Local perspectives on the spatio-temporal distribution of fish species in the Barotse Floodplain, Zambia

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MSc Thesis nr. T2212

November 2023

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Abstract

The worldwide trend of declining biodiversity is most severe in freshwater areas, under which floodplains. The Barotse floodplain (Zambia, Western Province) is a dynamic pulsating system that follows a natural disturbance regime which is induced by flooding. This disturbance pattern results in a spatio-temporal heterogeneity that promotes biotic productivity and diversity. In the Barotse, the indigenous Lozi-people depend on the floodplain for subsistence fisheries. The knowledge of local fisherfolk is invaluable when it comes to understanding and preserving floodplain areas. Therefore, the research question was: How do artisanal local fishermen perceive the spatio-temporal distribution of fish in the Barotse floodplain, Zambia? Objectives of this research were to systematically explore the knowledge of local fishermen, and to set up a habitat mapping, as covered by the following sub questions: (1) What habitats do fishermen distinguish and how can they be characterised? (2) Which fish species and life stages do fishermen distinguish and how does this relate to scientific distinctions? and (3) Where and when do fishermen find these fish species? Answers to these questions were explored by means of fourteen interviews with local fishermen on three different locations, participatory mapping exercises with community members (fishers and traders; men and women) on three different locations, and habitat surveys on 39 sample sites, exploring 31 environmental variables. A list with 37 local names of fish species was composed. The interviews resulted in an overview of migration times of 24 fish species, and five participatory maps were created. Results of the habitat surveys were exploratively analysed in R, producing a dendrogram and a NMDS-plot. The following conclusions were reached: (1) No clear clustering can be made based on the collected habitat data. (2) Local people distinguish at least 36 different fish species. (3) There is widespread local knowledge on the spatio-temporal migration patterns of at least 24 of those fish species. (4) Local people distinguish five types of habitats: floodplain, dam, lake, river and tributary. Recommendations for future research are amongst others: more interviews on different locations, additional participatory mappings with help of an assistant on top of the moderator and more habitat data, especially in different seasons.

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Introduction

Worldwide there is a trend of declining biodiversity (e.g. Dudgeon et al., 2006; Hooper et al., 2005; Rockström et al., 2009). This decline is the most serious in freshwater ecosystems, such as rivers and floodplains (e.g. Dudgeon et al., 2006; Harrison et al., 2018; Reid et al., 2019; Sala et al., 2000). Floodplains are dynamic pulsating systems, meaning that wet and dry phases alternate each other (Mosepele et al., 2022; Ward, 1998; Ward & Stanford, 1995a). This alternation of wet and dry phases promotes biotic productivity and diversity (Ward & Stanford, 1995a). The dynamics in the floodplain follow a natural disturbance regime which is induced by flooding and results in spatio-temporal heterogeneity (Mosepele et al., 2022; Ward, 1998; Ward & Stanford, 1995a). Often floodplains are hotspots for biodiversity, due to this natural disturbance regime and the complex mosaic of dynamic freshwater habitats (Ward et al., 1999; Ward & Stanford, 1995b). Many fish species depend on the floodplains for their larval and juvenile stages and many depend on floods to migrate between the main river and the floodplains (Thorstad et al., 2001; van der Waal, 1996). Declines in fish biodiversity have been measured in floodplains over the past decades, most likely due to the disconnection and loss of floodplain habitats (e.g. Roni et al., 2006; Ward et al., 1999), mostly caused by anthropogenic actors (Ward et al., 1999). This has caused changes in the natural disturbance regime of floodplains (Pander et al., 2018), such as the disruption of both lateral and longitudinal connections (Junk et al., 1989 as cited in Pander et al., 2018). However, some floodplains are still in a (nearly) pristine state. One of them is the Barotse floodplain in Zambia (southern Africa).

The Barotse floodplain is located in the Western Province of Zambia (Figure 1). It is part of the Upper Zambezi, which reaches from the source in northwest Zambia to the Victoria Falls as lower boundary (Moore et al., 2007). The Zambezi river system is the largest in southern Africa, with the river having a length of 2,575 km (Nugent, 1990), a catchment area of 1.32 million km^2 (Moore et al., 2007; Nugent, 1990) and flowing through eight countries (Nugent, 1990). The Barotse floodplain itself is about 250 km long with a width of 30 km (Tweddle, 2010). It stretches from Lukulu in the north to the Ngonye Falls in the south (Moore et al., 2007). The water level of the Zambezi river fluctuates throughout the year due to fluctuations in the precipitation in the upper catchment area (Figure 2). The Zambezi system includes a mixture of conservation areas and areas with intense fisheries (Tweddle, 2010). In the Barotse, the peak of the fishing season is from June until October (receding water until the lowest level, before the rainy season starts again) and the species that are caught mostly are tilapiine Cichlidae, Mormyridae and Clariidae (Kaminski et al., 2020). Subsistence fisheries largely exploit the natural seasonal cycles on floodplains (Tweddle, 2010).

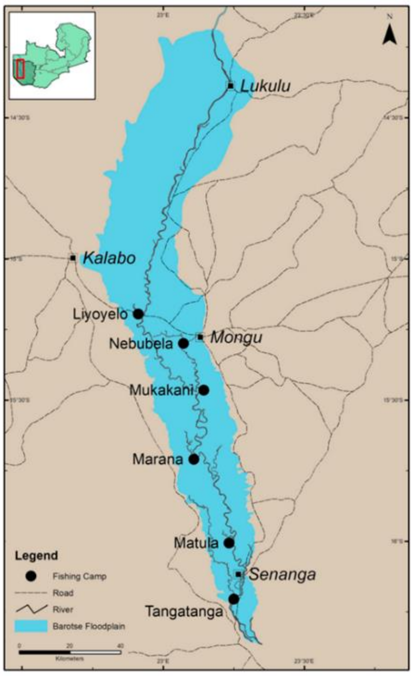

Figure 1: Map of the Barotse Floodplain with some villages indicated. Retrieved from Kaminski et al., 2020.

The inland fisheries in the Barotse are often small-scale, multi-species, multi-gear, highly dispersed and highly seasonal (Ainsworth et al., 2023; Bartley et al., 2015; Lynch et al., 2016). The majority of the catch is consumed on the floodplain by the local inhabitants and some of it is transported to Lusaka (Tweddle, 2010). The human population in the

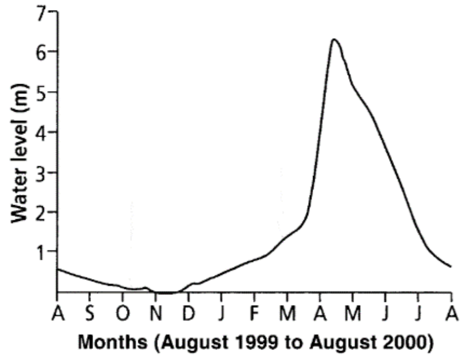

Figure 2: Water level in the Zambezi river. Modified from Thorstad et al., 2001.

region was already growing in 1996, leading to an increase in subsistence fishing in the Zambezi River (Hay et al., 1996). Since 1996 the population of Zambia has more than doubled (Ritchie et al., 2023), so it is likely that fishing pressure increased even more. This causes a threat to the system. There have been major management concerns about reports of reduced catches, mainly on the larger and valuable cichlids (MFMR, 1995 as cited in Thorstad et al., 2001). According to local fishermen, the perceived changes in climate also lead to a decline in fish production and catches (Muringai et al., 2022).

A previous study in Bangladesh found that local fisherfolk often have a lot of knowledge on the hydrology of the floodplain and small lakes, as well as on the habitat preferences of fish and the impact of human interventions on such ecosystems (Mamun, 2010). Therefore the knowledge of local fisherfolk is invaluable when it comes to understanding and preserving floodplain areas.

The aim of this study was to contribute to the understanding of the distribution, abundance and movements of the fish populations in the Barotse floodplain in relation to habitat characteristics and heterogeneity. This is of help for enhanced understanding of the natural functioning of the floodplain, which will support the development of guidelines for the conservation of this highly biodiverse area. Some research was already performed (Rennie et al., n.d.; Winemiller, 1991; Winemiller & Kelso-Winemiller, 1994), but much is still unknown so the understanding of the ecology of the Barotse floodplain was limited. The main objective of this study was to use local knowledge of artisanal fishermen[1] on spatio-temporal movement of different fish species. This novel approach was combined with a fishermen-independent grounding of the habitats in the Barotse. This resulted in the following research question:

How do artisanal local fishermen perceive the spatio-temporal distribution of fish in the Barotse floodplain, Zambia?

Objectives of this research were to systematically explore the knowledge of local fishermen, and to set up a habitat mapping, as covered by the following sub questions:

1. What habitats do fishermen distinguish and how can they be characterised?
2. Which fish species and life stages do fishermen distinguish and how does this relate to scientific distinctions?
3. Where and when do fishermen find these fish species?

[1] Since fishing is in principle considered to be a male activity in the Upper Zambezi region (Abbott & Campbell, 2009), from now on the word "fishermen" will be used.

Materials and methods

Study area

The research took place in the Barotse floodplain in the Western Province of Zambia (14°24'02.7"S - 16°12'29.9"S, 22°47'07.0"E - 23°18'33.1"E). The floodplain consists largely of treeless grassland and the Zambezi river flows through it (Winemiller, 1991). A road across the floodplain was constructed and completed in 2016 from Mongu via Lealui and Liyoyelo to Kalabo ("The Mongu-Kalabo Road Has Been Completed," 2016). The construction of this road may have influenced the natural disturbance regime of the floodplain to a small extent, based on visual observations of slightly different water levels on the north- and southside of the road, but it provided also an easy point of access into the floodplain.

The research was conducted from a WWF Zambia field office, located in Mongu (Figure 3). Since much of the area is hardly accessible -with exception of the Mongu-Kalabo road-, the places suitable to visit for data collection were limited. For the participatory mapping exercises and the interviews, I relied on the connections of WWF Zambia. They collaborated with several focus groups -groups of local people who are keen to participate with WWF Zambia for the aim of nature conservation- in the Barotse, so I interviewed fishermen from these focus groups. The participatory mapping exercises I conducted, were with three focus groups: Mongu harbour (15°16'21.6"S 23°07'12.2"E), Liyoyelo (15°11'36.8"S 22°54'50.2"E) and Lukanda (Situnga)(circa 16°01'00.3"S 23°19'35.4"E). The interviews I conducted, were in three series of four to five interviews in Lukanda (circa 16°01'00.3"S 23°19'35.4"E), Liyoyelo (15°11'36.8"S 22°54'50.2"E) and Lealui (15°13'35.2"S 23°01'15.6"E) with the help of a translator.

Figure 3: Satellite image of the Barotse Floodplain with indicated in yellow locations of interviews and in red locations for participatory mappings.

Before starting interviews and participatory mappings, it was essential to have a list with fish species in Lozi, the local language. This enabled more fluent communication and allowed the translator not to translate any of the fish species, since translating all those species accurately would have been a major challenge -if not impossible- to him or her. I took the internal "technical report nr 1" of WWF as a starting point, since this report describes the known fish species of the Upper Zambezi (Barotse and Kabompo area), and it includes pictures of almost every fish mentioned in this report (Rennie et al., n.d.). Then I went into a community (Liyoyelo), where I asked four people to help me identify the fish in Lozi. On purpose, I asked two men and two women to help me, since they most likely use different methods to fish, which could result in different fish species observed and known (Abbott & Campbell, 2009). Subsequently this list with the Lozi names and pictures was used as a base during the interviews and mappings. To check the found names, participants in Lukanda were asked to correct any possible mistakes and add missing names if known, during the first mapping exercise after the composition of the list.

1) Fishermen's perceptions through interviews and mapping

Materials used for this part of the research were: Panasonic Lumix DC-TZ90 camera (Manufactured by: Panasonic Corporation, Kadoma, Osaka, Japan; Importer for Europe: Panasonic Marketing Europe GmbH, Panasonic Testing Centre, Winsbergring 15, 22525 Hamburg, Germany), flipchart paper and pens and the smartphone application "Voice Recorder" (Version 3.23 released by Splend Apps).

Semi-structured interviews -a qualitative approach of collecting data through interviews, based on a pre-conceived interview guide (Bryman, 2006; Young et al., 2018)- with fishermen were carried out to gain insight into their perception of the (fish)habitats and life cycles of fish species in the area. It was important to talk to fishermen in the field, where I expected more reliable and elaborate answers than when talking to them in an office. Concerning language, it was preferred to work with a translator (to whom Lozi was the mother tongue and English the second language), and let the interviewees respond in Lozi, their mother tongue. This enabled every fisherman to participate as well as to give more detailed answers. Next to that, I also conducted a participatory mapping exercise. Participatory mapping is an exercise in which community members participate together to communicate their local knowledge on a certain topic; it enables communities to articulate their spatial knowledge to external agencies (IFAD, 2009). It remains important to be aware of the fact that not all indigenous knowledge can or will be transferred via mapping. Much of the knowledge is transferred through proverbs, stories, songs and dances, etc. (IFAD, 2009). In collaboration with WWF Zambia, I organised three sessions in which five to ten fishermen and fish traders of the community were invited and encouraged to draw a map on what species were found where and in what season. Discussion was allowed and encouraged, because in the end this could lead to consensus and a lot of information from the indigenous knowledge perspective. In return for their participation and time, all participants received a refreshment and a snack after the interview or mapping exercise.

Methodology for the interviews was as follows (Figure 4):

1. WWF assisted me to find a translator and interviewee, since they have many connections in the area.
2. Each interview started with local greetings and brief introduction of the aim of the study. It was culturally important to do so.
3. Subsequently, the interviewee was asked to complete the consent form and ask permission to record the interview, so in case of an unclear translation or other doubts, another speaker of the local language could relisten and translate what had been said.
4. The interviews were semi-structured. This allowed the respondents to tell their story, and avoided bias from the questionnaire. A checklist with key topics to be covered during the interview was made, and the interviewer made sure that those issues were addressed during the interview. To guide the interview, questions were formulated in a questionnaire as well (Appendix I).
5. Starting questions included: age of fisher, years of experience, fishing methods used and areas/localities fished (over the past year, over his lifetime fishing).

6. Key issues were questions about what fish is found where in the floodplain - aiming for answers on habitats rather than exact location- in what time of the year and when movement of the fish towards different habitats took place.
7. The interviewee was thanked for cooperation, and received a refreshment in return.
8. In total four to five fishermen were interviewed on each location, because with that number a consistent picture of the local situation can be acquired, and more interviews will hardly retrieve any new information. This is a process called data saturation: new collected data will repeat what was already collected in previous data (Morse, 1995 as cited in Saunders et al., 2018).

Figure 4: Interview in progress, with an interviewee, interviewer and translator.

The methodology for the participatory mapping evaluated during the research. The final and best set-up was as follows:

1. Greet the participating people and explain the aim of the research and the exercise they were going to perform. Allow participants to introduce themselves as well.
2. Encourage the participants to draw a map of how they view the area (Figure 5). I found out that with a large group it was helpful to split the group and ask half of the group to draw the *muunda* situation (flood, February-April) and the other half the *mbumbi* situation (low water, August-October). The participants drew the map together, I did not start or give examples.
3. A list with fish species in Lozi was provided, and participants were encouraged to place as many fish species as they knew in the map. Sometimes this led to discussion among the participants, which was fine. After they agreed upon the information, it was added to the map.
4. Participants were asked to draw arrows with numbers to indicate the order of the fish moving out of the river into the floodplain or vice versa.
5. Afterwards a short wrap-up was done, to let participants explain what they had drawn and why, and all participants were thanked for their cooperation and received some refreshments in return.

Figure 5: Participatory mapping in progress.

2) Habitat surveys

Materials used for this part of the research were: Olympus Tough TG-820 camera (Olympus Imaging Corp., Shinjuku Monolith, 3-1 Nishi-Shinjuku 2-chome, Shinjuku-ku, Tokyo, Japan; Olympus Europa Holding GmbH, Wendenstrasse 14-18, 20097 Hamburg, Germany), measuring tape on a stick, and the smartphone application "KoboCollect" (v2023.1.2; "KoboCollect" is part of Kobo Toolbox and based on ODK Collect).

