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The power of consensus: Developing a community voice in land use planning and tourism development in biodiversity hotspots

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ABSTRACT

In regions rich in natural resources, nature-based tourism is advancing rapidly. This form of development is identified as an important economic opportunity for local communities but can impact ecosystem services through rapid landscape transformation, threatening the livelihoods of the most impoverished sectors of a community. While it is accepted that communities should participate in the planning process, variation in community and household-level landscape dependencies and priorities can create a fractured viewpoint that is difficult to integrate into the land planning process. Power structures and special interests can subvert participatory processes and input at the community level. In the Chobe District, Northern Botswana, tourism, and other related developments had occurred at a rapid pace around the Chobe National Park creating access barriers, in some instances, to essential natural resource areas. We evaluate community landscape dependencies and participatory approaches to the development of inclusive land use maps. Spatial information on land use dependencies from household surveys were used to form the bases of reiterative village-level participatory mapping exercises ($n = 179$ households, six villages). The activities were conducted through traditional leadership structures. Landscape dependencies were widespread across study villages in both natural resource and agricultural sectors. Cluster and CART analysis of household data identified important variation in landscape dependencies between and within study villages. Fishing was the most important factor predicting gender of headship with male-headed households using this resource more frequently. Spatial data from these household consultations were used to create a draft map that was reiteratively refined through participatory map building exercises until final approval was provided by community members and their traditional leaders in a village. Scaled consultations and involvement of the traditional leadership limited the ability of power structures to control the process and/or subvert the interests of more vulnerable members of a community. Mapping outputs were later successfully used in land planning exercises and consultations. Development of inclusive community consensus on landscape dependencies should be undertaken before lucrative tourism ventures and land allocations are advanced in competition to the needs of more vulnerable and often voiceless sectors of a community.

1. Introduction

Nature-based tourism ventures and accompanying developments are on the rise in Africa particularly in biodiversity rich landscapes (Balmford et al., 2009). These enterprises are often promoted as providing important economic opportunities for local communities with related revenue streams considered an opportunity to offset associated resource costs, contributing to improved livelihoods (Stronza, 2007). However, demands for land access around these resources rich sites is noted as a growing conflict influencing both wildlife conservation and community livelihoods (Fisher and Christopher, 2007; Hansen et al., 2002).

While nature-based tourism developments can provide important economic opportunities, it is not necessarily a substitute for existing rural livelihoods, but a mechanism to diversify activities and stabilize incomes for a subset of households (Mowforth and Munt, 2015). Opportunities may also only be available to a subset of a particular community. Rapid development in these regions can have significant negative impacts on ecosystem services and local populations when land use changes occur at the expense of the

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environment and livelihood needs of a community (reviewed (Xu et al., 2017)). Here, development can become an engine of spatial conflict among community members, where infrastructure and exclusive land use rights create barriers to traditional natural resource access and land use, impacting livelihood elements, particularly of the more vulnerable members of a community. There is an urgent need to increase the involvement of communities in order to ensure that household landscape dependencies can be identified and secured in a balanced manner with other landscape needs before land transformation and ecosystem service provisioning is lost.

A large body of work has focused on the importance of empowering local communities to participate and benefit directly from nature-based tourism (community based tourism, reviewed in (Stone, 2015)). Here, community participation in the land planning process is seen to be a fundamental component of landscape sustainability and social equity (Eizenberg and Jabareen, 2017; Fraser et al., 2006). These considerations are particularly important in landscapes where traditional land ownership and common use practices have historically prevailed and underscore household livelihood strategies (Kalabamu, 2000). In these systems, traditional land access and extended land use rights were reciprocally engaged across households in a community, providing a platform to support the development of diverse livelihood strategies resilient to changing landscape conditions (e.g., drought and wet cycles, household needs, etc.) and varying land suitability (Kalabamu, 2000) reducing household vulnerability. However, in transitioning landscapes, where land reform and land allocation processes replace traditional land control practices, communities can be rapidly separated from essential land areas and associated resources without replacement opportunities, undermining livelihood strategies (Juru, 2012).

Diverse household priorities across a community can, however, be difficult to identify and summarize equitably into the land planning process. These problems are compounded by the complexity of integrating traditional knowledge systems with technology-dominated management processes, a further hurdle to the creation of common knowledge sets of natural capital stocks and landscape needs. So, while inclusive community involvement in tourism, land development, and natural resource planning is pursued ideologically; practically, communities are not positioned to participate and remain bystanders in the process, particularly the impoverished and more vulnerable sectors of a community. These effects may be particularly pronounced when community decisions are focused on profit-making land allocations, such as wildlife-based tourism ventures, where expectations of benefits are an anticipated outcome. Here needs of affected households may be unknown or ignored. Tourism developments (i.e., hotels and lodges) are also often promoted to communities as an income generating "win" for everyone, irrespective of differences in landscape dependencies, vulnerability, and/or likelihood of benefit streams reaching divergent household types. Of critical importance is the concern that power structures within a community will influence the consultation process, potentially subverting concerns of disempowered members. This is of particular concern when livelihood concerns of a minority of households are placed in competition with more lucrative nature-based development opportunities. The challenge here is creating inclusive approaches that identify the diversity of household landscape needs in an inclusive and transparent manner *before* land transformation plans are proposed and agreed.

Participatory land planning approaches have been used extensively to address these types of problems and can provide powerful tools for incorporating communities into the planning process across a myriad of sectors (natural resources, agriculture, public health etc., (Kapiriri et al., 2003; McCall, 2003; Talen, 2000)). The primary aim in this methodology is to ensure that socially and economically marginalized people are incorporated into decision-making processes that involve them directly (Guijt and Shah, 1998). However, it is also recognized that these approaches may also be compromised in their effectiveness where age, economic status, religious beliefs, caste systems, ethnicity, gender, and other power subverting structures among community members may limit equal participation in the process (Guijt and Shah, 1998). Here, gender is recognized as being particularly important (Guijt and Shah, 1998), with gender inequality a persistent barrier to sustainable development goals across many regions of the world (UNICEF, 2006).

In Northern Botswana, a region rich in natural capital, early development of the tourism industry concentrated along the river front (hotels, lodges, jetties) within the towns of Kasane and Kazungula. Properties were then fenced, blocking river access over much of the region, limiting the ability of local community members to access associated river resources over a large stretch of the river reach. Leases were developed for larger tourism land allocations with the local land authority (Land Boards), but community needs were not specifically incorporated as they were largely unknown. Over time, access to the riverfront in Kasane and Kazungula has continued to diminish, and with it, associated provisioning ecosystem services, causing anger and resentment among households that were once dependent on those resources. Once the developments were in place and consequences realized, little could be done to address these problems. Preventing community conflict is difficult, however, without agreement on the spatial land needs required for agriculture production and natural resource abstraction (i.e., food, fiber, and fuel) among communities; information that is most effectively identified before land transformation is proposed.

With reduced availability of land, focus rapidly transitioned to available areas around communities on the other side of the Chobe National Park, an area termed the Chobe Enclave. While a number of socio-economic studies had been conducted in this region (Ecosurv, 1996; Painter, 1997; SIAPAC, 1992), the spatial attributes and characteristics of household landscape dependencies were inadequately understood and more commonly determined by third parties when land planning or allocation processes were advanced at the community level. Here, we investigate variation in land use dependencies among households in the village of Kazungula, a transitioning urban center, and five villages in the Chobe Enclave and describe an approach for participatory land mapping that is hierarchical in nature (household to community under the control and guidance of traditional leaders). We evaluate the overall utility of this scaled approach in its ability to proactively and inclusively place communities in front of the land-planning process.

