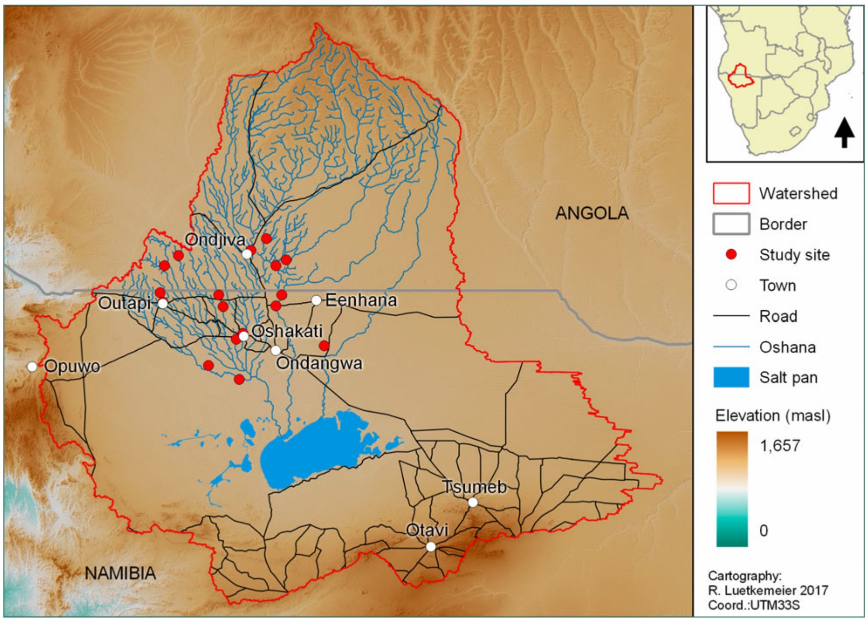

Figure 1: Cuvelai-Basin, indicating the locations of the empirical household survey in southern Angola and northern Namibia.

As commonly found in developing countries, food and water consumption follow complex patterns (Nauges, 2008; Fiedler, 2013). Households utilize a broad range of source types (e.g., shallow wells and tap water, self-collected wild food and supermarkets), depending on determinants such as seasonal availability and quality aspects, infrastructural endowment, and price and distance. Though this consumption strategy reduces the risk of individual source failures, the traditional food and water source types respond quickly to drought-induced blue and green water scarcity. As a result, households that strongly depend on unreliable sources are highly sensitive to drought events and suffer second-order effects if they are not able to switch to more reliable sources (Luetkemeier & Liehr, 2015).

Methodologically, the assessment of household water demand in developing countries remains a challenge because of complex patterns and multiple influencing factors. Household surveys are a commonly used method to assess the water quantities withdrawn and the purposes water is used for (Gleick, 1996; Inocencio et al., 1999; Nauges, 2008; Dagnew, 2012). Similarly, food consumption, especially nutritional content, is typically assessed via interviews. In these surveys, methods such as 24-hour recall and observed-weighed food records are preferred but require larger assessment efforts (Fiedler, 2013). The household economy approach (HEA) instead takes a pragmatic perspective and assesses the range and relative importance of food sources by converting available dietary energy into monetary terms (Seaman et al., 2014). Conventional household surveys deliver less detailed information on water and food consumption since they neglect the underlying complexity by focusing on the main sources utilized (NSA, 2013; INE, 2016). Recently, Elliott et al. (2017) made a strong case for considering multiple water sources when assessing consumption patterns. They found that detailed assessments in this regard provide valuable information to determine the adaptive capacities of communities in the Pacific Island countries, particularly with respect to climate change adaptation (Elliott et al., 2017). This study takes up these methodological developments and expands the focus to include food consumption patterns as well.

The more in-depth consideration of water utilization in northern Namibia is particularly relevant because of the increasing share of unsafe water sources in recent years. The utilization of safe water sources (WHO & UNICEF, 2017) declined in Namibia from 2001 to 2011, which is true for the northern regions of Ohangwena (78% to 56%), Oshikoto (88% to 70%), Oshana (93% to 84%), and Omusati (83% to 52%) (NSA, 2013). Research is needed to uncover the underlying complexity of consumption patterns. Conventional survey techniques that assess the main water and food source types are not suitable for this purpose and hide valuable seasonal and structural information.