To investigate the habitats, a protocol with a quick habitat survey was set up in a Kobo toolbox form. This encompassed a questionnaire with questions about the location (GPS), types of habitat, water width and depth estimations, turbidity, flow, riparian vegetation, land use activity (within 500m), connectivity. Also pictures were taken during the survey, to capture the human perspective of different habitats. Additional to the Kobo-form, pictures were taken with a camera for higher resolution and the option of taking underwater pictures to capture the fish perspective as well. The questionnaire was set up in an online Kobo toolbox form, which allowed for offline collection of data in the field. Different ways of access to the floodplain were used: on 14 June and 11 July 2023, the floodplain was accessed by car and all points of data collection were within walking distance with a maximum water depth of knee height from the road. On 23 June 2023, a boat was used to access the floodplain, so data collection sites were further apart and typically with deeper water. Once within the network again, all the forms were submitted to a central server. Here, all forms (possibly from different accounts and devices) were collected and stored in one place. The data were downloaded to an Excel file for further analysis. While performing the habitat surveys in the field, I came across minor bugs in the form that could be and were improved. Now this form is future-proof, and the use can be continued for future data collection on habitats. The most recent version of the questionnaire can be found in the appendix (Appendix III).

In addition an attempt was made to create a general overview of the area, coupled with satellite images and changes over time, especially concerning the receding water level. This turned out to be beyond the scope of this thesis, but a (preliminary) methodology has been set up and is included in the appendix (Appendix IV).

3) Data processing

The interviews were transcribed. Although software was available to transcribe audio-recordings automatically, the decision was made to transcribe them manually, because that allowed to dive deeper into the material, and start processing and comparing while transcribing. After completing all transcriptions, a table was set up in Excel for the fish species and their habitats of residence as well as the months they moved to another habitat, according to the interviewees. This table enabled comparison of the results and statements of different fishers. Subsequently a qualitative comparison of those results to the outcomes of the participatory mappings was performed.

The habitat data from KoboCollect was put in an Excel file. First all data was made numerical. This was achieved by creating a 0/1 matrix for all variables. In case of ordinal values, an ascending number was given (e.g. for *Flow*: *no, little, moderate* and *much* were given the values 0, 1, 2, 3 respectively). Gaps in the data file occurred for *water depth*, due to the water being too deep to be measured. This was corrected by filling in 500 cm, which was ample twice the highest value measured.

This cleaned dataset was analysed exploratively, by a cluster analysis to learn about the structure of the dataset. The cluster analysis grouped objects that are more similar to each other in one group called a cluster (Hahsler, 2021). First the correlations of the variables were checked with corrplot (Wei & Simko, 2017). Parameter settings were: cor_vars1, method="pie", col=colour1(10), type="lower", outline=TRUE, tl.cex=0.7, tl.col="black", diag = F, cl.pos = "b", cl.align.text="c", cl.ratio=0.2, cl.length=11, mar = c(0,0,0,0). Subsequently a non-hierarchical way of clustering was explored, the Non-Metric Dimensional Scaling (NMDS), using the package vegan (Oksanen et al., 2022). NMDS is a type of Principle Component Analysis (PCA), which aims to show which variables explain the most variance within a dataset. NMDS is based on a distance matrix of the Euclidean distances between items, and the location of each item in the low-dimensional space. Parameter settings were kept in default. This resulted in a NMDS-plot. Subsequently, a hierarchical approach was explored. A dendrogram was produced, using the package pvclust (Suzuki & Shimodaira, 2015). Parameter settings were: distance method bray-curtis with 3 degrees of freedom (vegdist(df3, “bray”)); agglomerative hierarchical clustering (hclust(method=”ward.D2”)); for the clusters, the tree was cut on height 0.8 (cutree(hc, h=0.8)) and the maximum amount of clusters for this cut was displayed (nclust <- max(clusters)). These cluster numbers were added to point coordinates and centroids were calculated for the clusters in the NMDS-plot. A selection of variables was made, to only show the five most determining variables in the final plot. Lastly, the NMDS-plot was visualised again with ggscatter, now with the samples coloured according to the clusters of pvclust and the centroids and most-determining variables added.

The entire analysis was performed in R-4.2.1 (R Core Team, 2022). The R packages ggplot2 (Wickham, 2016), ggpubr (Kassambara, 2018), tidyverse (Wickham et al., 2019) and vegan (Oksanen et al., 2022) were used in order to plot, edit and explore data. Correlations and clustering were performed with corrplot (Wei & Simko, 2017) and pvclust (Suzuki & Shimodaira, 2015). Packages factoextra (Kassambara & Mundt, 2017) and ggrepel (Slowikowski, 2018) helped visualisation of PC.

Results

1) Fishermen’s perceptions through interviews

The first result obtained was the list with Lozi translations of fish names (Appendix II). With this list as a base, I managed to interview fourteen fishermen in three different locations. During the interviews, 34 different fish species were discussed. Due to the same local names being used for different taxonomic species, this corresponds to 47 scientifically described species (Table 1). In some cases, more Lozi names were given to the same species. In the case of *Hydrocynus vittatus* (tiger fish) this is an important cultural distinction between small and large specimens of this species – *ngwelele* and *ngweshi*. In all other species, names are used interchangeably.

Table 1: Lozi names of fish species of the Barotse and the frequency at which they were mentioned during interviews. Interviews were conducted on three locations: Situnga, Liyoyelo and Lealui. In light grey double names, corresponding numbers are also light grey and are not added to calculate the total.

Lozi	Family	Scientific	English	Situnga	Liyoyelo	Lealui	Total
kenga	Cyprinidae	*Enteromius barotseensis*	Barotse barb	0	0	4	**4**
kenga	Cyprinidae	*Enteromius paludinosus*	Straightfin barb	0	0	4	4
kokwe	Clariidae	*Clarias gariepinus*	Sharptooth catfish	0	2	2	**4**
likishi	Cichlidae	*Serranochromis thumbergi*	Brown-spotted bream	0	4	2	**6**
likumbwa	Cichlidae	*Sargochromis codringtonii*	Dusky bream	2	4	4	**10**
linyonga	Cyprinidae	*Labeo cylindricus*	Redeye labeo	1	4	1	**6**
linyonga	Cyprinidae	*Labeo lunatus*	Upper Zambezi labeo	1	4	1	6
lituta	Cichlidae	*Pseudocrenilabrus philander*	Southern mouthbrooder	1	2	2	**5**
liulungu	Cichlidae	*Hemichromis elongatus*	Banded jewelfish	1	4	5	**10**
liveko	Mormyridae	*Hippopotamyrus asorgii*	Slender stonebasher	0	1	2	**3**
liveko	Mormyridae	*Hippopotamyrus szaboi*	Upper Zambezi mormyrid	0	1	2	3
liveko	Mormyridae	*Petrocephalus longicapitis*	Long-head churchill	0	1	2	3
liwetete	Clariidae	*Clarias stappersii*	Blotched catfish	0	1	3	**4**
lubango	Schilbeidae	*Schilbe intermedius*	Butter barbel	1	3	4	**8**
lubango	Schilbeidae	*Schilbe yangambianus*	Yangambi butterbarbel	1	3	4	8
mamunyandi	Cichlidae	*Serranochromis angusticeps*	Thinface largemouth	4	4	5	**13**
mbaala	Alestiidae	*Brycinus lateralis*	Striped robber	2	2	4	**8**
mbaala	Cyprinidae	*Enteromius afrovernayi*	Spottail barb	2	2	4	8
mbaala	Cyprinidae	*Enteromius poechii*	Dashtail barb	2	2	4	8
mbanda	Cichlidae	*Pharyngochromis acuticeps*	Zambezi happy	1	4	3	**8**
mbufu	Cichlidae	*Coptodon rendalli*	Redbreast tilapia	4	5	5	**14**
mbuma	Cichlidae	*Sargochromis carlottae*	Rainbow bream	3	4	5	**12**
mbundu	Anabantidae	*Ctenopoma multispine*	Many-spined climbing perch	2	4	3	**9**
minga	Clariidae	*Clariallabes platyprosopos*	Broadhead catfish	0	2	3	**5**
mulumeshi	Hepsetidae	*Hepsetus cuvieri*	African pike	1	4	4	**9**
mushuna	Cichlidae	*Serranochromis altus*	Humpback largemouth	3	4	4	**11**
musuta	Anabantidae	*Microctenopoma intermedium*	Blackspot climbing perch	0	0	0	**0**
mutome	Mastacembelic	*Mastacembelus frenatus*	Longtail spiny eel	0	0	0	**0**
mutome	Mastacembelic	*Mastacembelus vanderwaali*	Ocellated spiny eel	0	0	0	0
muu	Cichlidae	*Oreochromis macrochir*	Greenhead tilapia	3	5	3	**11**
nchelele	Cyprinidae	*Enteromius barnardi*	Blackback barb	0	0	3	**3**
nchelele	Cyprinidae	*Enteromius eutaenia*	Orangefin barb	0	0	3	3
nchelele	Alestiidae	*Micralestes acutidens*	Silver robber	0	0	3	3
ndikusi	Mormyridae	*Mormyrus lacerda*	Western bottlenose	2	5	3	**10**
ndombe	Clariidae	*Clarias ngamensis*	Bluntooth catfish	2	2	4	**8**
nembele	Mormyridae	*Marcusenius altisambesi*	Bulldog	2	3	3	**8**
nembwe	Cichlidae	*Serranochromis robustus jallae*	Nembwe	2	5	3	**10**
ngwelele	Alestiidae	*Hydrocynus vittatus (small)*	Tigerfish (small)	0	0	0	**0**
ngweshi	Alestiidae	*Hydrocynus vittatus (large)*	Tigerfish (large)	2	4	4	**10**
ninga	Mormyridae	*Cyphomyrus cubangensis*	Parrotfish	0	1	1	**2**
njenga	Cichlidae	*Serranochromis macrocephalus*	Purpleface largemouth	1	5	4	**10**
njinji	Cichlidae	*Oreochromis andersonii*	Threespot Tilapia	4	5	3	**12**
pepe	Mormyridae	*Petrocephalus okavangoensis*	Okavango churchill	2	0	1	**3**
pepe	Mormyridae	*Pollimyrus marianne*	Zambezi dwarf stonebasher	2	0	1	3
seo	Cichlidae	*Sargochromis giardi*	Pink bream	3	4	4	**11**
seo	Cichlidae	*Sargochromis sp. "dusky bream"*		3	4	4	11
singongi	Mochokidae	*Synodontis nigromaculatus*	Spotted squeaker	2	3	4	**9**
situhu	Cichlidae	*Tilapia ruweti*	Okavango tilapia	1	4	5	**10**
situhu	Cichlidae	*Tilapia sparrmanii*	Banded tilapia	1	4	5	10
siwanya	Amphiliidae	*Amphilius uranoscopus*	Stargazer mountain catfish	0	2	1	**3**
siwanya	Claroteidae	*Parauchenoglanis ngamensis*	Zambezi grunter	0	2	1	3
				52	**106**	**111**	**269**

During interviews, different habitat types were discussed with the fishermen. The concept "habitat" turned out to be a complicated one to discuss and to ask for, since it is such an abstract concept. In interviews only *river, dam, lake* and *floodplain* were mentioned (Table 2).

Table 2: Habitat definitions from interviews.

Habitat	Definition
River	Zambezi; large natural stream of flowing water
Lake	Natural waterbody
Dam	Man-made lake/waterbody
Floodplain	Flooded plain

Some fish species were mentioned by thirteen or fourteen out of fourteen fishermen, whereas others were only mentioned by three or four of the interviewees. For most fish species (24 out of 34 discussed species), there is consensus between the interviewees that all those fish species move between river, lakes or dams and the floodplain. If months are mentioned, the fish mainly migrate out of the river, lakes or dams towards the floodplain between December and February, with the peak in January. There is no clear order of movement that can be derived from the interviews (Table 3). Fish species for which there is disagreement on the movement are: *likumbwa, mamunyandi, mbufu, mbuma, mushuna, muu, ngweshi, njenga, njinji* and *seo*. These fish belong all to the family of Cichlidae, except for *ngweshi*, which is an Alestiidae.

Ngweshi -*H.vittatus*- is an exception, since it is the only non-cichlid on which there is disagreement on its movement. *Ngweshi*, the large specimens of the species, is a totem[2] animal, which has an important position in traditional Lozi culture. Traditionally, *ngweshi* is only eaten by the Lozi-king. In interviews, we discussed *ngweshi*, but from which length onwards a specimen is called *ngweshi* and not *ngwelele* anymore, remained unclear.

For all other species on which there is disagreement between the interviewees, it is interesting to see that the interviewees that mentioned that the species do not move out of the river into the floodplain were interviewed in Lukanda[3] and all those fish species belong to the family of Cichlidae.

There is a larger spread in the months mentioned for the species to return from the floodplain to the river, lakes or dams. It is variable for the different species, but some start returning as early as March according to one interviewee, and some return as late as September and October according to another interviewee. For some species the return dates that are mentioned, are really concise. For *likishi, likumbwa, mamunyandi, mbuma, mushuna, nembwe, njenga* and *seo* (all Cichlidae) only May and June are mentioned by at least four different interviewees. For the return date it is also not possible to derive a clear order of movement of the different fish species from the interviews. In Table 3 can be seen that according to most interviewees all fish species migrate in January towards the floodplain and in June towards the river.

[2] "Totemism is the belief that human beings and animals or plants have a spiritual connection and respect each other." (Kelbessa, 2022)
[3] Note: the interviews and mapping were conducted in Lukanda, but the people came from the community of Situnga, which is located 5 to 10 km upstream.

Table 3: Movement of the different fish species according to interviewed fishermen in the Barotse. Note: "towards river" should be read as "towards river, dam or lake" but it was shortened for the sake of readability. Only statements of fishers including the months are included in this table, the total number of fishers mentioning specific months for the migration is stated on the right.