2. Materials and methods

2.1. Study site

Botswana is a politically stable, landlocked country located in Southern Africa. It is considered a semi-arid country where only 5% of land area is suitable for agricultural production and 80% considered desert (Republic of Botswana, Central Statistics Office 2000). Tourism is Botswana's second biggest foreign exchange earner after the diamond industry and contributes significantly to Botswana's economy (4.5% GDP) (Mbaiwa, 2005). Botswana's tourism industry is wildlife-based, with 39% of the country utilized for nature-based tourism, predominately focused in Northern Botswana (Jones, 2002). We conducted our study in this region of the country in Chobe District (Fig. 1) and focused on one larger, urban-transitioning village of Kazungula (pop. est. 4113) located

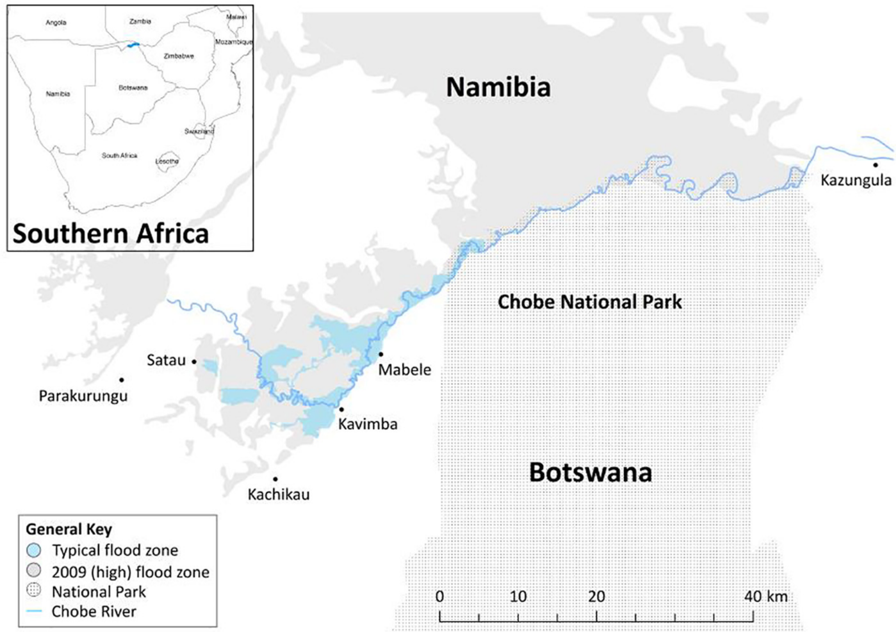

Fig. 1. The study was conducted in Chobe District in Northern Botswana. Botswana is located in Southern Africa (inset). Villages in the Chobe District where surveys were carried out include Kazungula, Mabele/Muchenje, Kavimba, Kachikau, Satau, and Parakurungu. The Chobe River is indicated in blue and represents the international border with Namibia. Floodplains are variably inundated during the flood pulse (blue–gray) arising from rainfall at the headwaters in the Angolan Highlands. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

on the eastern side of the Park near the urban centre of Kasane, and five rural villages on the western side of the Chobe National Park collectively called the Chobe Enclave (Mabele/Muchenje (pop. est. 773), Kavimba (pop. est. 549), Kachikau (pop. est. 1356), Satau (pop. est. 605) and Parakarungu (pop. est. 845) (2011 Botswana Population Census (Botswana Government, 2011)). Chobe Enclave villages are bounded by protected areas and the international border of Namibia (Ecosurv, 1996). The Chobe National Park is 10,000 km^2, while the Enclave is 1690 km^2 and is predominately made up Chobe River floodplains (Jones, 2002).

The Chobe River is a flood pulse dryland system and is the only source of permanent surface water in the District, flooding annually (Gaughan and Waylen, 2012). The Chobe River in the Chobe Enclave region is more of a backwater with inundation and flow determined by the magnitude of local rainfall and the flood pulse dynamics. Access to wetland resources in this area can be variable and influenced by flow and inundation dynamics. After the Okavango Delta, the Chobe villages are located within the second largest tourism locality in Botswana.

Land tenure in the country is categorized into three types: freehold land, state land (once Crown Lands), and tribal land (Kalabamu, 2000). Freehold land is privately owned, while state land comprises of protected areas, including national parks, game reserves, and forest reserves. Tribal land includes land used for residential properties as well as livestock grazing and arable farming. Study villages were situated on tribal land areas. Instituted in 1970, tribal land allocation and management is directed under established land boards (Wynne, 1990) that are governed by the Botswana Ministry of Lands and Housing.

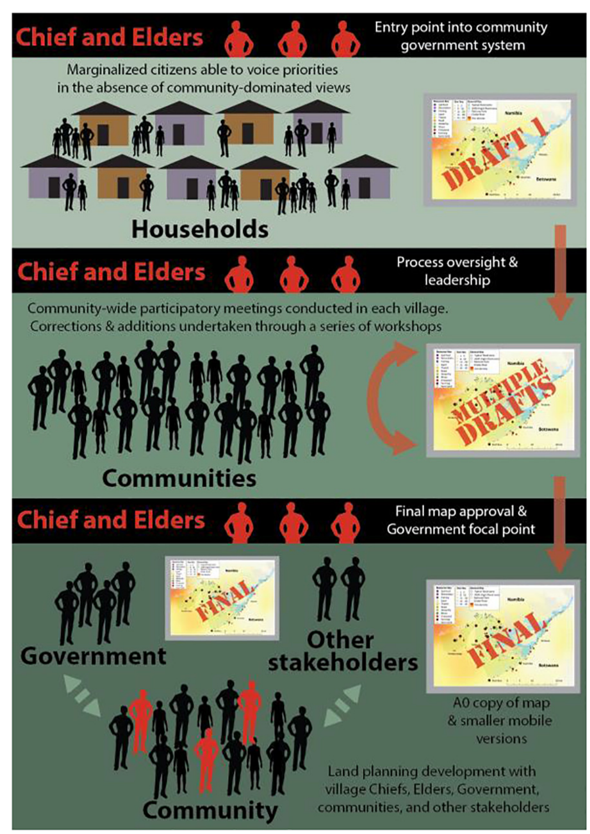

Fig. 2. Schematic of community land use planning approach.

2.2. Hierarchical survey design-overview

The study approach was designed to be hierarchical in nature starting at the household level up to the village with oversight provided by traditional community leadership structures at each step (Kgosi or chief, and the community elders, Fig. 2). At the household level, data were acquired through the use of a questionnaire survey tool and used to provide insight into the variation in landscape needs among household types within and between study villages. This data was also used to construct the first draft map to be used in community consultations, capturing information in its entirety that might not be expressed by individuals in larger community gatherings. At this same stage, the Dikgosi (plural for chiefs) reviewed initial maps, provided recommendations for inclusion of key landmarks that could facilitate the orientation of participants in the mapping reading exercises, and approved the final version for use at the community level. Community consultations were twofold in their intent. First, participatory mapping exercises allowed a wider gathering of information, adding to and refining data obtained from the household level. Secondly, continued revision until acceptance and approval ensured that community members and leadership identified the map and contents as a form of agreement of inclusive community needs.

2.3. Household survey methodology

For each village, the research team started the process by obtaining permission to conduct the study through traditional community leadership structures (Kgosi and elders; Fig. 2). Once permission was obtained, a second community meeting was held at the Kgotla (meeting hall) where, under the direction of the Kgosi, the research team explained the purpose and answered questions regarding household surveys, participatory mapping exercises, and the expected outcome of the activities (Fig. 2). Once the community agreed to conduct the study, an attempt was made to interview at least thirty households in each study village.