Building on qualitative insights into drought risk in the Cuvelai Basin, methodological opportunities and shortcomings, and development challenges in Namibia and Angola, this paper seeks to determine a household's sensitivity to drought by assessing seasonal water and food consumption patterns. This supports the integrated Household Drought Risk Index (HDRI) as a holistic drought risk assessment tool (Luetkemeier, ISOE, unpubl.) and presents a transferable methodology to be included in conventional census survey techniques for continuous drought sensitivity monitoring.

Specifically, this study develops and applies an empirical assessment tool to make contributions to:

- determine unreliable water and food source types under dry conditions,
- identify households that strongly depend on unreliable water and food source types,
- use those data to estimate drought sensitivities on the household level and thereby contribute to the household drought risk assessment, and
- present methodological advancements to improve conventional survey techniques.

This paper first introduces the conceptual approach of risk research and the study area in northern Namibia and southern Angola. Subsequently, the key methodological techniques of the empirical survey are presented alongside the analytical steps to draw conclusions on source reliability and consumption dependence. The results provide insights into drought sensitivity estimates for the Angolan and the Namibian populations as well as people living in rural and urban settings. The discussion and the conclusion will reflect on the results with special emphasis on the method's potential to improve conventional survey techniques.

Methods

The following sections provide a brief description of the study's methodological setup. First, the conceptual approach is presented, in which drought sensitivity is incorporated into the concept of risk and vulnerability. Second, the study area is introduced by highlighting the most important geographical features. Third, the design of the household survey is presented, followed by a description of the analytical procedure to analyse and process the data.

Conceptual approach

Droughts are regarded as a critical hazard in the study area. For the purpose of assessing the impact of drought hazard on the local population, a holistic conceptual approach is adapted in which risk is a function of hazard and vulnerability (Wisner et al., 2003; Cardona et al., 2012). While drought is regarded as the hazard that can be characterized by frequency of occurrence, severity, and duration (Luetkemeier et al., 2017), vulnerability incorporates sensitivity and coping capacity to characterize the ability of a household to handle a drought situation. Within this conceptual framing, this study specifically focuses on the sensitivity aspect to make a contribution to the integrated Household Drought Risk Index (HDRI) (Luetkemeier, ISOE, unpubl.).

Study area

The Cuvelai Basin is located in southern Angola and northern Namibia, covering a total area of about 172,000 km2 with a population of about 1.7 million people (NSA, 2013; INE, 2016). From a hydroclimatic perspective, the watershed is a complex system with a strong seasonal variation of precipitation and associated surface and subsurface water availability. The ephemeral streams, locally known as iishana (sing. oshana), are a key characteristic of the endorheic watershed, carrying water during the rainy season and regularly leading to flood events (Mendelsohn & Weber, 2011). The rainfall variability over time is pronounced, resulting in changes in soil moisture and vegetation conditions (Luetkemeier et al., 2017).

The socio-economic setting of the area is predominantly characterized by a rural subsistence economy based on rain-fed farming and extensive livestock management. Despite these traditional structures, urbanization has gained momentum throughout the past decades, partly changing peoples' lifestyles. This is particularly true for the Namibian side of the basin, as it is better endowed with modern infrastructure such as a road network, electricity, and a tap water system. The Angolan part is however, generally less developed, providing these systems only in major urban agglomerations (Mendelsohn & Weber, 2011).

Structured household survey

The primary assessment tool is a structured questionnaire that is divided into two major parts. Part A assesses water and food consumption patterns on a seasonal basis, while part B focuses on the coping capacities of households. Relevant to this study is part A of the survey, while the results of part B are incorporated into the HDRI assessment (Luetkemeier, 2015, Luetkemeier, ISOE, unpubl.).