		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	#fishers
kenga	towards floodplain	0	0	1	0	0	0	0	0	0	0	0	0	**1**
	towards river	0	0	0	0	0	1	1	0	0	0	0	0	**1**
kokwe	towards floodplain	1	2	2	0	0	0	0	0	0	0	0	0	**3**
	towards river	0	0	0	0	1	1	2	1	0	0	0	0	**2**
likishi	towards floodplain	2	3	1	0	0	0	0	0	0	0	0	0	**4**
	towards river	0	0	0	0	0	1	3	0	0	0	0	0	**3**
likumbwa	towards floodplain	1	5	1	0	0	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	0	3	3	0	0	0	0	0	**5**
linyonga	towards floodplain	2	4	2	0	0	0	0	0	0	0	0	0	**4**
	towards river	0	0	0	0	0	2	4	1	0	0	0	0	**4**
lituta	towards floodplain	1	1	1	0	0	0	0	0	0	0	0	0	**2**
	towards river	0	0	0	0	0	1	2	0	1	1	1	0	**3**
liulungu	towards floodplain	2	3	2	1	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	1	1	4	1	1	1	1	0	**6**
liveko	towards floodplain	1	2	1	0	0	0	0	0	0	0	0	0	**2**
	towards river	0	0	0	0	0	0	1	1	0	0	0	0	**1**
liwetete	towards floodplain	0	2	1	0	0	0	0	0	0	0	0	0	**3**
	towards river	0	0	0	0	0	1	1	0	1	0	0	0	**3**
lubango	towards floodplain	2	4	4	0	0	0	0	0	0	0	0	0	**4**
	towards river	0	0	0	1	2	3	6	1	0	0	0	0	**7**
mamunyandi	towards floodplain	1	5	2	1	0	0	0	0	0	0	0	0	**7**
	towards river	0	0	0	0	0	3	4	0	0	0	0	0	**6**
mbaala	towards floodplain	2	3	1	0	0	0	0	0	0	0	0	0	**4**
	towards river	0	0	0	0	0	3	4	1	0	0	0	0	**4**
mbanda	towards floodplain	2	3	2	0	0	0	0	0	0	0	0	0	**4**
	towards river	0	0	0	0	0	1	4	1	1	1	1	0	**5**
mbufu	towards floodplain	2	4	3	0	0	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	0	2	4	1	1	1	1	0	**6**
mbuma	towards floodplain	1	5	2	1	0	0	0	0	0	0	0	0	**7**
	towards river	0	0	0	0	0	3	4	0	0	0	0	0	**6**
mbundu	towards floodplain	2	3	0	0	0	0	0	0	0	0	0	0	**4**
	towards river	0	0	0	0	0	0	2	0	1	0	0	0	**3**
minga	towards floodplain	1	2	2	0	0	0	0	0	0	0	0	0	**3**
	towards river	0	0	0	0	1	1	2	1	0	0	0	0	**2**
mulumeshi	towards floodplain	1	4	3	1	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	1	2	5	1	0	0	0	0	**6**
mushuna	towards floodplain	1	5	1	0	0	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	0	3	3	0	0	0	0	0	**5**
musuta	towards floodplain	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
mutome	towards floodplain	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
muu	towards floodplain	2	4	2	0	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	0	3	4	1	1	1	1	0	**6**
nchelele	towards floodplain	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
ndikusi	towards floodplain	3	4	3	0	0	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	0	2	4	1	0	0	0	0	**5**
ndombe	towards floodplain	1	3	2	0	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	0	2	3	1	1	0	0	0	**5**
nembele	towards floodplain	2	3	2	0	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	0	1	3	1	0	0	0	0	**4**
nembwe	towards floodplain	2	3	1	1	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	0	2	4	0	0	0	0	0	**4**
ngwelele	towards floodplain	0	0	0	0	0	0	0	0	0	0	0	0	**0**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
ngweshi	towards floodplain	0	0	0	1	0	0	0	0	0	0	0	0	**1**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
ninga	towards floodplain	0	1	0	0	0	0	0	0	0	0	0	0	**1**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
njenga	towards floodplain	2	3	1	1	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	0	2	4	0	0	0	0	0	**4**
njinji	towards floodplain	2	4	2	0	0	0	0	0	0	0	0	0	**5**
	towards river	0	0	0	0	0	2	4	1	1	1	1	0	**6**
pepe	towards floodplain	0	1	0	0	0	0	0	0	0	0	0	0	**1**
	towards river	0	0	0	0	0	0	0	0	0	0	0	0	**0**
seo	towards floodplain	1	5	1	0	0	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	0	3	3	0	0	0	0	0	**5**
singongi	towards floodplain	2	2	1	0	1	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	1	2	4	1	1	0	0	0	**6**
situhu	towards floodplain	2	4	1	1	0	0	0	0	0	0	0	0	**6**
	towards river	0	0	0	0	0	1	4	0	0	0	0	0	**4**
siwanya	towards floodplain	1	1	1	0	0	0	0	0	0	0	0	0	**2**
	towards river	0	0	0	0	1	1	2	0	0	0	0	0	**2**

Lozi fish names collected during this research were compared to Lozi names found in literature. Not many species have been identified in Lozi. The Lozi names mentioned in the literature are summarised in Table 4. In the majority of the cases (eight out of twelve), the Lozi name used in the literature is in accordance with the names that were found during this study, although sometimes with a different spelling. However, for four species there is disagreement. A possibility is that the research of the mentioned papers took place in a different part of the Barotse. It is a vast area and even within the Lozi-language there are multiple sublanguages and people speaking the different varieties of Lozi are not always able to understand each other (Mutemwa, 2023, personal communication). On two of the names for which I indicated that there is agreement, this agreement is for the translation of the English common name to Lozi, not for the scientific name. This is the case for "mulomezi" and "ngweshi".

When looking at the scientific names, the species names used by Winemiller (1994), differ from the names retrieved from the technical report nr. 1 (Rennie et al., n.d.) which was used as a base for the species list in this study (Appendix II). It concerns the African pike, *Hepsetus odoe* according to Winemiller, but according to Fishbase (Froese & Pauly, 2023), this was a misidentification in Zambia, and *H. odoe* does not occur in Zambia (Froese & Pauly, 2023). This should be changed to *Hepsetus cuvieri* which does occur in Zambia (Froese & Pauly, 2023; Rennie et al., n.d.). For tigerfish the difference between the scientific species names is not so easy to solve, since both *Hydrocynus forskahlii* and *H. vittatus* occur in Zambia (Froese & Pauly, 2023). However, the two species have a very similar appearance except for the elongated body shape of *H. forskahlii*. Hence, it is assumed that if the two species occur both in the Barotse floodplain -which is not certain-they are both called "ngweshi".

Table 4: Lozi fish names as mentioned in available literature compared to the findings of this study.

Reference	**Lozi**	**English**	**Scientific**	**Note**
(Kaminski et al., 2020)	Ndombe	-	*Clarias* spp.	Consistent with my findings
(Kaminski et al., 2020)	Nembele	Small mormyrids	e.g. *Marcusenius altisambezi*	Consistent with my findings
(Kaminski et al., 2020)	Lipapati	Tilapia species	-	Inconsistent; unknown how to solve, I found situhu for *Tilapia spp.*
(Winemiller & Kelso-Winemiller, 1994)	Mulomezi	African pike	*Hepsetus odoe*	Consistent with my findings on the English common name, though spelled differently: mulumeshi. Scientific name different: *H.cuvieri*
(Winemiller & Kelso-Winemiller, 1994)	Ngweshi	Tigerfish	*Hydrocynus forskahlii*	Consistent with my findings on the English common name. Scientific name different: *H.vittatus*
(Winemiller, 1991)	Nembwe	Yellow bream	*Serranochromis robustus*	Consistent with my findings

(Winemiller, 1991)	Mununga	Brown-spot bream	*Serranochromis thumbergi*	Inconsistent; I found likishi
(Winemiller, 1991)	Njenja	Purple-headed bream	*Serranochromis macrocephalus*	Consistent with my findings, though spelled differently: njenga
(Winemiller, 1991)	Mushuna	Thin-faced bream	*Serranochromis angusticeps*	Inconsistent: I found mamunyandi for *S. angusticeps* and mushuna for *S.altus* / Humpback largemouth
(Winemiller, 1991)	Syeo	Pink bream	*Sargochromis giardia*	Consistent with my findings, though spelled differently: seo
(Winemiller, 1991)	Mbuma	Rainbow bream	*Sargochromis carlottae*	Consistent with my findings
(Winemiller, 1991)	Syeo	Green bream	*Sargochromis codringtoni*	Inconsistent: I found likumbwa

2) Local people's perceptions through participatory mapping

The participatory mappings gave useful additional insights. The way the mapping exercise was performed, evolved during the process. Participants were fishers and fish traders in focus groups of WWF. The first mapping exercise in Mongu harbour, mainly generated insight into the difference between the low-water and flood seasons (Supplementary Figures 1 and 2, in Appendix V). The second mapping in Liyoyelo resulted in a detailed geographical overview of different habitat types. On this map, more different habitat types were mentioned than during the interviews. Drawn were: the Zambezi river (*nuka*), the Little Zambezi (*kanukana*), dams (*likisi*), lukungu lake (*lisa*) and a tributary (*siko* in Lozi) (Figure 6). For the dry season, all fish species were put into the specific areas where they are typically found. The third mapping in Lukanda[4] resulted in two maps, one during flood and one during low water (Figure 7 and Supplementary Figure 3 in Appendix V). Here participants drew arrows with numbers to indicate the order of migration of the different fish species.

[4] Note: the interviews and mapping were conducted in Lukanda, but the people came from the community of Situnga, which is located 5 to 10 km upstream.

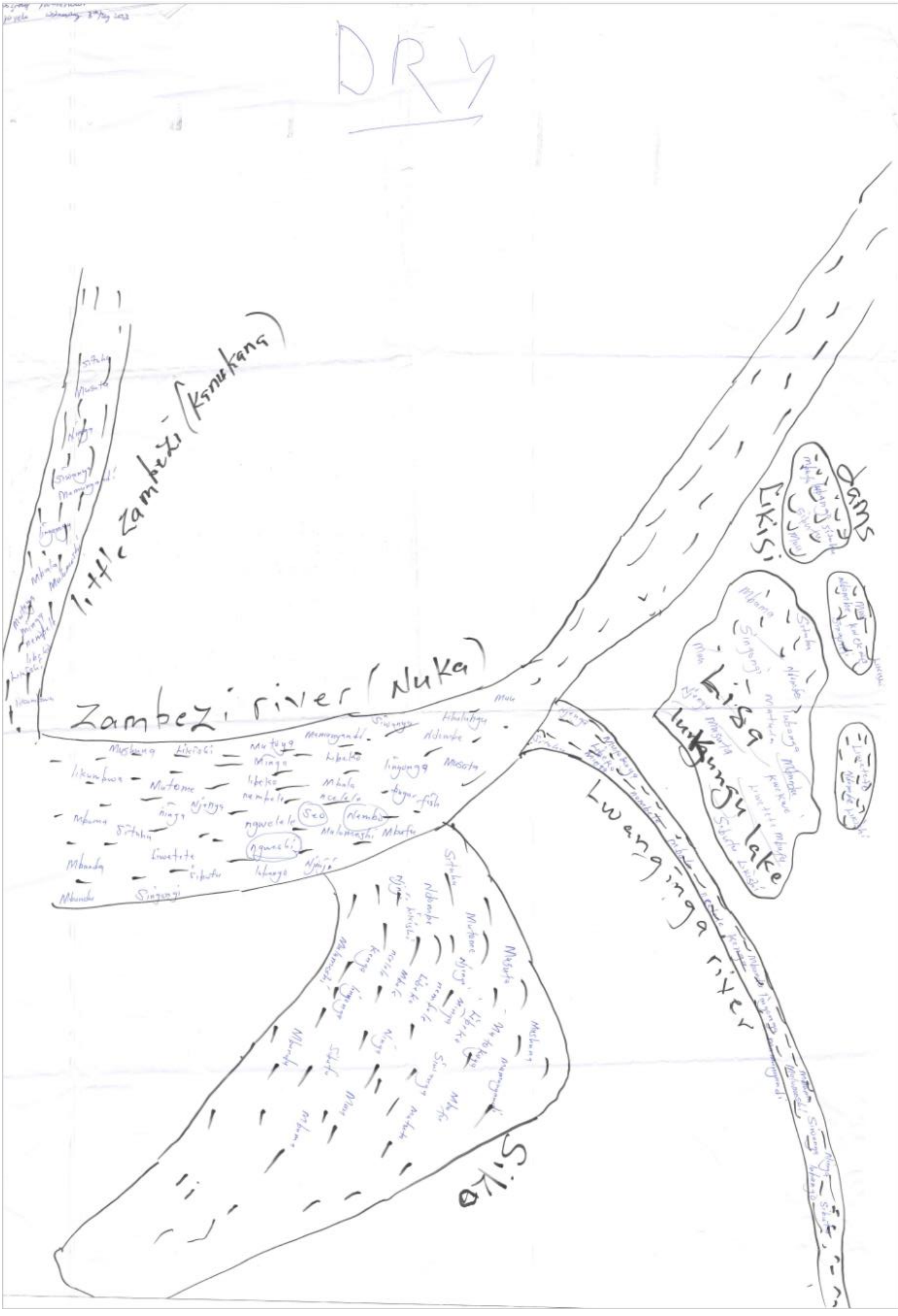

Figure 6: Participatory mapping in Liyoyelo during the low water season. Various habitat types were indicated and all fish species found there were added.

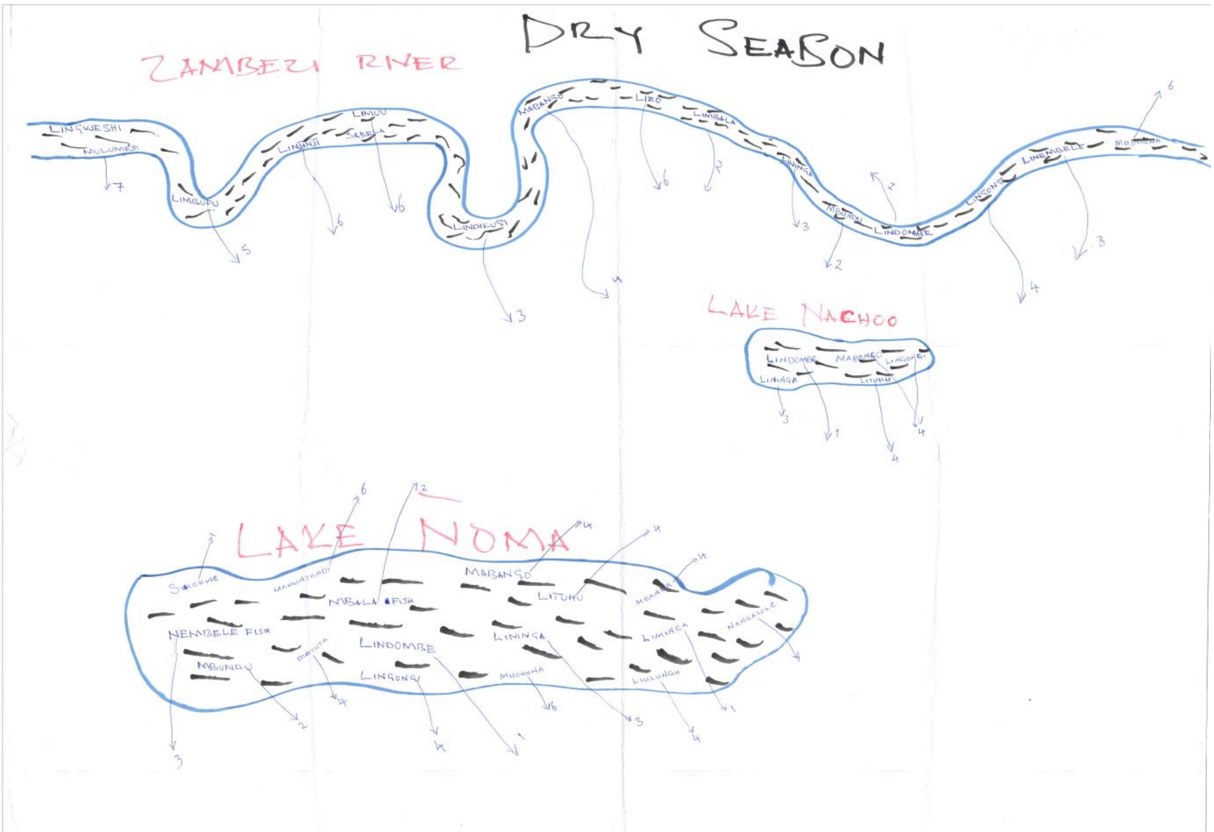

Figure 7: Participatory mapping of the dry season by the community of Situnga (in Lukanda). Fish species were added as well as the order of movement indicated by arrows.

The mappings provided additional information in the sense that they display a habitat-related overview of different fish species and the order of movement. However, sometimes the movement of fish species according to the mappings is in conflict with the statements in the interviews (Table 5). An inconsistency is that during the discussion of the map in Liyoyelo, it was stated very clearly that *nembwe, ngweshi* and *seo* never move out of the main river, while in the interviews *nembwe* and *seo* were reported to move out according to five and four fishermen respectively, out of five that were interviewed from the community of Liyoyelo. Furthermore, no clear distinction between the time of migration of any of the fish species can be made according to the interviews, while the mapping exercise in Lukanda resulted in an order of migration of the different fish species. In Lukanda, the participants grouped the fish into six different groups that follow each other when moving out of the river and lakes into the floodplain. However, this can be interpreted as further detail to the data collected during the interviews.

Table 5: Inconsistencies between the interviews and participatory mapping exercises.