Developed survey tools was prepared in English (national language) and administered by the same individual with translation assistance provided by the same interpreter throughout the survey. Questions regarding agricultural and natural resource abstraction activities were closed in structure and focused on key landscape dependencies/utilization activities: chickens, flood plain farming, field ownership, livestock ownership, waterlily, musa, reed, fish, thatch, firewood, wild fruit, river sand, medicinal plants, wood for kraal, wood for home construction, and wood for crafts. The respondents were also asked to provide location data using a base map for respective resource areas, with remote imagery, roads, water, international boundaries, and the Chobe National Park noted. In some cases, where the site could not be obtained through this method, the respondent would travel with the research team member to the site to collect spatial data directly.

The initial starting point for the household surveys was randomly selected by the use of a pin drop on an aerial image of the respective village area. A coin was then flipped to identify left or right direction from that initial point. A random number table was used to generate a number between 1 and 5 which became the number of households to be skipped between survey households. We defined a household as "a family-based co-residential unit that takes care of resource management and the primary needs of its members" following Niehof (2004). For consistency, the interview targeted the head of the household (HH), although in some instances the head was unavailable and the second most senior person in the house participated in the survey acting as the HH. If no one was available to participate at the household being visited, the next house would be visited until a home could be successfully interviewed. In some cases, when the HH was not available, household members requested the team to schedule a follow up visit in order to complete the survey.

Households self-identified tribal affiliation and headship. Headship was identified as the person responsible for decision-making within the household. *De Jure* or *de Facto* categorization for female-headed households (FHH) were based on marital status and presence of a husband or male partner (*de Facto* – widowed or unmarried, *de Jure* – married or having a partner but male not in residence at the time of study). Determining headship can be problematic and we recognize the limitations with the approach as it ignores the potential complexity of decision-making processes engaged at the household level and disagreement among members on perspectives of headship, resource provisioning, and influence of non-resident males (reviewed by (Mookodi, 2000)).

Research activities were conducted under permit from the Ministry of Environment, Natural Resources Conservation and Tourism, and the Virginia Tech Institutional Review Board (permit # 11-573).

2.4. Participatory GIS

Spatial data on natural resource use areas obtained from respondents during household surveys were used to develop a draft map of land area use in ArcGIS (version 10.3, Redding California). Iterative consultations were conducted with the Dikgosi and community elders from each respective village until a base map was created specific to that village. Key community landmarks were identified by the traditional leadership and were specially included to orient participants and reduce confusion during community-wide participatory mapping exercises (for example, two large baobabs that flank the road at a specific location and known to everyone in the community). The Dikgosi and elders reviewed final consultation maps, providing corrections until they gave approval for their use in further community-wide consultations.

Community-wide participatory mapping exercises were then conducted in each village again under the leadership of the Kgosi. Corrections and additions to village maps were undertaken through a series of community meetings held at each respective village Kgotla. This process continued until each community and their traditional leaders approved the final prepared maps as a correct representation of their village land use dependencies. Initially, meetings were conducted with the use of a printed map without remote imagery. Once electricity was available, additional meetings were conducted using maps with remote imagery as the base projected on a wall of the Kgotlas, and revision of the map through participatory processes were then implemented in real-time. On finalization, A4 maps were bound and provided to the Dikgosi together with a framed A0 base map for use in the Kgotla.

Given the focus on land planning, it is important to note that the scope of our investigations was limited to evaluating household activities and dependencies arising in relation to specific landscape opportunities. Thus, our study did not incorporate the full spectrum of elements that make up the livelihood concept or evaluate political influences on community access and involvement.

2.5. Statistical analysis

All statistical analyses were conducted in the open source integrated programming environment R 3.3.2 (Team, 2012). The *epitools* package (Aragon, 2010) was used to calculate exact binomial confidence intervals with Bonferroni adjustment. Surveys with significant missing data were dropped from the final analysis ($n = 2$). Count data comparisons of natural resource use and agricultural use between villages were calculated with the Kruskal–Wallis test in the *pgirmess* package (Giraudoux, 2012). Post hoc evaluations were conducted using the *conover.test* package and the Conover test with Bonferroni adjustment.

2.5.1. Exploratory data analysis: cluster and CART

Exploratory data analysis provides an opportunity to uncover underlying structure to data and identify the most influential variables. Cluster analysis is an exploratory data mining technique which attempts to evaluate a set of objects in such a way that they can be grouped (called a cluster) as more similar to each other than other groups (clusters). We used the add-on package *Cluster* and the Daisy algorithm used in R-statistics (R Development Core

Team, 2012) to undertake the hierarchical cluster analysis and create dendrograms. We used two nominal (village ($n = 6$) and headship type ($n = 4$): female *dejure*, female *defacto*, female unknown, and male) and sixteen binary, symmetrical variables (landscape dependencies/utilization activities: chickens, flood plain farming, field ownership, livestock ownership, waterlily, musa, reed, fish, thatch, firewood, wild fruit, river sand, medicinal plants, wood for kraal, wood for home construction, wood for crafts) for the cluster analysis. The use of village allowed us to assess whether there was an explicit spatial component to the nature of landscape use and level of variability among households by village. Inclusion of gender and headship characteristics allowed us to explore the effect of these elements on natural resource use and agricultural activities across households and villages. We used the general dissimilarity coefficient of Gower as our linkage method (Gower, 1971). It has the advantage of handling different types of data in the analysis (nominal, ordinal, and (a)symmetric binary). We evaluated a number of distance measures (ward, single, average, complete, centroid, and mcquitty) and compared goodness of the dendrogram fit with the dissimilarity matrix using both the Gower Distance Assessment and Cophenetic Correlation (Borcard et al., 2011). Dendrograms were pruned at the level where the major cluster groups appeared to form and could be seen on a clustering heat map where associations are visualized along a color gradient (Jacobson et al., 2011). We also used the *sil_width* function in the *Cluster* package to identify the optimal number of clusters (Pacheco, 2015). This function provides an assessment of the variance explained by the number of clusters (k-means clusters, "elbow method") where adding additional clusters provides limited improvement on the modeling of the data. We used the *rafalib* package in R and the *myplclust* function to plot the final dendrogram.

Decision tree or recursive partitioning is used to group members of a population into subpopulations based on dichotomous independent variables (Lemon et al., 2003). We used classification and regression tree (CART) analysis, a nonparametric decision tree methodology, to evaluate associations between livelihood dependencies and headship as it can have an important influence on livelihood diversification providing further insight into variation in landscape dependencies among households (Dolan, 2004; Ersado, 2006). We used the *rpart* package and the "class" method to create decision trees (Liu, 2016). We set "headship" as the dependent variable. To avoid overfitting the data, we selected the lowest xerror (estimate of the cross-validation predication error) and corresponding cp in the *rpart* object to identify the optimal level to prune the resulting tree. We used the function *as.party* in the *partykit* package in R to plot the final decision tree.

3. Results

Household surveys were conducted in Kazungula ($n = 31$, two households requested call backs), Mabele/Muchenje ($n = 30$), Kavimba ($n = 30$), Kachikau ($n = 30$), Satau ($n = 30$) and Parakarungu ($n = 28$). Respondents provided summary information on survey household characteristics (Table 1), and landscape resource use or activity (Table 2).

Associated summary spatial data provided the foundation for the initial draft participatory maps developed, finalized, and approved through tribal leadership and community participatory techniques, in a reiterative methodology (Fig. 3).