The questionnaire was carried out in northern Namibia with a total of 310 households and in southern Angola with about 151 households. The entire sample of 461 households was selected based on a three-stage procedure. In the first stage, 10 administrative areas were randomly selected using the probability proportional to size (PPS) approach (Lavrakas, 2008). Herein, administrative units with a higher population receive a higher probability of being selected, resulting in a more equal probability that each household will be part of the sample. In the second sampling stage, two villages were selected in each of the chosen administrative units in close collaboration with local experts. They were encouraged to choose representative settlements (urban and rural), taking aspects such as water infrastructure endowment, livelihood settings, and accessibility into account. In the third stage, the trained interviewers followed a random walk approach and tried to interview as many households as possible from the selected villages. Figure 1 depicts the study sites in the centre of the Cuvelai Basin, covering the area where most of the population lives.

Demand for water and food

The overall demand for water and food on the household level is regarded as essential for depicting sensitivity to drought. Though the capacity to cope with drought situations is likely to be higher in a household with more members (e.g., more workforce), the challenge of acquiring adequate quantities of high-quality water and food is more acute than in a smaller household. Hence, larger households are regarded as being more sensitive to drought than smaller households. This assumption was incorporated by estimating the demand for water and food from the number, age, and gender of the household members. While in the case of water consumption a nonlinear degressive relationship was assumed (Arouna & Dabbert, 2009), food consumption per household member was adapted to the age- and gender-specific dietary energy requirements (Institute of Medicine, 2005).

Consumption quantities

Beside the water and food quantities that a household requires, it is important to characterize the predisposition of the households' consumption patterns to drought. This predisposition is composed of two parameters, (1) relative water and food quantity withdrawn per source type and (2) source type reliability. To assess data on both parameters, a pretested structured questionnaire was designed to assess the number and type of water and food sources a household utilizes as well as the relative quantities that are withdrawn from these source types (Fig. 2).

As a first step, the household head or his/her partner was supposed to select the water and food source types they utilize in an average rainy and an average dry season. If the respondents mentioned more than one source type, they were asked subsequently to rank the selected source types according to the amount of water or food withdrawn. In this regard, higher quantities are withdrawn from a source type ranked 2nd than from a source type ranked 4th, for instance. This assessment and the evaluation of source types was conducted for the rainy and the dry seasons in order to uncover changes that serve as an indication of a source type's reliability under dry conditions. Both the water and food source types included a range of traditional and modern types that were assessed in a qualitative research phase (Luetkemeier & Liehr, 2015) and the pretest.

The rankings constitute a household's expression of how much water and food are withdrawn from a specific source type during the dry and the rainy seasons to meet household demand. Thus, the responses are aggregated statements that incorporate a complex decision-making and evaluation process. Therein, influencing factors such as price, distance, and quality aspects are already incorporated by the respondents, but this complexity is hidden in the ranking scheme.

While the assessment of absolute values for water and food quantities via questionnaires is time-consuming and prone to misinterpretation, the assigned rankings had to be transformed into relative estimates of water and food quantities. Herein, it was assumed that the source types mentioned meet 100% of the entire household demand and that the rankings provide insight into the relative quantities obtained.

1. **Which water sources do you use for domestic purposes in the rainy season? (Tick boxes)**
2. **If two or more sources are used, please rank (R:) them according to the amount of water withdrawn.**

WATER (DOMESTIC)	CATEGORY	SOURCES	CODE	RAINY SEASON		DRY SEASON
	Modern sources	Private tap	[01]	☐ R:	**3. Different in dry season? If yes, please fill in here →**	☐ R:
		Public tap	[02]	☐ R:		☐ R:
		Bottled water	[03]	☐ R:		☐ R:
		Borehole	[04]	☐ R:		☐ R:
		Water vendor	[05]	☐ R:		☐ R:
		Canal	[06]	☐ R:		☐ R:
		Improved deep well	[07]	☐ R:		☐ R:
	Traditional sources	Unimproved deep well	[08]	☐ R:		☐ R:
		Shallow well	[09]	☐ R:		☐ R:
		Earth dam	[10]	☐ R:		☐ R:
		Oshana / Lake / Pan	[11]	☐ R:		☐ R:
		Rainwater	[12]	☐ R:		☐ R:
	Other: ...		[13]	☐ R:		☐ R:
	Comments: ...					