Interviews	Participatory mapping
Nembwe does move out (10 out of 10).	Nembwe never moves out (Liyoyelo).
Seo does move out (8 out of 11).	Seo never moves out (Liyoyelo).
On average, all fish species migrate from the river and lakes into the floodplain in January (Table 3).	There is a particular order when groups of fish species migrate from the river and lakes into the floodplain, seven groups are distinguished in Lukanda. This can be further detail within the month January.
On average, all fish species migrate from the floodplain back to the river and lakes in June (Table 3).	There is a particular order when groups of fish species migrate from the floodplain back to the river and lakes; six groups are distinguished in Lukanda. This can be further detail within the month June.

3) Fishermen-independent habitat surveys

All analyses are explorative, due to the small size of the dataset (39 samples with 31 variables). No clear clusters of data points were found in the NMDS ordination (Figure 9). The original dissimilarities were reasonably conserved in the reduced number of dimensions, with a stress value of 0.22. (See additionally the Shepard plot with a high non-metric fit of $R^2=0.952$ in Supplementary Figure 4 in Appendix VI.) Next to that, a dendrogram was produced (Figure 8). In this dendrogram, the data were divided into four different clusters.

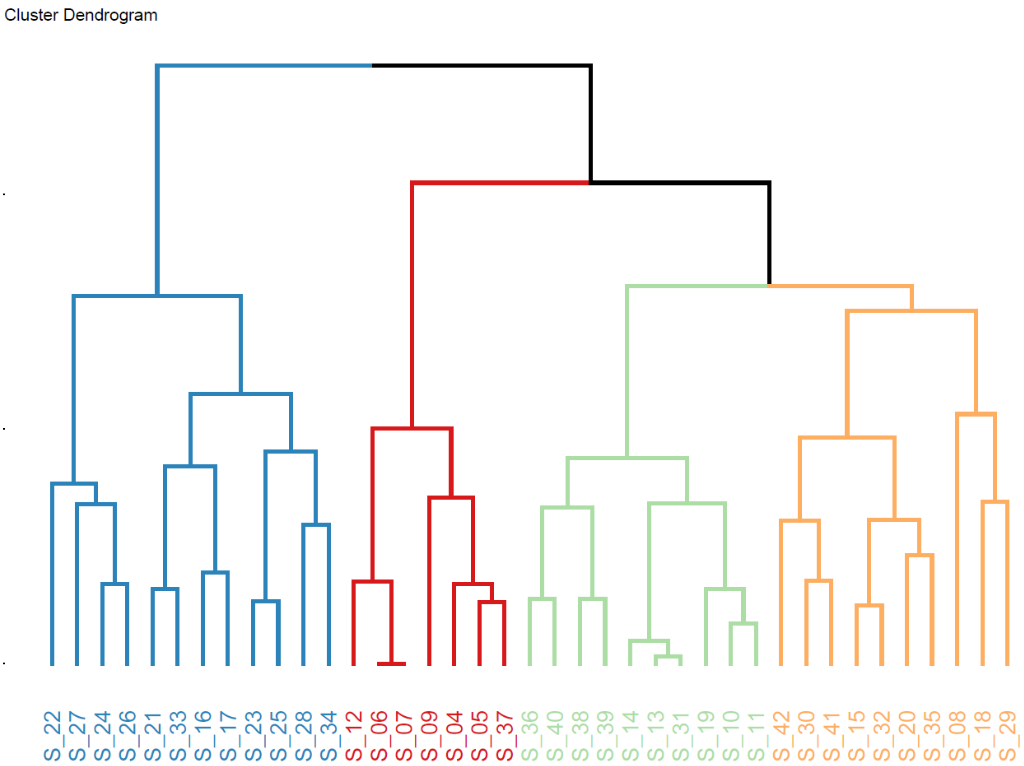

Figure 8: Cluster dendrogram of all habitat data based on a pvclust analysis in R. Colours were randomly assigned to the four different clusters.

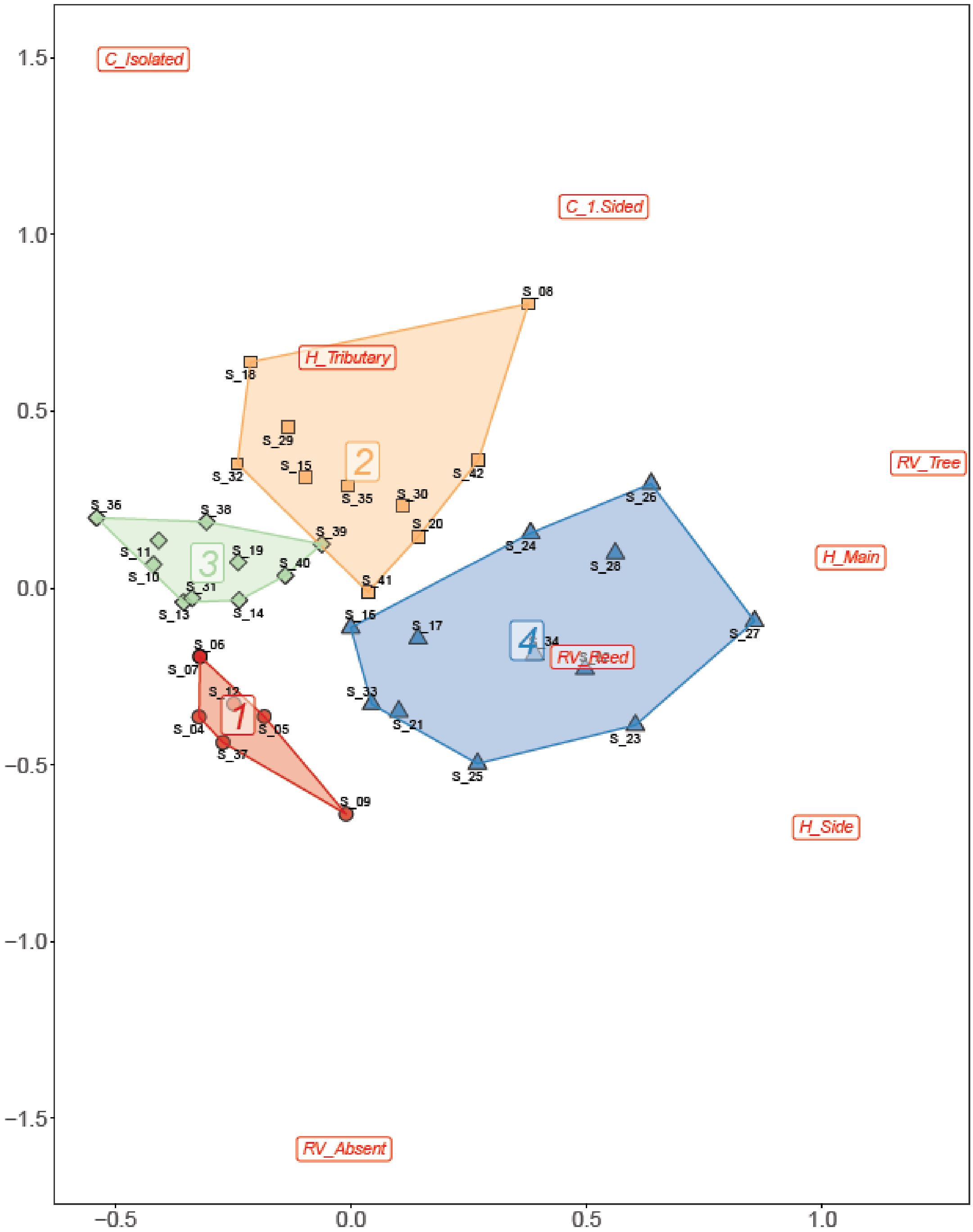

Figure 9: Coloured NMDS-plot with the colours based on the clustering of the dendrogram (Figure 8). The eight most determining variables are included.

Those two outputs were compared with each other by colouring the samples according to the group they are in. In the coloured NMDS plot, it can be seen that the samples that are together in a cluster in the dendrogram, are roughly situated together in this plot as well (Figure 9). When looking back at the original data, there is not a clear reason for this division. As a last check, the samples were plotted on the satellite image, where the markers were coloured according to cluster (Figure 10). Only the blue markers can be interpreted to have a reason for being together in one cluster: those samples were mainly collected in main channels, often with sandy sediment and reedy riparian vegetation (Figure 11). In the dendrogram, the blue branch is also the first branch to split of, so the most confident cluster (Figure 8). For the other clusters (red, green and yellow), no clear reasons for the clustering can be found when looking either at the raw data (Appendix VII) or at the satellite image (Figure 10). Hence the clustering is not very convincing.

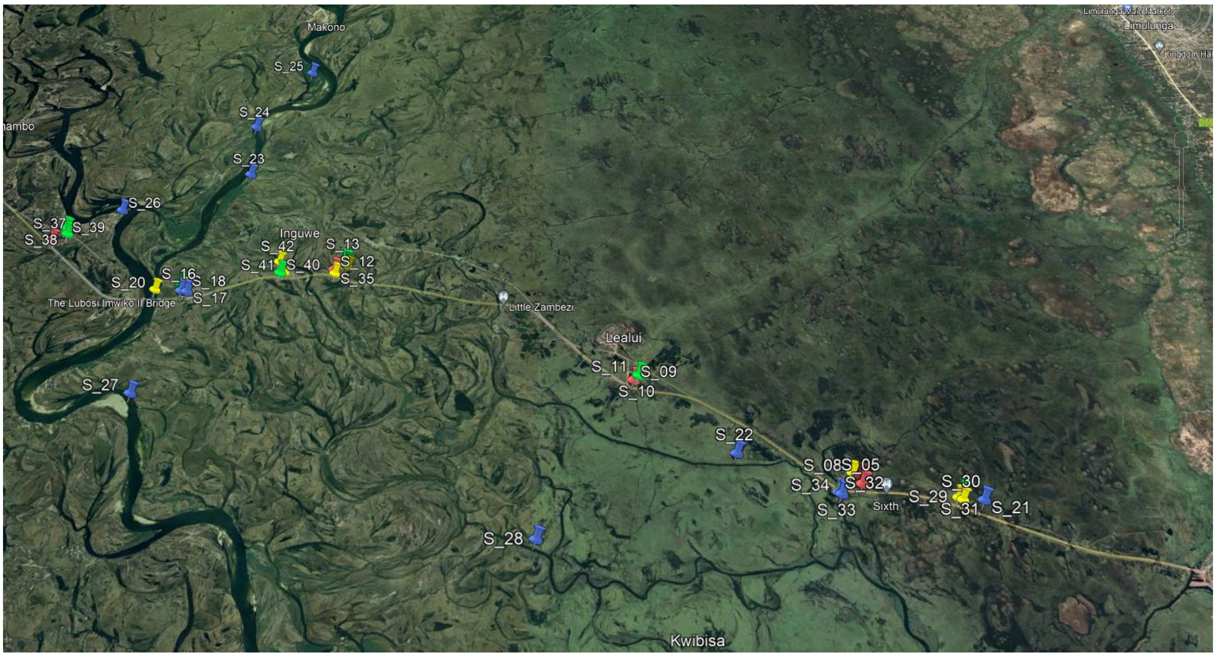

Figure 10: Sample sites for habitat surveys marked in a satellite image retrieved from GoogleEarth. Displayed are: 15° 07 39.33"S to 15° 17 10.00"S and 22° 54 15.62"E to 23° 07 22.55"E. Left half of the image is from 5 August 2023 (low water), right half from 7 April 2023 (flooded); pay attention to the effect of different water levels that is visible.

Figure 11: Habitat photos of the human and fish perspective of S_22 (blue cluster; a-b), S_37 (red cluster; c-d), S_10 (green cluster; e-f) and S_30 (yellow cluster; g-h). a-b are representative for the blue cluster, c-h are random examples of the rest of the samples from the other clusters, since no clear distinct representations for the red, green and yellow clusters were found.

Discussion

1) Fishermen's perceptions through interviews

The quantification of the information on fish movement as provided by the interviewed fishermen, was used to create a clearer picture of local knowledge of artisanal fishermen on fish species and their migration patterns. During the process of interviewing, sometimes was asked for movement and its direction yes or no, and sometimes the months of movement were asked for. When analysing the data, the months of movement were better quantifiable and provided more detailed information than yes or no. There is still a lot of variability in the months mentioned for migration. Despite this variability between the months mentioned by interviewees, overall a consensus is reached that fish species do migrate from the river/dams/lakes to the floodplain in January and in June they migrate back. This information is of help to provide an answer to the third sub question on the spatio-temporal movement of the different fish species.

The information collected during the interviews with fishermen provides an answer on the local fishermen's perception on habitats. Habitat turned out to be a complicated concept to ask fishermen about. When explaining to them what a habitat is, it is almost impossible not to mention some examples in order to trigger them to come up with different habitat types. The danger is that the interviewer introduces an unintended bias by mentioning these examples. On top of that, translation issues complicated the process of interviewing. It happened that responses given to open questions, were not answering the actual question. In those instances, a shift was made towards more closed questions. For example when "where do you catch this fish?" resulted after multiple attempts in "with a net" or something similar that was not answering the question, the question was changed to "do you catch this fish in the river or in the floodplain?" This strict way of asking the questions was not necessarily a disadvantage, given the fact that it excluded the misinterpretation of either questions or answers that were lost in translation. It also allowed for discussion of all the fish species on the species list during each interview – as far as the interviewee knew all species.

Ngweshi and *ngwelele* -both *H.vittatus* in different sizes- were already mentioned in the results as an exception to the consensus on fish movement. Due to the arbitrary distinction between their sizes, some confusion possibly derived from this. My careful conclusion based on a synthesis of ten interviews in which either *ngweshi* or *ngwelele* was discussed, would be that *H.vittatus* does move out of the river into the floodplain when it is still young and small, but the big specimen -called *ngweshi*- remain in the river.

Methodological constraints & potential impact

During the interviews, language issues concerning translation and interpretation of questions and answers arose, and to discuss 35 species in a consistent manner turned out to be a huge challenge. A recommendation is to limit the number of species covered during one interview. Either identify a maximum of ten to fifteen species to discuss with each interviewee, or set up multiple rounds of interviews -potentially with different fishers for each round- in which every round covers at most ten to fifteen fish species. Another recommendation I could come up with is to put all species on their own piece of paper, and shuffle them during the interview. Now many interviewees gave the same answer for all the fish species on one page, which might have introduced a bias, since this list was taxonomically arranged (Appendix II).

The geography of the different sites might have played a role in the answers of the interviewed fishermen: Situnga is located towards the south end of the floodplain, where the plain narrows down. So there is less surface of land flooded where the fish could potentially move to. Another side note is that a "yes, I find this species here" is a more convincing type of data than a "no I don't encounter it here", because the "no" might also be a "not yet" or it happens but the interviewee is not aware of it.

Another methodological constraint is that I only managed to interview men, not women. Although fishing is in principle considered to be a male activity, in practice women fish as well (Abbott & Campbell, 2009). Women were also during this study observed while fishing. Typically, men use different fishing gear then women, so this might have affected the results, since the gear determines the sizes of the fish that are caught and hence it also potentially influences the knowledge of the interviewee (e.g. McClanahan & Mangi, 2004).

The strength of this research was that it covered those 35 fish species in fourteen interviews at three different locations, so there was a high information density and efficiency in conducting the research. In the fourth and fifth interview on the same location, I found out that not so much new data shows up during the interview. This is a process called data saturation: when continuing to interview and thus collect data, replication will occur, so the new data will repeat what already has been collected (Morse, 1995; Saunders et al., 2018).

Broader in literature/scientific relevance
The collection of data on the local perspective has added value compared to collecting only data on remote sensing. Although remote-sensing has many advantages in Central African context, given the challenging field conditions on the ground (e.g. Kerr & Ostrovsky, 2003; Mayaux et al., 1999; Potapov et al., 2008). Thus for a long time, a bias has existed by neglecting the knowledge of local inhabitants (Demichelis et al., 2023). Combining and comparing scientific knowledge with local knowledge looks promising to collect new information, since the two sources may complement each other (Silvano et al., 2008). In some cases local knowledge can provide detailed information on trophic interactions and potential ecological roles of fish in ecosystems (Silvano et al., 2008). This is in agreement with my impressions during the interviews. It was beyond the scope of this study, but some fishermen gave very detailed information on how specific fish species breed, and with the right formulation of questions in follow-up research, there is a lot more to be discovered.