3.1. Data limitations

Due to logistical constraints, the majority of households were interviewed during traditional business hours (Monday–Friday). Given that only 36% of household respondents reported being employed (Table 1), information obtained from the household surveys may have been biased towards unemployed members of the community rather than employed persons. The person interviewed, however, was instructed to provide aggregate information on summary household attributes and landscape use across all members of the household (employed and unemployed). Information obtained at the household on landscape use areas were further vetted through traditional leaders and multiple community meetings where community-wide participatory approaches further developed and refined community landscape use maps.

3.2. Survey household characteristics by village

There was a statistically significant effect of village on age of the HH as determined by a one-way ANOVA ($F(5,169) = 5.425$, $p = .001$). Post hoc comparisons using the Tukey HSD test indicated that the mean age for Kazungula ($M = 64.6$ years old (y/o), SD = 14.8) was significantly different than Mabele/Muchenje ($M = 47.4$ y/o, SD = 14.8), Kavimba ($M = 45.9$ y/o, SD = 17.1), and Kachikau ($M = 49.3$ y/o, SD = 17.6) but not Parakarungu ($M = 54.8$ y/o, SD = 13.8) and Satau ($M = 54.1$ y/o, SD = 15.9) the more remote rural villages in the Enclave. There were no significant differences in mean age among Chobe Enclave villages.

Male and female headships were equal across households (46% females, $n = 179$, 95% CI = 39–53% and 53% males, 95% CI = 46–60%), $X^2 = 0.18885$, $p = 0.169371$). Of FHH, 80% ($n = 82$, 95% CI = 69–87%) were defined as *de Facto* according to the definitions used in this study. Education levels among and between survey households in study villages varied greatly (Table 1) with 18% (95% CI = 13–25%) indicating that they had no education at all. Most respondents reported being unemployed (66%, 95% CI = 59–72%). Of those that were employed ($n = 45$), 71% (95% CI = 57–82%) worked for the Botswana Government (53% full-time ($n = 32$, 95% CI = 36–69%) and 47% part-time (95% CI = 31–64%)), and 29% (95% CI = 18–43%) worked in the private sector (92% full-time ($n = 13$, 95% CI = 67–99) and 8% part-time (95% CI = 1–33%; Table 1). Households self-identified diverse tribal affinities ($n = 12$ tribal groups) with Basubiya being the dominant self-reported tribal group (Table 1).

3.3. Landscape use

3.3.1. Agriculture

Significant differences were present in the mean number of agricultural activities (including arable farming, pastoral farming, chicken production and livestock use) between Kazungula (mean = 1) and all five Chobe Enclave villages ($p = 0.0000$ for all five villages; Kachikau = 3; Kavimba = 3; Mabele/Muchenje = 2; Parakarungu = 3; Satau = 3), with marginally significant differences identified between the five Chobe Enclave villages ($p = 0.0565$).

By village, the proportion of households reporting arable farming activities ranged widely (3–50% by village) and was undertaken on floodplain areas abutting the Chobe River (referred to as malapo farming). Maize was the primary crop produced (95%, $n = 79$, 95% CI = 88–98%). In the Chobe Enclave, over half of the households reported owning a plough field (56%, 95% CI = 49–63%). In Kazungula, however, only one household reported owning a field and engaged in arable farming. Livestock ownership was identified in roughly half of the interviewed households (54%, 95% CI = 46–61%) and herd sizes varied substantially from 87 cattle to a single cow. There were no differences in livestock ownership by gender of headship ($n = 96$, FHH 42%, 95% CI = 32–52%, MHH 58%, 95% CI = 48–68%). Grazing of livestock was done over large areas of the landscape and not restricted to the village area. Chickens were owned by 65% of households ($n = 179$, 95% CI = 58–71%)

Table 1
Demographic characteristics of surveyed households by village. Calculated 99% binomial confidence intervals with Bonferroni adjustment for multiple comparisons are presented in parentheses. Respondents self-identified tribal affiliations.

Demographic	Kachikau (*n* = 30)	Kavimba (*n* = 30)	Kazungula (*n* = 31)	Mabele/Muchenje (*n* = 30)	Parakarungu (*n* = 28)	Satau (*n* = 30)
Age of head of household/respondent						
<25 years	3% (0–23%)	10% (1–33%)	0% (0–16%)	7% (0–28%)	0% (0–18%)	7% (0–28%)
25–35 years	30% (11–56%)	30% (11–56%)	0% (0–16%)	17% (4–41%)	4% (0–24%)	10% (1–33%)
36–60 years	37% (16–62%)	43% (21–68%)	42% (20–67%)	60% (35–82%)	61% (34–83%)	43% (21–68%)
61–75 years	20% (5–45%)	13% (2–37%)	19% (5–44%)	13% (2–37%)	18% (4–44%)	33% (13–59%)
>75 years	10% (1–33%)	3% (0–23%)	29% (11–54%)	3% (0–23%)	14% (2–39%)	7% (0–28%)
Headship						
Female unknown	7% (0–28%)	0% (0–17%)	23% (7–47%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Female dejure	0% (0–17%)	3% (0–23%)	13% (2–36%)	3% (0–23%)	7% (0–30%)	0% (0–17%)
Female defacto	43% (21–68%)	47% (23–71%)	13% (2–36%)	40% (18–65%)	39% (17–66%)	37% (16–62%)
Male	50% (26–74%)	50% (26–74%)	45% (22–70%)	57% (32–79%)	54% (28–78%)	63% (38–84%)
Tribal affiliation						
Bakgalagadi	0% (0–17%)	0% (0–17%)	3% (0–22%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Bambukushu	7% (0–28%)	0% (0–17%)	0% (0–16%)	0% (0–17%)	7% (0–30%)	0% (0–17%)
Banajwa	0% (0–17%)	3% (0–23%)	0% (0–16%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Bangwato	0% (0–17%)	0% (0–17%)	10% (1–32%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Basarwa	3% (0–23%)	0% (0–17%)	16% (4–40%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Basubiya	10% (1–33%)	90% (67–99%)	16% (4–40%)	87% (63–98%)	89% (65–99%)	90% (67–99%)
Batawana	30% (11–56%)	0% (0–17%)	13% (2–36%)	13% (2–37%)	0% (0–18%)	0% (0–17%)
Bathoka	0% (0–17%)	0% (0–17%)	6% (0–27%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Batswapong	0% (0–17%)	0% (0–17%)	3% (0–22%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Baxhereku	3% (0–23%)	0% (0–17%)	0% (0–16%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Bayei	47% (23–71%)	7% (0–28%)	26% (9–51%)	0% (0–17%)	4% (0–24%)	10% (1–33%)
Lozi	0% (0–17%)	0% (0–17%)	3% (0–22%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Education						
Bachelors	0% (0–17%)	0% (0–17%)	0% (0–16%)	0% (0–17%)	0% (0–18%)	3% (0–23%)
Diploma	0% (0–17%)	7% (0–28%)	0% (0–16%)	0% (0–17%)	4% (0–24%)	0% (0–17%)
Senior secondary	7% (0–28%)	10% (1–33%)	0% (0–16%)	7% (0–28%)	14% (2–39%)	3% (0–23%)
Junior secondary	43% (21–68%)	50% (26–74%)	32% (13–58%)	57% (32–79%)	36% (14–62%)	50% (26–74%)
No education	17% (4–41%)	0% (0–17%)	55% (30–78%)	0% (0–17%)	18% (4–44%)	20% (5–45%)
Other education	33% (13–59%)	33% (13–59%)	13% (2–36%)	37% (16–62%)	18% (4–44%)	23% (7–49%)
Employment						
Unemployed	70% (44–89%)	50% (26–74%)	61% (36–83%)	63% (38–84%)	68% (41–88%)	83% (59–96%)
Retired	10% (1–33%)	0% (0–17%)	32% (13–58%)	0% (0–17%)	0% (0–18%)	0% (0–17%)
Government full-time	3% (0–23%)	10% (1–33%)	0% (0–16%)	13% (2–37%)	21% (6–48%)	10% (1–33%)
Government part-time	13% (2–37%)	33% (13–59%)	0% (0–16%)	0% (0–17%)	4% (0–24%)	0% (0–17%)
Private full-time	3% (0–23%)	3% (0–23%)	0% (0–16%)	23% (7–49%)	4% (0–24%)	7% (0–28%)
Private part-time	0% (0–17%)	3% (0–23%)	0% (0–16%)	0% (0–17%)	0% (0–18%)	0% (0–17%)

Table 2
Landscape use activities by village obtained from household surveys across six study villages in northern Botswana. Calculated 99% binomial confidence intervals with Bonferroni adjustment for multiple comparisons are presented in parentheses.