4. **Where does your household normally receive food from in the rainy season? (Tick boxes)**
5. **If two or more food sources are used, please rank (R:) them according to the amount of food received.**

FOOD	CATEGORY	SOURCES	CODE	RAINY SEASON		DRY SEASON
	Own production	Field / grain basket	[01]	☐ R:	**6. Different in dry season? If yes, please fill in here →**	☐ R:
		Garden / fruit trees	[02]	☐ R:		☐ R:
		Livestock (meat, milk, eggs)	[03]	☐ R:		☐ R:
		Self-collected wild food	[04]	☐ R:		☐ R:
		Self-caught fish	[05]	☐ R:		☐ R:
		Self-hunted bush meat	[06]	☐ R:		☐ R:
	Markets	Local market	[07]	☐ R:		☐ R:
		Supermarket	[08]	☐ R:		☐ R:
	Social network	Relatives	[09]	☐ R:		☐ R:
		Neighbors	[10]	☐ R:		☐ R:
	Donations	Church	[11]	☐ R:		☐ R:
		Government	[12]	☐ R:		☐ R:
	Other: ...		[13]	☐ R:		☐ R:
	Comments: ...					

Figure 2: Part A of the household drought risk survey. Upper plot assesses the water source types for domestic purposes, while the lower plot assesses the food source types.

Source type reliability

Now that each household has provided information on how much water or food it withdraws from a particular source type, the patterns can be compared between the two seasons. If a difference between the seasons is apparent, conclusions can be drawn on the reliability of specific source types under dry conditions. As an example, a household might utilize three water source types in the rainy season: (1) shallow well, (2) improved deep well, and (3) public tap. In the dry season however, the pattern might switches to (1) public tap and (2) improved deep well. The shallow well was abandoned because of either quantity or quality constraints, while the public tap is now the primary source type.

From this seasonal consumption change it is possible to draw conclusions on reliability, assuming that during a drought period, dry-season conditions prevail and are even more intense. Hence, analysing the sample with regard to the average change in source type utilization offers the possibility of calculating a reliability benchmark for every single source type.

Drought sensitivity

Sensitivity to drought is defined in this study as a household's dependence on unreliable water and food sources. Formally, the source-specific reliability levels are multiplied by the relative quantities of water and food obtained from the specific source types and subsequently divided by a households' total water and food demand. The resulting sensitivity scores were normalized on a scale from 0 (high, unfavourable) to 1 (low, favourable) using a min-max normalization technique.

Results

The results section will first present the seasonal consumption patterns and subsequently show the reliability levels of the individual water and food source types. Third, the drought sensitivity estimates are given, grouped according to certain socio-economic characteristics.

Seasonal consumption patterns

The households provided information on the number and type of food and water sources they utilize during an average rainy and dry season and indicated the relative quantities they withdraw. Figure 3 provides an overview of the shares of households that utilize specific water source types on a seasonal basis.

Modern water source types such as tap water and purchased water from vendors are used more intensively during the dry season, whereas the rainy season shows a higher utilization of traditional source types such as earth dams, shallow wells, and rainwater that make use of local water resources. This seasonal change between the water source types is statistically significant ($p < 0.05$). In particular, the urban agglomerations in Namibia (Oshakati and Outapi) show higher shares of tap water utilization in both seasons compared to rural Namibian areas. Furthermore, the data shows that the Angolan population does not use tap water, except in major urban agglomerations such as Ondjiva. This confirms the limited access people have to tap water, as the infrastructural endowment of the area is weaker than in Namibia. Instead, water vendors are a more common institution in Angola who often take over the role of public water supply but at higher costs.