2) Local people's perceptions through participatory mapping

The approach of the participatory mapping turned out to be a bit broader than the original research question. A variety of members of the community participated. Not only fishermen but also fish traders participated in the mapping exercises. This is very positive, since it adds even more value to the answers of the research questions, because all these people are users of the socio-ecological system and thus part of this socio-ecological system that forms the Barotse floodplain (Ostrom, 2009).

The participatory mappings provided insights on habitat types as perceived by the participants. From the mappings it became clear that a variety of habitats is distinguished by local people. However, the areas indicated on these maps might be geographical points of reference for them, rather than habitat distinctions per se. Still, the areas indicated on the map are important enough to them to mention and distinguish. As in the interviews the habitat types *river, dam, lake* and *floodplain* were mentioned. The mappings led to an additional habitat type *tributary*, when comparing the results of the mapping to those of the interviews.

Concerning the spatio-temporal movement of different fish species, the mappings provided useful insights. The mappings were good visualisations of the perception of the community of local people of their environment and surroundings. It also provided insights into where different fish species are found in different seasons and where they migrate to in what order.

Methodological constraints & potential impact

The discussion the participants had when creating the map was not translated, because translation of the discussion would slow down the conversation of participants too much. The result is that only the drawn maps and a short wrap-up at the end of each session were transferred to me. Potentially, some points of discussion or disagreement have escaped my attention, due to the lack of translation. Next to that, during focus group discussions there is a possibility of biases in the form of dominance effect (a dominant person taking the lead and shaping the discussion), halo effect (enlarged influence of one person because of his perceived status) and groupthink (similar thinking in a group to maintain group cohesion) (Mukherjee et al., 2015). Besides issues on translation another constraint is that throughout the process the approach of the mapping exercise evolved, due to new insights that I gained. This makes it harder to compare the three maps. But on the other hand: they build on each other and information was added during each mapping round. A recommendation for future mapping sessions is to facilitate the session with two researchers: a moderator and an assistant to document the observed non-verbal interactions as well as the group-dynamics (Kitzinger, 1994, 1995).

The strengths of the mapping exercises are that they took place in different places and that both men and women, fishers and traders took part. The duration of the meetings was between one and two hours, as is described as an ideal length for the participants to come into depth and not to suffer from upcoming fatigue (Nyumba et al., 2018). A convenient venue was chosen for the participants, making sure that there was not too much distraction, and it was comfortable with sufficient seats and easily accessible for all participants (Sampson, 1972 & Smith, 1972 as cited in Nyumba et al., 2018). In total, three mapping sessions were organised, as is in line with recommendations for such research in the literature (Burrows & Kendall, 1997 as cited in Nyumba et al., 2018). The output was in the form of physical maps drawn on flipchart paper without external support or pre-existing maps (Janssens de Bisthoven et al., 2020). These maps display the perspective of local people on their surroundings and the fish species that are part of the system.

Broader in literature/scientific relevance

Focus group discussions have been an emerging technique to collect qualitative data and to bridge between local knowledge and scientific research (Bennett et al., 2017; Cornwall & Jewkes, 1995). However, methodology for participatory mapping exercises or focus group discussions has often been poorly displayed in conservation-based research (Nyumba et al., 2018). This is a concern, since it might lead to the false impression that focus group discussions are not a solid method for the collection of data (Nyumba et al., 2018).

It was argued that the best results would be obtained with a group as homogenous as possible in terms of ethnic and social class background, age range and gender (Krueger, 1994 as cited in Nyumba et al., 2018). However, according to Freitas et al., a mix in gender among the participants improves the quality of the discussion (1998). Participatory mappings and focus group discussions provide useful insight into indigenous people’s perceptions of their surroundings, and everyday forms of resource use are shaped by norms and customs, since natural resources are central to people’s livelihoods in rural Africa (Bisong, 2001).

Another structured group-based technique that can be used to build consensus is the Nominal Group Technique (NGT). In this technique the exploratory and interactive character of focus group discussions is combined with the exclusion of unwanted social pressures and the depth of individual reflections, since participants start by reflecting individually on their ideas and subsequently prioritise these ideas as a group (Hugé & Mukherjee, 2018). NGT has not yet been applied on the African continent, and it could be a useful follow-up for evaluating local people’s perceptions of ecosystem services in the Barotse floodplain (Hugé & Mukherjee, 2018). In this way a wide diversity of values and knowledge can be included in decision-making for conservation (Reed, 2008).

3) Fishermen-independent habitat surveys

The habitats were surveyed without relating them to the fish living there so only the sub question on habitats -What habitats do fishermen distinguish and how can they be characterised?- can partially be answered by the results from this part of the research. The objective of the research was to create a habitat clustering system in order to be able to subdivide the Barotse into different habitat types. Although the data of the habitat surveys could be divided into four clusters, as was previously shown in the result section, the clusters turned out not to make sense after further analysis and looking back to the original raw data (Appendix VII) and satellite image (Figure 10), except for the blue cluster as described already in the results. However, the methods of analysing are based on completely different fundamentals and yet there is a similar pattern in clustering. In other words: samples that are clustered together in the hierarchical way of clustering (the dendrogram; Figure 8) are also situated close together in the non-hierarchical output (the NMDS-plot; Figure 9). Thus, although not convincingly visible in the raw data and on the map, there might be an underlying pattern. This could be further investigated by collecting more data.

Methodological constraints & potential impact

Little data was gathered during the habitat surveys (39 samples on 39 different locations, with 31 variables). A preliminary analysis was conducted with these data, which led to a clustering in four reasonable clusters. However, after critical analysis of those four clusters, no clear reason or underlying pattern could be found for this clustering. Another potential constraint is that the habitat surveys were conducted on different dates, and the water level was receding in the meantime. The advantage of the receding water level was that more locations became reachable for the habitat survey. The disadvantage was that the water depth should have been corrected by the water level at that date. There is a gauge station near the Mongu-Kalabo road. Despite multiple attempts that were made to come into contact with the gauge reader, it remained unsuccessful. Even with access to these measurements, the water level of the Little Zambezi is known and logically it will be the same in all connected water bodies. However once isolated, the water levels in isolated waterbodies might recede slower or quicker than in the remaining connected stream due to for example evaporation, and it will be hard to identify a way to relate it to the water level measured by the gauge reader.

Despite the above-mentioned limitations, a good methodology was set up and this can be used for future research. In addition, the habitat survey Kobo-form could be improved by adding more picture-questions (capturing views towards the North, East, South and West) in order to create more of a 360-degree picture of the surveyed locations.

Broader in literature/scientific relevance

In the Barotse itself, not much research on fish habitat has been done. Previous studies described different habitat types, but mainly from the human perspective. The Barotse floodplain was described as “a largely treeless grassland” in 1991 (Winemiller, 1991). This corresponds with my observations. Only in two older fish ecology studies, descriptions of the different habitat types are provided. The distinction made in these papers is very basic and it encompasses only river channel, lagoon and floodplain (Winemiller, 1991; Winemiller & Kelso-Winemiller, 1994). Since research on the Barotse floodplain itself is very limited, I started looking broader to comparable floodplain systems in the region (Southern Africa), and found several habitat types are recognised according to different studies. In the region, there are permanent ancient channels (*kisaya*) (van der Waal, 1996), which have also been observed in the Barotse floodplain, but were not mentioned in the literature about the Barotse. In the Okavango Delta, five different major habitat types were recognised: riverine floodplain, perennial swamp, seasonal swamp, drainage rivers and sump lakes (Wilson & Dincer, 1967 as cited in

Merron & Bruton, 1995). This can be compared to findings in the Barotse based on the descriptions of interviewed fishermen and participants of the mappings: river, dam, lake, floodplain and tributary are recognised (Table 2). However, comparisons like this need to be evaluated critically, since the systems all have their unique composition.

Conclusions

Habitat characterisation according to fishermen

There is an answer to the first sub question on habitat characterisation according to fishermen: the interviews led to a number of habitats mentioned by the interviewees as described in the results section (Table 2). Subsequently, the participatory mapping led to an additional habitat type (tributary). The characteristics of these habitats were not in detail discussed with the interviewees nor with the participants of mapping exercises. However, in the internal technical report nr. 1 of WWF (Rennie et al., n.d.), several habitat types were described and defined for the Upper Zambezi region. Not all of them are applicable to the Barotse floodplain, but still this list is more comprehensive than the habitat types mentioned by local people. This could be due to the fact that the Barotse floodplain is a very homogenous environment mainly consisting of only a few larger habitats. Analysis of fishermen-independent habitat surveys (39 samples with 31 variables) led to a clustering for which no clear underlying pattern could be found.

Fish species and life stages according to fishermen

Fishermen in the Barotse distinguish at least 36 fish species. These fish are valued and appreciated by the people since they have taken the effort to give names to them at a certain stage in history. For the majority (25 out of 36 species) the names are one to one coupled to a scientific species (Table 1). For life stages hardly any information was collected, although it was investigated during the interviews. Most fishermen (eleven out of fourteen) have knowledge on the reproduction of at least one fish species. Species that are mentioned more frequently could be more abundant in the area. Another possible explanation could be that the Lozi-people might give a higher value or appreciation to certain species. This needs to be further investigated. Recommendations for further research are to make sure that the interviewees represent a spread in gear and gender, and to conduct more interviews on different locations. Although five interviews per location is sufficient to reach a saturation on information.

Spatio-temporality of the different fish species according to fishermen

Concerning the third sub question both the interviews and the participatory mappings generated answers. During the interviews the timing of migration of different fish species was discussed to the level of months. However, not all fishermen state the same months. Nevertheless, there is a pattern visible when comparing all data. The mappings resulted not in specific months, but in an order of migration. This could be further detail within the months as mentioned in the interviews. Summarising, there is a lot of local ecological knowledge is present among local fishermen.

The local perspective on the natural functioning of the Barotse floodplain

Overall local fishermen have a lot of knowledge on fish species, they distinguish many species and are well aware of the migration patterns of the different fish species. Habitats are only distinguished to a minimal extent, which could be due to the homogenous nature of the Barotse floodplain, compared to other floodplain systems in Southern Africa and around the world. In short my conclusions are:

1. No clear clustering can be made based on the collected habitat data.
2. Local people distinguish at least 36 different fish species.
3. There is widespread local knowledge on the spatio-temporal migration patterns of at least 24 of those fish species.
4. Local people distinguish five types of habitats: floodplain, dam, lake, river and tributary.

Recommendations

Based on my findings in the course of this study, I would like to make a number of concrete recommendations for subsequent research.

Concerning interviews I would suggest to limit the number of species covered during one interview, as well as to make sure that participating respondents represent a spread in gear and gender. On top of that it would be useful to conduct more interviews on different locations. To uncover local knowledge on trophic interactions, it would be interesting to tailor a series of interviews to those questions (Silvano et al., 2008). This was beyond the scope of this study, but it is valuable information to map out more details on the ecology of different fish species in the Barotse. In that case it is advisable to start interviewing elderly people who are locally recognised to have a lot of knowledge and experience (Demichelis et al., 2023).

Concerning participatory mappings my suggestion is to add an assistant during the mapping exercise. This assistant can be of help with documenting the observed non-verbal interactions as well as the group-dynamics (Kitzinger, 1994, 1995). The Nominal Group Technique (NGT) would also be a valuable additional technique to use, especially when discussing conservation management strategies, as hopefully will be the case as result of the total scope of the research going on in the Barotse (Hugé & Mukherjee, 2018).

Concerning habitat surveys it is of course useful to gather more data, in order to expand the dataset that I started on. Due to the pioneering nature of this study, the dataset is not yet very extensive. Additional data might lead to new emerging patterns. Given the high diversity throughout the year in the very dynamical Barotse floodplain, there is added value of conducting more habitat surveys in different months. For example during the lowest water levels in October, and during the rising phase in December or January.

Acknowledgements

This journey of writing a thesis has now come to an end. First of all, I would like to thank my supervisor Leo Nagelkerke for his guidance and support throughout the process of this thesis both on academic and personal level. Also a thank you to Tom Buijse, Agness Musutu and Paul van Zwieten for their input on shaping this research. Then to my colleagues of WWF Zambia for practical support, and welcoming me in their office: thank you Machaya, Jameson, Kakoma, Micah, Mulako, and to Luc Rozendaal, a fellow student from Wageningen also present during my time in Zambia. To my parents and best friend Sasja, a thank you for their time, love and support during numerous phone calls. To the missionaries at Mutaya missionary base who welcomed me as a family member to live with them: thank you Clarissa, Tanya, Sam and Marelize, Brad and Andrea, Kevin and Carine, Petri and Waldo. And above all I would like to express my thanks to God, my heavenly Father, who placed the desire in my heart to go to Africa in the first place. He has been so faithful and provided me with everything I needed, both material and spiritual, throughout the entire journey. Thank you all!

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Appendix I - Questionnaire interviews fishermen

Interview Questionnaire Fishermen Barotse
Landing site:
Date of Interview:
Time Start of Interview:
Interview number/code:

PARTICIPANT'S STATEMENT of INFORMED CONSENT
I understand that the purpose of this survey is to study the distribution of fish species in the Barotse Floodplain and how members of the community perceive the distribution of fish species throughout the year. I understand that all information provided by me is confidential and will not be released by the researcher to anyone else. I agree that information gathered from this study may be published provided that no information that would identify participants is used.

I agree to be interviewed. I understand that I do not have to answer particular questions and am free to withdraw from the interview and study at any time.

All my questions regarding the survey have been answered satisfactorily.

Signature of Participant: ______________________________ Date: ……./……./…….

I have explained the purpose of the project to the participant

- ☐ who has preferred to give oral consent to the interview under the conditions stated above:

Signature of Investigator: ______________________________ Date: ……./……./…….

Interview fishermen Barotse

Starting questions:

Location and time of interview	
Name	
Age	
Experience: start fishing (age or year)	
Experience: start owning a boat/gear (age or year)	
Fishing methods used now (gear)/in the past	
What places do you fish?	
Always same places? If no, where before?	
Different areas/localities seasonally?	

In depth questions: *see checklist topics below*

Habitats, seasons, gear use

1. Which different areas to fish do you distinguish/recognise (=**habitat**: e.g. river, open water, lake, floodplain, …)? →*map*
2. What **seasons** do you distinguish?
3. How does the floodplain **change** over the year?
4. Do you fish in different places in different seasons?
5. What **gear** do you use in what place?
6. And in what season?

Fish species, catch, location fish species

7. What **fish species** do you catch? →*bring photobook with species. Compose a list of species mentioned here for questions 8-11*
8. **Where** in the Barotse do you catch them? →*map*
9. Do they move when flooding occurs? Where do they go?
10. **Where** and **when** do you catch that species most? →*map*
11. Are there any **regulations**? E.g. areas closed for fishing (permanent or seasonal)?
12. What are **breeding grounds**? What are **nurseries**? What are **feeding grounds** for different fish species?
13. Do you catch **fry/juveniles** (baby-fish) in other areas then the breeding or nurseries? If yes: where and with what gear?
14. What determines (makes) a good fishing spot in terms of **habitat/surroundings/vegetation**? And why? Please indicate on a map?
15. We have come towards the end of this interview. Is there anything you would like to add?

Topics:

- Habitat
- Gear
- Fish species caught
- Location in floodplain
    - Where do you fish normally
- Seasonal change floodplain
    - Habitat
    - Fish species
    - Gear
- Regulations
- Life stages of fish (fry, juveniles, immature and mature fish)
    - Breeding grounds
    - Nurseries
    - Feeding grounds

Appendix II - Species list Lozi fish names (incl. pictures) as used during the interviews

Notes on this species list with names in Silozi:

Straight text: collected at the focusgroup of Liyoyelo on 03/05/2023

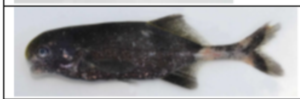
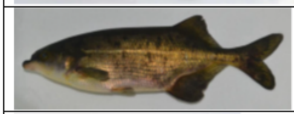
Bold text: names as in the CAS-form of WWF, in accordance with the names found in Liyoyelo (sometimes a comment *in italics*)

Italic text: updates given by people from the Situnga focusgroup (near Senanga) on 18/05/2023

Additional notes and thoughts: some names are double, e.g. mbaala occurs for multiple species with a similar appearance, though from different families.