Landscape use	Kachikau (*n* = 30)	Kavimba (*n* = 30)	Kazungula (*n* = 31)	Mabele/Muchenje (*n* = 30)	Parakarungu (*n* = 28)	Satau (*n* = 30)
Agriculture						
Poultry	60% (35–82%)	43% (21–68%)	45% (22–70%)	67% (41–87%)	93% (70–100%)	83% (59–96%)
Livestock	57% (32–79%)	60% (35–82%)	13% (2–36%)	60% (35–82%)	75% (49–92%)	60% (35–82%)
Arable farming	23% (7–49%)	13% (2–37%)	3% (0–22%)	50% (26–74%)	43% (20–69%)	50% (26–74%)
Pastoral farming	20% (5–45%)	23% (7–49%)	3% (0–22%)	20% (5–45%)	11% (1–35%)	3% (0–23%)
Arable and pastoral farming	27% (9–52%)	33% (13–59%)	0% (0–16%)	7% (0–28%)	36% (14–62%)	33% (13–59%)
Field ownership	53% (29–77%)	47% (23–71%)	3% (0–22%)	67% (41–87%)	89% (65–99%)	83% (59–96%)
Natural resources						
Fishing	30% (11–56%)	57% (32–79%)	13% (2–36%)	73% (48–91%)	36% (14–62%)	37% (16–62%)
River sand harvesting	47% (23–71%)	90% (67–99%)	16% (3–40%)	60% (35–82%)	25% (8–51%)	17% (4–41%)
Waterlily harvesting	3% (0–23%)	57% (32–79%)	32% (13–58%)	100% (83–100%)	25% (8–51%)	40% (18–65%)
Musa harvesting	10% (1–33%)	0% (1–17%)	10% (1–32%)	3% (0–23%)	18% (4–44%)	17% (4–41%)
Reed harvesting	57% (32–79%)	73% (48–91%)	35% (15–61%)	53% (29–77%)	75% (49–92%)	73% (48–91%)
Thatch grass harvesting	77% (51–93%)	83% (59–96%)	23% (7–47%)	63% (38–84%)	100% (82–100%)	80% (55–95%)
Wildfruit harvesting	93% (72–100%)	77% (51–93%)	23% (7–47%)	90% (67–99%)	50% (25–75%)	93% (72–100%)
Medicinal plant harvesting	10% (1–33%)	7% (0–28%)	10% (1–32%)	23% (7–49%)	7% (0–30%)	3% (0–23%)
Firewood harvesting	100% (83–100%)	100% (83–100%)	35% (15–61%)	100% (83–100%)	100% (82–100%)	100% (83–100%)
Wood harvesting for kraals	47% (23–71%)	67% (41–87%)	0% (0–16%)	37% (16–62%)	32% (12–59%)	33% (13–59%)
Wood harvesting for house construction	30% (11–56%)	13% (2–37%)	3% (0–22%)	7% (0–28%)	32% (12–59%)	47% (23–71%)
Wood harvesting for crafts	43% (21–68%)	63% (38–84%)	3% (0–22%)	30% (11–56%)	46% (22–72%)	50% (26–74%)

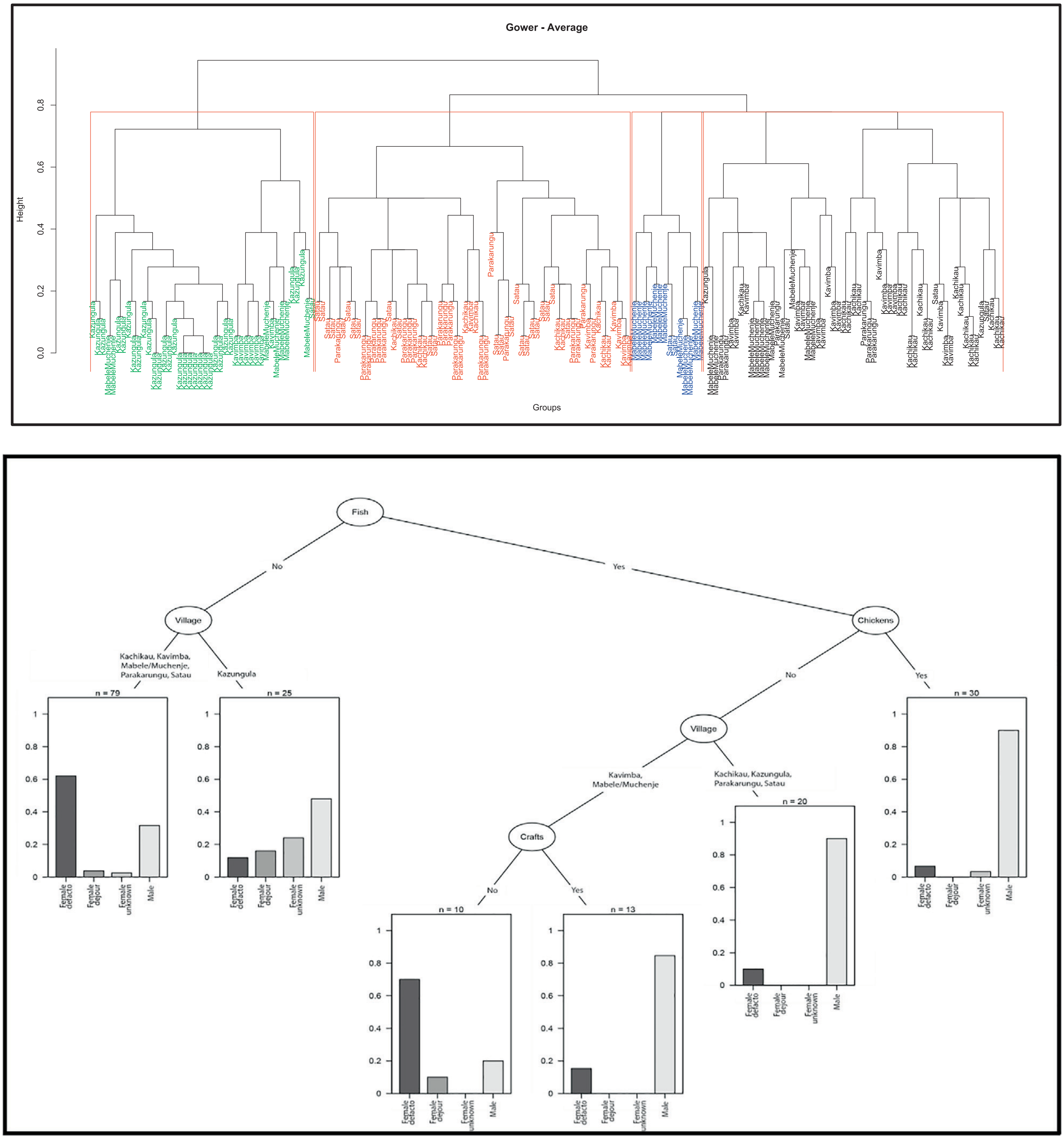

Fig. 3. Cluster and classification and regression tree analysis (CART) of landscape dependencies in Chobe District, Botswana. A – Dendrogram of the cluster analysis of questionnaire data collected from households in study villages in Chobe District: Kazungula, Mabele/Muchenje, Kavimba, Kachikau, Satau, and Parakarungu. The dendrogram was constructed with the Gower dissimilarity linkage method and average distance metric. B – CART classification tree. Headship was designated as the dependent variable. Crafts refers to the collection of wood for the production of wood-based crafts.

dominantly for meat production. Again, there was no difference in levels of ownership by gender of HH ($n = 116$, FFH 42%, 95% CI = 42–60%, and MMH 48%, 95% CI = 39–57%). Chickens were kept at the household plot.