With regard to the utilization of specific food source types, Figure 4 shows

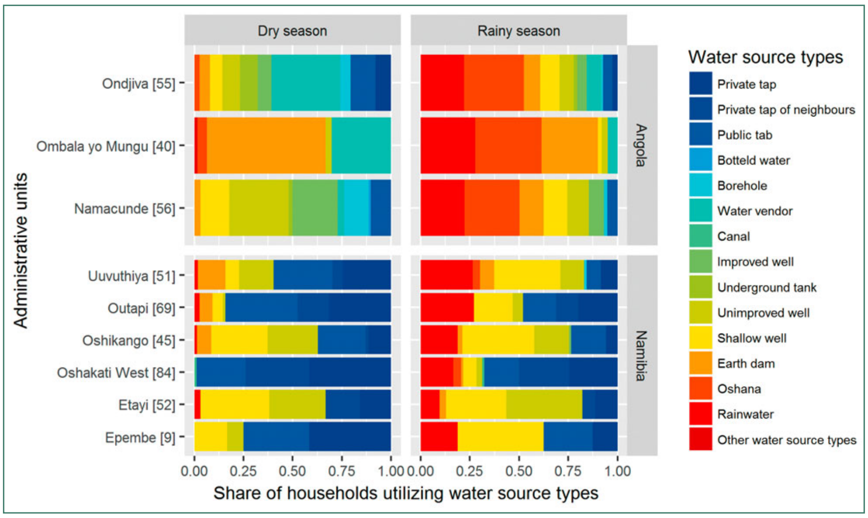

Figure 3: Relative utilization of water source types in the dry and the rainy season in administrative units. Values in brackets behind names of administrative units indicate the sample size.

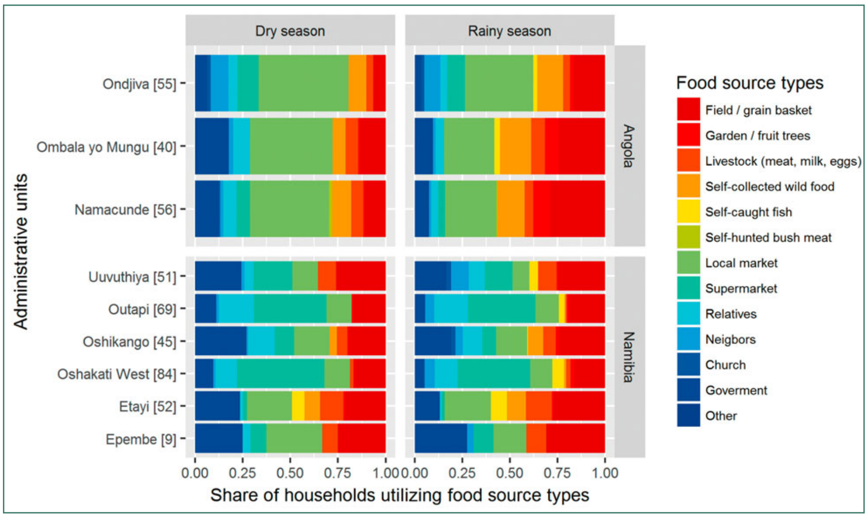

Figure 4: Relative utilization of food source types in the dry and the rainy season in administrative units. Values in brackets behind names of administrative units indicate the sample size.

that the change between rainy and dry season is less pronounced compared to the water consumption. Nevertheless, changes are evident particularly in Angola, with subsistence food products from own grain farming and livestock being important during the rainy season, while under dry conditions, local markets and governmental relief gain importance. The latter source type also plays an important role for Namibian households, for instance providing food to around 25% of the sampled households in Uuvuthiya, Oshikango, Etayi and Epembe constituencies. Thus, for many people, relief food items are essential to complement their diets even during the rainy season before the first harvests become available. Overall, nearly half of the households' food demand in rural areas is covered via neighbours, relatives, supermarkets and local markets. In urban areas, this share increases but subsistence food products still play a supplementary role and are acquired via the extended family network that reaches into the villages.

Source type reliability

Shifting the focus from the administrative units to the water and food source types and their reliability under dry conditions, Figure 5 illustrates the seasonal changes in utilization.

The coloured categories indicate whether a specific source type gained or lost importance from the rainy to the dry season. In other words, the coloured categories reveal whether a specific source type was (1) newly used in the dry season, (2) increasingly used, (3) persisted, (4) was decreasingly used, or even (5) was abandoned. If this last case appeared, the specific source type was not available anymore because of either quality or quantity constraints.