This list is based on, and all pictures are retrieved from: "Technical Report 1: Literature review of the Upper Zambezi fish fauna", NRF-SAIAB/WWF-Zambia Upper Zambezi Floodplain Ecology and Fisheries Project (Agreement No. 40001528-2019-G02), by: Craig L Rennie, Albert Chakona, Dennis Tweddle, Olaf LF Weyl for WWF-Zambia.

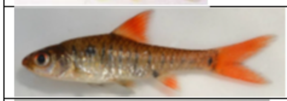
Page 1:

	Family	Species	Common name (English)	Silozi
	Mormyridae	*Mormyrus lacerda*	Western bottlenose	Mutokoya / **ndikosi**
		*Hippopotamyrus asorgii*	Slender stonebasher	Liveko *Ngumwesi*
		*Hippopotamyrus szaboi*	Upper Zambezi mormyrid	Liveko *Ngumwesi*
		*Cyphomyrus cubangensis*	Parrotfish	**Ninga**
		*Marcusenius altisambesi*	Bulldog	Nembele
		*Petrocephalus longicapitis*	Long-head churchill	Liveko
		*Petrocephalus okavangoensis*	Okavango churchill	**Pepe**
		*Pollimyrus marianne*	Zambezi dwarf stonebasher	**Pepe**
	Kneriidae	*Kneria polli*	Northern kneria	-

Page 2:

	Cyprinidae	*Enteromius afrovernayi*	Spottail barb	Mbaala
		*Enteromius barnardi*	Blackback barb	Nchelele *Njiva*
		*Enteromius barotseensis*	Barotse barb	Kenga
		Enteromius cf. bellcrossi	-	
		*Enteromius bifrenatus*	Hyphen barb	*Mingale*
		*Enteromius brevidorsalis*	Dwarf barb	
		*Enteromius eutaenia*	Orangefin barb	Linyonga *(?)* Nchelele Nyengele
		*Enteromius "sharp-eutaenia"*	-	
		Enteromius cf. miolepis	-	
		*Enteromius "short-stripe eutaenia"*		

Page 3:

		*Enteromius "red-eye eutaenia"*		
		Enteromius sp. 'dark eutaenia'		
		*Enteromius 'purplestripe'*	Undescribed	
		*Enteromius fasciolatus*	Red barb	
		*Enteromius haasianus*	Sicklefin barb	
		*Enteromius kerstenii*	Redspot barb	
		*Enteromius lineomaculatus*	Line-spotted barb	
		*Enteromius multilineatus*	Copperstripe barb	
		*Enteromius neefi*	Sidespot barb	
		Enteromius "Manyinga spot"		
		Enteromius "pectoral spot"		

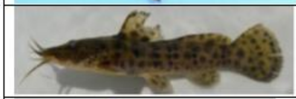
Page 4:

		*Enteromius paludinosus*	Straightfin barb	Kenga
		*Enteromius poechii*	Dashtail barb	**Mbaala**
		*Enteromius radiatus*	Beira barb	
		*Enteromius thamalakanensis*	Thamalakene barb	
		*Enteromius unitaeniatus*	Longbeard barb	
		Enteromius "chubby head"		
		*Enteromius "Kabompo twin stripe"*		
	Cyprinidae	*Coptostomabarbus wittei*	Upjaw barb	
		*Labeo cylindricus*	Redeye labeo	Linyonga
		*Labeo lunatus*	Upper Zambezi labeo	Linyonga

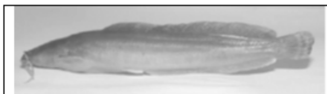
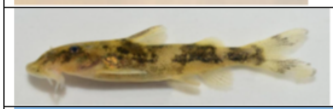
Page 5:

		*Labeobarbus codringtonii*	Upper Zambezi yellowfish	**Linyonga?** *In the list of WWF, not mentioned as linyonga by fishers*
		*Opsaridium zambezense*	Northern barred minnow	
		Engraulicypris brevianalis	River sardine	
	Distichodontidae	*Nannocharax machadoi*	Dwarf citharine	
		*Nannocharax multifasciatus*	Multibar citharine	
		*Nannocharax macropterus*	Broadbar citharine	
		*Neolebias lozii*	Banded Neolebias	
	Alestiidae	*Brycinus lateralis*	Striped robber	**Mbaala**
		*Hydrocynus vittatus*	Tigerfish	Ngwelele (small) **Ngweshi** (big)
		*Micralestes acutidens*	Silver robber	Nchelele

Page 6:

		*Rhabdalestes maunensis*	Slender robber	
	Hepsetidae	*Hepsetus cuvieri*	African pike	**Mulumeshi**
	Claroteidae	*Parauchenoglanis ngamensis*	Zambezi grunter	Siwanya *Siabela*
	Schilbeidae	*Schilbe intermedius*	Butter barbel	**Lubango**
		*Schilbe yangambianus*	Yangambi butterbarbel	**Lubango**
	Amphiliidae	*Amphilius uranoscopus*	Stargazer mountain catfish	Siwanya *Siabela*
		*Zaireichthys pallidus*	Pallid sand catlet	
	Clariidae	*Clariallabes platyprosopos*	Broadhead catfish	Minga
	Claridae	*Clarias gariepinus*	Sharptooth catfish	Kokwe

Page 7:

		*Clarias liocephalus*	Smoothead catfish	
		*Clarias ngamensis*	Bluntooth catfish	**Ndombe** *WWF: "all catfish types"*
		*Clarias stappersii*	Blotched catfish	Liwetete *Litole*
		*Clarias theodorae*	Snake catfish	*Minga*
	Mochokidae	*Chiloglanis fasciatus*	Okavango rock catlet	
		*Synodontis nigromaculatus*	Spotted squeaker	Singongi Siwutu
		Synodontis macrostigma	Large-spotted squeaker	
		Synodontis macrostoma	Large-mouth squeaker	
		Synodontis leopardinus	Leopard squeaker	
		Synodontis thamalakanensis	Bubble-barbed squeaker	
		Synodontis vanderwaali	Fine-toothed squeaker	
		Synodontis woosnami	Woosnam's squeaker	
	Nothobranchidae	*Nothobranchius capriviensis*	Caprivi killifish	

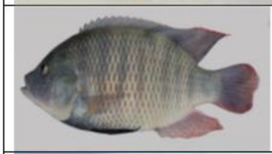
Page 8:

	Poeciliidae	*Micropanchax hutereaui*	Meshscale topminnow	
		*Micropanchax johnstoni*	Johnston's topminnow	
		*Micropanchax katangae*	Striped topminnow	
		*Micropanchax sp.*		
		*Hypsopanchax jubbi*	Southern deepbody	
	Mastacembelidae	*Mastacembelus frenatus*	Longtail spiny eel	Mutome
		*Mastacembelus vanderwaali*	Ocellated spiny eel	Mutome
	Anabantidae	*Ctenopoma multispine*	Many-spined climbing perch	**Mbundu**
	Anabantidae	*Microctenopoma intermedium*	Blackspot climbing perch	Musuta *Mbundu* *mochila/mushala*

Page 9:

	Cichlidae	*Coptodon rendalli*	Redbreast tilapia	**Mbufu**
		*Hemichromis elongatus*	Banded jewelfish	**Liulungu** *WWF: "small breams"*
		*Oreochromis macrochir*	Greenhead tilapia	Muu
		*Oreochromis andersonii*	Threespot Tilapia	**Njinji**
		*Pharyngochromis acuticeps*	Zambezi happy	Mbanda
		*Pseudocrenilabrus philander*	Southern mouthbrooder	Lituta *Nangalole*

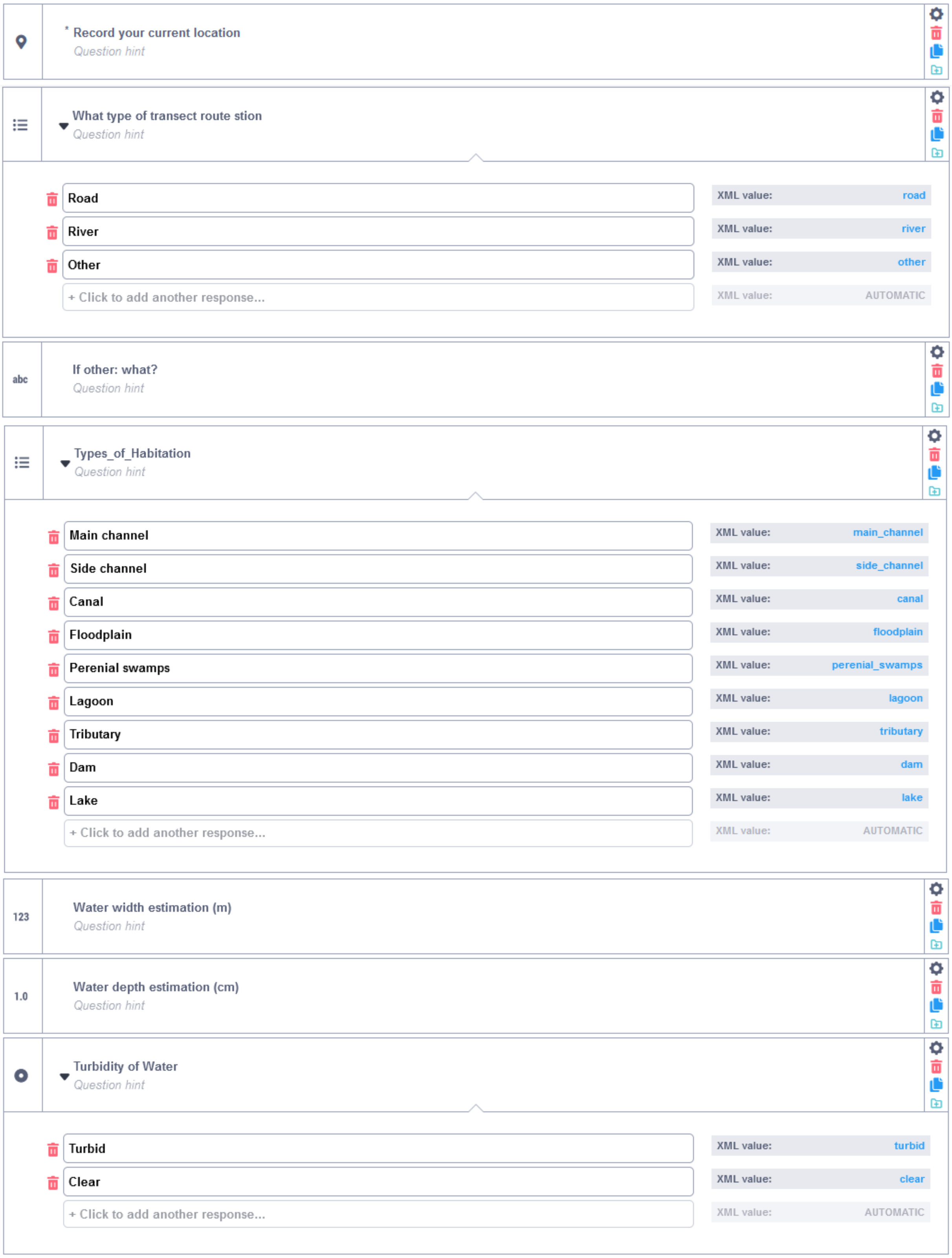
Page 10:

		*Sargochromis carlottae*	Rainbow bream	Mbuma
		*Sargochromis codringtonii*	Dusky bream	Likumbwa
		*Sargochromis giardi*	Pink bream	**Seo**
		*Sargochromis sp. "dusky bream"*		Seo
		*Serranochromis altus*	Humpback largemouth	**Mushuna** *Nahushwa*
		*Serranochromis angusticeps*	Thinface largemouth	Mamunyandi

Page 11:

		*Serranochromis longimanus*	Long-finned bream	Likishi
		*Serranochromis macrocephalus*	Purpleface largemouth	**Njenga**
		*Serranochromis robustus jallae*	Nembwe	**Nembwe**
		*Serranochromis thumbergi*	Brown-spotted bream	Likishi *Njenga*
		*Tilapia ruweti*	Okavango tilapia	*Lituta* Situhu/**situku** WWF: “small breams”
		*Tilapia sparrmanii*	Banded tilapia	Situhu/**situku** WWF: “small breams”

Appendix III – Habitat survey Kobo toolbox form


* Record your current location
Question hint

What type of transect route stion
Question hint

	XML value
Road	road
River	river
Other	other
+ Click to add another response...	AUTOMATIC

If other: what?
Question hint

Types_of_Habitation
Question hint

	XML value
Main channel	main_channel
Side channel	side_channel
Canal	canal
Floodplain	floodplain
Perenial swamps	perenial_swamps
Lagoon	lagoon
Tributary	tributary
Dam	dam
Lake	lake
+ Click to add another response...	AUTOMATIC

Water width estimation (m)
Question hint

Water depth estimation (cm)
Question hint

Turbidity of Water
Question hint

	XML value
Turbid	turbid
Clear	clear
+ Click to add another response...	AUTOMATIC

Flow
Question hint

Response	XML value
No	no
Little	little
Moderate	moderate
Much	much
+ Click to add another response...	AUTOMATIC

Riparian vegetation
Question hint

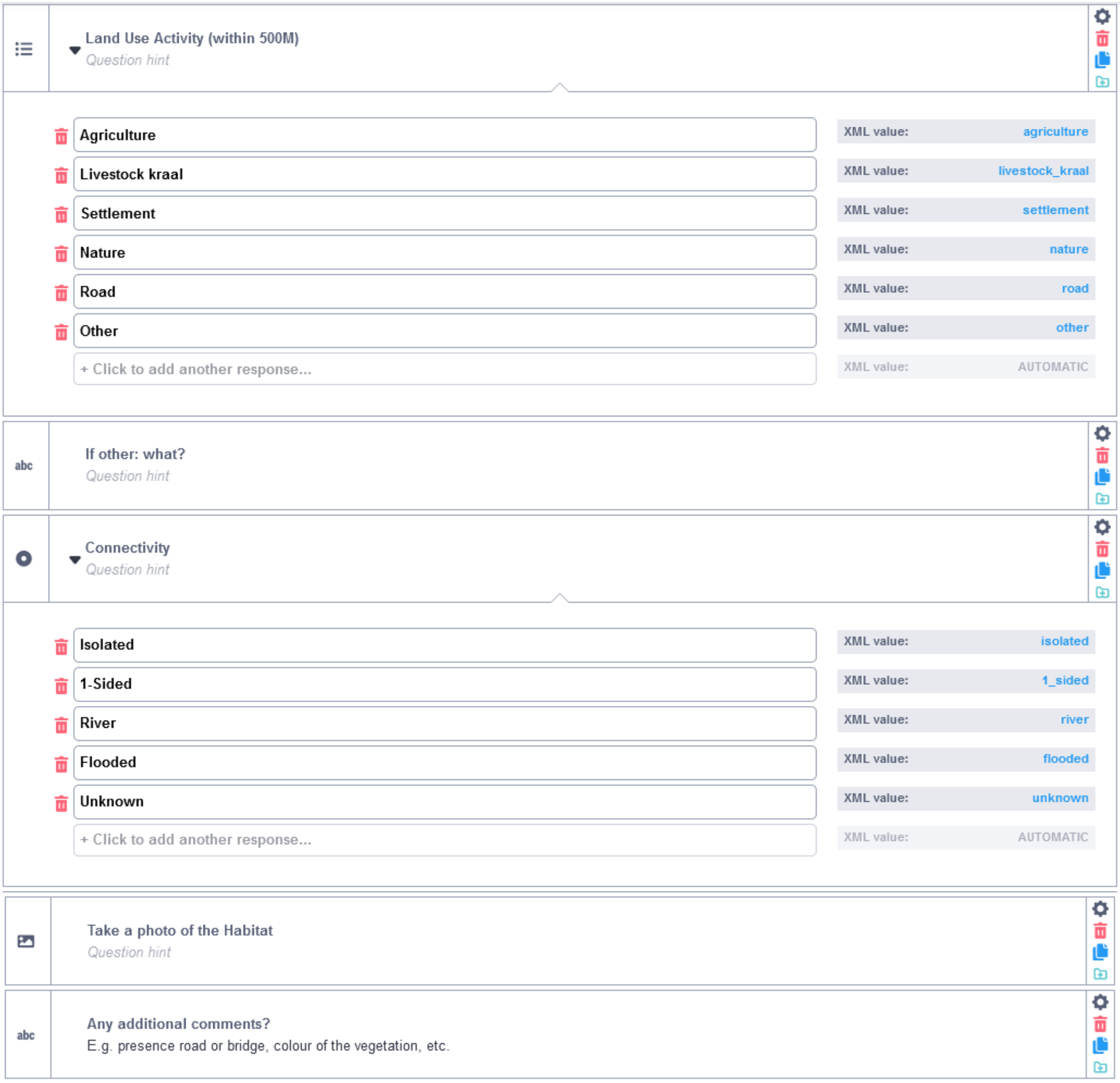
Response	XML value
Grass	grass
Reed	reed
Rice	rice
Tree	tree
Mimosa pigra	mimosa_pigra
Other	other
Vegetation absent	vegetation_absent
+ Click to add another response...	AUTOMATIC

abc **If other: what?**
Question hint

Canal Characteristic
Question hint

Response	XML value
Reed Vegetation	reed_vegetation
Shrubs	shrubs
Tree	tree
Sand	sand
Other	other
+ Click to add another response...	AUTOMATIC

abc **If other: what?**
Question hint



Land Use Activity (within 500M)
Question hint

Agriculture	XML value: agriculture
Livestock kraal	XML value: livestock_kraal
Settlement	XML value: settlement
Nature	XML value: nature
Road	XML value: road
Other	XML value: other
+ Click to add another response...	XML value: AUTOMATIC