3.3.2. Natural resource use

Natural resource use was identified across villages. Collection sites were focused along riparian areas but dependent on flood dynamics. River flow and flood dynamics, in addition to fire, were seen to have the most important influence on these resources (Fig. 5). Significant differences were seen in the mean number of natural resource products used between Kazungula (mean = 2) and all five Chobe Enclave villages ($p = 0.0000$; Kachikau = 5; Kavimba = 7; Mabele/Muchenje = 6; Parakarungu = 5; Satau = 6). Significant differences in natural resource use were also identified between Kavimba and Kachikau ($p = 0.0045$), and Kavimba and Parakarungu ($p = 0.032$).

Wetland product use was widespread among households. Of those surveyed, 43% (95% CI = 36–50%) of respondents reported using water lily. Respondents felt, however, that water lily was rare in the Chobe River, occurring more commonly when water was present all year-round. At the time of the survey, there was no permanent water in the back channel near the survey villages and the river was thought to stay dry too long to allow water lily to thrive in the system. The harvesting of thatch grass was an important activity for 70% of respondents (95% CI = 63–77%). Only 10% of households reported harvesting musa tubers (95% CI = 6–15%). Reed was harvested by 61% of respondents (95% CI = 54–68%) along the river in the main channel and was collected primarily for building huts and shelters (61%, n = 120, 95% CI = 54–68%). Kazungula village respondents felt continued expansion of the residential areas had reduced reed availability preventing their use of this resource. Forty-two percent of respondents (n = 179, 95% CI = 35–50%) reported extraction and use of river sand.

Of villagers surveyed overall, 41% (n = 179, 95% CI = 34–48%) reported currently fishing, with 62% (n = 73, 95% CI = 50–72%) indicating it was for subsistence, while 34% (95% CI = 24–46%) reported fishing for both commercial and subsistence purposes. Specific fishing spots were identified along the Chobe River across all villages, their use governed by flow dynamics. Fishing was dominantly a MHH activity (80%, n = 73, 95% CI = 69–87%) with a significant difference in use between the two genders of HH (X^2 = 4.6695, p = 0.0307). Across FHH type, fishing was a resource used on a limited basis (female *defacto* (20%, n = 65, 95% CI = 12–31%), female *dejour* (13%, n = 8, 95% CI = 22–47%) and female unknown (11%, n = 9, 95% CI = 20–44%)), with many women reporting that they did not know how to fish because "it was a man's job."

The majority of respondents reported collecting wild fruits (71%, 95% CI = 64–77%), with only 10% collecting plants for medicinal use (95% CI = 6–15%). Overall, wood products were used frequently among households in villages, with the vast majority reporting firewood use (89%, 95% CI = 83–93%), with 31% indicating that they did not have an alternative source of energy for the household. Collection spots were wide spread but focused more intensely around village areas within apparent walking distance of households. Wood was collected for kraal building by 36% of those surveyed (95% CI = 29–43%), while 22% (95% CI = 16–28%) collected wood for house construction, and 39% (95% CI = 32–46%) collected wood for crafts.

3.3.3. Recreational and spiritual use

Swimming was the only recreational use of the river. Of households surveyed, 10% (95% CI = 6–15%) reported swimming in the river. Spiritual use of the river was more common with 51% (95% CI = 43–58%) of respondents reporting baptisms and one respondent reported using the river for spiritual cleansing. As with the river, the floodplain is also used for spiritual activities, which includes baptism, traditional healing, and cleansing.

3.3.4. Cluster and CART evaluations

The average distance metric provided the best fit to the dissimilarity matrix on both the Gower Distance Assessment and Cophenetic Correlation. The analysis of questionnaire data identified four primary clusters (Fig. 3A). Households landscape dependencies did not cluster by village.

The CART analysis included 177 household surveys and identified two splits in the classification of study households (cp = 0.02) and the tree was pruned accordingly (Fig. 3B). The CART classification tree indicates that both household level activities and village are important in determining livelihood dependencies by gender of the HH. The first node of the CART analysis classified members into sub-populations of households that engaged in 'Fishing' and those that did not. For those households where fishing was not identified, 'Village' separates the terminal nodes or subpopulations into Kazungula with primarily MHH from households, and villages in the Chobe Enclave with primarily female headed *de facto* households. Of those households that did fish, most were MHH. Owning chickens separated subpopulations or nodes with the terminal node, delineated by those households that collected wood for crafts (primarily MHH), from those that did not (primarily FHH *defacto*).

3.4. Ranked livelihood activities

When asked to report their most important livelihood activity (n = 169), 27% reported arable farming, 26% employment of a family member (including temporary jobs and drought relief), 13% reported livestock farming, 12% retail sales (sweets, pastries, clothing) and services (fencing, washing clothes etc.), and the remaining 22% related to other livelihood activities such as selling traditional beer and firewood, fishing, basketry, and receiving old age pensions. Village livelihood rankings were considerably different when examined at the village level (Fig. 4).

3.5. Participatory maps

Participatory maps were produced for each village and provide summary community landscape uses (Fig. 5). The finalized map is represented at a scale that will prevent the identification of the exact location of the resource. Kachikau (315 km^2) and Satau (239 km^2) used relatively larger areas than Mabele (60 km^2) and Kazungula (10 km^2), areas restricted by the river and limited availability of tribal land. Overlapping of livelihood activities by resource and village, specifically in the Chobe Enclave, are evident (Fig. 6, Table 3), with Parakarungu and Satau having the greatest overlap (112 km^2) of the villages, and Kachikau overlapping with the most villages (n = 4; Parakarungu 14 km^2, Satau 66 km^2, Kavimba 40 km^2, and Mabele/Muchenje 3 km^2).

4. Discussion

Households across study villages utilized a diverse portfolio of landscape resources which included both subsistence agriculture production and natural resource abstraction activities (Table 2). While grazing of livestock and firewood collection were spread more widely, most natural resource extraction sites were focused on the riparian floodplain areas (Figs. 4 and 5). Of survey households, Kazungula reported engaging in the lowest number of agricultural and natural resources abstraction activities. Kazungula sits on the eastern side of the National Park in an area that has been the focus of development for a considerable amount of time, in contrast to Chobe Enclave villages, which are only now beginning to be fully exploited for tourism opportunities. Kazungula is an important example of a transitioning urban center under developmental change with more recent surveys (2016) identifying that Kazungula residents still maintain important landscape dependencies more than ten years later (Joos-Vandewalle et al., 2018). Survey approaches and objectives were different, however, and results are not directly comparable. Differences in natural resource and agriculture based landscape use among Chobe Enclave villages located on the western side of the national park were not evident apart from Kavimba and Kachikau, and Kavimba and Parakarungu households (Table 2) which appear to relate to the location of these villages in respect of the river.