With respect to the water source types, the tap water sources show increased utilization while the traditional source types such as open water (iishana) and rainwater are abandoned in the dry season.

With regard to the food source types, the evaluation is less consistent. In general, subsistence food sources such as households' own agricultural activities decline in utilization during the dry season while types such as local markets and supermarkets as well as governmental relief gain importance. This visual impression is confirmed by quantifying the reliability of the source types. Table 1 presents the results on a normalized scale from 0 (less reliable) to 1 (more reliable).

Though the results of some source types such as "Canal" and "Self-hunted bush meat" have to be interpreted with caution since they are based on only a few cases, the overall ranking seems reasonable. As such, the most reliable water source types appear to be water vendors, tap water sources, and boreholes and deep wells that make use of groundwater that is less prone to drought conditions. Similarly, the most reliable food source types are governmental relief, market infrastructures, and relatives who provide food in the case of emergencies.

Drought sensitivity

From the findings above, drought sensitivity estimates can be calculated for every household by combining the specific source reliability benchmarks with the relative quantities obtained from each source type and the total household demand. Figure 6 illustrates the distribution of drought sensitivity scores in the sample, grouped according to rural and urban as well as Namibian and Angolan households.

It becomes obvious that rural households are more sensitive to drought events than urban citizens as their histograms are rather skewed to low values and the median sensitivity scores are closer to 0.

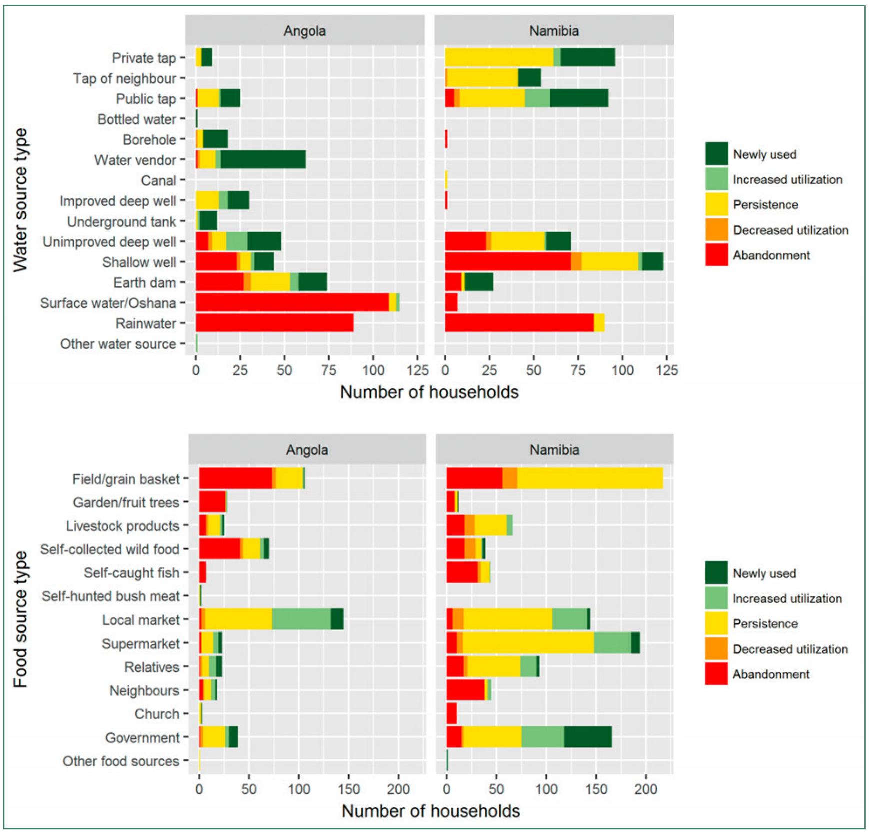

Figure 5: Seasonal changes in water and food source type utilization. The coloured categories indicate changes in utilization from the rainy to the dry season.