If other: what?
Question hint

Connectivity
Question hint

Isolated	XML value: isolated
1-Sided	XML value: 1_sided
River	XML value: river
Flooded	XML value: flooded
Unknown	XML value: unknown
+ Click to add another response...	XML value: AUTOMATIC

Take a photo of the Habitat
Question hint

Any additional comments?
E.g. presence road or bridge, colour of the vegetation, etc.

Stored at: https://kf.kobotoolbox.org/#/forms/aEoZnqHbNrUg3NycgsKJdb/edit
Ask Machaya Chomba for access to the form (mchomba@wwfzam.org).

Appendix IV - Habitat survey methodology including preliminary results

Study area: the Barotse floodplain as viewed from the Mongu-Kalabo road (Figure 3 in the main text).

Panasonic Lumix DC-TZ90 camera (Manufactured by: Panasonic Corporation, Kadoma, Osaka, Japan; Importer for Europe: Panasonic Marketing Europe GmbH, Panasonic Testing Centre, Winsbergring 15, 22525 Hamburg, Germany), Minolta binoculars (Konica Minolta Classic III 7x35WR, older model).

From the Mongu-Kalabo road (Figure 3 in the main text) on seven different spots, habitat photos were taken towards the north and south side of the road on four dates with intervals of 14 +-1 days. Survey dates were: 31 May, 14 June, 27 June and 11 July 2023. The locations were recorded with a GPS device and stored in a gpx-file. Additionally, fieldnotes -based on observations both with the naked eye and with support of a pair of binoculars- were written down in order to support correct interpretation of satellite images accessed via Sentinel. Sentinel is a satellite taking satellite photos every five days with a reasonably high spatial resolution (10-60m). Being in the field, it was a bit playing around to find a way of grasping and documenting everything visible and noteworthy in your surroundings. I did an attempt, to estimate distances, and used landmarks such as electricity lines to ground my estimations. From the satellite images, then distance estimations could be corrected. I also estimated the angle towards the road to describe or estimate the locations of objects, such as for example a village in the distance. With this method, I took the road (fairly straight) as the 0 to 180°- line with me standing at the centre. In practice I estimated up to 90° and indicated whether it was left hand or right hand of where I was standing, always taking looking in the direction of the road as 0°. A village perpendicular to the road would be noted down as ∠90° (or ⊥), while a water body situated on my right hand could be estimated to stretch from ∠20-60°, righthand side (Figure H1 for visual explanation). The four recordings on different days allowed for observations on the receding water levels and its consequences for the vegetation. Ideally, in future research these collected data will be analysed, combined with an analysis of Sentinel images (accessible via: https://apps.sentinel-hub.com/sentinel-playground/?source=S2&lat=-15.569301041707499&lng=23.147850036621094&zoom=12&preset=1-NATURAL-COLOR&layers=B01,B02,B03&maxcc=100&gain=1.0&gamma=1.0&time=2023-05-01%7C2023-11-04&atmFilter=&showDates=false) which potentially can be modelled into a coarse habitat typography from satellite images.

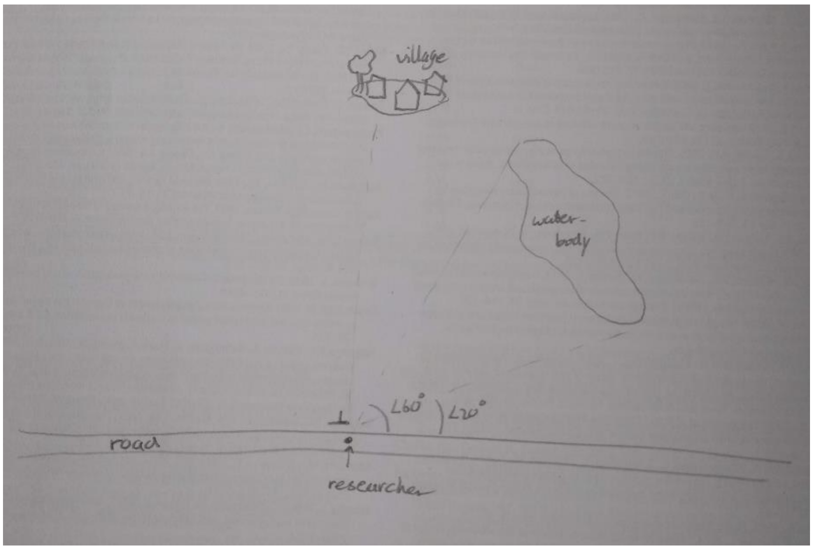


Figure H1: Illustration of the methodology for taking notes on the surroundings.

This methodology is based on discussions with Leo Nagelkerke, Tom Buijse and Paul van Zwieten in combination with my own experience in the field, therefore it is not backed up with literature references.

Some preliminary results are added below. No analysis was conducted and no coupling to Sentinel images was made yet, but photos from the same location on the four different survey dates were put next to each other to show the receding water level and its influence on the vegetation (pay attention to the change in colour) (Figures H2, H3 and H4).

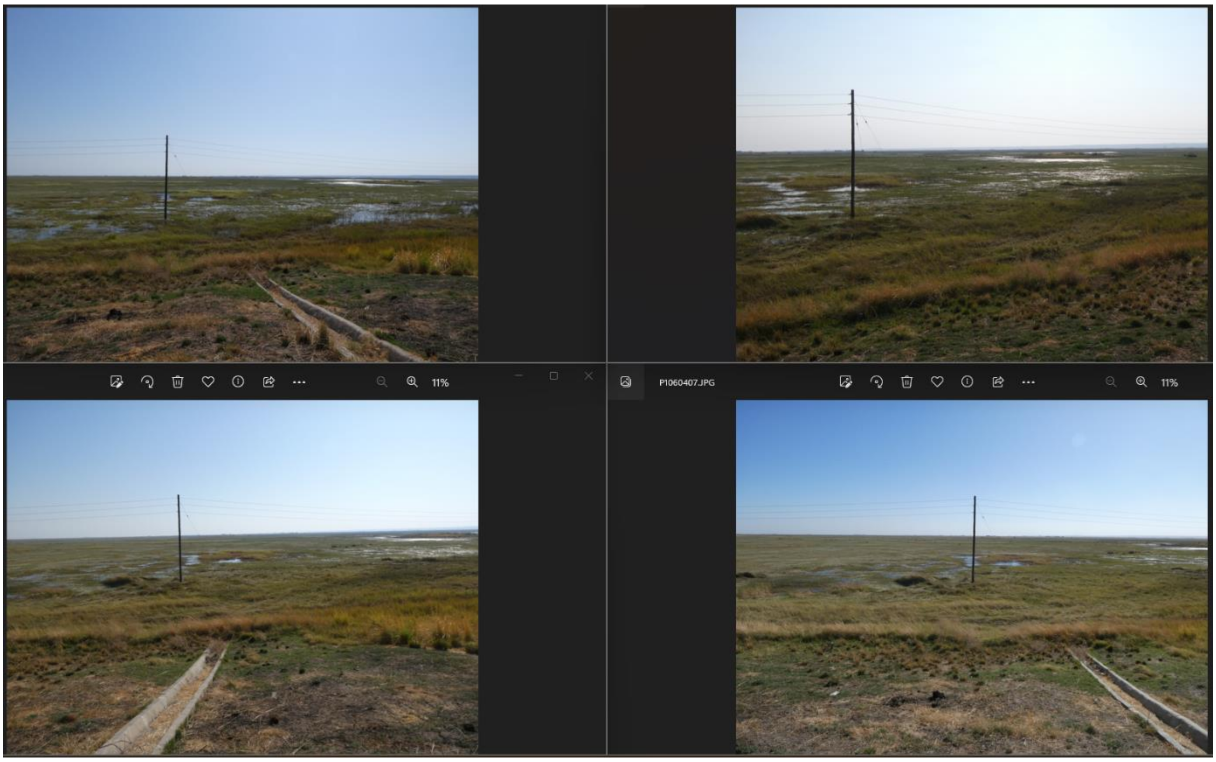


Figure H2: Receding water in the Barotse floodplain on survey point R01 towards the north. Photos taken on 31 May (top left), 14 June (top right), 27 June (bottom left) and 11 July 2023 (bottom right).

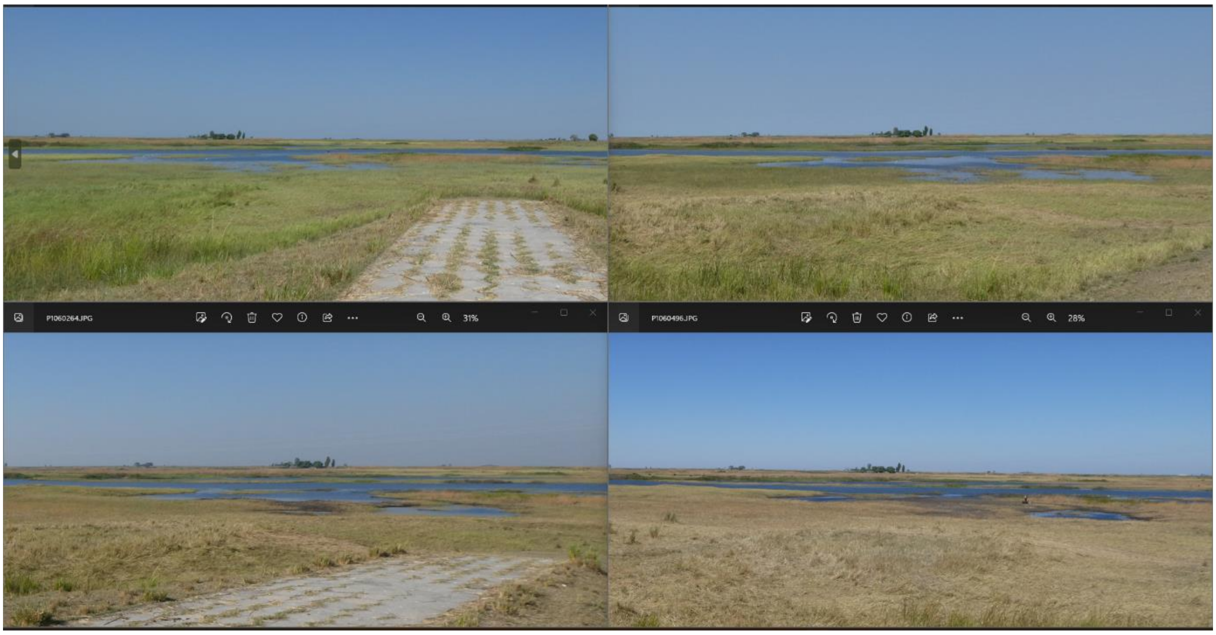


Figure H3: Receding water in the Barotse floodplain on survey point R04 towards the south. Photos taken on 31 May (top left), 14 June (top right), 27 June (bottom left) and 11 July 2023 (bottom right).