Cluster analysis provided an opportunity to evaluate how households separated into subpopulations based on selected variables (Fig. 3A) and provides insight into the level of variability among households within and across villages. Clusters within the generated dendrogram were not exclusively characterized by village (Fig. 3A) or headship (data not shown) but were rather mixed, suggesting that households landscape dependencies were not defined by these attributes but rather an interaction with other variables on land use in the data set. Clustering of households together across villages and headship, as for example seen with

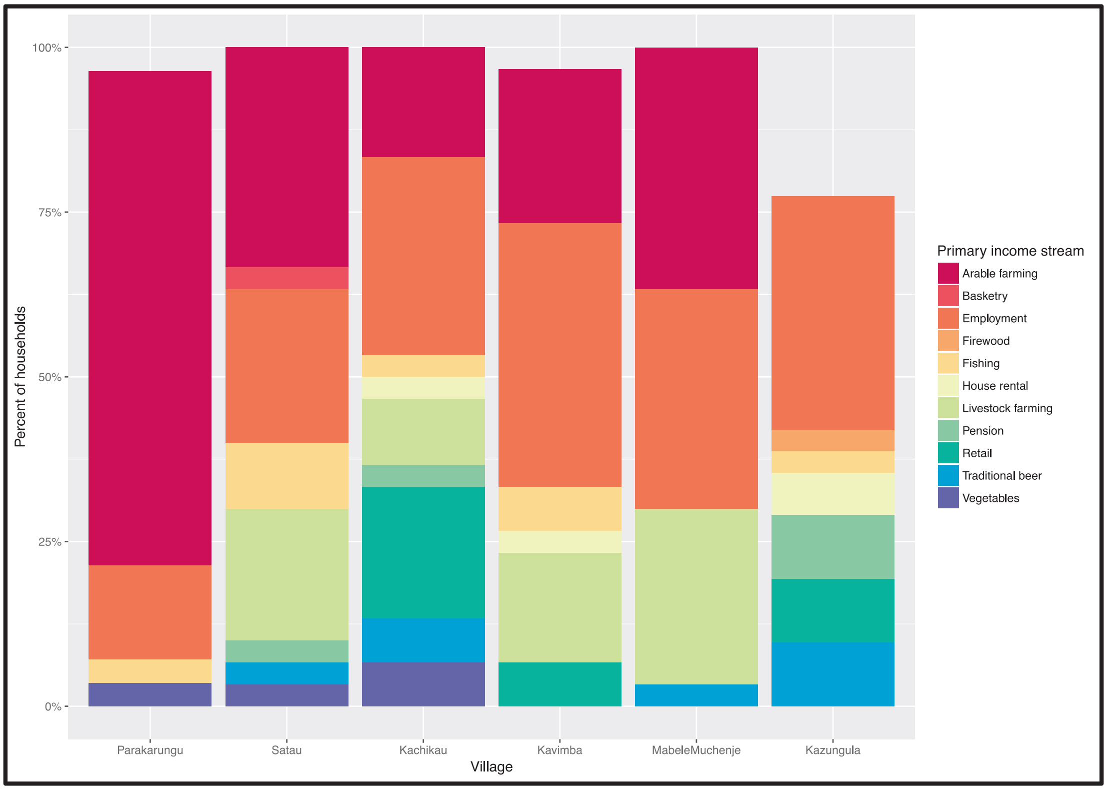

Fig. 4. Livelihood activities that were ranked first in importance to households interviewed by village in Northern Botswana.

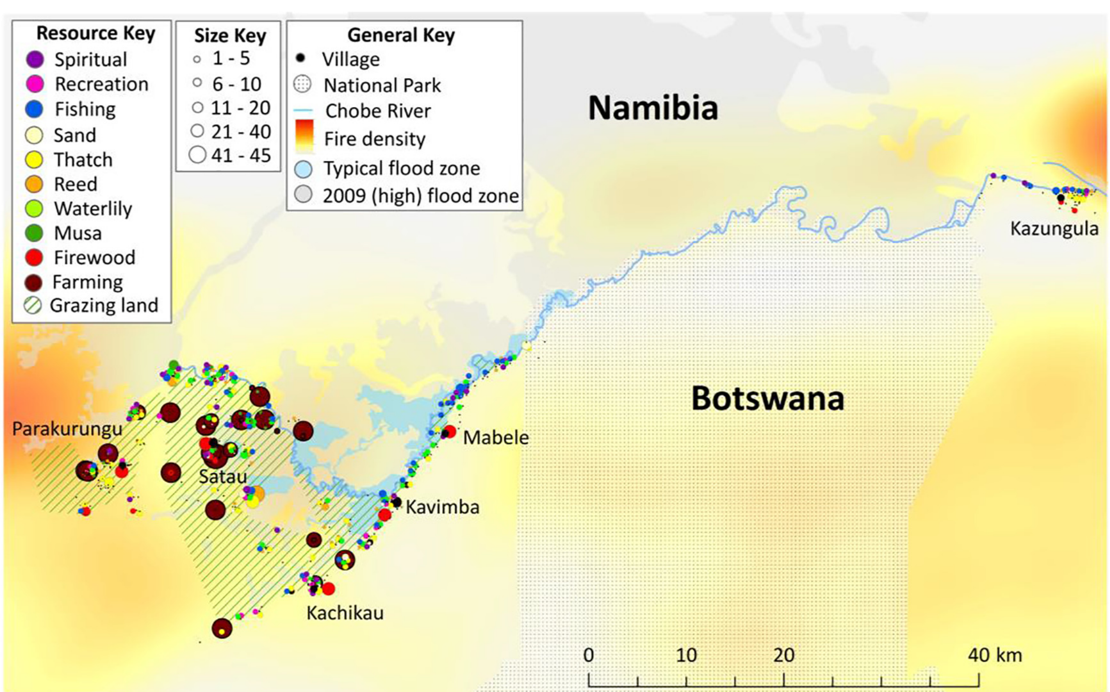

Fig. 5. Natural resource extraction locations, agricultural locations and cultural, spiritual, and recreational use by village in the Chobe District, Northern Botswana. Through household surveys and village meetings, local communities developed a spatially explicit land use map that incorporates merged landscape priorities. Key environmental features are noted including average fire frequency over the area (2004–2008) and flood extent.

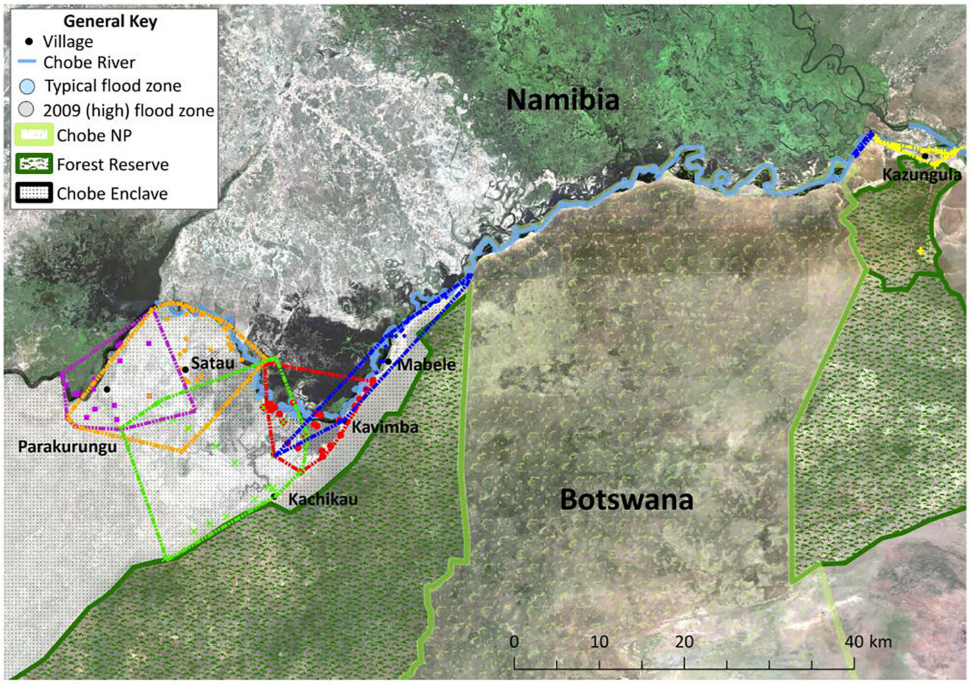

Fig. 6. Community utilization regions. Minimum convex polygons represent the reported area used by respective study villages. Kazungula and Mabele/Muchenje villages are restricted in area access with the river designating the international boundary and location of protected areas.