Though Namibian rural households show a similar distribution range of sensitivity values as their Angolan neighbours, they score better when considering their median, giving a hint to better infrastructural endowment of the Namibian area. By focusing on the urban households, the differences become more apparent. While the Namibian urban households show the best sensitivity scores (values close to 1), their Angolan counterparts give a more heterogeneous picture. This is particularly driven by urban agglomerations in Angola that are less well equipped as only the main town in the Cunene Province, Ondjiva, has good infrastructure.

Table 1: Reliability levels of water and food source types (0: less reliable; 1: more reliable).

Water source types	Reliability	Food source types	Reliability
Water vendor	1.00	Government	1.00
Public tap	0.98	Local market	0.92
Private tap	0.97	Supermarket	0.78
Tap of neighbour	0.84	Relatives	0.69
Borehole	0.84	Self-hunted bush meat	0.69
Improved deep well	0.84	Other food sources	0.69
Underground tank	0.83	Church	0.65
Unimproved deep well	0.81	Livestock products	0.56
Bottled water	0.79	Garden/fruit trees	0.51
Canal	0.78	Neighbours	0.51
Earth dam	0.77	Self-caught fish	0.48
Other water sources	0.76	Self-collected wild food	0.41
Shallow well	0.45	Field/grain basket	0.00
Surface water/*oshana*	0.26		
Rainwater	0.00		

Discussion

The following sections will specifically reflect on the results and the methodology applied against the background of the study's intention.

Reflection on results

The population utilizes a wide range of source types and responds to dry conditions by switching sources on a seasonal basis. While this aspect is assumed for developing countries, empirical surveys to explore this complexity are lacking (Elliott et al., 2017). This study confirms that the population follows complex water and food consumption patterns both structurally (multiple sources simultaneously) and temporally (different sources in the dry and the rainy seasons).

In addition, the estimates on water and food source type reliability that stem from the seasonal changes seem reasonable against the background of conventional classification systems (e.g., WHO & UNICEF, 2017). Traditional types that make use of local green and blue water are less reliable, since many households reduce the level of utilization or even abandon them during the dry season. Modern infrastructural types such as tap water and water vendors as well as local markets and supermarkets are often used when traditional types fail under dry conditions.

The sensitivity scores show that rural Angolan households are most sensitive to drought. This is a reasonable result, as the rural population has little access to modern water and food infrastructures compared to the rural Namibian households. Nevertheless, it is interesting to see that urban inhabitants are also closely connected to drought conditions, in particular with regard to consumed food items that are obtained from family members living in the villages. This link would have been hidden if the study had explored only the main food source (Crush & Caesar, 2017).

The drought sensitivity scores build on local knowledge of the population to depict their consumption patterns. Nevertheless, these scores can be only one part of a more holistic consideration of drought risk. Hence, the results will be integrated into a drought risk assessment

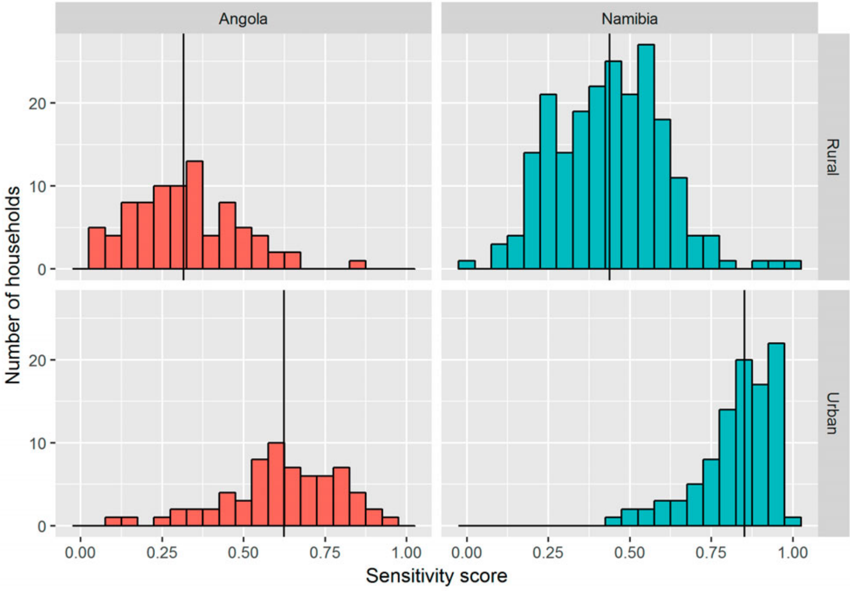

Figure 6: Histograms of drought sensitivity estimation of households, grouped according to settlement pattern and citizenship. The vertical line indicates the median sensitivity score for the respective groups.