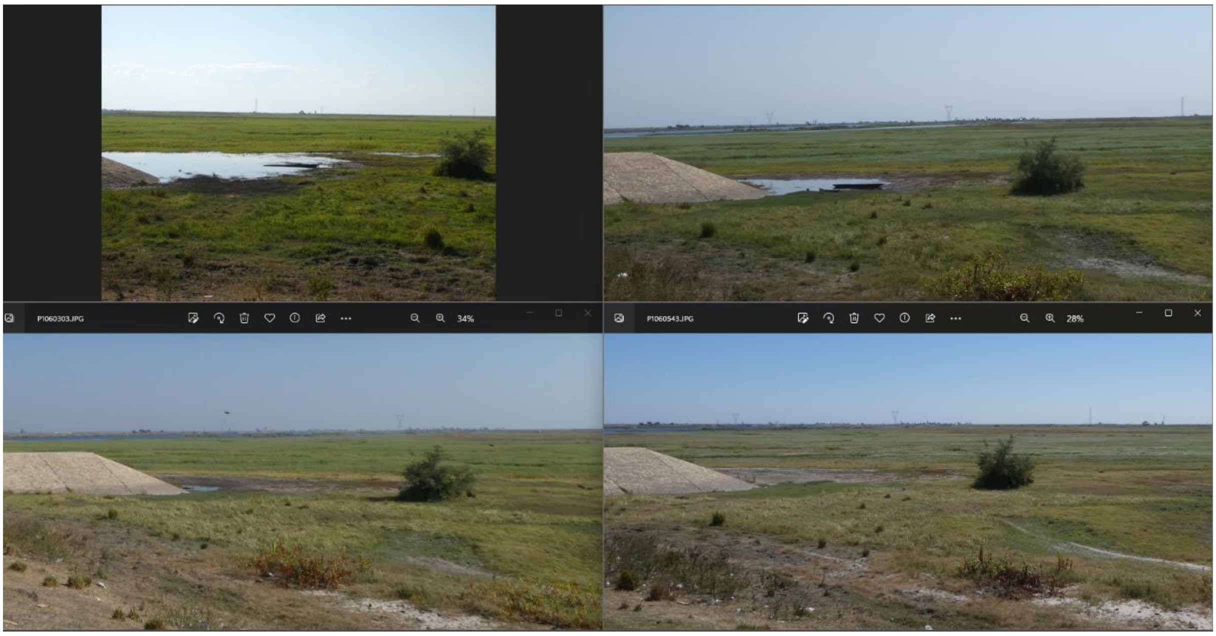
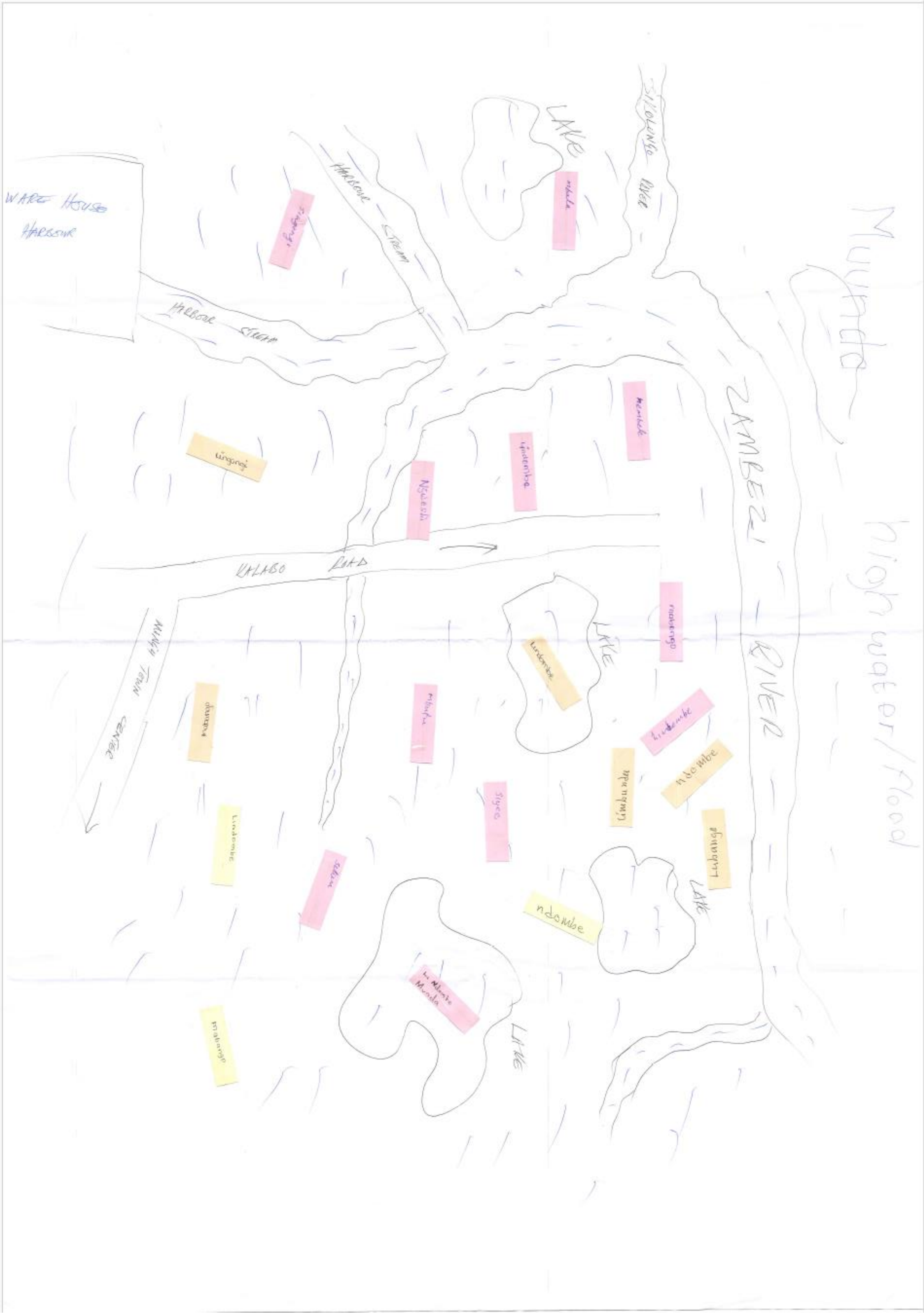


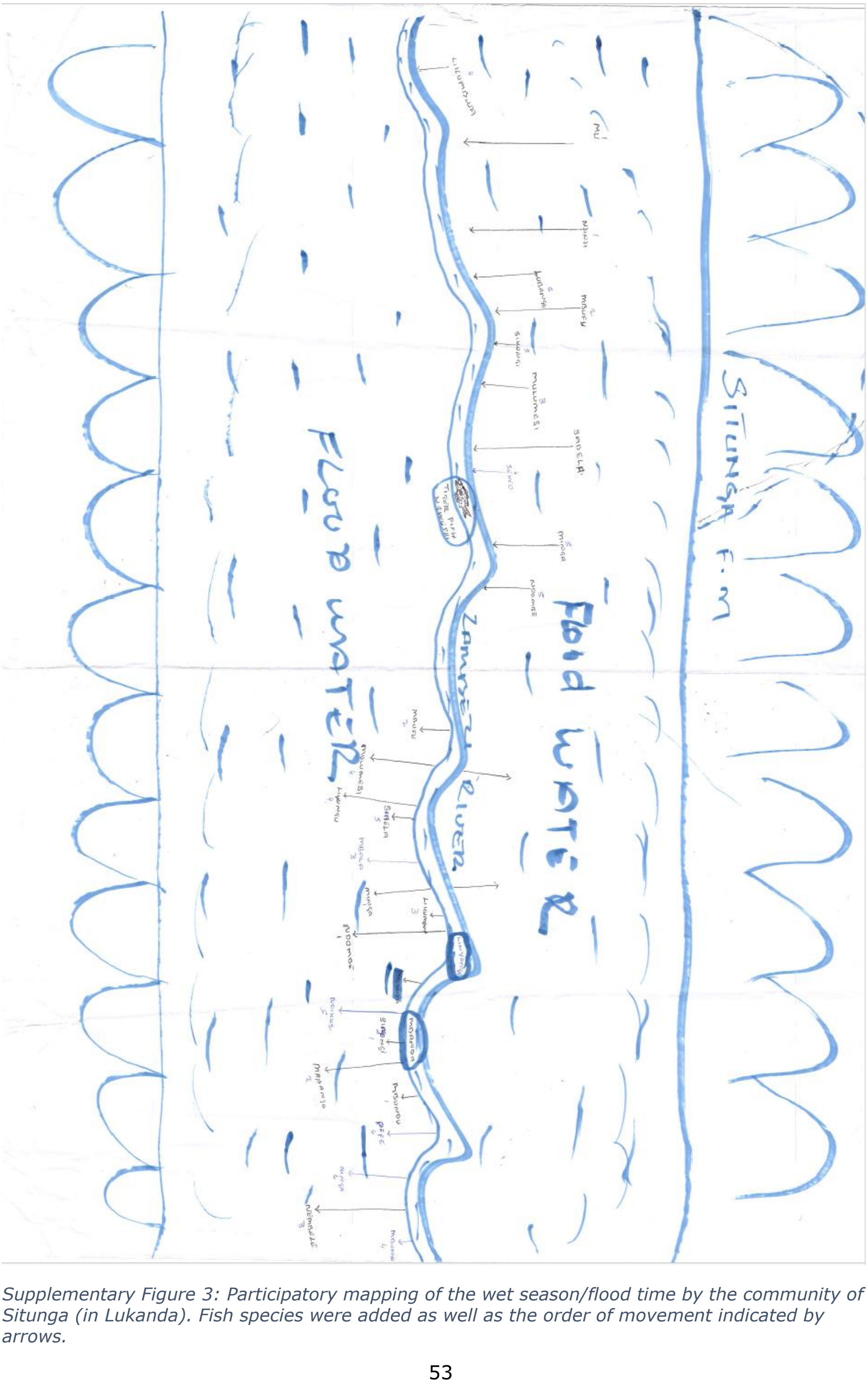
Figure H4: Receding water in the Barotse floodplain on survey point R05 towards the north. Photos taken on 31 May (top left), 14 June (top right), 27 June (bottom left) and 11 July 2023 (bottom right).

Appendix V – Participatory mappings

Supplementary Figure 1: Participatory mapping of the low water situation (mbumbi) by the Mongu harbour focus group in Mongu.

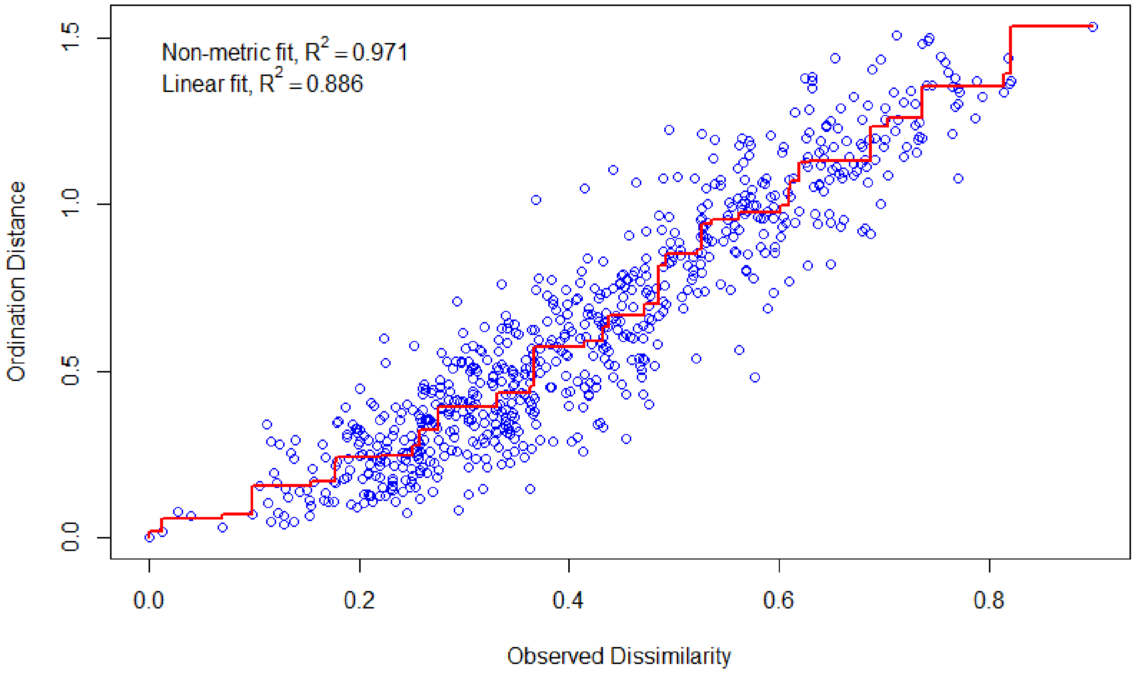


Supplementary Figure 2: Participatory mapping of the high water/flooded situation (muunda) by the Mongu harbour focus group in Mongu.



Supplementary Figure 3: Participatory mapping of the wet season/flood time by the community of Situnga (in Lukanda). Fish species were added as well as the order of movement indicated by arrows.

Appendix VI – Shepard plot



Supplementary Figure 4: Shepard plot of the NMDS-analysis.

Appendix VII - Raw habitat Kobo survey data after cleaning, arranged to cluster

Cluster	Sample	T_Road	T_River	H_Main	H_Canal	H_Lagoon	H_Perenia	H_Floodp	H_Tributa	H_Dam	H_Lake	H_Side	W_width	W_depth	Turb_Clea	Turb_Turb	F_No	F_Little	F_Modera	F_Much	RV_Reed	RV_Grass	RV_Tree	RV_MPigr	RV_Other	RV_Absen	RV_Rice	LU_Agricu	LU_Kraal	LU_Settle	LU_Nature	LU_Road	LU_Other	C_Isolatec	C_1-Sided	C_River	C_Flooded
1	S_16	1	0	0	0	0	0	1	0	0	0	0	200	52.0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1	1	0	1	0	0	0	1
1	S_17	1	0	0	0	0	0	1	0	0	0	0	200	66.0	1	0	0	1	0	0	1	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1
1	S_21	1	0	0	1	0	0	1	0	0	0	0	20	500	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1
1	S_22	0	1	1	0	0	0	0	0	0	0	0	40	210.0	1	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0
1	S_23	0	1	0	0	0	0	0	0	0	0	1	15	203.0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
1	S_24	0	1	1	0	0	0	0	0	0	0	0	200	500	1	0	0	0	0	1	1	1	0	0	1	0	0	1	0	1	1	0	0	0	0	1	0
1	S_25	0	1	0	0	0	0	1	0	0	0	1	100	217.0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1	S_26	0	1	1	0	0	0	0	0	0	0	0	200	500	1	0	0	0	0	1	1	1	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0
1	S_27	0	1	1	0	0	0	0	0	0	0	0	250	166.0	1	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0
1	S_28	0	1	0	0	0	0	0	0	0	0	1	40	135.0	0	1	0	0	1	0	1	1	1	0	1	0	0	0	0	1	1	0	0	0	0	1	0
1	S_33	1	0	0	0	0	0	1	0	1	0	0	150	44.0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1
1	S_34	1	0	0	0	0	0	0	0	0	1	0	40	104.0	0	1	0	1	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1
2	S_04	1	0	0	0	0	0	1	0	0	0	0	30000	31.5	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1
2	S_05	1	0	0	0	0	0	1	0	0	0	0	30000	52.0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1
2	S_06	1	0	0	0	1	0	1	0	0	0	0	400	58.0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0	1
2	S_07	1	0	0	0	1	0	1	0	0	0	0	400	73.0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0	1
2	S_09	1	0	0	0	0	0	1	0	0	0	0	30000	75.0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1
2	S_12	1	0	0	0	1	0	1	0	0	0	0	100	74.0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	0	0	1
2	S_37	1	0	0	0	0	0	1	0	0	0	0	3000	45.0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
3	S_10	1	0	0	0	0	0	1	0	0	0	0	30000	12.0	1	0	1	0	0	0	0	1	0	0	1	0	0	1	1	1	1	1	0	0	0	0	1
3	S_11	1	0	0	0	0	0	1	0	0	0	0	30000	62.0	1	0	1	0	0	0	0	1	0	0	1	0	0	1	1	1	1	0	0	0	0	0	1
3	S_13	1	0	0	0	0	0	1	0	0	0	0	30000	18.5	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	0	0	0	1
3	S_14	1	0	0	0	0	0	1	0	0	0	0	30000	40.0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	0	0	0	1
3	S_19	1	0	0	0	0	0	1	0	0	0	0	150	39.0	1	0	0	1	0	0	0	1	0	0	1	0	0	1	1	1	1	1	1	0	0	0	1
3	S_31	1	0	0	0	0	0	1	0	0	0	0	3000	29.0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	1	1	1	0	0	0	1
3	S_36	1	0	0	0	0	0	1	0	0	0	0	3000	38.0	0	1	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1
3	S_38	1	0	0	0	0	0	1	0	0	1	0	35	56.0	1	0	0	1	0	0	0	1	0	1	0	0	0	1	1	1	1	1	1	0	0	0	1
3	S_39	1	0	0	0	0	0	1	0	0	1	0	250	53.0	0	1	0	1	0	0	1	1	0	1	0	0	0	1	1	1	1	1	0	0	0	0	1
3	S_40	1	0	0	0	0	0	1	0	0	0	0	3000	39.0	1	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0	0	0	0	1
4	S_08	1	0	0	0	0	0	0	0	1	0	0	50	97.0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0
4	S_15	1	0	0	1	0	0	0	0	0	0	0	20	56.0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	1	1	1	0	0	0	1
4	S_18	1	0	0	0	0	0	0	0	0	1	0	30	89.0	0	1	1	0	0	0	0	1	0	0	1	0	0	1	1	1	1	0	0	1	0	0	0
4	S_20	1	0	1	0	0	0	0	0	0	0	0	300	500	1	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	1	1	1	0	0	1	0
4	S_29	1	0	0	0	0	0	0	0	1	0	0	20	83.0	0	1	1	0	0	0	0	1	0	1	1	0	0	1	0	1	1	1	1	0	0	0	1
4	S_30	1	0	0	0	0	0	0	0	1	0	0	80	72.0	1	0	0	1	0	0	1	1	0	0	0	0	0	1	0	1	1	1	1	0	1	0	0
4	S_32	1	0	0	1	0	0	0	0	0	0	0	10	44.0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
4	S_35	1	0	0	1	1	0	0	1	0	0	0	500	38.0	1	0	0	0	1	0	1	1	0	0	1	0	0	1	1	1	1	1	1	0	0	0	0
4	S_41	1	0	0	0	0	0	1	0	1	0	0	150	50.0	1	0	0	0	1	0	1	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1
4	S_42	1	0	0	1	0	0	0	0	0	0	0	20	45.0	0	1	0	0	1	0	1	1	1	0	0	0	0	1	0	1	1	1	0	0	1	0	0