Table 3
Area (km^2) of resource use overlap for villages in the Chobe Enclave.

Parakarungu				
112 km^2	Satau			
14 km^2	66 km^2	Kachikau		
–	–	40 km^2	Kavimba	
–	–	3 km^2	27 km^2	Mabele/Muchenje

Mabele/Muchenje, $n = 11$, and Satau, $n = 3$ (Fig. 3A, blue cluster), suggests that important variation in landscape dependencies can occur at the household level that might be substantially different from the village of location and larger community profile, underscoring the utility of conducting household surveys before participatory mapping exercises.

We identified gender of headship as an important variable of interest in our analysis. Previous research has found significant differences in livelihood portfolios between MHH and FHH (Dolan, 2002) influencing gender determined access and control over resources (reviewed (Ngwenya et al., 2012)). In our study, FHH represented a significant portion of the survey population with equal number of male and female headed households, with the majority of FHH defined as *de Facto*. In the CART analysis, fishing was the most important predictor of headship of household in the classification tree, followed by chicken ownership, and collection of wood for the production of crafts (Fig. 3B). Village was the final variable at the leaf or terminal nodes. In this study, MHH dominantly reported fishing as a landscape activity. Studies conducted in the Okavango Delta in north-western Botswana identified important barriers to women fishers associated with development interventions as well as the regulatory framework (Ngwenya et al., 2012). In our study, many FHH indicated that they did not fish as they did not know how or felt it was a man's job. It is likely that there are multiple factors, including the environment, influencing the involvement of women in the fisheries sector in Chobe. As fish can be a critically important livelihood opportunity, further research is needed to understand gender dynamics in the fisheries sector and opportunities for addressing obstacles that might limit access for FHH in study villages. Of interest is the identification of Kazungula as a village separate from the Chobe Enclave villages that do not fish, again identifying the more unique nature of Kazungula as a transitioning urban center and the general perception that Kazungula and Kasane have lost access to the river due to development.

4.1. Approach evaluation

The hierarchical approach employed here provided a critical mechanism to limit the potential for power structures within the community to influence the participatory mapping process, increasing the breadth of information included in the maps. Surveys of households allowed for the collection of landscape use activities of family units and their spatial attributes unimpeded or controlled by power structures that might have limited information flow in a community-wide participatory setting. Taking maps created from anonymously sourced households through traditional leadership structures provided a further vetting and approval process that limited special interests from re-shaping or eliminating information in downstream participatory activities. In participatory mapping activities at the community level, effort was directed at adding and correcting rather than deleting information from the map, the latter in this approach would have been difficult to advance having been approved by the Kgosi and elders without substantive reasoning. This was seen as a critical element contributing to a more inclusive nature of the land use mapping exercise and minimizing the potential for individuals participating at the community level to have a disproportionate contribution to mapping outcomes.

On finalization, small portable maps were provided to the chief of each village with remote images of the land area and land use activities spatially detailed (transparencies with use overlaid on remote image background). This provided a mechanism for the Kgosi to use the information as the contact point for the community for both Government and other stakeholders. Given the lack of other material for visualizing natural resource needs in the region, the maps (and the information they contained) became an important focus of discussion among and within communities and other agents, including Governments. Large framed A0 size maps were also provided to the chief and were used for community discussions and planning at the village Kgotlas. Community-developed spatial data were later used in an integrated land use planning exercise for the Enclave (2016, BioChobe Project).

In Botswana, the critical strength of this approach was seen to be linked to cultural values where respect for others and community is seen as an important guiding principle of traditional Botswana society with individualism, in contrast, being frowned upon (Nhlekisana, 2017). A key Setswana proverb underlying this belief system states *motho ke motho ka batho* or 'a person is a person because of other people' (Nhlekisana, 2017). The developed maps in this study became a powerful record of inclusive community *agreement* on land needs that had potential to influence community responses to future developments, protecting the needs of more vulnerable sectors of a community.

4.2. Approach limitations

In order to safeguard access to natural resources and landscape use for marginalized groups, landscape requirements should be articulated and agreed upon *before* land allocation proposals are generated so they are not placed in competition with less lucrative and diffuse priorities that might exist among a subpopulation of households. Erosion of traditional values in the future may weaken the strength of this approach, reducing equity benefits in the process and limiting outcomes to simple community consultation and the collection of information on spatial land use. The political receptiveness of a government to community involvement and direction in the land planning process will also influence the impact of this approach.

Landscape dependencies can be influenced by spatial and temporal distribution and accessibility of landscape resources related to climate controls that can be driven by local and distant hydrometeorological conditions (flooding, rainfall etc.) (Fig. 5). In this study, respondents indicated that natural resources varied considerably in availability in both space and time because of the dynamic hydrological nature of the river floodplain system where the annual flood pulse influences system characteristics. Here, tropical rains in the highlands of Angola and Zambia influence the size and timing of the flood pulse, with temporal variation in the area of inundation can varying significantly across years as seen in 2000 where the flood covered only 401 km^2 in the Chobe River Basin in contrast to a larger flood year where the flood expanse covered more than fourteen times that area (5779 km^2 (Burke et al., 2016)). Variation in environmental conditions and the influence on land use should be considered when utilizing these products.

No matter how they are formulated, participatory products need to be integrated into the decision-making processes or they quickly become irrelevant to both the community and the land planning authority (Fraser et al., 2006). It becomes important to ensure that spatial data remains available for consideration in land planning exercises and that the data products can be used by community members as they individually and collectively advance land use in the area. This can be challenging. It is important to note maps may not represent all of the essential land areas and wide community consultation must be engaged to ensure inclusive input. The biggest challenge with the approach overall rests on ensuring that data are updated as needed (again through community consensus) to reflect correctly on the elements being evaluated.

5. Conclusion

Land planning can be a central influence on livelihood options in both urban and rural landscapes, requiring active engagement of communities in the land planning process in order to determine what land access is needed to maintain landscape derived household needs. Rapid development may undermine ecosystem service provisioning and limit community access, isolating vulnerable sectors of the community from essential resources. The approach described in this paper integrates traditional knowledge systems with technology, and advances the capacity of communities to negotiate landscape dependencies in the face of development in a manner that can be more inclusive, providing a voice for the more marginalized sectors of the community. This approach has limitations as it is time consuming, must be updated, and requires longer-term partnerships and political will between government, communities, and other non-state actors. This approach has the potential to contribute to the protection of community livelihoods by identifying agreement over necessary landscape assets and bringing this information forward into the development and land-planning dialogue.

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