tool that combines a physical hazard perspective (Luetkemeier et al., 2017) and empirical information on the coping capacities of the population into a single composite indicator, the Household Drought Risk Index (HDRI) (Luetkemeier, ISOE, unpubl.). In this index, drought risk is perceived as a combined outcome from both environmental stressors that act as hazards and societal characteristics of vulnerability that culminate in drought risk. This will enhance the decision base to improve short-term emergency responses and design targeted adaptation measures for drought policies and strategies (e.g., Republic of Namibia, 1997).

Methodological reflections

The complexity in consumption patterns is often overlooked, in particular in larger-scale assessments such as census surveys where only the main water and food sources are assessed (NSA, 2013; INE, 2016; Elliott et al., 2017). These surveys hide the underlying complexity and thus prevent more in-depth analyses. This study provides an adequate household sample size to analyse seasonal consumption patterns and gain insights into the way households act during the course of a year under rainy to dry conditions. In addition, the data offer the opportunity to estimate the reliability of water and food source types. These estimates stem solely from a socio-empirical survey and might help to support and complement the assessment of water resources from a hydrogeological perspective (Wanke et al., 2018).

Two major tasks for future research in this field require priority: First, the temporal resolution of the empirical assessment should be increased to quarterly or even monthly time steps with adequate questionnaire tools (i.e., by combining the ranking scheme with seasonal calendar assessments that are well known in food security assessments). Second, the drought sensitivity scores need to be validated (i.e., via household surveys during pronounced drought periods using conventional food security and nutrition surveys).

Conclusion

The assessment of drought sensitivity via the empirical investigation of seasonal water and food consumption patterns revealed that the population in the Cuvelai Basin utilizes a multi-resource mix to cope with drought situations. This mechanism is an expression of a self-regulated social-ecological system to alleviate the potential impact of drought. The risk of failure is mitigated by utilizing a broad range of source types that have varying levels of reliability under dry conditions. In this regard, modern water and food infrastructures serve as an important backup resource, if traditional, free sources fail.

Whereas the Namibian households show improved access to respective backup resources, their Angolan neighbours are less well equipped and hence require more investments in infrastructure development. Specifically, the extension of the tap water network in Angola is an important step to reduce the rural population's sensitivity to drought. Experiences gained in Namibia with the establishment of community water point committees can be a feasible solution (Schnegg & Bollig, 2016) as long as shortcomings in the institutional design can be resolved (Hossain & Helao, 2008). Furthermore, households require access to local market systems to sell and buy food items. Market systems need to be established in remote areas and people need to be enabled to purchase food if necessary (e.g., via grant or subsidy systems). Since many households rely on subsistence grain framing, the improvement of both the local production system (e.g., via small-scale irrigation schemes) and grain storage facilities (e.g., renewal of grain baskets) enhances people's ability to get through the dry season in general and drought events in particular. Positive experiences were already gained with the introduction of rain- and floodwater harvesting techniques (RFWH) alongside small-scale irrigation schemes and associated capacity development efforts to enhance technical and business skills, in particular among women (Kluge et al., 2008; Woltersdorf et al., 2014).

The methodology employed to assess seasonal consumption patterns proved to provide reasonable insights using an assessment procedure that is quick and simple to apply. Hence, if this ranking scheme procedure were to be incorporated into conventional household surveys such as regular census assessment (NSA, 2011), a continuous monitoring of consumption patterns and thus of drought sensitivity, among other phenomena, would be possible. Furthermore, the methodology is transferable to other regions with similar drought challenges, even if drought might affect additional consumption domains such as energy provision.

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